CTA-2019

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Organized by:
EiTEX- Ethiopian Institute of Textile and Fashion Technology, Bahir Dar University

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CTA-2019

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8th International Conference on Cotton, Textile and Apparel Value chain in Africa

Edited by:
Dr. Tamrat Tesafye
Dr. Berihun Bizuneh

… and with the participation of all of you!!!

8th INTERNATIONAL CONFERENCE

ON

COTTON, TEXTILE AND APPAREL VALUE CHAIN IN AFRICA
[CTA-2019]

June 7-8, 2019

Conference Proceedings

ISBN 978-99944-75-31-5

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Million Ayele
Organizing Committee Chair of CTA-2019

Preface

Ethiopian Institute of Textile and Fashion Technology (EiTEX), Bahir Dar University is long stayed higher education in Ethiopia, offering textile education and training. The institute is working to be the center of excellence for textile education research and community services. For this reason, the institute is organizing annual series international conferences on 'Cotton Textile Apparel and Value Chain in Africa (CTA)' for it's an integral part of preserving efforts on research promotion and knowledge dispersal in the textile sector and policy makers. As earlier conferences the 8th international conference has endeavoured to bring together people and organizations from across the country, Africa and other parts of the world for mutual benefit.

The 8th international conference organizing committee received large number of research papers around the globe which covers wide areas of textiles. The abstracts were critically evaluated by the publication committee with regard to their originality, Research comprehensiveness and relevance to the theme.

The selected paper covers areas of cotton and other textile fibres, textile production, textile chemistry, apparel production, leather technology and production, environment and value chains. Therefore, it is hoped that the conference participants will not only gain the current existing knowledge and experiences in textile and leather related areas but also new ideas and knowledge for enhancing further developments in their specific production and business area.

On behalf of the organizing and publication committees, I extend a warm and hearty welcome to all the participants.

Million Ayele
Chair- Organizing Committee of CTA- 2019

Dr. Abera Kechi
Scientific Director - EiTEX

Message

I am extremely pleased to welcome you all to the 8th international conference on ‘Cotton, Textile and Apparel Value Chain in Africa (CTA - 2019)’. This international conference is a continuing effort in the part of Ethiopian Institute of Textile and Fashion Technology (EiTEX), Bahir Dar University to encourage, promote and disseminate research and knowledge in the Textile and Apparel sector with focus on cotton. The presenters are drawn from across the globe while the target audience is the Textile and Apparel sector stakeholders in Africa in general and Ethiopia in particular.

The purpose of the conference is to initiate involvement among the stakeholders so that the ideologies of the government regarding importance and growth of the Textile and Apparel industry are realized. This conference will continue the tradition of the previous years’ conferences that served as an effective platform in provoking and that they will provide you with an invaluable opportunity to share ideas with peer researchers and practitioners.

Hence, it is matter of immense pride that EiTEX remains the corner stone of CTA and I extend a warm welcome to the honored guests, respected presenters and valuable participants. I take this opportunity to thank our chief partron Bahir Dar University and sponsors at all levels. I look forward to meeting you all during the conference and making it a grand success.

Dr. Abera Kechi
Scientific Director - EiTEX

CTA-2019 Organising Committee

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About Bahir Dar University

Bahir Dar University was established by merging two former higher education institutions, namely the Bahir Dar polytechnic and Bahir Dar Teachers College and was officially inaugurated on May 6 2000. The Bahir Dar Polytechnic Institute, with time transformed itself into having two main institutes, a Technology Institute and Textile Institute established in 1963 under the technical cooperation between the Government of USSR and the imperial Government of Ethiopia, propelling the institute as a premier in producing technicians for the nation.

Presently, Bahir Dar University is among the largest universities in the federal Democratic Republic of Ethiopia with population of more than 3500 students. The university consists of four colleges, four

institutes, three faculties and one school.

Mission

To contribute substantially to the nation and beyond through high quality education, research community services.

Vision

To become one of the top ten premier research universities in Africa by 2025.

Motto

Wisdom at the source of Blue Nile

Core values

Quality, Discourse, Innovation, Integrity, Democratic Culture and Social Responsibility

About EiTEX

EiTEX is a premier higher education institute under Bahir Dar University for more than 50 years. It is pioneer institute in offering programs in Textile, Apparel, and Fashion and Leather Technology. The Institute started its training programs in 1963 at diploma level as department under Bahir Dar Polytechnic Institute and later on the department was promoted to institute level in 2009. Since its establishment the institute has expanded its activities to include industrial and vocational training in the textile sector.

The Institute continues to strive to strengthen research community service and technology transfer activities in order to contribute to economic development of country as per Growth and Transformation Plan (GTP). Furthermore, the institute regularly organizes international conferences to provide a forum for stakeholders to address problems encountered in the cotton, textile, apparel and leather sectors. Hence the 8th international conference is planned to facilitate in this respect providing a platform for exchange of its ideas as well as supplementing critical issues to the policy makers.

EiTEX Goals

1. Serving the local community and the industries by providing research and consultancy services related to fashion and textiles.
2. Support and develop Ethiopian textile and garments industries with the aim of sustainable progress and keen competitiveness in the world market.
3. To support, enhance the capacity and competitiveness of Ethiopian textile and garment industries including small and medium enterprises.

Academic programs offered at EiTEX

Undergraduate

B.Sc Textile Engineering
B.Sc Textile Chemical process Engineering
B.Sc Garment Engineering
B.Sc Fashion Design
B.Sc Leather Engineering
B.Sc Textile & Apparel Merchandising
B. Ed Textile Technology
B. Ed Garment Technology

Postgraduate

M. Sc Textile Chemistry
M. Sc Textile Manufacturing
M. Sc Fashion Technology
M.Sc Fashion Design
M.Sc Fiber Science and Technology
M.Sc Leather Products Design & Engg.
M. Ed Textile Technology
Ph.D Textile Technology- Sandwich
Ph.D Fashion Technology- Sandwich

EiTEX: *Mission, Vision & Values*

Mission

Ethiopian Institute of Textile and Fashion Technology is working:

- To create suitable and excellent academic environment.
- To train students with high level of competence taking the social and industries' needs in to consideration.
- To build the capacity of students to be morally concerned about the environmental and social progress.
- To conduct problem solving research, proper community service and technology transfer programs.

Vision

EiTEX aspires to be one of the top three institutions in Africa in 2025 recognised for its quality education, research and community services.

Values

The values that describe the Ethiopian Institute of Textile and Fashion Technology are:

- Quality
- Creativity
- Trustworthy
- Democratic culture
- Social accountability
- Team work

ORGANISATIONS / UNIVERSITIES WITH WHICH *EiTEX* HAS *MEMORANDUM OF UNDERSTANDINGS* (MoUs)

International

S.No.	UNIVERSITY /ORGANIZATION	Major Areas of Collaboration include, but not limited to
1	Texas Tech University, USA	Exchange of Faculty members and students, Research Data, and Educational and development programs
2	Hof University of Applied Sciences, Bavaria, Germany	Exchange of staff, Joint research, Support and sponsor projects, staff development and student training
3	Institute of Chemical Technology, Mumbai, India	
4	Faculty of Textile Engineering Technical University of Liberec, Czech Republic	
5	Ukraine Engineering Pedagogics Academy, Ukraine	Exchange of faculty members, persons working for a doctor's degree, graduate and undergraduate students for training, Exchange of specialties, Joint research, participation in international conferences
6	Ivanovo State Textile Academy, Ivanovo, Russian Federation	Staff and student exchange, visiting scholar programs, Joint research, cultural exchange programs, co-operative learning programs, development and application of educational methods and technologies, collaborative exchange lectures, conferences and seminars, short term training programs and seminars
7	Kyambogo University, Kyambogo, Uganda	Exchange of faculty members, exchange of students, Joint research, participation in international seminars programs and joint participation in international projects & academic meetings, Special short-term academic programs & joint participation in international projects
8	National University of Science & Technology, Zimbabwe	Exchange of Information, faculty, and students both on academic programs and research activities, finance joint projects
9	Arch Academy of Design, India	Research, Staff and students exchange
10	EPTAINKS S.P.A. Socio Unico, Italy	Support and sponsoring projects/fellowships, R&D projects, joint workshops and seminars, share experience, training, advertising products to company
11	Donghua University, China	Student trainings, joint research and innovation, exchange of technology, experience and capacity building, support and sponsor projects, staff and student exchange
12	Chengdu Textile College, China	
13	Ghent University, Belgium	Exchange technology & experience, trainings, research & innovation, support & sponsor projects, share experience through staff student exchange
14	ETHOTECH Limited, UK	Establishing a pilot project, facilitation of machine purchase, exchange of knowledge, promote training, mentoring and market awareness, job creation and export expansion
15	Common Market for Eastern and Southern Africa – Leather and Leather Products Institute (COMESA/LLPI)	Research, training, technology transfer, consultancy, exchange of programs, development of SMEs
16	HELA ENDOCHINE (Hawassa Industrial Park)	Research and training in terms of internship, practical attachment and final year project, staff exchange, exchange of innovative ideas, training of workers and organize seminars and public lectures
17	EPIC Apparel (Hawassa Industrial Park)	
18	BECONNECTED INDUSTRIAL	

National

S.No.	UNIVERSITY /ORGANIZATION	Major Areas of Collaboration include, but not limited to
1	MoST [Ministry of Science and Technology]	Research, Technology Transfer
2	ETIDI [Ethiopian Textile Industry Development Institute]	• Training and other related activities: initiate & develop new academic programs in textile industry related discipline, exchange of experts & faculty members, co-organizing seminars, trainings, workshops & expert consultations, develop and offer demand driven soft skills training for private & public small, medium and large-scale textile industries, capacity building programs to TVET & related community • Research & Development: Promote & launch joint, need-based, industry demanded, and problem-solving research & development program, focus on reverse engineering & prototype production approaches, • Consultancy and advisory services: Design & deliver capacity building programs and consultancy services along the country's GDP
3	LIDI (Leather Industry Development Institute)	Initiate and develop new academic programs in textile industry related discipline, exchange of experts and faculty members, co-organizing seminars, trainings, workshops and expert consultations, Joint research, consultancy, capacity building programs
4	ETGMA [Ethiopian Textile, Garment Manufacturers Association]	Research, Consultancy, Training
5	PPESA [Privatization and Public enterprises' supervisory agency]	Short- and long-term training, Joint research, joint workshops, seminars
6	ECPGEA [Ethiopian Cotton Producers and Ginners Association]	Training and consultancy, documentation and data exchange, research
7.	African Mosaique	Joint Research, Internship, Training & Joint Project works on indigenous products in the current Fashion industry
8	Mizan Tepi University	Research, training, technology transfer, consultancy, exchange of programs, development of SMEs
9	Bahir Dar TVET College and Bahir Dar City Small Scale Enterprises	Short- and long-term training, technology transfer, encouraging SSE, facilitating market linkage
10	Warka Leather Products	Training and education, joint workshops seminars, technology transfer, testing of prototypes and products, design and manufacturing of prototypes
11	Hawassa Industrial Park	Research and training, internship, practical attachment and final year project, staff exchange, exchange of innovative ideas, training of workers and organize seminars and public lectures
12	Textile and Garment Industries in Ethiopia	Training, internship, practical attachment and final year project

Contents

Business Case for Sustainable Cotton in Ethiopian

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Abstract

The results shown in this publication are the analysis of a pilot project called Sustainable Cotton Initiative Ethiopia, implemented in 2 cropping seasons of 2017 & 18. Three commercial farms, 36-76 lead farmers & extension staff from Afar and Tigray regional states participated in the program. Project farms who used improved cotton varieties achieved higher yield than the conventional variety at the same farm & even more with comparison farmers. The productivity gain achieved through a high yielding variety, improved water use efficiency & crop protection activities. Farmers benefited from reduction of cost of pesticides through lower use of insecticide. The environmental advantages achieved with the reduced use and contamination of water, the use of less active ingredient of hazardous pesticide, through the systematic adoption of revised economic threshold spraying method, higher adoption rate of IPM & bio-intensive crop protection practices. Capacity building of farmers & their organisations on sustainable farming techniques, improved farmers and workers' health, created an awareness on compliance issues, certification & greater resilience of the farming community. The productivity advantage of 23-45%, benefiting farmers with an income of ETB 13,000-23,000 per ha, reduced cost of production, could be an input to develop a business case which can attract an investable proposition, better market options & higher return on investment.

Keywords: **Ethiopia, Cotton, Business Case Sustainability**

I. INTRODUCTION

The Mid-term review of GTP II of Ethiopia indicates that export earning has been declining during the last 3 years of GTP II period. The report stated that agricultural commodities dominated the export earnings with 75% share followed by manufacturing of goods accounted for 13% on average. The share of export earning of the textile was between 2.7-3.1%. Poor value chain integration between agriculture and manufacturing sector, the political instability, market demands for sustainable products contributed for the declining of export earnings & unmet targets. [1]

The pilot "Sustainable Cotton Initiative Ethiopia" (SCIE) implemented in cotton growing regions, Afar & Tigray Ethiopia in 2017/18. The primary outcomes of this pilot is to bringing cotton as sustainable mainstream commodity through improvement of farmers' income & livelihoods, environment variables, working conditions, chain integration & market linkages.

Cotton farmers and their supporting organizations have a vital role in adopting and promoting sustainable practices to ensure consumers, retailers and brands demand for the transparency of raw materials & value addition of cotton, towards achieving GTP II targets.

II. METHODOLOGY

Measurements on the indicators of the production principles taken according to standard set by FAO & ICAC [2].

III. BUSINESS CASE FOR SUSTAINABLE COTTON

There are significant improvement on environmental & economic variables, which proofs the business case of production of sustainable cotton in Ethiopia (Tab. 1 & Fig 1).

Table 1. Summary of benefits for producers

Principles	Benefits
Minimize the harmful impact of crop protection practices	Environmental, Social & better market
Promote water stewardship	Contributes to productivity enhancement, distribution efficiency & reduction of salinity
Care for soil health & enhance biodiversity	Increase soil fertility & greater resilience by producers
Care for fiber quality	So far very limited reduction of contamination poly bags
Promote decent work	Improve farmers' and workers' health & safety, income
Productivity improvement	More produce & cotton by-products
Profitability	Higher return on investment, family's wellbeing and the wider community
Capacity of the management entity	Improved input & output marketing, sustainable farming, compliance issues, certification, partnerships

A. Water Stewardship

Project farms showed significant improvement on water scheduling & measurement from unknown amount of application to 529-640 liter/hectare per irrigation.

B. Environmental & Social Benefits

Benefits from the reduction of the use 0f hazardous pesticides was ranging from 25-100 %, which is a direct contribution to environmental & health benefit of the workers, families & communities.

C. Social Benefits

Successive trainings on social issues, labor & gender inclusivity, distribution of manuals strengthened the awareness of the producers.

D. Cost of Production

Reduction of cost of pesticide ranges from 34-97% which is a gain of 395 -1,703 ETB per ha. The highest reduction of cost is for smallholders.

E. *Productivity & Additional Income*

Productivity enhanced through the introduction & multiplication of a new cotton variety with higher lint percentage (7% over the conventional) [3], 23 & 45% yield advantage over the conventional variety & comparison farm, respectively. This is a gain of 800-2000 kg/ha seed cotton, 373-898 kg/ha lint & and a potential income of ETB 13,000-23,000, a contribution from an inherent characteristic of the variety, enhanced by better water & pest management improvements.

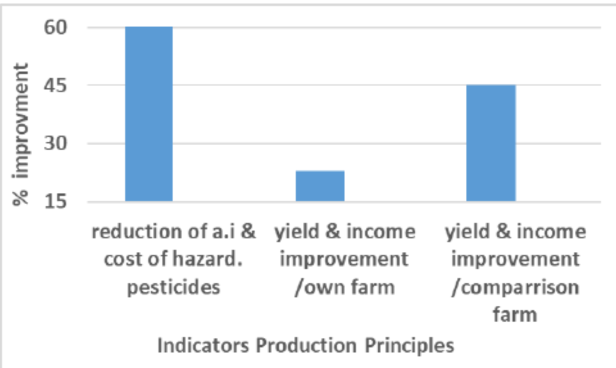

Fig. 1. Environmental & Economic Improvements

IV. Lessons Learned

A. Input & Output Marketing

Availability & access to environmentally friendly crop protection materials & technologies (inputs) needs the attention of the policy makers to enable the role the private sector engagement. Field days, matchmaking sessions between producer's organization & processors resulted in facilitating the marketing of 1100 ton of sustainable lint cotton to AYKA, MNS & ELSE textile industries reaching the intended chain of custody in 2018

B. Encouraging Seed Producers

The significant achievement of this pilot is development of a seed multiplication unit at a model private commercial farm Aweke Fente with TA support by Solidaridad, reached 111 ha in 2018 a scaling up of seed multiplication activity from 16 ha in 2017. Strong support is required to seed producers to make them a registered seed companies to improve access to planting seeds & other related technologies.

C. Certification Support

There are significant improvements for all project farms, addressing the remaining compliance issues in the upcoming project implementation. However, two of the ginneries have passed third party verification test under CmiA model in 2018.

D. Enforcing Mechanisms

Sector & country wise analysis of supply chains, for a policy dialogue with governments' institutions, investors, and evidence-based communications with financial institutions, donors' communities to stimulate enabling & business environment, creating & sharing impact related results. The expectation is high from the enforcing mechanisms of government institutions to Enabling Policy Environment through capacity building even with the existing policies on promoting & enforcing sustainability standards through improving:

- The research system to generate & demonstrate registered agricultural technologies
- Access to timely inputs, including IPM compatible pesticides accepted by WHO, quality seed, ginning & seed treatment facility, credit, timely payment for the produce
- Availability for season-long farmer training & commitments of extension agents, staff & management of commercial farms
- Introducing technologies to alleviate the current shortage of labor & contamination issues
- Increasing involvement of local cotton producers, ginners, textile industries & brand retailers in integrating the value chain
- Availability of contamination free packaging material for raw cotton bagging & transportation

E. Traceability of the Supply Chain

Data collection requires a systemic change through digital tools & ICT solutions in aggregation, analysis of project & country level information for an evidence-based communication, ensuring traceability & scaling up of good practices.

V. Recommendation

An in-depth economic analysis is highly recommended on the current achievements to develop a business case, based on agro climatic conditions, production system, adoption rate of good agricultural practices, cost of input & market price of lint cotton.

VI. CONCLUSION

From Pilot to Scale: Drawing lessons during the implementation period, exploring funding options through creating a success case that can serve as example for scaling up of similar support models, resulted in the approval of a project called Bottom Up!.

The scaling up project aims in "Promoting a sustainable cotton & garment value chain from Ethiopian cotton to European consumers"- To contribute to a sustainable, inclusive and transparent value chain that generates business growth, improves working conditions, and promotes labor and environmental standards and responsible purchasing practices in the cotton and garments industry in Ethiopia and Europe by 2021

ACKNOWLEDGMENT

I would like to express my deepest appreciation to our funding partners; EP, H&M & the Dutch government, implementing partners; ETIDI & ECPGEA for successful implementation of the project.

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Evaluation of Electrospun Polystyrene Filament as Sorbent Materials for Oil Cleanup

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Abstract

Electrospun Polystyrene (PS) fibers have been of increasing interest due to their unique structures and properties. The Porous structure of electrospun PS fibers can make it a promising candidate for high-capacity oil sorbent. The continuous length of PS filament with a porous structure on the surface through conventional electrospinning is reported in this study. PS was chosen to be a functional polymer to process in the conventional electrospinning system, it tends to produce porous structure while the addition of a relative amount of Lithium chloride produces continuous filament. Effects of the relative amount of N, N-dimethylformamide (DMF) and Tetrahydrofuran (THF) as a solvent and the addition of anhydrous Lithium Chloride (LiCl) to produce continuous filament and porous structure were investigated. The oil sorption experiment shows that continuous filament with porous structure has the advantage of showing larger sorption capacity. The results show that the sorption capacities of the PS filament with addition relative amount of LiCl 0.25 %, 0.50 %, 0.75 % and 1.0 % in the sorbent with different sorption times from 5 minutes to 15minutes of engine oil. The maximum sorption percentage is 82, 62, 50, and 45 g/g, at 5 minutes respectively. The PS filament sorbent used also oil/water filtration and high buoyancy in the cleanup of oil over water. The SEM analysis indicated that voids among porous structure on the filament surface were the key factor for the high sorption capacity. And also expected that the continuous length of PS filament can make its potential applications in that fields such as oil sorption, filtration, and intelligent devices.

Keywords- **Conventional electrospinning; Polystyrene filament; Porous structure**

I. INTRODUCTION

Electrospun microfibers with porous structure have been of increasing interest due to their large surface area and large porosity, and therefore find applications in sorption and filtration materials [1-3]. Many researchers have explored the production of porous fibers using electrospinning technology. Polystyrene (PS) porous formation of electrospun fiber, which is involved in different polymer concentrations and solvent mixing ratios, were studied in many works [4-7]. Poly (methyl methacrylate) (PMMA) porous fibers were reported to be electrospun from different solvent systems to compare their surface morphology [4]. The use of chloroform as the solvent of Poly (lactic acid) (PLA) in electrospinning gives rise to circular pores of 100 nm diameter confined to the fiber surface [8, 9]. PS is one of the most widely used polymers in producing electrospun porous fibers, which shows high liquid sorption capacities and finds application in oil cleanup materials. However, electrospun porous structure fibers usually have poor mechanical performance due to the intrinsic property of PS and the porous structure in the fiber surface. On the other hand. The previous researchers have been produced nonwoven PS porous fibers sheet. But now we have focused on the nonwoven PS porous filament sheet and fewer details of the continuous length of the polystyrene filament were presented. Effects of the processing parameter, conventional electrospinning method and the solution parameter the relative amount of the solvent ratio and additive) on the characteristic continuous length/porous structures are investigated. To verify the advantage of the new structure, the oil sorption experiment is carried out to compare the sorption capacity of filament sorbents with different amounts of porous structures. Herein we obtained filament sorbent consists of a large surface area of the porous structure will have a large prospection for sorption application.

II. EXPERIMENTAL METHOD

Material Preparation

Polystyrene (PS; Mw = 350 000, Sigma-Aldrich) were purchased from (Beijing Yili Fine Chemical Co., Ltd., China. N, N-dimethylformamide (DMF; 0.945–0.950 g/mL at 20 °C), and tetrahydrofuran (THF; 0.887–0.889 g/mL at 20 °C) were purchased from Sigma-Aldrich. Lithium chloride anhydrous (LiCl) was from Macklin. All of these materials were used without further purification.

Homogeneous PS solution was prepared by dissolving the PS pellets in a mixture of DMF/THF (1/1 volume ratio) with 0.25%,0.50%,0.75% and 1.0% LiCl stirring for 12 h at Room temperature and All experiments were performed at about 25 °C in air at 40–60% relative humidity.

Experimental Setup

In this article, we used a conventional electrospinning method, which was introduced in previous work [10, 11]. The conventional electrospinning system is shown in Fig. 1. The steel needle was a blunt-type stainless needle with inner and outer diameters of 0.84 and 1.27 mm, respectively. The solutions were fed into the spinneret via corresponding syringe and pump (KDS 220, KD Scientific, Inc. USA). A high-voltage supply (ES-60P 10W/DDPM, Gamma High Voltage Research, USA) was applied to the spinneret and the collector, which was a rotating cylinder with a linear velocity of 14.24 cm/s

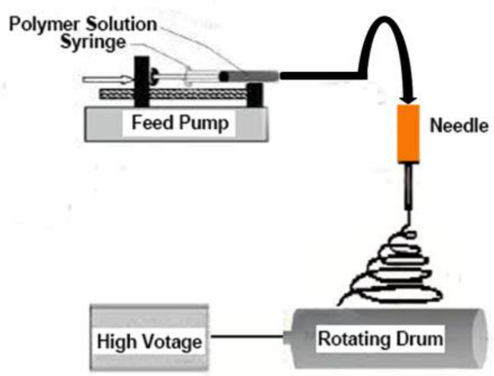


Fig. 1. Schematic of conventional electrospinning system.

Characterization

The morphology of the resultant filaments was observed under a scanning electron microscope (SEM; Flex SEM 1000, HITACHI, JAPAN) after gold coating (coating time was 60 s). The average filament diameter was calculated from the SEM images using Photoshop CS6 (Adobe Systems Inc., San Jose, CA, USA) software from a collection of filaments.

III. RESULTS AND DISCUSSION

Morphology and Porous Structure of Polystyrene Filament

The SEM image of the electrospun PS filaments is shown in Fig. 2. We can see that the sheet contains a large part of PS filaments. These filaments were generated by conventional electrospinning 30 wt % PS in DMF/THF by stainless steel needle. The processing conditions used were 12 cm working distance and 15 KV applied voltage. To further observe it shown in Fig. 2a low magnification of PS nonwoven filament sorbent sheet. The filaments morphology structure is not the circular shape is shown in Fig. 2b and the filament diameters vary from about 12 to 25 μm. The microscale filament produced porous and groove structures on the surface, which is clearly shown in Fig. 2c. Show the nanoscale pores and grooves on the filament surface. It is worth noting that in this study the porous structure comprises nanoscale pores and grooves.

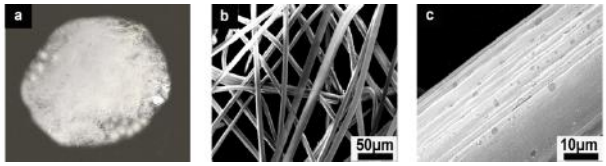
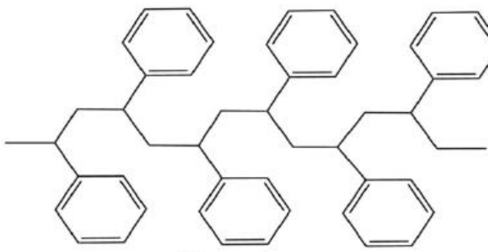


Fig. 2. PS filament sorbent sheet (a), SEM image of electrospun PS filaments (b) and (c) identifying the porous structure.

The mechanism of the continuous length of the filament and porous structure produced via conventional electrospinning may be very complex. First, the molecular structure of PS polymers (shown in Scheme 1) indicates that PS is more rigid due to the existence of the benzene rings in the chain. We have studied to produce PS fibers in previous work [12].



Scheme. 1. Molecular structure of Polystyrene polymer.

Secondly, the fibers electrospun from PS polymer with THF/DMF mixed solvent in the solution then appear irregular nanopores on the fiber surface from the high vapor pressure of THF with added DMF. The formation of the porous structure of the filament utilizes the addition of additives of a functional polymer, in which PS tends to produce porous structure and a continuous length of the filament.

Effect of Parameters on Producing PS Polymer Filament

To produce continuous PS filaments presented in this process by various factors, such as the properties of materials, the properties of solutions, the electric field generated from the spinneret to the collector, as well as the processing parameters and the ambient atmospheric conditions. The PS filament is electrospun from 30 wt % PS under the various relative amount of LiCl. The flow rates of PS solution were constant 1.0 mL/h, respectively, indicating the rigid component with solvent DMF/THF (1:1 volume ratio), and the applied voltage were kept as 15 kV. We can see that, under the different amount of LiCl from 0.25% to 1.0% in the PS solution, when increasing the percentage of LiCl, the porous structure on the PS filament surface reduced.

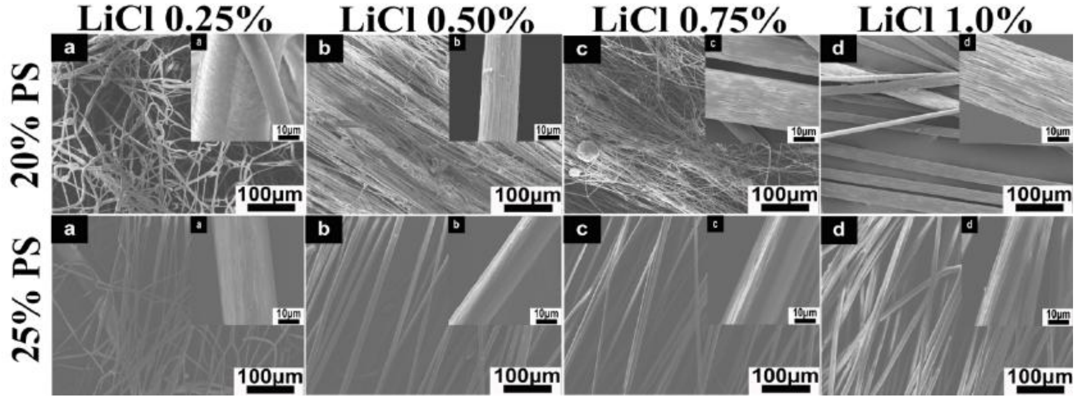


Fig. 3. SEM images of the PS filaments morphology with grooves structure under different concentration of polymer with different concentration of LiCl.

Effect of PS Concentration on Producing Filament

The PS nonwoven filaments sheet are electrospun with different concentration of polymer under the various relative amount of LiCl it shown in Fig. 3. With a constant flow rate, we can see that this sheet contains a large part of PS nonwoven filaments. These filaments were generated by conventional electrospinning by 20wt % and 25wt % PS in DMF solvent by stainless steel needle. To further observe the filament morphology and surface structure of filament is a circular shape at 0.25% concentration of LiCl its shown in Fig. 3a but when increasing the concentration of LiCl from 0.5% to 1.0% the filament's morphology and surface structure of filament is not circular shape and also found some beads are shown in Fig. 3b to 3d and the same condition of filament morphology and surface structure, we have seen in 25% concentration of PS polymer.

Fig. 4 show the SEM images of PS filament morphology structure under different voltages. Other processing parameters were kept unchanged of 12 cm distance and 1.0 ml of flow rate. The LiCl amount has been an effect of filament morphology structure. We can see that LiCl at (1.0%) (Fig. 5a), to produce the continuous filament but not in circular shape due to the high conductivity of LiCl. If we increased the voltage from (Fig. 5b to 5d), not produced the continuous filament due to the high voltage.

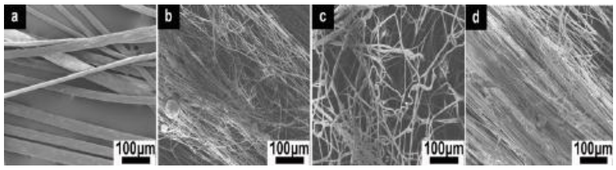


Fig. 4. SEM images of the PS filaments morphology structure under different voltages. (a) 5KV, (b) 9 KV, (c) 15KV, (d) 20KV.

Fig. 5 show the SEM images of PS filament porous structure under various amounts of LiCl, i.e LiCl (0.25%), (0.50/), (0.75%) and (1.0%) . Other parameters were kept unchanged of 12 cm distance and 15 kV applied voltage. The LiCl amount has been an effect on the porous structure because the porous structure is influenced significantly by the polymer type, rather than the solvents. On the other hand, the porous structure is strongly dependent on the DMF/THF solvents system. We can see that LiCl at (0.25%) (Fig. 5a), best porous structure on the filament surface due to the low concentration of LiCl. If we increase the concentration of LiCl (Fig. 5d), grooves and very few pores appear on the filament surface.

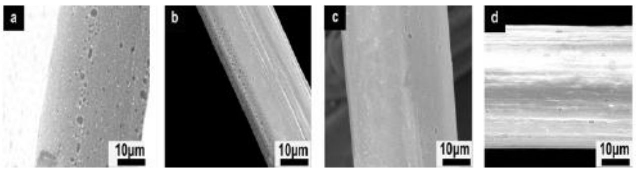


Fig. 5 SEM images of the PS filaments under different concentration of LiCl. (a) LiCl (0.25%), (b) LiCl (0.50%), (c) LiCl(0.75%) and (d) LiCl(1.0%).

Potential Application in Sorption

To find out the advantage of the PS filament sorbents, we carry out the oil sorption test to compare the sorption property of filament sorbent containing different amount of filaments Fig. 7 shows four filaments sorbents produced under different concentration of LiCl and influences the porous structure significantly. As we discussed above, 0.25% LiCl can produce continuous filaments and best porous structure more easily. PS filament with a few porous is obtained when increased the percentage of LiCl 0.50 % to 1.0% respectively. To check the liquid wettability of the PS filament sorbents, the samples were dipping in the 100% engine oil, oil/water blend, and pure water, respectively. From Fig. 6 we can see that the sample can be completely immersed in the oil, while it floats on the water surface. This indicates that PS filament sorbent shows oleophilicity and hydrophobicity nature.

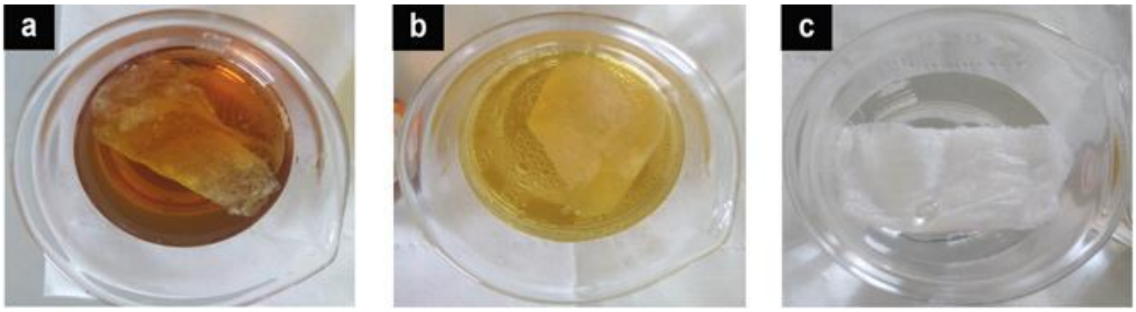


Fig. 6. Images of PS filament sorbents dipping in the liquid solutions. (a) Oil, (b) Oil/Water, (c) Pure water.

To analyze the maximum oil sorption capacity of PS filament sorbents, we placed 1.0 g of sample in a glass beaker filled with 50 mL of oil. After 5, 10, and 15 min of sorption. The wet sorbents were drained for 2 min until no residual oil droplet was left on the surface. The oil sorption capacity of all sorbents was determined by the following Equation.

$$q = \frac{(m_f - m_o)}{m_o} \quad \textbf{(1)}$$

Where q is the sorption capacity (g/g), m_f is the weight of the wet sorbent after 5 min, 10 min and 15 min of drainage (g), and m_o is the initial weight of the sorbent (g) in the pure oil medium without any water.

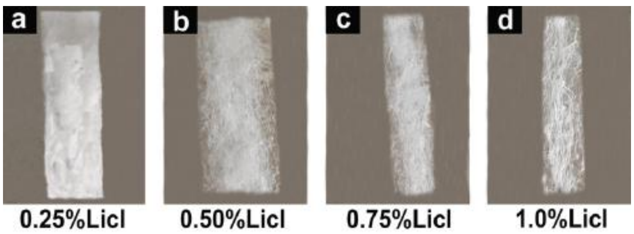


Fig. 7. PS filament sorbents under different LiCl concentration. At a constant flow rate of solution and voltage.

The oil sorption capacities of continuous PS filament sorbents with or without porous structure (Sample A, B, C, and D) were investigated. Fig. 8 shows that at around 5 minutes the maximum oil sorption achieves. For Sample A the best PS continuous length of filament with the best porous structure, the sorption rate is 82.4% in 5 minutes, 66.9% in 10 minutes, and 53.8% in 15 minutes. For Sample D that indicates the PS filament with no porous, the sorption rate is 38.9% in 5 minutes, 32.6% in 10 minutes, and 25.2% in 15 minutes. It is clear that higher sorption achieved for the filament sorbent with the best porous structure. PS filament provides more surface area and therefore more nanoporous on the filament surface. This filament/porous structure contributes to a better capacity of oil sorption.

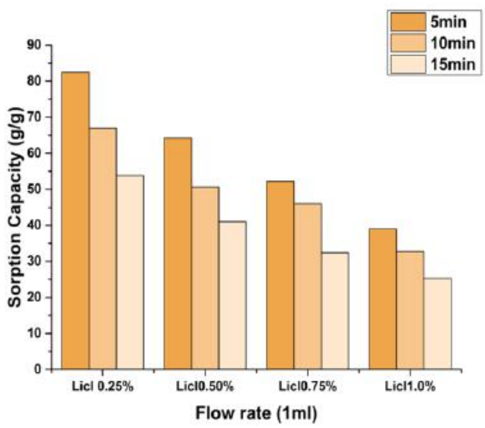


Fig. 8. Maximum oil adsorption capacities of nanoporous PS filament sorbents with different Concentration of LiCl.

VI. CONCLUSION

PS filament with porous structure has been generated via electrospinning. PS filaments are electrospun with conventional electrospinning

system. The effects of different concentration of PS polymer, voltage, the relative amount of DMF and THF solvent, and the addition of LiCl on morphology and porous structure of the filament were investigated. The results show that polymer concentration and voltage plays an important role in a produced continuous length of filaments. The concentration 30% PS polymer and 15KV voltage tends to produce continuous filament. The relative amount of DMF and THF solvent and LiCl influence the porous structure. Around the DMF/THF ration of 50/50 and 0.25% LiCl leads to produce the porous structure on the filament surface. However, increasing the concentration of LiCl cannot produce a porous structure on the filament surface. The porous structure filament will be used as an economic and efficient sorbent material of engine oil, are highly promising for environmental protection.

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Relaxation Behaviour of Elastic Therapeutic Tapes under Different Thermo-mechanical Conditions

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Abstract

Elastic therapeutic tape is an adhesive tape, which composed of cotton, elastic filament, and adhesive glue. It is widely used for clinical treatments to recover soft tissues. According to producers, the stress field gets generated through time on the skin surface by the tape has more significant in the rehabilitation process. The aim of this paper to determine the relaxation behavior of the therapeutic tape under different thermo-mechanical conditions with a function of time. A commercially available tape has been selected, and relaxation test was conducted under a static condition with two extended levels (25% and 50%) for one hr and under the dynamic condition for 300 cyclic loading - unloading condition. For the analysis, various cyclic loading – unloading value in (gm) such as (150-50,150-100, 400-200 and 400- 200), strain rate (70 and 100 mm/min) and temperatures (25 and 50 ^{o}C) have been selected. OriginPro 9.0 software has been used for the analysis. Overall the result showed that the therapeutic tapes for both static and dynamic conditions, higher loss of internal stress. Also, faster losses of efficiency have been depicted at the lower strain rate, higher load, and higher temperature conditions. The stress provided by the tapes has been decreased rapidly within a short period under all the selected conditions. From the present study, it might be concluded that manufacturers must ensure their product quality in the fabric point of view. Also, when it applied to a patient for a longer period, factors like, temperature, load and the rate of extension might interfere with each other to determine the overall efficiency of the therapeutic tape.

*Keywords- **Therapeutic tape, Relaxation behavior, Static condition, Dynamic conditions***

I. Introduction

Elastic therapeutic tape (ET), also known as Kinesio tape, was developed by Japanese Chiropractor Dr Kenzo Kase in the 1970s with the intention to alleviate pain [1]. It is an elastic adhesive tape recover the healing in soft tissues [2], and widely used for various clinical treatments such as the provision of structural support, reduced muscle fatigue, muscle facilitation, reducing edema, and improvement of lymphatic drainage and blood flow [3]. In general, elastic therapeutic tapes are made from a combination of cotton with polyurethane synthetic fibre with the coating of hypoallergenic thermos active acrylic acts as an adhesive. The crucial therapeutic factor is the transfer of tension by the tape to the skin, nerves and circulatory system of the human body to solve the problem. During clinical treatment before taping to the human body need to stretch for some levels for providing appropriate tension, but the level of stretch has depended on the problem to fix [4]. For instant for lymphatic and Fascial problem tape recommended 25 – 50% and 0 – 15% stretch level respectively also 50 – 75% for ligament and tendon problem. Generally, the tape can be stretched longitudinally 120 - 140% from its original length.

The previous study on the Kinesio taping method is devoted to examining its therapeutic effects, or its effect on clinical treatment like athletic performance, lymphatic drainage, healing, blood flow performance [5]-[10]. From a methodological viewpoint, these studies are mostly enclosed as randomized clinical trials with an experimental and control group of propends. Unfortunately, the Approach's does not relate to the performance of kinesiology tape on the musculoskeletal system from a fabric properties point of view. Such studies are considerably low in the literature. To understand the whole performance, the description of the stress field over time generated by kinesiology tape on the skin surface would be helpful. For evaluation, the structural, physical and mechanical properties, as well as time dependence holding a performance of therapeutic tape under different condition, should be known. A few kinds of literature[11]-[15] examined the material properties of different types of tapes (i.e., inelastic tape, elastic tape, and elastic therapeutic tape), structure, chosen mechanical and comfort properties. Producers often promote various comfort properties of kinesiology tapes such as low mass per unit area, elasticity, breathability, and high strength. However, the time-dependent Stress relaxation or the change of dimension of the tape under various temperature regime should be overlooked.

Stress relaxation means a gradual drop of stress or decreasing holding performance of tapes with time at constant strain. So the facts of this stress generated by therapeutic tape over time would help us to know after how much time the tape should be replaced for further compression treatments, some important variables under dynamic and static condition should be considered like Temperature (^{0}C) load (gm), the percentage of extension, strain rate (mm/min) etc could influence the holding capacity of therapeutic tape over time. The aim of this paper is to study the stress relaxation behavior of tapes under different extension and temperature then assess the dynamic and static response of the stress field developed by tapes under varying cyclic loading and unloading conditions.

II. MATERIALAND METHODS

1 Sample preparation

Therapeutic tapes manufactured by producer Mueller has chosen for this study. The tapes were brand new and within the validity period indicated by the manufacturers.

2 Methods of Stress relaxation test

Stress relaxation tests were performed under two different conditions (i) static condition, and (ii) dynamic condition. For the test Four important factors namely the strain rate (mm/min),load (gm),Tape extension (%) and Temprature (^{0}C) were

chosen to analyse their impact on the holding performance of the therapeutic tapes.

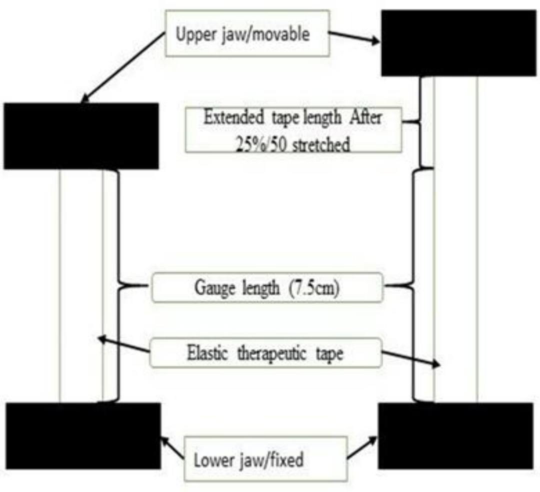

Fig. 1. Method of *Stress* relaxation test under 25% and 50 % level of extension

2.1 Static relaxation test

The stress relaxation under static conditions effectively performed on the therapeutic tape according to the following step (1) the tape was cut (20 cm x 5 cm) in 'I' shape and mounted between the jaws (upper movable jaw and lower fixed jaw) with covered paper then removed the paper only from gauge length, (2) the sample was stretched up on 25% and 50% from the original length at a strain rate of 300 mm/min and at room temperature then retain for a relaxing period of 1 hr. Fig. 1 shows that the method of static test performance.

The purpose of this test, how much the tape is deformed Statically at the given time and to understand the effect extension level on the stress profile generated by the therapeutic tape, at room temperature.

The test was performed by using ASTM D 2256 on Instron Uiversal Tester in a textile testing laboratory. Three samples were examined. The test results recorded Load (N) vs Time (s). Also, the average of maximum load (N), time at total relaxation (s) and load at total relaxation (N) have been determined Table 3.1

2.2 Dynamic relaxation test

For dynamic relaxation test was examining through variation of load, strain rate (speed) and temperature, the test was accompanied on a tensile testing machine with the heating chamber in Analytical laboratory. The sample size and the method of sample mounting on the machine are similar to the first test method (static test). Three samples were examined for each test.

A. **Load variation**

For analysis of the effect of load variation on the stress relaxation behavior of therapeutic tape, to begin with choosing four different cyclic loading - unloading value, its has taken from the result of static relaxation test, So that the peak load (loading value) of the therapeutic tape under 25% and 50% of extended state has 150 gm and 400 gm respectively, Although two unloading value has been selected for each, which is 50 gm and 100 gm for the 1st loading value and 200 gm and 300 gm for 2nd loading value.

All test are complemented at two different strain rate (speed of tape movement) which is 70 mm/min and 100 mm/min under room temperature, the result has recorded after 300 cyclic loading - unloading state.

B. Strain rate or speed of tape movement variation

The test indicates that change of in strain or deformation of the tape with respect to time, the test performed under two strain rate which is 70 mm/min and 100 mm/min. the stress relaxation considers change length after 300 cyclic loading and unloading state and analyses the effect of strain rate or speed of tape movement variation on the holding performance of therapeutic tape. The test was conducted at room temperature and under constant cyclic loading – unloading condition (400-300 gm).

C. Temperature variation

For this test two temperature at 25 ^{0}C and 50 ^{0}C has been selected which is designated minimum and maximum temperature respectively. The other corresponding parameters are constant alike strain rate (100mm/min) and cyclic loading - unloading value (400-300 gm). The test was performed on a tensile testing machine with a heating chamber in an analytical laboratory.

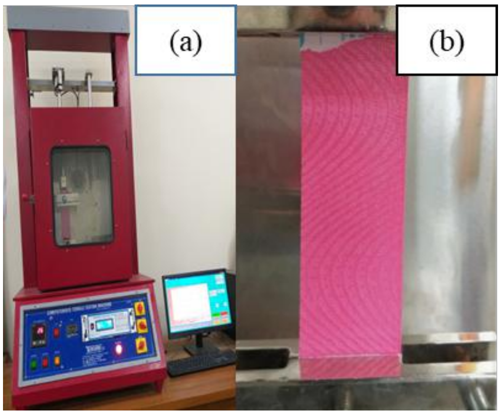

Fig. 2. (a) Tensile testing machine with the heating chamber, and (b) sample mounting position

3. Analytical methods

3.1. Percentage of stress reduction

Therapeutic tape was subjected to a stress relaxation test under static condition. The obtained response force(N) (tape resistance) were measured as a function of relaxation time. The peak force and the force after the given time obtain from each extension value is figure out from the recorded data then calculate the stress (N/m2) reduction of sample through equation (1). the achieved result used to understand the effect of extension value on the stress relaxation behavior of the tape. Also to make sure the truthful of company description about their products.So the percentage of stress reduction of each tape under different extension value is calculated by the following formula.

$$\sigma = F/A \qquad (1)$$

Where σ, F and represent Stress (Pa), Force (F) and and Cross-sectional Area (m^2)

$$r = \frac{\sigma_{\max} - \sigma_{\min}}{\sigma_{\max}} \qquad (2)$$

Where $\sigma_{\max}$, $\sigma_{\min}$ and r represent the maximum stress (stress at peak point), the minimum stress (stress at total relaxation) and percent reduction of stress respectively.

3.2 Percentage of Elongation

During cyclic test implemented of therapeutic tapes under different temperature, load and strain rate, in all case we observed an increase of gauge length of each tape samples as the number of cycles increased Fig 3.so the change of gauge length calculate according to the following formula.

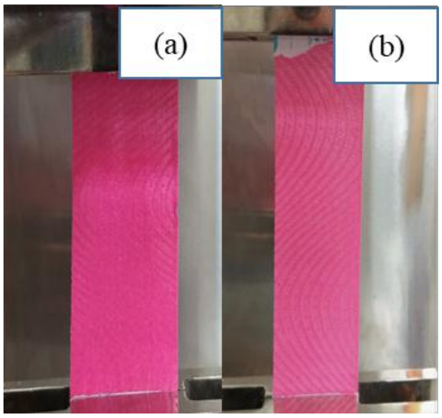

Fig. 3. a) original length l_0 and b) final length l_f

$$r_e = \frac{l_f - l_0}{l_f} \times 100 \qquad (3)$$

where l_f, l_o, and r_e represent final length or lenthe after deformation original gauge length of the tape sample, and percent of eleongation respectively.

III. RESULT AND DISCUSSION

1 Relaxation behaviour of therapeutic tape under static condition

All the tape samples exhibited stress relaxation under different extended rate Table 1 shows the stress relaxation behavior of Therapeutic tape sample under different tension level.

Table 1 Stress relaxation of therapeutic tape over time

Level of extension (%)	Maximum Force (N)	Maximum Stress (N/m^2)	Stress reduction after (N/m^2)			Stress Reduction
			20 min	40 min	60 min	in 1hr (%)
25	1.33	3.55	2.67	2.59	2.61	26.3
50	3.34	8.91	5.84	5.6	5.36	39.8

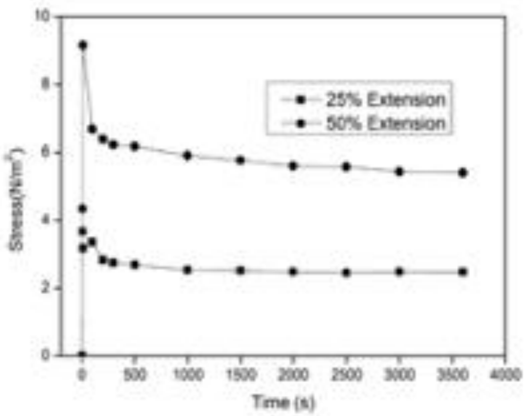

Fig. 4. Stress response of the therapeutic tape under two level of extension

All the specimens' exhibit stress relaxation under extended state Fig. 4 i.e. the maximum stress is going to decrease with an increase in time. The variation of stress relaxation as a function of time was calculated according to equation (2). During 25% of extension, the rate of reduction of stress is more dominant in the first 4 sec up to 500 sec and for 50% extension, the stress reduction is more dominant in the first 4 sec up to 1000 sec after that the rate of stress reduction is lower and then become almost constant for a longer period.

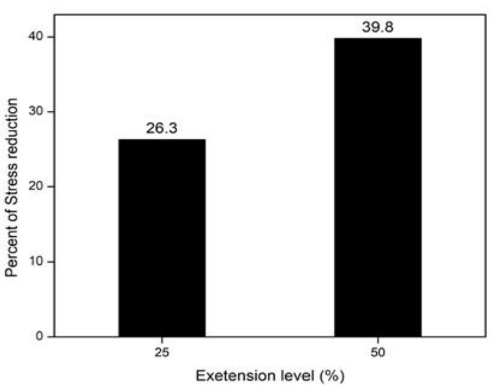

Fig. 5. Percent of stress reduction at 25% and 50% of extension.

In both extended case the tape sample easily gate relaxed which is clearly showed their viscoelastic behavior which means the internal stress at higher load reaching a peak and then reducing or relaxing over time under a fixed level of elongation.

As shown Fig. 5 the percent of stress reduction at 50% extension is higher than the stress reduction at 25% extension state. It is obvious that increasing the extension level on the tape, by applying higher force, it leads to an increase the internal stress in the structure as well as yarns and fibers and the fabric become degrade.

2 Relaxation behavior of therapeutic tape under Dynamic condition

All the samples were tested under dynamic repetition condition with at various load and rate of extension and temperature. The elongation value of all sample after 5, 20, 50, 100, 150 and 300 cycles has been selected also the percentage of elongation after 300 cycles have been calculated according to equation (3).

2.1 Effect of Load and strain rate

All tape sample exhibited stress relaxation under the same applied load and same strain rate (Table 2).

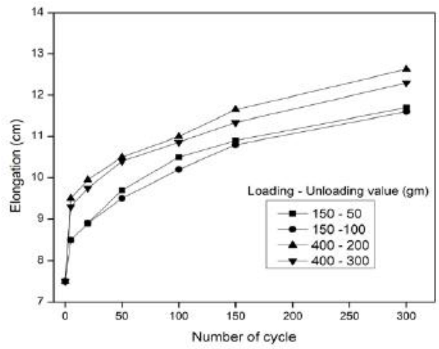

Fig. 6. Elongation behavior of therapeutic tape under various cyclic loading – unloading condition at a constant strain rate of 100 mm/min.

Table 2 Variation of elongation under various cyclic loading –unloading state and different strain rate.

Strain rate (mm/min)	Initial length (cm)	loading (gm)	unloading (gm)	Elongation of the tape after (cm)						Elongation After 300 cycle (%)
				5 cycle	20 cycle	50 cycle	100 cycle	150 cycle	300 cycle	
70	7.5	150	50	8	8.5	9.7	10.3	10.68	10.95	32
70	7.5	150	100	8.5	8.95	9.5	9.9	10.2	10.9	31
70	7.5	400	200	10.5	11.15	12.2	12.8	13	13.4	44
70	7.5	400	300	10.5	10.95	11.85	12.3	12.75	13.15	43
100	7.5	150	50	8.5	8.9	9.5	10.2	10.8	11.7	36
100	7.5	150	100	8.5	8.9	9.7	10.5	10.9	11.6	35
100	7.5	400	200	9.5	9.95	10.5	11	11.65	12.63	41
100	7.5	400	300	9.3	9.75	10.4	10.86	11.34	12.3	39

The result shows that elongation as a function of cyclic numbers, in all cases the elongation behavior has increased for the first 5 to 100 cycle and after that, it's slower and then become slower for a longer period Fig 6. additionally, the elongation behavior depends on the value and duration of cyclic loading-unloading state. Therefore, the percentage of elongation is higher at 400-200 gm and lower at 150-100 gm of cyclic loading – unloading state Fig 7.

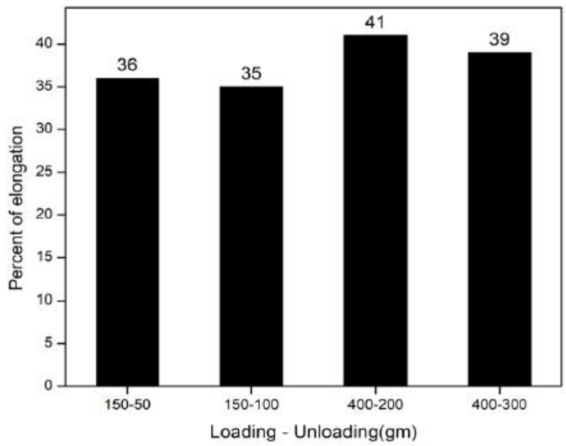

Fig. 7. Percent of elongation under various loading unloading state.

Although the tape sample subjected to two different strain rata as a function of cycle number at the constant duration of cyclic loading –unloading state shown in fig 8 it is observed that both strain rate the elongation fastly increased 0 to 50 cycle, after that the elongation speed reduces. The percentage of elongation at the lower strain rate is higher than the percentage of elongation at the higher strain rate Fig 9. This may when the fabric extended for a longer duration the more its mechanical properties damage. which means increase the stress in the structure as well on the yarns and fibers, this lead to increase stress relaxation behavior of therapeutic tape.

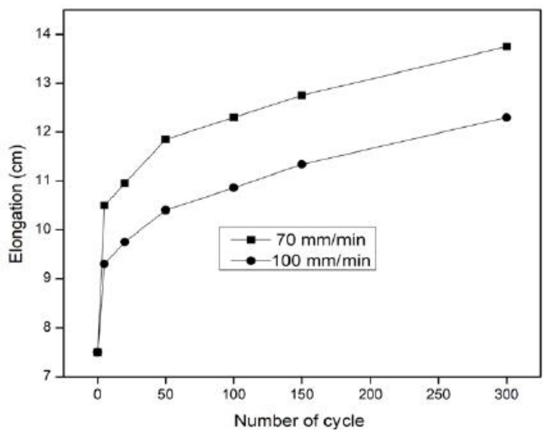

Fig. 8. Elongation behavior of therapeutic tape under two different strain rate at a constant cyclic loading unloading condition (400 – 300).

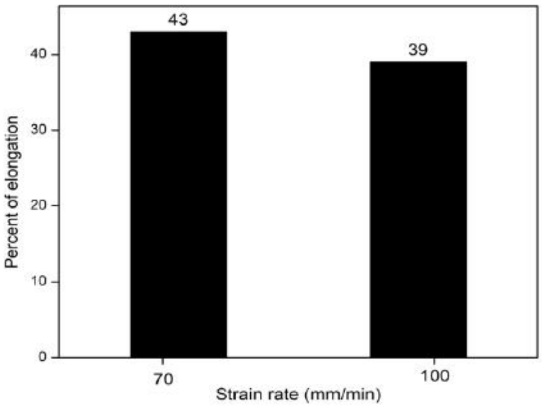

Fig. 9. Effect of Strain Rate on the percent of elongation of therapeutic tape.

2.2 Effect of Temperature

Fig 10 shows the effect of temperature with a constant speed of tape movement and constant cyclic loading - unloading circumstance. In both cases, the elongation increases rapidly in the first 150 cycles and then its rate slows down. The percentage of elongation under 50 °C temperature is higher than that of under 25 °C temperature as shown in Fig 11. thise may increasing of the temperature caused a decrease a strength value of the yarn and the fiber in the structure so it leads to an increase the relaxation state, so that the temperature may be one of the major factors for holding a performance of therapeutic tape

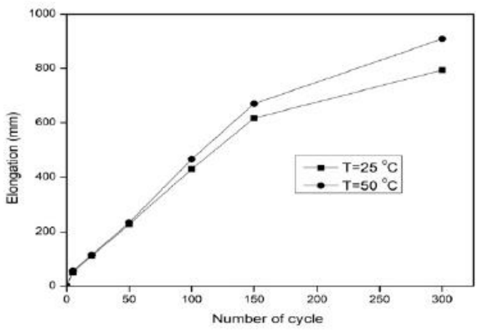

Fig. 10. Elongation behavior of therapeutic tapes under different temperature (a) 25 ^{0}C, and (b) 50 ^{0}C.

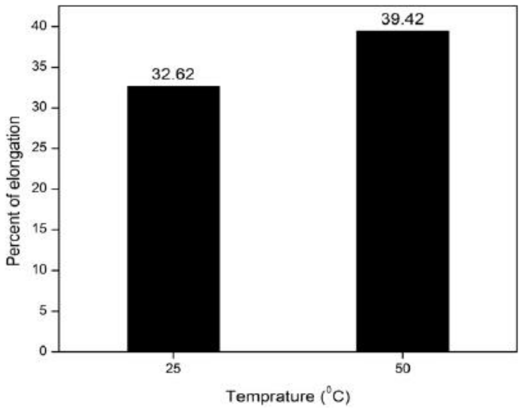

Fig. 11. Effect of temperature on the elongation percent of therapeutic tape

V. CONCLUSION

The following points mention the detail about the General stress relaxation behavior of therapeutic tape under a static and dynamic condition with various parameters. The holding performance of a material deteriorate due to cyclic loading - unloading; hence the therapeutic efficiency of the tapes will diminish over time. A standard has to be developed for the replacement time for such products. Therapeutic tapes losses efficiency faster at the higher extension. So, such a product should be frequently replaced if it is used at high extension compared to when used at a low extension. The therapeutic tapes show different responses under static and dynamic conditions. Especially under dynamic conditions the loss of internal stress is higher as compared with that of static conditions. This indicates different recommended methods and evaluations should be check when compared on static patients as compared to a dynamic patient. The stress relaxation increase at higher temperature , low strain rate and longer duration of cyclic loading – unloading condition, this indicate the therapeutic tape when used on patients for a longer period, these factors could interfere with each other to determine the overall efficiency.

Table 1 Variation of elongation under cyclic loading and unloading condition at a different temperatur

Temp ºC	Strain rate (mm/min)	Initial length (mm)	loading (gm)	unloading (gm)	Elongation of the tape after (mm)						Elongation After 300 cycle (%)
					5 cycle	20 cycle	50 cycle	100 cycle	150 cycle	300 cycle	
25	100	75	400	300	51	112	227	430	617	794	32.62
50	100	75	400	300	56	115	233	466	670	909	39.42

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AGOA market Access Utilization and Challenges ፡-The case of Ethiopian Textile and apparel Industry

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Abstract

The United State Congress passed the African Growth and Opportunity Act (AGOA) in 2000 which allows eligible Sub-Sharan African countries to export qualified products to the U.S market free of tariff and quota. Ethiopia is among the beneficiary countries in terms of different qualified products including textiles and garments. Kenya, Lesotho and Mauritius share of textiles and apparel exported to US through AGOA cover more than 87% in 2015, whereas the share of Ethiopia was below 2%. The purpose of this study is to analyze US apparel market and identify challenges in utilizing AGOA market access for Ethiopian textile and apparel industry. Ethiopian textile and apparel sub-sector are not fully utilizing AGOA compared to other some SSA countries. Primary data needed for the study were collect from 15 exporting firms under AGOA privilege and other stakeholders through depth interviews. Required secondary data related to US apparel market, Ethiopian textile and apparel import and export was collected from different sources. The main findings of this study are: AGOA LDC average utilization (2012-2015) from the total demand was only 24 %. Ethiopian Apparel export share to US through AGOA increased from 0.21% in 2004 to 5.07% in 2017.The major challenges in utilizing AGOA were found to be: scarcity of raw material in local market, less competitive product quality, difficulty to meet US market Social compliance, custom procedural obstacle, low awareness on AGOA, foreign exchange shortage, less competitive logistics performance and others. This study shows availability of huge market potential for those able to compete in US market, challenges of the sector in achieving the maximum benefits out of the African Growth Opportunity Act, and possible recommendations to overcome the challenges.

Keywords: **Africa Growth and Opportunity Act, lesser-developed countries, Textile and apparel**

V. INTRODUCTION

Ethiopian industrial sector contribution to the economic development of the country is very low and it is a sheer fact that the industrial sector is at a very low development stage in penetrating international market. The share of textiles and garments is very less in the exports. Ethiopian government has given a special attention to develop this sector by giving investment and export trade duty Incentive schemes to develop the sector's export growth [1].

According to a series of theories of international trade and global economy circumstances currently, free trade as one of the essential aims of WTO for international trade development, even though the existing of trade protectionism. Therefore plenty of trade agreements among different countries and regions have led to lower, even no tariff in categories of products importation and exportation although import and export barriers still exist from the very beginning [2].

Of the regional preferential schemes, in 2000, US Congress passed the African Growth and Opportunity Act (AGOA), a U.S. trade preference program, in order to help spur market-led economic growth and development in sub-Saharan Africa (SSA) and deepen U.S. trade and investment ties with the region. Ethiopia meet US AGOA Eligibility requirement and became the beneficiary countries in terms of textiles and garments [3]. AGOA gives Ethiopia the opportunity to export textiles and garments to the United States duty free and quota-free until 2025.

The writer of this paper therefore aims at assessing US apparel market, Ethiopian textile and garment manufacturer export potential and trend in US market and major challenges in utilizing AGOA market access for Ethiopian textile and garment industries.

VI. OBJECTIVE

A. Major objective

To analyze US apparel market and identify challenges in utilizing AGOA market access for Ethiopian textile and garment industry

B. Specific Objectives

- To assess Ethiopian textile and garment manufacturer export potential and trend in US market.
- To assess US market trend and potential (size) for textile and garment products.
- To show the level of US apparel demand for AGOA LDCs and current utilization of AGOA LDCs from US market.
- To identify major challenges of Ethiopian textile and apparel sector to utilize AGOA market access.
- To forward appropriate suggestions and recommendation to major challenges.

III. RESEARCH METHODOLOGY

This study was based on primary and secondary data collection methods. Required secondary data were collected from various websites mainly International Trade Center (ITC), ERCA, office of textiles and apparel (OTEXA), AGOA.info and USITC.

Primary data needed for the study was collected from exporting firms under AGOA privilege. This study use simple random sampling by using the following sample size determination formula [4]:

$$n = \frac{z^2.p.q.N}{e^{2}(N-1)+Z^2 p.q} \quad [1]$$

Where; n: sample size

N: number of total populations

Z: value of confidence level from *Z*-table

E: precise (error) margin of error

P: proportion of sample in the universe

Total size of this study is 38 and the researcher take 95% confidence level.

$$n = \frac{z^2.p.q.N}{e^{2}(N-1)+Z^2 p.q} = \frac{1.96)^{\wedge}2.(0.5).(0.5).(38)}{(0.1)^{2(38-1)}+1.96^{2(0.5)(0.5)}} \quad [2]$$

$$\frac{3.8416 \times 9.5}{1.37338 + 0.9604}$$

$$= 15.5 \quad [3]$$

Selected companies were questioned about the specific nature of the problems they faced when they export in US market through AGOA. Typically, survey respondents were general managers or the company's employee responsible for the export and import process.

For quantitative data collection the most common methods used for this basic level of analysis are charts, tables, percentage, graphs, average and exponential smooth forecasting. For qualitative data collection, where analysis consist of the researcher‘s own interpretation of what was assessed and find, the information during the study of this project.

IV. DATA ANALYSIS

1. US apparel market performance and market size

In US market there was large imbalance still, which is about the share of apparel import was very high compared to apparel export (that was average apparel import share was 93.25% whereas apparel export was 6.75%) from the year 2013-2017 (Table 1). This indicate the availability of huge market potential for those able to compete in US market.

Table 1: US garment import and export trend (Sources: ITC calculations based on UN COMTRAD)

US Apparel import export	Value in thousand USD					Five-year average share in %
	2013	2014	2015	2016	2017	
US Apparel export trend	7,231,587	7,529,871	7,511,306	6,950,139	7,085,480	93.25
US Apparel import trend	97,149,156	99,628,682	103,998,901	102,005,321	99,078,407	6.75

2. Ethiopian textile and apparel Industries performance

Export on textile and apparel products in general had been moving up and down from year to year for the last 5 years. From this analysis it can be reasonably concluded that export of apparel products in general will be expected to increase for the coming years also.

When we see the import of textile and apparel in Ethiopia from 2013-2017, the value was increased consecutively from year to year (fig 1). There was large imbalance still, which is about the share of textile and apparel import is very high compared to textile and apparel export (averagely textile and apparel import share was 92.4% whereas textile and apparel export share was 7.6% from the year 2013-2017).

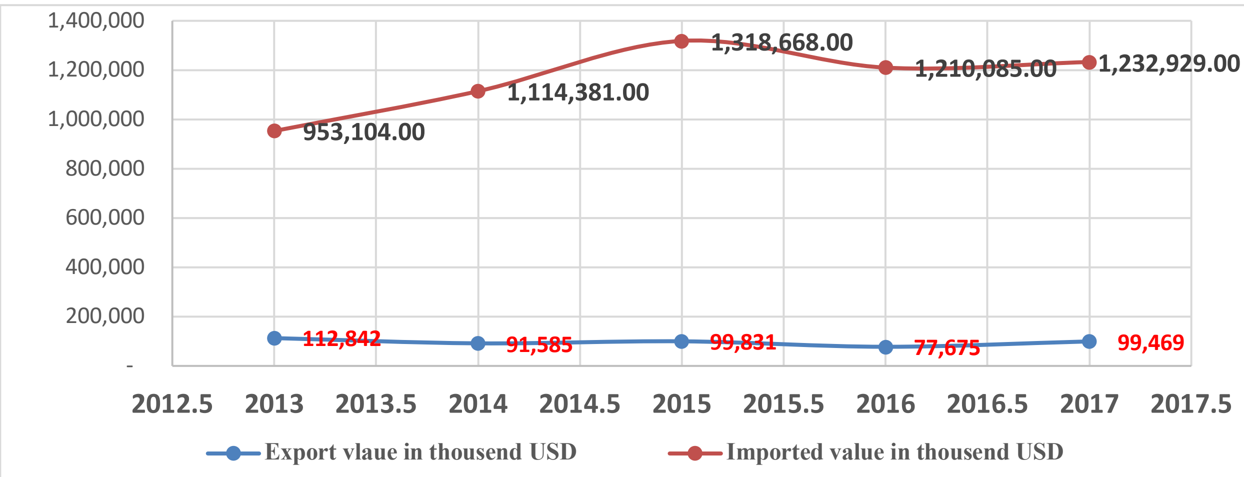


Fig 1. Ethiopian textile and garment import export trend (Source: Ethiopian revenue and custom Authority (ERCA))

A. Ethiopian textile and apparel import and export share in product category

Considering the last 5-year Ethiopian import and export of textile and apparel in global market, the following import and export performance was take place (Table 2).

Table 2: Ethiopian textile and garment import and export

Product category	Import share of textile and garment	Export share of textile and garment
Garment	More than 72%	More than 68%
Textile	21%	11%
Yarn	5.9%	14.9%

Source: Ethiopian Revenue and Custom Authority (ERCA)

B. Ethiopian destination markets trend

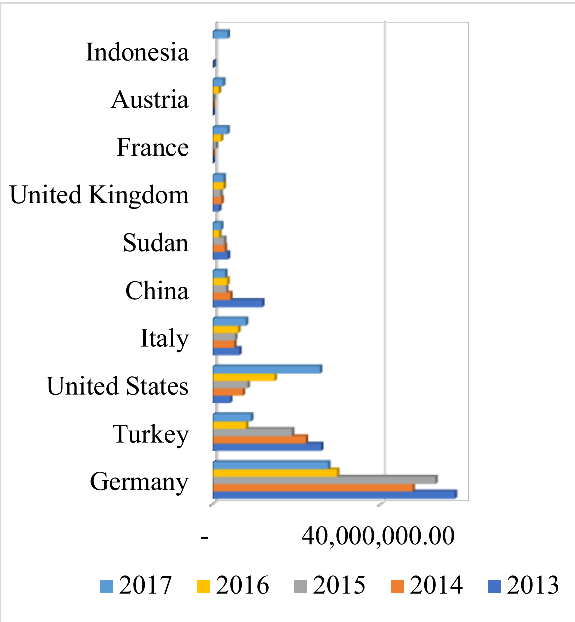


Fig: 2 Ethiopian Destination market growth over last 5 years in value

Source: Ethiopian revenue and custom Authority (ERCA)

For the last five-year Ethiopian export performance of textile and garment product increases from year to years. The above figure indicates textile and garment export of Ethiopia in Germen market decrease from 57.7 million USD in 2013 to 27.4 million USD in 2017.Whereas in US market, Ethiopian textile and garment export increases from 3.9 million USD in 2013 to 25.4 million USD in 2017.

C. Ethiopian textile and garment supply trend in US market

In apparel category, the share of Ethiopia supplied to US market was increase from year to year. For the year 2013, Ethiopian apparel export share to US market was 0.01% whereas after three and four year the share increases from 0.03 % (in 2016) and 0.05 %(in 2017) respectively [i]

D. Ethiopian textile and garment export in US market by product categories

Considering the last 5 year (2013-2017), Ethiopian export of textile and garment in US market by product category was listed as followed:

- More than 88.3% of Ethiopian export in US market was garment.
- Next to garment cultural cloth export share in US market covers 10.9%.
- The share of fabric and Yarn was less than 1%.

As per Ethiopian apparel export data for the year 2013-2017, the export performance of knitted garment was highest compared to woven garment and warn apparel products. For the last five years from apparel product categories the share of knitted, woven and worn apparel export to US market was 54.8%, 30% and 15.25% respectively.

3. *AGOA Preference level and Utilization share of LDCs for textile and apparel*

From the total Sub-Saharan country overall amount, apparel imported under the Special Rule for Lesser-developed countries is limited to an amount not to exceed 3.5 percent of apparel imported into the United States in the preceding 12-month period. SME: (Square Meter Equivalent, also referred to as "M2"): Conversion Factors are used to convert units of quantity into SME was 1.66 meter.

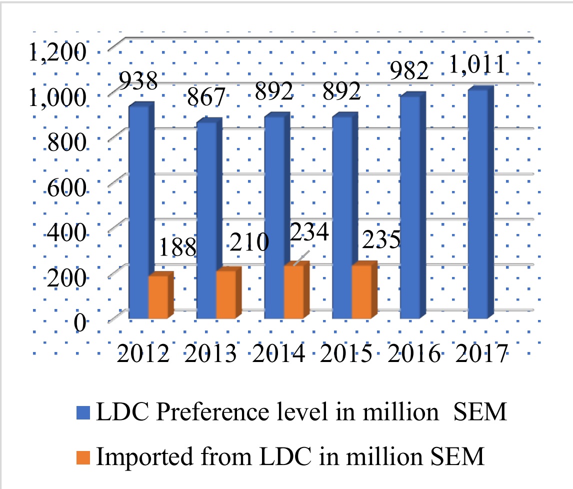
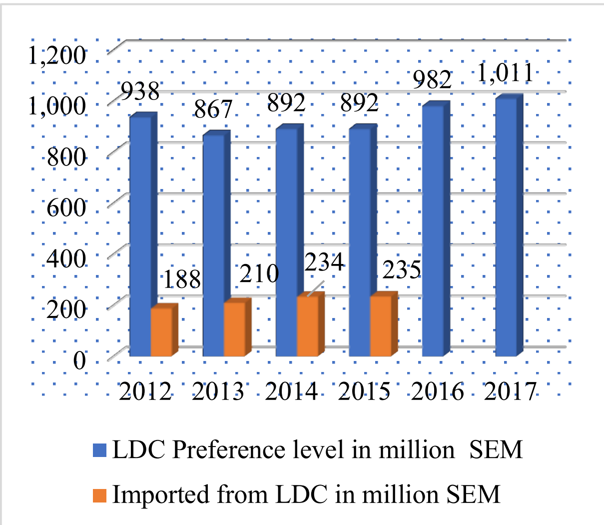


Fig 3: AGOA preference level and import utilization from LDC



Source: OTEXA, AGOA LDC preference level and import utilization

As per the above AGOA preference level and Import utilization from LDC, the average utilization (from 2012-2015) from the total demand or market size is only 24.26 %. In order to estimate potential demand volume for Ethiopia, it is assumed that about 8 percent of AGOA preference level and import utilization from LDC, the average yearly demand will be 91.4 million SME or 388.45 **million USD**. To calculate unit value of a product the researcher uses average unit value of 4.25USD.

3.1. Top ten SSCs Garment exporters to US through AGOA

For the year 2017 Kenya, Lesotho, Madagascar and Mauritius share of garment exported to US through AGOA (excluding GSP) were 33%, 28%, 14.4% and 13.6% respectively. This menace only these four countries cover more than 89% of Sub-Saharan garment exported to US market through AGOA. The share of Ethiopia was approximately 5.04%.

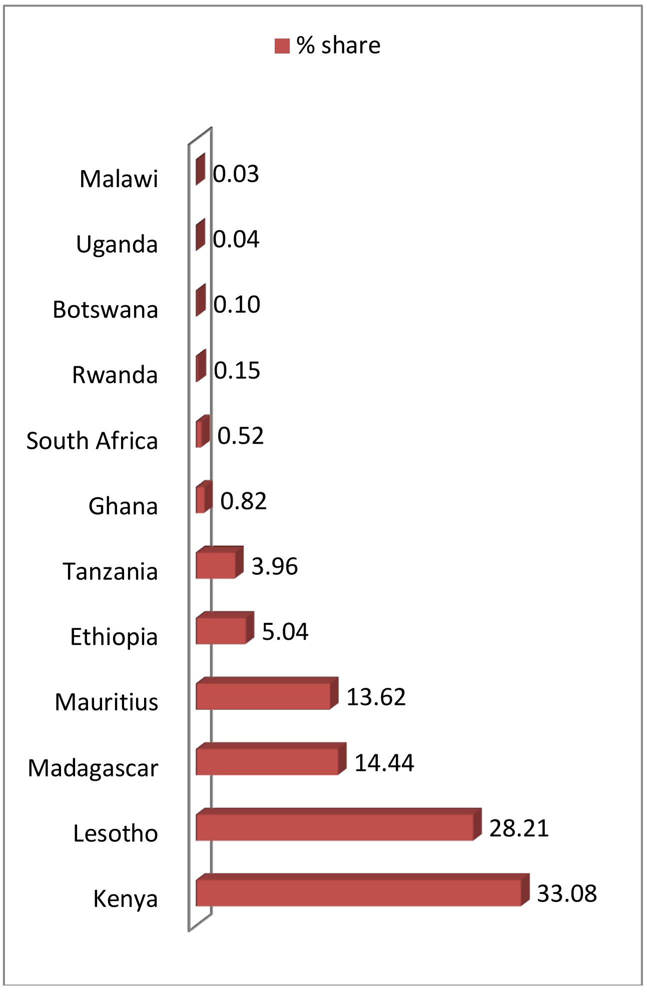


Fig 4: Top exporter to US through AGOA for the year 2017
Source: own compilation from http://www.usitc.gov

3.2. Ethiopian share of garment from SSCs exported to US through AGOA

Table 3: Ethiopian share of textile and garment exported to US through AGOA (exclude GSP)

Years	SSC (in 000 $)	Ethiopian (in 000 $)	Ethiopian Share in %
2004	1,614,980	3,329.00	0.21
2005	1,418,849	3,509.00	0.25
2006	1,256,181	4,869.00	0.39
2007	1,267,334	4,559.00	0.36
2008	1,136,803	9,357.00	0.82
2009	913,869	6,622.00	0.72
2010	726,484	6,518.00	0.90
2011	854,875	9,959.00	1.16
2012	812,776	9,971.00	1.23
2013	903,769	10,004.00	1.11
2014	985,757	11,963.00	1.21
2015	987,750	17,270.00	1.75
2016	1,004,710	32,341.00	3.22
2017	1,023,879	51,865.00	5.07

Source: own compilation from U.S. International Trade Commission Trade Data web, http://www.usitc.gov

As the data showed in the above table, Ethiopian share of textiles and Garment exported to US through AGOA (excluding GSP) increased from 0.21% in 2004 to 5.07% in the year 2017.

Ethiopian Development Challenges to export in US market through AGOA

- Scarcity of raw-material in local market (like fabrics, trim and accessory)
- Foreign exchange shortages
- Less competitive product quality, new product design or fashionable product, innovation (such as adoption of best technologies, apparel merchandising skill, marketing networks with buyers and retailers etc.)
- Difficulty to meet US market Social compliance certification
- Difficulty to most factories in creating good work environment and work discipline
- Custom procedural obstacle
- Less understanding of AGOA market
- Less competitive logistics performance compared to Other countries
- Fear of AGOA expire after 2026
- CMT mode of service

VII. Conclusion

- Ethiopian share of Garment exported to US through AGOA (excluding GSP) increased from 0.82% in 2008 to 5.04% in the year 2017.
- From the total Sub-Saharan country overall limit quota under the Special Rule for lesser-developed countries average used quota from the year 2009-2015 is only 24.26%. This indicates the availability of market for those meet the criteria.
- In domestic market scarcity of quality fabrics, trim and accessory was the big challenges, so they are forced to import from abroad for processing and then exporting again. To improve this issue the concerned body should provide additional incentives depending on their export performance for selected market destination and value addition.

VI. Recommendations

- In US market, share of apparel import is very high compared to apparel export (that was apparel import share was 93.25% whereas apparel export was 6.75%) from the year 2013-2017.This indicate the availability of huge market potential for those able to compete in US market.
- For the case of Ethiopia textile and garment export Utilization rate of AGOA compared to Sub-Saharan countries is less than 5.07% for the year 2017, and thus trying to maximize utilization would enable more LDC trade to take advantage of the preferences on offer.
- Ethiopian investment agency, Ethiopian textile Industry development institute and any concerned body should promote Ethiopian eligibility of AGOA third country fabric provision for both domestic and foreign investors to utilized AGOA like Lesotho and Kenya.

- For Ethiopian case due to AGOA (LDCs) the tariff rate is 100% exempted. From the above we conclude that doing business in Ethiopia will benefit averagely 17.5% of US tariff compared to doing Business in other non AGOA beneficiary countries in apparel sector.
- Concerned body should revise incentive mechanism for fabric and trim manufacturer exporters
- Encourage factories to work in FOB rather than CMT mode of service.

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Designing of quality parameters for Ethiopian cotton spinning industry based on TQM approach

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Abstract

Competition is truly global. Higher product quality is required for a company to become more competitive both locally and in international markets. Any textile company basically competes on its reputation for quality, reliability and capability of processes and costs of quality and delivery. Currently, most of textile industries in Ethiopia are suffering from quality related problems due to high process variations. These problems include poor performance of manufacturing products in the export market, insufficient qualitative raw material supply, customer dissatisfaction, low productivity, and poor utilization of the resources. These problems led to the manufacturing of low-quality product with a high cost and because of this, most of the Ethiopian textile companies in the country are not competitive and profitable. The main objective of this study is to examine the existing traditional models of quality and to introduce an improved and emerged quality measuring system based on a methodological approach by using six sigma total quality management tools and analyzed by STATA ver 14.0 software. The analytical findings shows that the application of Total Quality Management programs, tools, and techniques have been expanded beyond the traditional quality concepts and improve the acceptable quality level of the product by 57.96% with a lowest cost.

Keyword: **Total Quality Management, Process Variations, TQM Tools**

I. INTRODUCTION

The Ethiopia textile industry is prominently the oldest manufacturing sector, It has a very important place in building the economy of the country by contributing to industrial output, employment generation and earning the foreign revenue [1].

There are 56 textile factories [2] and there is an opportunity to export textile goods to the global market created through initiatives by the African Growth and Opportunity Act , the Common Market of Eastern and Southern Africa and bilateral trade agreements established with western countries. [3]

But the Ethiopian Textile Industry Development Institute stated that the country's textile exports for the year 2009/10-2015/16 are lagging behind the plan which is only 46.4%, 73.2%, 49.4%, 70% of the plan [4].

Currently, most of textile industries in Ethiopia are suffering from production related problems due to high challenges, i.e. low efficiency of 40 to 45% in production as compared to other countries and the production in Ethiopia takes about 45 to 60 days longer [5].

And the smallest variation in the quality of raw material, production conditions and operator behavior can result in a cumulative variation (defects) in the quality of the finished product in spinning stage.

So there are many strategies have evolved over the last several decades to improve the quality of manufacturing of an item[6], [7], process or system.

And the industries are under increasing pressure to improve quality of products by reducing variation. To overcome the above quality related problem, the Ethiopian textile industries have to shift from its traditional quality concepts to total quality management (TQM), program tools and techniques, although the traditional quality tools [8] are no longer sufficient to handle emerging challenges due to customized products, low production runs and high quality cost.

TQM refers to a management process and set of disciplines that are coordinated to ensure that the organization consistently meets and exceeds customer requirements. The goal is to deliver the highest value for the customer at the lowest cost while achieving sustained profit and economic stability for the company [9].

Besterfield defined TQM as both a philosophy and a set of guiding principles that represents the foundation of a continuously improving organization. It integrates fundamental management techniques, existing improvement efforts and technical tools under a disciplined approach [10].

In a study conducted by Scheuermann L. et al., the tools, classified as Qualitative tools include flow charts, cause-and-effect diagrams, multi-voting, affinity diagram, process action teams, brainstorming, election grids, and task list, where as Quantitative tools include Shewaryt cycle (PDCA), Pareto charts, control chart, histogram, run chart, and sampling [11].

Now a day the use of TQM tools and techniques[12],[13]like six sigma, [14] TPM, BPR, Lean six sigma[15], QFD, Poka Yoka, and BM, are improved process diagnosis. The six sigma DAMIC[16] methodology approach are used for improving any product manufacturing industry performance [17]–[20].

II. METHODOLOGY

The methodological approach of this research is applying the TQM Six Sigma based on the DMAIC (Define, measure, analyze, improve and control) principals for selected three best spinning industries which suffer the common quality related problem in carded yarn and apply in five different phases. The first phase, the define phase identifying the high-level process variation in spinning stages.

During the Measure phase, the relevant data were collected from the three spinning industry and the average data wer used. Then the magnitude of problems were described and measured by a histogram and a pie chart. In the Analyze phase, identify the potential root causes and severity of the defects have been done by fish bone diagram and Pareto analysis and the existing process performance ware evaluated by capability study. In the improve phase, the best solution was determined and by applying this pilot solution in the process and the solution was evaluated. Finally, in the control phase, which is the mistake proofing, monitoring and response plan and visual controlling were made.

III. RESULTS AND DISCUSSION

a. Define phase

As quality plays a pivotal role in all aspects of life, reducing the number of defects, wastes and lead time in the textile industry is an important function. Various defects are generated in cotton spinning mills due to small variations are arising in the process. The first section in spinning is Blow room and the cause of blow room defects are mostly waste generation NEP Formation, low cleaning efficiency, high variation in the chute and excessive lint loss are impacts on the quality of final yarn product in spinning.

The second section is Carding and it is the hearts of the spinning process and in this process also arise defects like Nep formation in cards, high waste generation, high card sliver variation and impurities in sliver are found.

The third section is roving frames and there are also potential defects occurring in draw frame also the results of the defect in the next process of speed frame which include roller lapping in draw frame, end breaks in drawing, impurities in sliver and high drawing sliver count variation.

Most of the time the causes of ring spinning defects are arising due to variation in roving frame process, i.e. high-count variation in roving, slubs in roving, high breakage in roving and roving laps on drafting zone.

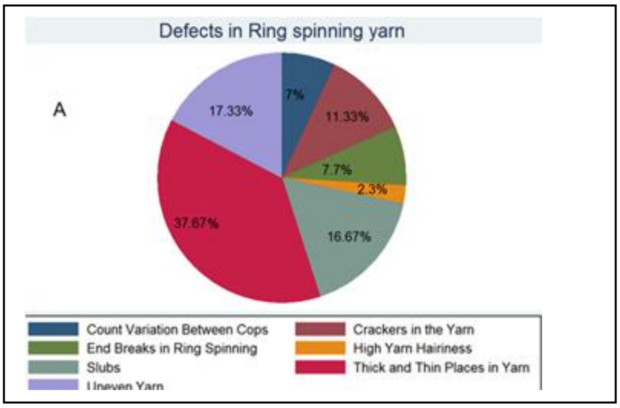
The various types of defects in ring yarn processed at ring spinning, particularly arising due to variation occurred in raw material, Improper process parameters, poor maintenance and the condition of the machines, i.e. uneven yarn, count variation between cops, crackers in the yarn, thick and thin places in yarn, end breaks in ring spinning, and slubs problems are found.

b. Measure phase

The measure phase identifies the percentage of defects and its severity in the product, gathers valid baseline information about the process and establishes the improvement goals. The defect which generated in the spinning process from blow room to ring spinning sections have been identified and a plotted by a pie chart.

The defects found in the process are shown below

Figure1.



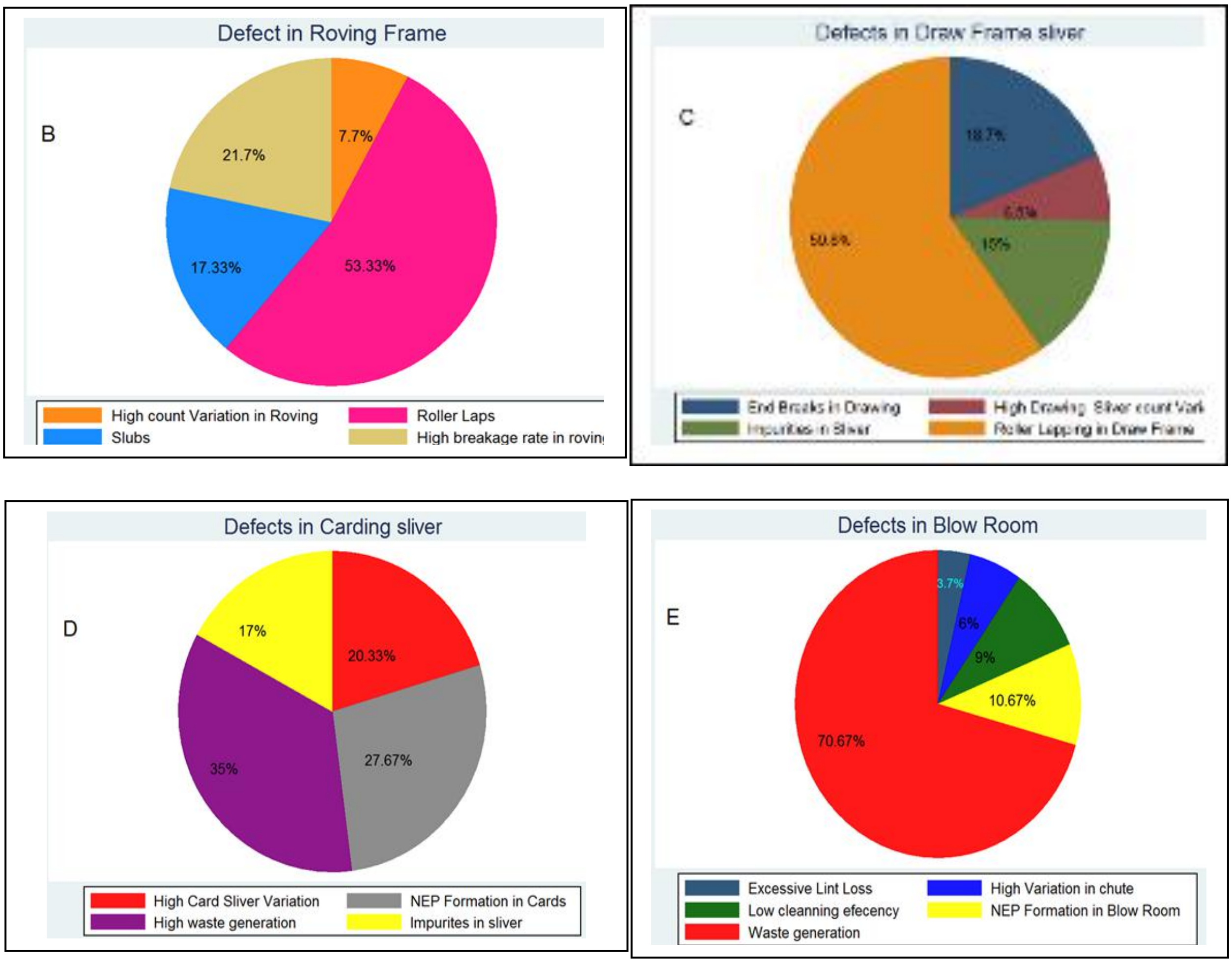
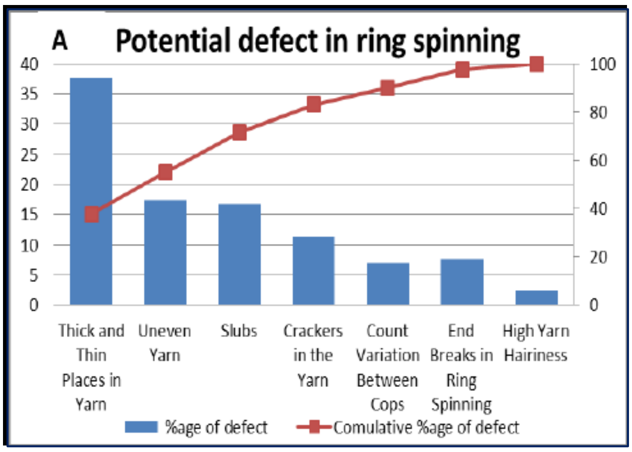


Figure.1 Defects frequently occurring in ring spinning yarn (A), roving (B), draw frame sliver (C), card sliver (D) and blow room (E)

c. Analyze phase

To analyze the input variables or factors that might affect the ring spinning yarn quality. The potential defects and their root causes were detected and analyzed from blow room to ring spinning process.

The identification of potential root causes of a given defect was analyzed by Pareto charts which also known as 80%/20% rule. And the root cause of the problems for ring spinning yarn, roving, draw frame sliver, carding sliver and blow room were also analyzed by Ishikawa or fish bone diagram as shown Figure 2 below.



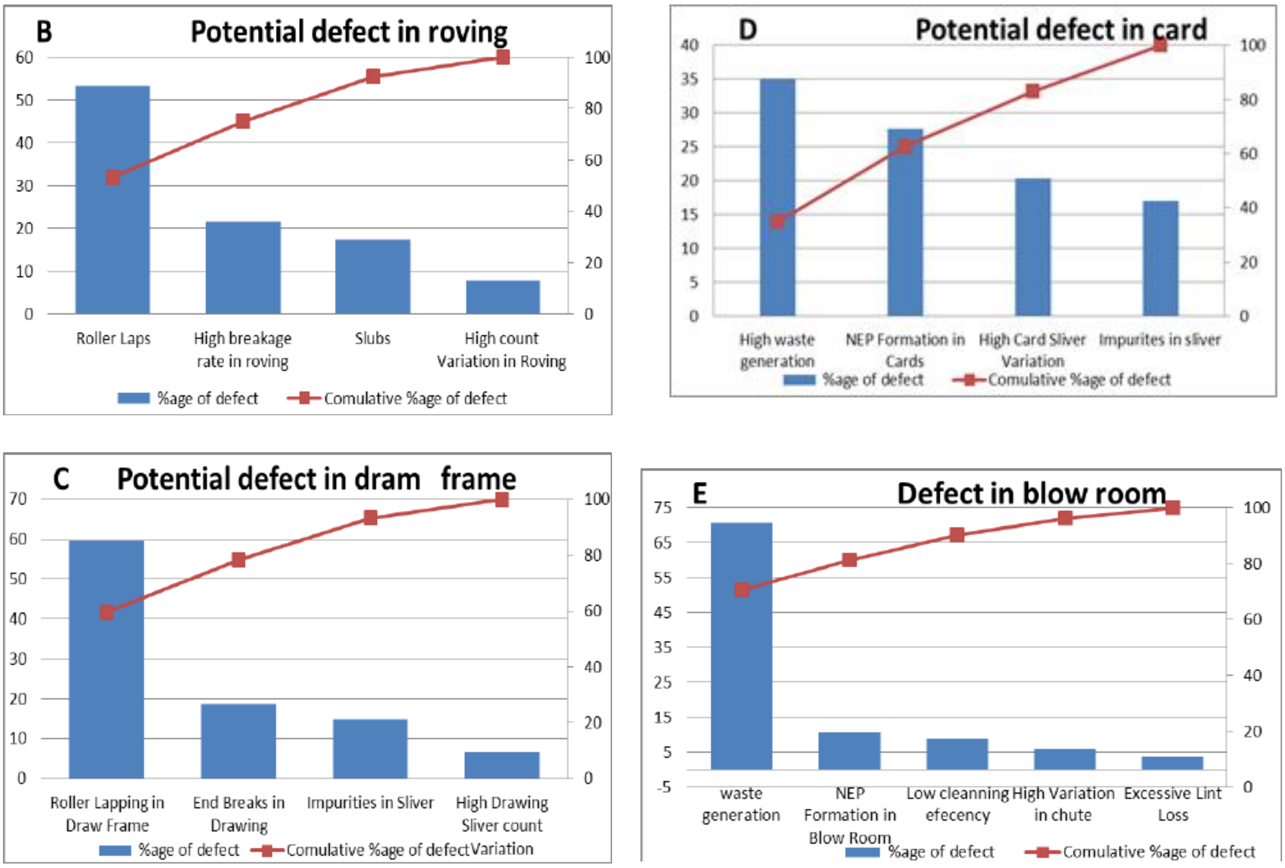
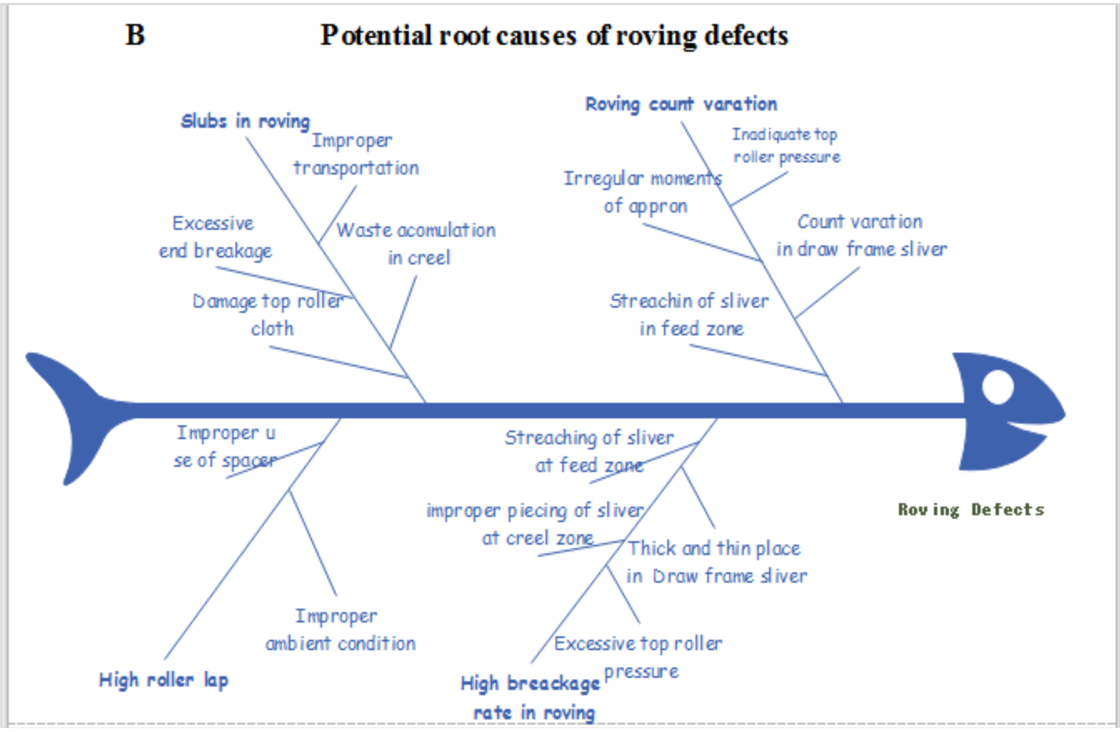


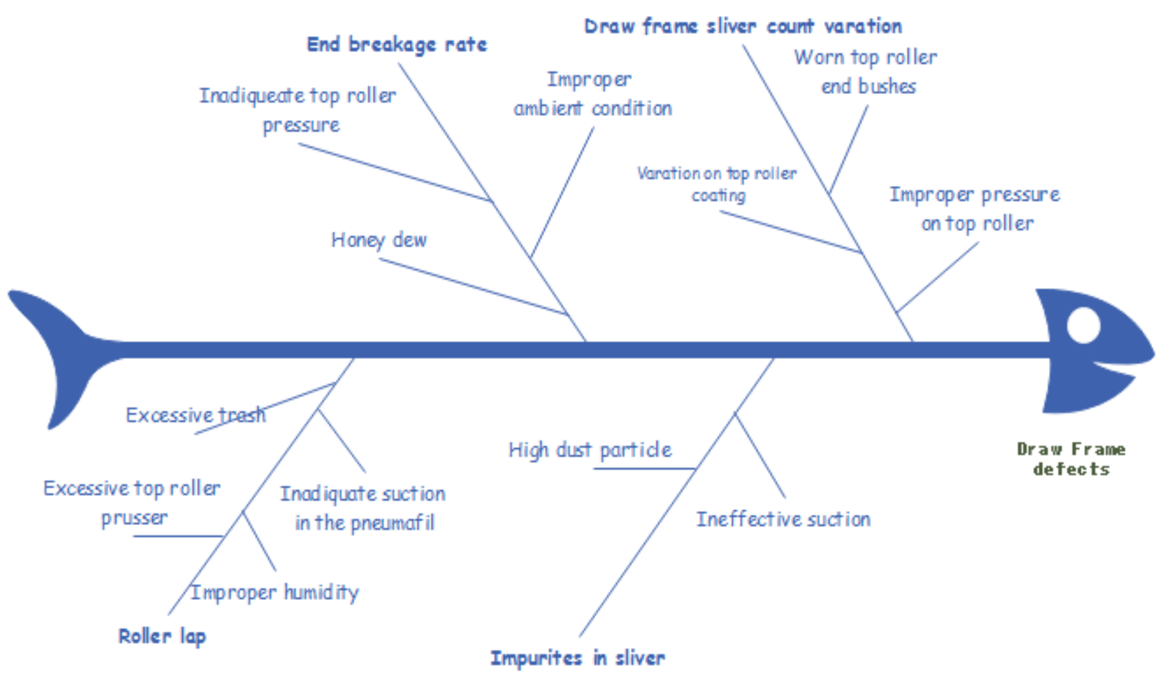
Figure.2 Potential defect in ring spinning yarn (A), roving (B), draw frame sliver (C), carding sliver (D), and blow room (E).

From Figure 2, the results show that the 20% of few root causes is the result of 80% of problems in ring spinning, which is thick and thin place, unevenness, slubs and crackers, from roving frame the roller lap, slubs and high breakage rate are found, from draw frame, which are roller lapping and end breaks are found and for card sliver high waste generation, NEP formations in cards and card sliver variation are generated. And also from blow room, high waste generation and NEP formation are found. And the cause and effects of the root causes of the potential defects are described as shown in Figure 3 below by fish bone diagram.

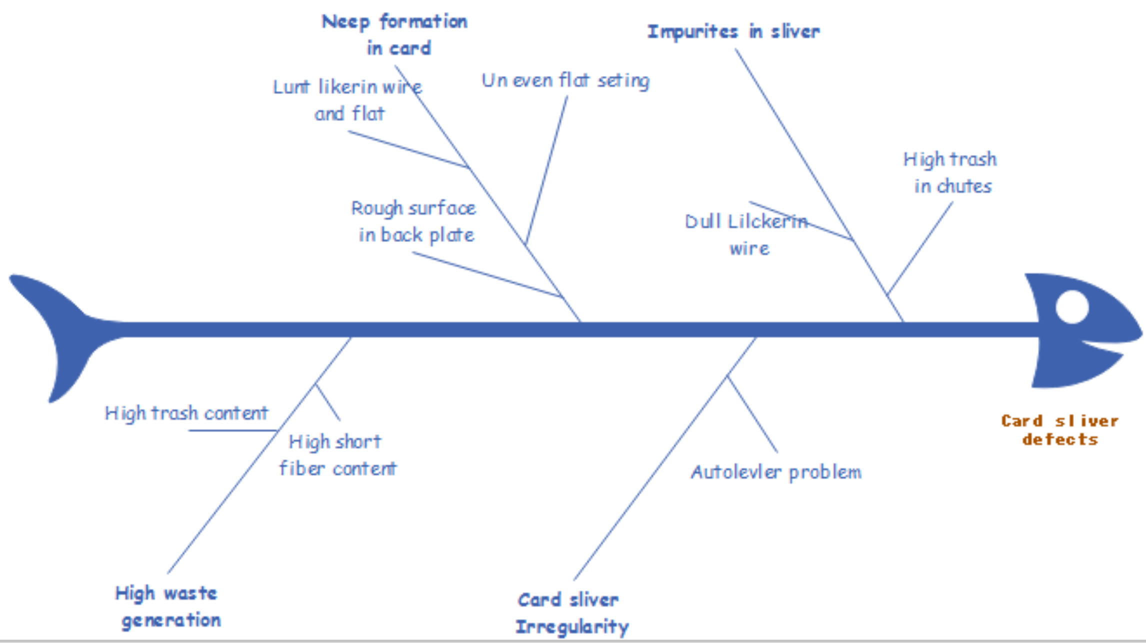

A
Potential root cause of yarn defect in ring spinning
Un evenness
Brocken Roving guide
Long roving piecing
Bottom rollers eccentric
Un even Roving feed
Cracks in Yarn
Inadiquate top roler pressure
Mix wide range staple length
Improper cardle holder
Insuffecent top roller pressure
Imature Fiber used
Eccentric top roller
High fiber length varation
Thick and Thin place
Improper piecing in roving
Bad piecing in ring
Excessive short fiber in mixing
Slubs
Yarn Defect


B
Potential root causes of roving defects
Slubs in roving
Improper transportation
Excessive end breakage
Waste acomulation in creel
Damage top roller cloth
Roving count varation
Inadiquate top roller pressure
Irregular moments of appron
Count varation in draw frame sliver
Streachin of sliver in feed zone
Improper u se of spacer
Improper ambient condition
High roller lap
Streaching of sliver at feed zone
improper piecing of sliver at creel zone
Thick and thin place in Draw frame sliver
Excessive top roller pressure
High breackage rate in roving
Roving Defects

C **Potential root csuses in Draw Frame defects**



D **Potential root causes in carding defect**



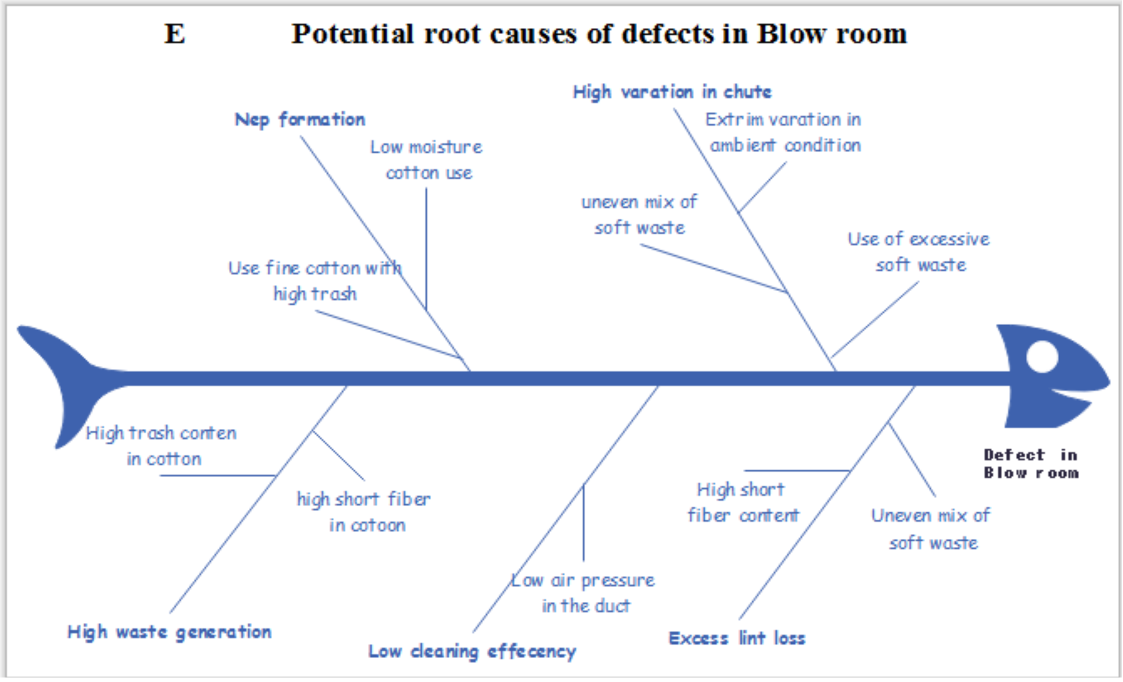


Figure. 3 Cause and effect (Fish bone) diagram of ring yarn (A), roving (B), draw frame sliver (C), carding sliver (D) and blow room (E) defects.

2.4 Improve phase

After the root causes have been determined, the DMAIC's "improve" phase aims at identifying solutions to reduce and tackle them. A major component in successful quality improvement is driving the use of the proper statistics and engineering tools into the right places in the textile mill. The following table 1. Show that, the potential defects and its remedies for the improving the overall quality in the spinning process.

Table. 1 Root causes and its remedies in carded yarn process.

No.	Section	Defect	Root causes	Action (remedies)
1	Ring spinning	Thick and thin place	Immature fibers.	Use mature fiber
			High fiber length variation	Properly mix
			Eccentric top and bottom rollers	Change Eccentric top roller
			Insufficient pressure on top rollers	Apply required pressure on top roller
		Unevenness yarn	Uneven roving	Control short term autolevler
			Bottom rollers eccentric	Change Eccentric bottom roller
			Long roving piecing	Give training to operators
			Broken or damaged roving guide	Change damage roving guide
		Slubs	Excessive short fibers in the mixing	Properly mix
			Improper piecing in roving	Give training to operators
			Bad piecing	Give training to operators
		Crackers yarn	Mixing cottons differing widely in staple length	Properly mix
			Inadequate top roller pressure	Apply required pressure on top roller
			Improper cradle holders	Change cardle holders
2	Roving	Roller lap	Improper ambient conditions in the department	Use required RH% and temperature
			Damaged surface in the top roller cots	Change top rollers
			Improper use of spacers	Change spacers
		Slubs on roving	Excessive end breaks.	Use adequate top roller pressure
			Waste accumulation at creels	Clean the creel periodically
			Damaged on roller cloth	Change top roller clothings
			Improper handling in transport	Properly transport the roving
		High breakage rate	Variation in draw frame sliver	Control short and long term autolevller
			Stretching of sliver at the feed	Properly feed in creel zone
			Irregular or clogged aprons	Change top and bottom apron

			Inadequate top arm pressure	Apply required pressure on top roller
3	Draw Frame	Roller lap in drafting zone	Improper humidity	Use required RH% and temperature
			Excessive top roller pressure	Use required RH% and temperature
			Inadequate suction in the pneumafil duct	Use required amount of suction air
			Excessive trash in the feed material	Use clean raw material
		High breakage rate	Improper pressure on top rollers	Apply required pressure on top roller
			Variation in top roller coating	Change top roller or grinding top roller coats
			Worn top roller end bushes	Change or grinding top roller coats
4	Carding	High waste generation	High short fiber in the raw material	Properly mix
			High trash content in the raw material	Use clean raw material
		Nep formation	High lickerin speeds	Adjust lickerin speed
			Uneven flat setting	Adjust flat to cylinder setting
			Rough surface in front and back plate.	Grind the wire
			Lunt lickerin wire or dull flats	Grind or change lickerin wire
		Card sliver variation	Bent / damaged back and front plate	Change front plate wire
			Feed roller weighting not acting properly.	Control short and long term autolevller
5	Blow room	High waste generation	Use of excessive soft waste in the mixing	Reduce soft waste use in Blow room
			Uneven mixing of soft waste with cotton	Properly mix
			Extreme variation in the ambient condition in the department	Use required RH% and temperature
		Nep formation in blow room	Cottons with too low moisture	Use required RH% and temperature
			Extremely fine cottons with high trash content	Completely rejects fine cotton with high trash content

2.5 Control phase

After implementation of the solutions, the progressive outcomes were documented and shared with everybody in the spinning mill from top managements to workers. The defects are identified and reduced. For this purpose, a control plan is prepared as shown below in Table 2.

2.6 Result and evaluating performance of the process

The effects of TQM tools and techniques of the DMAIC approach on reduction and elimination of process variation are analyzed by box plot as shown Figure 4 below.

Figure 4 Shows that the percentage of defects which were occurring in the process are reduced after TQM six sigma DMAIC tools are introduced to the process. Since the potential cause of the defect and its root cause are analyzed, so by formulating preventive action like adjusting mechanical root cause problems, and by minimizing and rejecting raw material faults and environmental variation, it can reduce and also eliminate the 80% of defects by eliminating 20% of root cause occurs in spinning mills.

Table. 2 Action plans

Responsible body	Action plan
Top Management	Management review could be adapted by organization to check the current capacity of DMAIC being implemented.
	Top management could commit to applying TQM programs.
	Management review could be adapted by organization to check the current capacity of DMAIC being implemented.
Employ	Everyone in the company view the organization as an internal system with common aims.
	Everyone in the company could do for improving the quality.
	Everyone in the company could take training for improving the productivity.
	Everyone in the company could apply continuous improvement tolls in the production area, rather than stability seeking.
	Everyone in the company could aware of the costs of quality.
	Everyone in the company could solve the problem at root causes.

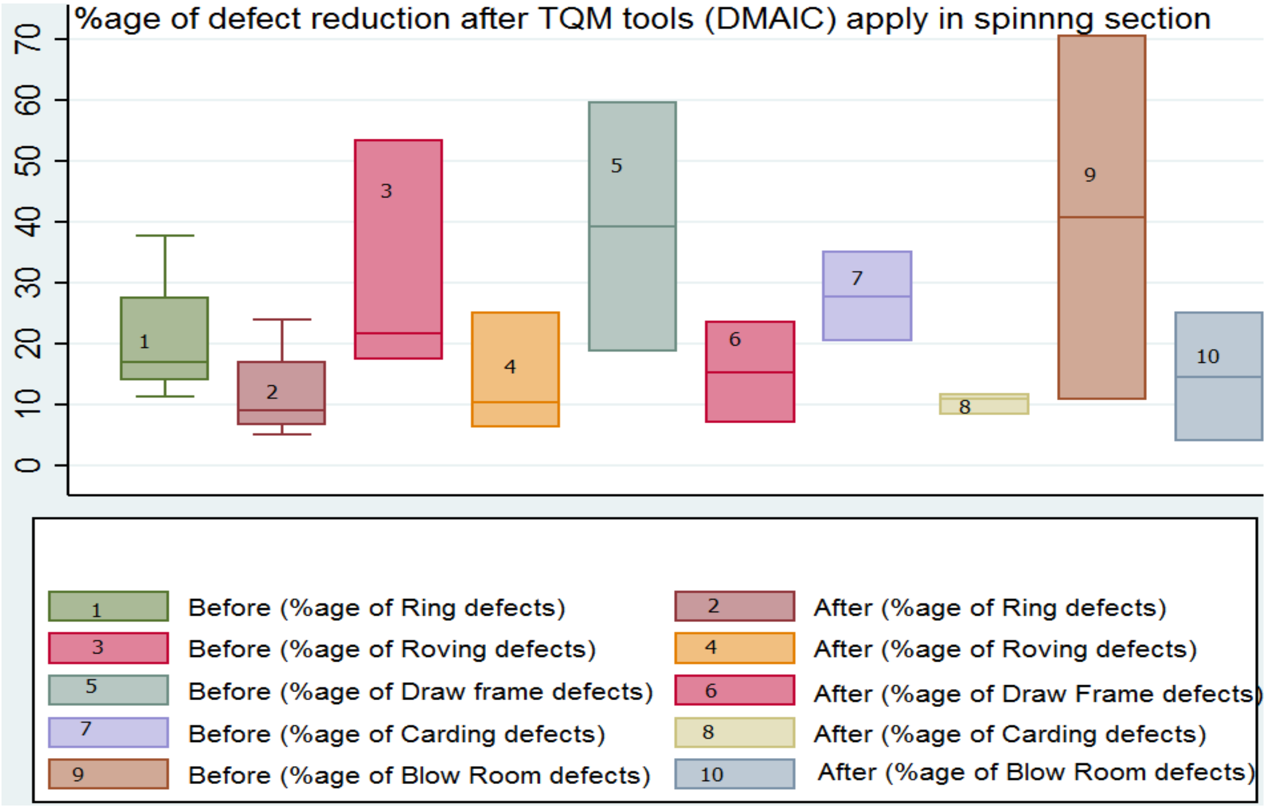


Figure.4 Percentage of defect reduction after preventive action is applied

CONCLUSION

The analytical findings show that the application of Total Quality Management programs, tools and techniques of six sigma DMAIC approach have been expanded beyond the traditional quality concepts and improve process performance and decrease the percentage of defects generated in the ring spinning, roving frame, draw frame, carding sliver and blow room by 53.39%, 43.47%, 38.56%, 38.2% and 36.45% respectively.

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Compounding, Spinning and 3D Printing of Kaolinite/ Polypropylene Nanocomposites

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Abstract

PP is the most widely used semi-crystalline thermoplastic polymers due to its good thermal and mechanical properties, high dimensional stability and excellent processability. Different molecular weight PP named HP500, Atofina HG265FB and Borealis PPH7089 used for production of nanocomposites at different kaolinite contents. Nanocomposites sample preparation starts by drying kaolinite and thorough mixing with PP and compounding at different formulations between 0 to 30 wt% of kaolinite for spinning of fibers and filaments for 3D printing. Melt flow and crystallisation temperature of HP compounded formulations shows an increase with kaolinite content which implies kaolinite acts as a nucleating agent. Nanocomposites fibers were prepared by melt compounding using a two-step process: melt-spinning and hot drawing at various draw ratios. Draw ratio up to 23 with elastic modulus of 19 GPa was observed. TEM and FESEM revealed good dispersion of the kaolinite nanoparticles in polypropylene matrix, although at higher concentrations and lower draw ratios the nanoparticles showed increasing tendency to form small agglomerates. Uniform distribution of kaolinite improved mechanical properties of the composite fibers. In as-spun fibers only one β relaxation peak can be observed while two peaks of β and α occurs for drawn fibers in DMA analysis. XRD also reveals a strong orientation of kaolinite along the chain axis after drawing of nanocomposites. HP and its nanocomposites were extruded filaments for 3D printing and measured density of filaments show lower theoretical density due to cavity and other defects. TGA analysis shows thermal decomposition temperature increases with increasing kaolinite content. HP and its composite were able to be 3D printed by coating of 3D printer bed with PP which improves poor adhesion behaviour of PP and it's composite on heated bed. DSC of 3D printed sample reveals crystallization temperature increase with kaolinite content and crystallinity content doesn't change after filaments productions.

Keywords: **Polypropylene, Kaolinite, Nanocomposites, Melt spinning, 3D printing**

I. INTRODUCTION

Polypropylene (PP) is known for its ability to crystallise soon and very successful product in many areas. Eventhough it is characterized by high rigidity, heat resistance and melting point, it is highly infected by poor impact resistance at low temperature (<0 ^{0}C) and relatively poor transparency [1]. The introduction of particulate fillers into polypropylene matrix in the fabrication of thermoplastic composites is mainly governed by price-performance relationships. The effects of fillers on the mechanical and other properties of the composites depend on their shape, particle and aggregate sizes, surface characteristics, and degree of dispersion [2–4]. Relatively there are few studies available in the literature regarding the development of kaolin-filled polymer composite [5]. Fibers of PP are employed in many end-use products thanks to their properties such as low density, resistance to moisture and chemicals, sufficient strength and easy processing [6]. The dispersion of nanoparticles enhanced the elastic modulus of PP, positively affected the stress at break, and decreased the strain at break for compositions at high nanofiller content [7].

Plastics are the most widely used materials in 3D manufacturing (additive manufacturing) and the important ones are acrylonitile butadiene styrene (ABS), polylactic acid (PLA), polyvinyl alcohol (PVA) and polycarbonate (PC) which requires high-temperature nozzle design. This technology attracts strong interest from both industry and academic for the challenging possibility to build objects with complex shapes and minimal use of harmful chemicals at a reasonable speed [8, 9]. Adding nanomaterials such as carbon nanotubes, nanowires, and nanoparticles to matrices such as polymers, metals, and ceramics via addition manufacturing has the potential to improve the performances of the resulting components [10, 11].

II. EXPERIMENTAL SECTION

Materials

Three types of polypropylene with different melt flow index of HP500 1.8 g/10min (HP), Atofina 12 g/10min (ATO) and Borealis 26 g/10min (B) are used to study the effect of nanofillers in different matrix. Kaolinite (K) in powder form with the density 2.6 g/cm^3, surface area 12m^2/g, average diameter 0.9μm was supplied by trade name Paralux from Vale, Brazil.

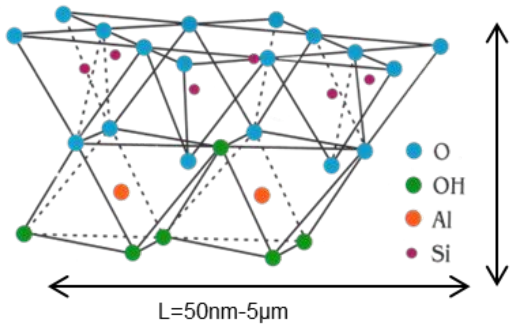

Fig. 1. Chemical bonding structure of Kaolinite [12].

Composite preparation

Compounding

Kaolinite and polypropylene were mixed in the molten state using a technique of melt compounding in Thermo-Haake Polylab Rheomix 600P counter-rotating internal mixer operating at a temperature of 200 °C and rotational speed of 50 rpm.

GRINDING

Once compounded sample was collected these formulations was grinded by using a grinding machine, Piovan RN166.

FIBER SPINNING

Monofilament fibers with the kaolinite fraction between 0 and 30 wt% were produced by Thermo Haake (Karlsruhe, Germany) PTW16 intermeshing co-rotating twin screw extruder (screw diameter 16 mm, *L*/*D* ratio 25, rod die diameter 1.50 mm). The temperature profile from the hopper to rod die was gradually increased (T_1 = 150°C, T_2 = 170°C, T_3 = 180°C, T_4 = 190°C, T_5 = 200°C).

FIBER DRAWING

The fibers from extrusion process were drawn in a hot-plate drawing apparatus 1.4 m length (SSM-Giudici srl, Galbiate, LC, Italy – www.ssm-giudici.it) at 145°C, in order to obtain highly extended fibers.

Fused Deposition Modelling (FDM)

3D printed specimens were manufactured by a Sharebot Next Generation Desktop 3D printer (Sharebot NG, Italy) feed with the extruded filaments of about 1.7mm diameter.

Experimental Techniques

Melt Flow Index (MFI) test has been performed at a fixed temperature of 230°C and 2.16kg weight for all specimens with a LMI 4000 series melt flow Indexer machine. DSC experiments were performed using a Mettler DSC 30 calorimeter device. Samples of around 14 mg were used and subjected to a heating – cooling – heating cycle between 0 °C and 220 °C at a rate of 10 °C/min. The FTIR spectra of PP, kaolinite and its composite samples were recorded in a controlled laboratory maintained at relative humidity of 48±2% and 23±1^{0}C using the Spectrum-One equipped with an UATR (Universal Attenuated Total Reflectance) accessory (PerkinElmer, USA). All tensile test specimens were prepared according to ISO 527-1-1993(E) [13]. Mechanical properties of PP composites fibers were performed at room temperature by using a dynamometer Instron 4502. Dynamic mechanical thermal analyses were carried out in tensile mode by using single cantilever clamp on samples by applying a sinusoidal strain with a frequency of 1 Hz and amplitude of 64 microns. TEM analysis has been performed on the ultramicrotomed cross section of as-spun, filaments and drawn nanocomposites fibers. The fractured surfaces were observed through a Carl Zeiss AG Supra 40 field emission scanning electron microscope (FESEM), operating at an acceleration voltage of 3 kV. Thermal Analysis was performed by a TGA Q5000-IR from TA INSTRUMENTS in a temperature range of 30 °C to 700 °C with heating rate of 10°C/min.

III. RESULTS AND DISCUSSIONS

Compounding

All compounded samples are grounded into small pieces of granules with size of about 2-3 mm before testing and/or filament extrusion.

Fig. 2. Photos of compounded samples (a) and grounded samples (b).

Table 1. Comparison of MFI of compounded and technical data sheet of PP.

PP type	Tested MFI (g/10min)	Data sheet MFI(g/10min)
HP500H	1.85 ± 0.13	1.8
PPH7089, Atofina	12.47 ± 0.48	12
HG265FB, Borealis	26.16 ± 2.71	26

FTIR spectra of Compounded neat HP, dried kaolinite and nanocomposites of HP-kaolinite observation of the bands at 3672 and 3646 cm^{-1} confirms that the used kaolinite is a highly ordered mineral.

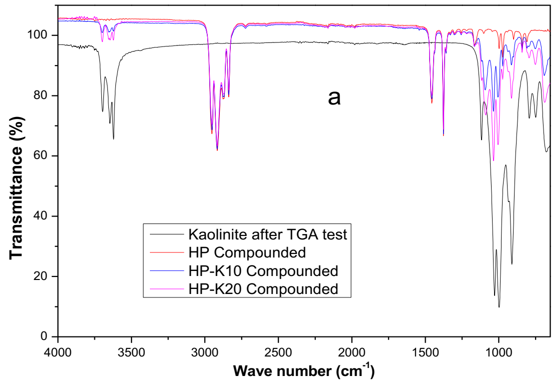

Fig. 3. FTIR spectra of neat PP, K and HP nanocomposites with 10 and 20 wt% of kaolinite

Fibers Production

The diameters of filaments obtained will decrease if the collection speed increases and vice versa. Fig.4 shows motor rpm versus fiber diameter by keeping screw rotation constant.

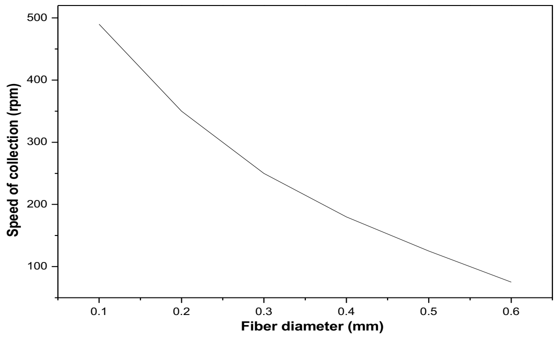

Fig. 4. Speed of collection versus fibers diameter variation during spinning process.

Undrawn fibers manifest a clear yield point at a low strain followed by a wide plateau (of cold drawing) and a strain hardening region until the break point. During this phenomenon tensile strength further increases and the stress whitening, due to the crystallization of aligned macromolecules takes place [14]. Drawing process produces a strong orientation of the macromolecules along the draw direction and the strain-induced crystallization in the amorphous regions, which accounts for the increase in the fibers stiffness and the disappearance of yielding phenomena.

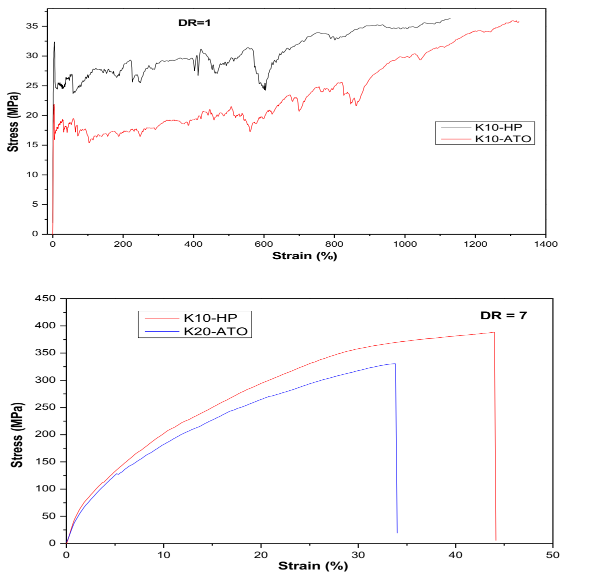

Fig. 5. Representative tensile stress-strain curves of (a) as-spun (b) drawn sample kaolinite filled nanocomposites.

Tensile modulus (E) of the PP-kaolinite nanocomposites fibers as a function of the draw ratio is represented in Fig.6.

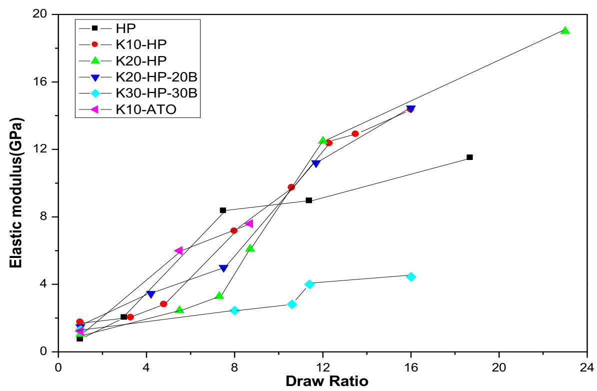

Fig. 6. Elastic modulus versus draw ratio of neat and PP-K nanocomposites fibers.

A negative effect of high concentrations of kaolinite on modulus is observed for composition with 30wt% of filler (K30-HP-30B) that results in decrease of modulus and drawability, which can be explained in terms of the aggregate formation and incomplete filler dispersion.

PP displays three relaxations (transitions, loss peaks) localized in the range of about –80°C (γ), 10°C (β) and 100°C (α), where β is the dominant relaxation. After drawing process, T_β shifts to higher temperatures for neat HP from 13°C to 23°C at a DR = 10.

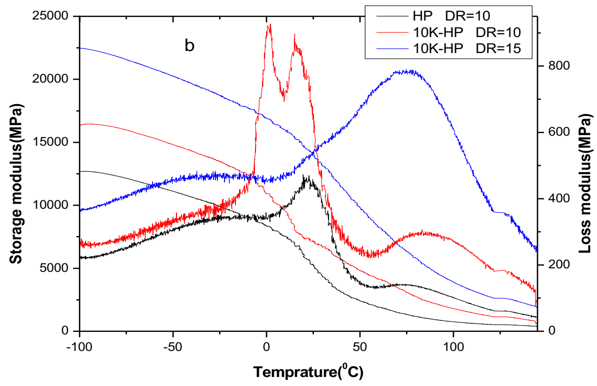

Fig. 7. DMA results of storage and loss modulus for neat HP and K10-HP nanocomposites at different draw ratio.

X-ray fiber diffraction images after drawing the polypropylene-kaolinite shows a strong orientation along the chains axis, the kaolinite texture is characterized by a (001) fiber like orientation with the basal/faulted planes perpendicular to it.

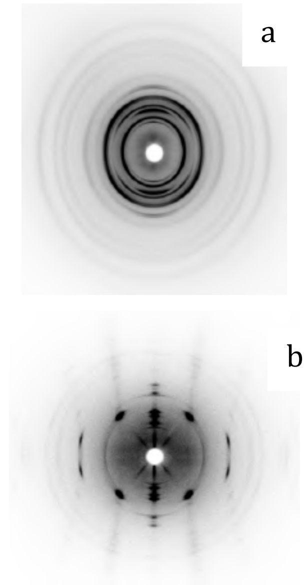

Fig. 8. X-ray transmission image of HP fibers with 10% kaolinite (a) as-spun 500µm (b) after drawing 160µm (DR=10).

TEM micrographs reveal that the kaolinite nanoparticles agglomerates are partially destroyed at higher draw ratios (Fig. 9 b and c).

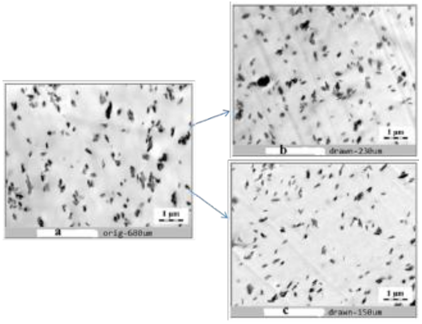

Fig. 9. TEM micrographs of K20-HP of; (a) as-spun filaments of 680 µm (b) drawn fibers of 230 µm, DR = 9 (c) drawn fibers of 150 µm, DR = 20.

Additive Manufacturing (3D Printing)

DSC cooling stage shows that crystallization temperatures of kaolinite filled filament were higher than for neat PP, i.e. up to 119.1°C for K20-HP versus 113.4 ^{0}C for neat HP filaments. This clearly implies that the incorporation of kaolinite results in the heterogeneous nucleation to the PP matrix. The degree of crystallinity ($\mathcal{X}$c) of PP nanocomposites was calculated using Equation:

$$\mathcal{X}_{PP}(\%) = 100\ \frac{\Delta H_i}{\Delta H_{PP}.(1-f)}$$ ….. Eq. 1.

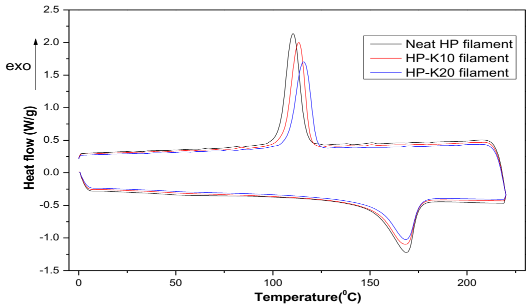

Fig. 10. DSC thermograms of neat HP, K10-HP and K20-HP filaments for 3D printing

Table 2. Results of the DSC analysis: melting temperature (Tm), crystallinity content (Xc) and crystallization temperature (Tc) for neat HP, K10-HP and K20-HP filaments for 3D printing.

Sample Compositions	**1st melting temp.**		**Crystallization temp.**		**2nd melting temp.**		**Crystallinity Content (%)**	
	peak (°C)	**integral (J/g)**	**peak (°C)**	**integral (J/g)**	**peak (°C)**	**integral (J/g)**	**1st Melting**	**After Cooling**
Neat HP	166.9	83.2	113.4	96.7	164.9	96.7	40.2	46.7
K10-HP	166.6	81.0	116.5	86.6	165.1	86.7	42.4	45.3
K20-HP	166.4	73.9	119.1	78.0	166.0	78.0	42.7	45.1

Table 3. TGA results of HP and HP-kaolinite nanocomposites decomposition temperatures at 5%, 10% and maximum rate of the weight loss (T_5, T_{10} and T_{dm}) and residue (R) at temperature of 700°C in air and nitrogen testing medium.

Gas	Air atmosphere			
Materials	T_5 [°C]	T_{10} [°C]	T_{dm} [°C]	R [%]
Neat PP	278	291	339	-0.2
HP-10K	277	300	403	8.5
HP-20K	292	323	427	16.2

Dumbbell shape sample were printed after the designing the specimen by CAD and slices into pieces by slic3r software. As cooling proceed from T_m to room temp, it will results in high warping stresses compared to typical 3D printing materials. It was found that HP and K-HP nanocomposites have also very poor adhesion behaviour on a heated 3D printing bed and results in *banana-shape* specimens.

To improve this problem a material made from polypropylene was used to cover a bed on which the sample would be printed. Also to avoid fast cooling and higher shrinkage a technique of covering 3D printing surround by thick clothes and hard papers was tried.

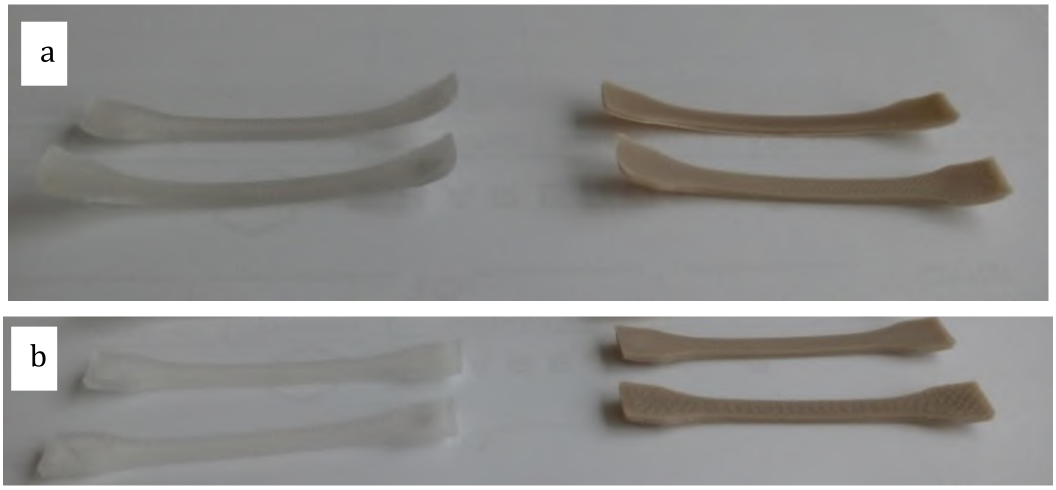

Fig. 11. 3D printed sample of dumbbell shape of neat HP and K10-HP on a heated bed (a) and adhesive strips coated heated bed (b).

As observed in FESEM micrograph, Fig. 12, it is possible to see the numbers of layers used to build dumbbell shape samples.

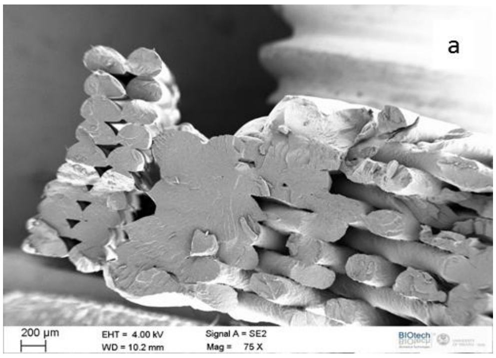

Fig. 12. FESEM micrograph of 3D printed dumbbell fractured surface of neat HP (X75).

IV. CONCLUSION

The presence of a kaolinite in the PP nanocomposites results in the enhancement of the PP crystallization temperature through heterogeneous nucleation. The melting behavior and crystallinity content of a material was not affected by the nanofiller content. FTIR analysis shows kaolinite used has good quality and different intensity of spectra was observed depending on kaolinite quantity.

Nanofiller presence affects the spinnability and drawability. Hot drawing in fibers induces the rupture of kaolinite aggregates and controls the intercalation or partial exfoliation of kaolinite in the PP matrix. XRD reveals strong orientation of kaolinite along the chains axis after drawing nanocomposites fibers. Morphology analysis by SEM and TEM confirmed good dispersion of the filler even though they tend to form small agglomerates frequently due to hydrogen bonds formed between kaolinite particles.

Incorporation of kaolinite into a polypropylene matrix enhanced its rheological properties, thermal stability and mechanical properties in both spun fibers and 3D printed samples. Therefore kaolinite-PP nanocomposites can be used for materials and processing requires higher-performance in stiffness and temperature compared to neat PP such as food packaging, automotive parts and other applications.

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Modeling Surface Roughness for prediction and evaluation of Bed-Sheet woven Fabric

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Abstract

Nowadays, evaluating fabric touch can be a great interest in the industry in order to match the quality needs of the consumer and the parameters for the manufacturing process. Modeling helps to determine how the structural parameters of the fabric affect the surface of a fabric and also identify the way they influence fabric properties. Moreover, it is helpful for estimating and evaluating without complexity and time-consuming experimental procedures, and even before the production of the fabric and the results available quickly, tangible, accurate and reliable, and project relevant. In this research prepare the regression model was developed that utilized for prediction and evaluation surface roughness of bed-sheet fabric and various types of woven fabric. The model was developed based on nine different half-bleached plain bed-sheet fabrics with three weft Yarn count 42TEX (14Ne),29.5 TEX (20Ne) & 14.76 TEX (40Ne) and three weft thread density (18ppc, 21ppc &24ppc) and then the surface roughness of bed-sheet fabric was tested by using Kawabata (KES-FB4) testing instrument. The Design-Expert®11 software was used for developing model equation and analysis of variance (ANOVA). Central Composite Design (CCD) with two independent variables (factors) was applied to investigate the effect of weft yarn count and linear density of weft yarn and each factor with three different levels on the surface roughness of fabrics. The effects of count and density on the roughness of bed-sheet fabric were found statistically significant at the confidence interval of 95%. The effect of weft yarn count on surface roughness values of fabrics was observed that surface roughness values increase with weft yarn count coarseness increase, while it decreases as the weft yarn get finer and finer. The surface roughness of the fabrics was decreased as the pick density of the fabrics increases and the vice versa. The correlation between the measured value by KES-FB4 and the calculated value by the model equation show that how they are strongly correlated at 95% (R^2 OF 0.97). This model can be used to select a suitable fabric for various end use applications and it was also, used for testing and predicting surface roughness of woven fabrics.

Keywords- **Surface Roughness, Regression Modeling, Design Expert, Prediction, Bed-sheet, and Structural Paramete**

I. Introduction

Nowadays, consumers demand clothing which not only looks good but also feels comfortable. Consumers choose comfort as the most important attribute that they seek in apparel products, which is followed by easy care and durability. As comfort is definitely an individualistic sense it is very difficult to define, design or determine it [1]. Evaluating fabric touch can be a great interest in the industry in order to match the quality needs of the consumer and the parameters for the manufacturing process [2]. One of the most important characteristics of the fabric which affects the comfort properties of cloth is the constructional specification. Parameters such as thickness, weight per square meter, the pattern of weave thread density, crimp%, and yarn count can be counted as the most effective parameters [2].

Roughness is a descriptive term for a fabric surface which has the feel of sandpaper (ASTM-D123–09, 2009). Smoothness and roughness of fabric materials are important fabric tactile properties for engineering design of many textile products including medical textiles, hygiene and healthcare products, sportswear, underwear, bed-sheet, lingerie, and other consumer products having special requirements is sensitive surface tactile properties[3-5].

Modeling of the process of perception of textiles by the skin fills the gap between two contemporary existing solutions: objective and subjective assessment of handling properties of fabrics [6]. Numerous mathematical models involving the human body, clothing, and environment provide useful tools for identifying key parameters in material design and for predicting clothing performance under extreme environmental conditions[2]

The evaluation of fabric surface roughness is possible by using either contact or non-contact methods. In this regard, many devices and techniques have been developed and employed. The Kawabata Evaluation System for Fabrics (KESF), Fabrics Analysis by Simple Tests (FAST), and Fabric Touch Tester (FTT) systems are available for measuring the fabric handle related characteristics under the contact methods. But, as far as the tactile responses are concerned, all the low-stress mechanical characteristics directly or indirectly stimulate the touch, pressure, roughness and other mechanoreceptors of human skin[6-8] .

The measurement, quantification, and analysis of surface roughness have been the subject of many research works, due to the decisive role of these parameters in the selection of an appropriate fabric for different technical and clothing end-uses. Many studies have focused on the measurement of fabric surface roughness by objective and subjective methods.

Recent years have seen huge advances in the accuracy, realism, and predictive capabilities of tools for the theory and simulation of materials. Predictive modeling has now become a powerful tool which can also deliver real value through application and innovation to different industries. It forms an essential part of the research and development effort of many of the world's leading organizations and can be incredibly valuable for businesses. By using modeling, it is possible to identify the effective aspects of bed-sheet fabric structure on surface roughness and also discover the way that they influence the property of surface roughness of bed-sheet fabrics. Used in a combination of good analysis and experimentation, materials modeling can drive progress, saving time, cost, effort and resource. Results are tangible, available quickly and project relevant. Materials modeling can be used to solve real issues and problems and push cutting edge research.

Most of the researchers were focused on experimental methods for characterizing the surface roughness of fabrics but, their focus on modeling the roughness of a commonly used bed-sheet fabric is limited and hence most industries are suffering to knowing the level of surface roughness of their product. In this research, a regression model was developed based on the geometrical parameter of fabrics. Thereby the designers in the weaving looms have the ability to design a bed sheet and various types of woven fabrics with specific surface roughness; simply by applying changes in fabric structural parameters (such as weft yarn density and weft yarn linear density) and a laboratory personnel can simply calculate surface roughness of a given fabrics by identifying structural parameter and using the regression model equations. The model is a guide to select a suitable fabric for various end uses and a way to test and predict surface roughness of any kind of woven fabrics.

II. MATERIALS AND METHODS

A. Materials

Nine 100% cotton plain woven fabrics were produced with different structural parameters by Picanol air jet loom in; with three different weft density (ppc) and three different weft yarn linear density (weft count) while the other parameters are kept in constant such as warp density, warp count, tension, speed, and RH% as shown in Table 1. The warp tension force is 1.58KN and the speed of the loom is 500 RPM. All the fabric specification is mentioned as shown in below Table 3. Then each fabric was treated with combined pretreatment process. The chemicals used were sodium hydroxide 3%, hydrogen peroxide 4%, sodium silicate 2%, wetting agent 0.5% and EDTA 0.5 on the weight of the fabric and one to ten liquor ratio.

B. Experimental design

A central composite design (CCD) was selected to determine the experimental conditions as the inclusion of axial experimental points allow for a larger spread of conditions to be examined, which is beneficial when the required complexity of the model is not known for accurate predictions to be made. Central composite design (CCD) is an efficient technique for experimentally exploring relationships between investigated factors and system response. Central composite design experiments need a minimum numbers of trials for estimating the main effect, require less number of runs, allow sequential experimentation,which provides flexibility and time saving in running the experiment and analysis's[9]. The experiment has 8 non-center and 5 center points and the total run is 13 with five numbers of replications as shown in the Table 2.

C. Experimental procedure

Five test specimens 20.0 × 20.0 cm are prepared for measuring surface roughness by Kawabata Evaluation System (KES-FB4) from each produced samples and conditioned at 65 ± 2% relative humidity and 20 ± 2°C for a minimum of 24hr before testing according to ASTM-D1776 practice for conditioning and testing textile materials[10].

D. Developing an empirical model

Several statistical approaches are now available to researchers to analyze multiple outcomes or informants. With multiple informants, researchers can jointly model the associations between informant and outcome using a modeling approach available in standard software packages [11]. Design Expert provides prediction equations (model) in terms of actual units and coded units. The coded equations are determined first, and the actual equations are derived from the coded. To get the actual equation each term in the coded equation is replaced with its coding formula.

$$X_{coded} = \frac{X_{actual} - \bar{X}}{(X_{High} - X_{Low})/2} \dots\dots\dots\dots\dots\dots\dots (1$$

Table 1 Construction parameters of bed-sheet woven fabric

Fabric code	Weave type	Warp density (EPC)	Warp count (Ne)	Weft density (PPC)	Weft count (Ne)
FK_1	Plain	24	20	18	14.76
FK_2	Plain	24	20	21	14.76
FK_3	Plain	24	20	24	14.76
FK_4	Plain	24	20	18	29.5
FK_5	Plain	24	20	21	29.5
FK_6	Plain	24	20	24	29.5
FK_7	Plain	24	20	18	42
FK_8	Plain	24	20	21	42
FK_9	Plain	24	20	24	42

Assumptions:

- All the fibers have the same properties.
- The fabric is produced with a constant tension force.
- The fabric is produced with the same warp count and density.
- The effect of fabric surface hairiness is ignored (neglected).
- Normal yarn elongation % is maintained
- The cross-section of yarns is regarded as a circle.
- The twist factor of the yarn is maintained as per the standards.

The experimental results from the forming trials performed according to the matrix by central composite are tabulated in Table 9. These values are feed to the Design Expert software for developing the surface roughness of the fabric by only considering the count and density of the bed-sheet fabric.

$$SMD = \beta_0 + \beta_1 A + \beta_2 B \ldots (2)$$

E. Model validity test

It is always necessary to examine the fitted model to ensure that it provides an adequate approximation to the true system and verifies that none of the least squares regression assumptions are violated. Proceeding with the exploration and optimization of a fitted response surface will likely give poor or misleading results unless the model provides an adequate fit [9, 12].

F. Model test

A plain fabric consists of the different structural parameter which has different weft densities and weft counts were used for model test against surface roughness measured values by KES-FB4. Structural parameter analysis (density, count and crimp %) will be done for the fabrics which are used for model validation purpose. The count of weft yarn from the fabric is measured according to ISO 7211-5; density of weft yarn will be measured by using ISO 7211-2 standard [13], [14]. Finally, the average value of each measurement was used for calculating surface roughness of the fabrics by developed SMD model equation as shown in Table. 4. The surface roughness of the fabrics was also measured by Kawabata KES-FB4 instrument. Finally, the calculated and the measured value were checked their correlations by plotting graphs.

III. Results and Discussion

A. Effects of count and density on the surface roughness

The data's which were collected from the KES-FB4 instrument of surface roughness values in Table 9 under the response column is normally distributed as shown in Fig. 1. From the box plot in Fig. 2, it is observed that the collected data have no out layers either an upper limit or lower limit. This implies that the collected data are normal and it can be used for further statistical analysis.

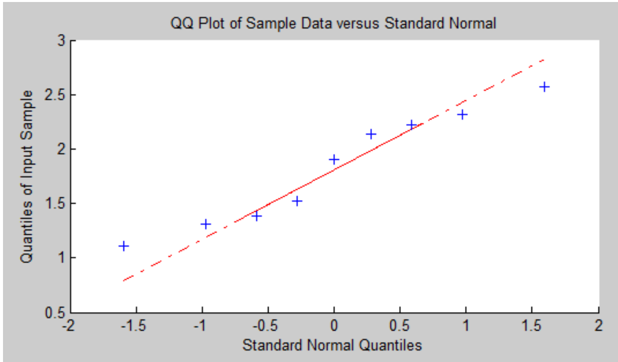

Fig. 1. The QQ-plot of the input data Vs. standard normal.

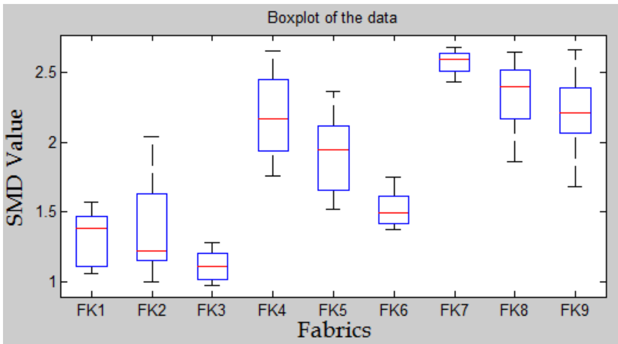

Fig. 2. The box plot of the data.

Table 2 The experimental design with two factors and three levels.

Code	Run	Factor 1 Count (Ne)	Factor 2 Density (PPC)	Response1 SMD
FK_2	1	14.76	21	1.31542
FK_5	2	29.5	21	1.90625
FK_8	3	42	21	2.32167
FK_1	4	14.76	18	1.38958
FK_5	5	29.5	21	1.90625
FK_5	6	29.5	21	1.90625
FK_9	7	42	24	2.32167
FK_5	8	29.5	21	1.90625
FK_4	9	29.5	18	2.13792
FK_5	10	29.5	21	1.90625
FK_3	11	14.76	24	1.11375
FK_6	12	29.5	24	1.52
FK_7	13	42	18	2.56625

ANOVA results of the linear models presented in Table 3 indicates that the model can adequately be used to describe the surface roughness of the fabrics based on the fabric parameters viz. count and density of weft yarn. The F-value is 166.83 ($P < 0.0001$) which implies that the model is significant for surface roughness. There is only a 0.01% chance that an F- value this large could occur due to noise. A P-value is the indicator of the significance of the test. Values of less than 0.05 ($P < 0.05$) indicate the significance of the model terms. Both the model terms count and density is statistically significant at 95% of the confidence interval, since they have a P- the value of 0.0001 and 0.0002 respectively. The Predicted R^2 of 0.9407 is in reasonable agreement with the Adjusted R^2 of 0.9651; i.e. the difference is less than 0.2, which ensures a satisfactory adjustment of the model to the experimental data.

A smooth fabric surface provides a bigger contact area with the human body, while a rougher fabric surface has less contact area when it gets contact with the human bodies [2]. The effect of weft yarn count on surface roughness values of fabrics was observed that surface roughness values increase with weft yarn count (coarser), while it decreases as the weft yarn get finer and finer as shown in Fig. 3. Also, the surface smoothness of the fabrics increases as the pick density of the fabrics increases and the surface roughness of the bed-sheet fabric increases as the weft thread density decreases as shown in Fig. 3. This was due to the fact that as the thread density of weft yarn increases the pick and valley on the fabric surface decreases which was resulted during the interlacement of warp and weft yarns.

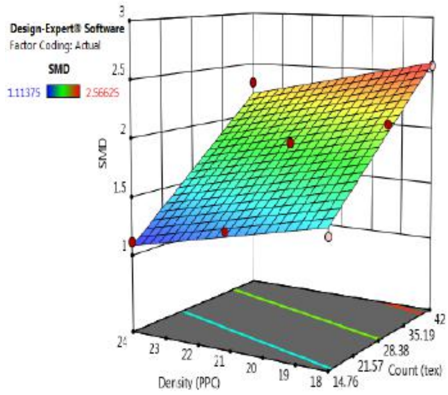

Fig. 3. The effects of both density and count on the surface roughness of the fabric.

B. Model equation for surface roughness

The actual model equation was developed by using surface roughness values of the nine samples which were measured by KES-FB4 instrument. The equation in terms of actual factors (count and density) can be used to ake predictions about the response (surface roughness) for given levels of each factor. Here, the levels should be specified in the original units for each factor. This equation should not be used to determine the relative impact of each factor because the coefficients are scaled to accommodate the units of each factor and the intercept is not at the center of the design space.

$$SMD = +1.98837 + 0.041492 * \text{Count} - 0.063241 * \text{Density} \dots\dots\dots\dots\dots\dots (14)$$

C. Model validity test

The model validation test was done by checking the correlation between the measured data obtained from the experimental method (KES-FB4) and the calculated (estimated) data obtained from the developed actual model equations (SMD). As it is shown in Fig. 4, the proposed model equation can properly correlate the experimentally measured data from (KES-FB4) at the confidence interval of 95% (R^2 of 0.97).

TABLE 3 ANOVA table for linear model

Source	Sum of Squares	df	Mean Square	F-value	p-value	Decision
Model	**2.14**	**2**	**1.07**	**166.83**	**P < 0.0001**	**Significant**
Count	**1.92**	**1**	**1.92**	**299.98**	**P < 0.0001**	**Significant**
Density	**0.2160**	**1**	**0.2160**	**33.69**	**P < 0.0002**	**Significant**
Residual	**0.0641**	**10**	**0.0064**			
Lack of Fit	**0.0641**	**6**	**0.0107**			**Not-significant**
Pure Error	**0.0000**	**4**	**0.0000**			
Cor Total	**2.20**	**12**				

TABLE 4 Samples for model test

Fabric code	Weave type	Warp density (EPC)	Warp count (Ne)	Weft density (PPC)	Weft count (Ne)	Measured (SMD)	Calculated (SMD)
MT_1	Plain	32	28	32	28	1.25	1.12644
MT_2	Plain	20	20	20	20	1.437	1.5533
MT_3	Plain	21	36	21	36	2.277	2.154
MT_4	Plain	28	18.5	28	18.5	1.023	0.9859

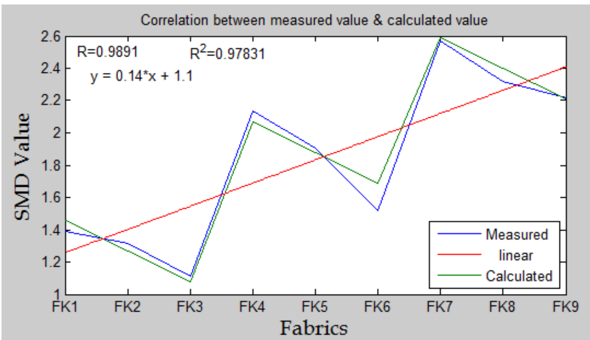

Fig. 4. The correlation between the measured SMD values by KES-FB4 and the calculated SMD value by the model equation.

C. Model test

The model efficiency was tested by using three different fabrics which are not used for the model equation extraction. The fabric's properties were studied and identified the weft density and count by using the ISO 7211-5 and ISO 7211-2 standard.

The fabric's properties of the fabric that were used for the model test which was 100% cotton half-bleached and parameter of construction was as shown in Table.4. The correlation between the surface roughness values from KES-FB4 and the surface roughness values from the developed model equation were found strongly correlate at the 95% degree of freedom as shown in Fig. 5. The model can be used for prediction and evaluation of bed-sheet and other woven fabrics which is hundred percent cotton fabrics.

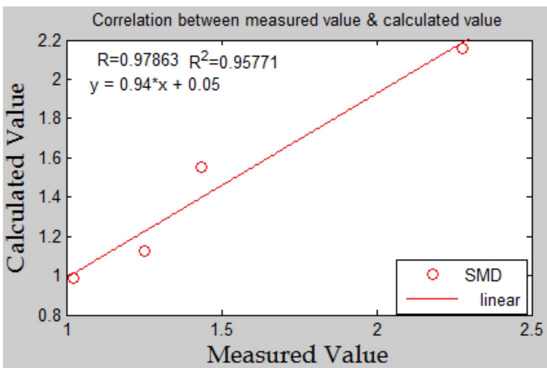

Fig. 5. The correlation between the measured SMD values by KES-FB4 and the calculated SMD value by the model equation for model testing fabrics.

VI. CONCLUSION

Even though there were different structural parameters that affect the surface properties of the fabrics, it is possible to control the surface behavior of the fabric with the developed model. The surface roughness of bed-sheet fabric was mainly affected by weave type, thread density, weft, and warp linear density. The weft count and density were used for the model equation which can be used prediction and evaluation of surface roughness of woven fabric. The model statistically significant and can adequately be used to describe the surface roughness of the fabrics. The surface roughness increases with count increases and the surface roughness decrease as the density of the weft thread increases. In order to produce fabrics with smooth surface properties yarn density should be increased and weft yarns fineness should also increase. The model was validated and tested the correlation between measured by KES-FB4 and calculated by the developed model equation reveals that the model was strongly correlated with the confidence interval of 95% (R^2 of 0.95).

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Assessment of the Quality of Leather Footwear for School Children made by SMEs in Kariokor Kenya.

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Abstract

Footwear is the man-made outer covering of human foot. It is an assembly of top and bottom parts and each part is composed of various components. They are mainly produced from various materials such as textile fabric, leather and synthetics. Leather shoes contain an upper made of leather and the sole varies from leather, rubber, PVC, PU or other material. Various component plays a vital role in the quality and performance of the shoe and failure of one may affect the overall performance of the shoe. The quality of footwear is evaluated based on whether or not the shoe carries out its intended function, its effects on the wearer, and the extent to which it meets the requirements of the user. Poor quality shoe can result from poor quality of inputs, lack of quality control of the shoe during fabrication process and poor workmanship. The shoe made by SMEs in Kariokor are often not subjected to quality check hence their quality is unknown. A study was conducted to assess the quality of school children's leather shoes produced by SMEs of Kariokor market in Nairobi, Kenya. Shoe samples were collected from SMEs for laboratory analysis. Samples were analysed using IUP/IUC methods. The tests carried out were tensile and tear strength, elongation, flex endurance, thickness, distension and strength of grain, pH, sole hardness, abrasion resistance, total chromium among others. The findings indicated that the samples tested failed Kenya Bureau of Standards (KEBS) standards. Although the majority of the shoe uppers met KEBS requirements, the soles for the samples tested failed to meet the requirements. In conclusion, the shoes failed the quality tests as per the KEBS requirement. In line with the outcome, there is a need for a strategy to improve the quality of leather footwear fabricated by the SMEs in Kariokor Market.

Keywords- **Leather, Quality, KEBS, SMEs**

I. INTRODUCTION

A shoe is an assembly of top and bottom parts as shown in Fig. 1 and each part is composed of various components [1]. The upper is the entire part of a shoe that covers the human foot. It consists of all parts of the shoe above the sole [2]. These parts are attached by stitches or more likely moulded to become a single unit then the insole and outsole are attached [2]. Shoe uppers are mainly produced from materials such as textile fabric, leather, synthetics among others.). A leather shoe contains an upper made of leather and the sole varies from leather, rubber, PVC, PU or other material [2]. The sole is an important part of the shoe. It is the part in contact with the ground and protects the foot from injury thus required to have superior qualities. The quality of inputs used in the production of shoes affect the quality and hence performance of the shoe as each part plays a key role and failure of one may affect the overall performance of the shoe.

Footwear come in different kinds and for all purposes. They are used to protect human foot from injury, in fact the health of feet is largely affected by type and condition of shoes [3].

Fig. 1. Anatomy of a shoe

Source: Ganguly, 2003

An accurate choice of a good quality shoes will be able to maintain the health and vitality of feet [4]. The quality of footwear is generally evaluated based on whether or not the shoe carries out its intended function, its effects on the wearer, and the extent to which it meets the requirements of the user.

Given the remarkable flexibility of the foot, it is essential that the foot be accommodated in a manner that enables it to function as designed [5]. Ergonomics dictate that good posture and other specific areas such as perception and biomimetics can be reasonably well integrated into the design and development of footwear therefore, shoe making requires high skills and diverse knowledge in many aspects that may affect the appearance, quality and the functions of a shoe. As a result, standardization of size and quality control measures are important aspects in the production of shoes [6].

Leather is flexible yet durable [7]. Its elastic, so it can be stretched yet it resists tearing and abrasion. It's a breathable material and it insulates heat, helping to regulate temperature of the foot [8]. These properties make leather shoes conform to the feet of the wearer like no other shoe material can. Hence making it widely used.

Generally, the performance properties of upper leather depend on the origin of the raw material, how it is prepared for chemical modification and how it's processed to make leather [9]. Comfort associated with a good quality leather shoe can be explained in terms of comfort provided by the structural formation of the leather together with its various physical and chemical properties [10].

Prolonged use of unsuitable shoe can lead to detrimental changes that alter the protective nature of the shoe into a barrier between the contact surface and the normal behavior of the foot [11]. These changes can lead to altered foot morphology, reduced or impaired postural stability, muscle imbalance and the development of a sensitive foot [12]. Failure to give due emphasis to footwear quality can have a negative health impact on the consumer and can also hurt the goodwill of the business organization and result in decline in market share [13]. Wrong shoes can also lead to longer lasting orthopedic problem [14].

There are common feet problems associated with poor quality shoes as shown in the subsequent figures below. Blisters and corns are as a result of ill-fitting shoes. Fit is a quality parameter in footwear technology [2].

Fig. 2. Corns

Figure 3. Blisters

Source: Internet

II. EXPERIMENTAL PROCEDURES

A. *Materials and Methods*

Pairs of school children's shoes of sizes 7,8,9, 10, 12, and 13 were samples from SMEs of Kariokor market for laboratory testing. They were subjected to physical and chemical testing following IULTCS methods as outlined in the subsequent sections.

B. *Visual Inspection of the Shoe*

The shoe samples were visually inspected for the presence of any defects. The defects/problems were noted and pictures taken.

C. *Sample Preparation*

The shoe samples were dismantled to obtain various clicked components. Whereby the upper parts of the shoes were separated from the bottom parts. Sampling of the upper parts was carried out in accordance with the official sampling method IUP 2, 2001 [15].The obtained samples were subjected to physical and chemical analysis

D. *Measurement of Thickness*

The thickness was measured in accordance with the official method IUP 4, 2001[16].

The apparatus was placed on a flat, horizontal surface. The sample was placed in the gauge grain side up. The load was applied gently for a specified time and the thickness recorded after full loading was reached. The results were expressed in arithmetic mean. The thickness test was carried out on each of the following components of a shoe; Inner lining, insole, sock, stiffener, toe puff, upper material(leather).

E. *Tensile Strength and Elongation at Break*

Tensile strength was determined in accordance with IUP 6, 2001[17]. Half of the test pieces were taken in one direction and the other half at right angles to the initial directions on the upper parts of the shoes. The press knife cuts out the specimen and slot in one operation (template machine) with the angle formed at the cutting edge between the internal and external surfaces of the press knife being about 20°.

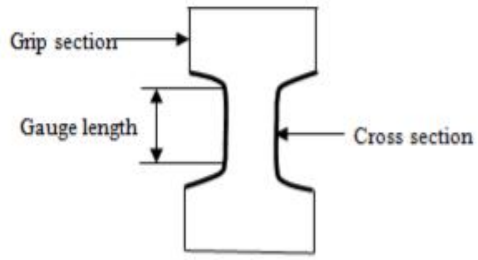

Fig. 4. Dumb bell shape for tensile strength

The jaws of the tensile testing apparatus (Instron) was set 50 mm apart. The six test pieces were clamped in the jaws of the Instron instrument one at a time. The machine was run until the test pieces broke and the highest force exerted recorded as the breaking force.

F. Tear Strength

Tear strength was determined in accordance with IUP 8, 2001 [18].

The specimens were clamped in the jaws of a tensile test machine with the slit edge of each tongue centred in a manner that the originally cut edges of the tongue formed a straight line joining the centres. Six rectangular specimens were cut, each 5 cm long and 2.5 cm wide as shown in Figure 3. The tearing force and elongation were recorded by the machine.

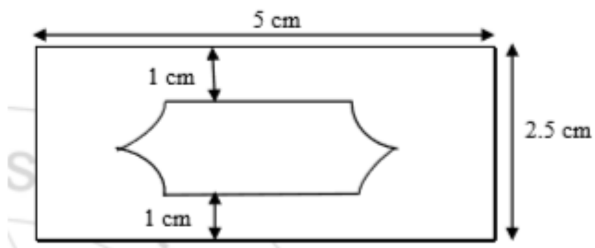

Fig. 5. Dumb bell for tear strength

G. Flex Endurance

The experiment was carried out according to IUP 20, 2001[19]. The test piece was folded and clamped at each end to maintain it in a folded position in a flexometer machine. One clamp was fixed as the other moved backwards and forwards causing the fold in the test piece to run along it. The test piece was examined periodically to assess whether damage has been produced

H. Distension and Strength of Grain

This test was determined in accordance with IUP 9, 2001 [20]. A circular specimen was tightly clamped in the machine. The sample was bent, grain outwards around a mandrel of known diameter under minimum required force to keep the sample and mandrel in contact. The grain was kept under observation and any cracking noted. The machine was started by forcing the plunger at the rate of 0.2±0.05 mm/s. The surface of the specimen was continuously observed at the center for initial crack on the grain. The maximum distance and force were recorded.

I. pH

The pH of the upper leather was determined in accordance with IUP 11, 2001 [21]. The ground samples were soaked in distilled water over a given period of time and the pH of the solution was be determined with a glass electrode pH meter.

J. Sole Hardness

Sole hardness was measured in accordance with ISO 7619-1. The hardness of a soling material was determined by measuring the penetration of a rigid ball into the test piece under specific condition by apparatus known as hardness tester.

K. Abrasion Resistance

Abrasion resistance of the sole was determined in accordance with IUP 26, 2001 [22]. A circular test specimen was rubbed against standard fabric abradant under a constant force. The relative movement between the abradant and specimen is a complex cyclic pattern which produces rubbing in all directions. The test was stopped after a prescribed number of cycles and the damage to the specimen was assessed subjectively.

L. Total Chromium Analysis

The leather uppers were ground by milling them into powder form in accordance with IUC3, 2001.

Total chromium in leather was determined in accordance with IUC 18, 2001.

M. Data Analysis

The data was subjected to statistical analysis using the Statistical Package of Social Sciences (version 21.0; Inc, Chicago IL) software. One-way analysis of variance (ANOVA) was performed for all the data. Duncan's Multiple Range Test was used for the analysis to compare the mean values amongst samples. Results are presented as the mean and the standard deviation of the mean (± SD).

III. RESULTS AND DISCUSSION

A. *Quality Analysis of the Leather Shoe*

A number of quality tests were carried out on the shoe products obtained from the SMEs. The findings are discussed in the subsequent subsections below.

B. *Visual Examination of Shoes*

The shoe samples were visually inspected and were found to have a number of defects. The defects range from poor pattern cutting, poor finishing, poor edge treatment, poor sole attachment among others. Some of these defects are caused during production whilst others are as a result of poor-quality raw materials [1].

Defect

Poor finishing.

Poor edge treatment. Asymmetrical

Poor sole attachment, wrinkles on the upper

Causes

Poor workmanship during edge treatment, lasting and attachment of the sole. Poor quality raw materials and accessories

Fig. 6. A pair of school shoe

Fig. 6 shows the defects captured on the shoe sample and their possible causes.

Defect

Hole on the upper

Holes on the sole

Causes

Poor quality of sole

Poor workmanship during sole attachment and finishing

Fig. 7. Upper and bottom parts of a school shoe

Fig. 7 shows the defects captured on the inner part of the shoe sample and their possible causes.

Defect

Poor edge treatment

Poor stitching of upper and insole

Causes

Poor workmanship during stitching and edge treatment

Fig. 8. Inner part of a school shoe

Fig. 8 shows the defects captured on the inner part of the shoe sample and their possible causes

Defect

Poor finishing on the inside of the shoe

Poor attachment of insole

Poor pattern cutting

Causes

Poor workmanship during attachment of the insole and pattern cutting

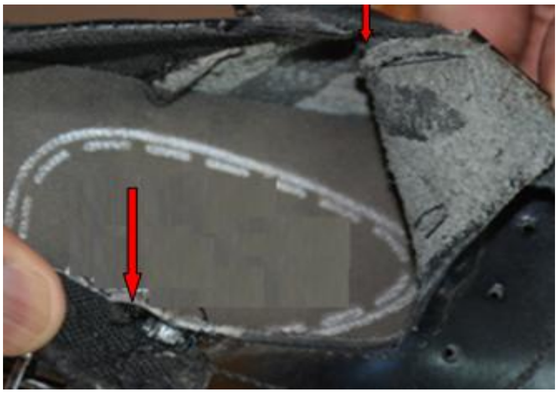

Fig. 9. Inside part of a school shoe

Fig. 9 shows defects captured on the inner part of the shoe and their possible causes.

Defect

Poor attachment of the insole

wrinkles on the insole, poor edge treatment

Poor attachment of lining material

Causes

Poor workmanship during attachment of the insole

Poor edge treatment

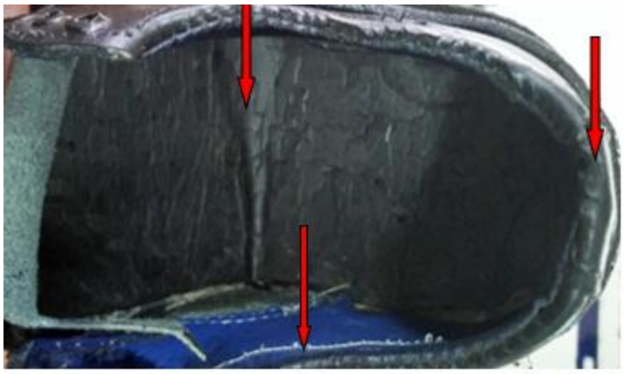

Fig. 10. A school shoe

Fig. 10 shows defects captured on the inner part of the shoe and their possible causes.

Defect

Poor attachment of lining material on the upper, holes on the insole

Poor finishing

Causes

Use of poor-quality adhesives

Poor workmanship during attachment of the lining on the upper

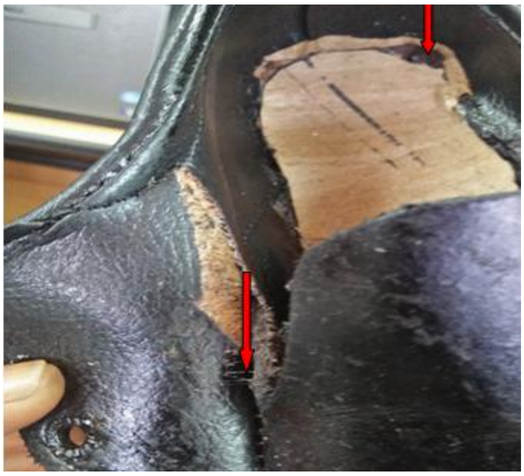

Fig. 11. Inner part of a shoe

The above defects as shown in figures are associated with poor-quality raw materials, lack of necessary machinery and poor workmanship of the footwear SMEs with regard to unskilled or little training on shoe fabrication. The findings are in agreement with those obtained from the field survey where majority of the footwear SMEs in Kariokor use low quality adhesives and low-quality soles, they carry out hand lasting and use old machines. A number of them have not received formal training on footwear technology as they learnt the art through on job training [23].

C. Analysis of the Physical Properties of Leather Upper

The leather uppers were subjected to analysis. Triplicates were carried out for each sample and the average values are reported in subsequent tables below.

The shoe uppers were analysed and their thickness ranged between 1.78 ± 0.03 mm to 2.42 ± 0.23 mm as shown in Table 1. The results conform to the minimum required thickness of 1.00 mm recommended by KEBS. Therefore, all the leather upper for the shoe samples passed the thickness test as the values obtained were within KEBS minimum requirements. As shown in Table 1, the upper leather for shoe sample 4 presented slightly higher thickness of 2.42±0.23 mm and shoe sample 1 showed a slightly lower thickness of 1.78 ± 0.03 mm than others. These results are similar to those obtained by Zengin et al. 2017 [24], whose values ranged between 0.78mm to 2.04 mm. The findings are also comparable with those of Ferrer et al. 2012 [25], whose findings were 2.2 mm. Thickness of upper leather ranges between 1.00 mm to 2.00 mm depending on the type of shoe to be made [22].

Table 2. Thickness of upper leather

Sample	Thickness (mm)
1	1.78±0.03
2	2.02±0.18
3	1.96±0.18
4	2.42±0.23
5	1. 85±0.20
6	1.82±0.22
KEBS standard*	1.00 mm Minimum

*Kenya Bureau of Standards (KEBS) specification for thickness of leather upper

The results for tensile strength are illustrated in Table 2, and the outcome ranged from 6.26 ± 0.57 Mpa to 25.17 ± 1.23 Mpa. These values are within the minimum tensile strength requirement of 15.00 Mpa recommended by KEBS except for shoe sample 1 which recorded a significantly lower tensile strength of 6.26 ± 0.57 Mpa. These results were comparable with those Ferrer et al. 2012 [25] and their findings were 20.40 Mpa and Ali et al. 2013 [26] whose findings were 25.52 Mpa.

Tensile strength determines the structural resistance of upper leather to tensile forces hence its state and usability. During the lasting process, the footwear uppers are submitted to a tensile stress that occurs when they are pulled on the last and they have to maintain their spatial shape [27]. The variation in tensile strength among the upper leather across the shoe samples could be due to variation in origin of the raw materials, how the materials were prepared for chemical modification and how they were processed. Similarly, animal breed, sex and age, environmental conditions among others are among the factors that influence the quality of hide and the resulting leather [22].

Table 3. Tensile strength of upper leather

Sample	Tensile Strength (Mpa)
1	6.26 ± 0.57
2	19.59 ± 0.54
3	23.50 ± 1.91
4	16.63 ± 2.55
5	25.17 ± 1.23
6	21.41 ± 1.55
KEBS standard*	15.00 Mpa Minimum

*Kenya Bureau of Standards (KEBS) specification for tensile strength of upper leather

The results for elongation are reported in Table 3. From the results, the hedonic rating for the shoe samples ranged between 36.73 ± 0.65% to 45.39 ± 1.41%. The percentage elongation for all the shoe samples were within KEBS requirement of 30-80% elongation. These results were comparable with those obtained by Ali et al. 2013 [26] and their findings were 65.48±3.80 and 67.16±9,42. These findings are also similar to those of Habib, et al. 2015 [28] and their results ranged between 32.90 ± 11.72 and 46.14 ± 7.11.

The behavior of upper leather in the manufacturing process and use is established through its elongation which determines its flexibility and elasticity and highlights the deformation capacity of upper leather during the lasting process. Upper leather should possess maximum flexibility to prevent the appearance of cracks and tears in the ball area due to prolonged motion. High elasticity allows the upper leather to withstand the elongation stresses to which it is subjected during footwear lasting, especially on the toe area [29].

Table 4. Elongation of upper leather

Sample	Elongation (%)
1	40.10 ± 0.36
2	37.60 ± 0.53
3	36.73 ± 0.65
4	45.10 ± 0.20
5	45.39 ± 1.41
6	43.39 ± 0.41
KEBS standard*	30-80 %

*Kenya Bureau of Standards (KEBS) specification for elongation of upper leather

The results for tear strength are shown in Table 4. Shoe sample 1 recorded the lowest value of tearing force 35.21 ± 0.72 N whereas shoe sample 5 recorded the highest value of tearing force 99.77 ± 1.21 N. As shown in Table 4, shoe samples 1 and 4 failed the tearing strength test as they recorded a tearing force of 35.21 ± 0.72 N and 38.31 ± 0.73 N respectively which is lower than the minimum tearing force of 50 N recommended by KEBS. These values are comparable with previously found results by Ali et al. 2013 [26], whose findings were 42.92 ± 7.56 N and 43.43 ± 3.56 N. However, there was a significance difference in tear strength among all the shoe samples. The observed variation could be attributed to the structural properties of the upper leather that vary depending on the origin, sex and chemical modification of the leather [30].

Table 5. Tear strength of upper leather

Sample	Tear Strength (N)
1	35.21 ± 0.72
2	83.75 ± 2.10
3	70. 47 ± 1.49
4	38.31 ± 0.73
5	99.77 ± 1.21
6	79.33 ± 1.32
KEBS standard*	50.00 N Minimum

*Kenya Bureau of Standards (KEBS) specification for tear strength of upper leather

The results for pH of the leather upper are illustrated in the Table 5 above. The pH ranged from 4.08 ± 0.48 to 5.18 ± 0.60 for the shoe samples. The upper leather for all the shoe samples had a pH within the range except sample 3 which recorded a pH higher than the recommended pH range of 4.0-4.5 by KEBS. However, the pH level of shoe samples 2 and 6 were within the range of 4.5-5.0 and in agreement with literature reports [22], where the recommended pH should be 4.8 to 5. pH indicates the acidity of the upper leather and possible oxidation of chromium oxide.

Table 6. pH of upper leather

Sample	pH
1	4.14 ± 0.33
2	4.57 ± 0.43
3	5.18 ± 0.60
4	4.08 ± 0.48
5	4.45 ± 0.54
6	4.6 ± 0.36
KEBS standard*	4.00-4.50

*Kenya Bureau of Standards (KEBS) specification for pH of upper leather

The results for distension at grain crack are shown in Table 6. From the results, shoe sample 1 recorded lowest value of 6.30 ± 0.19 mm whereas shoe sample 4 recorded highest value of 7.90 ± 0.07 mm. Shoe samples 1, 2 and 5 failed the distension at grain test as they recorded values of 6.30 ± 0.19 mm, 6.52 ± 0.17 mm and 6.91 ± 0.05 mm respectively, which are lower than the minimum value of 7.00 mm recommended by KEBS. Shoe samples 3, 4 and 6 passed the distension at grain test. These results are compared with those of Ali et al. 2013 [26] whose findings were 9.46 ± 0.42 mm and 10.22 ± 0.74 mm. These findings are also similar to those of Habib et al. 2015 [28], whose findings ranged between 6.60 ± 0.32 mm and 8.54 ± 0.30 mm.

The distension at grain crack test is intended particularly for use with shoe upper leather where it gives an evaluation of the grain resistance to cracking during top lasting of the shoe uppers. The resistance of the grain to cracking depends on the humidity content of the leather, the test is performed on conditioned leather, low results can give good information to the shoe manufacturer about the need to humidify, damp or wet the leather before lasting [22].

Table 7. Distension at grain crack of upper leather

Sample	Grain Crack (mm)
1	6.30 ± 0.19
2	6.52 ± 0.17
3	7.06 ± 0.14
4	7.90 ± 0.07
5	6.91 ± 0.05
6	7.33 ± 0.55
KEBS standard*	7.00 mm Minimum

*Kenya Bureau of Standards (KEBS) specification for distension at grain crack of upper leather

The results for flex endurance of upper leather are illustrated in Table 7. From the results, all the shoe samples had no cracks at 50,000cycles which is the minimum required number of flexes before a leather upper cracks during flexing as recommended by KEBS. Flex resistance test determines the resistance of a material to cracking and other types of failure on flexing. The results imply that the upper leathers for the shoes sampled were potential for the manufacture of footwear as they can withstand maximum flexes during walking.

These results are compared with those obtained by Ferrer et al. 2012 [25], whose leather had no cracks at 200,000 cycles.

Table 8. Flex endurance of upper leather

Parameter	Upper leather					
Sample	1	2	3	4	5	6
Flex endurance	No damage After 150,000	No damage After 150,000	No damage After 150,000	No damage After 150,000	No damage After 150,000	No damage After 150,000
KEBS Standard*	No damage after 50, 000 cycles	No damage after 50, 000 cycles	No damage after 50, 000 cycles	No damage after 50, 000 cycles	No damage after 50, 000 cycles	No damage after 50, 000 cycles

*Kenya Bureau of Standards (KEBS) specification flex endurance of upper leather

D. An*alysis of Dimensions of other Shoe Components*

The shoe components were subjected to dimensional analysis. Triplicates were carried out for each sample and the average values are reported in subsequent tables below.

The results for thickness of lining material are illustrated in Table 8. The thickness ranged between 0.43±0.11 mm to 1.06±0.79 mm. A wide range of thickness of lining materials across the shoe samples was observed. However, all the linings for the shoe samples passed the thickness test as they recorded a thickness higher than the recommended thickness of 0.6 mm by KEBS except shoe sample 2. The variation in thickness of the lining could be attributed to the fact that the linings were made of different materials obtained from different sources

Table 9. Thickness of lining material

Sample	Lining (mm)
1	0.87±0.09
2	0.43±0.11
3	0.75±0.12
4	0.62±0.09
5	0.98±0.27
6	1.06±0.79
KEBS standard*	0.60 mm Minimum

*Kenya Bureau of Standards (KEBS) specification for thickness of lining material

The results for the thickness of insole are illustrated in Table 9. Shoe sample 1 recorded the highest value of thickness of 2.38±0.02 mm whereas shoe sample 2 recorded the lowest value of thickness of 1.04±0.06 mm. Shoe samples 2, 3 and 5 recorded a thickness lower than minimum thickness of 1.50 mm recommended by KEBS, while shoe samples 1, 4 and 6 recorded a thickness that is higher than the minimum requirement. Samples 1, 4 and 6 passed a thickness test. There was a significance difference in thickness of the insole across the shoe samples**.** This could be attributed to the fact that the insoles were obtained from different sources hence processed differently and their thickness varied significantly.

Table 10. Thickness of insole

Sample	Insole (mm)
1	2.38±0.02
2	1.04±0.06
3	1.11±0.20
4	1.98±0.11
5	1.30±0.07
6	1.60±0.51
KEBS standard*	1.50 mm Minimum

*Kenya Bureau of Standards (KEBS) specification for thickness of insole.

Toe puff retains the last shape and solidify the toe portion of the shoe. As shown in Table 10, the thickness of the toe puff for the shoe samples ranged between 1.01±0.21 mm to 1.72±0.34 mm. The toe puff of shoe samples 5 and 6 passed a thickness test as they recorded a thickness that is higher than the minimum thickness of 1.30 mm recommended by KEBS. However, the toe puff of shoe samples 1, 2, 3 and 4 failed the thickness test as the toe puffs recorded a thickness lower than the minimum required thickness of 1.30 mm recommended by KEBS.

Stiffeners are usually inserted at the counter/seat portion of the shoe to keep the shape of the shoe intact. As illustrated in Table 10, the stiffener for shoe sample 2 recorded the lowest value of 0.56±0.20 mm for thickness whereas the stiffener for the shoe sample 1 recorded the highest value of 1.31±0.39 mm for thickness. The stiffener for shoe sample 2, 3, 5 and 6 failed a thickness test as they recorded a thickness lower than the minimum thickness of 1.00 mm recommended by KEBS. However, the stiffener for shoe sample 1 and 4 passed the thickness test as they recorded a thickness higher than the minimum thickness recommended by KEBS.

Table 11. Thickness of toe puff and stiffeners

Sample	Toe puff	Stiffeners
1	1.01±0.21	1.31±0.39
2	1.25±0.40	0.56±0.20
3	1.22±0.10	0.84±0.14
4	1.03±0.18	1.20±0.22
5	1.32±0.16	0.97±0.18
6	1.72±0.34	0.78±0.08
KEBS standard*	1.30mmMinimum	1.00mm Minimum

*Kenya Bureau of Standards (KEBS) specification for thickness of toe puff and stiffeners

The results for thickness of the sock are shown in Table 11. The values ranged from 0.98±0.10 mm to 2.01±0.2 mm. All the sock for the shoe samples passed a thickness test as they recorded a thickness higher than the minimum thickness of 0.8 mm recommended by KEBS. The variation is thickness of the insole across the shoe samples could be attributed to the fact that the materials are from different sources thus possess different properties.

Table 12. Thickness of sock

Sample	Sock (mm)
1	0.98±0.10
2	2.01±0.25
3	1.24±0.08
4	1.77±0.60
5	1.71±0.25
6	1.63±0.08
KEBS standard*	0.80 mm Minimum

*Kenya Bureau of Standards (KEBS) specification for thickness of sock

E. Analysis of Physical Properties of Soles

The shoe soles were subjected to physical analysis. Triplicates were carried out for each sample sole and the average values are reported in subsequent tables below.

The results for tensile strength of the soles are shown in Table 12. The outcome ranged between 4.80 ± 0.74 Mpa to 7.6 ± 1.19 Mpa. Shoe samples 3 and 5 failed the tensile strength test as they recorded as tensile force of 4.80 ± 0.74 Mpa and 7.6 ± 1.19 Mpa respectively which is lower than the minimum tensile strength of 6.00 Mpa recommended by KEBS. This indicates that based on the effectiveness of the sole to tensile force, the two samples were not fit for use. However, shoe sample 1, 2, 4 and 6 passed the tensile strength test as they recorded a value which is above the minimum tensile strength required by KEBS. The results for tensile strength reveal information about the mechanical properties of the sole material. When a sole material can no longer withstand the stress applied on it, it causes failure or excessive deformity [2].

Based on elongation of the sole as s shown in Table 12. Shoe sample 3 recorded the lowest value of 149.00± 1.00% while shoe sample 1 recorded the highest value of 256.00 ±1.00%. However, all the soles for the shoes sampled passed the elongation test as they recorded a percentage elongation which is higher than the minimum required elongation of 100% recommended by KEBS. Elongation of a sole until it breaks helps to obtain the material's complete tensile profile. It highlights the deformation capacity of the sole material.

Table 13. Tensile strength and Elongation of soles

Sample	Tensile Strength (Mpa)	Elongation (%)
1	6.26 ± 0.57	256.00±1.00
2	7.57 ± 1.20	187.00± 2.00
3	4.80 ± 0.74	149.00± 1.00
4	6.35 ± 0.90	212.00± 2.00
5	5.58 ± 0.53	203.33 ± 3.51
6	7.60 ± 1.19	220.67 ± 2.08
KEBS standard*	6.00 Mpa Minimum	100% Minimum

*Kenya Bureau of Standards (KEBS) specification for tensile strength and elongation

The sole hardness ranged from 31.90 ± 1.73 to 52.87 ±2.30 as shown in Table 13. All the soles for the shoe samples failed the hardness test as they recorded hardness lower than the recommended range of 50-60 by KEBS except shoe sample 6. This sample had a hardness of 52.87 ±2.30 that is within the range of 50-60 recommended by KEBS. However, based on ISO requirements for the shoe soles, all the soles for the samples tested failed a hardness test as they recorded hardness lower than the recommended range of 58-74 by ISO standards [22]. The hardness of the sole influence the comfort and safety of the shoe. Flexing is also affected by hardness. A thin soft sole may not withstand mechanical irresolution whereas a hard-sole will be discomfort for flexing as well as tendency to slippery, it also relates to the durability due to variability in abrasion resistance which results to poor wear resistance [2]. As a result, hardness within the range is required.

Table 14. Hardness of soles

Sample	Hardness IRHD (N)
1	35.17± 1.07
2	31.90 ± 1.73
3	43.64 ±0.68
4	46.76 ±1.13
5	38.07±1.68
6	52.87 ±2.30
KEBS standard*	50-60
ISO standard**	58-74

*Kenya Bureau of Standards (KEBS) specification for sole hardness

The results for abrasion loss are illustrated in Table 14. All the soles for the shoe samples failed the abrasion resistance test as they recorded values higher than 450mm^3 maximum value recommended by KEBS. This indicates that, based on abrasion resistance parameter, the soles for the shoe sampled were not fit for use. However, the study reported a higher variation in abrasion resistance across the shoe samples as there was a significance difference in abrasion resistance among all the shoe sampled. Even though the soles were obtained from the same company, the process modification involved during manufacturing is different [1]. Thus, leading to variation in the abrasion resistance across the soles.

Table 15. Abrasion loss of soles

Sample	Abrasion Loss (mm^3)
1	695.00± 2.00
2	570.00 ± 1.00
3	587.00 ± 2.00
4	765.00 ± 2.00
5	471.00 ± 2.00
6	909.00 ± 1.00
KEBS standard*	450 mm^3 Maximum

*Kenya Bureau of Standards (KEBS) specification for shoe uppers

F. Analysis of Total Chromium in Upper Leather

Total chromium was analysed in the upper leathers. Triplicates were carried out for each sample and the average values are reported in table below.

The findings for chromium content are illustrated in Table 15. The upper leather for shoe sample 1 and 6 recorded a value of 3.9±0.86 and 3.90±0.17 respectively that exceeded the permissible limit of extracted 3mg of chromium per kg leather material as recommended by KEBS. This indicates that the two shoe samples would pose potential risk to the wearer. These results are in partial agreement with the results reported by Rezic, et al, 2009 [30]. As the results obtained exceeded the permissible value of 50.0 mg/kg of total chromium in leather

The presence of chromium in chromium-tanned leather represents a considerable health problem as indicated in literature [31]. For this reason, they may pose a serious health problem. It is recommended to avoid direct contact of shoes with the skin. Also, there is need for quality analysis of upper leather prior to shoe fabrication.

Table 16. Total chromium of upper leather

Sample	Total Cr (mg/kg)
1	3.90 ± 0.86
2	0.28 ± 0.27
3	0.20 ± 0.33
4	0.86 ± 0.79
5	0.86 ± 0.79
6	3.90 ± 0. 17
KEBS standard*	3.00 mg/kg detection limit

*Kenya Bureau of Standards (KEBS) specification for shoe uppers

IV. DISCUSSION

Poor stitching, poor pattern cutting, poor edge treatment and poor finishing were the common defects that were observed. These defects are associated with poor workmanship of the footwear SMEs with regard to unskilled or little training on shoe fabrication. Majority of the shoe uppers were fit for use as they met KEBS standards. However, all the soles failed to meet KEBS standards. This finding is in agreement with the data that was collected from the field study, which indicated that 50% of the consumers of the SMEs produced footwear had reported complaints on non- durable soles. Thus, the overall quality of the shoe will be affected as each shoe component plays a vital role in the overall performance and hence quality. Failure of one component will affect the overall performance of the shoe.

V. CONCLUSION

The sampled footwear fabricated by SMEs in Kariokor failed to meet the KEBS standards. The defects result from poor workmanship and poor-quality soles. Even though some leather upper passed the recommended values, the whole product did not.

VI. RECOMMENDATION

Owing to the failure of the shoe to pass the KEBS requirement there is need for the SMEs to be sensitized on the need of quality checks and quality assurance mechanism on footwear manufacture. Also, a corrective measure and strategy to be instituted to help SMEs in producing quality products.

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Prediction of Psychological Comfort of 100% Cotton woven Fabrics from Yarn Properties

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Abstract

A pleasant mental satisfaction of a wearer is the first criteria for evaluating clothing to be worn. Inherently or due to processing, cotton cloths have different psychological comfort behavior. Lack of aesthetic value, fashionably and physical appearance contributes to psychological discomfort to the users. For this reason, manufacturers need to produce fabrics with optimum psychological comfort parameters. The objective of this research work was to study the effect of cotton yarn parameters on psychological comfort properties of woven fabrics. Four woven fabrics were produced from cotton yarns of different parameters. Psychological comfort parameters like wrinkle, drape, crease, bending modules and flexural rigidity were measured and analyzed scientifically. A model was established to predict comfort properties of clothing in relation to the yarn parameters. Statistical analysis showed that wrinkle and drapeability of fabrics were highly affected by yarn twist, count, tenacity and elongation of yarns. However, statistical analysis showed that yarn twist, count, tenacity and elongation had insignificant effect at F-value of 3.546 and P-value of 0.069, respectively. Stiffness of fabrics like Flexural rigidity and bending modules also showed insignificant difference between samples at F=38487.969, Sig=0.057 and F=25.506, Sig=0.055 respectively. Multiple regression analysis proof that the relation between yarn parameters (factors) and response was a positive correlation. It was Adj. R^2 = 0.0998, Adj. R^2 = 0.975 and Adj. R^2 = 1 for crease recovery, wrinkle recovery and drape coefficient, respectively. The model developed is helpful to fabric manufacturers in sourcing yarns with specific parameters to produce the desired comfort level in a fabric.

Keywords- **Psychological comfort, Cotton fabric, wrinkle, Crease, Bending modules, Flexural rigidity**

I. Introduction

In recent years, psychological comfort is receiving attention from manufacturers due to consumers demand of aesthetic value, fashion-ability and good clothing appearance considered during purchasing. Apparel cloths with poor wrinkle, low drapeability and crease recovery will decrease wearers' psychological satisfaction. Natural fibers have good comfort properties when compared to synthetic fibers. Even though they have several advantages, there are also some disadvantages, such as poor wrinkling of fabric during wear [1].Yarn parameters are very crucial in producing a suitable fabric with optimized performances for specific end use. Several researchers have shown that yarn properties affect the properties of clothing. Gong has studied cotton fabrics made from five control factors in order to examine their effects on the yarn cross-sectional shape changes along the yarn path. The studied factors were fiber type, yarn linear density, twist factor, and warp and weft cover factors. The study focused on the cross-sectional structure and its influence on woven fabric [2]. Pattanayak and Luximo pointed out that there are many factors that influence the aesthetic appearance of a fabric and the outstanding effect on the formal beauty of the cloth. Drape is one of the critical factor for psychological comfort. Drape or drapeability of a fabric refers to the manner in which the fabric falls, shapes, gathers, or flows with gravity on the model form or on a human body. In recent years, fabric drape has attracted the attention of many researchers because of the attempt to create a clothing CAD system by introducing fabric material properties in which drape is the key element [3].Fabric drape is an important parameter for the selection and development of textile material for apparel industry [4]. The predictions of drape property of cotton woven fabrics have been developed by using multiple regression method. Another researcher investigated the improvement of crease recovery of cotton fabrics. Reactive dyed fabrics were treated with dimethylol dihydroxy ethylene urea (DMDHEU) resin in order to improve their crease recovery characteristics of fabrics. Two types of treatments were carried out; conventional thermal curing and gamma irradiation. Finally, the effect of treatments on the crease recovery, mechanical and thermal properties of fabrics were studied. It was found that the finishing of cotton fabrics with gamma irradiation shows better crease recovery [5].The effect of yarn twist has also been studied and it is observed that the crease recovery of cotton fabrics decreases with increasing yarn twist [6]. Similarly, Liu et al. investigated the impact of mechanical action on the wrinkling of cotton fabrics in a drum washer [7].

Hala [8]. has studied the effect of yarn twist direction on drapability of fabrics. And it was observed that twist direction has effect on drape property. Moreover, bending and drape properties of woven fabrics and the effect of weft density, weft yarn count and warp tension on these properties were investigated by sule [9]. They reported that the woven fabrics with thicker weft yarns and higher weft densities had higher bending rigidity. In addition to this, bending rigidities of the fabrics in the warp directions increased as warp tension increased. King and Johnston [10]. studied the effect of stiffness, shear, extensibility, thickness and density on drape coefficient of fabrics. Multiple regression analysis equation was developed to determine drape coefficient based on stiffness, shear, extensibility and density. The drapeability characteristics of a fabric are believed to be affected, to some extent, by fiber stiffness [11]. Multiple regression models were built based on the factors like bending, shear, tensile, compression and aerial density. It was found that tensile and compression factor have little effect on the drape property of fabrics. It was observed that bending, shear and aerial density affect the drape characteristics [1], [4]. In this research work, the effects of yarn parameters such as yarn count, twist, strength and elongation of yarns on psychological comfort of woven fabrics were studied. Multiple regressions were also carried out to predict stiffness, wrinkle recovery, crease recovery and drape property of fabrics.

II. Experimental

A. Materials

Four type of cotton yarns were manufactured at Bahir Dar textile Share Company by using C-60 IDF (Integrated Draw frame) machine and Rotor spinning system (RIETER- R 923). After yarn preparation the yarns were verified by testing to assure their properties. Table 1 shows properties of selected yams for the study. Yarn twist, yarn count, strength and elongation were evaluated according to their standard methods.

Table 1: YARN PROPERTIES

Yarn code	Yarn count (Tex)	Twist Turns/m	Tenacity (cN/tex)	Elongation (%)
Y1	21.5	937.2	14	6.29
Y2	22.9	916.7	5.74	4.43
Y3	24.1	876.7	11.22	5.10
Y4	36.4	843.5	8.78	5.04

Statimat me+ instrument was used to measure yarn strength and elongation. Table 2 shows actual thread density and thickness of the fabrics as well as nominal yarn count and twist. For woven samples preparation the warp yarn had a constant yarn count for all fabrics and air jet loom speed was 350 rpm. After fabric production samples were treated via half bleaching combined treatment system using Jigger machine. The fabric and water solution were prepared MLR 1:5, H_2O_2 4% of weight of fabric, NaOH 3% of weight of fabric, Na2SiO3 2% of weight of fabric and wetting agent 0.5% of weight of fabric. By mixed up the solutions each sample was treated at 95^0 C temperature for 1:30hrs and working speed of machine was 40m/min.

B. Methods

For all knid of test, specimens were conditioned at 65 ± 1% relative humidity and 20 ± 1°C before conduct to testing.

Structural properties

Structural parameters of the developed samples like thread density and weight of fabric were tested according to ESISO 7211-2 and ES ISO 3801 test methods respectively. The nominal thread density (set at loom) of fabric and the actual thread density (after manufacturing and test) are presented.

Stiffness test

Fabric stiffness is the resistance of the fabric to bending. This test measures the bending stiffness of a fabric by allowing a narrow strip of the fabric to bend to a fixed angle under its own weight. The length of the fabric required to bend to this angle is measured and is known as the bending length.

Cantilever stiffness test system is often used as a measure of a fabric's stiffness as it is an easy test to carry out. During test, a horizontal strip of fabric is clamped at one end and the rest of the strip allowed hanging under its own weight. This is shown diagrammatically in Figure 1

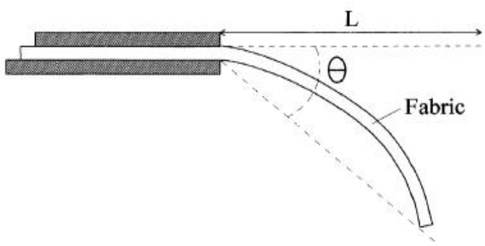

Fig. 12. Fabric stiffness test cantilever method

Where L = length of fabric projecting,
Θ= angle fabric bends to
M = fabric mass per unit area.

The test specimens were cut in the dimension of width 25 mm X 200 mm in lengthwise. Five numbers of tests were measured in each sample at warp and weft direction according to ASTM D1388-08 standard. The measurement of the stiffness analysis includes the parameters such as flexural rigidity, bending modulus, bending length. Bending length is measured, and then fabric bending modulus and flexural rigidity are calculated.

Flexural rigidity = Mc^3 ………… (1)

$$\text{Bending modules} = \frac{G}{\text{Thickness (mm)}} \quad \text{……… (2)}$$

Whereas;

M = weight of fabric in g/m^2

C^3 = Bending length

G = Flexural rigidity

T = thickness of fabric

Drapebility property

Drape is the degree of fabric deform when it is allowed to hang freely under its own weight. Drape is quantitatively expressed by a drape coefficient [10]. The drape coefficient has been defined as the percentage of the area of the annular ring of fabric obtained by vertically projecting the shadow of the draped specimen. This test is used for the indication of garment appearance properties when fabric orients itself into folds in more than one plane under its own weight. In the study, for assessment of drape of fabrics 30 cm diameter circles template was used for testing with Cusick drape tester. Five numbers of tests were measured in each sample as directed in ISO 9073-9 test method. The samples were positioned over a horizontally placed circular rigid disk of 18 centimetres in diameter. The fabric deforms into series of folds around the disk. The paper ring containing the shadow image of the draped configuration represents the weight w1. The shadow image cut from the paper ring is weighed and marked as w2. Finally, the drape coefficient (DC) was calculated using equation 3:

$$DC\% = \frac{w2}{w1} \times 100 \quad \text{…………………… (3)}$$

W_2= mass of the shaded area
W_1=total mass of paper ring

Wrinkle property

These test procedures measured the appearance of textiles after crushing. The sample was maintained at the specified pressure for a specified period under standard atmospheric conditions using a wrinkle tester. The sample was removed and conditioned again under standard atmospheric conditions. Acording to ISO 9867 appearance of tested samples were visually compared to a reference sample and rated.

Crease recovery

Creasing of a fabric during wear has high influence on wearer psychological satisfaction as well as viewer acceptances. Therefore, any apparel clothing must have satisfactory in crease recovery. Crease recovery is the ability of the fabric to return from the collapsed deformed state. In this investigation, crease recovery was measured quantitatively in terms of crease recovery angle.

Textiles used in clothing need to have the ability of creasing and folding to conform to body shapes, giving better comfort in wear. However, to retain their appearance, they must be able to shed the crease that occur in wear and laundering. When a fiber bends, cross-links may break and rejoin in a new position, restricting recovery; or they will merely stretch and recover when the load is removed. The Principle of the crease recovery test is a conditioned rectangular specimen of specified dimensions is folded and maintain folded for a measured time under a specified load, using the loading device supplied. This creasing load is then removed and the specimen allowed to recover for a specified duration in the crease recovery tester. The Shirley crease recovery tester M003A was used to evaluation based on ISO 2313 standard method.

III. RESULTS AND DISCUSSION

Structural properties

As observed in Table 2, the samples were woven using the same fabric structure, thread density and other loom settings. The planed and actual thread density had slightly difference.

Table 2-WOVEN FABRIC CHARACTERISTICS

Sample Code	Type of Weave	Nominal-thread density/cm (warp/weft)	Actual thread density/cm (warp/weft)	Thickness (cm)	GSM
F1	Plain	26/18	27/20	0.37	168
F2	Plain	26/18	26/17	0.38	140
F3	Plain	26/18	27/18	0.35	145
F4	Plain	26/18	26/16	0.4	160

Stiffness of fabrics

Table 3 shows fabric stiffness including flexural rigidity and bending modules were not significant changed. The effect of yarn count, yarn twist, strength and elongation on woven fabrics was insignificant with F=38487.969, Sig=0.057 for Flexural rigidity and F=25.506, Sig=0.055 Bending modules. As shown from statistical analysis, the fabrics made from 21Tex to 36Tex with others properties had not difference in Flexural rigidity and bending modules. Moreover, the correlation of factors and responses were not consistency.

Drapebility of fabrics

As it can be seen from Table 4, the developed woven fabrics had high significant change in drape coefficient with F-value = 113.610 and P-value = 0.000. Drape coefficient is the inverse of drapeability. Drape results of fabrics depend on yarn count and fabric weight rather than other properties.

Table 4 shows Multiple Linear regression equation of fabrics' properties. These equations would be useful to predicate crease, wrinkle recovery and drape coefficient of fabrics. The adjacent R^2 value is indication of correlation of yarn properties (factors) and fabric characteristics (responses). When adjacent R^2 go to 1or -1 there will be strong correlation between them. In the study, the correlation of stiffness and yarn parameters were low correlation (Adj. R^2 = 0.231 for Flexural rigidity and Adj. R^2 = 0.125 for bending modules).
However, crease recovery, wrinkle recovery and drape coefficient showed very good correlation with studied yarn parameters. It was Adj. R^2 = 0.0998, Adj. R^2 = 0.975 and Adj. R^2 = 1 for crease recovery, wrinkle recovery and drape coefficient respectively.

Wrinkle recovery

Wrinkle recovery of woven fabrics made from four types of yarn properties had significant change at F-value=30.917 and P- value=0.000 (see Table 5). As this investigation results shows, wrinkle recovery was highly affected by yarn count, twist, elongation and tenacity of yarns respectively. High wrinkle was observed in fabric (F_4) made from low twist, coarser count, low elongation and tenacity of yarn. This is because when some load is applied on the fabric, it become compressed and deformed. When the applied load is removed, the tendency to recover to original position is very low due to low twist yarns tend to damaged. The individual correlation of yarn parameters were analyzed by linear regression. The results showed that yarn elongation and tenacity were highly correlated to wrinkle recovery at Adj. R^2 = 0.928 and Adj. R^2 = 0.924 respectively. Yarn twist also had good correlation at Adj. R^2 = 0.879. But yarn count was correlated with low Adj. R^2 = 0.596.

Figure 2 shows the average grade of wrinkle recovery of developed fabrics. Grade 4 mean-very good wrinkle recovery, Grade 3-modrate recovery, Grade 2 – Low recovery or high wrinkle and grade 1- poor recovery (extremly wrinkle formed) . Therefore, the wrinkle recovery grade reduced from fabric one (F1), F2, F3 to F4 respectivily.

Crease recovery

As shown in Table 5., between four types of woven fabric made from different yarn parameters were not found significant change with statistical value of F-value=3.546 and P-value=0.069. When P-value is ≥ 0.05, it indicates there is no difference between samples. As observed from Figure 3, crease recovery of F3 and F4 samples seems to have greater value; however, it was insignificant statistically. To predict crease recovery of fabrics, multiple regression equation was developed and presented in Table 4. All factors in one had Adj R^2 = 0.998. Further this, linear regression also has done to show the relation of single factor and response (crease recovery). Yarn twist-Adj R^2 = 0.991, elongation- Adj R^2 = 0.973, yarn count - Adj R^2 = 0.955 and tenacity of yarn - Adj R^2

= 0.854 were correlated with crease recovery of fabrics. Analysis individual factor Adj R^2 value the remaining yarn parameters were taken as constants.

TABLE 3 STATISTICAL DESCRIPTIONS OF FABRICS PROPERTIES

Properties	Fabrics	Mean	Std. Deviation	Std. Error	Minimum	Maximum
Crease recovery of fabrics	F1	102.6000	4.77493	2.13542	97.00	109.00
	F2	99.6000	6.18870	2.76767	95.00	110.00
	F3	110.6000	9.58123	4.28486	98.00	120.00
	F4	111.8000	6.97854	3.12090	104.00	120.00
Wrinkle recovery of fabrics	F1	4.4000	.54772	.24495	4.00	5.00
	F2	2.4000	.54772	.24495	2.00	3.00
	F3	2.2000	.44721	.20000	2.00	3.00
	F4	2.0000	.00000	.00000	2.00	2.00
Drape coefficient of fabrics	F1	73.3220	.83527	.37354	72.25	74.35
	F2	66.1060	.60455	.27036	65.25	66.91
	F3	72.7300	.45645	.20413	72.12	73.21
	F4	74.8000	1.15972	.51864	73.00	76.12
Flexural rigidity	F1	2014.2000	1.78885	.80000	2012.00	2016.00
	F2	1398.0000	5.70088	2.54951	1390.00	1405.00
	F3	1596.6000	2.30217	1.02956	1595.00	1600.00
	F4	2238.4000	5.94138	2.65707	2230.00	2245.00
Bending modules	F1	5439.6000	11.32696	5.06557	5425.00	5450.00
	F2	3664.4000	16.75709	7.49400	3648.00	3684.00
	F3	4430.2000	813.02380	363.59530	3680.00	5650.00
	F4	5636.4000	33.42604	14.94858	5600.00	5665.00

Table 4 MULTIPLE LINEAR REGRESSION EQUATION OF FABRICS PROPERTIES

Properties	Multiple Linear regression equation	Adj. R^2
Crease recovery in angle	169.89411+0.39761*X1-0.06034*X2+2.54839*X3-8.73989X4	0.998
Wrinkle recovery (Grade)	-22.94906+0.05257*X1+0.02249*X2+0.02214*X3+0.76871X4	0.975
Drape cofficient (%)	86.12092+0.22059*X1 -0.03755*X2+0.7464*X3+1.14481*X4	1
X_1= yarn count, X_2=yarn twist, X_3 = tenacity, X_4 = elongation		

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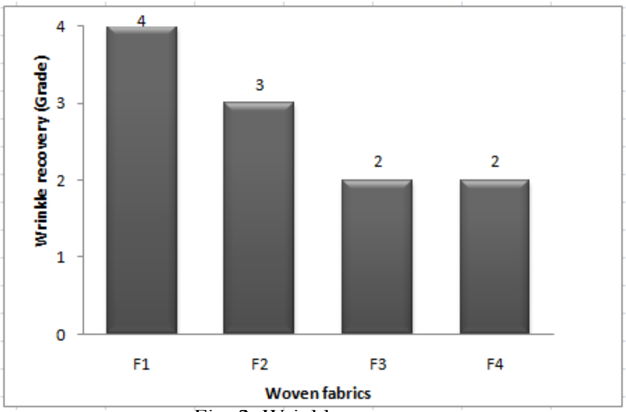

Fig. 2. Wrinkle recovey

Table 5-ANALYSIS OF VARIANCE OF FABRIC PROPERTIES

Properties	Fabrics	Sum of Squares	df	Mean Square	F	Sig.
Crease recovery	Between Groups	536.150	3	178.717	3.546	.069
	Within Groups	806.400	16	50.400		
Wrinkle recovery	Between Groups	18.550	3	6.183	30.917	.000
	Within Groups	3.200	16	.200		
Drape coefficient	Between Groups	222.942	3	74.314	113.610	.000
	Within Groups	10.466	16	.654		
Flexural rigidity	Between Groups	2202474.000	3	734158.000	38487.969	.057
	Within Groups	305.200	16	19.075		
Bending modules	Between Groups	12673882.150	3	4224627.383	25.506	.055
	Within Groups	2650136.400	16	165633.525		

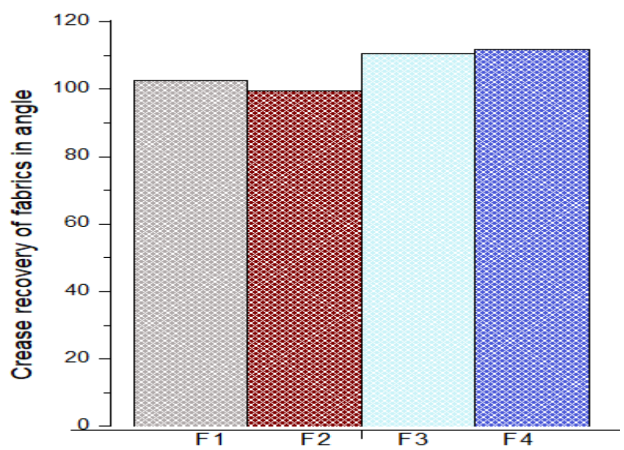

Fig.3. Crease recovery of fabric

IV. CONCLUSION

In the study, four types of woven fabrics were developed from yarns with different properties by varying yarn count, twist, strength and elongation. The effect of these yarn properties on psychological comfort of woven fabrics were studied and analysed statistically. To predict the value of crease recovery, wrinkle and drape coefficient of fabrics; an equation was developed by using multiple regression. As statistical analysis showed that, yarn twist, count, tenacity and elongation was insignificant change at F-value=3.546 and P-value=0.069. Stiffness of fabrics like Flexural rigidity and bending modules also showed insignificant difference between samples at F=38487.969, Sig=0.057 and F=25.506, Sig=0.055 respectively. However, wrinkle and drapeability of fabrics was highly affected by yarn twist, count, tenacity and elongation of yarns.

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Environmentally Friendly Bio-preservatives Preparation for Curing of Hides and Skins

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Abstract

When fresh animal hides or skins cannot be processed in a tannery, they are preserved in order to protect decay and then stored. The most common method of preservation globally utilized is preservation using sodium chloride. The dual benefits of common salt are dehydrating ability and bacteriostatic effects. This salt based curing system usually employs huge quantity of common salt ranging from 35-40% based on raw weight. Nevertheless, this method is associated with diverse environmental problems viz. huge amount of chlorides (55%), total dissolved solids (more than 40%) to the effluent. The long-lasting solution for the problems associated with salt based curing system is to find environmentally friendly alternative curing methods which are free from salt. Apparently, the best alternative preservation method would be natural plant material extract. Screening studies are primarily conducted on different plant species (Gesho, Grawa, and Endod) to test efficacy of extracts which gave rise to characterization and application of the same for preservation for hides and skins with respect to the conventional salt-based system. The pollution load of bio preservative on the final soaking stream was also be tested and compared with salt based. The structural characteristics of leathers prepared using bio preservative was compared with salt based one. The strength properties of resulting leathers with bio preservative were also compared with conventional.

Keywords- **Gesho, Grawa, Endod, bio-preservative**

I. Introduction

The leather industry generally uses hides and skins as raw materials, which are the by-products of meat and meat products processing industry. In this respect, the leather industry could have easily been distinguished as an environmentally friendly industry, since it processes waste products from meat production. However, the leather industry has commonly been regarded as a polluting industry due to the bad smell, organic and inorganic wastes and high-water consumption caused during traditional manufacturing processes.

Leather is animal skin that has been chemically modified to produce a strong, flexible material that resists decay. Almost all the world output of leather is produced from cattle hides and calfskins, goatskins and kidskins, and sheepskins and lambskins. Other hides and skins used include those of the horse, pig, kangaroo, deer, reptile, seal, and walrus.

The leather can generally be processed in three steps. The first step is removal of the unwanted components, hair, adipose tissue, fats, etc., leaving a network of fibers of hide protein. The second step involves reacting of this network with tanning materials to produce a stabilized fiber structure. The third step is to build onto the tanned fibers characteristics of fullness, color, softness and lubrication and finish the fibers surface to produce a useful product. The transformation of hide or skin into leather utilizes many chemical and mechanical processes.

Leather is a natural product which decomposes over time due to the bacterial or fungal activity. Bacteria exist everywhere in our environment. These microorganisms quickly colonize on surface, as well as the internal part of freshly flayed hides and skins putrefying it with time. Hence, after flaying of slaughtered animal, the hide or skin has to be treated by salt in order to stop bacterial action. Although there are different curing methods, the wet salted method is the best preferable one. This dehydrates the hide and create unfavorable environment for bacterial activities. Wet salted hide or skin accelerates rehydration of the skin during soaking process. Once reached the tannery, the raw material should be stored in best aerated store house and has to be preserved accordingly. To start soaking process, it is trimmed, counted and weighed.

The salt curing method followed for the preservation of skin/hide, sodium chloride used up to 40-50%. The soaking process contributes to more than 40% of the total dissolved solids (TDS) load that is generated in the entire process of leather manufacturing and chlorides (about 55 percent) in the composite tannery effluent. There is still no technology available for treating the effluent containing such high concentration of neutral salts. So, the additional investment is needed for the removal of TDS and chloride in the waste water

In this research study the development of alternative curing method will be experimented based on plant material available in Ethiopia for the purpose of raw hide and skin preservation, so as to find an effective way to decrease large quantities of wastes generated specially in soaking operation.

Grawa (Amharic), Veronia amygdalina (scientific name) is a very common shrub or small tree, sometimes attaining a height of 10 m. Shrubs usually grow in overgrazed areas or forest edges and in secondary scrub, in altitudes between 1700 and 3000m. Veronia amygdalina is very conspicuous when in full bloom and is sweet-scented. It is often popular with bees when it is in bloom and is one of the fastest growing shrubs under cultivation, it reseeds itself and transplants easily.

The Gesho plant (R. prinoides), which is different from hop is widely cultivated in Ethiopia and is available dried in the local market. Leaves and stems are good sources of a healthy diet; and they are not exposure routes to some metal contaminations under the current existing situation. The leaves and stems of this plant are used to impart the characteristic bitter flavor to domestically brewed beverages known as 'Tella' and 'Tej' and it is estimated that well over 5 million people consume these beverages daily.

Endod (Amharic), Phytolacca dodecandra is a relatively common plant throughout Ethiopia, especially in the semi-highland regions. The root is used in the treatment of excessive pelegra (kuruba). The decoction of the root (1 in. long) is used in the treatment of genorrhea. The harvested, dried and ground fruit makes a good detergent as it probably contains saponins.

II. MATERIALS AND METHODS

A. *Materials*

Gesho, Grawa, Endod, sheep skins, the leather chemicals used for processing were of commercial grade, Beakers, Standard Measuring Flask., shrinkage temperature measurement apparatus, Cutter, testing drums, fleshing machine, shaving machine, Sam-setting machine, vacuum dryer, staking machine and roto-press machine, Tensile strength, tear strength,

B. *Methods*

Sample Collection

In order to investigate the potential of grawa, gesho and endod for raw hide and skin preservation, freshly flayed skins of average mass 1 kg per skin were procured from a nearby local market kality, Addis Ababa, Ethiopia. The leaves of the plants used for this study except gesho were collected from Addis Ababa University (Main campus), Ethiopia. The gesho leave was collected at Megenagna, Addis Ababa. The leaves were carefully washed with tap water. And the juice of the leaves which used for preservation experiments was extracted using juicer. Commercial sodium chloride was used for the preservation experiments and commercial auxiliaries were used for pre-tanning and post tanning processes to make crust leathers.

Characterization of extract

pH

From the leaves of each plants the juices for the preservative treatment was extracted. After extraction the PH of the juice was measured using pH meter.

Smell and Color

The Extracted juice was stored for two months without any additional chemicals. And initially the color of the juice was green. The color and smell of the juice was assessed periodically for two months

Experimental structure and application system

We also bought 1 fresh skin and we prepared 11 pieces of samples then we applied the juice alone and in combination on 9 samples. And we left one sample (sample 11) as it was (without applying any treatment) and 1 control (sample treated with conventional NaCl). The code & percentage applied is presented below. The effect of the juices on fresh skin was assessed for 30 days.

1. Endod "A"
2. Gesho "B"
3. Grawa "C"

Table1. Experimental structure and application system

Experimental code	Preservation materials	Percent(w/w)
1	B & C	20% (10% each)
2	A & C	20% (10% each)
3	A & B	20% (10% each)
4	A, B &C	30% (10% each)
5	B	20% (10% each)
6	C	20% (10% each)
7	A	20% (10% each)
8	A & Salt	20% (10% each)
9	B & Salt	20% (10% each)
10	Salt(control)	35%
11	Nothing is added	-----

Characterization of leathers

Organoleptic properties are subjective and it's used to know whether the leather property is fitted to its purpose or not. Our leather is processed for shoe upper purpose.

So, organoleptic properties were assessed by three leather expertise, who is working at Leather Industry Development Institute (LIDI) as senior researchers. And overall appearance rated as on a scale of 0–10 points, higher values indicate better property. The testes done were Fullness, Softness, Color uniformity, Roundness and general appearance.

Tensile Strength

Strength properties of leather are very important characteristics for leather as the leather products have to meet force, stress and strain throughout the life of the product. We have done Tensile and Tear strength to check the strength of our product.

The sampling protocols for physical testing were carried out as specified in the official sampling method (International Union for Physical Testing). For all physical strength experiments, samples were conditioned at 20 ± 2 °C and 65 ± 2% relative humidity for 48 h prior to testing. The properties such as tensile strength, percentage elongation at break and tear strength were measured. Ten samples were tested.

Shrinkage Temperature

After 30 day of preservation period, both the control and experimental sheep skin samples were processed up to tanning and their shrinkage temperature is tasted. The results are given on the table below.

Scanning Electron Microscope Analysis

The cross sections of the corresponding control and experimental crust leathers were studied by using a Scanning Electron Microscope in order to analyze the effect of the applied preservatives on the fiber structure of the leather. Samples for SEM analysis were prepared by cutting from the official butt portion.

Pollution Load Measurement (TDS)

The spent liquor from the experimental and control soaking process was collected and analyzed for Total Dissolved Solids (TDS). The results of TDS determination are expressed in terms of mg per liter. All the experiments were analyzed in triplicates.

III. RESULTS AND DISCUSSION

A. Characterization of extract

pH

From the leaves of each plant the juice for the preservative treatment was extracted. After extraction the PH of the juice was measured and the PH for each juice is shown below in the table.

Table2. pH of the juice

Sample	PH
Endod	8
Gesho	7.2
Grawa	7.8

Smell and Odor

The extract was stored for two months without any additional chemicals. and we observed the following changes.

Initially the color of the juice was green.

There was no color as well as odor change for the first 15 days in both samples. But after 20 days the color of endod started to change. After a month both the color of endod and grawa juice changed, and the bad smell of endod was observed.

Finally, we left the juice for additional 30 days then the following changes are observed.

-The first sample which is Endod have bad smell and change of colour is observed.

-The second sample Gesho on the other hand there was no change of smell and colour.

-The third sample Grawa does not have any bad smell but there was color change

Effectiveness of preservation method

The preservation efficacy of the experimental and control sheep skins have been assessed at different time intervals for 30 days. Experimental preservation system with their respective control was assessed for visual evaluation.

Skin degradation evaluation and standardization

The putrefaction of skin is initiated through the production of proteolytic enzymes by bacteria. Hair follicles on the skin and hide are fairly appropriate structures for many species of bacteria to easily colonize. Hence, hair slip is the first indication of putrefaction as the protein present in the bulb of the hair is degraded by the bacteria during the commencement of putrefaction. During putrefaction process, there is a breakdown of the protein to amino acid and further break down to ammonia (Covington, 2009). This implies that a smell of ammonia is also one of the signs when bacteria begin to attack the proteins of the hides/skins. Therefore, in this study, physical evaluations such as hair slip and putrefaction odor were taken as two of the measurements for assessing the efficacy of the preservation method.

Fig.1. Raw skin preserved by the juices

Day 1:

1	**2**
No putrefaction	no putrefaction
No hair slip	no hair slip
3	**4**
No putrefaction	no putrefaction
No hair slip	no hair slip
5	**6**
No putrefaction	no putrefaction
No hair slip	no hair slip
7	**8**
No putrefaction	no putrefaction
No hair slip	no hair slip
9	**10**
No putrefaction	no putrefaction
No hair slip	no hair slip
11	
Putrefaction	
No hair slip	
Parasites	

Day 3

1	**2**
No putrefaction	no putrefaction
No hair slip	no hair slip
3	**4**
No putrefaction	no putrefaction

No hair slip	no hair slip
5	**6**
No putrefaction	no putrefaction
No hair slip	no hair slip
7	**8**
No putrefaction	no putrefaction
No hair slip	no hair slip
9	**10**
No putrefaction	no putrefaction
No hair slip	no hair slip

11

Putrefaction

Bad smell

No hair slip

The Parasites were increased

Day 5

1	**2**
No putrefaction	there was little putrefaction
No hair slip	little hair slip
3	**4**
No putrefaction	no putrefaction
No hair slip	no hair slip
5	**6**
No putrefaction	no putrefaction
No hair slip	no hair slip
7	**8**
No putrefaction	no putrefaction
No hair slip	no hair slip
9	**10**
No putrefaction	no putrefaction
No hair slip	no hair slip

11

Putrefaction

Bad smell

There was hair slip

Parasites

Day 10

1	**2**
No putrefaction	there was little putrefaction
No hair slip	little hair slip
3	**4**
No putrefaction	no putrefaction
No hair slip	no hair slip
5	**6**
No putrefaction	little putrefaction
No hair slip	little hair slip
7	**8**
No putrefaction	no putrefaction
No hair slip	no hair slip
9	**10**
No putrefaction	no putrefaction
No hair slip	no hair slip

11

Putrefied

Day 20

1	**2**
No putrefaction	putrefied
No hair slip	
3	**4**
No putrefaction	no putrefaction
No hair slip	no hair slip
5	**6**
No putrefaction	putrefied
No hair slip	
7	**8**
No putrefaction	little putrefaction
No hair slip	little hair slip
9	**10**
No putrefaction	no putrefaction
No hair slip	no hair slip

11

Putrefied

Day 30

1
No putrefaction
No hair slip

2
putrefied

3
No putrefaction
No hair slip

4
no putrefaction
no hair slip

5
No putrefaction
No hair slip

6
putrefied

7
No putrefaction
No hair slip

8
putrefied

9
No putrefaction
No hair slip

10
no putrefaction
no hair slip

11
Putrefied

Structural stabilization of the skin matrix

Natural plant materials can cause interactions in the collagen matrix that can bring changes in the thermal properties of the preserved skins. It can stabilize or destabilize the skin proteins depending on the type of interactions involved. Putrefaction leads to destabilization of collagen. The hydrothermal stability of skin is determined through shrinkage temperature measurements The shrinkage temperature is the measurement of the breakdown of stabilizing linkages and the bases for the type of interactions existing in the collagen matrix. In this study, the shrinkage temperature values of the experimental and corresponding control samples are given below. The results revealed that the shrinkage temperature of the experimental skin shows only a marginal difference (1–5 °C) in comparison to the corresponding control skin samples. From the results, thus, it can be concluded that the newly developed plant based preservative materials do not alter the stability of the collagen matrix of the skin protein.

Table3. Shrinkage temperature

Sample	Ts value 0C
1	96
2	95
3	98
4	92
5	101
6	97
7	93
8	100
9	103
10	105

Physical strength and organoleptic characteristics

The organoleptic properties and physical strength characteristics for the matched pairs of control and experimental upper crust leathers are depicted below. The results of the hand and visual assessments indicate that properties such as fullness, softness, grain tightness, smoothness and the general appearances of the experimental crust leathers are comparable to that of the corresponding control leathers. The results tabulated in shows that the physical strength of leathers processed from the experimental skins treated with our product had strength properties viz., elongation at break, tensile strength and tear strength is comparable with that of the corresponding control samples. The physical strength results indicate that effective preservation can be achieved at a minimum percentage offer of 20% Gesho juice alone and 10% gesho with 10% NaCl without affecting the quality of the final leathers and also no difficulty was observed during leather manufacture with the skins preserved with this plant-based salt less and less-salt approach.

Scanning Electron Microscope (SEM) Analysis

Scanning electron micrographs of the experimental and corresponding control upper leathers for the cross section are depicted below. The cross section of the samples were analyzed at a magnification of 250×

and the scan shows that the fiber structure of the experimental samples seem to be comparable to that of the corresponding control samples.

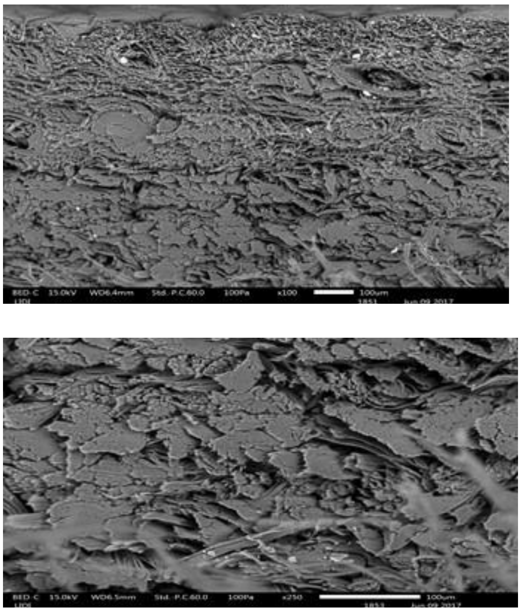


Fig 2. SEM analysis of Sample 1

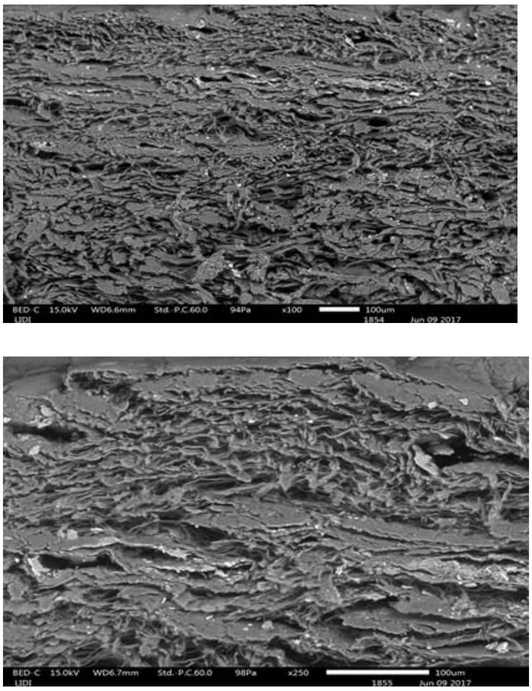


Fig.3. SEM of Sample 3

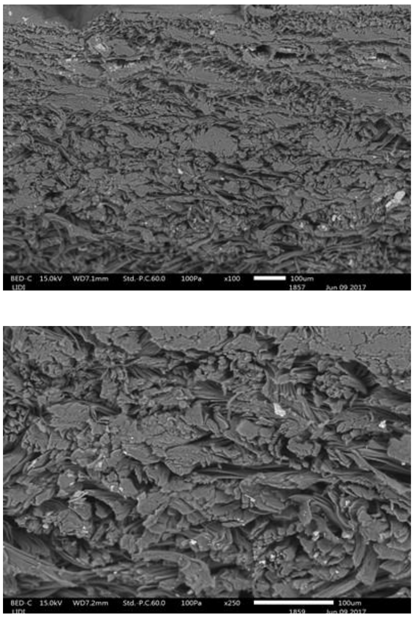


Fig. 4. Figure Sample 4

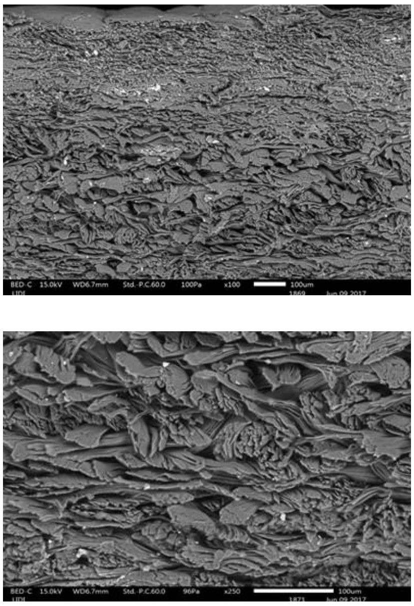
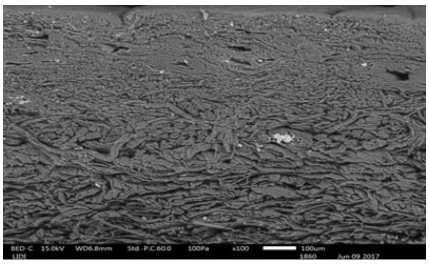


Fig. 5. Figure of Sample 5



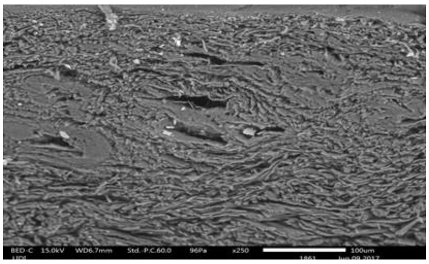
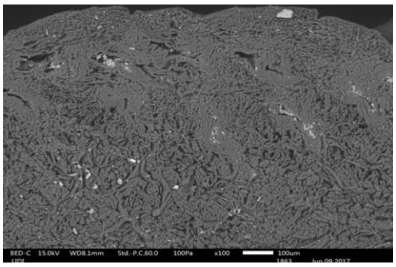


Fig. 6. Figure of Sample 7



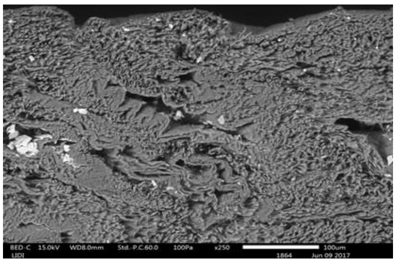
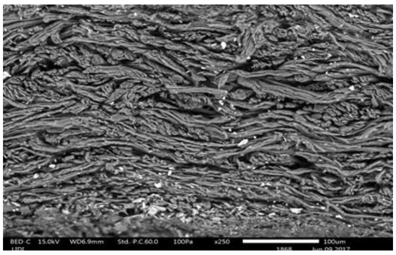


Fig.7 SEM of Sample 9



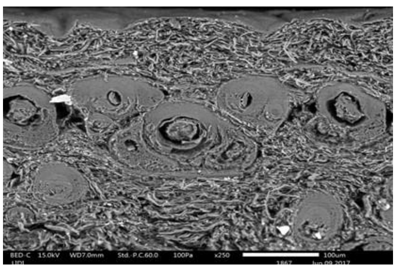


Fig 8. SEM of Sample 10

Total Dissolved Solids (TDS)

After 30 days of preservation, experimental and control skins used for pilot scale trial, were subjected to soaking operation using conventional processes. The table below shows the amount of the pollution load viz. TDS generated in the soaking process of the optimized experimental and the corresponding control samples. From Table 6, it is clearly observed that TDS from the soak liquor of plant-based preservation is reduced due to the replacement of the conventional salt curing methods by salt less and less-salt preservation approaches based on 20% gesho alone and 10% gesho juice with 10% NaCl. The results demonstrate that the developed gesho based salt less and less-salt preservation method can be considered as one of the cleaner production approaches to reduce salinity in tannery wastewater. The process scheme of application of the developed preservation method does not require any sophisticated new skills or additional facility. The availability of gesho within Ethiopia is widespread and hence the introduction of new preservation method will not be expected to incur more cost than salt-based preservation and can be translatable to industrial scale production of leathers.

Selected Preservatives and Optimal Percentages

From the 10 experiments, two trials provided a good result

Different percentage formulations of the three plants juice were applied to optimize the amount required to preserve the sheep skins. The preservation efficacy and leather properties of the skins preserved by 20% Gesho and 10% offer of Gesho along with a fixed amount of 10% NaCl showed analogous trend to the corresponding conventional salting method of preservation. Hence, a minimum 10% offer of Gesho juice is taken as an optimized value for pilot scale trials.

Table 4. Organoleptic properties

Sample	Fullness	Softness	Color uniformity	Roundness	General appearance
1	8	8	8.5	8	8.5
2	7	9	7.5	7.5	8
3	8	7.5	8	8	8
4	7.5	8	8.5	7	8
5	9	8.5	9	9	9
6	8	9	8.5	7.5	8.5
7	8	8	8	7.5	8.5
8	7.5	8	7.5	8	7.5
9	8.5	9	9	9	9
10	8	7	6.5	7.5	7

Table 4. Organoleptic properties

S/No	Type of Sample	Tensile strength (N/mm^2)	Elongation at break [%]	Tear Load
1	Sheep Leather	12.4	71.6	28.0
2	Sheep Leather	14.8	75.5	26.3
3	Sheep Leather	12.4	79.9	26.0
4	Sheep Leather	14.5	62.0	23.1
5	Sheep Leather	15.1	87.0	24.2
6	Sheep Leather	10.0	70.9	23.7
7	Sheep Leather	14.7	85.6	27.7
8	Sheep Leather	11.3	73.3	22.8
9	Sheep Leather	14.8	86.3	21.9
10	Sheep Leather	12.1	90.9	21.5

Table 5 TDS value of soak liquors

Samples	TDS value g/l
1	7.83
2	6.23
3	7.69
4	6.69
5	4.51
6	7.3
7	7.36
8	6.91
9	5.1
10	13.2

IV. CONCLUSION AND RECOMMENDATIONS

Conclusion

The new salt less and less-salt curing system based on Gesho plant material formulation could be a cleaner preservation option to the conventional salt curing methods. The results of the investigation show that the juice from the leave parts of Gesho could advantageously be used as a material for the preservation of skins. 20% Gesho alone and formulation of 10% Gesho along with 10% NaCl could be able to preserve the skins for a period of 30 days and more. The reduction of salinity is the main concern for tanners worldwide. Thus, this plant-based salt less and less-salt preservation method reduces the major pollution load i.e. TDS. Hence, the developed plant-based preservation system seems to be a viable alternative option for the conventional salt-based preservation method.

Recommendation

Based on the results and conclusions of this study, the following recommendations are formulated

- As indicated from the organoleptic properties and physical measurements results it should be clear that skins and hides can be preserved by the combination of gesho juice and salt but it needs careful control of parameters
- Substitution of conventional preservation agent by gesho juice and salt combination is one option by which we can minimize TDS and Chloride generated from beamhouse effluent. Other alternatives (particularly plant based) can be researched as a partial or whole substitute for salt that could efficiently preserve the skins and hides and eliminate the chloride and TDS discharge from beamhouse effluent specialy soaking operation.
- This product may have good application for other industries like food processing, beverage processing….

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Development and Characterization of Bamboo yarn Knitted Wound care dressing coated with Aloe Vera Rind Nanoparticle and Enhanced with rhEGF

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Abstract

The demands for natural based wound healing dressing are more in need during these days. There is also a room to improve upon currently on the market as it is either lacks the degradation and/or slow in healing practice. In this research work bamboo yarn have been used to produce single jersey knitted fabric with three variable stitch length. Next the bulk sized aloe Vera is converted to nano size by mechanical grinding method. Then the developed knitted samples are coated with nano sized aloe Vera. After coating the developed samples are loaded with drug (Epidermal Growth Factor). Scanning electronic microscope (SEM) was used to observe the morphology of developed wound dressing for process versatility and the highly specific surface area. Knitted samples loaded with rhEGF were applied over the wound surface and the wound closure was studied in equal interval of days. The formation of zone of inhibition in antibacterial test and wound closure rate in In Vivo evaluation reveals that a specified composition of natural extracts of aloe vera enhanced with rhEGF reveals that coated fabric samples exhibits good antibacterial property and higher rate of wound healing nature. Hence therefore these coated fabrics can be suitable for faster wound healing process. It offers a very attractive opportunity for producing a variety of medical products with great potential for bio medical end uses due to its superior biocompatibility.

Keywords- **Bamboo, knitted fabric, aloe vera, rhEGF, wound dressing**

I. Introduction

With growth of industrialization and usage, there has been a rapid growth in different pathogens. Humans have become a prime victim of these pathogens causing several malignant wound in them [1-3]. To cope with this situation, there has been a growing concern among consumers for clean and hygienic products for wound healing [4]. As textiles are one of the most important commodity products in daily life which are also prone to base material to be used as barrier with bacterial attack[5]. Nano aloe vora can be incorporated by the agent treated on the textiles during a finishing process i.e. surface treatment of the fabric. A lot of research works [6-9] have been carried out on aloe vora finishing of textile [10]. Thus there has been a growing tendency to produce bamboo fibres in wound healing but it still at the initial stage [5]. Bamboo fibers are enhancing the antibacterial property [3].

Aloe vera has been used for many centuries for its curative and therapeutic properties and although over 75 active ingredients from the inner gel have been identified, therapeutic effects have not been correlated well with each individual component [11].

Aloe vera has been used for traditional medicine for a long time. It is consider as one of the most recognizable herbs in the world and the medicinal part is the succulent leaves. Dry Aloe gel, leaf juice, fresh or leaf gel, obtained by breaking or slicing a leaf, are principally used in natural medicine. A topical skin gel provides wonderful healing support for the skin [12 -13]. Aloe vera contains many important nutrients for the body, such as amino acids, B vitamins, and other nutrients that support general health [14]. It also has pharmacological properties including wound healing, antioxidant, antibacterial, antifungal, and immunomodulating effects. Although burn wound healing is one of major indications of aloe vera gel use in several animal and clinical studies, few studies have compared the efficacy of this gel with SSD in the treatment of wound [12].

In this study, single jersey knitted fabric was produced using and coated with different proportions of aloe vera along. The ability of the antimicrobial and *in vivo* evaluation was also studied.

II. METHODOLOGY

A. Fabric preparation

Knitted fabric was produced with half and full needle mechanism by using 26/1 Ne and 30/1 Ne 100% bamboo yarn. For this purpose a knitting machine was used which has 4.5 inch diameter with 64 needles capacity. 2.5 gauge is considered for knitting of fabrics.

The fabric were observed under a PROJECTINAD MM 2000 digital microscope and the images obtained are shown in (Figure 1).

B. Scouring bleaching and sterilization

Scouring bleaching and sterilization The knitted fabrics were scoured for removing natural impurities using 3 g/L Na_2CO_3, 5 g/L NaOH, 2 g/L detergent in presence of 1 g/L wetting agent and 1 g/L sequestering agent at 90° C for 60 minutes with 1:20 MLR (material liquid ratio). The bleaching process was carried out by 5 g/L H_2O_2 , 0.5 g/L Stabilizer and 3 g/L Na_2CO_3 with 1:20 MLR at 90° C for 60 minutes. After that the sterilization process was carried out at 134°C and 15 atmospheric pressure for 20 minutes.

TABLE 1.

SAMPLE PREPARATION FOR THE STUDY

Sample Code	Aloe Vera (w/v)	EGF (mg)
KA 30	30	10
KA 50	50	10
Ka 75	75	10

C. Method of Coating

The knitted fabric that is to be coated is pre treated in an alkaline medium (NaOH) at 120° C for 10 minutes. Using Aloe vera nano particle was applied onto knitted fabric using pad-drycure method with drying in room temperature and then curing at 120°C for about 2 minutes.

D. Incorporation of rhEGF on the coated fabric

Incorporation of rhEGF on the coated fabric The predetermined EGF (Table 1) was dissolved in 100 ml of distilled water and constant stirring was carried out for 10 mins. Then the developed fabrics were coated with rhEGF as described in Table 1.

E. Antibacterial Test

Antibacterial efficacy was assessed using AATCC 147 standards. The coated fabric samples were tested for antibacterial activity against Gram-negative (Escherichia coli) and a Gram-positive bacteria (Staphylococcus aureus). The line of incubation of antimicrobial agent was shown by the presence of growth inhibition zones measured by using MullerHinton (HiMedia).

F. Scanning Electron Microscopy

Surface Morphology and cross – section of the coated samples were studied by scanning electron microscope (SEM, JEOL, JSEM-6390LV, Japan).

G. Wound Creation

Male Wistar Albino rats were used for the study. Animals weighing about 200 ± 50 g were selected for the animal models. All animal procedures were according to guidelines of the Committee for the Purpose of Control and Supervision of Experiments on Animals and Institutional Animal Ethics Committee (IAEC). Hair – removal cream was used to shave the skin of the animal and cleaned with ethanol (98 % concentration). A full – thickness wound was created and size of the wound was approximately 2.45 cm long and 1 cm wide. Wounds were created in group 1 and no treatment was done on it. For group 2 rats wounds were created and treated with the commercially available drug Povidone-Iodine (PVP-I) for every two days. In group 3, wounds were created and treated with control group (coated fabric) for every 3 days. In the remaining 3 groups wounds were created and treated every 3 days with the developed wound dressing samples.

III. RESULTS AND DISCUSSION

Two gauge knitted bamboo fabric was produced by changing coating nature of aloe vera.

A. Morphological study of the coated fabrics

The morphology of the coated fabric samples were studied using SEM. The images shown in Figure 1. The extent of penetration of extract coated on the fabric reveals that the different extracts prepared coated were penetrated interior into the fabric which plays a major role in wound healing property of the developed wound dressing material.

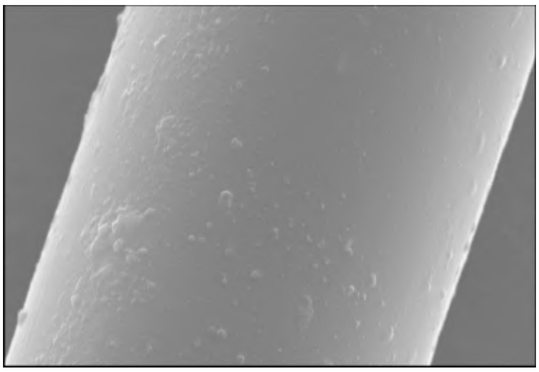

Fig.1. SEM micrograph of the coated Bamboo fabric

A. Antibacterial Test

The developed knitted fabric was subjected to test antimicrobial efficacy against Escherichia coli and Staphylococcus aureus through agar diffusion test method. The samples were grouped in the way that group 1 was untreated fabric, group 2 was fabric treated with the commercially available drug Povidone-Iodine (PVP-I) (Control Group) and group 3, 4 and 5 (already named as KA 30, KA 50 and KA 75 respectively) were fabrics coated with the ratio mentioned in Table 1.

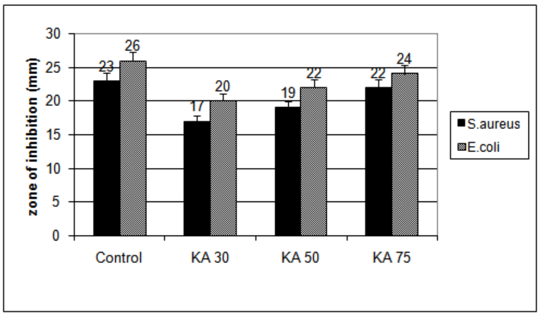

Fig. 2. Antimicrobial Activity

The comparative analysis of the test results of antibacterial activity is shown in the Fig. 2. The zone of inhibition is high against *Escherichia coli* and *Staphylococcus aureus* in the sample KA 75 which is about 24 mm and 22 mm after 24 h of inhibition. From the results it is observed that as content of aloe vera and rhEGF increases, the zone of inhibition also increases. The result also gives way to understand that the aloe vera coated and rhEGF enhanced fabrics can be used as a wound dressing with antibacterial properties.

A. Wound closure in rats

In open wound-healing tests, full-thickness wound was made on the back of each rat. Fig. 3. & Fig. 4. shows representative animals from each group (wound without treatment, commercial product, KA 30, KA 50 and KA 75) on 2nd, 5th, 7th, 10th, and 15th days after grafting. Among these dressings, the wound area treated by KA 75 seemed to be smaller than other samples at different days after inflicting wound.

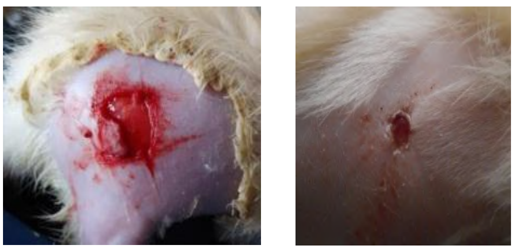

Fig.3. Sample wound size reduction

Fig.4. depicts the wound closure rates of wounds treated with that aloe vera. Fig. 3. shows the wound contraction after 0, 2^{nd}, 5^{th}, 7^{th}, 10^{th}, and 15^{th} day, a significant increase in the rate of wound closure in the KA 75 when compared to the commercial product. Compared with other groups, the wound treated with KA 75 exhibited fastest wound closure.

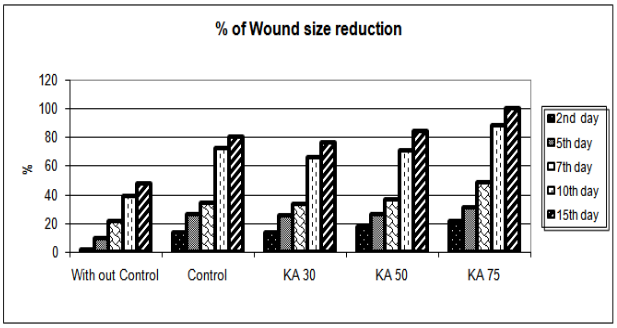

Fig. 4. Percentage of wound size reduction.

IV. CONCLUSIONS

In this research, aloe vera coated bamboo knitted fabric show excellent antibacterial properties. The knitted fabrics prepared with 75% proportion of nano aloe vera impregnated bamboo fabric exhibit bacterial colony reduction of 90% or more. The proportion of bamboo coated aloe vera is the most dominant factor influencing the antibacterial properties of knitted fabrics. This research investigated the effect of bamboo coated aloe vera fabric on the wound-healing process by using rats. The feasibility of prepared bamboo coated aloe vera and its controlled rate of drug release is investigated and the results are shown in in vivo models using Wistar Albino rats. The results establish that the bamboo coated aloe vera can promote the healing process and recovery of deep type of wound in rats. The application of this bamboo coated aloe vera would be advantageous in the context of tissue engineering, especially on wound. This work serves as a foundation for future long-term research on bamboo coated aloe vera as tissue engineering-based wound dressing and it was also found that the bamboo coated aloe vera dressing had a synergitic effect in accelerating wound closure with improved quality of healed skin.

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Study on Availability of Wool Fiber in Ethiopia

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Abstract

The present study is about Ethiopian sheep population, wool fiber potential, sheep growing techniques, the purpose of sheep growing, potential areas, current situation of wool fiber, wool fiber handling effect (on economy, social health and environmental issues), physical properties of wool fiber and future opportunities of Ethiopian wool fiber. As per the investigation it is found that there are more than thirty million sheep population with more than 20 breeds of indigenous, exotic and crossbreed. Ethiopian sheep wool fiber is characterized for its physical properties (fineness, length, strength, crimp and yield), graded for classification and its application is identified. In this regard the sheep breeds at the milk teeth and even teeth removed age groups from the four main body parts (sides, neck, back and belly) provide super fine to very coarse wool type because the fiber in American grading system is fine, ½ Blood, 3/8Blood, ¼ Blood, Low ¼ Blood and Braid. As a result of property study, the wool fiber from the Ethiopian sheep breeds can be processed to produce underwear, shirts, suits, socks, rugs, carpets, blankets, outer wears, knit wear, knitting yarns, weaving yarns, quilt filling, furnishing and technical textiles.

Keywords: **Ethiopian sheep breeds, sheep population, sheep growing areas, wool fiber properties**

I. Introduction

Ethiopia possesses 30,612,976 sheep population composed of 27.82 % ram and 72.18 % ewe indigenous with quite number of ewe hybrid and exotic sheep broad categories (CSA-2017, 2017). There are more than fourteen local sheep breeds (see Figure 1) with few exotic as Awasi, Dorper and Corriedale (see Figure 2) and hybrid breeds.

Figure 1: Some of the indigenous sheep breeds in Ethiopia

Figure 2: Exotic sheep breeds (Corriedale, Awasi, Dorper-from left to right)

Menz sheep are adapted to the rugged climate of the region (Figure 3) and can thrive on poor quality roughages (Gebisa, Banerjee, & Taye, 2017).

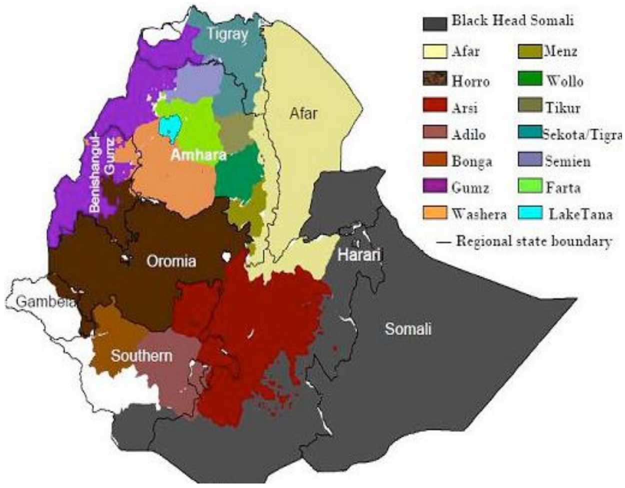

Figure 3: Geographical distribution of Ethiopian indigenous sheep

The physical properties of wool fiber such as fineness, staple length, strength, crimp and trash have been used to set market price and select appropriate raw material by textile industries for their products (Holman & Malau-Adul, 2012).

The fiber diameter, strength, crimp frequency and staple length are the most important characteristics (A.F. & L., 2010; Ansari-Renani, 2012; Cottle, 2010; D.P. & S.R., 2010; Gillespie & Flanders, 2010). Fiber fineness considered as a major factor in determining the value of wool (Getu, Kefale, & Arega, 2015).

The differences between younger and older sheep wool properties reported as the result of a positive relationship between diameter of wool fiber and age of the animal (M., I., R., E., & L., 2008). The influence of year of shearing, breed and sex of the lamb were non-significant sources of variation for fiber diameter (A., Khan, Shafique, Sabir, & Ahmed, 2013). The breed and age of sheep had significant effect on fiber diameter r(Gouri, Lateef, Mustafa, Muhammad, & Bashir, 2014). On the basis of their wool characteristics sheep breeds can be classified into fine, medium, long, and carpet (coarse) or mixed wool breeds. The diameter range of fibers in the carpet wools is between 11-90µm (Eyduran et al., 2016; Gouri et al., 2014; Jafari & Hashemi, 2014; Li Q., Brady P.R., Hurren C.J., & Wang X.G., 2011; Mahgoub et al., 2010; Tester, 2010). Wool samples showed coefficients of variation of 29% and 36% (Morton & Hearle, 2008). Researchers reported that the highly negative correlations between fleece traits and post-weaning live body weight provide a warning of potential problems associated with selecting only one group of traits. Further studies should focus on wool characteristics, in particular wool quality parameters and their correlations with body weight and other traits (Jafari & Hashemi, 2014). Menz, Wollo, Farta and Tikur sheep breeds are the main woolly sheep breed in the highlands of Ethiopia. Many scholars have been focused on meat production of sheep. Limited works have been done in Ethiopia to address the wool fiber physical properties mainly the fineness, crimp and strength of wool fiber of Ethiopian indigenous sheep breeds.

In this study handling, current status, fiber yield per shear (annum) and physical properties of the Ethiopian sheep (both ewe and ram) wool fiber explored. Moreover, the properties of wool samples taken from four main body parts (side, neck, back and belly) of each sheep breed clustered on four age groups on basis of Milk teeth and number of even teeth removed (see Figure 4 and Figure 5) have been investigated.

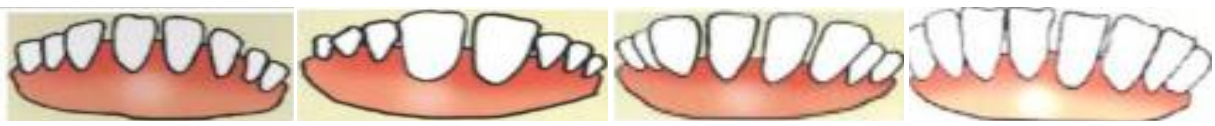

Figure 4: Ages (milk teeth, two teeth, four teeth and six teeth removed from left to right) of sampled sheep

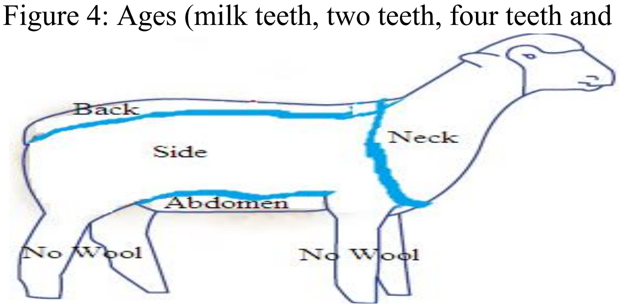

Figure 5: Distinct body parts of sheep for sampling

II. Material and Experiments

Materials

Ethiopian indigenous sheep breed (mainly Menz, Wollo, Farta and Tikur), exotic (Awasi, Dorper, Corrediale) and crossbreed (75%Awasi, 50%Awasi, Awasi/Washera, 50%Dorper) sheep breeds were considered for the study. The 50%Dorper sheep breed is found by cross breeding of South African originated Dorper and Ethiopian origin Menz sheep with breeding ratio of 50%Dorper and 50%Menz in 50%Dorper crossbreed sheep. The 75%Awasi found from 25%Menz and 75%Awasi (Israeli), 50%Awasi found by crossbreeding of 50%Menz and 50%Awasi (Israeli) and Awasi/Washera is found from 50%Awasi(Israeli) and 50%Washera (Ethiopian indigenous) sheep breeds. In this research, the Corrediale and Wollo sheep have no wool fiber (to shear) in their belly. The samples are collected from the sheep farm of Debre Birhan Agricultural Research Center and farmers, North Shewa (09^{0}35'45" to 09^{0}36'45" N latitude and 39^{0}29'40" to 39^{0}31'30" E longitude, Amhara), South Wollo (10^{0}54'49.644"N latitude and 039^{0}12'47.574"E longitude), North Wollo (11^{0}4617.927"N latitude and 038^{0}4423.622"E longitude), Awi Zone (11°65'54.785"N latitude and 036°42'55.181"E longitude), South Gondar (11^{0}51'42.958"N latitude and 037^{0}59'50.181"E longitude) and North Shewa in Oromiya region (10^{0}54'49.644"N latitude and 039^{0}12'47.574"E longitude).

Experiments

Samples have taken from four body parts at four defined ages of each sheep breeds. All samples have been conditioned for 24 hours at 21°C temperature and 66% relative humidity. The wool fiber fineness, crimp, length, strength and yield of these breeds have been investigated. The fiber diameter tests are done as directed in ASTM D2130-01 (ASTM-D2130, 2001; ASTM-D3991, 2000; ASTM-D3992, 2000) using MESDAN VIDEO ANALYZER with LEICA DM500 microscope with eyepiece 13613240PLAN 4X/0.10 ∞/- magnification size. The measurement unit used for fiber diameter in this study is micrometer (µm). The crimp frequency (number of crimps per inch) of wool fiber is measured using crimp gauge which has ruler and magnification glass. The length is measured using ruler and by lying the bundle of fibers on the table. The fiber strength is measured as a value of fiber tenacity using FAVI MAT+ single end strength tester as per ASTM D-3822 (ASTM-D3822, 2007).

III. Result and Discussion

Wool fiber handling

Currently the sheep growing is by farmer, research centers, multiplication centers and some investors for meat and skin application. The wool fiber handling is poor, in general. In some areas like North Shewa the wool fiber is used for local carpet, hat and wears in the cold season called Zitet and Caba for Woe (see Fig. 6a). But, in most areas of Ethiopia (example: North and South Wollo, South Gonder, North Shewa) the wool fiber is lost in the field after shearing to cure the sheep from parasites and make fatty (Fig. 6b). The sheep develops the habit of eating the hair of own and other sheep in the drought season and in case of shortage of food (Fig. 6c). In some areas, the hair of the sheep is removed from the skin of the sheep itself as dead because of absence of scheduled shearing (Fig. 6c).

Fig. 6a: Some of the wool fiber used for local carpet, hat

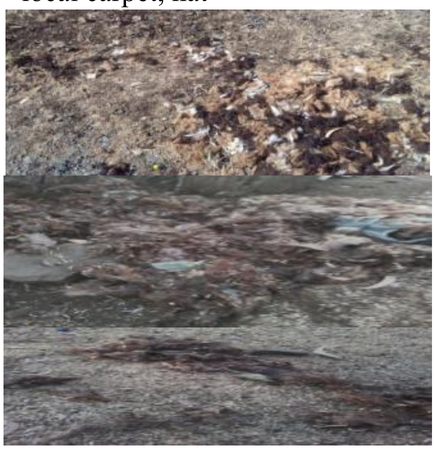

Fig. 6b: In most areas of Ethiopia, wool fiber lost in the field

Fig. 6c: In case of shortage of food, sheep develops the habit of eating their hair

Fig. 6d: Hair of the sheep is removed from the skin by itself as dead fiber because of absence of scheduled shearing

Physical Properties

FINENESS

The fineness of wool fiber is measured in micrometer (micron). The wool fiber fineness property is studied by considering different factors for comparison. These factors are wool sheep breeds, sheep age, body parts and sex (ewe-E and ram-R) of the sheep.

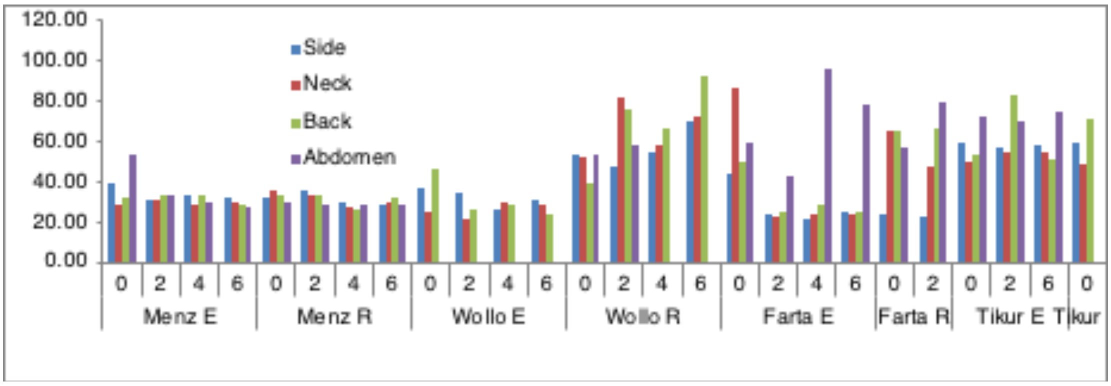

Figure 7: Fiber diameter of Ethiopian indigenous sheep breed

As shown in Figure 7, the fiber fineness of Ethiopian indigenous sheep breeds is different at different age groups and from different body parts. The Menz sheep wool fiber provides the wool fiber with the lowest fiber diameter as compared to other Ethiopian indigenous sheep breeds, on average. The fineness of indigenous sheep wool fiber is studied in two sexes as female (ewe) and male (ram). The Farta ewe sheep provides the wool fiber with the lowest fiber diameter while the Wollo ram sheep provide wool fiber with the highest fiber diameter as compared to other indigenous sheep breeds.

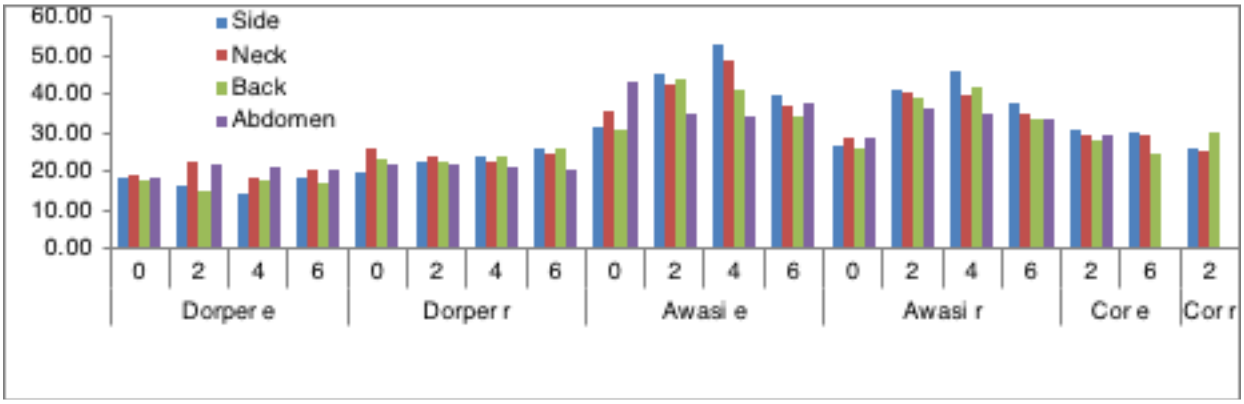

Figure 8: Fiber diameter of Ethiopian exotic sheep breed

As shown in Figure 8, the fiber diameter of female (e) and ram (r) pure Dorper sheep is lowest while Awasi sheep provides the wool fiber with the highest fiber diameter as compared to the wool fiber found from the other exotic sheep breeds, on average. The Milk teeth sheep provides wool fiber with the lowest fiber diameter on average as compared to the wool fibers found from the exotic sheep breed at two, four and six teeth removed age groups. The ewe Dorper sheep wool fiber has lower fiber diameter as compared to its ram sheep while the ram Awasi sheep provide wool fiber with lower fiber diameter as compared to its ewe sheep. The Corrediale sheep breed provide the medium fiber diameter (see Figure 8).

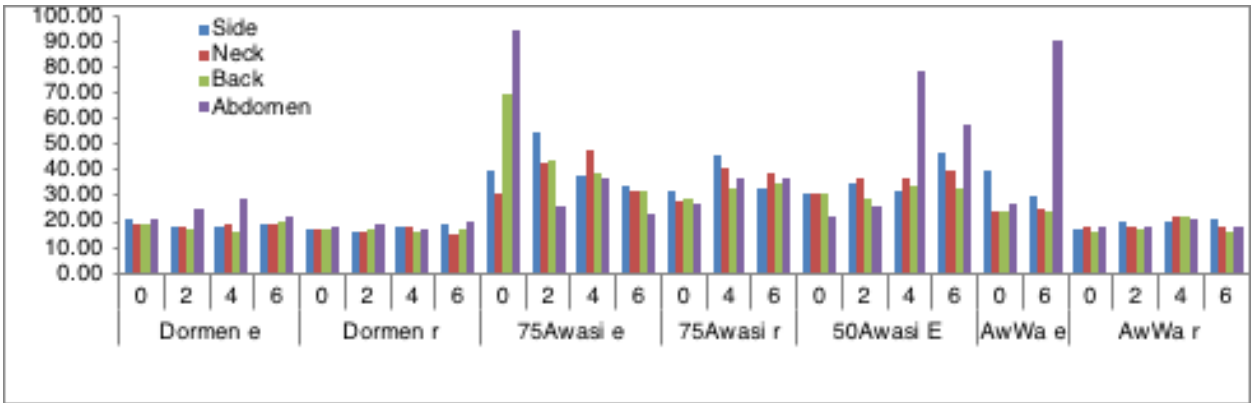

Figure 9: Fiber diameter of Ethiopian crossbreed sheep breed

The wool fiber from the crossbreeding of pure Menz and Pure Dorper at 50% ratio of breeding (Dormen) provides better fineness as compared to other crossbreeds. As shown in Figure 9, the 50%Dorper female and male sheep provide the wool fiber with the lowest fiber diameter as compared to the other crossbreed sheep. The male (r) sheep wool fiber is lower in fiber diameter as compared to female (ewe) cross breed sheep (see Figure 9).

WOOL FIBER GRADE

The Ethiopian sheep wool fiber grade is identified as per ASTM-D3991 for the sampled sheep breeds so that we can select its proper application to produce proper products. Generally, the sheep breeds at the four different ages from the four main body parts and two sex types is graded (categorized) from super fine to very coarse wool type because the fiber in American (Blood) grading system is Fine, 1/2Blood, 3/8Blood, 1/4Blood, Low 1/4Blood and Braid or in English (count) system Ethiopian sheep wool fiber is found between Finer than 80s and coarser than 36s. With this regard, the wool fiber from the Ethiopian sheep breeds can be processed to produce underwear, suits, shirts, fine yarns, technical textiles (medical cloths), socks, hats, rugs, carpets, blankets, outer wears, knit wear, weaving and knitting yarns, quilt filling, furnishing, and related textile products. So that investors can be attracted to Ethiopia for the abundant raw material for their factory. Similarly the government of Ethiopia can attract investors for processing wool fiber to produce the mentioned products. With this we can avoid disposal of the raw material because of textile factories are not available.

LENGTH

Ethiopian sheep Wool fiber length is measured in hand using ruler and table. The result showed that Ethiopian sheep wool fiber length ranges from 58mm to 180mm depending on breed type and body parts (sides, neck and back) of each breed. Ethiopian sheep wool fiber from an abdomen/belly of each sheep lies from 20-60mm in length. As per the requirement of the wool fiber length to process for textile applications, Ethiopian wool fiber is a perfect fit.

CRIMP

The processing and performance of wool products depend on number of crimp in Wool fiber. The wool fiber crimp is measured as number of crimps in inch^{-1}. The crimp of wool fiber is the determining factor for wool fiber quality during production (spin ability/twisting) and fiber cohesion in the yarn.

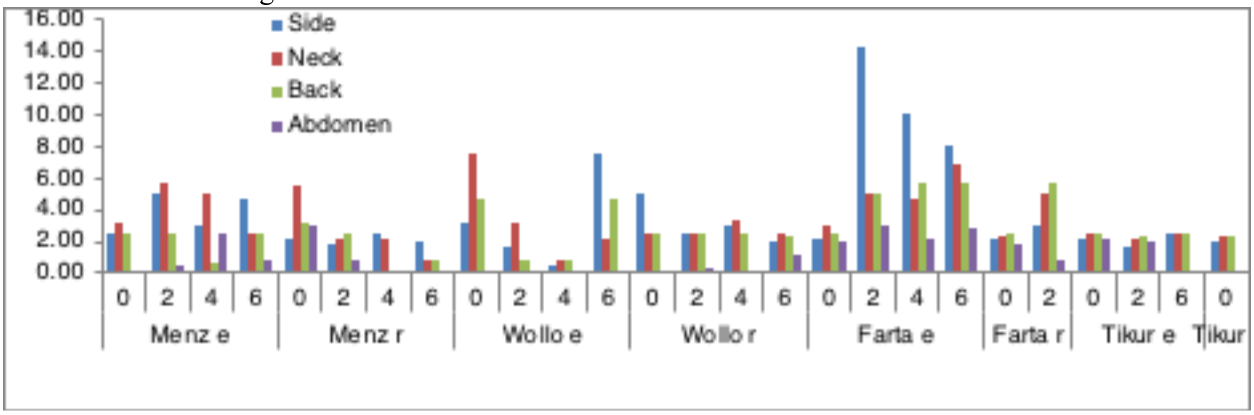

Figure 13: Fiber crimp of Ethiopian indigenous sheep breed

Ethiopian indigenous sheep breeds provide wool fiber with different number of crimps. The Farta sheep has the wool fiber with high number of crimps while the Tikur sheep provide the wool fiber with the minimum number of crimps, on average. The descending order of indigenous sheep breeds by their crimps is Farta, Menz, Wollo and Tikur. The Wollo ewe sheep at four teeth age has the lowest fiber crimp while the Farta ewe sheep at six teeth removed age group has the highest wool crimp, on average (see Figure 10).

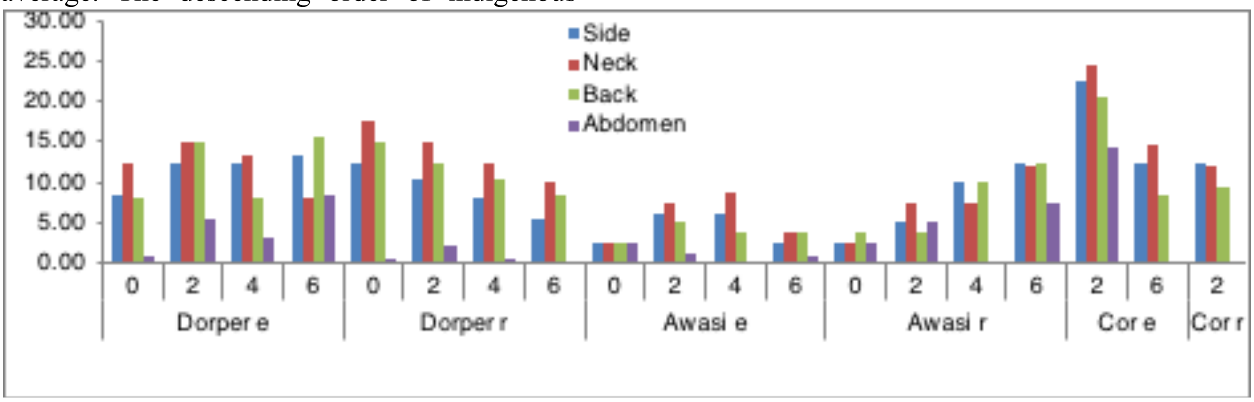

Figure 11: Fiber crimp of Ethiopian exotic sheep breed

As shown in Figure 11, the Corrediale sheep breed has the wool fiber with the highest number of crimps at two teeth age group while the Awasi sheep at milk teeth age group provides wool fiber with the lowest number of crimps. On average, the pure Awasi exotic sheep wool fiber has the lowest number of fiber crimps per inch. The wool fiber from the neck of the sheep has the highest number of crimps as compared to the wool fiber from the other body part. The number of crimps per inch for pure Awasi sheep ranges from 2.5 to 8.75, Dorper from 6 to 17.5 and Corrediale from 8.5 to 24.5. Therefore, The Dorper and Corrediale sheep breeds can provide the wool fiber suitable for spinning with the required twist insertion.

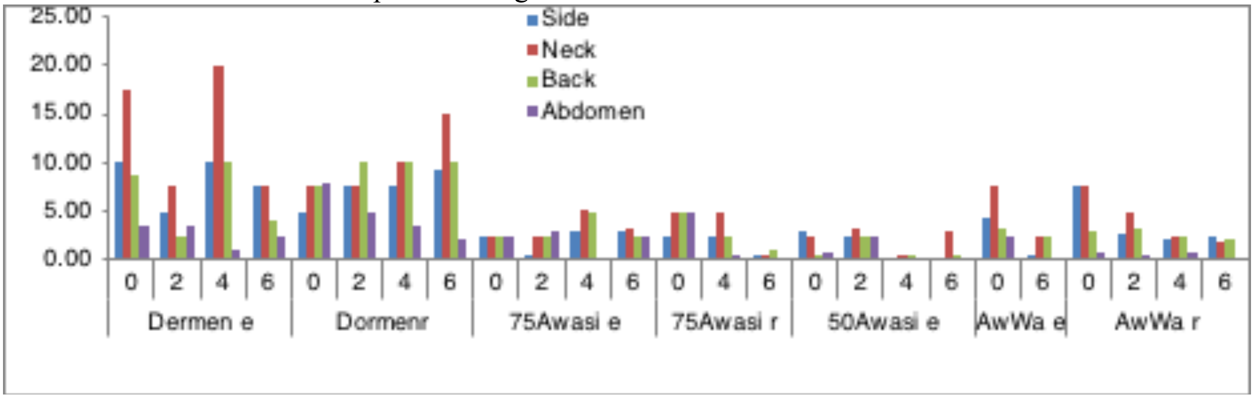

Figure 142: Fiber crimp of Ethiopian crossbreed sheep

The number of crimps per inch is highest in 50%Dorper sheep while the 50%Awasi sheep wool fiber is with the lowest number of fiber crimps, on average. 50% Awasi sheep provides wool fiber with zero crimps per inch from the side of the sheep at six teeth removed age group. The crossbreed sheep wool fiber from their sides is highest in crimps per inch and lowest from an abdomen of the sheep, on average. The number of crimps per inch variation is not consistent from age to age and from different body part in each crossbreed. The 50%Dorper crossbreeding improves the spin ability of the Menz sheep wool fiber.

STRENGTH

The processing and performance of wool products depend on Wool fiber strength. The wool fiber strength is measured as tenacity in cN/Tex. The strength of wool fiber is the determining factor for wool fiber quality during production and for determining product performance.

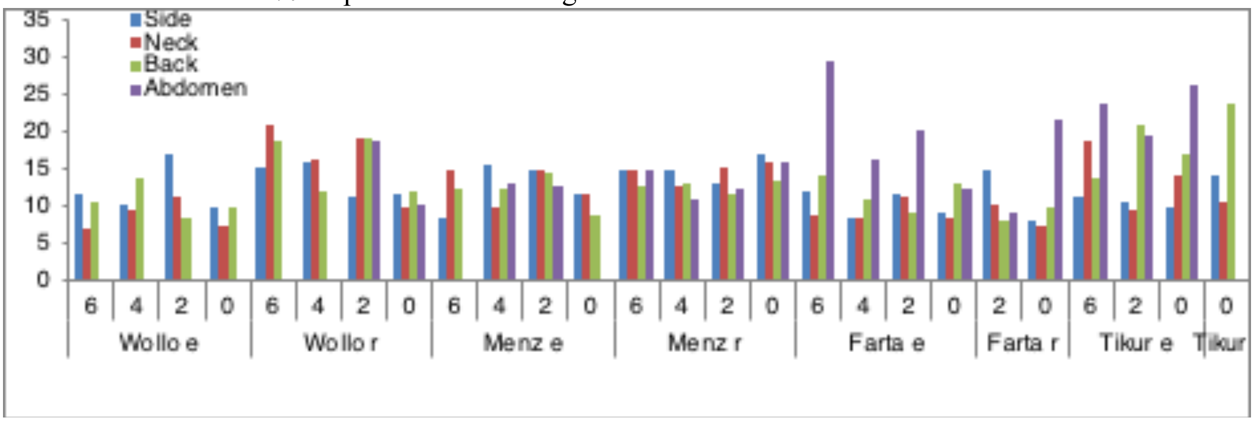

Figure 13: Fiber strength of Ethiopian indigenous sheep breed

The Wollo ewe sheep wool fiber strength is lower than its ram sheep. The Menz sheep wool fiber has similar fiber tenacity in female and male sheep. The Wollo ram sheep provides wool fiber with the highest fiber strength on average as compared to other Ethiopian indigenous sheep breeds while the Farta ram and female provides the wool fiber with the lowest fiber strength. The wool fiber from an abdomen of the sheep has the highest fiber strength on average as compared to the wool fiber from the other body parts of the sheep. The milk teeth sheep wool fiber has the wool fiber with the lowest fiber strength (see Figure 13).

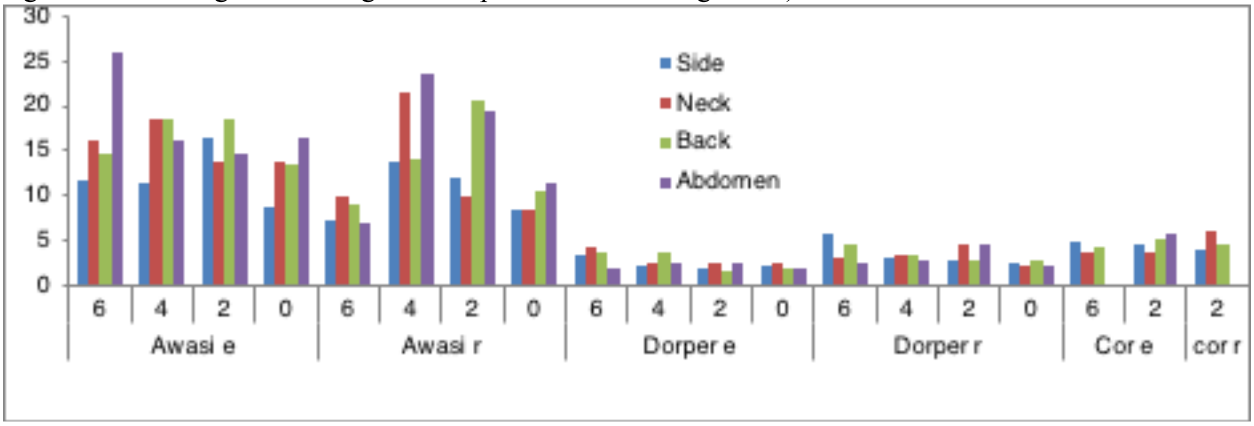

Figure 15: Fiber strength of Ethiopian exotic sheep breed

As shown in Figure 14, exotic sheep breeds those adapt and live in Ethiopia have different fiber strength. An Awasi ewe and ram sheep provides the wool fiber with the highest fiber strength as compared to the other exotic sheep breeds while the Dorper sheep wool fiber has the lowest fiber strength. An Awasi sheep wool fiber from the side of the sheep has the lowest tenacity, on average. The Corrediale sheep breed wool fiber is weak.

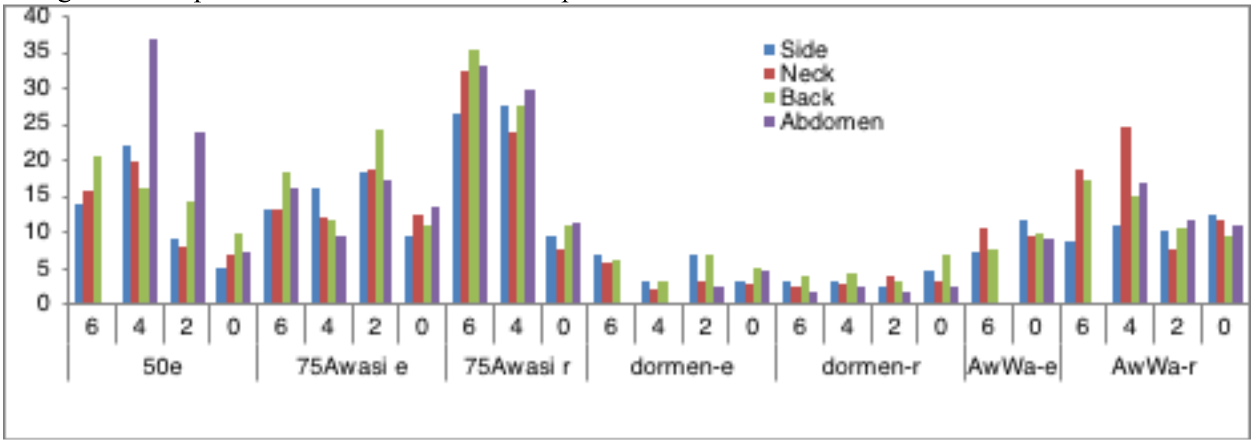

Figure 16: Fiber strength of Ethiopian crossbreed sheep

The 50% Awasi ewe, 75%Awasi ewe and ram, 50%Dorper ewe and ram and Awasi-Washera ewe and ram crossbreed sheep are investigated for their strength. The 75%Awasi sheep wool fiber is the strongest one as compared to the strength of the other crossbreed sheep while 50%Dorper sheep provides the weakest wool fiber, on average. The pure Washera sheep wool is short and not shorn for textile applications. However, the crossbreed of pure Awasi and pure Washera at 50% ratio provides wool fiber for textile applications. Awasi-Washera sheep wool fiber has medium strength as compared to the wool fiber from the other crossbreed sheep (see Figure 15).

Wool fiber yield

Ethiopian sheep wool fiber yield is lying in the IWTA standard for non wool supplying countries. As shown in Table 1 Ethiopia has high potential wool fiber. The fiber yield is significantly dependant on age, breed and sex of sheep.

Table 1: Wool fiber yield in from on shearing

Wool fiber yield in gram (Breed, Sex and Age)	SHEEP								
		Ram				Ewe			
	Location(growing center)	 <1yr	 1-2yr	 2-3yr	 >3yr	 <1yr	 1-2yr	 2-3yr	 >3yr
Wollo	Farmer & Inv't	797.56	1848.32	1435.76	2494.74	931.6	1667.02	1480.26	2711.82
Tikur	Farmer	984.72	1767.22	2288.06	1268.22	974.3	1443.96	2074.66	1121.46
Menz	Research, Improvement & Farmer	1246.44	1982.78	2274.46	1712.46	1008.78	1613.778	2378.64	1318.18
Awasi	Improvement	1671.88	2369.18	3133.36	2416	1481.28	2414.82	1830.68	1417.5
Dorper	Research	1144.96	1991.94	2119.8	2945.88	1101.58	1667.3	2017.02	1283.28
Correadiale	Farmer	1265.62	2473.72	3166.54	2894.96	1056.7	2029.8	2569.72	1704.72
75%Awasi	Research, Improvement & Farmer	1179.1	1671.34	2565.74	2558	1219.18	1951.88	2191.64	2369.28
50%Awasi	Research & Farmers	904.72	1478.42	2131.1	2003.64	1098.3	1661.72	1907.78	1427.1
Awasi/Washera	Research	1679.32	1846.54	2170.54	1649.66	1037.18	1651.06	1363.14	973.3
50%Dorper	Research & Improvement	1354.46	2211.22	2678.1	2896.1	902.62	1868.2	1630.74	1168.72

Conclusion

In this study the fiber handling, wool fiber properties such as fineness, length, strength, crimp and fiber yield are investigated. Ethiopian sheep wool fiber fineness shows that it is a suitable fiber for different textile applications. The fineness of Ethiopian sheep wool fiber lies between very coarse and superfine as per the fiber grade. The crimp frequency shows that Ethiopian sheep wool fiber fits the requirements for fiber quality to use for textiles and influenced by fiber diameter. The finer wool fiber has more number of crimps per inch and vice versa. Fiber fineness determines its strength i.e. the coarser the wool fiber is stronger and vice versa. The fiber yield of Ethiopian sheep also lies under the IWTA standard expected from not member countries in IWTA.

Generally, Ethiopian sheep breeds at the four age groups from the four main body parts of the two sex groups provides wool fiber from super fine to very coarse wool type because the fiber in American grading system is fine, ½ Blood, 3/8Blood, ¼ Blood, Low¼ Blood, Common and Braid and in British (spinning) system is from finer than 80s to coarser than 36s. Therefore, the wool fiber from the Ethiopian sheep breeds can be processed to produce underwear, shirts, suits, socks, rugs, carpets, blankets, outer wears, knit wear, knitting yarns, weaving yarns, quilt filling, furnishing and related textile products.

Therefore, Ethiopia has high wool fiber potential to use as a raw material in the textile industries. With this we should avoid (stop) the free (uncontrolled) disposal of wool fiber after shearing in order to protect environmental protection and use as source of income to support our economy. We recommend the government and research institutions planning further breeding for improving the yield and quality of the wool fiber.

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Dimensional Properties of Knitted Fabrics Made from 100%Cotton and Cotton/Elastane Blended Yarns

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Abstract

Dimensional properties of knitted fabrics are important properties and determines the materials consumption during production, productions and applications of different knitted structures. The dimensional properties such as thickness, shrinkage, width and weight of single jersey, 1x1rib, interlock, single pique and two thread fleece knitted fabrics made from 100%cotton and cotton/Elastane yarns (5%Elastane yarn content) are investigated in this research. The sample fabrics have been conditioned for 24 hours at 20±1°c temperature and 65±2% relative humidity. The number of specimens for sampling were determined as per the test standards described in materials and methods section for each yarn type, property and structure. As observed in the result the properties are related to each other. It is found that the thickness, shrinkage, width and areal density (weight) of single jersey, 1x1rib, interlock, single pique and fleece knitted fabrics made from 100%cotton and cotton/Elastane yarns is significantly different to each other and except width of the knitted fabrics the other properties of the knitted fabrics increased with cotton/Elastane blended yarn as compared to the same fabrics made from 100%cotton yarn.

Keywords: **Cotton, Cotton/Elastane blend yarns, knitted fabrics, dimensional properties**

I. Introduction

Weft knitted fabrics have greater extensibility, form fitting and comfortable properties. For these properties knitted fabrics demand has become increasing in all over the world. The material type, property and process parameters influence the characteristics of knitted fabrics. Weft knitted fabrics made from different materials have different characteristics [1-3]. Weft knitted fabric is widely used due to their formability and improved drape ability [4, 5]. The knitted fabric properties such as dimensional, mechanical and comfort properties of knitted fabrics depend on type of yarns used, type of machines, and process parameters, in general. Knitted fabrics dimensional properties such as loop length, weight, thickness, width and wale and course spacing are influenced by the type of yarns used during knitting[6-8]. Elastic knitted fabrics are normally produced by plating of spandex with companion yarn in a circular knitting machine. Elastic fabrics and their garments have immediate response and return to their original size and shape due to physical exertion by any organ of the human body[9]. These garments are mainly used in sports activities such as cycling, swimming and athletics. They improve the sportsmen performance by offering least resistance during garment stretch and by enhancing the power by the quick recovery of the fabric dimensions, because of the usage of the elastane in these garments. The recovery power of single jersey fabrics are generally sufficient for normal garment fit and it doesn't enough for stretch activities. Spandex yarn is capable of giving large stretch and dimensional recovery than can be achieved by cotton yarn alone [10, 11]. Fabric thickness is not affected with loop length in case of 100% cotton, while by introducing Lycra to the knitted fabric thickness increases as the loop length increases; this increase is due to the tightness of the fabric [3, 12]. Fabric width increases, as the loop length increases; the increase in width in case of 100%cotton is higher than with 5.7% Lycra [13]. Fabric weight measured for single jersey knitted fabrics made from cotton/spandex yarn and cotton alone. The fabric weight had been improved significantly by increasing spandex ratio. Textured threads increase thickness and area density of knits[14, 15].

Many of the researchers investigate properties of single jersey only. But, this paper studies the dimensional properties such as thickness, width, shrinkage and weight of knitted fabrics such as single jersey, 1x1rib, interlock, single pique and two thread fleece made from 100%cotton (cotton alone) and cotton/Elastane (at 95%/5% blend ratio) yarns. Though many researchers investigated the effect of spandex yarn as core spun in cotton fiber (friendly fiber), in this research Elastane is used as naked filament (not friendly with cotton fiber).

As reviewed in different articles and books, many of the researchers study some of the dimensional properties only for single jersey; they use elastane as core spun with cotton fiber; and they did not show the relationship of these properties, and the effect of structural differences between structures. In this research the dimensional properties such as thickness, weight, shrinkage and fabric width of knitted fabrics such as single jersey, 1x1rib, interlock, single pique and two thread fleece knitted fabrics made from 100%cotton and Cotton/Elastane (Elastane is fed to needles as naked filament), the relationships of the studied properties and analysis of structural effect are investigated clearly. These make this research is novelty from the previous research works.

1. Material and Experiments

1.1. Materials

100% cotton and Cotton/Elastane blended yarns are used for this study. An Elastane accounts for about 5% contents (40denier = 133Ne) while cotton accounts for 95% content (35Ne) in the 28Ne combed cotton/Elastane blended yarn (cotton/Elastane = 95/5%) and an Elastane yarn is fed to the needles as naked filament with the cotton yarn in the same yarn feeder (carrier) but neither plied nor core spun with cotton. Cotton fiber harvested from Upper Awash-Ethiopia has 28mm staple lengths, 12.8 short fiber index, 300 neps, 4.06trash percent, 4.2Micronaire fineness. The cotton yarn has 750m^{-1} twist, 28 Ne count, 9.21% U%, 11.70 CVM, 0 thin-50%, 33.6 thick+50%, 29.8 Neps+200% and 63.4 total imperfection percent. The single jersey, single pique and two thread fleece are produced by the single bed circular knitting machine with 30rpm, 34" diameter, 2976 needles, 4 cam tracks and 108 feeders. 1x1Rib/interlock is produced by double bed circular knitting machine with 20/14rpm, 30" diameter, 2630 needles, 94/112 feeders, 1/2 cam tracks respectively. The study was carried out by keeping these materials and their parameters constant except for the yarn's (raw material type).

There are 28 needles per inch in a cylinder in single jersey, single pique and fleece. In 1x1rib knitting machines there are 18 needles per inch in cylinder and 18 needles per inch in Dial. In interlock knitting machines there are 24 needles per inch in cylinder and 24 needles per inch in Dial. The working principle and arrangement of needles in 1x1rib and interlock knitting machines is different in gaiting [6].

1.2. Experiments

Single jersey, 1x1rib, interlock, single pique and fleece knitted fabrics were produced for this study. Dimensional properties such as thickness and weight of single jersey, 1x1rib, interlock, single pique and two thread fleece knitted fabrics made from 100%cotton and cotton/Elastane yarns have been measured using digital thickness tester and digital balance (weight) tester respectively. Other properties such as shrinkage and width of knitted fabrics are measured using pick glass and length measurement.

i. *Yarn properties*

The yarn properties such as U% (irregularity), CVM (coefficient of variation in mass), Thin and Thick places and the amount of Neps in cotton yarn are tested using Uster tester-5 machine and Uster testing standards

ii. *Thickness*

The thickness of single jersey, 1x1rib, interlock, single pique and fleece knitted fabrics were tested using digital thickness tester as directed in ASTM D1777-02 Standard Test Method for Thickness of Textile Materials [16].

iii. Weight

The weight of single jersey, 1x1rib, interlock, single pique and fleece knitted fabrics were tested using digital balance (weight) tester as directed in ASTM D3776-02 termed as Standard Test Method for Mass Per Unit Area (Weight) of Fabric [17].

III. Result and Discussion

3.1. Thickness

The thickness of single jersey, 1x1rib, interlock, single pique and fleece knitted fabrics are measured using digital thickness tester in millimeter (mm) and the average test results are shown in Table 1. The thickness of single jersey, 1×1rib, interlock, single pique and fleece knitted fabrics made from 100% cotton and cotton/Elastane (95/5%) blended yarns is different. The thickness of single jersey, 1x1rib, interlock, single pique and fleece knitted fabrics made from 100%cotton are lower as compared to the same fabrics made from cotton/Elastane blended yarn. This is because the fabrics made from cotton/Elastane yarns have greater widthwise shrinkage which leads to higher thickness of the fabrics. The thickness of interlock knitted fabric made from 100%cotton and cotton/Elastane yarns is the highest as compared to the other knitted fabrics made from the same yarns because interlock is made when two 1x1rib loops are locked together and appeared in their technical face of loops in addition to the shrinkage of fabrics. Single jersey has the lowest thickness in both 100%cotton and cotton/Elastane yarns as compared to the other fabrics made from the same materials in two reasons. Firstly, single jersey is made on one needle bed with one set of needles and has single faced appearance as compared to interlock and 1x1rib knitted fabrics. Later, in single jersey only one yarn is fed to the needles and one loop is formed at each needle continuously while in single pique knitted fabric each loop is formed from one tuck loop, one held loop and one knit loop; and in fleece knitted fabric two yarns floating at the technical back of the fabric, which gives more thickness as compared to single jersey made from the same materials.

The thickness of single jersey, single pique, 1x1rib, interlock and fleece knitted fabrics has been increased due to the presence of 5% Elastane in 95% cotton yarns. This is because the widthwise shrinkage of all knitted fabrics is higher in cotton/Elastane yarn than 100% cotton yarn.

In Table 1, the mean, standard deviation (SD), coefficient of variations (CV%), standard error, minimum and maximum values of the test specimens are shown. The standard deviations of all sampled fabrics made from 100%cotton (C) and cotton/Elastane(C/E) are similar with slight deviations from their mean. This shows that the values in a statistical data set are closest to the mean of the data set, on average.

Table 1: Description for thicknesses of knitted fabrics made from 100%cotton and cotton/Elastane yarns

Fabrin types	Yarns	N	Mean	SD	CV%	Std. Error	Minimum	Maximum
Single jersey	C/E	10	.7500	.02667	3.556	.00843	.72	.78
	C	10	.6210	.01370	2.206119	.00433	.60	.65
1x1Rib	C/E	10	1.3250	.02321	1.751698	.00734	1.29	1.37
	C	10	.8350	.01581	1.893413	.00500	.81	.85
Interlock	C/E	10	1.4950	.02321	1.552508	.00734	1.46	1.52
	C	10	1.2530	.01494	1.192338	.00473	1.23	1.28
Pique	C/E	10	1.0320	.03190	3.091085	.01009	.99	1.08
	C	10	.7470	.02312	3.095047	.00731	.71	.78
Fleece	C/E	10	1.4300	.03232	2.26014	.01022	1.38	1.48
	C	10	.9240	.01713	1.853896	.00542	.90	.95

The thickness of single jersey, single pique, 1x1rib, interlock and fleece knitted fabrics mean differences are significant at 0.05 levels. As shown in Table 2, the thickness of knitted fabrics is significantly influenced by the types of yarns (100%cotton and Cotton/Elastane-95/5%). 1x1Rib has the highest F-Value as compared to other knitted fabrics which shows that 1x1rib has a high dispersion rate as compared to other knitted fabrics.

Table 2: Analysis of variances on thickness of knitted fabrics made from 100%cotton and cotton/Elastane yarns

Fabrics		Sum of Squares	df	Mean Square	F	Sig.
Single jersey	Between Groups	.083	1	.083	185.129	.000
	Within Groups	.008	18	.000		
1x1Rib	Between Groups	1.201	1	1.201	3043.521	.000
	Within Groups	.007	18	.000		
Interlock	Between Groups	.293	1	.293	768.332	.000
	Within Groups	.007	18	.000		
Pique	Between Groups	.406	1	.406	523.282	.000
	Within Groups	.014	18	.001		
Fleece	Between Groups	1.280	1	1.280	1913.890	.000
	Within Groups	.012	18	.001		

3.2. Shrinkage

Shrinkage (%) of single jersey, 1x1rib, interlock, single pique and fleece knitted fabrics calculated from machine gauge and wales per centimeter as:

$$\%Shrinkage\ (S) = \frac{\text{Wales per inch } - \text{Gauge of the machine}}{\text{Wales per inch}} x100.$$

The shrinkage of single jersey, 1×1rib, interlock, single pique and fleece knitted fabrics made from 100% cotton and cotton/Elastane (95/5%) blended yarns is different (see Table 3). The shrinkage (%) of single jersey, 1x1rib, interlock, single pique and fleece knitted fabrics made from 100%cotton are lower as compared to the same fabrics made from cotton/Elastane blended yarns. This is because knitted fabrics made from cotton/Elastane yarns have greater elastic recovery property as compared to cotton yarn alone. The shrinkage percent of 1x1rib knitted fabric made from 100%cotton and cotton/Elastane yarn is highest as compared to the other knitted fabrics made from the same materials because 1x1rib is made when the two consecutive technical face and reverse loops are meshed in one side of the fabric and appears as a vertical corrugation in both front and back of the fabrics. These technical face and reverse meshed loops on one side of the fabrics leads to high shrinkage opposite to its corrugation. The two-thread fleece has the lowest shrinkage in both 100%cotton and cotton/Elastane yarns as compared to the other fabrics made from the same materials. Fleece knitted fabrics has two floating threads at the back of the fabric. These floats provide dimensional stability by increasing the fabric bulkiness at the back in order to minimize the widthwise shrinkage of the fabric.

The shrinkage of single jersey, single pique, 1x1rib, interlock and fleece knitted fabrics has been increased due to the presence of 5% Elastane in 95% cotton yarns. These fabrics have different shrinkage percent in cotton and cotton/elastane yarns. An ascending order of shrinkage of the fabrics is fleece, single pique, single jersey, Interlock and 1x1rib. 1x1Rib and interlock knitted fabrics made from 100% cotton is also shrinks more than fleece, single pique and single jersey knitted fabrics made from cotton/Elastane.

In Table 3, the mean, standard deviation (SD), coefficient of variations (CV%), standard error, minimum and maximum values of the test specimens are shown. The standard deviations of all sampled fabrics made from 100%cotton (C) and cotton/Elastane (C/E) are similar with slight deviations from their mean. This shows that the values in a statistical data set are closest to the mean of the data set, on average.

Table 3: Description for shrinkage of knitted fabrics made from 100%cotton and cotton/Elastane (95/5%)

Fabric types	Yarns	N	Mean	SD	CV%	Std. Error	Minimum	Maximum
Single jersey	C/E	10	34.5450	1.57999	4.573715	.49964	33.19	37.01
	C	10	22.3480	1.40460	6.285126	.44417	21.26	23.98
1x1Rib	C/E	10	79.7400	.61137	0.766704	.19333	79.16	80.32
	C	10	70.6770	.70467	0.997029	.22284	69.98	71.65
Interlock	C/E	10	54.7890	2.10599	3.843819	.66597	52.76	58.92
	C	10	27.1980	.82798	3.044268	.26183	26.18	28.42
Pique	C/E	10	28.2640	1.44392	5.108689	.45661	26.51	30.32
	C	10	9.2580	1.22770	13.26096	.38823	8.14	11.10
Fleece	C/E	10	23.5750	1.68146	7.132386	.53173	21.26	26.02
	C	10	1.0040	2.14983	214.1265	.67984	-1.13	4.97

Shrinkage of knitted fabrics is inversely related to an actual width of knitted fabrics ($\text{Width (cm)} = \frac{\text{Number of needles(N)}}{\text{Wales per centimeter(wpc)}}$).

Knitted fabrics with high shrinkage have low width (narrow) and vice versa. As shown in Figure 1, the width of two thread fleece is highest as compared to other fabrics made from the same yarns whereas 1x1rib has the lowest width as compared to other fabrics made from the same yarns. Table 3 and Figure 1 shows us, shrinkage and the width of knitted fabrics are inversely proportional to each other.

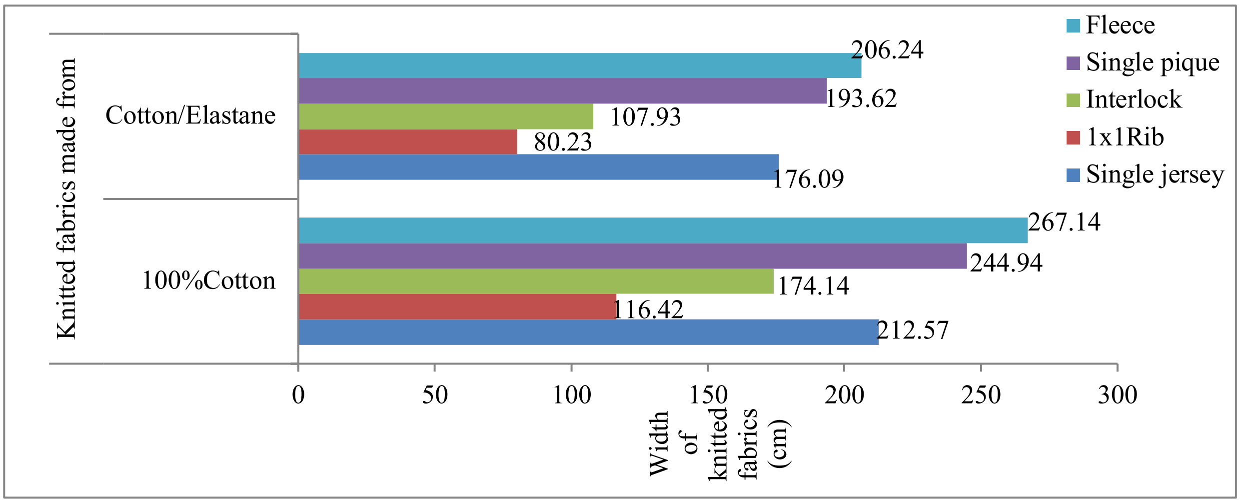

Figure 1: width of knitted fabrics made from 100%cotton and cotton/Elastane yarns

The shrinkage of single jersey, single pique, 1x1rib, interlock and fleece knitted fabrics mean differences are significant at 0.05 levels. As shown in Table 4, the shrinkage of knitted fabrics is significantly influenced by the types of yarns (100%cotton and Cotton/Elastane-95/5%). An interlock has the highest F-Value as compared to other knitted fabrics which shows that an interlock knitted fabric has a high dispersion rate as compared to other knitted fabrics.

Table 4: Analysis of variances for shrinkage of knitted fabrics made from 100%cotton and cotton/Elastane yarns

Fabrics		Sum of Squares	Df	Mean Square	F	Sig.
Single jersey	Between Groups	743.834	1	743.834	332.866	.000
	Within Groups	40.223	18	2.235		
1x1Rib	Between Groups	410.690	1	410.690	943.752	.000
	Within Groups	7.833	18	.435		
Interlock	Between Groups	3806.316	1	3806.316	1486.621	.000
	Within Groups	46.087	18	2.560		
Pique	Between Groups	1806.140	1	1806.140	1005.602	.000
	Within Groups	32.329	18	1.796		
Fleece	Between Groups	2547.250	1	2547.250	683.910	.000
	Within Groups	67.042	18	3.725		

3.3. Weight

The weight of single jersey, 1×1rib, interlock, single pique and fleece knitted fabrics made from 100% cotton and cotton/Elastane (95/5%) blended yarns is different (see Table 5). The weight (GSM) of the sample knitted fabrics made from 100%cotton is lower as compared to the same fabrics made from cotton/Elastane blended yarn, because fabrics made from cotton/Elastane yarns have greater shrinkage (%) property as compared to the same fabrics made from 100%cotton yarn. The weight of interlock knitted fabric made from 100%cotton and cotton/Elastane yarn is the highest as compared to the other knitted fabrics made from the same materials, because interlock is made when two 1x1rib loops are locked together to form a four-loop interlock structure. Interlock is the thickest fabric which leads to the highest weight (heaviest fabric) of knitted fabric. Similarly, single jersey made from 100%cotton (C) and cotton/Elastane (C/E) blended yarns has the lowest weight as compared to the other fabrics made from the same materials. The weight of single jersey, single pique, 1x1rib, interlock and fleece knitted fabrics have been increased due to the presence of 5% Elastane in 95% cotton yarns. These fabrics have different shrinkage percent, width and thickness in cotton and cotton/elastane yarns (see Table 3, Figure 1, and Table 1 respectively). Thickness, shrinkage and width variation have an influence on weight (GSM) of the knitted fabrics. The descending order of weight of the fabrics is interlock, fleece, 1x1rib, single pique and single jersey.

In Table 5, the mean, standard deviation (SD), coefficient of variations (CV%), standard error, minimum and maximum values of the test specimens are shown. The knitted fabrics made from cotton/Elastane and 100%cotton yarns have different standard deviations due to the values in a statistical data set and it shows different closeness to the mean of the data set, on average.

Table 5: Description for areal weight of knitted fabrics made from 100%cotton and cotton/Elastane yarns

Fabrin types	Yarns	N	Mean	SD	CV%	Std. Error	Minimum	Maximum
Single jersey	C/E	10	223.5000	1.90029	0.850242	.60093	220.00	226.00
	C	10	164.8000	2.34758	1.424502	.74237	162.00	168.00
1x1Rib	C/E	10	294.8000	7.28469	2.471062	2.30362	281.00	307.00
	C	10	196.9000	4.88649	2.481712	1.54524	190.00	206.00
Interlock	C/E	10	320.0000	2.98142	0.931694	.94281	316.00	326.00
	C	10	213.7000	5.77446	2.702134	1.82605	206.00	222.00
Pique	C/E	10	278.9000	2.92309	1.048078	.92436	276.00	284.00
	C	10	180.3000	2.49666	1.384725	.78951	176.00	184.00
Fleece	C/E	10	307.7000	2.86938	0.932525	.90738	304.00	312.00
	C	10	204.2000	3.58391	1.755098	1.13333	197.00	208.00

The weight of single jersey, single pique, 1x1rib, interlock and fleece knitted fabrics mean differences are significant at 0.05 levels. As shown in Table 6, the weight of knitted fabrics is significantly influenced by the types of yarns (100%cotton and Cotton/Elastane-95/5%). Single pique has greatest F-Value as compared to other knitted fabrics which showed that single pique has a high dispersion rate as compared to other knitted fabrics.

Table 6: Analysis of variances of knitted fabrics made from 100%cotton and cotton/Elastane yarns

Fabric types		Sum of Squares	Df	Mean Square	F	Sig.
Single jersey	Between Groups	17228.450	1	17228.450	3777.248	.000000
	Within Groups	82.100	18	4.561		
1x1Rib	Between Groups	47922.050	1	47922.050	1245.627	.000001
	Within Groups	692.500	18	38.472		
Interlock	Between Groups	56498.450	1	56498.450	2675.538	.000004
	Within Groups	380.100	18	21.117		
Pique	Between Groups	48609.800	1	48609.800	6578.770	.022000
	Within Groups	133.000	18	7.389		
Fleece	Between Groups	53561.250	1	53561.250	5082.248	.000024
	Within Groups	189.700	18	10.539		

IV. CONCLUSION

The dimensional properties such as thickness, shrinkage, width and weight of knitted fabrics made from 100%cotton and cotton/Elastane yarns have been investigated. As clearly explained in the result and discussion the 5%Elastane content in 95%combed cotton yarn significantly changes the dimensional properties of knitted fabrics. These properties are interrelated each other and has an effect on each other. The knitted fabrics have different thickness, weight, shrinkage and width one from the other due to structural differences between them. Thickness, weight and shrinkage of the fabrics are increased with cotton/Elastane yarn as compared to the same fabrics made from cotton alone (100%cotton). This is because of the high shrinkage and elastic recovery tendency of Elastane yarn. The width of knitted fabrics reduced with cotton/Elastane yarns as compared to the same fabrics made from 100%cotton (cotton alone). This is due to the high shrinkage tendency of knitted fabrics made from cotton/Elastane blended yarns than 100%cotton.

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Analysis of wicking performance of Core spun yarn with octalobal polyester fibre

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Abstract

In this article, wicking performance of Core spun yarn made from octalobal multi filament polyester yarn as a core and Cotton and staple polyester fibre as a sheath was analyzed. All yarns were tested for their horizontal, vertical and loop wicking. It was observed that, equilibrium wicking height/distance and wicking rate are maximum for horizontal, intermediate for vertical and lower for loop wicking. Wicking parameters for Cotton yarn were found to be less than core spun yarns. As the percentage of octalobal polyester multi filament yarn in the yarn increase from 0% to 30%, the wicking height/distance and wicking rate increases. As a result, 30% core spun yarn has higher wicking parameters. Wicking height of polyester staple yarn was always lowest in comparison to cotton-polyester and polyester-polyester core spun yarns. Polyester- polyester core spun yarn has greater wicking parameters than 100% polyester and Cotton-polyester core spun yarn.

Keywords: **wicking parameters, Core spun yarn, vertical wicking, horizontal wicking and loop wicking.**

I. INTRODUCTION

Core spun yarn is a technical textile yarn made by carefully placing filament in the core and staple fibre in sheath. The Core may be mono or multi filament hard or soft and the sheath contains natural, manmade fibres or their blends. Filament and staple combination enhance the basic characteristics (strength, extension), reduce twist, and increases moisture transmission. Core spun yarns can be made by Modified Ring spinning, Rotor spinning and Friction spinning. From these methods, Modified Ring frame is widely used by different researchers [1]- [5]. The wrapping effect is an important quality index of core-spun yarn. Main factors that influence the wrapping effect include: Filament pre tension, number of rooving feed (double or single), twist and sheath fibre to core filament ratio. Filament pretension determines the proper wrapping of sheath by placing the filament at the core of the yarn. At high tension the wrapping effect may decrease, similarly at low tension, filament comes out to the surface of the yarn as a result reduces the quality of the wrapping and quality of the yarn.

A strong twist in the core filament will increase its strength and abrasion resistance, and thereby gives a good foundation for spinning a core-spun yarn [6]. A strong twist of the sheath fibre strand helps for proper wrapping, whereas very strong twist will cause yarn breakage. Therefore, the yarn twist must be determined reasonably so as to achieve an ideal wrapping and better yarn quality.

One of the functional requirements of Core Spun yarn is to improve moisture transmission and drying rate to enhance the comfort. The moisture transmission of the core spun yarn is depending on: nature of the fibre (natural or manmade), fibre cross section, core to sheath ratio, packing coefficient, twist and linear density of the yarn. Natural fibre such as cotton is hydrophilic in nature, and absorbs moisture and fail to transport and release. However, manmade fibres such as polyester are hydrophobic due to low surface energy and as a result better moisture transporting property. Beside nature of the fibres, twist is one of the factors that affects the moisture transmission in the spun yarns.

Wicking behavior in yarn is depends on twist, fibre denier, yarn denier, fibre cross-sectional shape and number of fibres in the yarn [7]. A fibre packing in yarn, fibre diameter, fibre surface condition and treatment have significant effects on yarn-wicking properties [8]. The performance of wicking through yarn and fabric made from polyester fibres of different cross-sections discussed that the rate of rise of liquid in the yarn from circular hollow polyester was much higher for first few minutes and then the rate reduced [9]. The wicking phenomenon in a fibrous material depends on time, dimension of the substrate, surface morphology and viscosity of the fluid [10]-[12]. Fibres with hexalobal cross-section which has higher shape factor than circular cross section has better wicking height[13]. Core and cover yarns containing profiled polyester filaments perform better in moisture absorption and release [14]. In fibrous materials, liquid raises more faster where packing coefficient are higher and at low packing coefficient is become low, due to empty holes tends to form, the liquid flow become low [15]. Profiled yarns with Low packing and number of micro level capillaries/fibre result in best wicking performance [16]. Capillary flow will be faster through well-defined capillaries.

Wicking in textile yarns, especially in staple yarns, is very complicated and the mechanism has not been fully understood. Since the core spun yarn is made from two different fibre, wicking in the core spun yarn becomes more complex [11]. Many researchers were reported the wicking properties of yarns made from staple fibres, continuous filament and yarns made from blends of fibres. However, none of them were reported the wicking behaviors (Vertical, horizontal and loop mode) of core spun yarn made from octalobal hollow multifilament polyester yarn as a core and Cotton or Staple polyester fibre as a sheath. In this study we sighted the wicking behavior in core spun yarn made up of octalobal multifilament polyester as a core and cotton or polyester as a sheath.

II. MATERIAL AND METHODS

A. Raw Material

In this study we were used Cotton roving, Polyester Roving and hollow octalobal polyester multi filament yarn. The detail specifications of the materials are stated in the Table I.

B. Method

Yarn samples were produced on LMW Ring frame. Yarns of 34 tex and 57 tex were made at twist of 17.3 TPI and 10.3 TPI respectively. Core sheath combination of the samples and production parameter are given in Table II.

Table I. Specifications of materials used

No.	Material Name	Count Roving/Yarn	Fibre	Fibre Length(mm)	Number of Lobs	Number of filaments
1	Cotton roving:	262.4 (tex)	3.85 (micro)	29.05(UHML)	-	-
2	Polyester Roving	805.11(tex)	1.88 (denier)	38	-	-
3	Hollow Polyester multi filament yarn:	37 (denier)	3.08 (denier)	-	8	12

Table II. Sample production parameters

Fibre	Sample Code	Nominal Yarn Count (tex)	Sheath/Core ratio	Twist (TPI)	(TM)	Total Draft	Filament Pre tension (cN)
Cotton	C-MT	34	100:0	17.3	4.15	16	-
Cotton/ Polyester	CP-15MT	34	85:15	17.3	4.15	16	21
	CP-30MT	34	70:30	17.3	4.15	16	37
	CP- 15LT	57	85:15	10.3	3.2	12	32
Polyester	P-LT	57	100:0	10.3	3.2	32	-
Polyester/ Polyester Core	PP- 15LT	57	85:15	10.3	3.2	32	32

Core spun yarns were made by feeding two rovings (Cotton or Polyester) along with the filament. Two rovings were fed through one trumpet in producing CP-15MT, CP-15LT and PP- 15LT. Since the ratio of core percentage in these yarns is low, better cover is easily obtained by feeding two rovings through a conventional trumpet and feeding the filament in between these two rovings behind the front roller. But in case of 30% Core, it was difficult to cover the filament properly by using conventional trumpet guide. For this a guide with two holes to accommodate the rovings was developed. By using the guide, better coverage was obtained. To keep the filament at center of the yarn, a tensioning device was used to feed the filament under the tension. The level of tension was measured by using Tensiometer. The draft was 16 for cotton covered core-sheath yarn and 32 for polyester-polyester core-sheath yarn. The cross section of the yarns are shown in the "Fig. 1." and "Fig. 2."

C. Wicking test

In preparation of yarns for wicking tests, Cotton based Yarns were scoured in lea form to remove the natural wax and finishing agents. The scouring was done by using Sodium Hydroxide of 2g/l at M: L (material weight in kg to Liquid in a litter) 1:30. To remove Alkali we used Acetic acid 5 ml/l. Scouring was done at a temperature of 95^0C for one hour. After scouring the yarns were washed by hot water (60^0C-70 ^{0}C) followed by washing twice by cold water.

Polyester based yarns (P-LT and PP-15LT) were washed by neutral pH solution of 1 gram of Na_2CO_3 and 1 gram of anionic Surfactant in 1 liter of water. The samples were washed in the stated solution for 45 minutes. After washing, the samples were thoroughly rinsed with water and kept in normal room temperature for 48 hours for proper drying.

Three types of wicking tests were performed. These are vertical, horizontal and loop wicking test. For Vertical and Loop wicking tests, a small set-up was made. The experimental equipment is similar to those commonly used for vertical yarn wicking by research [12]. The test set-up is shown in "Fig. 3." For Vertical wicking test, 250 ml solution of distilled water with 0.5 gm of red direct dye for identification of fluid rise was used. Yarn sample of 250 mm was hanged. Out of this, 30 mm was dipped in to the fluid and the remaining 220 mm was above the fluid. Similarly, for loop wicking, test was made by using vertical wicking instrument and same solution. It was made by using 500mm yarn folding into two. Cut ends are clipped at the top clip and loop end was dipped in to the solution. To keep the tension of the yarn constant deadweight of 5.85gm was hanged.

For Horizontal wicking test, simple instrument was developed according to [17] as shown in "Fig. 4.". One end of the yarn was clipped and the other end was passed over the glass rod and dipped in the solution. For keeping the yarn at constant tension, a deadweight was hanged. To carry out the test, 282 mm of yarn was used; out of this 30 mm was dipped in the solution, 12mm was the distance between solution and glass rod and 240 mm of the yarn was stretched between right-hand side clip and glass rod. To trace the wicking distance, a solution of 315 ml of distilled water and 0.63gm of red direct dye was used.

In all tests, video camera was used for recording the rise of fluid in yarn. The recorded video was played on the computer screen and the height or distance of fluid moved in the yarn with respect to time was recorded. The time interval was one minute up to the saturation point of the rise. At least 10 tests were performed for each sample at saturation (maximum) height or distance. The average values were calculated. The tests were undertaken at RH 65% and temperature of 27^0C.

For all tests a plot was made between wicking height (mm) and wicking time (s). To calculate wicking constant, another plot was made between wicking height (mm) and $\sqrt{time(s)}$. A linear relationship is expected and from the slope of the curve the wicking constant values can be estimated. In general wicking has been characterized by maximum wicking height, which consists wicking constant and time to attain the maximum height. The wicking constant is related to liquid properties and Capillary structure (shape, size, distribution and orientation).

D. Wicking theories

According to Washburn-Lucas equation, the rate of wicking is given by;

$$\frac{dL}{dt} = \frac{\sigma Cos\theta R}{4\,\eta\,L} \qquad (1)$$

By differential solution, equation (1) becomes;

$$L=\left(\frac{\sigma Cos\theta R}{2\,\eta}\right)^{1/2} * t^{1/2} \qquad (2)$$

$$L = C\sqrt{t}$$

For vertical and loop wicking the maximum wicking height was obtained by equating capillary pressure to weight of liquid column.

$$L = \frac{2\sigma Cos\theta}{R\rho g} \quad (3)$$

Where, R= radius of capillary, σ =, $\theta =$dynamic contact angle, η= viscosity of the liquid, L= the distance covered by the fluid in time t, $\rho =$ density of liquid, g=acceleration due to gravity.

Wicking in the yarn is depends on capillary pressure developed between fibres. Which is in turn depends on types of fibre, fibre shape factor, twist level and packing coefficient of the yarn. Fibres with higher shape factor have high specific surface area and as a result in better wicking characteristics than fibres have low shape factor. As packing density increases, since capillary radius decreases, results in high pressure and increases wicking height/ distance.

It is popular that, in staple spun yarns, packing density is directly proportional to twist factor and twist intensity. The relationship between packing coefficient and twist factor is given as;

$$tan\beta_D = \pi DZ = K \quad (4)$$

$$D_{(mm)} = \sqrt{\frac{4T_{(tex)}}{\pi\mu[-]\rho_{(\frac{kg}{m^3})}}} \quad (5)$$

$$\alpha = Z\sqrt{T} \quad (6)$$

$$\alpha = \frac{k}{2\sqrt{\pi}}\sqrt{\mu\rho} \quad (7)$$

Where: Z = twist of the yarn per given unit, β_D = angle of inclination of the twist respect to y-axis (yarn axis), D = Diameter of the yarn, K = twist intensity of the yarn, T = Count of the yarn in tex, μ= Packing density of the yarn, ρ = Density of the fibre and α = twist coefficient of the yarn.

As shown in the equation; twist coefficient is directly proportional to the twist intensity (k) and packing density (μ) of the yarn.

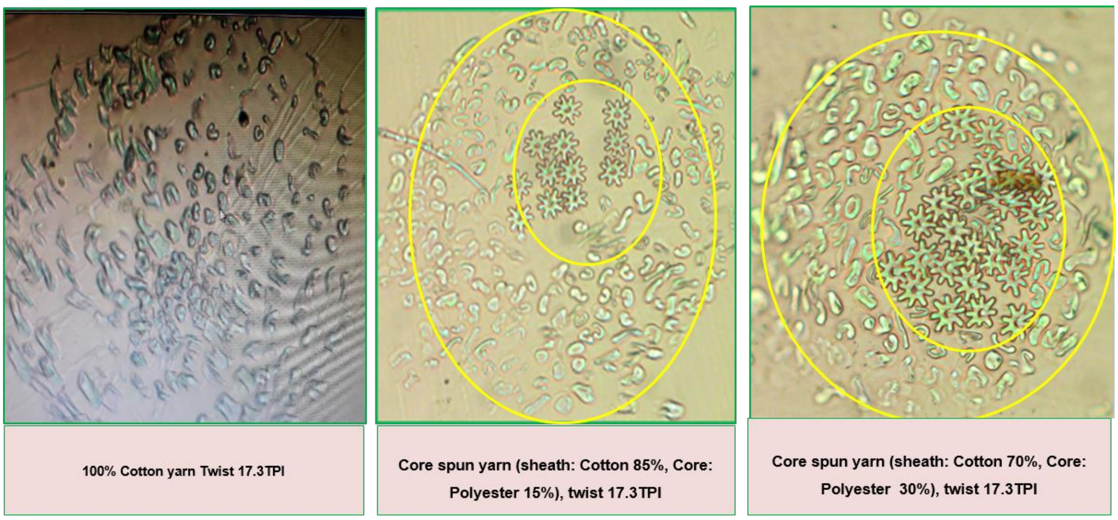

Fig. 1. Cross section of 34tex yarns.

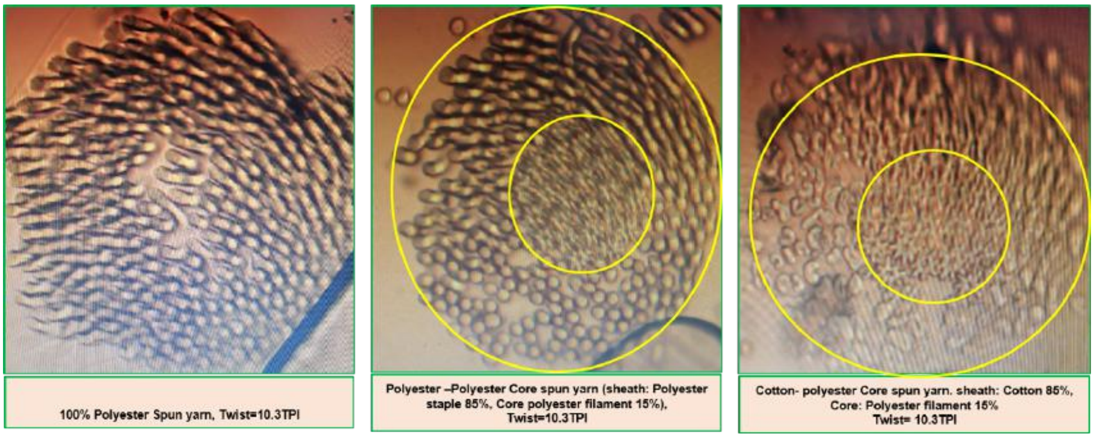

Fig. 2 Cross section of 57 tex yarns

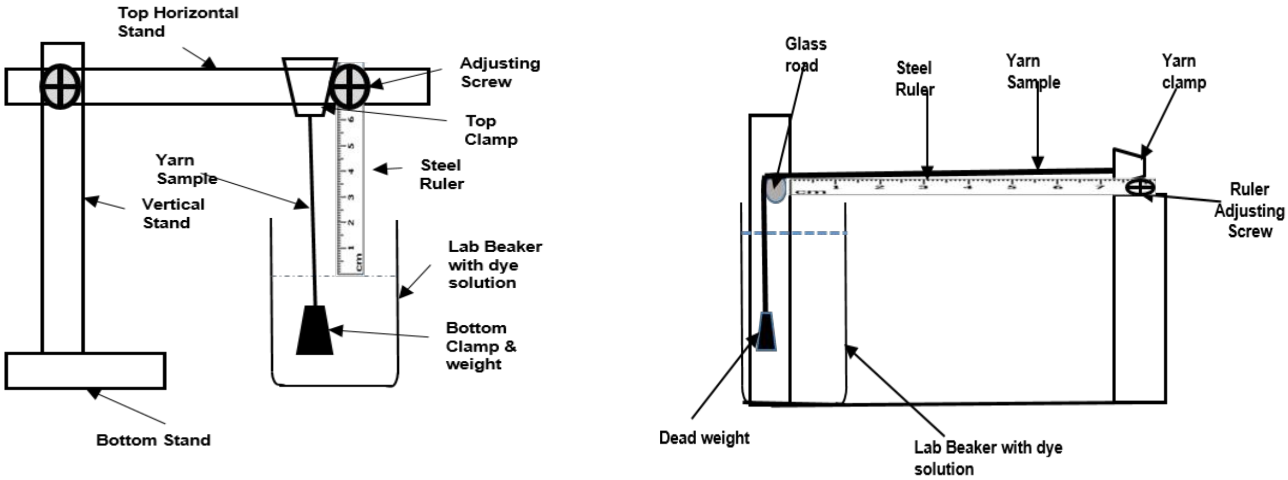

Fig. 4. Schematic diagram of Horizontal wicking measuring instrument [17]

III. RESULT AND DISCUSSION

A. Packing coefficient σ [-]

Packing coefficient of the yarns are shown in "Fig. 5." and "Fig. 6."

- The packing is maximum (0.51) for 100% Cotton yarn and minimum for 30% core spun yarn.
- As the percent of core increases (from 0% to 30%) the packing coefficient of the yarn decreases. As a result, packing coefficient of C-MT> CP-15MT > CP-30MT.
- For low twisted yarns i.e., P-LT, CP-LT and PP-LT, the Cotton-polyester core spun yarn (CP-LT) has low packing coefficient and Polyester spun yarn (P-LT) has greater packing coefficient.

The packing coefficient of core spun yarn decreases as the core percent increases from 0% to 30% due to incorporation of high shape factor of the octalobal filaments in to the center of yarn. As the number of profiled fibres in the yarn increases, the porosity of intra fibre increases resulting low packing density.

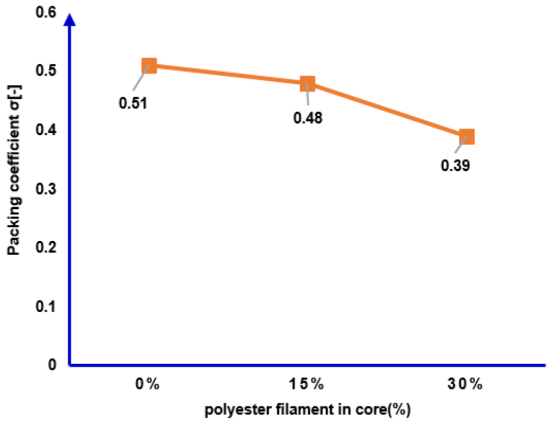

Fig. 5. Packing Coefficient of 34 tex yarns.

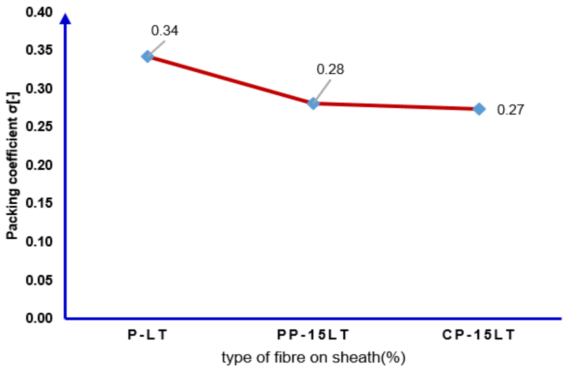

Fig. 6. Packing Coefficient of 57tex yarns

As the core spun yarn is dipped into water, the liquid penetrates the yarn and capillaries between cotton fibre and polyester filament start getting filled up. The liquid can be seen to rise through the both yarns due to wicking action. Overwhelming presence of cotton make capillary rise through polyester filament invisible. Once the steady state position is reached, the yarn reach the maximum wicking height obtained was untwisted to see whether the capillary flow in core polyester filament goes beyond. Photo graphs of yarns were taken as shown in 'Fig. 7." and "Fig. 8." It can be seen that, the liquid flow in polyester goes beyond the liquid mark seen in cotton or polyester staple fibres. The capillary flow rate through the polyester filament are faster in comparison to cotton and thus, equilibrium height attained by the capillary front is expected to be lower in cotton occupying sheath portion than polyester filament in core.

B. *Wicking process in core spun yarns*

Moisture absorption and release of the fibre depend up on nature of the fibre. Natural fibres such as cotton and wool are hydrophilic in nature, and absorbs moisture and fail to transport and release. However, manmade fibres such as polyester are hydrophobic due to low surface energy and as a result better moisture transporting property. So, neither natural nor synthetic fibres performs both moisture absorption and release simultaneously. To achieve this property, Core spun yarn is one of the solutions.

In combination of cotton sheath and octalobal polyester filament as a core. The filament (core) transports liquid faster. In contrary, cotton fibres transports the liquid at slower rate. So the saturation height become different. The same phenomenon was observed in combination of polyester-polyester core spun yarn also.

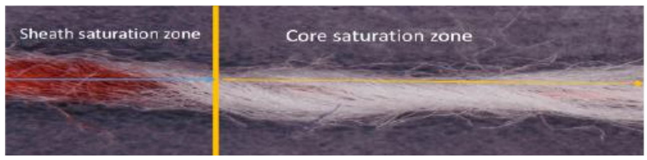

Fig. 7. Wicking behavior of core spun yarn with Cotton sheath and Octalobal polyester filament in core (85/15).

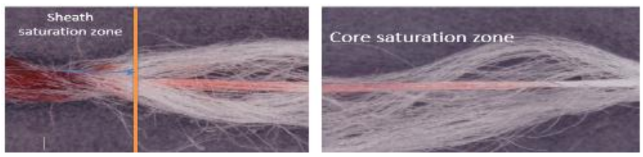

Fig. 8. Wicking behavior of core spun yarn with Polyester staple fibre sheath and Octalobal polyester filament in core (85/15)

C. *Wicking in the 34 tex yarns*

The wicking parameters (wicking height/distance and wicking constant), in the Horizontal, vertical and loop wicking modes were showed in the "Fig. 9." to "Fig. 14." Wicking graphs follow typically well-established pattern i.e. it rises fast at the beginning and gradually level off. The wicking height/distance -√time plots shows linear relationship. In all wicking modes, the following phenomenon were observed;

- The change in wicking height/distance and wicking constants with change in core percent is core-sheath ratio dependent. As percent of core increases, both wicking height/distance and wicking rate increases. As a result; 30% Core spun yarn has greater wicking parameters.

- Wicking height/distance and wicking constants of 100% Cotton yarns are less than core spun yarns.

Polyester filament has low surface energy in comparison to cotton fibre. The octalobal Polyester also have microchannel on its surface. When polyester is introduced into the core, the chemical nature of the filament and the micro channels helps in accelerating the wicking phenomenon due to capillary pressure.

More the number of polyester filaments, more capillaries available to transport a liquid through capillary channels made by discrete cotton fibres are irregular in shape and highly disoriented and discontinuous in nature. Therefore, one can expect capillary flow to be faster to the channels of polyester filament than those in between cotton fibres.

At the interface of polyester core and cotton sheath, the liquid may gate transferred from polyester dominated channels to cotton dominated channels. Therefore, near the interface between the channels, the flow may slow down.

When there are 30% polyester filaments, many capillary channels available near the core for transportation of liquid. Therefore, one would expect equilibrium of wicking height and wicking constant high in case of core spun yarn with 30% polyester filament in a core. However, if the yarn is twisted too much, the capillary channels distorted, channels more inclined with respect to yarn axis, and the fibres are more tightly packed. These phenomena, slows down the rate of wicking as well as wicking distance.

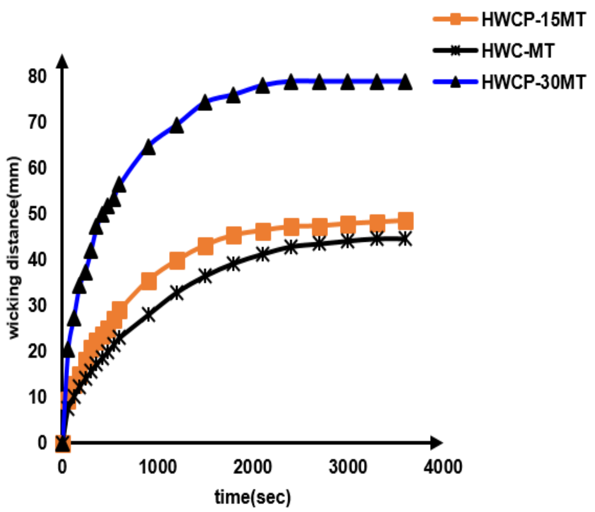

Fig. 9 Horizontal Wicking distance (34tex)

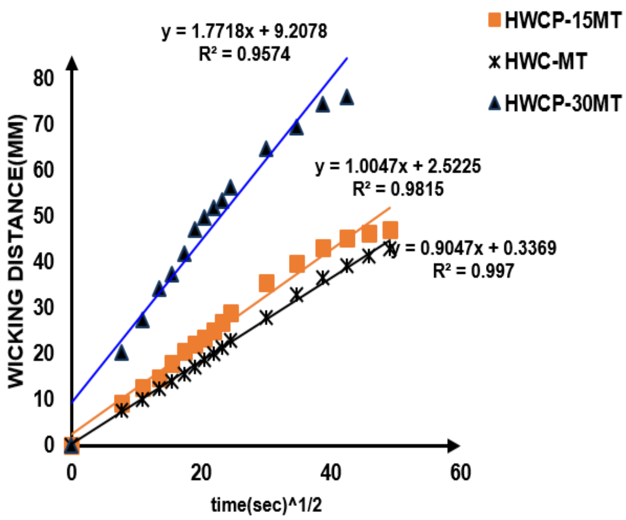

Fig. 10. Horizontal Wicking Constant (34tex)

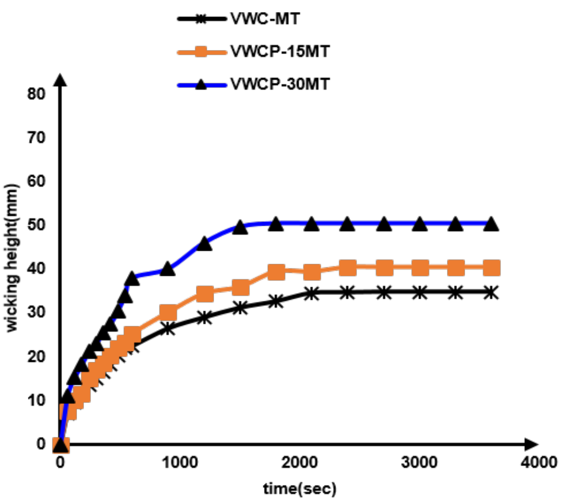

Fig. 11. Vertical wicking height of (34 tex)

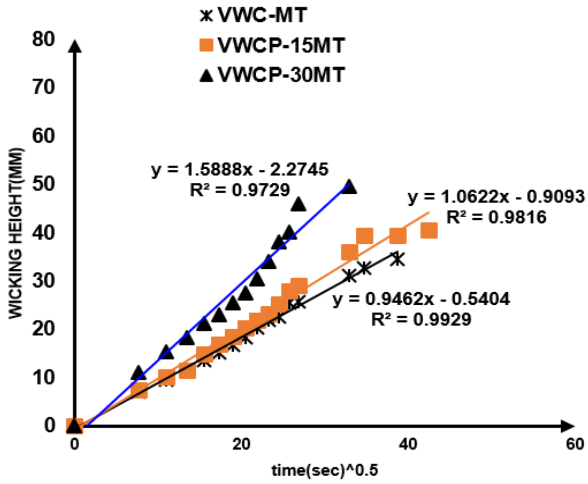

Fig. 12. Vertical wicking Constant (34tex)

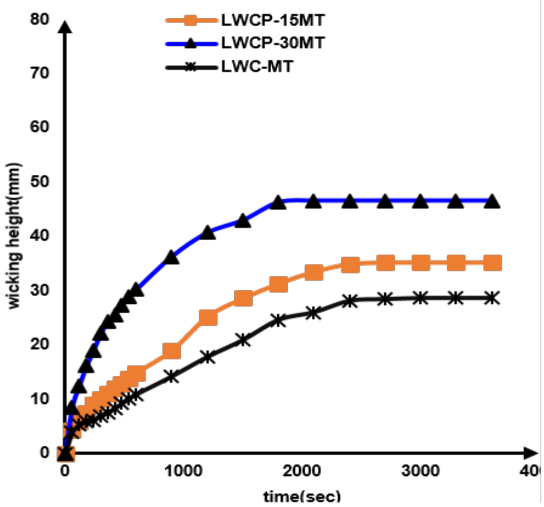

Fig. 13. Loop wicking height (34tex)

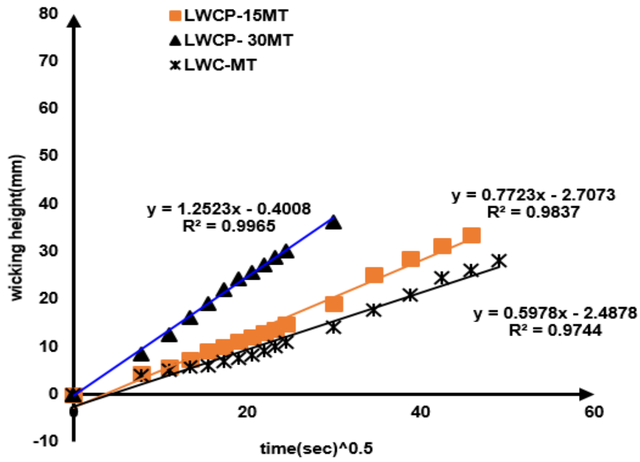

Fig. 14. Loop wicking Constant (34tex)

D. Wicking in the 57 tex yarns

The wicking height/distance Vs time and wicking constants of the yarns shown in “Fig. 15.” to “Fig. 20.”

- Both wicking distance and wicking constants are greater in Polyester-polyester core spun yarn and less in 100% Polyester spun yarn.
- When 15% octalobal polyester filament is incorporated in to polyester staple yarn, wicking parameters increased in all wicking modes.

Cotton yarn is expected to attain less wicking height than polyester yarn. The rate of wicking is also likely to be slower. However, by adding 15% octalobal polyester filament in core, the wicking height can be seen to surpass 100% staple polyester yarn. Few polyester filaments in core act as channel to transport the liquid to a greater height. However, it does not increase the wicking rate as reflected in wicking constant values since majority of the fibres are cotton.

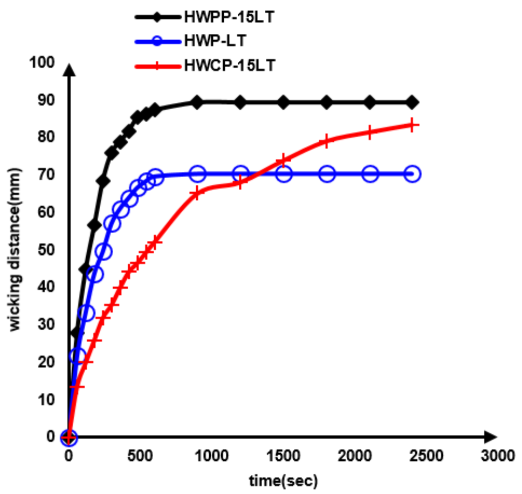

Fig. 15. Horizontal Wicking distance (57tex).

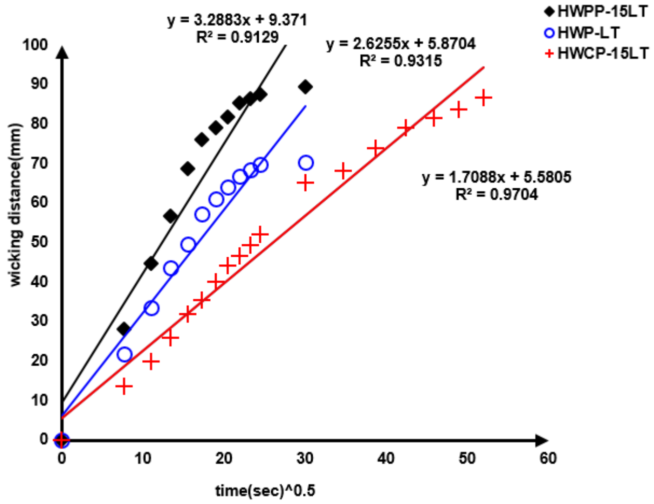

Fig. 16. Horizontal Wicking constant (57tex).

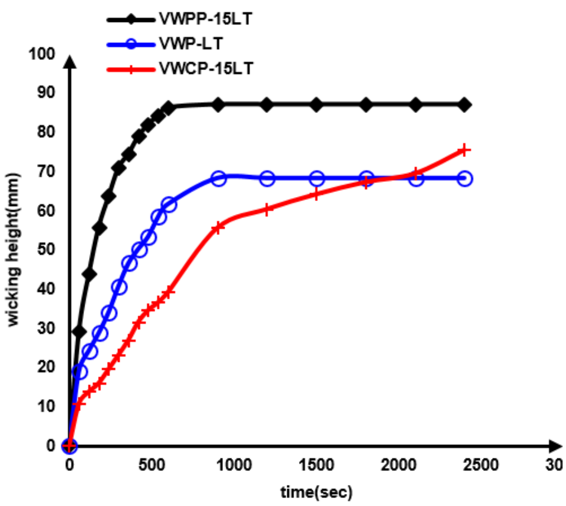

Fig. 17. Vertical Wicking distance (57tex).

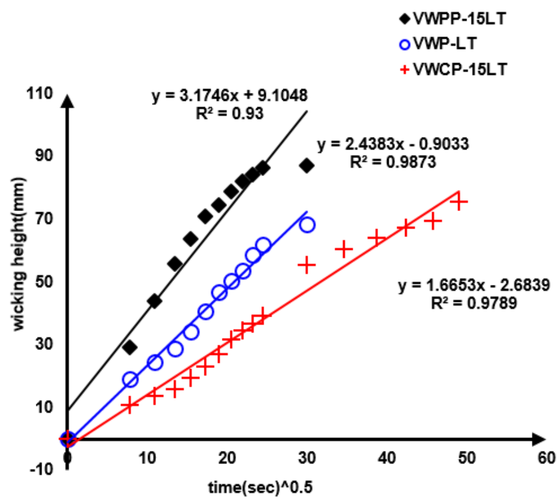

Fig. 18. Vertical Wicking constant (57tex).

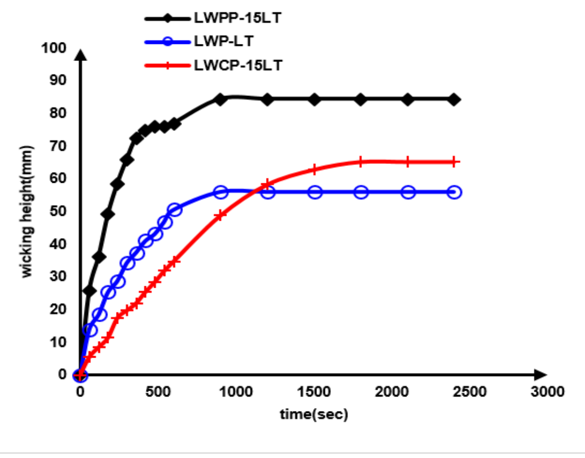

Fig. 19. Loop Wicking distance (57tex).

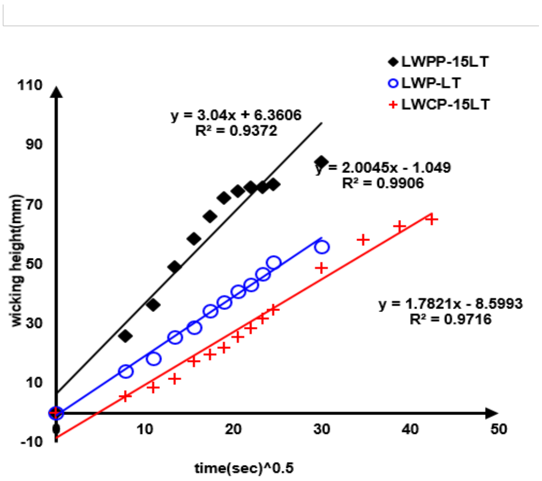

Fig. 20. Loop Wicking constant (57tex).

E. Comparison between wicking Parameters

The wicking height and wicking constants for three modes of testing for 34tex yarns are shown in "Fig. 21." (a & b). It was observed that:

- Wicking parameters are maximum for horizontal mode of wicking, intermediate for vertical wicking mode and low for loop wicking mode in all types of yarns used in the study.
- In all wicking modes, wicking parameters for Cotton yarn are less than core spun yarns.
- Presence of 30% of polyester in core results in highest wicking height and constant.

Wicking modes of 57tex yarns are shown in "Fig. 22." (a & b). It is observed that:

- The wicking parameters are always maximum for horizontal mode followed by vertical and loop modes of wicking.
- Wicking height of polyester staple yarn is always lowest in comparison to cotton-polyester and polyester-polyester core spun yarns.
- Addition of octalobal polyester filament in the case of Cotton and polyester staple fibre yarn make the yarn wick to greater height.
- Wicking constant lowest for Cotton-Polyester in Comparison to 100% Polyester staple yarn and Polyester-Polyester core spun yarn

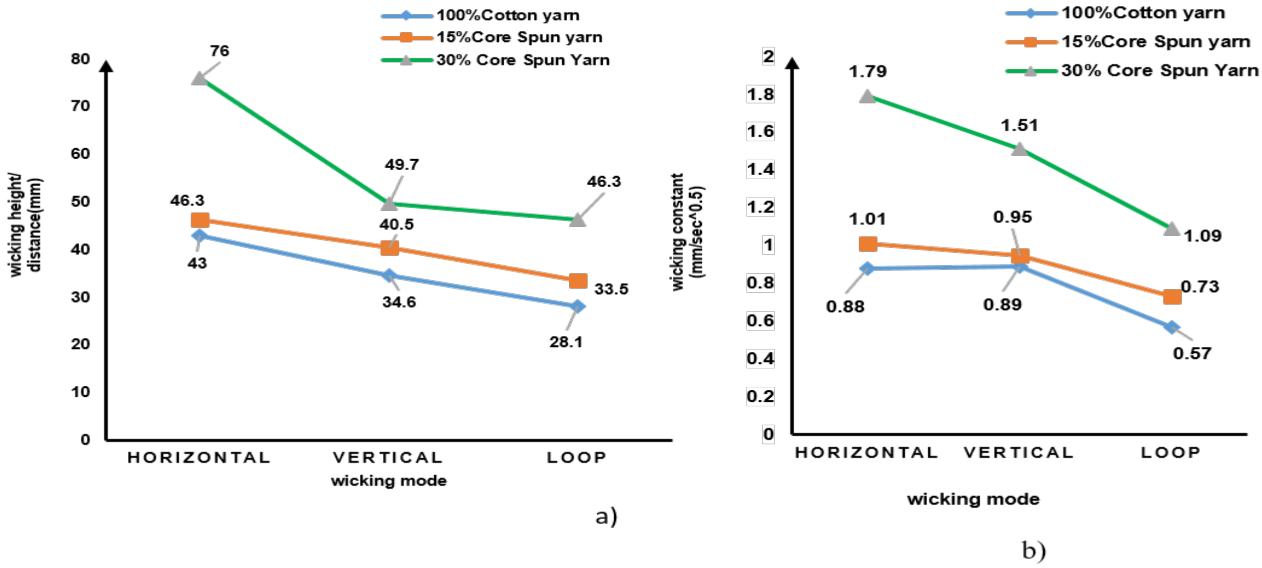

Fig. 21. Wicking mode Vs wicking parameters graphs for 34 tex yarn.

a) Wicking height. b) Wicking constant

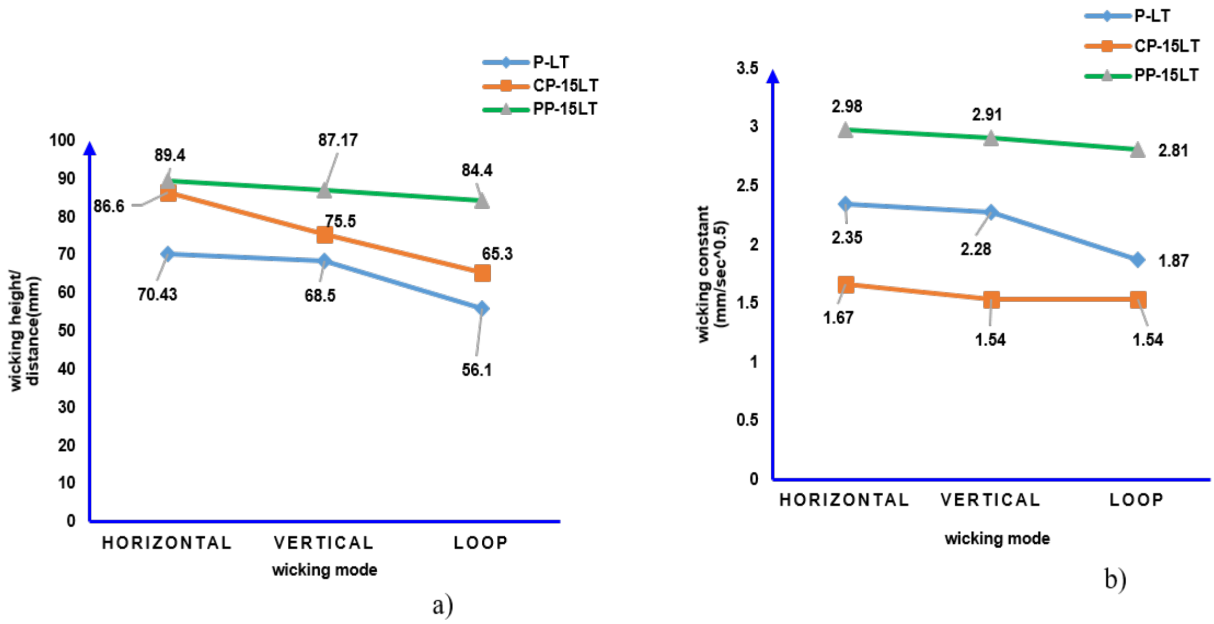

Fig. 22. Wicking mode Vs wicking parameters graphs for 57 tex yarn.

a) Wicking height, b) wicking constant.

In general, in the case of wicking in loop mode, since there is no cut ends, the liquid inters from the side of the yarn. Whereas in case of vertical and horizontal wicking, the liquid inters from the open cut end as well as from the side. In the case of side entry of liquid, the surface pores are available for entry of liquid through capillary pressure. As a result, the liquid flows from surface pores to the interior part of the yarn and moves up through the capillary channel. In the case of dipped cut ends, capillaries across the entire cross section of the yarn made available for liquid entry and flow through capillary channels. Thus, the wicking parameters become more in magnitude for horizontal and vertical wicking modes.

IV. CONCLUSION

- Packing coefficient of the core spun yarn decreases as percent of incorporated profiled multifilament polyester yarns as a core increases with respective of twist.
- Liquid wicking in the core spun yarn is affected by percent of core-sheath ratio, types of fibres from which the yarn made.
- Wicking parameters (Maximum wicking height/distance and wicking constant) of core spun yarns depends upon mode of testing. As a result, all ways horizontal wicking parameters are greater than vertical and loop wicking modes.
- In case of 34 tex yarns, the 30% Core spun yarn twisted at medium (CP-30MT) behaves better wicking in all wicking modes.
- In case of 57tex yarns, the core spun yarn made from polyester staple fibre as a sheath and octalobal Polyester filament as a core (PP-15LT) has better wicking property than Cotton – polyester core spun yarn (CP-15LT) and 100% Staple polyester yarn (P-LT).

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Optimizing Cost of Quality for an Export Oriented Readymade Garment Industry in Ethiopia

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Abstract

Ethiopia is fast growing to be one of the major sourcing destinations for major apparel brands viz. GAP, H&M, PVH, Decathlon to name a few. In order to sustain itself in the grueling global competition with countries like Cambodia, Vietnam and Kenya, it must be price competitive keeping up with the global quality standards. The researchers conducted an in-depth study of the operational costs incurred to produce a product right from the product development stage to the final shipment in 208 machines export oriented factory based out of Addis Ababa, Ethiopia. The results were startling with 26.8 % of the operational cost of the factory incurred against cost of quality whereas according to industry experts it should not be more than 10-15%. Cost of good quality accounted for 82.9% of the total cost of quality. Preventive cost, Appraisal cost, Internal Failure cost and External Failure cost were 27.6%, 55.3%,15.2% and 1.9% respectively. As per industry standards, the Failure cost should be maintained at half the level of Preventive cost. After quantifying and analyzing the components of Cost of quality, the researchers adopted the Six Sigma methodology of DMAIC to arrive at the root cause of the quality issues, find solutions for the same and formulate a standard mechanism to avoid their repetition in future. The researchers also developed an SOP document for quality and trained the responsible staff on the same. An improvement of 27.7% was recorded in DHU levels. It is highly believed that reducing the Cost of poor quality would have a direct impact on bottom line and would provide a competitive advantage to the factory.

Keywords- **COQ, DHU, TQM, SPC**

I. I. Introduction

The Ready-made garment (RMG) is the most important sector in Ethiopia in terms of employment, foreign exchange earnings and its contribution to Gross Domestic Product (GDP). It is the largest exporting industry in Ethiopia, which experienced phenomenal growth during the last 10 years. According to the financial reports 8-9% of its export earnings came from the garment industry. Trade incentives (AGOA, EBA, COMESA, GSP & TFTA), availability of cheap and readily trainable labor, low cost of power, export promotion schemes launched by the government, proliferation of world-class industry parks and rapid development of rail-road-air networks are the main contributary factors which would help Ethiopia in its growth path to be one of the major global apparel sourcing destinations. But, the major trade incentive, AGOA has been proposed to come to an end on 2025. Therefore, it is high time the Ethiopian Readymade Garment industry can gear up to optimize the productivity and quality.

On the other hand, most of the garment factories in Ethiopia do not have any well-laid out quality management system as per world class principles like Total Quality Management (TQM). Considering the reasons cited above, this study tried to identify and measures the cost of quality & non quality, introduce and implement the DMAIC methodology of Six Sigma in a selected garment industry to optimize the level of quality control as well as assurance.

DMAIC (Define, Measure, Analyze, Improve and Control) methodology helps to improve the existing processes through incremental improvements. DMAIC methodology is a problem-solving technique where process data is analyzed by different Six Sigma tools and identify the problems which cause the defects produce in the product.

A study by Antony et al., 2005, indicates Six Sigma as a more advanced level of quality, which will certainly implement those organizations that tend to business excellence after QMS (Quality Management System) certification per ISO 9000 series. It is a set of techniques based on Statistical Process Control (SPC) which can help companies to achieve significant improvement in product quality and therefore increase competitiveness.

What is Cost of Quality (COQ)?

COQ is defined as the sum of costs incurred in maintaining acceptable quality levels plus the cost of failure to maintain that level (cost of poor quality). COQ consist of Cost of Good Quality (COGQ) and Cost of Poor Quality (COPQ). Prevention cost and appraisal cost falls under COGQ, whereas, Internal Failure Costs, External Failure Costs comes under COPQ.

Prevention Cost: The costs of all activities (Fig. 1) specifically designed to prevent poor quality in an apparel product or associated processes.

Fig. 1. Components of Prevention cost

Appraisal Costs: The costs associated with measuring, evaluating apparel merchandise or auditing related to production in factory to assure conformance to quality standards and performance requirements (Fig. 2).

Fig. 2. Components of Appraisal cost

Internal Failure Costs (IFC): Failure costs that arise before apparel company supplies its product to the customer i.e. prior to delivery or shipment of the merchandise. The components of IFC are shown in Fig. 3.

External Failure Costs (EFC): These are typically due to errors found by customers. Failure cost that arises after a garment unit supplies the product to the customer. It is the amount of money incurred because the product was not manufactured right at the first time. The components of EFC are shown in Fig. 4.

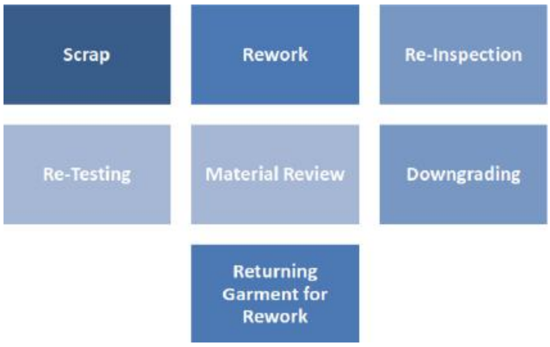

Fig. 3. Components of IFC cost

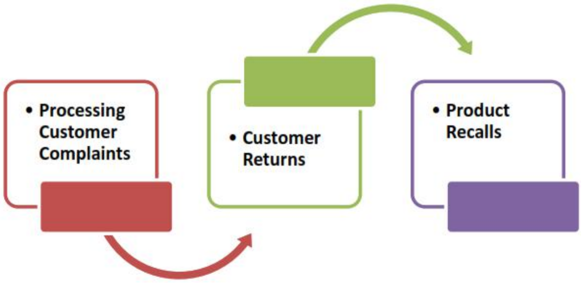

Fig. 4. Components of EFC cost

II. LITERATURE REVIEW

Experts point out that, for many organizations, quality-related costs go as high as 40 percent of total operating cost (Feigenbaum, 1961) or 15 to 20 percent of their sales revenue (Juran, 1951), whereas Corradi (1994) highlights that 20 to 30% of annual sales of a company are dissipated in bad quality costs, i.e. internal and external failures. The apparel factories lost on average 14.05 per cent of annual sales on account of Cost of Quality (Bheda, 2005). COPQ contributed to 39.76% of conversion cost and an annual loss of 171.7 Million in a 1200 machines factory (Gowda & Babu, 2014).

Heldt (1994) states that the gain from the elimination of failures can be multiplied by four without the need to increase sales. Harrington (1994) argues that any quality costs value that exceeds 6% of sales (without considering the costs of poor quality of administrative areas) should concern the company management. The standard is to keep the Prevention cost to be double the Failure cost. Ideally, for a company to thrive, cost of poor quality (COPQ) should not be more than 10 to 15 percent of the operating cost. However, an effective quality management program can lower this cost substantially. According to Tennant & Geoff (2001), a systematic continuous improvement process can largely minimize the defect percentage and increase the productivity.

Since 1951, when Dr Juran first published his Quality Control Handbook, the need for estimation of quality cost is highlighted as a stimulant for reducing the cost of non-conformance. However, very rarely does one find the application of quality costs in apparel industry. This case study demonstrates:

a) The process of quantification of the costs of nonconformance (CONC) in an export oriented Ethiopian readymade factory
b) The impact which optimization of CONC has on the bottom-line of the factory and
c) The process of its optimization using the tools laid down in the six-sigma methodology of DMAIC.

III. BACKGROUND OF STUDY

A case study was undertaken in one of the major sportswear and shirt manufacturing based out of Addis Ababa who had been doing job-work for a US buyer along with catering to the domestic market. The factory has total 208 machines with 299 employees.

This case study only focusses on cost of quality occurred on the shirt manufacturing line.

Limitation of study

Because of paucity of time, the researchers could not gauge the reduction in quality costs. But, on the contrary, clear reduction in other directly related contributory factors were recorded

IV. OBJECTIVE

Primary objective:

a. The Primary objective was to optimize the total cost of quality. It was achieved by quantifying the COQ through the formulation of a framework.

Secondary objective:

b. Improving processes capability through implementation of DMAIC methodology.
c. To assist in the establishment and implementation of quality management systems (QMS).

V. WORK METHODOLOGY

A. Calculation of COQ

The Cost of Quality was calculated by following steps:

1) Project Charter:

First, Project charter was prepared as shown in Fig. 5.

2) COQ - SIPOC:

In SIPOC (Supplier, Input, Process, Output, Customer) diagram is a tool prepared by the team to identify all relevant elements of the order fulfillment before work begins (Fig. 6).

3) Activity summary:

Detailed Road Map covering all activities was prepared. Then activities were identified and categorized, quantified which falls under COQ framework. Detail is given below:

a) A total of 100 activities were listed as part of entire manufacturing process.

b) 59 out of 100 activities were identified as quality oriented activities and therefore considered under COQ framework.

c) And then, approach to measure the separate cost element of each individual activity was calculated. (Fig. 7). The different components of COQ were calculated by using following formulae:

i) Preventive & Appraisal cost

Cost of Direct Manpower = A
Cost of Direct Consumables = B
Average % Operating Cost of Facility= C
Cost of Equipment Calibration = D
Cost for Each Activity = [(A +B + D) + {A x (1 + % C) – B – D)}]

Direct Manpower cost to be estimated and apportioned for each activity under Prevention and Appraisal Cost.

ii) Internal Failure Cost (IFC)

IFC= Cost of Rework + Cost of Material Loss

Cost of rework: {(A x B x C) + (D x C)}

- Defect Count, to be derived from Daily Quality MIS = A
- Rework SMV Value (for e.g. SMV of All Operations for Repairing +

Average Weighted SMV of Opening Seams + SMV of Re-cutting + SMV of Re-Inspection) = B

- Average Cost per SMV (Total Direct and Indirect Cost/Total SMV Available) = C
- SMV Consumed due to rescreen of Internal Audit Failures = D

Cost of Material Loss = {(A X B) + (C x D)}

- Per Unit Price of Material (Fabric/ Trims) = A
- Excess Consumption of Material (Fabric/Trims) with respect to Standard Allowance = B
- Cost of Per Garment = C
- Count of Garment Loss (Under Q3 (3rd quality) & Scrap Category) = D

iii) External Failure Cost (EFC)

EFC = Cost of Rework + Cost of Replacements

Cost of Rework = (A x B)

- SMV consumed for Rework & Repairing = A
- Average Cost Per SMV = B

Cost of Replacements under External Failure/Customer Complaints = (A x B)

- Average Cost of Garment Replaced = A
- Count of Garment Replaced = B

iv) IFC (Cost of Opportunity Loss)

- Average Revenue Per Garment = A
- Average Revenue Per Garment due to Q2 (2nd quality) = B
- Amount Debited to Material Supplier, if any = C
- Average Operating Cost of Warehouse & Logistics for Q2 = D
- No of Pieces as per Marketing Plan = R
- No of Pieces Dispatched as Q1 (1st quality) = S
- No of Pieces Dispatched as Q2) = T

Cost of Opportunity Loss = [{A x (R-S-T)} – (B x T) - C + D}]

Fig.5. Project Charter

As from Fig. 8, COGQ and COPQ were ETB 312,704 and ETB 64,412.80 respectively.

The percentage of COQ incurred was 26.8% of the total factory cost, which was very high (Fig.9). In detail, as it can been from fig. 10. that the percentage of Preventive cost, Appraisal cost, IFC and EFC were 27.6%, 55.3%, 15.2% and 1.9% respectively.

Ideally, for a company to thrive, cost of poor quality (COPQ) should not be more than 10 to 15 percent of the operating cost. It is possible to eliminate the costs of nonconformance, only if they can be identified. So, to identify the causes which are responsible for high cost of quality and to optimize the cost of quality DMAIC principles was used.

Cost Components	Jun' 18
Direct Factory Cost, Million ETB	1.00
Indirect Factory Cost, Million, ETB	0.40
Total Factory Cost, Million ETB	**1.40**
Cost of Good Quality, Million ETB	0.31
Cost of Poor Quality, Million ETB	0.06
Cost of Quality, Million ETB	**0.38**
Monthly Average DHU	80
%, CoQ to Factory Cost	**26.8%**

Fig. 9. overview of Factory cost and Quality Cost

A. Implementation of DMAIC

The DMAIC principle of Six Sigma was used as a baseline to identify the causes of high percentage of COPQ and then to optimize the COQ by taking proper actions. The steps followed are given below:

1. In first step of study, the researchers conducted gap analysis to assess the level of current quality systems, non-conformance/defect levels at various stages of apparel manufacturing which

were directly related to high COQ. The existing state of identified quality processes was mapped with the documents and formats being used, in unification with the process owners.

2. After mapping existing processes, those were analyzed constructively for strengths and weaknesses.
3. Based on the gaps analyzed, second phase of the study was initiated. During this phase designing of the QMS was carried out on the principles of Right First Time (RFT) and Process Control through Statistical Process Control (SPC) to minimize reliance on the final inspection.
4. On completion of process design, the important phase, training and communication of designed processes was commenced. People were trained on right, wrong and acceptable tangibles. Gaps related to process design were addressed with required training on SOP. The thought process of the organization was oriented to RFT mind set and ways to achieve it, were communicated which were mainly the various visual controls, statistical tools and the quality drills.
5. Finally, a sustainability plan and project continuity steps were shared with the core team which will take up the mantle of the continuous improvement team.

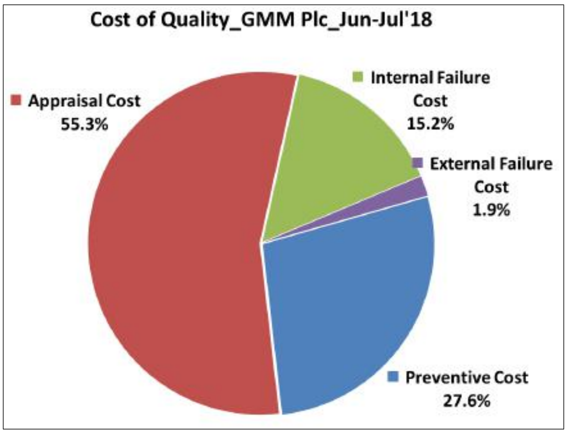

Fig. 10. Percentage of cumulative participation in quality cost

B. Diagnostic & Observations

To gauge and define quantitative and quality deliverables of the Quality Improvement Programme, a 2-days diagnostic was conducted. The findings on rework in the production line and audit (Internal as well Firewall), based on the 3 months data of duration March' 2018 to May' 2018 provided by facility during the diagnostic period is shown in Fig. 11. As it can been seen from fig, the actual values of rework at In line, EOL and FQC were very high. So, it needs to be revalidated with better MIS Implementation.

Rework at In-Line	Rework at EOL	Rework at FQC
2-4%	11.23%	7.31%

Pre-shipment and Final Audits

Audit type	Product	Total Audit	Failed Audit	Failure%
Internal Audit	Shirts	90	20	22%
Firewall Audit	Shirts	20	1	5%

Fig. 11. Rework and Audit percentage

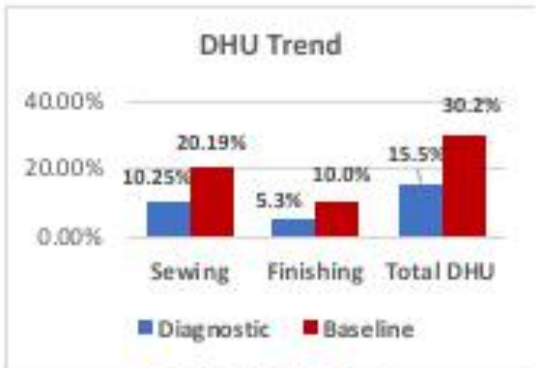

Fig: 12. DHU Trend

Product	KPI	Average: Historical Data	Average: During data validation	Basline
Shirt	EoL DHU	10.25	20.19	Baseline set for DHU for EoL & FQC at 27.8%
	FQC DHU	5.25	10.03	
	Total DHU	15.5	30.22	
	RFT-Internal Audit	71.70%	91.90%	71.70%

Table no.1. Baseline set for DHU

C. Observations Pertaining to Process and Systems in Place:

1) There was MIS for quality assurance. However, the data generated by the system, its usage for analysis and leveraging the information for improvement was at below average level.
2) The data suggests better quality performance at the beginning of process, parts and modules. The section reported an average alteration/rework level of 2-4% each. However, towards the FQC level it increases to 7%, followed by internal audit failures to the tune of 22% and external audit failures of 5% as shown in Fig. 11.
3) The nature of defects identified varies at each level of checking, indicating a lower maturity of common platform of product understanding. This was applicable to both internal and external checks/audits.
4) Structured tools for quality assurance were partly implemented but need to mature. Process audits were not conducted.
5) Statistical Analysis and approach to control process variations were missing, and reliable MIS system that must exist prior to any such approach was also missing.
6) The data of defects, defectives, stages of defects, DHU, alteration etc. was limited by the quality of MIS. The total DHU at sewing and finishing quality checkpoint was 18.5 % and RFT at internal audit was 71% as shown in Fig. 12 and 13 respectively.
7) Based on the data collected the baselines were set for individual KPIs (DHU & RFT), the baseline for DHU 27.8%, for RFT 71.7% set as shown in Table no. 1.
8) ***Process Gap:***

Process gap was carried out in each workstation/section and different observations were found as given below:

a) Fabric and Trims Stores

i) Activity: Fabric & Trims Receiving

Sub-activity: Receive, physical validation of quantity and temporary storage for quality inspection

Key Documents: Supplier Invoice

Observations:

- All incoming material should be stored in earmarked area for physical validation and preparation for Quality Inspection. Though there was an area marked for incoming material but in most of the cases material (specially fabric) was stored in other areas.

ii) Activity: Fabric & Trims Storage Post Inspection & Testing

Sub-activity: Inventory of quality pass material

Key Documents: Roll tag for fabric, Bin Card

Observations:

- For inspected fabric rolls, roll tag should be marked with color sticker (4 Numbers: 1– Fabric inspection, 2 – CSV, 3 - Lab test Report and 4 - Overall decision.
- Color Stickers for individual Roll was not being followed properly.
- Bin cards found not updated for part quantity issuances and balance stock properly.
- In Trims storage, many of shelves/storage cell found not marked properly.

b) Cutting

i) Activity: Spreading & Cutting Inspection

Sub-activity: Quality inspection during spreading & cutting

Key Documents: Control sheet, roll sheet, BOM, Gold seal sample, Spreading sheet

Observations:

- There was no spreading and cutting quality inspection report format available.
- No historical data analysis was available.

ii) Activity: End Bits Storage

Sub-activity: Mark & store end bits

Key Documents: Control sheet, Roll sheet and Spreading sheet

Observations:

- In most of the cases, End bits were not marked for fabric code, work order number, lay number and length.
- End bits were stored in carton boxes based on daily WIP irrespective of color, content etc.
- Due to no identification in most of the end bits and daily storage in cartons, it makes

nearly impossible to retrieve and use the right end bits for panel replacement.

iii) Activity: Panel Inspection

Sub-activity: Panel inspection of major components for fabric defects

Key Documents: Major and minor Defects, Panel inspection report

Observations:

- While inspecting the panels, only part serial number was recorded and not the part name.

c) Sewing

i) Activity: In Line Quality Audit

Sub-activity: In Line quality audit by roaming QC, Traffic light and Flag system based on random sampling

Key Documents: Gold Seal Sample, Traffic light card, Flags

Observations:

- In-Line Audit did not reflect the % defective at EOL Check Point through traffic light card and Flags in most of the cases.
- During change of operation or change of operator, the Flag should be able to identify the location and Traffic light card should also be updated for the same but in many of the cases the practice was not followed.
- In-Line QC should also conduct audit on EOL Checkers points to ensure quality of their output but in most of the cases it was diluted.

Effectiveness of In Line QC for Random Audit at Each Workstation in Sewing:

- Traffic Light Card of 31 operations / direct manpower were captured for 4 continuous days of random audit by In-Line QC.
- As Fig. 14. indicates that % observations by In Line QC for non-conformance was nowhere closer to % EOL recorded, hence indicates ineffectiveness of audit practice.

ii) Activity: End of Line (EOL) Checking

Sub-activity: 100% checking at EOL point by stationed checker

Key Documents: Gold Seal Sample, BOM sheet, Defects Taxonomy, EOL Report

Observations:

- Key points of Inspection, display of major & minor defects, fabric & trims specifications were not available at most of EOL Points.
- Many of the defects were returned to line for corrections without recording in the reports and pieces were send for alteration, once the first defect is found.
- There was an additional filter point after Sleeves Assembly EOL and no data was being recorded for defectives and passed.

d) Finishing

i) Activity: Internal audit/Pre-Final audit

Sub-activity: AQL based audit on 90% and above. Key Documents: Gold seal sample, Control sheet BOM sheet, Defects Taxonomy and Audit report

Date	Observation		Percentage	EOL for the Day
	Green – No Defect Found	Red – 1 or More Defect Found		
02 – June 2018	62	0	0.0%	12.7%
03 – June 2018	60	2	3.3%	10.8%
04 – June 2018	62	0	0.0%	9.2%
05 – June 2018	62	0	0.0%	9.2%

Fig: 14. Effectiveness of In-line audit on EOL audit

Observations:

- Appearance rating is one of key points of inspection but there was no standard available to gauge the required 5 appearance classifications (Excellent to Unsatisfactory)
- Key Inspection points and method of capturing primary observations was not clearly defined.

e) Illumination Level at various Quality Workstations

During gap analysis, it was also observed that Intensity of lux was not enough at some quality workstation as shown in Fig. 15.

9) Overall Gap Rating

Based on findings and analysis, the overall weighted score of the Gap was plotted as shown in Fig. 16.

a) Statistical Process Control

During gap analysis, it was observed that there was no concept of SPC, no analysis of data based on control chart, untrained staff on SPC. The score of SPC was zero as shown in Fig. 17.

Department	Point of Inspection	Type of Workstation	Lux Level		Major Influence of Sunlight
			Required	Observed	
Fabric & Trims Stores	Fabric Inspection	Fabric Inspection Machine	1000	1829	
	Trims Inspection	Inspection Table	1000	1332	•
Cutting	Cutting Table	Cutting Table	600	541	
	Panel Inspection	Inspection Table	1000	736	
	Bundle Audit	Inspection Table	1000	649	
Shirt Line					
Sewing	Sewing Machines - W/o Elect	Needle Point	600	218	•
	Sewing Machines - With Elect	Needle Point	600	502	
	Sleeves Section EOL	Inspection Table	1000	906	
	Body Section EOL	Inspection Table	1000	1047	
	Lining Section EOL	Inspection Table	1000	859	
	Body Assembly EOL	Inspection Table	1000	544	
	Sleeves Assembly EOL	Hanger Stand	1000	416	
		Inspection Table	1000	987	
	Spotting Machines	Machine Bed	600	590	
Finishing	FQC Point	Hanger Stand	1000	339	
	Internal Audit - Pre Final Audit	Hanger Stand	1000	390	•
		Inspection Table	1000	809	
Packing	Appearance Rating Audit	Hanger Stand	1000	246	
		Inspection Table	1000	588	

Fig. 15. Illumination level at different quality workstation

b) Visual Process Control

During gap analysis, it was observed that there were no visual cards, no display of quality performance of sections, key inspection points, defects etc. and score was only 22.5 out of 70 as shown in Fig. 18.

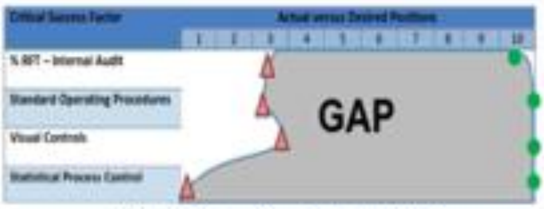

Fig:16. Overall weighted GAP

c) Standard Operating Procedures

Before conducting this study, there was no SOP. The SOP score was 16 (37.8%) out of 48 as shown in Fig. 19.

KPI	Maximum Score	Current Score	Rating %
SPC	50	0	0.00%

S. No.	Implementation of Any Advance Quality Concept	Score as mentioned Below	Number of Points of Conformance of Documented SOP: (0% = 0); (0-25% = 2.5); (25%-50% = 5); (50%-75% = 7.5); (75% - 100% = 10)
1	Introduction of Concept of SPC in Checking Procedure	10	0
2	Implementation of Concept of Control Charts in Sewing Lines	10	0
3	Staff of lines trained on SPC	10	0
4	Analysis of Data based on Control Charts	10	0
5	Action - Responsibility History Chart	10	0
	Weightage	100%	
	Score	50	0

Fig: 17. Statistical Process Control Score

10) *Process Loss*

Process loss is the loss of material in the manufacturing process. It is defined as the ratio of output up on input. Process loss in an apparel manufacturing process encompasses the different forms like rejection percentage of either of part or whole garment, excess consumption percentage of material than the standard value etc. Data for a duration of 5 months duration was analyzed (from January'18 to May'18) for process loss in terms of number of pieces and percentage which contributes to process losses. The percentage of first quality and seconds quality was 81.1% and 18.4 %, whereas scrap percentage found was 0.6 % as shown in Table no. 2.

a) Order Reconciliation:

Fig. 20. summarizes the occurrence of number of Orders accepted without debit, with Debit & RTS. The total no of orders pass without debit & with debit were 48 & 29 respectively, whereas total 3 orders rejected in duration of 5 months.

KPI	Maximum Score	Current Score	Rating %
VC	70	22.5	32.14%

S. No.	Visual Controls	Score as mentioned Below	Number of Points of Conformance of Documented SOP: (0% = 0); (0-25% = 2.5); (25%-50% = 5); (50%-75% = 7.5); (75% - 100% = 10)
1	Display of Major and Minor Defects	10	2.5
2	Display of Key Inspection Points	10	5
3	Display of Operator Quality DHU / DR	10	5
4	Display of Quality Performance of Section	10	5
5	5S Score Controls	10	2.5
6	Identification of CTQ	10	0
7	Visual cards	10	2.5
	Weightage		100%
	Score	70	22.5

Fig. 18. Scores in Visual Process Control

D. Design & Implementation of QMS

1. *Quality Workstation Design:*

The design of Quality workstation was standardized as shown in Fig. 21 encompassing followings:

i. Visual display of key points of inspection for the check point along with sequence of checking was started.
ii. Segregation of defective garments based on internal & external repairs for proper housekeeping of workstation and to enhance visibility.
iii. Slanted table base to facilitate ease of checking of part / garment.
iv. Workstation designed to facilitate enough illumination for checking to facilitate ease of checking.
v. Visual displays of critical, major and minor specifically related to operations in the area.
vi. Graphical display of Daily % defective & DHU Trend for EOL and Finishing Quality Check to communicate and enhanced awareness.

KPI	Maximum Score	Current Score	Rating %
SOPs	48	16	[illegible]

S. No.	Areas		Current Score
A	Documented Standard Operating Procedure Available in following Areas?	Score as mentioned Below	Current Score - "Yes" = 10; "No" = 0
1	Fabric inspection	10	10
2	Cutting Quality Procedures	10	10
3	Sewing Section	10	10
4	Finishing and Packing Section	10	0
	Weightage	30%	
	Score	12	9
B	Actual Shop Floor Implementation of these Documented Standard Operating Procedure Available in following Areas?	Score as mentioned Below	Number of Points of Conformance of Documented SOP: (0% = 0); (0-25% = 2.5); (25%-50% = 5); (50%-75% = 7.5); (75% - 100% = 10)
1	Fabric & Accessories Inspection	10	2.5
2	Cutting Quality Procedures	10	0
3	Sewing Section	10	2.5
4	Finishing and Packing Section	10	2.5
	Weightage	30%	
	Score	12	2
C	Generation of MIS in Following Areas?	Score as mentioned Below	Number of Points of Conformance of Documented SOP: (0% = 0); (0-25% = 2.5); (25%-50% = 5); (50%-75% = 7.5); (75% - 100% = 10)
1	Fabric inspection	10	2.5
2	Cutting Quality Procedures	10	2.5
3	Sewing Section	10	2.5
4	Finishing and Packing Section	10	2.5
5	Key Inspection Points - Over All	10	2.5
6	Quality Specification Sheet - Sewing Line	10	0
	Weightage	40%	
	Score	24	5

Fig: 19. SOP score

Fig. 20. Number of orders accepted without debit, with Debit & RTS

Fig. 21. Restructured Quality workstation

2. *Fabric and trim stores*

i. Restructured control sheet to facilitate the process with material specifications for orders.
ii. Strengthen fabric inspection and GRN process by establishing a section level daily MIS encompassing key parameters of the process (Fig. 22)

Fig. 22. Daily Fabric Inspection MIS

a. Trim inspection Format:

i. Strengthened trims inspection activity by restructuring the key points of inspection for trims required for the facility.
ii. Trims inspection workstation was redesigned to standardize the workplace based on 5S principles and to provide adequate illumination.

b. ***Fabric storage Layout:***

i. Re-planned the fabric storage area to support a minimum of 1.50 Lacs Meters fabric under Inspection and GRN process as shown in Fig. 23.

Fig. 23. Redesigned Fabric storage layout

3. ***Cutting***

a. Panel Inspection & Replacement:

i. Well-structured template was implemented to facilitate the panel inspection and panel replacement activities and to function as a key instrument for computation of fabric consumed for panel replacement

ii. Redesigned panel inspection workstation to standardize the workplace based on 5 S principles and to provide adequate illumination.

b. ***End Bits Storage:***

i. A visible and organized way of storing End bits for usages under panel replacement was implemented as shown in Fig. 24.

Before **After**

Fig. 24. End Bits Storage

4. ***Sewing***

a. EOL Checking Activity:

i. Template were re-designed as per sequence of checking and corresponding defects taxonomy.

b. **In Line QC Activity:**

Re-designed In Line QC function in tune with RFT & Lean principles, based on following guidelines:

i. In Line QC to check all points in the area in the first hours of day, in case of no defects, QC to mark Green on OPC Card.

ii. In case of defects, QC mark Red on OPC card, record on the report and QC to analyze the defects based on method, machine calibration, material quality, skill gap with respect to requirement, negligence.

iii. Post analysis and corrective action along with Operator, Operator to make next pieces and do 'Self Checking' up to 8 pieces.

iv. Post Self Checking, In Line QC to return to point and check pieces, in case of down ward trend of defects, QC to flag the point with Red color.

v. In case of no change in intensity, QC to involve line supervisor and quality supervisor for further action and move to next point,

vi. In next hours QC to only monitor flagged points along with CTQs (Critical to Quality) based on occurrence at EOL.

vii. Flag colors for New Operator, Operation Change, Critical to Product (CTP) and CTQ were as followed:

5. ***Finishing section***

a. Finishing Quality Checking Activity:

i. Restructured key points of inspection and template in tune with sequence of checking of garments.

b. Internal Audit

i. The audit report template for key points of inspection was restructured to facilitate accurate and objective approach for internal audit process.

6. ***System Adherence Analysis:***

For system adherence analysis, different scores were given by considering different key areas like availability of SOP, Follow up of documented SOP on the shop floor and generation of MIS in all different sections. The score during gap analysis was only 37.8% whereas after this study, it reached to 68.9%.

7. *Right First Time*

After completion of this study, RFT at internal audit was recorded. During diagnostic it was 71% whereas in last 4 week of project it became 82.6%, so there was significant improvement of 16.3% as shown in Fig. 25.

8. *DHU Trend*

DHU trend was analyzed in sewing and finishing section weekly wise (Fig. 26) and it was observed that there was an improvement of 27.7 % in total DHU from baseline as shown in Fig. 27.

9. *Framework for quality MIS*

Weekly as well as daily quality MIS framework along with top 3 defects analysis for each section was designed and implemented as shown in fig. 28 & 29.

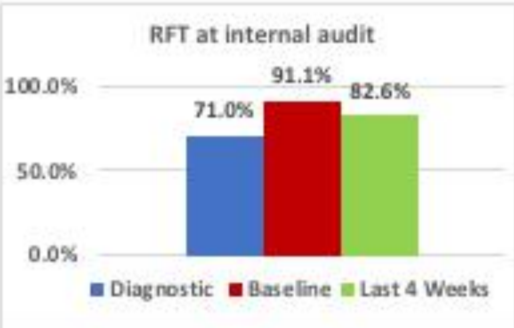

Fig. 25. Comparison of RFT % before & after QMS

Fig.26. Weekly Sewing and Finishing DHU Trend

Fig. 27. Comparison of DHU before & after QMS

10. *SPC*

Usages of SPC control charts were customized to make it user friendly in application in day to day working situation. SPC controls charts are to be used on all Critical to Product (CTP) points in the production lines. It was recommended to use of C-Chart for points which have attribute data characteristics and DNOM Chart on the points which have variable data characteristics as shown in Fig 30 and Fig. 31 respectively.

Classroom training on concepts, usages and analysis was conducted. It was followed by floor trials, implementation on scoped production area and then extension to rest of production area in facilities.

11. *Defined KPI & KRA for each position*

KRA and KPIs for each position in Quality department was designed and defined. The framework was designed for periodical evaluation of performance of each position on below parameters –

- System Adherence
- Amount of Rework
- Right First Time
- Process Loss

VI. CONCLUSION AND RECOMENDATION

This case study which was conducted in one the leading exporting factory in Ethiopia brings about many insights into the current status of high-quality costs and the reasons behind it. It also demonstrates how proper use of DMAIC principles can produce remarkable results in the optimization of excessive costs of quality. Because of paucity of time, the researchers could not gauge the reduction in quality costs. But, on the contrary, clear reduction in other directly related contributory factors were recorded.

On completion of this study the factory registered significant improvements. The DHU in the next 4 weeks after the project showed a distinct improvement of 27.7%. in DHU levels. The RFT% increased by 16.3% that is 69.5% from 79.5%. The system adherence score improved by 82.7%.

Therefore, it is highly believed that by following the model of quantification of cost of quality and DMAIC for its optimization, Ethiopian garment manufacturers can greatly benefit by being more competitive in the global sourcing market both in terms of costs and quality.

ACKNOWLEDGEMENT

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APPENDICES

Abbreviations

COQ - Cost of Quality

COGQ - Cost of Good Quality

COPQ - Cost of Poor Quality

KPI- Key Performance Indicator

KRA - Key Reserved Area

DHU - Defects Per Hundred Unit

RFT - Right First Time

EOL - End of Line

FQC - Final Quality Check

GRN - Goods Received Note

OPC - Operator Performance Card

QC - Quality Checker

RTS - Returned to Supplier

OPC - Operator Performance Card

DNOM - Deviation from Nominal

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Annex

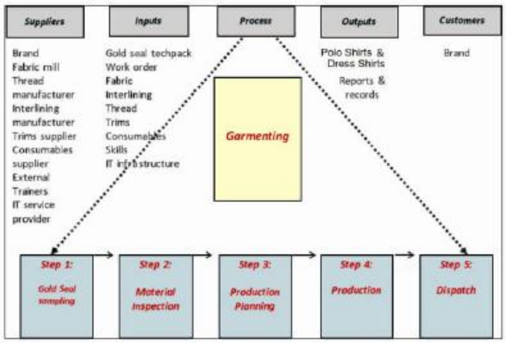


Fig. 6. SIPOC Chart

Broad Roadmap	Section	No of Activities	Activities Identified Under CoQ Framework			
			Preventive Cost	Appraisal Cost	Internal Failure Cost	External Failure Cost
Sampling	Sampling	16	3	3	3	
Material Inspection	Material Inspection	9	2	4		
Production Planning	Planning	4	3			
	Industrial Engineering	11	3			
Production	Training & Quality Improvement Projects	3	3			
	Maintenance	2	1	1		
	CAD, Cutting, Sewing, Finishing & Packing	54	6	19	6	2
Dispatch	Dispatch	1				
Total Activities		100	21	27	9	2
Total Activities Vs Activities Under CoQ Framework		100	59			

Fig. 7. Activity Summary

Cost Components		Preventive Cost	Appraisal Cost	IFC	EFC
Direct Manpower Cost		102,188	196,818		
Consumables		2,000	11,699		
Internal Rework - Defects				20,682	
Internal Audit				3,120	
Raw Material & Product Loss				33,447	
Rework Due to External Failure					164
Cost of Replacements					7,000
Total Cost		104,188	208,516	57,248	7,164
Cost of Good Quality	ETB	312,704			
	Million, ETB	0.31			
Cost of Poor Quality	ETB			64,412.86	
	Million, ETB			0.06	
Cost of Quality	Million, ETB	0.38			

Fig. 8. Summary of cost components

Daily Quality MIS Summary													
										Date	28-Aug		
Section	Operation	Observation											
Fabric & Trims Stores	Fabric Inspection	Inspected Lot Qty.				Inspected Meterage				Lot Qty. Pass Under Visual Inspection			
		20561.3				6858.3				19600.2			
Cutting	Panel Inspection & Replacement	No of Panels Inspected		No of Panels Defective		No of Panels Review & Pass		No of Panels - Replaced		No of Panels - Scraped		% Defective	% Pass & Replaced
		31996		333		51		274		8		1.0%	97.6%
	Panel / Parts Replaced for Pieces from Batch	Damage	Missing Parts	Stains	Fabric Defects	Shade Variation	Other sewing issues	Total Defective Garments	No of Panels - Replaced	No of Garments - Scraped	Daily Sewing Production	% Defective	% Replaced
		82	32	0	35	16	7	172	172	0	5184	3.3%	100%
	Bundle Audit	Audits Conducted	1st Audit Pass	Total Audit - Fail	Mis Cut /Wrong Cut/Wrong bundle card		Notch / Drill Defect		Missing - Extra Ply / Part		Fusing Defect	Fabric Defect	Numbering Defect
		43	35	8	0		2		5		0	1	0
Sewing	Sewing DHU - Jackets	Line 1			Line 2			Line 3			Sewing DHU - Overall Jackets		
		10.69			10.73			22.71			12.47		
	Sewing DHU - Trousers	Lean Line 1	Lean Line 2	Lean Line 3	Lean Line 4	Lean Line 5	Lean Line 6	Lean Line 7	Lean Line 8	Lean Line 9	Sewing DHU - Overall Trousers		
		7.24	8.14	12.32		0.00	11.30		11.43	12.78	9.86		
	Sewing DHU - Overall										11.17		
Finishing	Finishing DHU - Jackets	Line 1			Line 2			Line 3			Finishing DHU - Overall Jackets		
		13.67			7.95			7.67			10.40		
	Finishing DHU - Trousers	Lean Line 1	Lean Line 2	Lean Line 3	Lean Line 4	Lean Line 5	Lean Line 6	Lean Line 7	Lean Line 8	Lean Line 9	Finishing DHU - Overall Trousers		
		3.95	1.96	0.87		6.43	2.91		1.93	4.39	3.81		
	Finishing DHU - Overall										7.10		
	Internal Audit - Jackets	Audits Conducted				Audits - Pass					% RFT		
		9				9					100%		
	Internal Audit - Trousers	Audits Conducted				Audits - Pass					% RFT		
		30				23					77%		
	Internal Audit - Overall	Audits Conducted				Audits - Pass					% RFT		
		39				32					82%		
Packing	Fire Wall Audit - Jackets	Audits Conducted				Audits - Pass					% RFT		
		3				3					100%		
	Fire Wall Audit - Trousers	Audits Conducted				Audits - Pass					% RFT		
		7				7					100%		
	Fire Wall Audit - Overall	Audits Conducted				Audits - Pass					% RFT		
		10				10					100%		

Fig.28. Daily Quality MIS summary along with top 3 defects for each section

GMM Garment Plc	Name of Operation	Type of Machine	Name of QC		Chart Number
Attributes Data		Machine Gauge	Average DHU (C-Bar) =	Frequency of Sample Per Day	No of Pieces to be Checked
Count Chart (C-Chart)			UCL =	8 times	8 Pieces
			LCL = 0 (Zero by Default)		

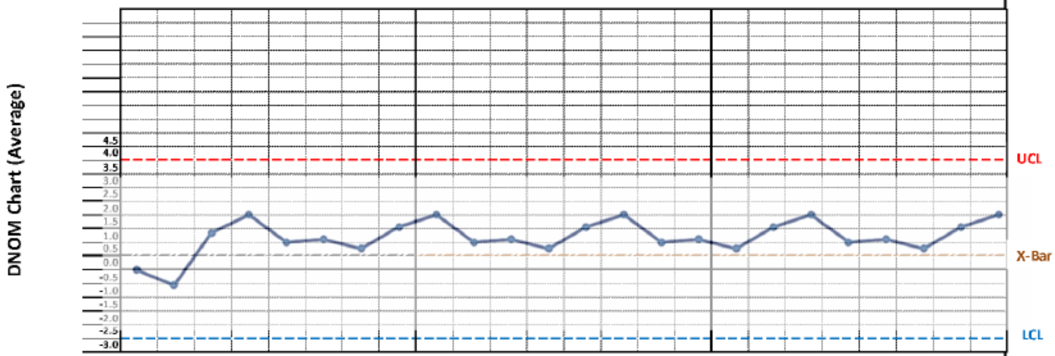
Date																									Supervisor's Comment:
No of Hours	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	
Defect Data																									
Total																									
DHU																									
Average DHU																									
UCL																									
LCL																									
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	
C - Chart 50																									
40																									
30																									
20																									
10																									
0																									
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	

Fig. 30 C-Chart for attribute data

GMM Garment Plc	Name of Operation	Type of Machine	Name of QC / Auditor		Chart Number
		SNLS			
Variable Data	Measurement of Front placket length in formal shirt	Machine Gauge 3/4"	X Bar	0.29	Frequence of Samples Per Day 8
			UCL=	3.60	
			LCL=	-3.03	
DNOM Chart	Measurement Specification		R Bar	5.75	No of Pieces to be Checked Per Sample
	S 75, M 77, L 79, XL 81, XXL 83		UCL=	12.16	
			LCL=	0.00	

Supervisor's Comment:

Date	Monday, July 2, 2018								Tuesday, July 3, 2018								Wednesday, July 4, 2018							
Sample No. »	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Sample Subset No. 1 Sizes	S	S	M	M	L	L	L	L	M	M	M	M	S	S	S	S	M	M	XL	XL	M	XXL	XXL	XXL
Variation	-0.50	-0.25	0.50	0.75	0.00	0.50	0.25	0.50	0.75	0.00	0.50	0.25	0.50	0.75	0.00	0.50	0.25	0.50	0.75	0.00	0.50	0.25	0.50	0.75
2 Sizes	M	M	M	S	S	S	M	L	L	L	M	M	M	M	M	L	L	L	L	L	S	S	S	S
Variation	-0.25	-1.00	0.75	0.25	0.00	0.25	-1.00	0.75	0.25	0.00	0.25	-1.00	0.75	0.25	0.00	0.25	-1.00	0.75	0.25	0.00	0.25	-1.00	0.75	0.25
3 Sizes	S	S	S	S	M	M	M	M	S	S	S	S	S	L	L	XL	XL	XXL	XXL	S	S	S	M	M
Variation	0.00	-0.50	-0.25	0.75	0.50	0.00	0.50	0.25	0.75	0.50	0.00	0.50	0.25	0.75	0.50	0.00	0.50	0.25	0.75	0.50	0.00	0.50	0.25	0.75
4 Sizes	S	S	S	S	M	M	M	M	S	S	S	S	S	L	L	XL	XL	XXL	XXL	S	S	S	M	M
Variation	0.00	-0.50	0.25	0.75	0.50	0.00	0.50	0.25	0.75	0.50	0.00	0.50	0.25	0.75	0.50	0.00	0.50	0.25	0.75	0.50	0.00	0.50	0.25	0.75
5 Sizes	S	S	M	M	L	L	L	L	M	M	M	M	S	S	S	S	M	M	XL	XL	M	XXL	XXL	XXL
Variation	-0.50	-0.25	0.50	0.75	0.00	0.50	0.25	0.50	0.75	0.00	0.50	0.25	0.50	0.75	0.00	0.50	0.25	0.50	0.75	0.00	0.50	0.25	0.50	0.75
Total Variation	-1.25	-2.50	1.75	3.25	1.00	1.25	0.50	2.25	3.25	1.00	1.25	0.50	2.25	3.25	1.00	1.25	0.50	2.25	3.25	1.00	1.25	0.50	2.25	3.25
Average Variation	-0.25	-0.50	0.35	0.65	0.20	0.25	0.10	0.45	0.65	0.20	0.25	0.10	0.45	0.65	0.20	0.25	0.10	0.45	0.65	0.20	0.25	0.10	0.45	0.65
Range	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75
X-Bar	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
UCL	3.60	3.60	3.60	3.60	3.60	3.60	3.60	3.60	3.60	3.60	3.60	3.60	3.60	3.60	3.60	3.60	3.60	3.60	3.60	3.60	3.60	3.60	3.60	3.60
LCL	-3.03	-3.03	-3.03	-3.03	-3.03	-3.03	-3.03	-3.03	-3.03	-3.03	-3.03	-3.03	-3.03	-3.03	-3.03	-3.03	-3.03	-3.03	-3.03	-3.03	-3.03	-3.03	-3.03	-3.03
R-Bar	6.04	6.04	6.04	6.04	6.04	6.04	6.04	6.04	6.04	6.04	6.04	6.04	6.04	6.04	6.04	6.04	6.04	6.04	6.04	6.04	6.04	6.04	6.04	6.04
UCL	12.16	12.16	12.16	12.16	12.16	12.16	12.16	12.16	12.16	12.16	12.16	12.16	12.16	12.16	12.16	12.16	12.16	12.16	12.16	12.16	12.16	12.16	12.16	12.16
LCL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00



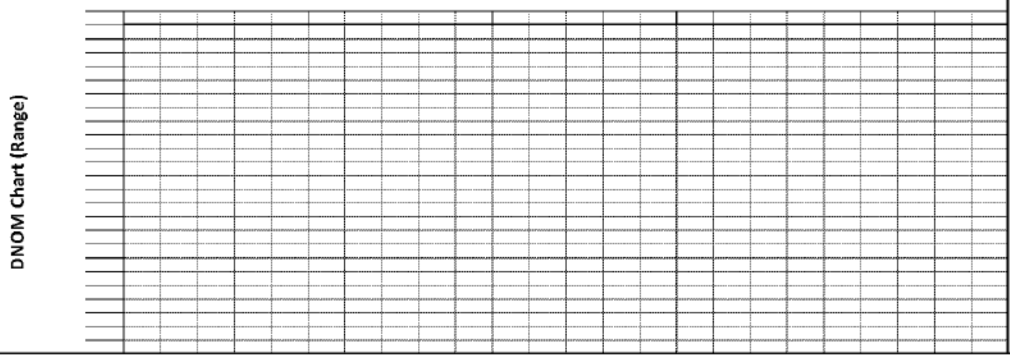


Fig. 31 DNOM Chart for Variable data

Microencapsulation for Imparting Aroma using *Artemisia Afra* Leaves on Cotton

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Abstract

Recently, herbal products have been widely used in textiles due to its ability to impart functional properties and aesthetics to textiles. They can be incorporated by direct adsorption or chemical reaction with fibre or by incorporating them through carriers. This work discusses an extraction of essential oil from the leaves of Artemisia afra (African wormwood) plant and its application for aroma finishing on cotton fabric using encapsulation techniques. Artemisia afra oil was successfully microencapsulated in gelatin as shell material by simple coacervation method. Microencapsulation of Artemisia afra oil can protect and prevent the loss of volatile aromatic ingredients and improve the controlled release and stability of the core material. The microencapsulate of Artemisia afra oil was characterized by means of optical microscopy, scanning electron microscopy (SEM), particle size analyser (PSA), thermal gravimetric analyser (TGA) and Fourier transform infrared spectroscopy (FT-IR). The efficacy of aroma of microcapsule treated fabric was studied in terms of wash durability. The microcapsule treated fabric can retain aroma up to 15 washes whereas microcapsule treated fabric with binder can retain aroma even after 15 washes compared to pure Artemisia afra treated fabric.

*Keywords***: *Artemisia afra* oil, Gelatin, Encapsulation, Padding, Cotton**

I. INTRODUCTION

Fragrances and flavours have been used widely in many fields of application, such as food, medicine, tobacco, textile, leather, paper making, cosmetics and so on [1]. In recent years, textile materials have been found in applications in the cosmetics field [2]. With rising global trends and changing lifestyle in terms of fashion, beauty as well as healthcare, awareness of consumers has enforced evolution of speciality value added textiles [3]. Fragrance finishing of textiles is one of the processes which enhances the value of the product by adding various odours to it. Fragrance finishing of textile materials has been greatly expanded and used in recent years [4]. The addition of essential oils on textiles makes feel the wearer fresh and relaxed by the unique aromas of oils [3]. Finishing a textile with fragrance is an important commercial target and an engineering challenge [1].

In aromatherapy textiles, essential oils are used for fragrance, antimicrobial, and medical properties. Over the last 50 years, plants are utilized as a potential source of natural aromas in the form of essential oils [5]. Fragrant textiles containing essential oils are new in aromachology and aromatherapy science. Aromatherapy textile plays an important role in removing important physiological requirements, making relaxation and happiness in the individual, and also help eliminate pathogenic bacteria [6].

The most of the volatile perfuming materials loses their effectiveness during the manufacturing process and storage, thus the most difficult task in aroma finishing of textile is to prolong the lifetime of fragrance [7]-[8]. By using microencapsulation technique, the retention of aroma on textiles has been proved to have improved and also offer diversified opportunities to improve aesthetics through application of additional compounds such as aromas, dyes, antimicrobial agents and phase changing materials with aid of binder with good wash durability [3]. The fast development of microencapsulation techniques has provided slower release of fragrances or flavours, which is spreaded out over longer period with fragrance smell, instead of being instantaneous [7]. During the past decade this approach has been explored widely by the food, agricultural, cosmetic, and textile industries [9].

The aerial parts of *Artemisia afra* have the strong characteristic odour of wormwood and a bitter taste. The leaves are the important components of the plant used along with roots and steam [3]. Very typical of *Artemisia afra* is the strong, sticky sweet smell that it exudes when touched or cut. It is the only indigenous species in the Artemisia genus in the Southern and Eastern parts of Africa [10]. The essential oils of *Artemisia afra* are frequently used for flavours and fragrance in the perfume, pharmaceutical, cosmetic and food industries [11]. *Artemisia afra* plant contains volatile oil, terpenoids, coumarins, acetylenes, scopoletin, flavonoids as well as triacontane and umbelliferone etc [3].

In this research work *Artemisia afra* oil which possesses properties like mood lifting during depression, deodorizing, inanition of human stimuli etc. is used as the core material for encapsulation and gelatin is used as a shell material. A simple coacervation method was used for preparation of microcapsules and these microcapsules were subjected for drying using freeze drying [12]-[13]. The dried microcapsules were then applied on to cotton fabric by pad dry cure method and the effect of aroma has been studied.

II. MATERIALS AND METHODS

2.1 Materials

Dried *Artemisia afra* plant leaves (purchased from local market, Addis Ababa, Ethiopia) were used for aroma finishing. The leaves were dried in sunlight and grinded into medium fine powder using mixer. Plain woven bleached cotton fabrics (116 gm/m^2) were procured from Piyush Syndicate, Mumbai, India. Gelatin and sodium sulphate were supplied by S D Fine Chemicals and Ami Chemicals Ltd. respectively. Pidicryl Binder SUN was supplied by Pidilite Industries Ltd. Ethanol (C_2H_5OH) and non-ionic detergent was supplied by S D Fine Chemicals Ltd., Mumbai.

2.2 Methods

2.2.1 Extraction of essential oil using Sohxlet

20 gm of air-dried *Artemisia afra* powder was taken in 350 mL of ethanol and extracted for 4-5 h at 80°C. The solvent from the extracts was completely evaporated using vacuum rotary evaporator (Heidolph, Germany)) and dried powder was stored at 4°C.

2.2.2 Preparation of microcapsules

10 gm Gelatine was dissolved in distilled water at 60°C for 30 min by continued stirring at 850 rpm. The stirring was continued for 20 min followed by the addition of 1gm core material (*Artemisia afra* oil). The mixture was stirred further for 30 min at 40-50°C. This was followed by addition of 15 mL of 20% sodium sulphate solution drop by drop, until the phase separation of gelatin and core material took place. The formation of polymer walls around the oil took place due to the addition of phase inducer. Stirring was continued further for 20 min and then the temperature was lowered to 10°C for 1 h, resulting in gel formation. The microcapsules slurry was further subjected to freeze drying (Labconco freeze dryer, Model No. 7948030) at -70 to -80°C for 24 h. Freeze drying is attributed to the least temperature used in freeze drying, enabling maximum retention of oil in the capsules. [13]-[12].

2.2.3 Application

In 100 mL water, 30 gm/L dried microcapsules and 100 gm/L Pidicryl binder SUN were added and the solution was stirred well. The cotton fabric was dipped in the dispersion for 3 min and padded with 90% weight pick up. Fabric was then dried in air and cured at 100°C for 1 min.

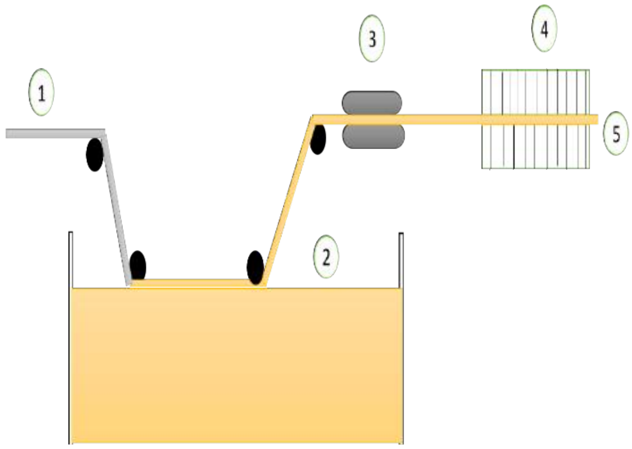


Fig. 17. Schematic representation of the microcapsules application process in fabrics

1. Untreated fabric, (2) microcapsule bath, (3) squeezing roller (4) drying and curing chamber (5) treated fabric containing microcapsules.

2.3 Characterization

2.3.1 Electro microscopic analysis

The electron microscopic evaluation of microcapsule slurry was carried out and magnified images of microcapsules were recorded on LEICA electronic microscope, (Brookhaven Instrument Corporation) which works on Dynamic Light Scattering (DLS) magnification of 10X to 50X.

2.3.2 Scanning electron micrograph (SEM)

Scanning electron micrograph (SEM) of microcapsules treated and untreated cotton fabric were recorded on Philips XL 30 SEM – Scanning Electron Microscope (Sr. No. D1217), Netherlands, to see the presence of microcapsules on the fabric. Each sample was fixed on a standard sample holder and sputter coated with gold. They were then examined with a SEM with suitable acceleration voltage of 10KV and 1500X magnification [13].

2.3.3 Particle Size Analysis

The characterization of microencapsulate was carried out by measuring the particle size distribution and the average particle diameter using a Laser Diffraction Particle Size Analyser (Malvern Master Sizer MSE, Malvern Instruments Ltd., Malvern, Worcestershire, U.K.).

2.3.4 FT-IR Analysis

FT-IR analysis was carried out for understanding the chemical groups present in untreated and treated cotton fabric, using pike miracle Attenuated Total Reflection (ATR) module with diamond/ZnSe crystal. The instrument was used to measure reflectance spectrum of the samples at 400–4000 cm^{-1} wavelength ranges and recording 45 scans in each case at resolution of 4 cm^{-1}.

2.3.5 Thermal analysis of microcapsules (TGA)

TGA-Q5000IR (TA Instruments, USA) was employed to evaluate thermal behaviour of core material (*Artemisia afra*) and the dried microcapsules. The samples of 6 mg were weighed and heated at 10°C/min from 25 to 500°C under a constant nitrogen flow of 20 mL/min [14].

2.3.6 Qualitative evaluation of odour and its fragrance rating

The method of odour evaluation was based on Lewis's procedure. To have relative idea about sensorial intensity of oil, the treated samples were kept in open desk at room temperature (22-25°C) and the fragrance evaluation was done by panel of 5 to 10 judges. The washed samples were evaluated within 24h after washing [8]. Standard sample of each scale was first given to all judges to rank the test specimen. Evaluation was done for all washed and unwashed treated samples which were packed in an airtight polyethylene bag so that there was no release of fragrance before the evaluation due to exposure to air or light. The samples were placed in a room for 1 h to stabilise the evaporation of fragrance prior to being judged [13]. To prevent biasing, the judges were not allowed in or near the stabilising room, and samples were brought to a judge in an evaluation room. To detect odour, a specimen was put on a flat hard board on a desk, a judge would use a fingernail to scratch a "×" mark on the specimen to rupture some capsules and smell the swatch. Judges were allowed to take 3–4 sniffs for each sample in an open corridor and rank them in prepared rating scales. No judge performed testing for more than 15 min period at stretch and was given minimum of 15 min rest period between the two sessions. In similar way fragrance durability after a selected number of washing cycles was evaluated using same panel of judges. Sometimes they were also given smell of strong coffee in between to clear off their nostrils from the smell of previous sample [15]. The judges rated the fragrance as per the following ranking: '+++++' denotes very strong, '++++' denotes strong, '+++' denotes common, '++' denotes weak, '+' denotes very weak, '-'denotes not detectable [15]

2.3.7 Wash fastness

Treated fabrics were tested for number of washing cycles according to ISO 105-C03 test method. The samples were washed in 5 gm/L standard non-ionic soap and 2 gm/L soda ash solution at 60°C for 30 min, keeping liquor to material ratio at 50:1 in wash fastness tester (Launder-o-meter)-Rosari lab tech, India [16].

2.3.8 Evaluation of colour change

The cotton fabric treated with microencapsulated *Artemisia afra* oil were subjected to test L∗, a∗ and b∗ values in terms of CIELAB colour space. All the samples were analysed for these values using Spectra flash® SF 300, Computer Colour Matching System supplied by Data Colour International, U.S.A.

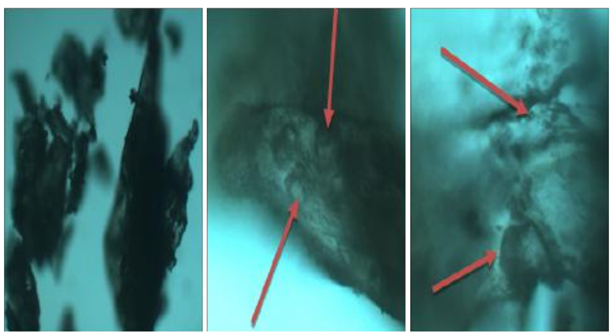
2.3.9 Evaluation of mechanical properties of the microcapsule treated fabric

The fabric strength was analysed according to ASTM D 5035 (1995), standard test method for measurement of elongation and breaking strength of the fabric on Tinus Olsen H5KS Universal Testing Machine (UTM) [13].

III. RESULTS AND DISCUSSION

3.1 Electro microscopic analysis of microcapsules

The electron microscopic evaluation of microcapsule slurry was carried out and magnified images of microcapsules were recorded on LEICA electronic microscope. Figs. 2a, 2b and 2c, demonstrates the aspects of the microcapsules in the bright field option at different magnifications (a= 20x and b & c= 50x respectively). Microcapsules have spherical shape with different sizes without any agglomerations.

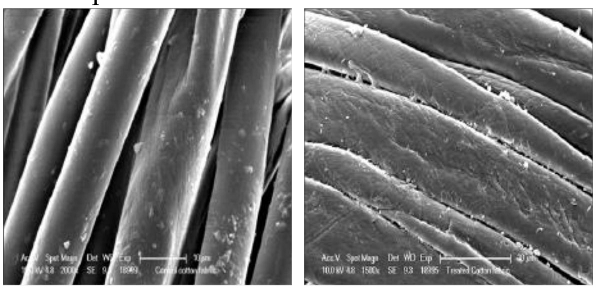


(a) (b) (c)

Fig. 18. Microscopic images of Artemisia afra microcapsules; a = 20x, b and c = 50x

3.2 Scanning Electron Microscopic (SEM) analysis of microcapsule treated fabric

The untreated and microcapsule treated cotton fabric were analysed by SEM. SEM images confirms the adhesion between textile fibre and microcapsule as shown in Fig. 3. From Fig. 3, it also confirms that the surface morphologies of the microcapsules can be of two types: (i) microcapsules with rough surfaces and (ii) microcapsules with smooth and soft surfaces.



(a) (b)

Fig. 3. Scanning electron microscopic images of (a) untreated and (b) microcapsule treated cotton fabric

Such differences of surface morphology of the microcapsules wall are favourable to the release of fragrance on the textile substrate, thereby increases the durability of fragrant textiles [17]. It is observed that the microcapsules are smoothly deposited on the fabric surface due to the binder. The fragrance was encapsulated in a polymer capsule finishing of textiles in the presence of non-ionic binder (Pidicryl binder SUN) showing better durability to laundering in terms of stability of fragrance.

3.3 Thermal gravimetric analysis (TGA) of microcapsules

The TGA patterns of microcapsules and *Artemisia afra* oil were shown in Fig. 4. It can be seen that encapsulated gelatine and *Artemisia afra* oil had three weight loss stages [18]. The first stage was in the range of 30~134°C, and the weight loss was approximately 10.0%, which was caused by the evaporation of free water [14], [18]. The second stage with a maximum weight loss rate at ~298°C was in the range of 134~309°C, and the 30% weight loss was due to the bound water and small molecules of gelatin and oil of *Artemisia afra* [14], [19]. The third stage with maximum weight loss rate at 456°C was in the range of 309-456°C, and 62.19% weight loss was caused by the thermal degradation of gelatin and oil of *Artemisia afra* [20]. For the core material essence oil, a dramatic weight loss was observed starting from 30-175°C, and the weight loss decreases with rise in temperature up to 244°C. The weight loss of the *Artemisia afra* oil in the process was about 85.32 % with maximum weight loss at 419°C.

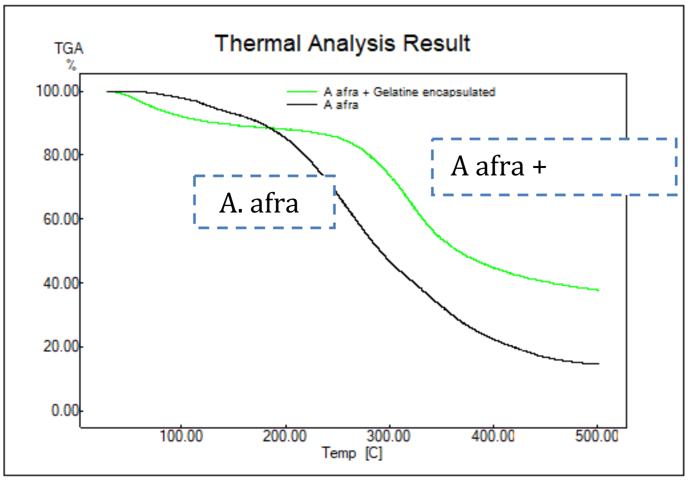


Fig. 19. Thermal degradation analysis of microcapsules (TGA)

Compared with essence oil, the microcapsules had a slower weight loss rate and a wider temperature range. Thus, it can be concluded that the encapsulation significantly improves the thermal stability of essence oil, suggesting that the shell material gelatin encapsulated the essence oil tightly rather than adsorbed loosely to the surface.

3.4 Particle Size Analysis of microcapsules

Particle size distribution results showed in Table I and Fig. 5 indicated that the average diameter of the microcapsule was 1.95μm and was quite uniformly distributed [13]. The prepared microcapsule particle size is less than 10μm. This indicated that their size distribution was narrower. Therefore, the prepared microcapsules in this study were adequate for the preparation of fragrant fabric due to their monodispersed size distribution [20].

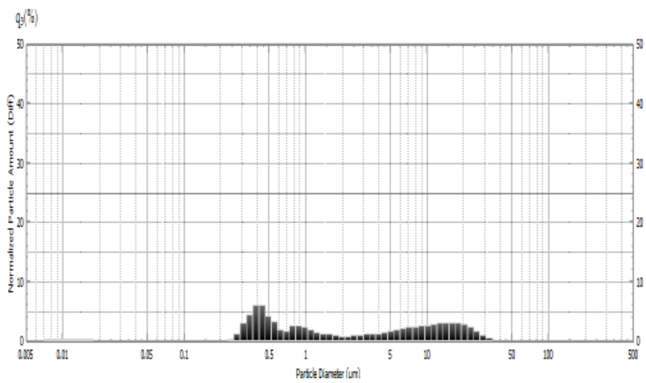


Fig. 20. Particle size distribution of microcapsules

Table I Particle size distribution of microcapsule

Types of microcapsule	Size range of microcapsules (µm)			
	Diameter at 25%	Diameter at 50%	Diameter at 75%	Mean diameter
Simple coacervation microcapsule	0.46	1.66	10.20	1.95

3.5 FT-IR Analysis

FT-IR spectra of the microcapsules treated and untreated cotton fabric are shown in Fig. 6. Several stretching and bending infrared vibrations are observed, which indicates the presence of different functional groups. The N-H aliphatic primary amine stretching mode assigned at 3355 cm^{-1} and presence of O-H alcohol stretching.

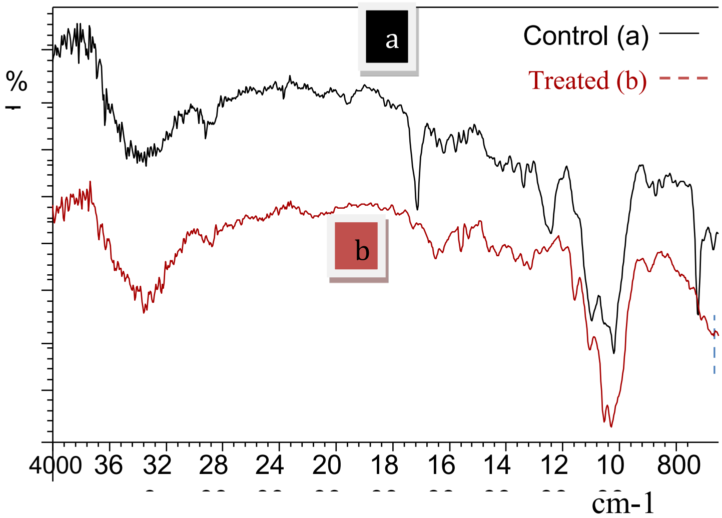


Fig. 21. FT-IR Analysis of the treated and untreated fabric

The C-C stretching conjugated alkene assigned at 1647 cm^{-1}, C-H bending alkane at 1429 cm^{-1}, O-H bending phenol at 1315 cm^{-1}, C-N stretching amine and C-O stretching ester are present at 1027 cm^{-1} and 1053 cm^{-1} and C=C bending alkene at 892 cm^{-1}. The presence of N-H aliphatic and O-H alcohol group shows the treated fabric gives more hydrophilicity due to the presence of gelatin. The removal of C-C alkene and C-H alkane shows unsaturation of the treated fabric which gives more reactivity and openness of the substrate. Such change improves wash durability of the fabric.

3.6 *Qualitative evaluation of aroma*

The rate of aroma intensity of the treated fabrics is given in Table II. The aroma retention of treated fabrics is determined subjectively by the panel of experts. The aroma intensity of pure *Artemisia afra* extract treated fabric is given "+++++" reading before washing that considered as very strong rating and "+" reading after 10 wash that considered as very week rating.

Table II Aroma retention capacity of Artemisia afra leaves extract treated fabrics at different washes

Sample	Aroma retention intensity (%)			
	No wash	5 wash	10 wash	15 wash
Pure *Artemisia afra* extract	5	2/3	1	0
Encapsulated *Artemisia afra* extract	4/5	4	3	2/1
Encapsulated *Artemisia afra* extract with binder	4/5	4	¾	3/2

The microcapsule treated fabric can retain aroma up to 15 washes compared to the nil retention ability of the pure *Artemisia afra* extract treated fabric. The microcapsule treated fabric with binder has better aroma retention capacity even after 15 washes in comparison to pure *Artemisia afra* treated and encapsulated without binder. The aroma of the core materials is released slowly in the microcapsules treated fabrics.

3.6 Evaluation of colour change

The whiteness index of the finished fabric decreased as compared to that of the control sample as shown in Table III. Conversely yellowness index on finished cotton with pure *Artemisia afra* was distinctly higher than that of control.

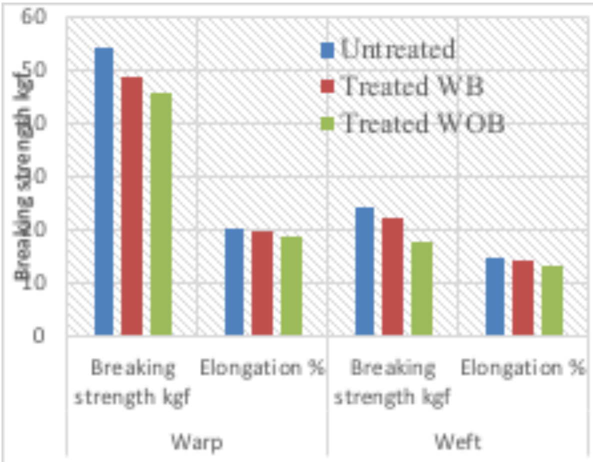
Table III Evaluation of colour change

Sample	Evaluation of colour change							
	L*	x	y	z	a*	b*	Whiteness index	Yellowness index
Control	32.189	6.844	7.169	8.291	0.499	-2.084	69.4	-8.87
Encapsulated *Artemisia afra*	27.127	4.991	5.139	7.07	1.516	-6.406	65.5	-31.98
Pure *Artemisia afra*	23.452	3.935	3.934	6.414	3.08	-10.16	55.6	-57.55

In the case of encapsulated, the finished cotton fabric indicates there was slight decrease in the whiteness which was mainly because of the coverage of the fabric by the microcapsules. The overall increase in the 'a*' value and decrease in the 'b*' values towards negative side, indicates the yellowish blue which is responsible for decrease in whiteness index.

3.7 Evaluation of mechanical properties of the treated fabric

According to Table IV and Fig. 7, the strength loss in warp and weft direction is observed in microencapsulate fabric compared to control sample. However, such decrease is well within the acceptable limit of 10 to 15% in warp and weft direction. Similarly, the elongation of treated samples decreased as compared to that of the control sample.



WB- with binder
WOB- without binder
Fig. 7. Effect of finishing in fabric strength

IV. CONCLUSION

Nowadays, the consumers around the world are increasingly focused on health and beauty. The renewed consumer interest in natural cosmetic products creates the demand for new products reformulated with botanical and functional ingredients. In cosmetic products, essential oils (EOs) play a major role as fragrance ingredients. In this work, *Artemisia afra* was successfully micro-capsulated in gelatin as shell material by simple coacervation method. Microencapsulation of *Artemisia afra* oil can protect and prevent the loss of volatile aromatic ingredients and improve the controlled release and stability of this core material. The particle size analyser results showed that the average diameter of microcapsule was 1.95µm and the particles mainly distributed uniformly due to its smaller sizes. The TGA analysis revealed that the microcapsule had good thermal stability. The microcapsule treated fabric retain aroma up to 15 washes compared to the nil retention ability of the pure *Artemisia afra* extract treated fabric. Microcapsule treated fabric with binder has better aroma retention capacity even after 15 washes in comparisons to pure *Artemisia afra* treatment and encapsulated treatment without binder. The breaking strength of treated fabric though affected, was in the acceptable limit of 10 to 15% loss. The microcapsule containing *Artemisia afra* oil gives aroma finish on cotton fabric with multiple wash durability. The methodology described for achieving aroma finish is simple, cost effective, reproducible, and no additional investments for textile finishing industries.

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Process loss optimization through implementation of Kanban & One-piece flow: Case study in ready-made garment factory in Ethiopia

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Abstract

Ethiopia is gearing up to challenge global apparel sourcing destinations like Myanmar, Kenya, Vietnam & Cambodia etc. To be more competitive in the global market and to achieve the GDP-II target, it must work hard to optimize the operational cost, standardized quality and increase efficiency. In this study, researchers tried to address the macro issues of one of the export-oriented factories based out of Addis Ababa. Those were high operational cost, poor quality, excessive lead time to ship an order and low marker efficiency due to absence of expensive CAD marker planning software. After doing an intensive root cause analysis of the problem, they came up with some concrete solutions. A unique and one of its kind indigenous Marker planning cum Kanban ticket generation application integrating Macros, VBA (Visual Basic for Applications) and Simplex Linear Programming was developed. It would solve the issue of financial losses incurred in the cutting room due to conventionally prepared marker planning resulting in low marker efficiency and fabric utilization. A unique amalgamation of Kanban as well as one-piece flow was implemented to take care of the process loss due to heavy WIP, poor quality, less efficiencies and more throughput time in the sewing section and missing pieces during packing which led to unnecessary delay in shipments. The WIP, throughput time and DHU (Defects per Hundred Units) were reduced by 73%, 83.3% and 66% respectively. The efficiency improved by 69% and Cost per SAM (Standard Allowed Minute) decreased by 25%. The time to pack a carton was decreased by 65%. The problem of missing pieces was also diminished. The manufacturing unit greatly benefited by the solutions thus proposed and implemented by the researchers and is being used successfully.

Keywords- **Marker Planning, DHU, Kanban, One-piece flow, Cost per SAM**

I. INTRODUCTION

Rapid increase in labor costs in major supplier countries viz. $ 550 – 600 in China, $ 160-180 in India, $ 170-190 in Vietnam etc. has been forcing apparel sourcing giants to migrate to low wage countries like Ethiopia where it is as low as $ 60-80 per month. Although, the price competitiveness card is not the only resort for Ethiopia to survive in the grueling competition with countries like Myanmar and Kenya, who are proving to better off due to their optimized processes, lower operational costs and shorter delivery times. Due to the specific market nature of the garment industries such as short production lifecycle, high volatility, low predictability, high level of impulse purchase and the quick market response, garment industries are facing further challenges these days (Lucy Daly and Towers 2004). Due to small order quantities and complex designs, the garment industry has to produce multiple styles even within a day; this needs higher flexibility in volume and style change over (Singh and Sharma, 2009). According to Womack and Jones (2003), Lean is the most powerful tools available for creating value while eliminating waste in any organization. It provides flexibility and save a lot of money by reducing production lead time, reducing the inventory, increasing productivity, training operators for multiple works, and by reducing rework (Drew et al, 2004).

High WIP (Work in Process) in traditional type of batch production is another major issue faced by industries. Due to high WIP, the throughput time as well as rework level is very high, and the quality produced is poor. The flexibility towards the style change over cannot be achieved easily giving rise to longer lead times; which is the current demand of garment industry to produce the small orders (Kumar & Thavaraj, 2015).

Therefore, to survive in this rapidly demanding environment of shorter lead times, low operational cost and quick response time, Process Optimization becomes imperative. Implementation of world class principles i.e. Kanban and Single Piece Flow, which are the most popular Lean Tools used in the Readymade Garment Manufacturing Industry today, definitively serves the purpose.

The major issues affecting the small and medium level Ethiopian owned garment manufacturing industries are higher operational costs, higher lead times, high quality costs, low skill level and high operator turnover. These are the prime reasons why they still struggle to manufacture high-fashion products and export for high end buyers like H & M

& PVH. Apart from job-working (Cut – Make) for US buyers like Champro Sports and Superior Uniform Group, they are trying to make up for their high operational costs by catering to the domestic market. In the backdrop of Ethiopia still struggling to meet the GTP-II (2016-2020) target of USD 2.7 billion and government heavily focusing on incentivizing and promoting exports, prioritizing the domestic market is certainly not a wise idea.

II. BACKGROUND OF STUDY

A case study was undertaken in one of the major sportswear and shirt manufacturing based out of Addis Ababa who had been doing job-work for a US buyer along with catering to the domestic market. It employs 299 workers, out of which 297 are locals and two are foreigner.

This study only focusses on the shirt manufacturing line. On conducting a preliminary survey, the researchers found the following problems:

i. Higher operational cost (Cost per SAM) at USD 0.12/ETB 3.36, where as per the author's computation, it should not be more than USD 0.047/ETB 1.37 to be profitable while working for buyers like H&M etc. (Author's computation)

ii. Line Efficiency as low as 17 % whereas the global average is 62% (Bheda, 2008)

iii. Time taken to cut an order quantity is 15.4% of the time taken to sew, whereas the optimum average should not be more than 7 % (Author's computation).

iv. Time taken to pack an order quantity is 117.2% of the time taken to sew, whereas the optimum average should not be more than 29 % (Author's computation).

III. MATERIALS AND METHODS

The descriptive research design was used by the researcher to gather information about present existing conditions needed in the chosen field of study. In this method of research, a combination of Qualitative and Quantitative Research were used to gather relevant data on current status GMM Garment Plc considering different parameters.

IV. WORK METHODOLOGY

First, a department-wise detailed study was carried out and during root cause analysis (Ishikawa) (Fig.1) the following reasons were identified:

Cutting Department

1. Manual marker making by the pattern master without calculating the marker efficiency or fabric utilization. This could be solved by developing an automated software for marker planning which could calculate the fabric utilization.
2. Manual bundle ticket preparation which alone resulted in a projected annual loss of ETB 3,08,752 against a planned cutting capacity of 30,000 pieces per month. This could be solved by the development of a software which could create ready to print bundle tickets.
3. No system of bundle tracking and end bit storage which resulted in difficulty, time loss and errors in searching for the fabric for panel replacement. This could be solved by allotting space for end-bit storage and proper training to the cutting staffs on how to record and its retrieval.

Sewing Department

1) High WIP in lines, 400-425% of the daily output, which could easily be reduced by 70% by change of production system to single piece flow and use of Kanban system.

2) Line working at an extremely low efficiency of 17% due to no strict follow up of targets by management. The reason was they were often not aware of the day-to-day development in the absence of an ERP system. They did not invest in an ERP system as it was thought as not important and expensive. This could be solved by development of an inexpensive MS-Excel based MIS & ERP system for entry and analysis of production, quality, costing issues & daily reporting to top management.

3) Low motivated and stressed operators due to no incentive scheme and ergonomically uncomfortable workplace which could be solved by:

   a) Proper division of work to eligible workers
   b) Job rotation
   c) Monitoring of worker performance
   d) Continuous training of hard, soft skills and world class principles to the operators as well as the middle managerial staff
   e) Development of incentive system,
   f) Development of ergonomically-proper work aids

4) High throughput time of more than 5 days for an order of 1500 pieces which could be reduced by 80-85% by:
   a) Change of production system into one-piece flow.
   b) Implementation of SMED (Single Minute Exchange of Die) for quick change over time.
   c) No properly designated work responsibility and evaluation mechanism for the middle to the upper level managerial staff. This could be solved by:
      i) Development of an SOP (Standard Operating Procedure) for the factory
      ii) Development of an HR manual for the factory with job-description and evaluation criteria.

Finishing and Packing Department

1. Only 35% of the Finishing and Packing Capacity was utilized. This was due to delay in packing of cartons due to unavailability of right sizes. This could be solved by the implementation of Kanban system.

Development of Automated Marker Planning Tool

A unique and one of its kind indigenous Marker planning cum Kanban ticket generation application tool was created for automated generation of the best possible size ratio and the fabric utilization percent. The algorithm was developed using Visual Basic for Applications (VBA), Macros and Solver® Add-in of MS-Excel. The software works on linear programming model using the Simplex method to produce an optimal solution to satisfy the given constraints and produce a maximum zeta value against introduced slack variables.

Code written into VB Editor are as following (Partial, Fig. 2)

```
Sub Solver_M1()
'
' Solver_M1 Macro
'
'
    SolverReset
  SolverOk SetCell:="$N$20", MaxMinVal:=1, ValueOf:=0, ByChange:="$D$17:$M$17", _
    Engine:=2, EngineDesc:="Simplex LP"
  SolverAdd CellRef:="$D$16", Relation:=1, FormulaText:="$D$14"
  SolverOk SetCell:="$N$20", MaxMinVal:=1, ValueOf:=0, ByChange:="$D$17:$M$17", _
    Engine:=2, EngineDesc:="Simplex LP"
  SolverAdd CellRef:="$E$16", Relation:=1, FormulaText:="$E$14"
  SolverOk SetCell:="$N$20", MaxMinVal:=1, ValueOf:=0, ByChange:="$D$17:$M$17", _
    Engine:=2, EngineDesc:="Simplex LP"
  SolverAdd CellRef:="$F$16", Relation:=1, FormulaText:="$F$14"
  SolverOk SetCell:="$N$20", MaxMinVal:=1, ValueOf:=0, ByChange:="$D$17:$M$17", _
    Engine:=2, EngineDesc:="Simplex LP"
  SolverAdd CellRef:="$G$16", Relation:=1, FormulaText:="$G$14"
  SolverOk SetCell:="$N$20", MaxMinVal:=1, ValueOf:=0, ByChange:="$D$17:$M$17", _
    Engine:=2, EngineDesc:="Simplex LP"
  SolverAdd CellRef:="$H$16", Relation:=1, FormulaText:="$H$14"
  SolverOk SetCell:="$N$20", MaxMinVal:=1, ValueOf:=0, ByChange:="$D$17:$M$17", _
    Engine:=2, EngineDesc:="Simplex LP"
  SolverAdd CellRef:="$I$16", Relation:=1, FormulaText:="$I$14"
  SolverOk SetCell:="$N$20", MaxMinVal:=1, ValueOf:=0, ByChange:="$D$17:$M$17", _
    Engine:=2, EngineDesc:="Simplex LP"
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  SolverOk SetCell:="$N$20", MaxMinVal:=1, ValueOf:=0, ByChange:="$D$17:$M$17", _
    Engine:=2, EngineDesc:="Simplex LP"
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  SolverOk SetCell:="$N$20", MaxMinVal:=1, ValueOf:=0, ByChange:="$D$17:$M$17", _
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  SolverOk SetCell:="$N$20", MaxMinVal:=1, ValueOf:=0, ByChange:="$D$17:$M$17", _
    Engine:=2, EngineDesc:="Simplex LP"
```

```
    SolverAdd CellRef:="$M$16", Relation:=1, FormulaText:="$M$14"
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        Engine:=2, EngineDesc:="Simplex LP"
    SolverOk SetCell:="$N$20", MaxMinVal:=1, ValueOf:=0, ByChange:="$D$17:$M$17", _
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    SolverSolve (True)
'Approve the solution and avoid popups
    SolverSolve userFinish:=True
    SolverFinish KeepFinal:=1
End Sub
```

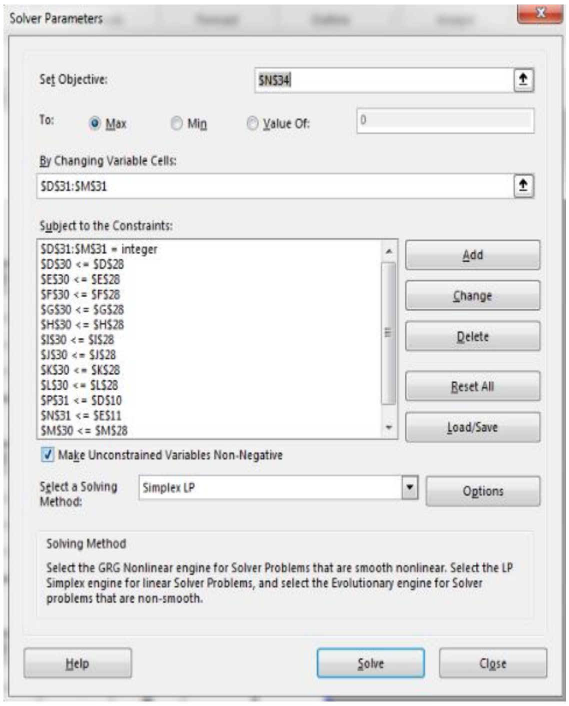


Fig. 2. VB editior in Excel

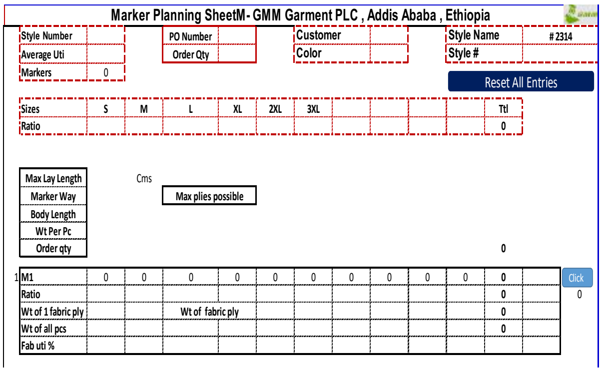
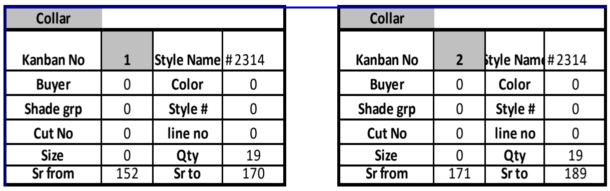


Fig. 3. Snapshot of marker planning tool

The snapshot of the marker planning tool final dash board of the marker planning tool is shown in Fig.3. The tool creates an automated bundle/Kanban ticket numbers which can directly be pasted on the Kanban cards (Fig.4). For Kanban ticket generation, some basic details regarding number of components of garment must be fill on Kanban bundle entry dash board (Fig. 5.). It can also generate a Bundle/Kanban Sheet which can be used for Bundle tracking (Fig. 6).



Collar			
Kanban No	1	Style Name	#2314
Buyer	0	Color	0
Shade grp	0	Style #	0
Cut No	0	line no	0
Size	0	Qty	19
Sr from	152	Sr to	170

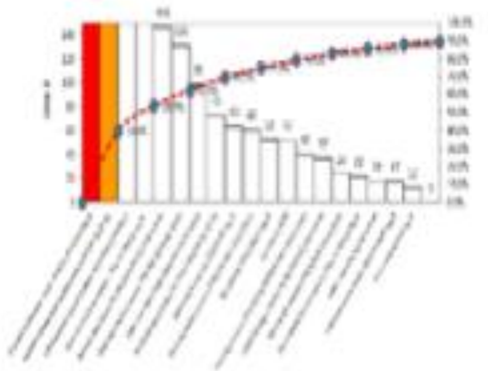
Collar			
Kanban No	2	Style Name	#2314
Buyer	0	Color	0
Shade grp	0	Style #	0
Cut No	0	line no	0
Size	0	Qty	19
Sr from	171	Sr to	189

Fig. 4. Kanban Tickets

Development of MIS Tool

The researchers developed the following tools which were basically based on advanced data analysis and visualization options along with automation option (Macros) available in MS-Excel as a cheaper alternative to ERP:

b.



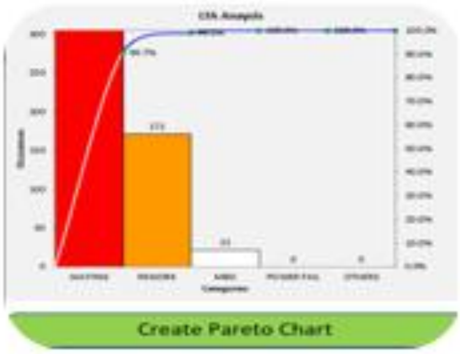


Fig. 7.a. Snapshot of MIS tool; b. Line wise defects analysis; c. Pareto chart of top five defects

1) Management Information System:

a) The computers belonging to the key management were connected through LAN.

b) The data were entered by the designated persons on daily basis. The analyzed reports viz:

   i) Month by Month trend of Cost per SAM (Fig. 7a).

   ii) Daily/Monthly Line-wise and Floor-Wise Cutting, Sewing and Finishing Efficiency (Fig. 7b)

   iii) Daily/Monthly Line-wise and Floor-Wise DHU

   iv) Pareto Analysis of top defects were available to be viewed by the top management (Fig.7c).

1) Operator Performance Monitoring Software:

a) 'Performance' is a ratio of the 'Minutes produced by the operator (SAM of operation * Pieces produced by the operator)' and the 'On-Standard Minutes available per shift'. A system was developed where the operators, operations and machines were coded and entered into the system. It was linked to a master data of operator salary prepared by the HR manager. The operators were encouraged to record their hourly output as well as their off-standard times against their reason. Line writers were trained to record the production data after proper verification on a daily basis and Off-standard time data on a weekly basis. The data generated was punched into the software which generated the following reports:

   i) Operator-wise performance and incentive earned (Fig. 8).

   ii) Top-10 performing operators

   iii) Details of machines with frequent breakdown which could be used for maintenance (Fig. 9).

   iv) Off-Standard time analysis

Fig. 8. Operator performance and incentive system

Implementation of KANBAN System, Single-Piece Flow and SMED

KANBAN (Fig. 10) refers to the visual signals that authorize the production or movement of items and sometimes referred to as the nervous system of a Lean Production System. 'Supermarket' is a tool of Kanban which manages the "Work in process" on the manufacturing floor (Cutting section) and it will have accountability as well as responsibility of the process. The flowchart of Supermarket is shown in Fig. 11.

Fig. 9. Machine breakdown deatils

Fig. 10. Kanban card

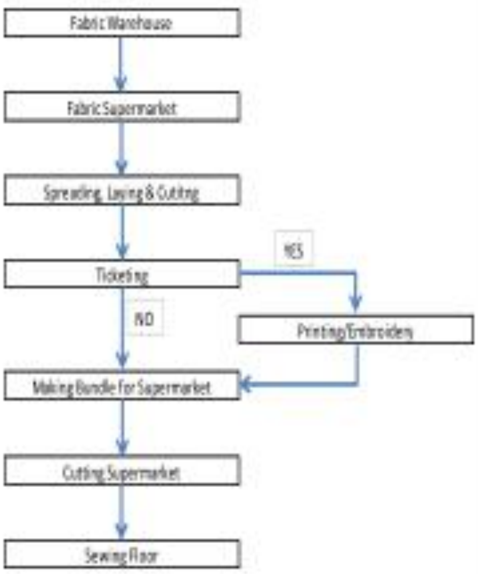


Fig. 11. Process flow of Supermarket

Process flow of KANBAN

Standard Operating Procedure (SOP) is given in Fig. 12. Kanban using cards signal often follow the routines below:

a. A card is displayed on the Kanban dashboard which means availability of bits in the supermarket (Fig. 13).

b. The batch/line signals to the dashboard which indicates requirement of bits in cutting table

c. The bits are moved from supermarket to cutting table along with the blue Kanban card.

d. The cutting of bits takes place according to micro-cut plan and white Kanban card is then displayed on the Kanban post of cutting table, to await to load back to the production line

e. When the white Kanban card returns to the Kanban post at the end of the production line that has been set up to provide a visual signal for operation of the line.

f. The Kanban card is displayed till the finishing of the garment along with the packing of garments in the cartons

g. The sticker attached to Kanban card is stick to Kanban input book after accepting that cartons in packing area

h. Kanban loading and Input Book is an assistant tool for Kanban card which keeps the record of loading Kanban to the batch and completion of that Kanban (Fig. 14).

i. The feeding helper maintains the record of those two books, and it is the responsibility of her/her to watch daily loading and completion of Kanban.

j. By observing the two books anyone can find the loaded quantity, WIP of the line, which Kanban is taking much time to operate.

Calculation of KANBAN size

A Kanban Loading plan is made before loading Kanban card to the batch which is made as per packing list.

The number of units should be of Takt time equivalent to one hour and multiplies of carton size.

1 Kanban + Number of Workstation * 3 Units + 1 Kanban

For the pilot Shirt Line undertaken for the study:

48 WS X 3 Units = 144 Units

Kanban Size = Takt Time Output = 63 Units

Ratio = 20 Units/ Carton

Therefore 63 Units/ 20 = 3 (Approx.)

Kanban Size = 3 Cartons X 20 = 60

Therefore, 60 + 144 + 60 = 264/60 = 5 (Approx.) Kanban = 300 units of WIP

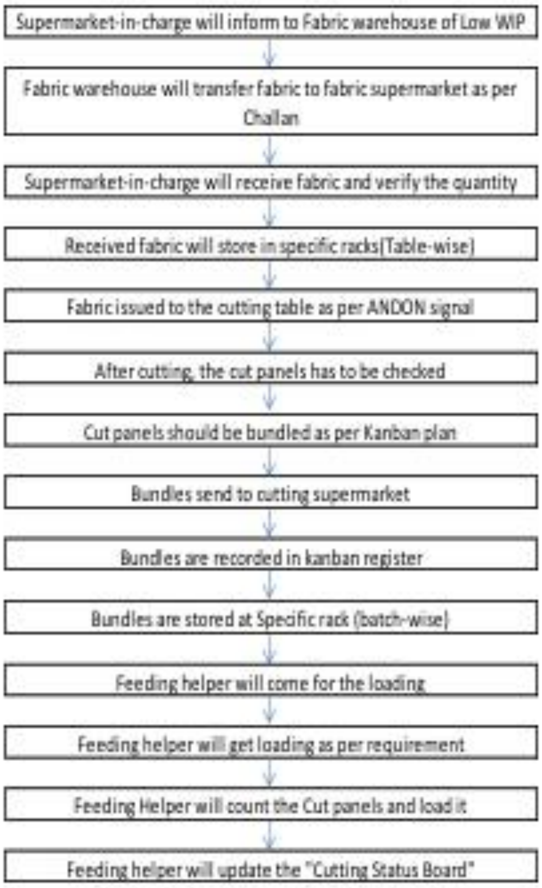


Fig. 12. SOP of Kanban Flow

Minimum of 3 Kanban is kept ready in cutting for ready to load and cutting section should display WIP Kanban on the cutting table.

Moreover, every Kanban needs to be completed as per loading quantity and offered for quality specifications and carton audit.

In Single-Piece flow system, bundles are replaced by single pieces. This reduces the WIP and throughput time. Single Piece Flow was introduced in the Assembly section of the pilot shirt line. A feeder was trained to clip the individual components i.e. sleeve, cuff, front, back, collar and cuff etc. and make it ready to feed into the assembly section as per the Kanban. The line output was again bundled as per the Kanban and issued into the Finishing Section.

SMED is the abbreviation of Single Minute Exchange of Die which helps in reducing the line set. Maintenance personnel were trained in the procedure of SMED. So, whenever a style change occurred, they parallelly made the machined ready for operation along with their attachments.

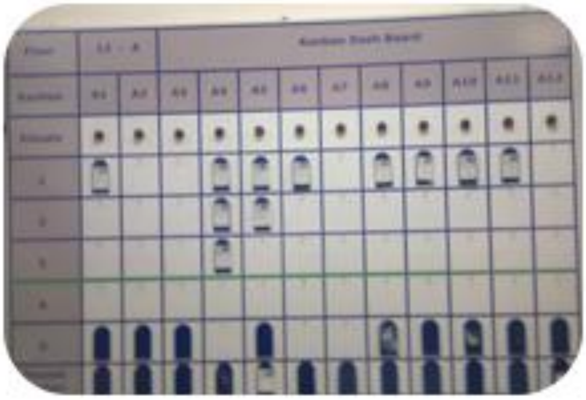


Fig. 13. Kanban dash board

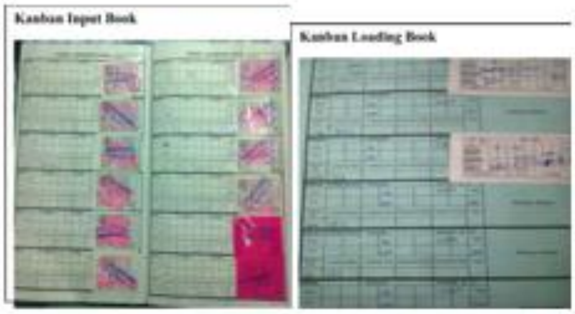


Fig. 14. Kanban input and loading book

V. RESULTS AND DISCUSSION

Comparison of Throughput time

Comparison is made between the throughput time achieved pre and post implementation of Kanban & single piece flow. The result is plotted as graph in Fig 15. The result shows that throughput time was 45.6 hrs. before single piece implementation. It drastically reduced by 43% (7.4 hrs.) after implementation.

Comparison of Daily Production

The Fig. 16. indicates that the average daily production was 310 in case of traditional batch system whereas after Kanban & single piece flow implementation it increased by 31% due to less throughput time and reached to 450.

Fig. 15. Comaprision of Throughput Time

Comparison of Line Efficiency

A focused research is done on analyzing line efficiency (Fig. 17). It was computed by dividing the total work content in seconds by the number of operators multiplied by the SAM. Earlier efficiency was 17.4% whereas after Kanban & single piece flow implementation it became 29.5%. Efficiency was increased due to increment in daily output and on the other hand, number of operators was also reduced. The efficiency (29.5%) was achieved with reduction in manpower from 62 to 53 operators.

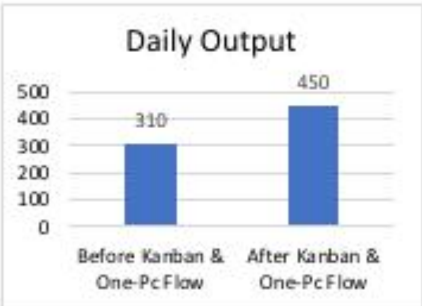


Fig. 16. Comaprision of daily output

Comparison of DHU

The improvement in terms of reduction in number of defects was considered in measuring the effectiveness of Kanban implementation. As Fig. 18. shows that DHU was 127, which was very high against international standard of 10-20 at End line (Author's observation) before Kanban & single piece flow implementation.

Fig. 17. Comaprision of line efficiency

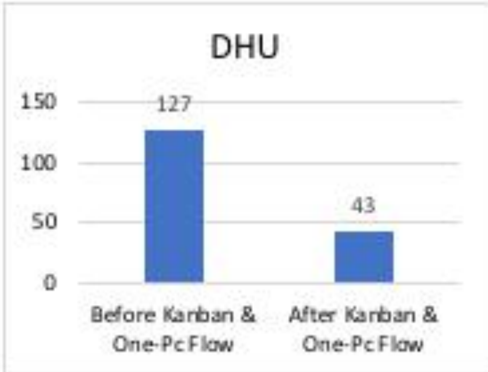


Fig. 18. Comaprision of Defects Per Hundered Unit

Comparison of WIP

Because of large bundle size, the WIP was 1248, which was very high as shown in Fig. 19. After implementation of Kanban & single piece flow, WIP drastically reduced to 327 by 73%.

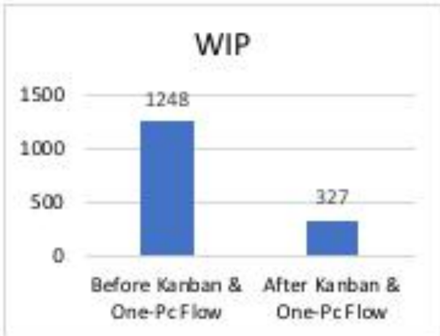


Fig. 19. Comaprision of WIP

Comparison of Cost per SAM

Comparison is made between the Cost per SAM pre and post implementation of Kanban & single piece flow. As Fig. 20 indicates that earlier cost per SAM was ETB 3.36 where as after this study it was reduced by 25% to ETB 2.52. There are different reasons behind the Cost per SAM reduction such as improvement in line efficiency, increment in daily production, reduction in DHU etc.

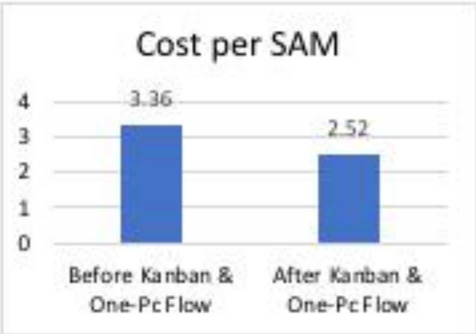


Fig. 20. Comaprision of Cost per SAM

Benefits in Finishing and Packing Department

The time taken to finish and pack a shirt was 8 minutes during study. There with 12 manpower employed, the installed capacity was 720 pieces per shift. But, the factory could only pack 200-250 pieces.

After successful implementation of Kanban, the waiting time for correct pieces drastically reduced. The time taken to pack a particular order reduced by 65 % which was really appreciated.

Overall Benefits of MIS and ERP Development Tool

The following results were achieved after MS excel based MIS and ERP tool which were highly encouraging

1. A skill matrix was prepared on the basis of performance of the individual operators.
2. Weak operators can easily be sorted out and sent to the training department for retraining.
3. The overall atmosphere of the production floor improved with motivated employees as they were rewarded with both verbal appreciation and with monetary benefits.
4. Operator attrition rate was also reduced from the present 8% to 5% due to incentive.
5. The maintenance department could easily locate machines with the maximum breakdown rate and taken necessary action.
6. Appropriate action could be taken to rectify the reasons behind the most frequent off-standard time activities.
7. Appropriate action could be taken to reduce top recurring defects.

VI. CONCLUSION AND RECOMENDATION

This study clearly indicates that proper implementation of Kanban and Single-Piece production system greatly helps in optimizing the process losses commonly occurring in the production floor. It reduces the throughput time, increase the efficiency of the production floor and finally optimizes the operational cost of the factory. Better quality and happy operators were a by-product of the intervention. The researchers have taken the Shirt Line as a pilot line for demonstration. The process adopted can be modified and replicated in any factory producing any product. The researchers have demonstrated that expensive ERP software are not the only solution for following up and optimization of process loss.

MS-Excel has numerous in-built add-ins like Solver® and options like VBA and Macros which can be used to prepare customized software which can be beneficial for small and medium scale factories who cannot afford to buy expensive software like CAD and ERP solutions.

ACKNOWLEDGEMENTS

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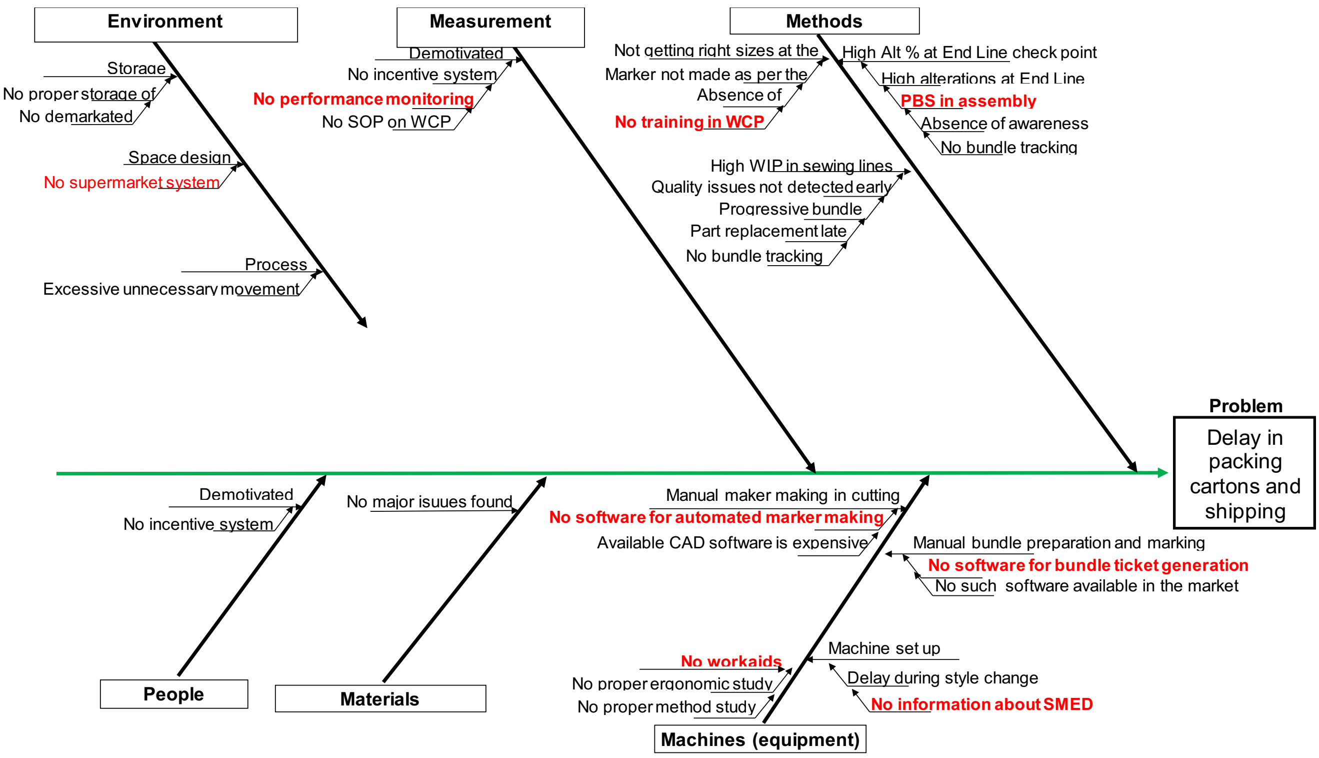

Fig. 1. Department-wise root cause analysis

Impact of Total Quality Management Practices on Organizational Performance in the Developing Country: A Case Study on Ethiopian Apparel Industry, Addis Ababa

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Abstract

Total quality management (TQM) is a widely used management philosophy across manufacturing and service sectors. Organisations implement TQM in order to gain competitive advantage in terms of quality, productivity, customer satisfaction, and profitability. This study provides empirical evidence from a developing country like Ethiopia. The aim of this study was to analyse the impact of TQM practices on employee performance (organizational performance) of Desta PLC one of the apparel industry in Addis Ababa (Ethiopia). For this study there are nine TQM factors were identified viz., top management commitment (TMC); supplier quality management (SQM); employee involvement (EI); customer satisfaction and relation (CSR); strategic planning and development (SPD); training and development of the employee (TDE); process management (PM); quality data and reporting (QDR); and knowledge and continuous improvement (KCI) as independent variables and employee performance as organizational performance as dependent variable. The hypotheses and conceptual framework were designed. The data used was the combination of primary and secondary data. Primary data were collected from the operational employees, supervisors, working on various production shop floor and human resource, quality, production managers, by using a structured questionnaire (based on five-point Likert scale). Simple random sampling technique was used to distribute the 200 questionnaires. The raw data collected was coded and then analyzed by using SPSS-20. The completely useful 176 questionnaires samples were used for mean, standard deviation, factor analysis, correlation and regression analyses to investigate the effect of TQM practices on organisational performance. Only two hypotheses were positively fit with the conceptual model and hence showed the positive impact of TQM on employee performance of the apparel industry. These findings support the divergence argument, which indicates that the positive effect of TQM on organisational performance is not limited only to companies located in developed nations, but can also be equally achieved in developing countries.

Keywords- **Total quality management, Employee performance, Garment industry**

I. Introduction

Total quality management (TQM) is a systematic quality improvement approach for firm-wide management for the purpose of improving performance in terms of quality, productivity, customer satisfaction, and profitability. Since TQM practices have been embraced by many firms around the world for decades, they have earned the attention of many researchers from diverse areas. While there are many success stories related to TQM practices, some TQM programs have failed, and some authors (Taylor & Wright, 2003; McCabe & Wilkinson, 1998; Masters, 1996; Whalen and Rahim, 1994) have found reasons for these failures. Results from studying the relationship between TQM practices and firm performance have been mixed (Hung, 2007; Nair, 2006; York & Miree, 2004; Sadikoglu, 2004; Prajogo & Sohal, 2001), so a need remain store-examine this relationship.

Replication research contributes empirical generalizations and knowledge development, and consistent research results among multiple studies using a variety of methodologies give support to the strength and generality of research results (Kaynak, 2003). Replication research also contributes to validating cause-and-effect relationships, uniting the empirical results of a discipline, and increasing knowledge by reducing type-I errors, by evaluating the robustness and generalization of empirical results, and by developing theory through satisfying the criterion of reproducibility (Nair, 2006).

II. Theoretical Background

After thoroughly reviewed the literature, the TQM factors were developed in the questionnaire viz., top management commitment (TMC); supplier quality management (SQM); employee involvement (EI); customer satisfaction and relation (CSR); strategic planning and development (SPD); training and development of the employee (TDE); process management (PM); quality data and reporting (QDR); and knowledge and continuous improvement (KCI), and the performance measure is employee performance. Although not exhaustive, these factor areas have often been considered the critical factors of TQM (Conca et al., 2004; Sila & Ebrahimpour, 2003; Claver et al., 2003). These factors were briefly explained in the following section.

A. Top Management Commitment

The review of empirical TQM studies show that organization leadership is an important TQM factor (Xiong et al., 2017). Top management leadership actively involved in communication and planning of organizational goals (Sabella et al., 2014). Management leadership provides significant means (resources) to improve and maintain quality (Basu & Bhola, 2016). In addition, top management views quality more important than production and they takes quality as their responsibility (Delic et al., 2014). Furthermore, management can interact with their concerned departments to anticipate changes and make plans to accommodate it. Finally, studies analyzed that top-management commitment significantly affects the organization performance (Qasrawi et al., 2017; Keinan & Karugu, 2018).

B. Supplier Quality Management

Effective supplier quality management supports a cooperative and long-term relationship with suppliers (Kaynak, 2003; Zakuan et al. 2010), gives them an opportunity to get involved in product design and production processes to improve the quality of their materials and/or services (Lai & Cheng, 2005), helps companies to attain competitive advantages (Sila, 2007), and improves organizational performance (Samson, 2017; Farish et al., 2017; Mehralian et al., 2017; Pradhan, 2017; Omar et al., 2018) noted that effective supplier management improves organisational performance.

***C.** Employee Involvement*

The emphasis throughout all stages of TQM implementation should be involving all employees in decision-making, problem-solving, and the financial success of the firm. That is, TQM encourages all levels of people to become more closely related to the organisation's goals and objectives (Collard, 1989). The basic concept is that everyone is responsible for producing quality goods and services, meeting customer requirements, and achieving a company-wide TQM organisation. Everyone is in control of their work and is able to participate in the business of the organisation. Involvement means to empower employees, give them information, increase their knowledge and reward quality performance (Oliver, 1998).

D. Customer Satisfaction and Relationship

For any organization customer satisfaction and relationship is the most important factor, while in TQM it is regarded the core issue for better business results (Qasrawi et al., 2017; Keinan & Karugu 2018; Omar et al., 2018). In this construct of TQM practices, the key customer requirements are identified and customer-oriented strategies are built and reviewed for further improvements (Swies et al., 2016).

Customer satisfaction feedbacks are taken after a regular interval and customer complaints are properly recoded and reviewed to maintain our quality standards (Sinha et al., 2016; Farish et al., 2017). In addition, encouragement is provided to partnerships with customers to make better relations (Kim et al., 2012; Pradhan, 2017).

Furthermore, concessions are provided for defective parts/products if delivered (Kaynak & Hartley, 2008). Therefore, customer satisfaction and relationship is an important element of TQM construct and it helps in upgrading business performance.

E. Strategic Planning and Development

In the TQM strategic planning and development element also has a major role in achieving a satisfied quality and increased performance as suggested by researchers (Al-Dhaafri et al., 2016; Qasrawi et al., 2017). It includes the quality policy, mission statements, improvement processes, use of quality control and other management tools. Strategic planning and development is essential to examine how a firm evolves, executes and refines its strategy and policy to achieve better performance (Prajogo & Sohal 2004, Talib et al., 2013).

The studies of Talib et al. (2013), Sabella et al. (2014), Sadikoglu & Olcay (2014), Parvadavardini et al. (2016), Al-Dhaafri et al. (2016), Aquilani et al. (2017), Ebrahimi and Rad (2017), Farish et al. (2017), Mehralian et al. (2017), and Omar et al. (2018) found that strategic planning and development has a significant impact on organisational performance.

F. Training and Development of the Employee

Training topics in a total quality setting involve technical skills (statistical process/quality control methods such as control charts and Pareto diagrams, design tools such as design of experiments, and quality function deployment), supervision skills (managerial problem-solving tools), communication, new work procedures (teamwork), and customer relations (Goetsch & Davis, 2006).

Empirical researchers, including Flynn et al. (1995), Ravichandran and Rai (2000), and Kaynak (2003), hold a common view that training is needed for developing employee participation in organizational quality management efforts and enhancing their knowledge and skills on data collection and its use. Researchers have confirmed that training is a basic factor in the success of quality management implementation. Unless employees know how to implement concepts or techniques of quality management in their jobs, employees may resist and lack commitment to change, instead of giving a positive impetus or benefit. A well-trained employee tends to work efficiently and effectively to improve performance. Appropriate training offers opportunities for improving teamwork, reducing errors, and enhancing job satisfaction. In particular, training is directly related to the way employees work (Mehra et al., 2001). Employees recognize that they should build strong teamwork. When an organization adopts quality management M, employees should learn how to implement quality techniques and quality principles in their innovation work.

G. Process Management

Process management emphasizes activities, as opposed to results, through a set of methodological and behavioral practices. Process management includes preventive and proactive approaches to quality management, such as designing fool-proof and stable production schedules and work distribution to reduce variations and improve the quality of the product in the production stage (Kaynak, 2003; Flynn et al., 1995).

This element of TQM is concerned with how the organization designs and introduces products and services, integrates production and delivery requirements and manages the performance of suppliers (Evans & Lindsay, 1995). The core idea behind this principle of TQM is that organizations are sets of interlinked processes, and that improvement of these processes is the foundation of performance improvement (Deming, 1986). Deming saw sets of interlinked processes as systems, and his treatment of organisational systems is generally consistent with the use of this term in management theory. According to Dean and Bowen (1994), the intellectual turf represented by this category has been abandoned by management theorists and is currently occupied by industrial engineers.

H. Quality Data and Reporting

In the study conducted by Saraph et al. (1989), the importance of quality data and reporting is appointed an important factor underlying a successful TQM implementation. The elements underlying quality data and reporting should be included in continuation of the above-mentioned critical factor, process management. Where process management addresses the aspect of continuous improvement and process mapping, quality data and reporting incorporates the importance of reporting and integrating quality data in the strategic planning.

Quality data and reporting involves a high degree of documentation, tracking and feedback. Clearly documenting various process procedures and waste and defect rates in the manufacturing process, as well as keeping the information readily available to every employee, is argued to be an important factor underlying the success of the organization (Kaynak, 2003). Saraph et al. (1989) likewise stresses the importance of providing information on quality data to employees and managers, for problem solving and prevention. In continuation hereof, applying quality data furthermore enables the possibility of evaluating employees and managers based on quality performance.

In several studies the importance of quality data is thus emphasized as a useful tool of monitoring performance and managing quality.

I. Knowledge and Continuous Improvement

The aim of continuous improvement is to attain levels of performance that are significantly higher that current levels (Hodgetts, 1998), so the company can attain long-term survival and development. It focuses on process not events. Vits and Gelders (2002) thought that the effectiveness of management efforts towards continuous improvement activities can have positive effects in establishing a learning organization.

Continuous improvement refers to searching for never-ending improvements and developing processes to find better methods in the process of converting inputs into outputs. By improving interlinked processes, a firm can do a better job of satisfying customers' needs and expectations (Stevenson, 1996; Dean & Bowen, 1994). In his fifth Point, Deming proposed decreasing the proportion of defects and continuously improving product/service design (Deming, 1986).

In a total quality setting, work processes are reviewed and improved constantly (Spencer, 1994), and process-management heuristics are used to improve team problem-solving and decision-making (Hackman & Wageman, 1995). Reduction in variation improves output, the need for rework, mistakes, and waste of staff, machine time, and materials (Anderson et al., 1994; Johston & Daniel, 1991).

J. Employee Performance

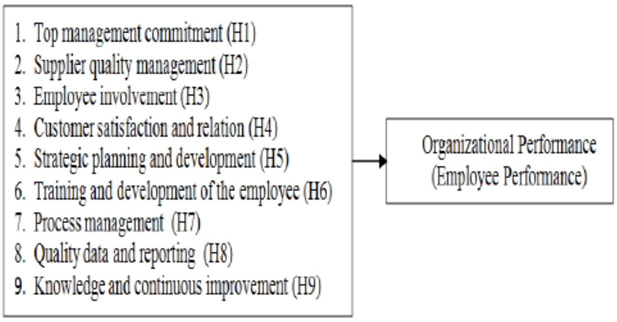
When discussing about internal marketing of the company, one of the most significant factors that need to be emphasized is the performance. To reach the highest level of performance is challenging and tough due to the more and more challenges faced. The performance is the indicator to ensure the continuous development and market standard and also requirements of innovation. Organizational efficiency depends on the employee performance (Gruman & Saks, 2011). Nowadays, the researchers are interested to do research on human capital as one of the factors in an organization's financial performance. Employee performance has positive effects towards organizational performance (Carmeli & Tishler, 2004). The organizational effectiveness improvement is currently seen as critical to the growth and survival of organization by the process of measuring and managing employee performance (Den Hartog et al., 2004). According to Hansen and Wernerfelt, (1989) they had illustrates the importance of employees and the relationship to the organizational performance. Human factor is one of the determining variables besides environmental factors and organizational factors on the organizational culture, which will influence employee behaviors and organization performance (Kidd, 2006). Author will describe employee performance into two criteria which are employee involvement and employee satisfaction and based on the previous studies (Walumbwa et al., 2011).

III. RESEARCH METHODOLOGY

A. Measurement Instrument

Based on the literature reviewed, following factors of TQM practices were considered for this study: top management commitment (TMC); supplier quality management (SQM); employee involvement (EI); customer satisfaction and relation (CSR); strategic planning and development (SPD); training and development of the employee (TDE); process management (PM); quality data and reporting (QDR); and knowledge and continuous improvement (KCI) and also included employee performance as one of the organizational performance. Figure 1 shows nine hypotheses developed and conceptual research model based on literature reviewed.

Fig. 1. Hypotheses and conceptual research model



We adopted the items of the questionnaires of TQM practices and employee performance from various literature reviewed mentioned in references.

The questionnaire included 75 TQM items and 7 items for the employee performance measures. The items included a five-point Likert-type scale anchored from (1) strongly disagree to (5) strongly agree, which indicates respondents' disagreement or agreement with each item, respectively.

B. Population, Sample and Data Collection Process

In this study a cross-sectional survey methodology was used, and the unit of the sample was at the department's level in the case company. The sample was selected from the company located in the Bole Sub city, Addis Ababa (Ethiopia).

The questionnaire was refined based on the comments taken from the company representatives (respondents), managers, and academicians. Questionnaire was also refined after conducting a pilot study and taking feedback from the respondents to make it simple, clear, understandable, and easy-to-follow. Respondents were asked about their company performance data based on the past experience in company with respect to their major competitor in the industry. Confidentiality was promised, and details of the respondents were not asked to improve accuracy of responses and response rate.

Questionnaires were administered with the help of Head, Human Resource Department. Simple random sampling technique was used to distribute the 200 questionnaires. The completely 176 useful questionnaires were obtained, with a good response rate of 88.00 percent.

C. Statistical Analysis

The raw data collected was coded and then analyzed by using SPSS-20. The completely useful 176 questionnaires samples were used for mean, standard deviation, bivariate correlation and regression analysis to investigate the impact of TQM practices on employee performance. All the hypotheses were tested as per conceptual model developed. The TQM index (TQMI) equals the aggregate of all TQM factors (Sadikoglu & Zehir, 2010).

IV. RESULTS

A. Results of the Reliability, Descriptive Statistics, and Correlations

Table I lists descriptive statistics, Cronbach's alpha values, and Pearson correlations for the variables in the research model. All factor loadings were greater than 0.50 thresholds. This means that unidimensionality and construct validity of the measures were satisfied. Cronbach's alpha values of the factors were between 0.718 and 0.958, which surpasses the 0.70 threshold. This showed that all TQM and performance scales had acceptable reliabilities.

The average score (mean) obtained from each factor was interpreted into degree of TQM practices used as follows: Average score = 1.00-1.80: Very low; Average score = 1.81-2.60: Low; Average score = 2.61-3.40: Moderate; Average score = 3.41-4.20: High; Average score = 4.21-5.00: Very high. As presented in Table I, the mean values of TQM practices were less than four. This means that the company in the survey, in general, have implemented TQM practices moderately in SQM, EI, and QDR, whereas in, TMC, CSR, SPD, TDE, PM, and CI, implemented highly.

Table I Descriptive statistics, cronbach's alpha, and bivariate correlation for the variables in the research model

Factors	TMC	SQM	EI	CSR	SPD	TDE	PM	CI	QDR	TQMI
TMC	(0.805)									
SQM	0.518**	(0.718)								
EI	0.653**	0.560**	(0.856)							
CSR	0.485**	0.662**	0.520**	(0.849)						
SPD	0.429**	0.793**	0.502**	0.752**	(0.781)					
TDE	0.530**	0.586**	0.724**	0.419**	0.594**	(0.744)				
PM	0.392**	0.363**	0.299**	0.589**	0.580**	0.429**	(0.831)			
CI	0.400**	0.549**	0.561**	0.621**	0.640**	0.691**	0.592**	(0.804)		
QDR	0.562**	0.623**	0.657**	0.632**	0.636**	0.602**	0.375**	0.770**	(0.776)	
EP	0.208*	0.426**	0.581**	0.300**	0.339**	0.582**	-0.081	0.420**	0.510**	(0.866)
TQMI	0.710**	0.792**	0.800**	0.795**	0.829**	0.803**	0.648**	0.826**	0.835**	(0.958)
Mean	3.461	3.333	3.262	3.420	3.447	3.458	3.518	3.466	3.366	3.415
SD	0.412	0.384	0.589	0.398	0.415	0.463	0.450	0.415	0.464	0.347

Note: N = 176; ** all correlations are significant at the p < 0.01 level (2-tailed); Values on the diagonal are Cronbach's alpha; TMC = Top management commitment; SQM = Supplier quality management; EI = Employee involvement; CSR = Customer satisfaction and relation; SPD = Strategic planning and development; TDE = Training and development of the employee; PM = Process management; QDR = Quality data and reporting; and KCI = Knowledge and continuous improvement; EP = Employee performance; TQMI = Total quality management index; SD = Standard deviation

The study has found that all factors are positively correlated with each other at the significance level of p<0.01. The measures have face validity because the questionnaire was refined with respect to feedback from the managers and academicians and the results of the pilot study.

The bivariate correlations among the TQM factors range from 0.299 to 0. 793.The correlations between the TQM practices and employee performance measure range from 0.208 to 0.582, except PM = -0.081. The measures have discriminant validity since the correlation coefficients between the TQM practices and performance measures are lower than the reliability coefficients. There is a strong criterion-related validity since the bivariate correlations of the TQM practices with performance measure are statistically significant.

Correlation coefficients values of independent variables are less than 0.8 (Table I). This suggests that results will be close to true value, and their multicollinearity does not have an undue effect on the regression models (Asher, 1983).

B. Results of the Regression Analyses between TQM Practices and Employee Performance

Table II shows the results of the regression analysis between TQM index and the employee performance measure. Regression model is significant (p<0.01) and TQM index is significantly and positively related to performance. This shows that TQM practices, in general, improve employee performance.

Table II Results of the regression analysis between tqm index and performance measure

Dependent Variable	**Independent Variable: TQM Index**		
	B	**T**	**p**
Employee Performance	0.709	5.928	0.000
	Result	**R Square Adjusted**	**F**
	Significant	0.223	35.143

Tables III present the results of the regression analysis between the TQM practices and employee performance. In regression table, the regression model is statistically significant (p<0.001). The coefficient of multiple determination, R square, shows the proportion of variation of the dependent variable accounted for by the independent variables in the regression model. R square value of regression model is greater than either 0.15 or 0.35 that can be interpreted as medium effect or strong effect, respectively (Cohen, 1988).

Table III Results of the regression analysis between tqm index and employee performance measure

IV	**Dependent Variable: Employee Performance**			
	β	**T**	**P (Result)**	**Collinearity Statistics Tolerance (VIF)**
TMC	-0.374	-3.378	0.001 (Insignificant)	0.434 (2.305)
SQM	0.064	0.441	0.660 (Insignificant)	0.288 (3.473)
TDE	0.572	4.630	0.000 (Significant)	0.275 (3.631)
EI	0.245	2.690	0.008 (Insignificant)	0.313 (3.195)
CSR	0.307	2.196	0.030 (Insignificant)	0.291 (3.442)
SPD	-0.079	-.505	0.615 (Insignificant)	0.216 (4.629)
PM	-0.542	-5.207	0.000 (Significant)	0.411 (2.431)
CI	0.007	0.045	0.965 (Insignificant)	0.223 (4.492)
QDR	0.240	1.871	0.064 (Insignificant)	0.255 (3.929)

Note: IV = Independent Variables; R Square Adjusted = 0.593; F= 20.241; p < 0.0001

V. DISCUSSION, AND MANAGERIAL IMPLICATIONS

A. Discussion of the Analyses

The study has found that TQM index is positively related to employee performance measure. TQM practices, in general, improve performance of the company.

Moreover, the study has found that how different TQM practices significantly affect employee performance. Although TMC (Top management commitment); SQM (Supplier quality management); EI (Employee involvement); CSR (Customer satisfaction and relation); SPD (Strategic planning and development); QDR (Quality data and reporting); and KCI (Knowledge and continuous improvement) are not significantly related to any employee performance measure.

TDE (Training and development of the employee); and PM (Process management) are only the two TQM practices (Hypotheses H6 and H7) that are positively related to employee performance. Allocating firm resources to training on quality pays off as professional employees know advanced statistical techniques, concepts of quality, basic characteristics of their industry, and the structure and processes of the firm. Furthermore, treating employees as a valuable resource increases their loyalty to the firm, motivates them and makes them proud of their jobs, improves their work-related performances, decreases absenteeism, and reduces intentions to quit. Educated employees will increase quality, reliability, and timely delivery of the products/services. With effective training, employees know the industry and the structure of the firm better. Effective training on quality also increases employees' skills to work effectively and efficiently. Furthermore, it will improve employees' loyalty to the firm, their motivation, and work-related performances. Employees' training on delivering high quality and reliable products and/or services reduces customer complaints.

B. Managerial Implications

Managers can use the model periodically to assess where their firm stands in the TQM journey. They can also measure the effects of TQM practices on various performance measures in order to evaluate the effectiveness of TQM practices. The positive relationships between TQM practices and employee performance measure can motivate the leaders of the company to commit resources in time, effort, and capital to the implementation of TQM practices in pursuit of improved innovation, employee, and firm performances and, ultimately, competitiveness in the market place. Company should work to improve the employees' (internal customers') satisfaction, motivation, commitment, and effort in order to improve innovation performance, customer satisfaction, and company performance.

VI. CONCLUSION

TQM is a holistic and ethical approach of the firms to continuously improve their products/services or processes involving all stakeholders in order to satisfy their customers and to improve performance and sustainability. The results give that overall TQM practices improve employee performance measure. Leadership does not affect performance. This is supported by the results of Choi and Eboch (1998), and Kannan and Tan (2005). Successful training and process management practices improve employee performance.

Company should improve top management commitment; supplier quality management; employee involvement; customer satisfaction and relation; strategic planning and development); quality data and reporting; and knowledge and continuous improvement to implement TQM successfully.

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A Green approach to integrate the Textile and Garment Industry for Sustainable Development a literature review

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Abstract

In today's world trade scenario increasing competitiveness of the textile and garment industry through reducing the consumption of resource is a vital issue. And, the increased awareness and concern of consumers for the need to protect the environment and following sustainability have adversely affecting the Ethiopian textile and garment industry along the value chain in the export market. With the other scenario the Ethiopia government is giving a high attention to the sector by establishing an industry park in different corner of the country. Therefore, to be more competent in the international market a great attention for the green processing of the textile and garment industry will be an emerging issue. This paper analysis how to make green the textile and garment sector along the value chain from raw material to disposal by collaborating the roles of different stakeholders.

Keywords- **Green processing, circular production, sustainable, textile and apparel industry**

I. INTRODUCTION

Ethiopia's textile industry is set to gain s steady foothold in the international textiles and garment export market. The country now has a unique chance to enable sustainable development and inclusive growth of the sector. The industry aims to export US$ 1 billion worth of garments every year by 2020 and has the potential to create jobs for more than 350,000 people. In the past five to six years, the textiles and apparel industry has growth at an average of 51%. 65 international textile investor projects have registered in the country. Growth is directly linked to the government's industrial development strategy. However, its textiles sector still faces many challenges. Efficiency in factories can often be slow, affecting between 40% and 45% of production volume. Processes need developing and the workforce requires more education. Cycle times can be up to 150 days due to lack of raw materials. Only 40% of the materials needed are available in Ethiopia, 60% are imported. Compared to other countries, manufacturing and production can take 45 to 60 days longer. Challenges also include restriction in technology, specifically in digital processing for transactions. Actors in the sector needed to address these challenges together. International buyers have raised social and environmental standards in past years, due to greater customer demand for fairly produced garments. Growth in the sector and its establishment in Ethiopia need to be sustainable, adhering to international standards and regulations. [1]

Consumers, governments and communities alike are concerned with how the manufacturing of consumer products affects the environment. While retailers and brands work to demonstrate good environmental governance across their supply chains, suppliers are concurrently being asked to continuously improve their environmental performance. A good environmental practices and commitment of different stakeholders along the supply chain will; reducing costs, improving material efficiency, practicing green manufacturing good practice, and, ensuring the organization meets the requirements of tomorrow's employees, communities, investors and customers. This will benefits the business providing greater visibility on environmental commitment and performance by:

- Meeting environmental regulatory requirements
- Reducing both environmental footprint and costs
- Improving material efficiency through better resource management, including recycling, reuse of materials, and waste reduction
- Acquiring sustainable business practices
- Leveraging insights for green production and sustainable purchasing
- Achieving good corporate governance and preferred supplier status
- Demonstrating commitment and robust "Green" credentials to stakeholders
- (Investors, Employees, Community and Customers) [2]

Eco friendly clothing is created from resources that are environmentally friendly and sustainable. Consideration is given to the product's total life span as well as its impact on the planet, in other words, the carbon footprint. Eco friendly clothing is created from resources that are environmentally friendly and sustainable, and efficient management of obtaining green clothing requires considering all stages, starting from designing for the environment, obtaining raw materials, producing garments, distributing them to the channels, stores and also considering their reverse logistics and waste. Along the stage of the textile product life-cycle there are many key inputs and key outputs that are very important in the green life-cycle procedure. Green aspects in the textile and clothing industry will be evaluated along the product-life cycle. To win the highly competitive market and restricted laws and regulations the textile and garment industries in Ethiopia have to follow the following green approaches. [3]

Greening the source of raw material

One of the largest polluters industries in the world is the textile industry. Study shows that more than 8,000 chemicals are used to manufacture clothes starting from raw materials. The choice of raw materials for clothing has large impacts on the environment. The most used natural fiber cotton is notorious for its intensive use of water and pesticides. Growing cotton takes a lot of water, land, pesticides, and fertilizers. Studies estimates that 10% of the world's pesticides, 25% of insecticides, and as 2.5 percent of all the world's water are consumed by cotton. Most pesticides that was used during the growing of cotton are likely carcinogens. According to the World Health Organization, 20,000 deaths occur annually in developing countries from the poisons in pesticides that are used in crops. The dyes used for aesthetic value addition on the textile products often also require the use of supplementary chemicals containing toxic metals. Chemicals used in the finishing and dyeing processes impair the quality of soil and groundwater quality. Fiber choice also drives consumer-care requirements, which can indirectly impact the consumption of water, energy and toxic chemicals. [7-8] Synthetic fabrics and dyestuffs processed with heavy chemical agents are facing a sustainability issues because of the harmful effects on our ecology as well as human health. Sustainable agriculture is a renewable resource, with the main idea being that the earth's natural resources are not exhausted. The focus is to have a minimal long-term effect on the environment. Key factors of sustainable clothing are the fibre source and renewability without the use of agro-chemicals, hormones, and pesticides, along the entire manufacturing process from raw fiber to textile. [3] As the current scenario Ethiopia are using only cotton as a natural raw material for the processing of textiles, apart from this research organization, university, governments have to take the initiation to develop fibers from different plant products that are thought at this moment to be considered as a waste.

Greening the Design process

The designing stage have a great impact on the processing and the final output in terms of waste management. The eco design is an approach that seeks improve the ecological quality of a product, by reducing its negative impacts on the environment throughout its life cycle. It is characterized by the taking into account of the environment in the design phase or for a product enhancement. The literature on eco design was focused on two approaches: The respectful of the environment design (environmentally conscious design ECD) and that of the life cycle analysis (LCA). Life cycle assessment (LCA) is used to forecast the impacts of different production alternatives of a product to able to choose the most environmentally friendly one. Today designers in the textile and clothing sector must focus on several different design approach according to several categories, such as energy use, toxicity, resource depletion, waste management and many others. By comparing different products, designers can make decisions about which environmental hazard to focus on in order to make the product more environmentally friendly. This causes the minimisation of waste and hazardous by-products, air pollution, energy expenditure and other factors. The approach of respectful of the environment design (ECD) is equivalent often to replace a hazardous input or doubtful by another less problematic. While that of the life cycle can be proposed to analyze all the consumptions of the product throughout its life cycle in order to reduce to the maximum.[7]

Greening the textile Processing

The processing of textile production involves a number of steps from the fibre stage until the final products. Along this processing stage a number of toxic chemicals are used which are often bonded to the fabric fibres. Many of these chemicals leave residues on the fabric that can never be easily washed out. Those chemicals are used in several places along the treatment of a single fabric such as sizing, scouring, bleaching, shrink resistance, anti-static and wrinkle reduction, stain and odour resistance, fireproofing and different dyestuffs. Those chemicals are primary responsible for all wastes generated along the processing (Table I).

Table I. Wastes generated during textile manufacturing

Process	Waste generated
Fiber preparation	Fibre waste and packaging waste
spinning	Packaging wastes; fibre waste; and processing waste
sizing	BOD; COD; metals, Fibre lint; yarn waste; packaging waste; size unused
Weaving	Packaging waste; yarn and fabric scraps; used oil.
Knitting	Packaging waste yarn and fabric scraps
Desizing	BOD, lubricants; anti-static compounds
	Packaging waste; fibre lint; yarn waste
Scouring	Disinfectants, insecticide residues; NaOH, detergents
Bleaching	H2O2, stabilizers; high pH
Mercerizing	High pH; NaOH
Dyeing	Metals; salt; surfactants; BOD; COD; sulfide; acidity/alkalinity;
Printing	Suspended solids; urea; solvents; colour; metals; heat; BOD; foam
Finishing	contaminants in purchased chemicals;
	formaldehyde vapors; COD; suspended solids; toxic materials; Fabric scraps and trimmings; packaging waste

Moreover more than 150 litres of water per kilogram of fabric was used in all over step of the textile process, which are full of chemicals, which in turn pollutes the environment via the effluent's, because it is saturated with dyes, chemicals, auxiliaries and many other chemicals used during the process. Those chemicals have a great impact on the ecosystem and marine life with have also a long-term impact on human health's as shown in Table II. [5]

The green processing of textile means the integration of the environment as a major component of the management of the firm. Today's consumers want high-quality textiles that are harmless to their health and made in facilities which are environmentally friendly and socially responsible. To make the textile and garment manufacturing process greener the companies along the value chain have to be more committed to improve their environment in a clear and transparent way by implementing different sustainable and social standards in which international retailers and brands are looking for.

Greening the operations and following a circular production

The main application of green operations is improving an existing product or process. These operations include manufacturing and re manufacturing, circular production, network design and waste management. The main goal of green manufacturing is to reduce the environmental impacts of a product by using proper material. Green manufacturing includes activities such as reducing and recycling; while remanufacturing includes reusing and product/material recovery. Also, green manufacturing and remanufacturing requires inventory management, production planning and scheduling besides the usual planning due to varying and unknown amounts of products returned for recycling.

Reducing is a technique in which the consumption rate of scarce materials and/or energy is minimised. Recycling refers to activities performed to recover material from products. Reusing is the concept of using intact parts of used products for manufacturing activities. Product/material recovery refers to activities performed to regain the product value at the end of its lifecycle. These activities include repair and dis assembly. Waste management is the management of waste generation and its impacts through activities such as source reduction, pollution prevention and disposal. Waste minimisation is defined as reducing hazardous waste generated during production and operations, and afterwards treating, storing or disposing wastes. Source reduction and pollution prevention strategies try to hinder pollution at the generation source, while disposal is intended to dispose waste after its generation.

Table II Environmental and social impact of textile manufacturing processes

Textile processing	Ecological impact	Social impact
Fibre production	Intensive use of pesticides, synthetic fertilisers Soil exhaustion and destruction of self-regeneration capacity Disturbance of soils' water balance. drying-out and contamination of sources,	High impacts on human health Financial dependence on pesticide, synthetic fertilisers and chemical companies
Spinning and fabric production	Energy intensity	
Dyeing and Finishing	Toxicity of chemicals (dyestuff and Chemicals) Pollution of waste - water and insufficient degradability Use formaldehyde, use of banned amines and heavy metals, high water and energy consumption	High impacts on human health
Clothing production	Low impacts	Labour conditions ,Minimum wages Child labour

Textile waste can be classified as either pre-consumer or post-consumer. Pre-consumer textile waste consists of by-product materials from the fibre, textile and garment industries. This waste is recycled into new raw materials for the automotive, furniture, mattress, coarse yarn, home furnishings, paper and other industries. Post-consumer textile waste consists of any type of garments or household articles discarded either because they are worn out, damaged, outgrown, or have gone out of fashion. They are sometimes given to charities but more typically are disposed of in the trash and end up in municipal landfills. Textile scrap categories can be classified as cotton, wool, jute, nylon, synthetic textile scrap, carpet scrap, used and recycled bags, used clothing, used footwear, leather scrap and other textile scrap. The average lifetime of any clothing is deemed to be for about 3 years, after which they are thrown away as old clothes.

Reusing; - There are important benefits of recovering and recycling textiles, chemicals both environmental and economical. The first advantage is reducing the need for landfill space. Certain synthetic fibre products do not decompose. The second advantage is reducing pressure on virgin resources. This includes materials traditionally used in textiles, such as cotton or wool, as well a soil and other chemicals employed to produce synthetic fibres. Reducing pollution as well as water and energy consumption and reducing the demand for dyes and fixing agents are other advantages. More than a million tons of textiles are thrown away each year, most of which by households rather than industry. Today especially in developed countries there are many recycling centres, charities and collection projects accept textile goods, as that in developing countries like Ethiopia this trend have to come in to practices. Integrating the garment factories with those textile recycling factories are very important to use effectively the scraps, currently dumped to the land which have a long-term impact on the environment.

Recycling; - The recycling process starts with sorting collected textiles according to their condition and the types of fibres used. Only 20% of clothing waste is collected globally for reuse or recycling. The remaining 80% is landfilled or incinerated, which results in a great loss energy and raw materials. [9] Un-wearable textiles are sold to the 'flocking' industry for shredding and re-spinning. The colour sorting means no re-dyeing is needed to save energy and avoids pollutants. Then textile materials are shredded or pulled into fibres and depending on the end use of the yarn, other fibres maybe incorporated. The blended mixture is carded to clean and mix the fibres. The yarn is re-spun ready for later weaving or knitting. In the case of polyester-based materials, recycling starts by cutting the garments into small pieces. The shredded fabric is then granulated and turned into polyester chips, which are melted and spun into new filament fibres used to make new polyester fabrics. Knitted or woven woollen and similar materials are reused by the textile industry in applications such as car insulation, roofing felt, loudspeaker cones, panel linings and furniture padding. Cotton is used to manufacture paper and to wipe and polish cloths for a range of industries from the automotive to the mining sector. Other types of textiles can be reprocessed into fibres for upholstery, insulation, and even building materials.

Green logistics; - For industries with lower margins, such as the clothing industry, green supply chain management can lead to lower supply chain related costs. These cost reductions can be translated into significant competitive advantages and profit. Other benefits of green supply chain management include reducing risk, improving productivity, increasing property value, improving public image and creating healthier environments.

Green supply chain management concepts manage environmental impacts where they occur, ideally before they occur. It tries to minimise the undesirable environmental impacts of supply chain processes within the participating organisations and the whole supply chain as well. It defined as "integrating environmental thinking into supply-chain management, including product design, material sourcing and selection, manufacturing processes, delivery of the final product to the final consumer as well as send-of-life management of the product after its useful life."

Reverse logistics (RL) is also a very important concept, and it was defined as "the process of planning, implementing and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal." Reverse logistics activities vary form product to product and industry to industry, but common activities are collection, transportation, inspection/sorting, storage, reprocessing (including recycling, reusing, repairing) and/or disposal. The eco-logistics and reverse logistics it is two different terms which belong to the great family of the logistics. The eco logistics refers to all actions that help reduce the impact of logistics on the environment. It concerns mainly the transport and CO_2 emissions which it is at the origin.

Recycling is a very important function in the context of the reverse logistics because it intervenes in the phase of recovery of the raw material used so that it can be reused in the production process.

Green procurement is another subject important in the green supply chain. It was defined as the process of "Deciding what, when and how much to purchase; the act of purchasing it; and the process of ensuring that what is required is received on time, and in the quantity and quality specified". Procurement activities include inventory management, identifying requirements, determining requirement specifications, finding appropriate suppliers, contract negotiation and management (price, amount, quality, delivery schedules etc.), receiving, quality inspection, storage and inbound distribution.

Green procurement tries to minimise the environmental impacts of selected products and services. The eco sourcing it encompasses the whole of supply made from suppliers, subcontractors, providers integrating environmental criteria. These criteria can be applied to all phases of the procurement process, but it is essentially in the requirements definition that these criteria are applied. Upstream of the procurement process, it is part of the definition of needs in materials/products and the identification of suppliers.

Green Packaging is very important, and the materials of which used for packaging must be environmentally friendly. This can be achieved through the reuse of shipping products, the elimination of unnecessary paper and packaging products, the efficient use of materials and space, the use of recycled or recyclable materials and also the use of packaging from the green sources. The end-of-life of a product is very important because some products emit dangerous chemicals into the air, ground and water after they are disposed of in a landfill.

All these negative environmental impacts could be significantly mitigated if the textile and clothing sector chose to replace the take-make-disposal model with a circular one. Effective recycling of the textile waste and reusing it as raw materials could largely reduce the demand for the end products and fibres. [8]

II. Conclusions

Problems such as global warming, caused by increasing atmospheric carbon dioxide levels from the burning of fossil fuels, natural resource depletion, toxic waste disposal, and increasing air, water, and soil pollution from both agriculture and industry are becoming issues of global importance, requiring concerted international action to solve them. In such a scenario, it becomes every individual's responsibility to contribute proactively and participate in the solving of these problems. Every industrial sector and the leading companies in each sector are also now being held to account for their impact on human health and the environment. [6] The aim of this review article was to analyse the current situation of textile and clothing industry to increase the awareness for making it greener and to be competitive in the international market. The competitive environment forces industries to redesign their existing structures, and today it is an obligation to be environmentally responsible in the textile and clothing industry. Starting from the product design stage, raw material selection, to the processing and production decisions, transportation, retailing and waste management, it is possible to make textile and clothing production more environmentally friendly by taking precautions and can be more competent in the international market (Table III). Therefore, different stakeholders that are involving in the value chain of the textile processing have to act in a proper manner to make the textile and garment industries greener for long term sustainable development.

Table III Summary of green SCM practices [4]

Process	Good practices
Eco-design	-use of ecologic raw materials and recycling product at end of life. -life cycle analysis of product -environmental product Conception - partners collaboration -Reduction of energy expenditure by good planning
Eco-Sourcing	-selection of suppliers with ecological manufacturing process -application of environmental criteria in choosing suppliers -Choice of suppliers that have environmental management systems -Ensure supplier compliance with the ISO 14001 standard, other sustainable standards -Establish an environmental partnership with suppliers -use of e-procurement - Inspection Hazardous Materials daily storage areas for hazardous waste -Energy Efficiency in Warehouses -Donation of surplus stocks or obsolete to local communities
Eco-Manufacturing	-Equipping an environmental management system -Use of production techniques respectful of the environment -Choice of plan the picks of production at the time or the energy demand is low -Minimization of packaging materials -Use of recyclable packaging
Eco-logistic	Limitation of the -distances travelled by the raw materials and products -Use of alternatives of transport which Optimization of the route of vehicles (reduction in fuel consumption) - -Reuse of packaging materials -consume less fuel
Reverse Logistic	Product recovery for recycling

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Factors Contributing to Job Satisfaction of Employees: A Case Study on Ambassador Garment Manufacturing Industry

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Abstract

The development of interest in job satisfaction in the organizational setting is not a recent phenomenon. Job satisfaction is defined as the degree to which individuals have positive or negative feelings about their job. It is an important issue that human resource management should understand their employees. Job satisfaction affects productivity, absenteeism and staff turnover. The study was conducted among employees working in a garment products manufacturing company (i.e., Ambassador Garment, Addis Ababa) to study the level of job satisfaction. The study focused on employee's level of satisfaction on factors contributing to job satisfaction and the relationship between level of job satisfaction (viz., nature of job, pay and benefits, supervision, interpersonal relations, career advancement, working conditions, and attitudes toward the company). A self-administered structured questionnaire (five-point Likert scale based) was used as the instrument to collect the primary data from sample size of 100 employees. The data obtained from questionnaire was analyzed by using statistical package for the social sciences (SPSS-20 version). The results were presented in forms of frequency, percentage, and mean. The overall results revealed that employees were moderately satisfied with their jobs presenting with mean score of 3.075. The first factor that employees were highly satisfied with was the interpersonal relations and supervision of their job with mean score of 3.76 and 3.42. Most of them reported moderate satisfaction on nature of job, career advancement, working conditions, and attitude towards company with mean score of 3.24, 2.81, 2.96, and 3.04. However, the respondents felt less satisfied with pay and benefits with mean score of 2.03 and 2.26 respectively. The results revealed that employees tended to focus on pay and benefits, career advancement, and working conditions of their job rather than other factors of job satisfaction. This finding implied that employees are generally motivated by pay and benefits. As a result, the increase in welfare and benefits will definitely result in greater level of job satisfaction. Based on the findings and conclusions of this study, it is recommended that company (i) should do job satisfaction analysis time to time to know the employees attitude towards company otherwise which may affect productivity, (ii) should do comparative analysis with other garment manufacturing companies at national level related to pay and benefits for employees (iii) should fix some criteria for career advancement for the employees related to trainings needs and further educations, and (iv) should keep proper arrangement for machine operators and maintenance person's items/tools required by them time to time to avoid breakdown in operations.

Keywords- **Job satisfaction, Employees, Garment manufacturing company**

I. INTRODUCTION

In this competitive world, people tend to spend at least one-third of their daily lives at work; they sometimes bring their work and mood back home. As a result, work currently becomes an important indicator of life quality. The most referred definition of job satisfaction was offered by Locke (1976) [1] who defined job satisfaction as a pleasing or positive emotional state resulting from the evaluation of a person's job [2]. Job satisfaction is also defined as an individual's general attitude regarding his or her job [3]. Mullins (1993) [4] mentioned that motivation is closely related to job satisfaction. Various factors such as an employee's needs and desires, social relationships, style and quality of management, job design, compensation, working conditions, perceived long range opportunities, and perceived opportunities elsewhere are considered to be the determinants of job satisfaction [5, 6]. Job satisfaction has a significant influence on employee's organizational commitment, turnover, absenteeism, tardiness, accidents, and grievances [5, 6]. According to Robbins (1999), a satisfied workforce can increase organizational productivity through less distraction caused by absenteeism or turnover, few incidences of destructive behavior, and low medical costs [3].

A high level of job satisfaction also results in greater productivity and a greater degree of life satisfaction. Meanwhile, a low level of job satisfaction contributes to greater absenteeism, turnover rate, and stress from work which affect organizations in terms of less productivity, opportunity loss, and cost increase. Furthermore, negative job satisfaction which one experienced from work reflects in his/her poor quality of life [7].

Job satisfaction is promoted through favorable perceptions of job characteristics, supervisors and co-workers and is also influenced by differences in individual personality [8]. The positive feeling associated with high job satisfaction that result from favorable evaluations of what organization supplies make people more willing to carry out behaviors associated with tasks that contribute to organizational effectiveness [9].

Various studies in the past have tried to explain how the work environment in different areas plays an important role. Research in pharmaceutical industry, in Bangladesh (Kabir, 2011) also found that working environment played an important role in the employee's job satisfaction [10].

Another important factor that affects job satisfaction is salary as shown by the survey conducted [11] in the automobile industry. That particular survey aimed at describing the different job characteristics and how they were ranked by the employees. The results, not so surprisingly, showed that the number one factor for job satisfaction was found to be compensation and number for motivation was salary. For retention and turnover, compensation is a very important tool. It also tends to motivate an employee who is committed to the organization and enhances either attraction or retention [12].

Many studies reveal that relationship with co-workers is the strongest determinant of job satisfaction. This finding reflects the importance that social relations in the workplace can have on employee job satisfaction. This result is in line with the extant research in collectivist cultures where employees are reported to put a strong emphasis on cooperative and collegial work [13].

According to Al-Hussami (2008) [14], employees want supervisors who have a bond with them and who trust them, understand them and show fairness. If the supervisor is abusive the worker is left with no choice but to be dissatisfied with their job.

According to Shoaib et al. (2009) [15], there exists a good and positive relationship between fairness of work policies, insurance policies and working hours and job satisfaction. Through a course of action based on work-life principle, a respond can find itself on a better position to be able to cater to the demands of customers for better service accessibility [16-18]. Through this, the organization can also reach tactics to work with the revolutionized ways that will end up satisfying both the employers' and the employees [19].

The studied company is a garment manufacturer that produces a variety of products. Since all the production processes are complicated, skilled and experienced employees are required to perform the tasks in order to enable the company to maintain product quality, timely delivery, and cost effectiveness for both internal and external customers. Therefore, employees are seen as one of the success factors in this business as several production processes rely on man rather than machine.

The study on employee's job satisfaction was conducted in order to help management to better understand employee's degree of job satisfaction. The result findings will be ground information for management for providing corrective action programs, plans and/or policies to prevent and/or solve the problems, which will help increase the level of job satisfaction and eventually lead to employee retention.

II. RESEARCH METHODOLOGY

A. General Objective

To explore the level of job satisfaction among employees working in a garment manufacturing company and their attitudes toward factors contributing to job satisfaction.

B. Significance of the Study

- The study demonstrates the degree of employee's job satisfaction and their attitudes toward factors of job satisfaction. The results will enable management to better understand their employees.
- The study will help management to access and diagnose employee's problems.
- The results will be a primary resource for management to use for future improvement in the company concerning company policy, compensations planning, and other factors of job satisfaction which will eventually lead to overtime reduction, cost effectiveness and employee retention.

C. Methodology

(i) Subjects and Materials

The participants of this study were operational employees working in a garment manufacturing company. There were total 723 permanent employees in the company who were eligible to answer the questionnaire. Among 723 permanent employees, 100 employees (sample size) have responded to the study.

A self-administered questionnaire was the instrument of the study. The questionnaire was checked by General Manager and Head, HR department of the company. From the primary questionnaire developed (39 items), two items were deleted as per suggestions given by General Manager and Head, HR department of the company.

The questionnaire was firstly designed in English language and translated into Amharic language before being distributed to the respondents in order to ensure that the respondents could understand the questions. The structure of the questionnaire was mainly based on five-point Likert scale, part of which included closed-ended and open-ended questions. The questions were grouped into two parts as follows.

Part I: Personal background of the respondents: The first part was designed in an attempt to collect the respondent's personal background. This part consisted of seven questions (gender, marital status, age, education, monthly income, years of service, and working position) which were presented in forms of closed-ended and open-ended questions.

Part II: Attitudes toward job conditions: This part consisted of 37 items asking for employee's attitudes toward each factor of job satisfaction in order to measure the degree of satisfaction with job aspects; the nature of the job, pay and benefits, career advancement, supervision, interpersonal relations, and working conditions. The items were presented in five-point Likert scale (5=Strongly agree, 4=Agree, 3=Uncertain, 2=Disagree, and 1=Strongly disagree).

(ii) Data Collection Method

The copies of the self-administered questionnaire were distributed to the 100 participants from various departments (Human Resource Department, Marketing Department, Production and Technique Department, and Finance Department) on 14 working days with the help of human resource department.

The participants were asked for their willingness to participate in the program before being handed the questionnaire. The participants were also informed of the objectives of the survey by a cover letter and were assured that all data obtained from the questionnaire word be treated as strictly confidential and used for study purposes only. The participants were requested to complete the questionnaires within one to two hours on same day. The response rate was 100 percent.

(III) Data Analysis Method

The data obtained from the study was analyzed using the SPSS program. The results were presented in forms of frequency, percentage, and mean. The five-point rating was scored as shown in Table I.

Table I Indicated points given to the items in questionnaire part II

Item with Positive Meaning	Item with Negative Meaning
5 = Strongly agree	1 = Strongly agree
4 = Agree	2 = Agree
3 = Uncertain	3 = Uncertain
2 = Disagree	4 = Disagree
1 = Strongly disagree	5 = Strongly disagree

The five-point scale was calculated and interpreted into the degree of satisfaction using the following formula.

$$\text{Interval} = \frac{\text{Highest score} - \text{Lower score}}{\text{Number of interval}} = \frac{5-1}{5} = 0.8$$

The average score (mean) obtained from each item was interpreted into degree of satisfaction as follows: Average score=1.00-1.80: Very low degree of satisfaction; Average score=1.81-2.60: Low degree of satisfaction; Average score=2.61-3.40: Moderate degree of satisfaction; Average score=3.41-4.20: High degree of satisfaction; Average score=4.21-5.00: Very high degree of satisfaction

III. Data Presentation And Analysis

A. Demographic Data of the Respondents

From Table II, the total number of respondents was 100 employees. 59 percent of them were male and another 41 percent were female.

Table II Respondent's gender

Gender	Frequency	Percent
Male	59	59
Female	41	41
Total	100	100

From Table III, 58 percent of the respondents were single, while nearly 42 percent of them were married.

Table III Respondent's marital status

Gender	Frequency	Percent
Single	58	58
Married	42	42
Total	100	100

From Table IV, the majority (63%) of the respondents were young people aged between 20-30 years old, while 31 percent were between 31-40 years old. 3 percent of them were aged betwee-50 years old and 2 percent of them were aged between 51-60 years old, followed by 1 percent of them were aged between 61-70 years old.

Table IV Respondents' age (years)

Age	Frequency	Percent
20-30	63	63
31-40	31	31
41-50	3	3
51-60	2	2
61-70	1	1
Total	100	100

From Table V, 6 percent of the respondents graduated from primary school and 27 percent of them graduated from secondary school. While 6 percent of them graduated with high school. Mostly, 45 percent of the respondents graduated from vocational/diploma school. While 14 percent and 2 percent of them graduated with first degree and second degree.

Table V Respondents' educational background

Education	Frequency	Percent
Primary school	6	6
Secondary school	27	27
High school	6	6
Vocational/Diploma	45	45
First degree	14	14
Second degree	2	2
Total	100	100

From Table VI, over 55 percent of the respondents earned a monthly income between 1000-2000 ETB, 28 percent earned an income between 2000-4000 ETB per month, and 5 percent income between 4000-5000 ETB per month. While only 12 percent of the respondents earned more than 6000 ETB per month.

Table VI Respondents' monthly income (etb)

Monthly Income	Frequency	Percent
1000-2000	55	55
2000-3000	14	14
3000-4000	14	14
4000-5000	5	5
5000-6000	-	-
Above 6000	12	12
Total	100	100

From Table VII, the majority of them (36 percent) have worked with the company for 0-3 years and 9 percent of the respondents have worked with the company for 3-6 years. While 10 percent of respondents have worked with the company for 6-9 years, 21 percent of the respondents have worked with the company for 9-12 years, and 24 percent of them have worked with the company for more than 12 years.

Table VII Respondents' years of service

Years of Service	Frequency	Percent
0-3	36	36
3-6	9	9
6-9	10	10
9-12	21	21
Above 12	24	24
Total	100	100

From Table VIII, the majority of them (20 percent) are working in "Finishing section/line", followed by 15 percent of the respondents are working in "R & D department". While 12 percent of respondents are working in "Cutting section/line", 6 percent of them have "Section head", and 2 percent have "Supervisors" position in the company.

Table VIII Respondents' working position

Position	Frequency	Percent
Department head	1	1
Section head	6	6
Supervisors	2	2
R & D department	15	15
Mechanic	4	4
Cutting section/line	12	12
Coat A section/line	5	5
Finishing section/line	20	20
Design	3	3
Coat B section/line	3	3
Trouser section/line	1	1
Others	28	28
Total	100	100

B. Degree of Satisfaction toward Factors of Job Satisfaction

Table IX, represents mean scores and respondents' satisfaction with the nature of the job. The average satisfaction with the nature of the job had a mean score of 3.24 representing moderate satisfaction on this factor. Respondents were very highly satisfied with item 2, "I enjoy working" with a mean score of 4.58. Although respondents were highly satisfied with item 1 and 3, presenting in mean scores of 3.87 and 3.60. The results revealed that the respondents were low satisfied with items 4 and 6, "I wish I could change my job" and "I am not being used to my full capabilities" with a mean score of 2.18 and 2.42. Nevertheless, employees reported moderate satisfaction on item 5, with mean score of 2.8.

Table IX Mean and level of satisfaction (ls) with the nature of the job (nj), n=100

Items	Mean	LS
My skills and abilities are effectively used on the job.	3.87	High
I enjoy working.	4.58	Very High
My workload is reasonable.	3.60	High
I wish I could change my job.	2.18	Low
I am not being used to my full capabilities.	2.80	Moderate
My job is not challenging.	2.42	Low
Average	3.24	Moderate

Table X, represents respondent's low satisfaction with pay and benefits with a mean score of 2.26. The respondents reported low satisfaction on items 7, 9, 10, 11 with means scores of 1.88, 1.84, 2.11, and 2.21. On the other hand, employees reported moderate satisfaction on item 8, "I am satisfied with company welfare e.g. medical pay, provident fund, transportation service" with a mean score of 3.28.

Table X Mean and level of satisfaction (ls) with pay and benefits (pb), n=100

Items	Mean	LS
My pay and benefits are fair.	1.88	Low
I am satisfied with company welfare e.g. medical pay, provident fund, transportation service.	3.28	Moderate
Salary increment it reasonable.	1.84	Low
I can earn better salary if I work with other companies.	2.11	Low
I feel that benefits I received are less than my expectation.	2.21	Low
Average	2.26	Low

Table XI, reveals that respondents were highly satisfied with supervision with a mean score of 3.42. The respondents reported high satisfaction on items 12, 14, and 15 with mean scores of 3.60, 3.77, and 3.44. The results also showed that most of the respondents reported moderate satisfaction on items 13, 16, and 17 with mean scores of 3.14, 3.28, and 3.29 respectively.

Table XI Mean and level of satisfaction (ls) with the supervision (s), n=100

Items	Mean	LS
My superior is reasonable and fair.	3.60	High
My superior keeps me up-to-date on company policies.	3.14	Moderate
My superior gives me useful and constructive feedback.	3.77	High
My superior does not listen to my suggestion.	3.44	High
I cannot freely share my opinion with my superior.	3.28	Moderate
I wish I could work with other superiors.	3.29	Moderate
Average	3.42	High

Table XII, reveals that respondents were highly satisfied with interpersonal relations with a mean score of 3.76. Most of the respondents admitted that they enjoyed working with their colleagues because they usually cooperated to get the work done. These findings presented in mean scores of 4.49 (very high) and 4.29 (very high) respectively. Respondents were also highly satisfied with "My colleagues do not listen to my opinions or suggestions" with a mean score of 3.73. Results also showed that respondents reported a moderate satisfaction on items 21 and 22 with a mean score of 3.10 and 3.20.

Table XIII, shows respondents' moderate satisfaction with career advancement presenting in a mean score of 2.81. Most of them showed low satisfaction on "promotion was based on individual's performance and ability" (mean=2.14) and in promotional system (mean=2.51). The results also showed that most of the respondents reported moderate satisfaction on items 23, 25, 27, and 28 with mean scores of 2.66, 3.13, 3.13, and 3.30 respectively.

Table XII Mean and level of satisfaction (ls) with interpersonal relations (ir), n=100

Items	Mean	LS
I enjoy working with my colleagues.	4.49	Very High
My team cooperates to get the work done.	4.29	Very High
My colleagues do not listen to my opinions or suggestions.	3.73	High
I do not have good friends at work.	3.10	Moderate
I wish, I could work with other colleagues.	3.20	Moderate
Average	3.76	High

Table XIII Mean and level of satisfaction (ls) with career advancement (ca), n=100

Items	Mean	LS
My company encourages its employees to study more.	2.66	Moderate
Promotion based on individual's performance and ability.	2.14	Low
I receive necessary training to do my job well.	3.13	Moderate
I am not satisfied with promotional system.	2.51	Low
My superior does not encourage and support me for professional development.	3.30	Moderate
I do not receive constructive and useful feedback from my superior that benefits my career developments.	3.13	Moderate
Average	2.81	Moderate

Table XIV, indicates respondents' moderate satisfaction with working conditions presenting an average satisfaction rate of 2.96. Most of the respondents reported moderate satisfaction on items 29, 30, 31, 33, and 34 with mean scores of 3.20, 2.73, 3.21, 3.18, and 3.15 respectively. Respondents reported low satisfaction on item 32 "workplace needed to be improved immediately" with mean score of 2.29.

Figure I, summarizes scores and level of satisfaction obtained from factors of job satisfaction. The overall results indicated that respondents were moderately satisfied with their jobs with a mean score of 2.18, which is near to low level satisfaction. The majority of respondents reported high satisfaction with the interpersonal relations with mean score of 3.53. The majority of respondents reported moderately satisfaction with the nature of the job, supervision, and career advancement with mean scores of 3.21, 3.07, and 2.78 respectively. Pay and benefits, and working conditions were registered as low satisfactory, with a satisfaction score of 2.03 and 2.45.

Table XIV Mean and level of satisfaction (ls) with working conditions (wc), n=100

Items	Mean	LS
My work environment allows me to be highly productive.	3.20	Moderate
I have adequate tools and equipment needed for my job.	2.73	Moderate
My working environment is safe.	3.21	Moderate
My workplace needs to be improved immediately.	2.29	Low
I experienced occupational illness in the last few years.	3.18	Moderate
I am not satisfied with my working environment.	3.15	Moderate
Average	2.96	Moderate

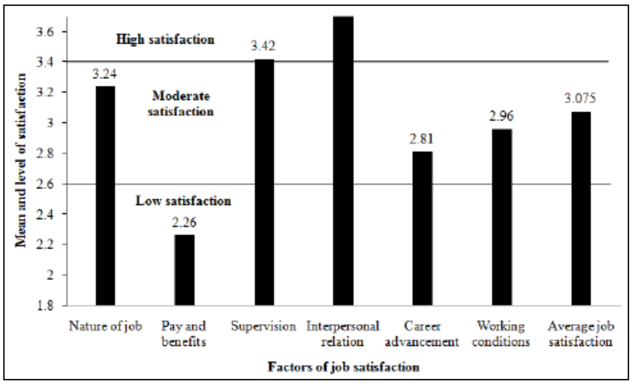

Figure I: Mean and level of satisfaction with factors of job satisfaction

C. Respondent's Attitudes toward the Company

Table XV, reveals that the moderate of the respondents (47 percent, mean=3.22) would probably work with the company in the next few years, while 31 percent of them gave a contrary answer.

Table XV Respondents' attitudes toward the company (atc), n=100

Items	SA	A	N	D	SD	Total	Mean	LS
In the next few years, I will still work with this company.								
Frequency (Percent)	12 (12)	35 (35)	31 (31)	7 (7)	15 (15)	100 (100%)	3.22	Moderate
I would work with this company until my retirement.								
Frequency (Percent)	7 (7)	5 (5)	32 (32)	28 (28)	28 (28)	100 (100%)	2.35	Low
I am proud to work in this organization								
Frequency (Percent)	29 (29)	35 (35)	9 (9)	17 (17)	10 (10)	100 (100%)	3.56	High
						Average	3.04	Moderate
Note: SA=Strongly agree, A=Agree, N=Neutral, D=Disagree, SD=Strongly disagree, LS=Level of satisfaction								

Over 56 percent (mean=2.35) of them were disagreeing if they would continue working with the company until their retirement. However, 12 percent of respondents would probably work with the company until their retirement. Furthermore, the majority (64 percent) of the respondents were proud to work with the company, while 27 percent of them disagreed with this idea.

IV. CONCLUSION

The results showed that the overall job satisfaction of employees working in a garment manufacturing company was 3.075 mean indicating a moderate degree of job satisfaction. The first factor that contributed to the highest satisfaction score (3.76) was the interpersonal relations, while pay and benefits gave the lowest satisfaction score (2.26). The results had indicated that employees were moderately satisfied with their jobs; however, most of them stated that they need workplace to be improved immediately (2.29), resulting in a low satisfaction score on working conditions.

The result also revealed that the majority of employees expected to see the improvement in welfare the most, followed by benefits. This finding indicated that employees generally focus on interpersonal relations and pay and benefits. As a result, the increase in welfare and benefits will definitely result in greater level of job satisfaction.

V. RECOMMENDATIONS

Based on the findings and conclusions of this study, the following recommendations are made for the case company.

It is recommended that company should do job satisfaction analysis time to time to know the employees attitude towards company otherwise which may affect productivity.

It is recommended that company should do comparative analysis with other garment manufacturing companies at national level related to pay and benefits for employees.

It is recommended that company should fix some criteria for career advancement for the employees related to trainings needs and further educations.

Company should keep proper arrangement for machine operators and maintenance person's items/tools required by them time to time to avoid breakdown in operations.

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DEVELOPMENT OF TWO LAYERED MULTICONSTITUE TECHNICAL TEXTILES IN SHUTTLESS LOOM FOR SPORTSWEAR

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Abstract

In this research work an attempt has been made to develop the Two Layered Technical Textiles for sportswear using Rapier Shuttless Loom with necessary setting alterations in loom and modifications in the essential components of the existing Shuttless loom. For the development of Two layered technical textiles for sportswear, the two different types of Sized Yarns have been used in a weaver's beam containing Lyocell micro fibre spun yarn and Polyester spun yarn for the two layered Technical textiles as inner and outer layers respectively, with suitable modification in the primary and secondary motion of the loom, such as Shedding, Let-off and Take-up motions. The two layered technical textiles for sportswear have been successfully developed in existing Rapier Looms. The modification in the shed geometry and shed crossing angle of the respective layers such as inner layer and outer layer has been done. In let-off motion the position and the load cell of the back rest were altered. Heavier load springs in oscillating bars have been changed. The warp tension has been maintained at the higher side. In the take-up motion three modification has been done which are the take up pressure roller diameter has been increased for better holding of fabric. Secondly the emery in the take up rollers have been changed to medium coarser and thirdly bigger spikes in the temple rings have been used for the better grip at fell of the fabric. With above modifications the development of two layered technical textile for sportswear has been successfully carried out.

Keywords: **Lyocell, Polyester, Rapier Looms, Temples, Two layered Fabrics**

I. INTRODUCTION

The recent R & D work reviles that two layered fabrics with different materials are performing better than single layer conventional fabrics. Based on the specified applications, the selection of different materials in the two layers has been used to get the required properties. In this work, the Two Layered Technical Textiles was developed for the specific use of sportswear. During sports activity, tremendous heat energy is developed which liberates sweat from body and the inner layer is directly contact with skin which should provide more comfort by way of absorbing the sweat and keeping the skin dry &cool. The outer layer used to protect the body from the environment conditions.

The sports activity has mainly divided into two categories such as, in-door and out-doors activities. Sport wear, Sport equipment's and Sport foot wear are the three major fields where Multilayered Technical Textiles have a very good scope. While designing the sportswear the shape, fit and comfort are the three major areas which play a vital role. The Sport wear is intact with the human body and it needs comfort. The constructional geometry, packing density, structure and constitute of materials are the important aspects which decides the comfort properties of the sportswear. The sportswear should withstand the environmental abnormal conditions such as heat, cold, radiations, rain and it should also have the required mechanical properties such as strength, drape, comfort and fit. Weaving, Knitting and Nonwoven Technologies have been adopted to develop the Two Layer Technical Textiles.

In this present work, the Two Layer Technical Textiles have been produced using the Shuttless looms with few modifications, alterations and adjustments in the settings. Since the warp constitute needs more number of shafts and different crossing points, the dobby attachments for shedding motion is very essential. While weaving technical textiles heavy beat-up is required. Hence the "beat-up cam" and "slay gears" are directly driven by the main motor. The take-up and let-off motions is controlled by servo motor.

Based on the above three concepts and necessary modifications with adjusting the settings the Two Layer Technical Textiles was developed in the existing Shuttless looms.

II. MATERIALS AND METHODS

The detail about the materials and the specifications to develop the Two Layer Technical Textiles are given in Table I.

Table I Material and specification

SL	Description	Inner	Outer
1	Material	Lyocell	Polyester
2	Fibre	0.7 D Tex	0.7 D Tex
3	Yarn Count	40.30	39.80
4	Fabric Weight	65 gram	65 gram
5	Weave Structure	Double Cloth	Double Cloth

The inner layer is Lyocell Micro fibre of 0.7 D Tex and yarn count of Ne 40.30^s was used. The outer layer is polyester Micro fibre of 0.7 D Tex and yarn of count Ne 39.80^s was used. Cotton yarn count of Ne 40.70^s has been used for the weft. The two-layer fabrics were constructed with the double cloth fabrics structure The weight of the two layer fabrics is 130GSM with 132 X 72 ends x picks per inch.

During warping the Lyocell and Polyester yarns are separately warped in the six warper's beam with 693 ends per beam. So that six warper's beam contains the 4158 ends. Then the two set of warper's beam have to be sized and to be wound on the weaver's beam. The "Double Sow Box" sizing was used in which one is for Lyocell sizing and another one is Polyester synthetic sizing. Both the sow box temperature has been maintained at 110° C for better penetration of the size.

The drying zones have 11 cylinders, out of which six cylinders are having Teflon coating. 120°C temperature has been maintained for the first two cylinders and gradually reduced from 120° C to 70° C in the subsequent cylinders the details in Table II.

Table II Parameters for two constituted warp sizing

SL	Description	Inner	Outer
1	Material	Lyocell	Polyester
2	Ends	4158	4158
3	Sow Box 1 Temp	110 °C	
4	Sow Box 2 Temp		110 °C
5	Add on %	14	14
6	Viscosity	12	12
7	Waxing	Yes	Yes

The size recipes for Lyocell and Polyester yarns are different and the viscosity of the size adds on % and solid content refractor meter % should maintain at 14 respectively. The details of size recipe for the Lyocell and Polyester are shown in Table III.

Table III Sizing Recipe

SL	Materials	Polyester	Lyocell
1	One sort Item	-	75.00 Kgs
2	Modified Starch	-	50.00 Kgs
3	Maize	50.00 Kgs	-
4	Thin Boiling Starch	50.00 Kgs	-
5	PVA	10.00 Kgs	10.00 Kgs
6	Softener	5.00 Kgs	7.00 Kgs
7	Antistatic Agent	2.00 Kgs	-
8	Binder	10.00 Kgs	14.00 Kgs
9	Wax	1.50 Kgs	1.00 Kgs
10	Water	600 Liters	600 Liters
11	Refractor meter Readings	14%	14%

The liquid wax is coated on the sized yarn following drying process. There are 18 lease rods which are used to separate the sized yarns. At the head stock, the denting was carried out. The winding tension of the sized yarn during winding on the weaver's beam should be maintained at 230KP. All the two constituted yarns were uniformly spreader over the entire weaver's beam. In drawing-in process: the drawing of ends sequencly starts with inner layer fabric threads followed by outer layer fabric threads. The 127/2 reed count was used to guide the warp during weaving and to maintain 132 EPI in the fabrics. The table IV shows the design for the two-layer technical textiles.

Table IV Design for Two Layer Technical Textiles

/	⊗	/	⊗	/	⊗	/	O	/	⊗
X		X		O		X		X	*
/	O	/	⊗	/	⊗	/	⊗	/	⊗
X		X	*	X		X		O	
/	⊗	/	⊗	/	O	/	⊗	/	⊗
X		O		X		X	*	X	
/	⊗	/	⊗	/	⊗	/	⊗	/	
X	*	X		X		O		X	
/	⊗	/	O	/	⊗	/	⊗	/	⊗
		X		X	*	X		X	

III. RESULTS AND DISCUSSION

The two-layer technical textile has been developed using the fabric structure of "Double cloth Fabric Design" in the inner & outer layer shown in table IV.

The following modifications and setting changes have been carried out in the loom for the development of two-layer fabric in the shuttless loom.

i) Changes in primary motion of the shed geometry and shed crossing.

ii) Modifications and adjustments in secondary motion of Let-off and Take-up.

The details of the above changes and modification are discussed below.

i) Changes in primary motion of the shed geometry and shed crossing.

The shed opening and shed height of the heald frames, influences the following factors:-The Cover of the fabrics, Warp and Weft breakage, Quality issues of warp & weft and bumping. In two layer fabrics the ten heald shafts were employed to distingue the layers. The first five shafts were used for inner layer of the fabric and the last five shafts were used for the outer layer of the fabric. The open shed positions were performed at 180 degree. The bottom shed should be lower than the curvature of the guide hooks and top shed should be higher than 3mm above the guide hooks. The staggered shed opening was used which has clear separation of warp threads. The first heald frame starts from 90mm from reference point and sequencly increased 1 mm until last heald frame. Shed staggering plays a vital role in clear warp separation. For the better cover of the fabric the late shedding has been used. The timing cycles was set in such way that the shed crossing of inner and outer layer should be occurring at 300 degree.

ii) Modifications and adjustments in secondary motion of Let-off and Take-up.

The back-rest height has a vital role in fabric forming. Since the basic weave structure is double cloth the back-rest position was kept at +10 mm above the mean line. The back-rest bar was made in oscillating manner so as to keep the sufficient space for the warp threads. The heavier spring were employed to maintain for uniform warp tension. The Let-off tension on machine was maintained at 180 kgs. The Back Rest was set at “Inner Position”. Warp Stop Motion bars was set at “Rear End”. More than 4 mm distance has been maintained between the fell of the cloth to avoid “Bumping”. And also “Heavy Duty Full Width Temples” were used to reduce the cloth bumping. The pressure roller diameter was increased by 20 percent to maintain the sufficient fabric holding pressure. 60 grains emery roller has been used for the better grip of the fabric while take-up. The following figure 1 shows the schematic diagram of material passage and Primary and secondary motion of Shuttless loom.

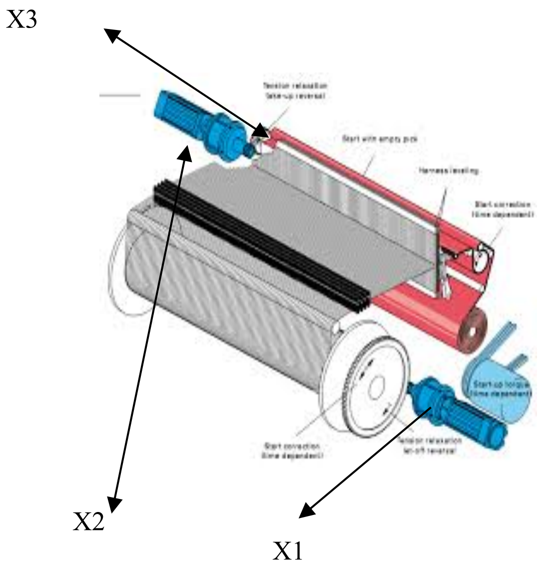

Fig 1 Schematic diagram of Shuttless Loom showing the Motions

X 1. Shows the necessary modifications carried out in Let-off motions such as attachments of Load cell to maintain warp tension and heavier spring at oscillating bar to have better warp threads separation

X2. Shows the necessary modifications carried out in Take-up motions such as attachments of servo drive for cramming pick variation and heavy duty full width temples to have heavier beat-up

X3. Shows the necessary settings to carry out in Shed Geometry such as different shed crossing for three layered fabric and increased shed opening / height for better shed formation for three layered fabrics.

IV. CONCLUSION

Using Rapier Shuttless loom with necessary alterations and modifications two-layer technical textiles has been developed. Lyocell Micro Fibre Spun Yarn was used for the inner layer and Polyester spun yarn was used in outer layer. The necessary modifications in the shed geometry and shed crossing angle place a vital role to produced Two Layer Technical Textiles in the shuttless loom. The shed crossing of inner and outer layer has been set at to occur 300 degree. The Back-rest position has been kept +10 mm above the mean line. The let-off tension on warp maintained at 180

Kgs. More than 4mm distance has been maintained at the fell of the cloth to avoid the cloth bumping. The weight of the developed two-layer fabrics is 130 GSM with 132 X 72 End and picks per inch.

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Current Cotton Marketing Constraints in Ethiopia

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Abstract

Ethiopian cotton and textile sectors are depicting progress in terms of increasing new investments, attaining export revenues and employment. But the achieved successes are not without challenges which are becoming the center of focus for government as well as all relevant stakeholders. It is therefore an important to look in to the chronic problems in order to address them considering the experience of other countries. The study focuses on identifying the current cotton marketing challenges prevalent in the sector affecting both the cotton farmers as well as textile mills. The study utilized primary data collected from targeted sources on the basis of convenience sampling method through direct interview and discussions. The study has identified the current major challenges in cotton marketing such as weak coordination among relevant stakeholders, poor infrastructure, and shortage of input supply for farmers, poor cotton quality, and unclear marketing system and so on. Accordingly based on the findings possible recommendations such as establishing proper marketing system, improve quality production of cotton, strengthening research and development and so on.

KeyWords: **Cotton marketing, Marketing Constraints and contract farming**

I. Introduction

Ethiopia has already started implementing Economic Development Plan, Poverty Reduction Plan, Industry Development Plan and other Development strategy to pave the way to reach its aim of becoming the middle-income country by 2025.Even though agriculture, construction and services accounted for most of the growth, with modest contribution from the manufacturing sector(world bank),developing light manufacturing industry specifically Cotton and Apparel Industry plays a dominant role in attaining the country's vision of 2025 and for its sustainable development.

The Ethiopian Textile sector to be competitive in the world market and thereby increase foreign earning the textile companies should be supplied with the required quantity and quality of cotton at the right time; but there is indication that limitations in production and marketing of cotton exist. It is estimated that Ethiopian has more than 3-million-hectare land suitable for cotton cultivation. The country transferred around 311.6 thousand hectares from this arable land to cotton producers of which only 72 thousand hectares has been covered for cotton production in 2018/19 cropping year. This may indicate the investors either has not started production at all or shifted the land to production of other crops.

For the smooth running of the production and marketing it is important to assess the current challenges faced by both the demand and supply side of the cotton sector to take appropriate remedial actions. Therefore, this study is accomplished with the aim of identifying the current marketing constraint in the sector and give suggestions on how to address the problems

II. Methodology

The study utilized primary data collected from targeted sources on the basis of convenience sampling method through direct interview and discussions. The interview and discussion was made with selected Cotton producers, Ginneries, textile producers, Cotton producers Ginneries and Exporters Association, the Textile and Apparel Manufacturers Association and Ethiopian Industry Input Supplier Enterprise and the findings from those sources were divided into cotton producers, textile produces and ginneries and a summarized report was made for each of the categories; and as per the findings conclusions were put and recommendations were forwarded to address the issues raised.

III. Findings

Findings on cotton marketing constraints from different players side (cotton producers, textile produces and ginneries) is summarized as follows

cotton producers

- Even though ETIDI delivers cotton supply, demand and price data, the information is not disseminated in an organized and timely manner. The marketing and selling of cotton produced is not centralized, no web site or other media continuously devoted to update the current stock and prices at certain quality level at different market place in the country. The producers are therefore obliged to knock at the door of different institutions (ETIDI, Associations, and EIISE) to get their product sold.

- It is indicated by the producers and association that there is some sort of bureaucracy and lack of transparency in EIISE in buying the cotton from cotton producers.
- The textile factories do not pay their loan to EIISE on time and this hinders EIISE from giving additional loan which limits the financial capacity of the textile factories and these results in low sale of their cotton for cotton producers which becomes one of the reasons that push these producers to shift their land to production of other crops.
- There is improper usage of packaging material during cotton transportation to ginneries due to high price and supply shortage of cotton packing material (Jute) in the country. The producers are then forced to use polymeric packing material (pp bag) which becomes a source of poor cotton quality as it causes the cotton to be contaminated with pp chips and creates negative effect during sale of this type of cotton.
- Cotton requires vast storage space due to its bulky nature. But the cotton ginneries and textile factories do not have big and standard warehouse for cotton storage. It is found out that as ginning factories are less in number, there is queuing in some ginneries which forces the cotton producers to leave cotton on open field, the ginneries keep the cotton outside the warehouse before ginning as they do not have enough space to store the cotton to be ginned and they also keep the ginned cotton outside the warehouse till the producers find market for their cotton. This deteriorates the quality of cotton which has direct effect on its price.
- The cotton marketing challenges are also created due to lack of coordination and trust among the stake holders that support the sector. A specific issue raised as an example that hinders trust among the sector was when cotton export was band, there was no consultation with the cotton association about the issue) this and others resulted in rough communication and affects the marketing process and information flow in the sector.
- In estimating the cotton demand and supply of Ethiopia, the cotton demand and consumption from traditional manufacturers are not taken in to consideration and this may lead to wrong conclusion for decisions regarding cotton marketing made based on this supply and demand data collected.

Ginneries

- The cotton which comes to ginning mill is said to be very poor in quality as it is mixed with a variety of materials on farm lands due to poor awareness and negligence. However hard tried to separate these foreign materials, it becomes almost impossible for the ginneries to clear all of those with available technology and labor force mentality. This creates obstacle for marketing as it is difficult for further processing and selling of the cotton mixed with polypropylene chips, leaves, grass, soil, stones, crowns etc.
- There is a bad practice of trying to fill the cotton bag beyond its capacity by exerting unnecessary force that may break the cotton fiber. They use stick and other instruments for pushing cotton fiber into the bag to increase the package quantity so as to decrease the number of bags to be loaded on a truck for the purpose of higher load capacity. It can be clearly seen that this damage the natural structure of cotton and breaks the fiber in to shorter ones which creates less competitive cotton product in the market as the quality becomes very poor.
- One of the issues mentioned as cotton marketing constraint is the distance between the cotton farm and the ginneries. The ginneries are very far from the farms and that results in longer hours drive while transporting cotton from the farm to ginneries. This causes the cotton quality to deteriorate not only due to the weather change but also due to loading other unnecessary material like coal, gas containers and animals etc along with the cotton to be transported.
- It was mentioned that most of the government institutions devoted to support the textile and apparel sector including banks and customs office do not equally appreciate the role the ginning sector plays to the development of the cotton value chain as compared to textile and apparel sector as they believe the export earning comes from the textile and apparel factories. Hence there is less attention given to solve different problems encountered by the ginning factories and the focus of the support directed towards textile and apparel factories. This affects effectiveness of ginning

factories and their competitiveness and influences the process of marketing and selling quality cotton in the value chain.

- Even though the Ethiopian Textile Industry Development Institute gives support for ginneries to import spare parts in duty free scheme, Ethiopian customs sometimes do not allow such scheme and the ginning factories are forced to pay all the necessary custom duties. This sometimes causes factories to halt ginning for a while till the spares are delivered and installed on the machines. This disturbs the marketing environment in the chain as it creates inconvenience for the buyer and other customers for the ginners are not able to deliver the ginned cotton on time and according to the contract agreement made.

Textile factories

- As importing process in Ethiopia is full of various challenges such as shortage of currency, poor transport and logistics services, etc textile factories are willing to buy domestically ginned cotton as long as it meets their quality requirement. But they complain that there is no system that manages and differentiates the price of cotton based on standardized cotton quality parameters that strictly gives higher value for better quality cotton. They also find it difficult to get organized market platform to have quick and easy access to buy the required type of cotton at any required time period.
- Although it is believed that the domestic cotton supply will satisfy the domestic cotton demand, the textile factories do not get the required quantity and quality of cotton due to the various problems that occur during cotton farming and ginning processes. In addition to this, some factories are not able to purchase cotton at the time it is available on the market as they frequently face shortage of working capital.
- The textile factories finally receive poor quality cotton which takes place due to mixing foreign materials such as stones, soil, pp bag chips and damaged cotton during cotton picking and packing and improper handling of cotton during transportation as a result of lack of awareness and greediness cotton farm owners and workers side .This creates mistrust between the cotton producers and textile factories in carrying out future market linkages and other business relationships.
- Even though the cotton producers state cotton is cheap, textile factories on the other side argue that cotton is expensive as compared to international cotton price which may be related to high cost of cotton production in Ethiopia and low subsidy and support level given by the government to improve the competitiveness of the sector as compared to other cotton producing countries.

V. CONCLUSION

Quality related issues that can easily be tackled if proper attention is given by relevant stake holders place significant constraint in marketing cotton in Ethiopia. It can also be seen that poor development of market media, infrastructure, legal frame works, support and subsidy mechanisms, coordination and trust among support institutions, and development of central market data contributes to the occurrence of inappropriately managed cotton market in the country. Hence the government and the sector's associations should work together for common goal to give solutions to the constraints by coordinating other concerned bodies in the value chain.

V. RECOMMENDATIONS

1.Even though the institute (ETIDI) is collecting, organizing and disseminating market data such as supply and demand and price, it needs to strengthen its service further on updating and delivering the required data on continuous basis. The institute must make its website functional and upload the current available market information to be used by stake holders concerned.

2.The government in collaboration with the concerned parties must establish market platform that brings the sellers and the buyers together to create a market linkage that encourages pricing mechanism to be based on the standardized cotton quality.

3.Ethiopian Industry Input supply Enterprise must make its service transparent, reach its stake holders and give its support on timely basis to protect the cotton producers at least from incurring loss.

4.To eliminate the cotton quality problems that exist at every stage of the value chain, it requires creating awareness for the staffs working in farming and ginneries and discussions should also be held with different stake holders to find a way for prohibiting usage of pp bag for cotton package to improve the quality of cotton.

5.Government must give due attention to ginning sub-sector in order to improve its effectiveness. The government must look at different ways of supporting the subsector such as preparing and placing incentive packages, making ginneries reachable to cotton producers by establishing ginneries not beyond 100km radius from the farm land.

6.Implementation of legally bound Contract farming scheme for cotton sector should be considered to bridge the information, technical and financial gaps that become challenge for small scale cotton producers in competing in big market environment.

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AN ASSESSMENT ON THE RELATIONSHIP BETWEEN JOB SATISFACTION FACTOR AND INTENTION TO TURN OVER AT SHEBA LEATHER INDUSTRY P.L.C

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Abstract

The present study attempts to examine the Relationship between job satisfaction and turnover intentions at Sheba leather industry. Utilizing the convenience sampling, a total of 100 were taken as Samples with 94.81% retrieval rate. Based on the data collected, analysis was made with the use of frequencies and percentages, mean and standard for determining the demographic profile of respondents and impacts of the job satisfaction factors on employee job satisfaction. Correlation and Regression were applied in determining the significant relationships of the job satisfaction factors and employee job satisfaction as well as the relationship between job satisfaction and employee turnover. The research was surveyed also by questionnaires; Samples were drawn by using the simple random sampling technique. The results showed a significant negative correlation between job satisfaction and turnover intentions. This signifies that higher the job satisfaction, lower is the intent of a person to quit the job. Further, comparative analysis was also done in order to measure the significance difference between the mean scores of two groups of employees (lower level and higher level). The results revealed that the two groups of employees do not differ significantly on the measures of job satisfaction and turnover intentions.

Keywords: - **Job Satisfaction, Turnover, Employee, Negative Correlation, Convenience Sampling**

I. INTRODUCTION

In every organization the Human Resources are considered as the main organizational source [1]. Today it became a huge challenge for Human Resource Managers to retain the employees for longer time of period and decrease the rate of employee turnover. Increasing the rate of employee turnover will result in increasing the cost of recruitment accordingly will decrease. And also, the Organizational efficiency and productivity will decrease (reduces). Therefore, it is essential to study the relation between employee turnover and job satisfaction [2].

What makes an employee leave or intend to leave are always become the big question for any company. Several studies have examined job satisfaction as an antecedent of turnover intentions [3], [4].

Employee turnover as a rotation of individuals around the labor market; it could be between companies, states of unemployment and employment, and between occupations and jobs [5].

A great concern that many organizations, turnover increases cost of the organization particularly in job with minimum wages. There are several factors influence the rate of turnover of an organization, and these factors could be from employees and employer. These factors could be compensation, benefits, wages, and job analysis and so on. According to [6], in case of turnover it causes indirect and direct expenses to an organization, which compromises the cost of human resource, training, advertising, retention and loss of productivity.

Job satisfaction may be defined as pleasurable or positive emotional state resulting from the appraisal of one's job or job experiences [6]. This positive feeling results from the perception of one's job as fulfilling or allowing the fulfillment of one's important job values, provided these values are compatible with one's needs [6]. Given that values refer to what one desires or seeks to attain [7] job satisfaction can be considered as reflecting a person's value judgment regarding work-related rewards. [7] Define job satisfaction as the pleasurable emotional state resulting from the achievement of one's job values in the work situation.

Many factors are related to job satisfaction for instance, social relationships, job analysis, employee training, desires and needs, recruitment and selection, orientation, working conditions, development and quality of management. [8] stated that many studies proved a positive relation between individual intention and leaving behavior. Usually, it is considered that employee turnover intention and job satisfaction are inversely associated.

COMPANY BACKGROUND

Sheba Leather Industry p.l.c is located on the northern part of Ethiopia, Tigray region, Wukro wereda around 825 km far apart from Addis Ababa. It had established in 1993G.C in accordance with the commercial cod of Ethiopia; with initial capital of 94 million birr under Endowment Fund for Rehabilitation of Tigray (EFFORT) and it has total production area of 1720m^2. Firstly, this company starts with one plant that is called tannery production. At this time the factory worked by producing leather product and exports only crust (semi-finished leather) products. But by build up its capacity the end product lasts until completely finished leather with different size and color.

Since, this past ten years Sheba factory extended by establishing another plant which called foot wear production (shoe production) plant. Through these two plants it vast its market locally and externally. During these ten years the company has become one of the leading leathers and footwear production in Ethiopia by efficiently use of resource, getting export currency and preventing global warming.

Currently the factory has production capacity to produce more than 1720ft2 finished skins, hides, 3000 per of shoes and 400pcs hand bag per day and totally 1149 employs are employed permanently.

Recently a study was carried out at Sheba leather industry. The aim of the study was to measure the rate of employee turnover annually, showed that the annual turnover of employees are increased for the last six years. The outcome of the study proved that managers are required to execute long term plan in order to be able to avoid high employee turnover. Identifying the level of job satisfaction considers an important factor to decrease rate of employee turnover [8].

Employee turnover is frequent and it is becoming a series problem at Sheba leather industry P.l.c. The following table shows terminated-employed rate at the organizations from 2013 to 2018 G.C.

Table 1 Terminated-employed rate

Year	**Average Employed**	**Terminated**	**Rate of Turnover%**
2013G.C	290	76	26.2069
2014G.C	250	72	28.8
2015G.C	260	80	30.76923
2016G.C	242	86	33.05785
2017G.C	305	108	34.7541
2018G.C	310	116	36.77419

Source: *HRD Report of* Sheba leather industry p.l.c 2013- *2018G.C*

The purpose of the study: - The primary objective of this research is to examine (assess) the relationship between job satisfaction and intention to turn over employees of Sheba leather industry p.l.c, so as to find (Identify) the major causes behind the frequent professional employee turnover and to provide positive suggestions in order to reduce turnover, increase job Satisfaction and retain competent employees.

II.MATERIALS AND METHODS

The purpose of this research is to investigate the impact of job satisfaction on employee turnover in Sheba leather industry P.L.C. Subjects were the executives and non-executives of company employee. 270 structured questionnaires were distributed through a control environment and 247 return back complete. That yields 91.48% of the respondents' size.

Random sampling technique was used to distribute set of questionnaires which were adopted and adapted from [9] and [10] in order to determine the employees' opinions regarding turnover intention in the company. The questionnaires were divided into four main parts. The first and the second part measured the respondent's working condition, supervision, co-workers, as well work value in the second part. A five-point Likert scale was used to indicate the respondent's answers (1-Strongly Disagree;2-Disagree; 3-Neither Agree nor Disagree; 4-Agree; 5- Strongly Agree).

The third part were used as an indicator of measurement to measure the respondents intention to leave which use multiple- choice that suits the best decision they will make representing their intention in the organization. The fourth part of the questionnaire was regarding the respondent's demographic background, which include gender, age, marital status, department, position and education.

Using the Statistical Package for Social Science

Version 12.0 for Windows, we process the data that collected from the respondents and several tests were carried out to test the variables. In addition, correlation analyses on the three variables were also obtained to identify the most relevant and significant relationship among the variables.

SAMPLING SIZE AND TARGET POPULATION

A random sampling technique was used, where all employees had equal chances of being selected for the sample. The study was carried out in all departments of Sheba leather industry P.L.C. The researchers distributed 270 questionnaires, only 256 questionnaires were received and from 256 questionnaires only 247 questionnaires were completed properly.

HYPOTHESES- H1: There's a negative relationship between job satisfaction factor and turnover intention of Sheba leather industry.

H2: There's a positive relationship between job satisfaction and turnover intention Of Sheba leather industry.

INSTRUMENTS

The questionnaire is structured in the form of multiple-choice questions. The participants were asked to rate how strongly they agree on each item on a five-points Likert order scale. The questionnaire is designed and adapted from [11].

III RESULTS AND DISCUSSION

The statistical analyses were computed using SPSS version 12.0 for Windows to extract the data and results. There are several results which are displayed below from the study. Table I below explains the background of the respondents. 56.68% respondents were percent female. In addition, 52.22percentage for age group18-24 these represents that the majority of the employees are in the active, energetic and productive groups which is good if the company can properly utilize this productive workforce group. The respondents 26-36 years are 36.8persent as well us greater than 37 years are 10.39 percent. And then, 63.15% of the respondents were single. Job tenure shows 38.45% group each work less than two years 78.13 % respondents were non executives On the other hand, 21.86% of employees are at the executive's level. This implies the majority employees are ambitious group to get higher positions and higher pay and they have high probability of looking for high pay and positions. Finally, the employees were divided into four groups; less than diploma level (high school level) 78.94%, diploma level 21.05%, first degree 17.4%, greater than first degree 1.2%.

Reliability analyses are conducted for job satisfaction and turnover intention scales. Cronbach alpha scores of three measures are ranged between 0.800 and 0.970. The means, standard deviations and reliability coefficients for each variable are given in Table II.

According to Table III there is a significant and negative relationship between turnover intention and external job satisfaction ($\beta = -0.127$, $t = -8.061$ and $p = 0.000 < 0.05$). Also, there is a significant and negative relationship between turnover intention and external job satisfaction ($\beta = -0.248$, $t = -4.195$ and $p = 0.000 < 0.05$). R^2 value is 0.650 which means 65.0% of the variation can significantly be explained by the independent variables.

Table I Respondents background

Sample no	Category	Respondents	Percentage (%)
Gender	Male	139	43.34
	Female	106	56.68
	Total		100
Age	18-25	129	52.22
	26-36	91	36.8
	> 37	27	10.39
	Total		100
Status	Single	156	63.15
	Married	91	36.8
	Total		100
Job tenure	<2 Year	95	38.46
	3-5 Years	66	26.72
	Above 5 Years	86	34.82
	Total		100
Income Level	<2000	127	51.4
	2001-5000	57	23.07
	5001-10000	44	17.8
	10001-20000	19	7.68
	Total		100
Education	< Diploma	195	78.94
	Diploma	52	21.05
	First Degree	43	17.4
	>degree	3	1.2
	Total		100
Position	Executive	54	21.86
	Non-executive	193	78.13
	Total		100

THE RELATIONSHIP BETWEEN TURNOVER INTENTION AND JOB SATISFACTION

H1 argues that there's a negative relationship between job satisfaction and turnover intention. Multiple regressions are used to analyze the hypothesis.

Table II Means, standard deviations and reliability coefficients of job satisfaction and turn over intention scales

Scale	Mean	Std. Dev	Cronbach α
Internal Job Satisfaction	3.4607	1.25452	0.900
External Job Satisfaction	4.0305	1.09798	0.920
Turnover Intention	2.6610	1.5790	0.931

Table III Regression analyses between intention to turn over and job satisfaction

Predictors	**Turnover Intention**		
	B	t	p
Internal Job Satisfaction	-0.127	-8.061	0.00
External Job Satisfaction	-0.248	-4.195	0.00
R^2	0.650		
Adjusted R^2	0.655		
F value	16.842		

Correlation analysis is used to state the relationship between the variables. Correlation Matrix is recalculated with the subscales found after the factor analyses and other scales.

H1 stating that there's a negative relationship between job satisfaction and turnover intention is confirmed by regression analysis. A decrease in the level of job satisfaction would lead to an increase in the level of turnover intention. This conclusion is supported by previous literature examples, either that they indicate job satisfaction to be one of the several factors determining someone's intention to quit the organization[3]. The results showed that there is a significant and negative relationship between internal - external job satisfaction and turnover intention.

The purposes of this study were to determine the effect of job satisfaction on turnover intentions on the employees in Sheba leather industry, the statistical results obtained in this study showed that both forms of job satisfaction (intrinsic and extrinsic satisfaction) have inverse relationship on employees' turnover intentions. This result is consistent with those of previous researchers [11], [12] and [13].

This study is considered to be important both to employer and the employee. To sum up, if an employer needs a highly motivated, innovative, productive human resource, the importance of job satisfaction and organizational commitment should not be forgotten. It is obvious that high job satisfaction factors will avoid turnover intention and actual turnover. Every employee has different kinds of needs and expectations and it is impossible to satisfy every need and expectation of the employees. Both employee and employer should try to generate a working condition that they will work in a happy, motivated and productive atmosphere to reach the certain goals.

V CONCLUSION

According to the research findings, the following conclusions are illustrated. Job satisfaction has significant influence on turnover intention of the participants. The outcome of this research could be used as useful administrative tools that might further improve the leather industries effectiveness and efficiency. This study showed that the greater is the employee‘s Job satisfaction the less likely they are to express the intention to quit, on the turnover intentions of Sheba leather industry, most of them would quit in case if they have a better opportunities.

this study has discussed about the relationship between job satisfaction factors and turnover intention in a Sheba leather industry.

The objective of the study is to examine the effects of satisfaction factors on turnover intentions has been reached and completed. Statistical analysis on a sample of 247 executive and non-executive employees revealed that both components of job satisfaction had a negative impact on turnover intention.

Based on the findings, internal (intrinsic) satisfaction, however, had a stronger influence on intentions to leave in the organization. The findings have proved that there are external (extrinsic) values that influence the turnover intention within the organization.

Thus, the objective of this study was accomplished. Since extrinsic satisfaction founded to have less influence with negative relationship on turnover intention, which mean the intrinsic value were fulfilled, the turnover rate among the employees will be low compare if only extrinsic values that focused by the management to be fulfilled. It is hoped that the contributions proposed by the researchers were able to contribute towards improving human resource management of Sheba leather Industry.

IV RECOMMENDATION

Based on this study here are five recommendations suggested to be adopted in the company;

I. Learn about jobs that are most likely to meet employee expectations

II. Do not allow employees job dissatisfactions to go unresolved for long

III. Overall job satisfaction is a trade-off: Educate employees and remind them that they should not expect 100% satisfaction or 0% dissatisfaction

IV. Telling the employee to look separately at the kind of work they are doing versus the conditions of work (pay, supervisor, co-workers, company and physical working conditions)

V. Encourage employees to look down the road at their possible career progress

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SYNTHETIC METALLIZATION OF COTTON FABRIC THROUGH CHARCOAL COATING APPROACH

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Abstract

Development of smart textiles is an emerging discipline in the last two decades. Most o f the smart textiles are made intelligent through conductivity enhancement. The purpose of this research was to develop a textile fabric with electrical conductivity. Primarily, eucalyptus wood was carbonized at a temperature of 928.391℃ and time of 37.274 minutes which offer 59.17% w/w of fixed carbon yield and conductivity of 463.337Sm^{-1} from immeasurable conductivity of wood; coupled with the characterization of different physical and chemical properties of charcoal. Thereafter, a fabric made from cotton was pad coated with a dispersion based on charcoal. The paper herein reports the results of preparing different recipes using a number of quantities of charcoal particles and other components of the coating mixture, which was tested in order to obtain the best results regarding electrical conductivity. The optimal concentration of conductive particles of charcoal was studied. Performance evaluation of the resulting fabric was done to check the resistance of fabric towards different fastening agents. The effect of charcoal loading in thermal and sensorial comfort of the fabric in addition to the air and water permeability was studied and a significant change was observed. Finally, proof of concepts was developed to evince as all the resulting pieces of information during the process were viable. It is realized that the pad coating of cotton fabric with charcoal prevail pronounced increase in electrical conductivity from 1.58x10^{-12}Scm^{-1} for controlled sample to 124.49 Scm^{-1} for coated sample almost by tredecuple that designate the resulting fabric in conductor category.

Keywords- **Carbonization, Charcoal dispersion, Conductive fabric, Pad coating, evaluation**

I. INTRODUCTION

In the last two decades, conductive textiles have gained great attention by many researchers due to their widespread applications in biomedical devices, sensing and actuating, data processing and communication, energy conversion and storage, electromagnetic shielding, etc[1]. Conductivity is the main requirement in smart and electronic textiles. Textile materials like cotton fabric has very low electrical conductivity typically has a surface resistivity of $10^7\,\Omega/square$ [2] - $10^{16}\Omega/square$ [3]. There are several options to make textiles conductive. Metal fibers in the form of thin metal filaments were used previously, but these are brittle, heavier and more difficult to process than conventional textile fibers [1]. In addition, metals have high environmental effect during their synthesis to fiber and their disposal is a polluting also[1, 4]. Coating of textile fibers with metallic salts was used as another option, but these have limited stability during laundering[5]. The development of intrinsically conductive polymers has opened up new possibilities for conductive textile materials. These polymers are conjugated polymers which electrical conductivity is dramatically increased by doping. In the doping, a small amount of chemical agent is added, and the electronic structure is changed. However, the doping process is reversible and involves a redox process[6, 7]. Conductive polymers are provided both as solid compounds or liquid dispersions or solutions. The liquid versions can easily be applied to a textile substrate by coating methods[8]. Textiles are frequently coated and printed to get different surface functional properties, of which electrical conductivity gains significance interest on smart textiles application [9], and surface properties. However, there has not been in-depth investigations about the possibilities to apply conductive coatings on the textile by similar methods as used in the textile industry. While this seems straightforward, there are several technical obstacles which must be overcome to realize successful application of conductive materials.

In the present work, the possibilities to obtain conductive surfaces on textile fabrics, by pad- dry – cure method with a dispersion containing charcoal particles in a similar manner used in the textile industry were developed. The resulting fabric is is expected to be conductive enough to be efficient for signal transport in the course of the development of smart textiles. To do that, wood was carbonized at different time and temperature to enhance the conductivity. Then, a dispersion based on charcoal particles was prepared and applied on to cotton fabric in pad -dry -cure process followed by an oven drying and curing. The electrical conductivity of the resulting coated cotton fabric was then measured and improved from 1.58 *10^{-12}Scm^{-1} of the controlled sample to 124.49 Scm^{-1} after coating almost by tredecuple. The tensile strength, tactile and thermal properties of fabric was also assessed and a significant change was observed between the controlled and charcoal coated samples.

II. MATERIALS AND REAGENTS AND CHEMICALS

A. *Fabric*

Half bleached cotton fabric with 21Ne, 28 ends per centimeter, and 32 picks per centimeter and 147 gram per square meter were obtained from Bahir Dar Textile Share Company (BDTSC).

B. *Wood*

Eucalyptus wood was collected in Abaymado, Bahir Dar, Ethiopia. Different parts of wood like branch, leaves, annual ring, pitch and bark was separated for further procedure. Separated components were then air dried for fifteen days. The annual ring and pitch were the parts carbonized in the current study.

C. *Chemicals*

Charcoal was carbonized from wood. Methanol was employed to facilitate sonication of charcoal particles in water. Butane tetracarboxylic acid (BTCA) with magnesium chloride as a catalyst assistant ($MgCl_2$) was used as a fixing agent for pad coating method. Throughout the course of the formulation of charcoal dispersion, a commercial grade dispersant was used to ensure uniform dispensability of charcoal.

III. EXPERIMENTAL PROCEDURES

A. *Carbonization of eucalyptus wood*

Charcoal was prepared by the carbonization of eucalyptus wood using a 48000 muffle furnace based on ASTM D 1762-84 test method [10]. The ASTM method was modified only by the employed time and temperature. Samples were carbonized at different temperature and time under 20°C min^{-1} heating rate. To do that, the air-dried annual ring and pitch parts of eucalyptus wood pieces were taken in a stainless steel retort which then put in a muffle furnace that can maintain the predefined carbonization temperatures Table I. The container was kept in the furnace for half an hour of cooling time.

B. *Characterization of eucalyptus wood charcoal*

The proximate analysis of the determination of ash, moisture, fixed carbon, and volatile matter contents was carried out on the resulting charcoal as per ASTM D 1762-84 test method [10] as it is detailed here.

One gram of air-dried powdered charcoal sample(X) was taken in crucibles and kept in a 48000 muffle furnace at a temperature of 105°C for 1 hour for moisture determination and 925°C for 7 minutes for volatile matter content determination. The crucibles then were taken out of the furnace and the samples were weighed. The moisture content and volatile matter were calculated as in the (1) and (2).

$$\%\ of\ moisture = \frac{X-M}{X} * 100\% \qquad (1)$$

$$\%\ volatile\ matter = \frac{X-Z}{X} * 100\% - \%\ moisture \qquad (2)$$

Where, M and Z are loss in weight of the sample after decomposition of 105°C for 1 hour and 925°C for 7 minutes respectively.

To determine the ash content, one gram of air-dried powdered sample was taken in a shallow disc of silica and kept in a furnace at a temperature of 775°C. The samples were heated at this temperature to complete burning for 1 hour in a muffle furnace. The percentage of ash content of the sample was calculated (3).

$$\%\ Ash = \frac{weight\ of\ residue}{Initial\ wt.of\ simple} * 100\% \qquad (3)$$

C. *Fixed carbon content determination*

The fixed carbon content in the sample was determined (4).

$$\%\ Fixed\ Carbon,\ FC = 100 - (\%\ Moisture + \%\ Volatile\ Matter + \%\ Ash) \qquad (4)$$

D. *Charcoal Yield and Fixed carbon yield*

The charcoal yield is conventionally used as a measure to evaluate the efficiency of a wood carbonization process. The carbonization yield was calculated (5). It represents the percentage of a dry eucalyptus that remains in the solid product after carbonization under given conditions in Table I. However, charcoal contains complex organic chemical compounds and inorganic species and the charcoal yield gives a rather poor quality indication.

$$Yield\ (\%),\ Y = \frac{(W1-W2)}{W1} * 100 \qquad (5)$$

Where W_2= is the dry mass of charcoal produced by carbonization of dry eucalyptus wood (w_1). For the charcoal to be used as a conductor, the fixed carbon content of the charcoal is the most important quality to be taken into account. A new measure for assessing the efficiency of a biomass carbonization process was defined as the fixed carbon yield (6).

$$\text{Fixed carbon yield (\%)} = Y(\%)\,\frac{(\%FC)}{100-\%Ash} \quad (6)$$

The fixed carbon yield is proposed for assessing the conversion efficiency of eucalyptus wood into fixed carbon. The fixed carbon yield approximates the percentage of pure carbon that can be obtained during the eucalyptus wood carbonization process. The fixed carbon yield has been widely accepted as an effective metric for evaluating the efficiency of the carbonization process and the quality of the produced charcoal as well.

E. Charcoal dispersion preparation

The carbonized charcoal first was crushed and grinded into small particle size. Then, the dispersion was prepared using the aqueous dispersion process, with the dispersion based on water. Initially, a quantity of water was poured in to a beaker along with dispersant. Then after ethanol was added drop by drop to assist sonication and improve disperssion[11], and finally different concentrations of charcoal particles shown in Table V. The mixture was stirred continuously using probe sonication for 15 minutes, and then ultrasound bath sonication was used for 30 minutes to obtain homogenization of well dispersed the charcoal particles[12, 13]. A cross-linking agent such as BTCA was added to improve the wash durability of the finish[14] and $MgCl_2$ to catalyze the reaction of BTCA. The quality of the dispersion was controlled by naked eye allowing the dispersion for a week settling time[13, 15, 16] in addition to the examination of the dispersion by AATCC test method 146-2006 procedure. When agglomerates of charcoal particles were observed, the dispersion will be qualified as insufficient and not put for further use. In case if a homogeneous black picture of the dispersion is observed, the dispersion was qualified as good fig. 1

F. Application of Charcoal dispersion on to the cotton fabric

After the charcoal dispersion is prepared, it was applied on to fabric following AATCC test method 140-2006 by pad coating with a vertical padder lab 300 padding mangle that has a wet-pickup of 100%. To increase charcoal loading coating was done quadruple times. Thereafter, the fabric was dried at 105°C for 3 minutes and cured at 135°C for 5 minutes in an oven.

IV. EVALUATION PARAMETERS

A. *FTIR Analysis*

Infrared spectroscopy is ideal to confirm the presence of the charcoal particles in the coated samples. The surface features of charcoal and charcoal coated fabric were examined by Perkin Elmer FTIR.

B. Conductivity Measurement of carbonized charcoal

The conductivity of charcoal was measured automatically by 4063 traceable Portable Conductivity Meter [17]. This type of contact sensor uses coulters as electrodes to make contact with the charcoal and to measure the electrical conductivity. In this approach, two coulters were mounted on a toolbar, where one coulter provide electrical current into the charcoal while the other coulters receiving electrodes measure the voltage drop between them. Thus charcoal electrical conductivity was recorded in terms of Sm^{-1}.

C. Conductivity Measurement of a charcoal-coated fabric

The conductivity of charcoal-coated cotton fabric was measured in terms of bulk resistance using a two-probe multimeter [18, 19]. Two electrodes were placed on the surface of the sample, the distance between the electrodes was arranged to be 4cm X 4cm. The measurements were performed according to AATCC test method 76-2005 standard test reference. The conductivity of the resulting fabric then was calculated in Scm^{-1} using the following formula

$$R \approx R_s = \rho\,\frac{L}{A} \quad (7)$$

$$\frac{RA}{L} = \rho \quad (8)$$

$$\sigma = \frac{1}{\rho} = \frac{L}{RA} == \frac{L}{RWt} \quad (9)$$

Where; R=resistivity, R_s=bulk resistivity of fabric=length of fabric, σ = conductivity, ϱ = resistivity, A = cross-sectional area of the fabric, W and t are width and thickness of the fabric.

D. Assessment of coating fastness properties

Wash fastness was tested according to ISO 105 C06 2010 standard. AATCC test method 8-2007 was used to measure both dry and wet rubbing fastness and AATCC test method 16 2007 was used to measure the light fastness. Perspiration fastness and fastness to hot pressing were also tested based on AATCC test method 15-2009 test standard and AATCC test method 133-2009 respectively.

E. *Durability test to washing*

The durability of surface resistance values against washing fastness was examined in accordance with the AATCC test method 61-2006 by Autowash code311f. The electricalconductivity of charcoal-coated cotton fabric was assessed after the water washing cycles.

F. *Evaluation of sensorial comfort properties*

Kawabata Evaluation System (KES FB-AUTO A) was used to evaluate the sensorial comfort of fabrics which included shear, compression, surface friction, and roughness. Before testing, specimens of 20cm X20cm were conditioning for 24 hrs at 20 ℃ and 65 % RH. Each trial was quintuple for each parameter in each sample and the average value was used. The surface roughness and surface friction were measured on KES-FBA of the surface tester. The compression and shear properties were studied on KES-FB3 and KES-FB1 compression and shear tester respectively using prescribed procedure by Kawabata and Nima [20].

G. *Testing of fabric drape*

The fabric drape was tested based on BSISO1051[21] by using Cusick drape tester. This test is used for the indication of the fabric appearance properties when fabric orients itself into folds in more than one plane under its own weight. The results obtained with this test method will be used as an indication of effects of coating on fabric stiffness. Upon testing, the samples were positioned over a horizontally placed circular rigid disk of 18 centimeters in diameter. The fabric was allowed to deform into a series of folds around the disk. The paper ring containing the shadow image of the draped configuration represents the weight w_1. The shadow image cut from the paper ring was weighed and marked as w_2.

The drape coefficient was calculated by the equation (10).

Drape coefficient, Dc= $\frac{W2}{W1} * 100\ (\%)$ *(10)*

H. Testing of tensile strength

The BS EN ISO 13934 test standard was followed to test the tensile strength of the fabric by tenso lab 1000 [22]. In this method, a fabric strip was extended to its breaking point by a fixed and movable jaws which could record the breaking load and extension. To do that, 60mm x 300mm sample were prepared and then frayed to get a 50mm wide specimen. The rate of the extension was set to 50mm/min and gauge length was 200mm. The mean breaking force and mean extension percentage of initial length was reported at last.

I. *Thermal comfort*

The effect of charcoal loading on thermal properties such as thermal resistance, thermal conductivity and actual insulating of both controlled and coated samples were assessed in accordance ASTM D5470 test method using a thermal interface tester (TIM Tester 1300A). Before testing, the specimens were conditioned for 24 h at 20°C and 65 % relative humidity. For the thermal behaviors, a contact area of 1.327 $inch^2$ was used during the testing.

J. Water permeability

Water Permeability test is used to determine the resistance of textiles to water in its vapor or liquid form penetration. Several indexes can be applied to evaluate this ability, such as water vapor permeability, water repellency, and water resistance. In this study, a water resistance test was done in accordance with AATCC 22 test method. In this method, the sample of 150mm diameter was fixed with an iron ring of diameter 152.4mm. The distilled water of 250ml was sprayed on the sample under the nozzle for 30 seconds. Thereafter a comparison between the spray sample surface with the standard chart card was made and rated. The SDL spray tester was used in the test. Each sample was tested in the standard atmosphere, 25°C temperature and 65% RH after conditioning for 24 hours.

K. *Air permeability*

The breathability of charcoal-coated and controlled samples was evaluated in terms of air permeability. The test was done to evaluate the effect of charcoal coating on the rate of air flow passing perpendicularly through a definite area of the fabric under 100 pa air pressures in accordance with BS EN ISO 9237:1995 by using Tester FX3300. A circular fabric was clamped into the tester and through the use of a vacuum; the air under pressure was allowed to pass through the fabric. From the air flow rate, the air permeability of the fabric was determined. Five trials were used for each controlled and charcoal coated samples.

VI. RESULT AND DISCUSSION

A. *Optimization of carbonization parameters of eucalyptus wood*

All Carbonized charcoals have not the same chemical structure. The structure and hence the electrical and thermal properties of carbonized charcoal depend on the amount of temperature employed to carbonize the wood. Beyond a carbonization temperature of 800 ℃, wood charcoal will have a graphite structure as it is illustrated by Parfen'eva, L., et al., [23] and carbon double bond and the aromatic ring are formed at a temperature of 600℃[24]. Upon carbonization at different time and temperature as shown in Table I, for a prolonged time and temperature, the amount of fixed carbon yield and hence the conductivity also increases but, the yield of carbonization was reduced with increasing time and temperature. The increase in electrical conductivity is most likely due to the graphitization of wood charcoal so that each carbon atom in the charcoal will be covalently bonded to three others. There will be always a fourth atom which is free atom. This atom contains free delocalized electrons that can carry and pass on an electric charge. In addition of formation of synthetic graphite upon the removal of volatile matters due to structural rearrangement[25], the remaining mineral impurities also act as donors or acceptors and thereby drastically improve the electrical conductivity of carbon charcoal[23, 26]. As it is shown in model Table II, it is 95% confident that there is a difference in fixed carbon yield between different runs Table I. From the analysis of variance, the percentage of fixed carbon in terms of time and temperature is related (11).

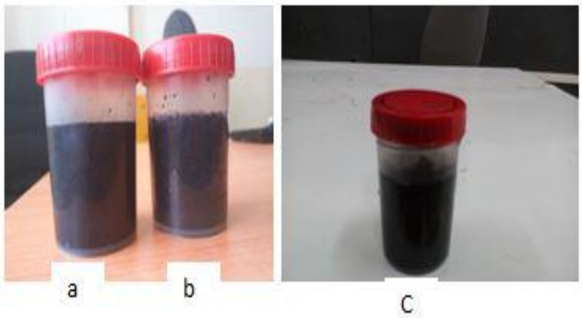

Fig. 1. Photographs of dispersision of charcoal particles after (a) two weeks (b) a month (c) a week

$$FC = 14.15 + 0.12\,T + 0.26t + 0.000133Tt - 0.000055\,T^2 - 0.002000\,t^2 \quad (11)$$

This equation used to make predictions about fixed carbon yield for the given temperature and time. The predicted coefficient of determination which is measure of how close the data are to the fitted regression line is 0.8597 which is in a reasonable agreement with its adjusted value which is, 0.938.

Table I : Effects of time and temperature on fixed carbon content and conductivity

Run	Temperature(T) (°C)	Time (t) (Min)	Fixed carbon content (FC) (%)	Conductivity(σ) (Siemens per meter)
1	596.447	45	78	396
2	950	45	94	476
3	700	30	81	455
4	950	66.2132	97	532
5	950	45	93	473
6	950	45	95	503
7	950	45	94	481
8	1200	60	98	540
9	950	45	91	466
10	950	23.7868	89	453
11	1303.55	45	96	523
12	1200	30	90	460
13	700	60	87	437

Table II: ANOVA for the quadratic model of fixed carbon content

Source	*Sum of Squares*	*df*	*Mean Square*	*F-value*	*p-value*	*Decision*
Model	422.18	5	84.44	37.35	< 0.0001	significant
T-Temperature	258.28	1	258.28	114.26	< 0.0001	
t-Time	80.10	1	80.10	35.44	0.0006	
Tt	1.00	1	1.00	0.4424	0.5273	
T^2	82.80	1	82.80	36.63	0.0005	
t^2	1.41	1	1.41	0.6232	0.4558	
Residual	15.82	7	2.26			
Lack of Fit	6.62	3	2.21	0.9598	0.4930	not significant
Pure Error	9.20	4	2.30			
Cor Total	438.00	12				

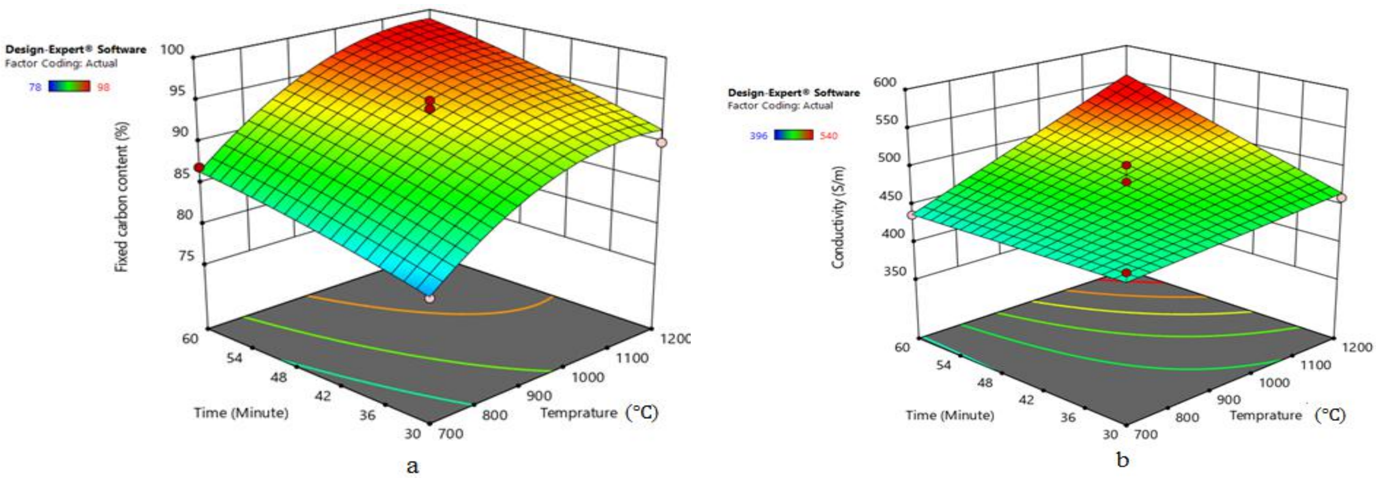

Fig. 2. 3-D graph of relations of time and temperature with fixed carbon content (a) and conductivity (b)

Table III: ANOVA for two-factor interaction model of conductivity

Source	*Sum of Squares*	*df*	*Mean Square*	*F-value*	*p-value*	*Decision*
Model	16513.04	3	5504.35	16.88	0.0005	significant
T-Temprature	10339.59	1	10339.59	31.71	0.0003	
t-Time	3772.45	1	3772.45	11.57	0.0079	
Tt	2401.00	1	2401.00	7.36	0.0238	
Residual	2934.19	9	326.02			
Lack of Fit	2143.39	5	428.68	2.17	0.2366	not significant
Pure Error	790.80	4	197.70			
Cor Total	19447.23	12				

where it increases only if the new term improves the model more than would be expected by chance; It decreases when a predictor improves the model by less than expected by chance, of 0.9381; i.e. the difference is less than 0.2. Adequate precision measures the signal to noise ratio. A ratio greater than 4 is desirable, where a ratio of 19.9547 indicates an adequate signal. The fixed carbon yield increases with increasing time and temperature as shown in fig. 2a.

As shown in Table III, the conductivity of carbonized charcoal has a difference among the different runs with a 95% confidence level. The relation between conductivity with carbonized time and temperature were explained in (12).

$$\sigma(S/m^{-1}) = 554.08 - 0.15\,T - 4.75t + 0.007Tt \qquad (12)$$

The predicted and adjusted coefficients of determinations are in a reasonable agreement which is 0.6206 and 0.7988 respectively. The adjusted coefficient of determination may decrease by less

than 0.2 if the model could increase by chance, i.e. the coefficient of determination is only 0.8491. As shown in fig. 2b, the conductivity of charcoal with determinant variables indicates that as the tempraturre and time increases, conductivity also increases, since conductivity is directly related to fixed carbon content. The optimum value of fixed carbon content with the desirability of 0.585 is 91.156% carbonizing the wood at a temperature of 928.391 ℃ and 37.274 min; this gives an electrical conductivity of 463.337Sm^{-1} of charcoal from immeasurable conductivity of wood.

B. Characterization of eucalyptus wood charcoal

The carbonization yield obtained at a temperature of 928.391 ℃ and time of 37.274 min was 64.7% whereas the fixed carbon yield was 59.17%.

Table IV: Proximity analysis of charcoal

Parameters	Values (%)
Moisture	3.5
Volatile matter	5
Ash	0.5
Fixed carbon content	91
Yield	64.7
FC yield	59.17

For coating of cotton fabrics, a charcoal particle prepared from the properties explained in Table IV were used.

C. Coating formulation and improved electrical conductivity of charcoal-coated fabrics

The cotton fabric was easily pad coated by a solution based on charcoal. After pad coating, the charcoal coated textiles becomes black as shown in fig. 5. The coated textile shows a drastically decrease in electrical resistance. This owing to the formation of a conductive pathway on textiles due to the adherent of charcoal particles on to textiles. There is a significant difference in the conductivity of coated fabrics among different coating mixtures with a 95% confidence level as shown in Table VI. The conductivity charcoal coated fabric is related to the coating mixture factors (13)

$\sigma\,(S/cm^{-1}) = 16.38 + 8.25A + 0.57B + 7.45C$ (13)

Though the conductivity increase with increasing charcoal particles as shown in fig 4; the optimum value of coating mixtures with a desirability of 0.882 were selected among 52 solutions were 9mg/ml charcoal particles, 7mg/ml dispersant and 4mg/ml ethanol. Appling the resulting mixtures in the sample gives the conductivity of 124.49 S/cm^{-1}.

D. Analysis of charcoal and wood in FTIR

The FTIR spectra of the original eucalyptus original wood and charcoal carbonized at 928.391 ℃ for 37.274 min are illustrated in fig.3 below. The spectra of the carbon product shows the following main features in fig. 7. Initially, the intensity of the band around 3111.8 cm^{-1} due to the vibrational mode of OH stretching bond in the wood is relatively higher than in charcoal, which suggests loss of the constitution water that is impregnated in the cell wall of wood and decomposition OH group of cellulose by an increase of the temperature. The decomposition of lignin is evident by the reduction of C = C vibrational bands of aromatic rings, in 1153 cm^{-1}. The nonconjugated bonds C=O in 1725cm^{-1} assigned to hemicelluloses decreased markedly in intensity. A formation of an aromatic network with the appearance of three bands at low frequencies 881, 823 and 772 cm^{-1}, from the angular deformation outside the plane of the ring CH groups. Nishimiya, K., et al. [24] suggested that the aromatic mode due to lignin was changed to a different type of aromatic compound by the carbonization process.

Table V: Coating mixtures and improved conductivity of the fabric

Run	A: Charcoal particles mg/ml	B: Dispersant mg/ml	C: Ethanoal mg/ml	Conductivity S/cm
1	7.5	8.5	2.5	108
2	6	10	4	109
3	6	7	1	81
4	7.5	8.5	2.5	106
5	7.5	8.5	2.5	89
6	9	7	4	126
7	6	7	4	98
8	7.5	8.5	2.5	119
9	7.5	8.5	5.02269	112
10	9	10	1	103
11	4.97731	8.5	2.5	79
12	7.5	5.97731	2.5	101
13	10.0227	8.5	2.5	148
14	6	10	1	96
15	9	10	4	121
16	7.5	8.5	2.5	103
17	7.5	8.5	0	73
18	7.5	11.0227	2.5	86
19	7.5	8.5	2.5	91
20	9	7	1	87

Table VI: ANOVA for the linear model of conductivity

Source	*Sum of Squares*	*df*	*Mean Square*	*F-value*	*p-value*	
Model	3804.06	3	1268.02	8.54	0.0013	Significant
A-Charcoal particles	2092.41	1	2092.41	14.10	0.0017	
B-Dispersant	10.15	1	10.15	0.0684	0.7971	
C-Ethanoal	1701.50	1	1701.50	11.46	0.0038	
Residual	2375.14	16	148.45			
Lack of Fit	1745.81	11	158.71	1.26	0.4236	not significant
Pure Error	629.33	5	125.87			
Cor Total	6179.20	19				

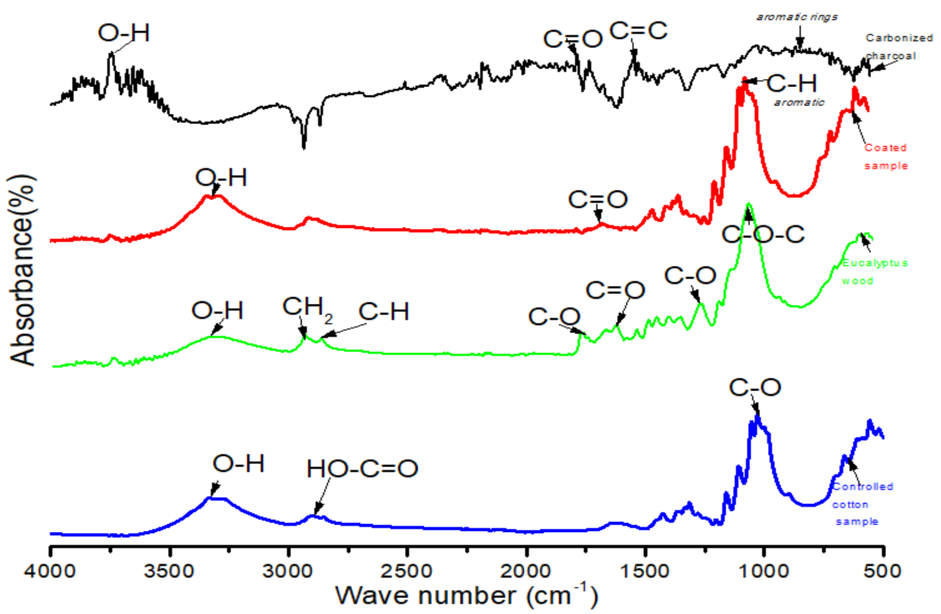

Fig.3. Infrared spectra of eucalyptus wood and charcoal

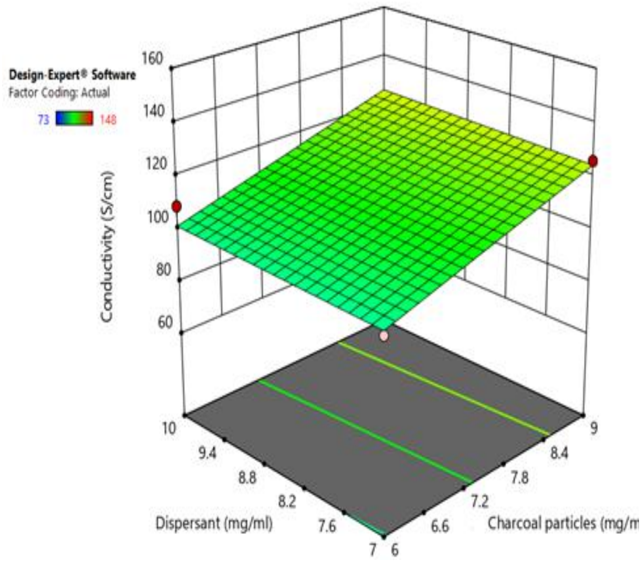

Fig. 4. 3D graphical relation of σ, dispersant and charcoal particle at 4mg/ml of ethanol

The peaks in FTIR curve fig.3 showed that there was a change in chemical composition after being pad coating of the cotton textile with charcoal dispersion, the charcoal was attached to the fabric. This is recognized by the introduction of aromatic groups in cotton fabric. The cotton fabric introduces an aromatic C=C conjugated group at 1500 cm^{-1} after it is coated by charcoal that conforms the adhesion of charcoal loading on cotton fabric. The intensity of band around 3335 cm^{-1} in cellulose due to OH vibration is higher than the controlled sample where there is C=C-H in at this wave number in the coated sample. Below 1000 cm^{-1} the aromatic absorption of coated sample is higher. This all signifies charcoal dispersion were properly adhered on to the surface of the cotton substrate.

E. Coating fastness properties and wash durability

Conductive textiles should not only have the desired electrical conductivity properties, but also acceptable quality characteristics as explained by Smith, W.C. [27]. Smith also suggests determining different coating fastness properties using their respective textile standards as is done in this paper, or modified versions.

Coating fastness to washing and perspiration of the charcoal coated fabric was evaluated. It was assessed in respect of color change and staining on cotton and polyester as shown in Table VII. It can be seen that charcoal coated fabric had color change by half grade lower than the original both in wash and perspiration fastness with no staining to polyester fabric. Though cotton textile remains black just as it is coated after normal washing, it is observed that when it is exposed for repeated laundering the charcoal particles had detached from the textile and precipitated in the water. As a result, the bare parts of the cotton fiber increase and conductivity of cotton fabric decreases as it is shown in fig.6. This may be due to the disruption of the formed conductive path which was formed by

Table VII: Effect of different fastening agents on coated fabrics

Fastness properties	Colour change		Staining			
			Cotton		Polyester	
Wash fastness(ISO 105 C06 2010)	4/5		4/5		5	
Lightfastness (AATCC Test Method 16 2007)	7					
Perspiration fastness (AATCC Test Method 15-2009)	Alkaline	Acidic	Alkaline	Acidic	Alkaline	Acidic
	4/5	4/5	4/5	4/5	4/5	5
Hot pressing (AATCC Test Method 133-2009)	Dry	wet	Dry	Wet	Dry	Wet
	5	4/5	5	4/5	5	4/5
Rubbing fastness (AATCC Test Method 8-2007)			Rubbing cloth			
			Dry		Wet	
			5		4/5	

charcoal particles earlier. For the case of rub fastness, dry rub fastness of the coated fabric was outstanding with no change; whereas wet rub fastness was half grade lower than its nature as shown in Table VII, the light fastness and hot pressing were still reasonable. due to the fact that the adherent of charcoal particles on to cotton textiles by BTCA cross linkers[14] and electrostatic adhesion of charcoal particles at the surface of cotton fabric in addition to the deposition of the charcoal particles on the amorphous and pores part of the cotton textile assisted in obtaining high coating fastness properties.

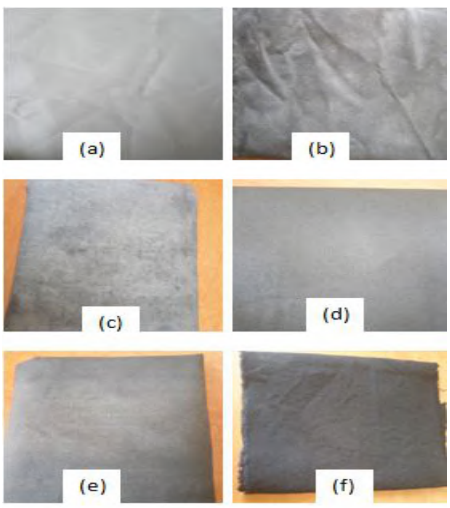

Fig. 5. controlled sample (a) and coated samples using coating mixtures of 7mg/ml dispersant, 4mg/ml ethanol, 6mg/ml BTCA, 4 mg/ml of MgCl2, with 4mg/ml (b) 6mg/ml (c) 7.5mg/ml (d) 9mg/ml (e) 10 mg/ml (f) charcoal particles.

F. Evaluation of comfort properties

It is 95% confident that the tactical and thermal properties of charcoal-coated and controlled samples have significant difference except for the roughness as shown in Table VIII. The coefficient of friction is inversely related to slipperiness. The controlled sample is more slippery than charcoal coated cotton fabric. MMD is correlated with the smoothness and roughness felt when the surface of an object is rubbed, and a larger MMD value indicates a rougher surface. Although the charcoal coated cotton fabric has higher roughness than the controlled sample, it is not statically significant. SMD which is a measure of surface topography indicates the surface physical evenness, and a higher value shows uneven surface. The charcoal coating creates a bumpy surface on the cotton fabric surface. These observations were both in the warp and weft direction.

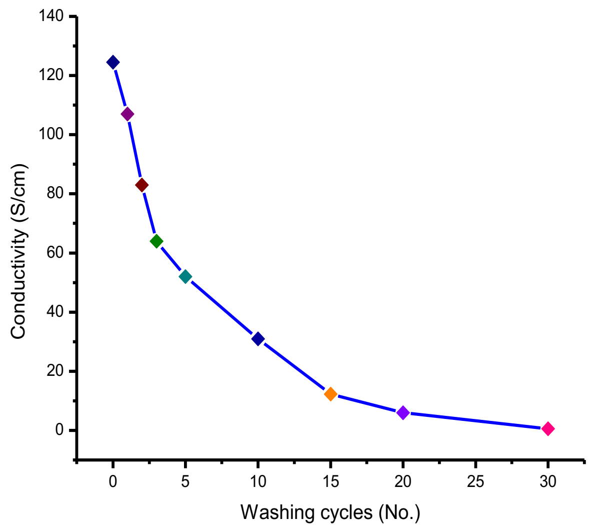

Fig. 6. Wash durability of conductivity of charcoal-coated fabrics

The shear rigidity of charcoal-coated fabric is higher than the controlled sample. This may be the higher coefficient of friction and flexural rigidity of the coated sample due to the effect of charcoal loading on increasing the compactness of the fabric. The 2G and 5G Hysteresis of shear force at 0.5° and 5° respectively are higher for charcoal coated cotton textiles than the bare controlled sample.

Since as a result of compact structure in the coated sample, once the yarns are sheared, it will be difficult to recover for both warp and weft observation. The linear compressibility of fabric which is a reduction in thickness with the application of 50gf/cm^2 pressure is difficult for coated fabric and hence the lower compressional energy is obtained in coated fabric [28]. The controlled sample has better retention after compression. This may likely due to the fact that the increase in the thickness of the fabric after coating, and the effect of coating on bending stiffness.

Thermal conductivity is looking at the transmission of molecular vibrations through a material which is measured as temperature. Generally the more rigid the material the faster the transmission and the higher the amount of heat that can be transmitted. Since the intermolecular spacing in the charcoal coated fabric is larger than the controlled sample, the motion of molecules in the charcoal coated fabric will be more regular than the corresponding controlled sample thereby thermal conductivity will be more effective and will be ineffective in thermal resistance and actual insulation. In addition, entrapped air which is act as a barrier for thermal conductivity is reduced for coated fabrics[29].

G. *Effect of coating on tensile strength and drapability of fabric*

The mean tensile strength of the charcoal-coated cotton fabric is 294N which is higher than the corresponding controlled sample of 269N at a mean elongation of 10.5% and 6% respectively in the warp direction. The mean tensile strength of the filling is 245N and 271N with mean elongation of 17% and 15.9% for controlled and coated samples respectively. The effect of coating on mechanical properties will be detailed in the next proceedings.

The drape coefficient of charcoal-coated cotton fabric was 84.23% which was stiffer than the controlled sample having a drape coefficient of 81.92% despite the fact that both samples are neither rigid nor limp. This is mostly due to the stiffening effect of the charcoal coating as a result of an increase in compactness because of charcoal loading.

H. *Effect of coating on air permeability*

The air permeability controlled fabric sample was 49.38 ± 0.528583 cm3/cm2/s at 100 Pascal air pressure which was decreased to 48.04± 0.7560423 $cm^3/cm^2/s$ for charcoal coated cotton fabric. The decrease in air permeability was due to the fact that the coating material to some extent blocked the interstices and pores in the fabric.

I. Water permeability

The spray rating of charcoal-coated cotton fabric in chart card rating was 70 which means partial wetting of the whole of the upper surface. However, the controlled fabric sample was completely wetting of whole of the upper surface with the chart card rating of 50. This most likely the hydrophobic nature of charcoal due to the formation of low energy surfaces on cotton textiles [30].

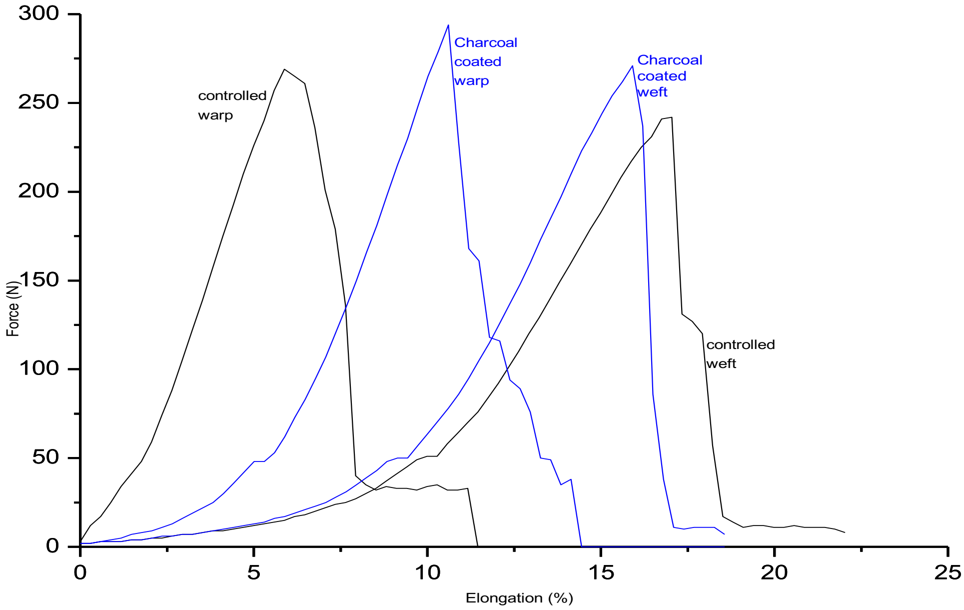

Fig. 7: Mean tensile strength and breaking elongation of controlled and charcoal coated samples

Table VIII: Effect of different fastening agents on coated fabrics

			Mean	Standard Error	**T** statistics	± **t** critical	Decision P(T<=t) two-tail, α = 0.5
Surface roughness and friction properties							
MIU	Weft	Controlled	0.1288	0.00281	-2.91376	2.776445	0.0435139
		Coated	0.1514	0.00549			
	Warp	Controlled	0.1634	0.00344	-13.4007		0.000179
		Coated	0.4116	0.01784			
MMD	Weft	Controlled	0.0128	0.00026	-1.93679		0.124836
		Coated	0.0143	0.00062			
	Warp	Controlled	0.0163	0.00034	-13.4008		0.000179
		Coated	0.0411	0.00178			
SMD	Weft	Controlled	1.2832	0.02684	-2.29398		0.08349
		Coated	1.6180	0.14371			
	Warp	Controlled	1.6320	0.03356	-13.4727		0.000175
		Coated	4.1660	0.17837			
Shear properties							
G, gf/cm.deg	Weft	Controlled	1.722	.005831	-9.21842	2.776445	0.000769
		Coated	2.362	.0688041			
	Warp	Controlled	1.778	.0159374	-13.1844		0.000191
		Coated	2.488	.0476865			
2HG, gf/cm	Weft	Controlled	3.468	.0511273	-17.4063		0.000064
		Coated	4.098	.0662118			
	Warp	Controlled	3.538	.0897441	-3.91313		0.017347
		Coated	4.408	.1658433			
5HG, gf/cm	Weft	Controlled	5.794	.105385	-14.8459		0.000119
		Coated	6.51	.1345362			
	Warp	Controlled	6.54	.1126499	-13.6907		0.000165
		Coated	7.552	.1096084			
Compression properties							
LC(-)	Controlled		.4372	.0016248	4.67618		0.009474

	Coated	.4826	.0082498			
WC (gf.cm/cm^2)	Controlled	.1894	.0015684	-3.30055	2.776445	0.029918
	Coated	.1798	.0021772			
RC (%)	Controlled	36.372	.2813965	7.69694		0.001532
	Coated	34.098	.0315278			
T(mm)	Controlled	.5212	.0047582	-20.9027		0.0000
	Coated	.635	.0022361			
Thermal properties						
Conductivity (w/mk)	Controlled	0 .045	.0012247	-22.4189	2.776445	0.000023
	Coated	0.079	.0013784			
Resistance (inch^2.k/w)	Controlled	2.1516	.0099328	34.56214		0.0000000
	Coated	1.79	.0007071			
Insulation (k/w)	Controlled	2.0718	.0384375	6.755395		0.002503
	Coated	1.764	.0222711			
Air permeability						
Air permeability (cm^3/cm^2/s)	Controlled	49.38	.528583	-3.9757	2.776445	0.0164598
	Coated	48.04	.7560423			

Where; MIU= Coefficient of friction, MMD= Mean deviation of MIU, SMD= Geometrical roughness, G= Shear rigidity, 2G= Hysteresis of shear force at 0.5°, 5G= Hysteresis of shear force at 5°, LC= Linearity of compression thickness curve, WC= Compressional energy, RC= Compressional resilience.

V. PROOF OF CONCEPTS

To corroboration conductivity, a light-emitting diode was lit up by easily powering a charcoal coated cotton textile in a dc power supply verifying that charcoal coated cotton fabric is electrically conductive.

Fig. 8. A conductive cotton fabric light up by light emitting diode connected with dc power

VI. CONCLUSION

Immeasurable conductivity of eucalyptus wood changes the form to become electrically conductive through carbonization at high temperature and time. A stable dispersion can be able to prepare from charcoal particles by reducing the particle size and producing homogenization through probe sonication and ultrasound sonication respectively. An elevated conductivity of 124.49 Scm^{-1} was developed by pad coating of a higher resistive cotton textile through a dispersion based on charcoal. Reasonable fastness properties of the coating were obtained when the coated sample assessed for different fastening agents in a way as it is done in textile industries. This is most likely be due to the electrostatic attraction between the cotton substrate and charcoal particles besides the crosslinking effect of BTCA. Coating affects the tactical and thermal properties significantly, however, it seems not to affect the general performance of the fabric than other existing systems of conductive fabric fabrication like the integration of metallic fibers to textiles. Apart from the electrical conductivity and its application for the development of smart articles; coating of cotton fabric through charcoal dispersion should be attempted to develop multifunctional finishes for thermal and flame retardant, UV blocking, photocatalytic resistance article. The technology will have commercial potential as it has a high possibility to integrate over the existing wet processing methods.

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TREATMENT OF INDUSTRIAL EFFLUENTS BY OZONATION PROCESS FOR ENERGY RECOVERY AND COLOR REMOVAL

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Abstract

Most industries produce effluents which are environmental hazards due to presence of color and recalcitrant COD. One useful way of remediating these effluents is by using them in production of biofuels through fermentation process. The use of industrial effluents as substrate for producing biofuels is advantageous in that on top of producing energy, the effluent is bioremediated before discharge. However, in many occasions, the production process is limited by its low energy yields and productivity due to presence of toxicants and refractory substances. This necessitates some form of substrate pretreatment like; biological, physical-chemical and the advanced oxidation processes (AOPs). Ozonation is one of the AOP process applied in industrial effluent pretreatment. The current study reviews the use of ozonation is used to enhance biofuel fermentation process and remove the colored recalcitrant substances before its discharge. Ozonation was found to increase the biodegradability of recalcitrant and toxicants in substrates for higher bioenergy yields. In pretreatment of solid substrates like the sludge, the process solubilizes the particulate substrate with minimal effects on energy contents of the substrates. Our data on digested distillery effluent indicate that the process can be used to remediate the color before the effluent is discharged. Though the process produced some increase in biodegradability, it was observed that the use of ozone overdose caused reduction in the biodegradability enhancement possibly due to production of toxic intermediates. Ozonation is one of the most selective AOP to unstable bonds. Its application in treatment of colored textile effluent results in almost complete color removal but with low COD elimination. More studies are required on integration of ozonation with other processes with the aim of enhancing both technical and economic cost-effectiveness of bioenergy production and the color removal.

Keywords: **Oxidation, effluent, treatment, color, bioenergy**

I. INTRODUCTION

The treatment of industrial effluents & handling associated sludge contributes significantly to the production cost of most industrial processes. The methods of water and sludge treatment have in recent past experienced great advancement due to strict standards by environmental regulation bodies. One of the preferred methods of remediating industrial wastewater is by producing bioenergy. In addition to energy generation, biofuels are preferable to fossil fuels because their production and usage do not increase greenhouse emissions unlike the later. Some of the biofuels which can be produced from industrial effluent include; like biogas, bioethanol, and biohydrogen. Another advantage of biofuels over hydrocarbon energy sources is that they are renewable.

There are several methods of biofuel production from organic substrates. Thermo-chemical processes entail gasification, pyrolysis, steam reforming [1; 2] and fermentation of organic substrates [3; 4]. Some of the organic materials which can be used as substrate for biofuel production include; organic effluent [5; 6], lignocellulosic biomass [7], agricultural residues [8], solid wastes [9] and excess sludge [10]. The low biodegradability of most substrates is the main limitation to biofuel fermentation. This is due to inhibition caused by substances like lignin [11], polyphenols [12], toxicants [13] or refractory substances [14]. The use of advanced oxidation processes (AOPs) to selectively remove these inhibitors ensures that the biodegradability of the substrates is enhanced for higher bioenergy yields.

In order to improve the yield and productivity of biofuel production from organic effluent substrate, multi-facet strategies have to be employed. These include modifying the reactor to retain the substrates, optimizing the reactor conditions for biofuel production, selection and enrichment of the microbial specialist culture, use of biorefinery production concept, application of advances in biotechnology, substrate choice, and pretreatment of organic substrates [15].

There are various methods for pretreatment of organic effluent substrates for bioenergy production. These include; heat treatment methods [16]. The use of thermo-chemical treatment mainly using alkali is most widely used method of substrate pretreatment for bioenergy fermentation [17; 18]. More recent methods include the use of Advanced Oxidation Processes (AOPs) which utilize in situ generated radicals. The radicals are powerful oxidants that react and mineralize recalcitrants and toxicants in biofuel substrates. Traditionally, AOPs were used for treatment of toxic or hazardous materials [19]. However, the methods have recently found wide applications including in pretreatment of bioenergy substrates or in final treatment of bioenergy effluents. The main advantage of AOPs over other methods of treatment lies in their ability to increase the biodegradability of the substrates.

Another application of AOPs in industrial effluent is in final remediation for color and COD removal before discharge of colored effluents. Their selectivity on unstable bonds makes them good for application on most recalcitrants, toxicants and colorants. Various AOP processes commonly applied in industrial effluent treatment include; ozonation [20], ultrasonication [21], Fenton oxidation [22], ultraviolet treatment [23], hydrogen peroxidation [24], microwave heating [25], photocatalysis [26], wet air oxidation [27] and electrochemical oxidation [28]. The suitability of using AOPs on a given substrate largely depends on the characteristics of that particular substrate. There is little documentation on applications of AOPs in bioenergy sector. In this paper the application of ozonation in promotion of biofuel production from organic effluent and final treatment of the effluent for color and COD removal is reported.

II. OZONATION PROCESS

Ozone is a state of oxygen where its molecule occurs in 3 atoms (O_3). It has oxidation potential (+2.07V) and has high reactivity. The gas has high selectively for unstable bonds like olefins.

$$O_3 + CH_2{=}CH_2 + H^+ \rightarrow 2CH_2O + OH^-$$

The process mechanism may entail either electrophilic addition which results in formation of substrate radical or insertion process that results in prolongation of the substrate chain. In presence of little hydrogen peroxide, the reaction results in formation of superoxide which reacts with water to form hydrogen radical. The ozonation process is therefore enhanced by addition of small amount of hydrogen peroxide and water. The process is also favored by operation at alkaline pH conditions, because hydroxyl ions facilitate the formation of the radicals.

III. USE OF OZONATION IN BIOENERGY EFFLUENT PRE-TREATMENT

One of the applications of ozone in bioenergy sector is pretreatment of excess sludge and anaerobic sludge before biohydrogen fermentation [29]. The ability of the process to increase biodegradability without much elimination of COD makes the process appropriate for application as a pretreatment. Another common application of ozone in biofuel production is in pretreatment of palm olive mill wastewater to increase its biodegradability [30]. The presence of high quantity of polyphenols in such effluents makes them completely non-biodegradable despite their high COD load. Moreover, ozone is applied in pretreatment for biodegradability increase in landfill leachate [31]. This effluent also contains high amount of phenolics which are toxic to anaerobic digestion. The high selectivity of ozone helps in the removal of phenolic toxicants [32].

The use of ozonation in elimination of phenols entails mineralization to more biodegradable compounds as shown in fig. 1 below. In mechanism (a), phenol reacts with free hydroxyl radicals to produce water and phenoxyl radicals which after rearrangements reacts with hydroxyl radical and forms catechol, quinones and their derivatives. These compounds are then mineralized by ozone and hydroxyl radicals to simpler straight chain compounds like organic acids, ketones, aldehydes, alcohols and carbon dioxide. In mechanism (b) the ozone and hydroxyl radical first attacks straight chain substrate which forms a radical. The radical attacks the phenol and results in elongation of phenol side chains. Further reaction with hydroxyl radicals and ozone results in simple straight chain compounds. The last mechanism entails direct addition of ozone on the phenol after which it loses oxygen and reacts with hydrogen radical to form catechol and its derivatives. These are then attacked by hydroxyl radical and ozone to form simple straight chain compounds.

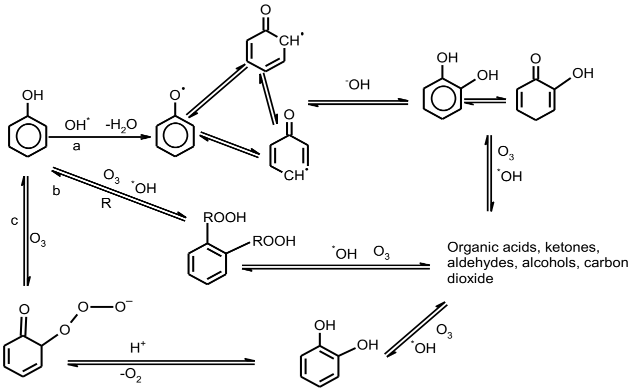

Figure 1: Pathways for phenol degradation by ozonation

Our investigation with digested molasses wastewater was carried out in Technical University of Berlin, Germany. The ozonation experiment was carried out at room temperature on a batch laboratory jar reactor with 1litre volume and 500ml working capacity. The ozone dosage was set 20-50 g/L and experiment was carried out between pH 5-9. Ozone was continuously supplied to the reactor through a porous diffuser placed at the bottom of the reactor. The off gas was passed through a 2% potassium iodide (KI) solution to remove ozone before its discharge. The substrate was digested molasses distillery wastewater with very dark color and COD 1.5-2 g/L.

The results from the experiment indicate that ozone is effective in final color remediation with 90% of colorants removed (Fig. 2). This was accompanied with little COD removal which demonstrates the selectivity of ozone to colored recalcitrants. The BOD_5/COD values in Fig 3 indicates a maximum ozone dosage after which the biodegradability starts to decrease. This is possibly due to formation of intermediate compounds which are more toxic than the substrates. Optimization of ozone dosage is therefore necessary when applied to increase biodegradability. A summary of how ozone treatment can be used to enhance from other investigators using various organic effluents is given it table 1. The results indicate that ozonation can be applied in pretreatment of many organic effluents like bioethanol effluent, municipal wastewater and pulp and paper effluent with high improvement bioenergy yield.

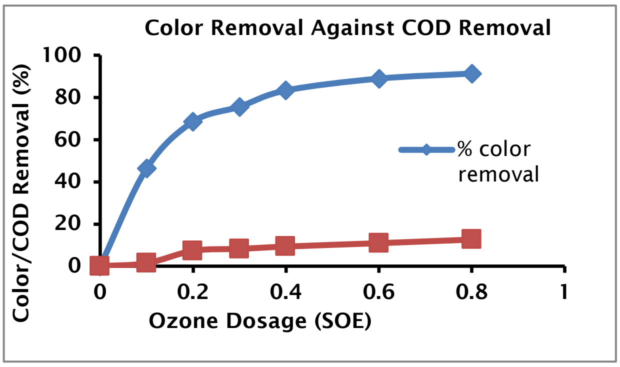

Figure 2: The relationship between color/COD removal and ozone dosage

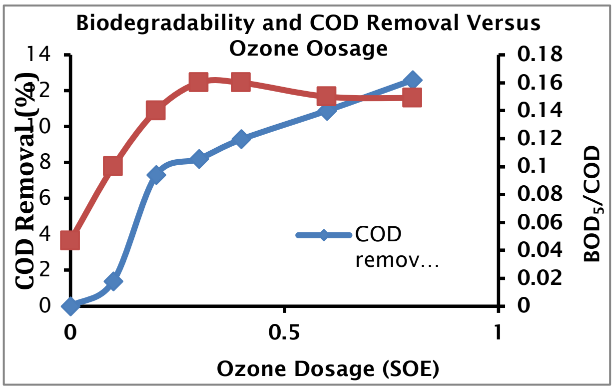

Figure 3: The effect of ozone dosage on substrate biodegradability

The results from our experiment show that only 10% COD was eliminated in the treatment process which suggests that ozonation is not effective in final COD removal before the effluent discharge. However, the effectiveness of the process can be improved by integrating ozonation process with other methods like biological or physical-chemical processes. The summary of how ozonation can be integrated with other processes for maximum effectiveness is given in table 2 below. The results indicate that integrating ozonation with biological digestion can achieve almost 80% COD removal [39].

The sludge from wastewater treatment plants contributes up to 50% of the total cost of treatment process. Moreover, the land space for the disposal of the sludge and biosolids has been diminishing due to increased human activities. This necessitates some treatment before the sludge is disposed. A prudent way to treat the sludge before disposal is by anaerobic digestion. In addition to reduction of the sludge volume, the process helps recover energy from biodigestion. In order to maximize on the sludge biodigestion, the sludge pre-treatment is necessary. Some of the methods used to pretreat the sludge before anaerobic digestion include; physical-chemical methods [45], advanced oxidation methods [46; 47], and biological methods [48].

The use of ozone and sonolysis are the most applied AOP methods in sludge pretreatment before anaerobic digestion. The two methods have the potential to solubilize organic particles therefore releasing sugars and other biodegradable compounds into the solution. This enables anaerobic microbes to easily access and attack the substrate which increases the substrate biodegradability, bioenergy productivity and the yields. A summary of how ozone can be used to pretreat various sludge substrates for enhanced bioenergy recovery is given in table 3. The results indicate that ozonation is effective in disintegration and solubilization of sludge and other organic substrates.

IV. Ozonation in Textile Color Remediation

One of the most produced colored effluent globally is the textile and dyestuff industry effluent. The environmental regulating bodies have in recent past become strict on the effluent standards. The colorants and excess COD in textile effluent must be removed before the effluent is discharged. The textile effluent is recalcitrant and cannot be removed by conventional methods including biological and physical-chemical treatment methods. One of the recent methods with great potential for application in remediation of textile effluent are the advanced oxidation methods like Fenton [54], ozonation [55], photocatalysis [56], and electrochemical oxidation [57].

Most of the colorants contain aromatic functional groups and other unstable functions in their structure. Ozone is the most selective advanced oxidation process and targets these unstable groups for mineralization and therefore the most suitable for color removal compared to COD elimination as indicated in Table 4. The results indicate that ozonation can remove 90-99% color with less than 50% COD removal. In applications where the effluent COD is high, a combination of ozone with other processes like biological treatment should be applied. Ozonation removes toxicity and increases the biodegradability of the effluent [58]. The biological process eliminates the COD. The combination of the two processes minimizes the costs by reducing ozone consumption [59].

V. Discussion and Conclusion

Ozone is one of the AOPs which have great potential for wide application in bioenergy production from industrial effluents [70; 71]. It is among the most selective AOPs in that it targets the unstable bonds like alkenes, alkynes or aromatic groups. Many organic effluents have substances which hinder their biodigestion or minimize their energy yields. These include polyphenols in olive mill wastewater [72], phenols in leachate effluents [[73], chlorophenols in pharmaceutical effluents [74], and various phenolic toxicants in industrial effluents [75]. Other bioenergy effluents may also contain recalcitrants like lignin in pulp and paper effluent or melanoidins in distillery effluents. There presence in organic effluents hinders full biodegradation of these effluents for bioenergy recovery. The use of ozone helps to demineralize the toxicants and recalcitrant to simpler compounds which can be easily mineralized. It is therefore suitable to use ozone in the pretreatment of these effluents for enhanced bioenergy recovery. Ozone has been used to treat pharmaceutical wastewater [76], olive mill effluent [77], agricultural wastes [78] and distillery effluent [79] which resulted in improvement in the effluent biodigestion.

The mineralization by ozonation causes solubilization of particulate substrate which helps to enhance its biodegradability for higher bioenergy yields. The use of ozone has been reported to increase the solubilization of excess sludge [80] and solid wastes [81]. Other studies have reported that ozone pretreatment of organic substrate can enhance enzymatic saccharification for subsequent fermentation processes [82]. The presence of high sugars imply that the bioenergy microbes have easier access to the substrate which increases their action.

Many effluents from industrial production are problematic in their disposal. This is due to their dark color and recalcitrant COD which can not be removed by conventional physical-chemical or biological treatment methods. The use of AOPs is one of the few methods that can effectively remediate the effluent so that it meets the regulations by environmental governing bodies before its discharge. Ozonation has been shown to be an effective process for color remediation but its ability to remove the COD is poor. Future studies should be geared at investigating the potential of integrating ozonation with other methods like Fenton, coagulation, adsorption or biological treatments which are known to produce high COD removal. In addition to technical effectiveness, more studies should be geared towards establishing the cost effectiveness of integrating the ozonation process with other processes in treatment of bioenergy effluents.

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Annex

Table 1: Application of ozonation in enhancement of bioenergy effluent biodegradability

Substrate	AOP	Effect	Reference
Bioethanol wastewater 68 g/L	Ozonation 17 O3 g/L 5 mins	14% methane yield, 41% methane productivity and 50% phenol removal	[33]
Pulp and paper	Ozonation	40% increase in biodegradation	[34]
Municipal WW	Ozonation	200-300% increase in methane production	[35]
OMW	Ozonation and photo-Fenton	Decrease in biohydrogen production	[36]
Pulp and paper effluent	Ozonation	30% increase in low molecular weight compounds	[37]
Waste activated sludge	Ozonation	80% increase in biogas production	[38]

Table 2: Integration of ozone and other processes in treatment of bioenergy effluent

Wastewater	AOP type	Combined processes	Effects	Reference
Secondary effluent,	Ozonation 10 mg/L, 5 mins	Biofiltration pretreatment	Removal of 50-80% organics, 55-70% inorganics and >95% heavy metal	[40]
Distillery effluent	Ozonation	Electrocoagulation	Removal of > 95% color, 80% COD	[41]
Molasses wastewater 4.58 g/L	Ozonation 0.17-1.26 g/g-COD	Aerobic-anaerobic pretreatment	71-93% color removal and 15-25% COD removal	[42]
Wine distillery effluent COD 27-29 g /L	Ozonation	Aerobic pre-treatment	Almost 90% COD removal by combined processes and 15 % by ozone	[43]
Waste activated sludge	Ozone 0.16 g O3/g MLSS	Membrane bioreactor	Permeate quality improvement and sludge reduction	[44]
Distillery wastewater 60 g/L COD	Ozonolysis	Aerobic digestion before and after ozonation	100% color removal, and ~80% COD removal	[39]

Table 3: Application of ozone in sludge pretreatment for bioenergy recovery

Wastewater type	**AOP used**	**Reactor**	**Results**	**Reference**
Sea food industry WW - 110g TSS/L	Ozone 0.02 g O3/g TSS		6.8%, 7.5% and 50% removal of TSS, sludge and biomass respectively	[49]
Municipal WW plant 3.5-5 g/L-TSS	Ozone 0.06-0.16 g O3/g TSS	Microbubble contactor	16-21% mineralization	[50]
Domestic WW WAS 7.99 g/L TSS	0.1 g O3/g COD ozonation	Batch bubble column	29% organic solubilization, 38% removal	[38]
Textile effluent sludge	Ozonation, 0.01g/g-COD	Beaker	20% increase in biogas	[51]
Municipal WW sludge 3.2-3.6 g/l TSS	Ozone 0.27 g O3/g TSS	8L batch	60% TSS disintegration	[52]
Urban sewage 3.1-3.6 gTS/L	Ozone 50 mg O3/g DS	3L glass contactor	46% sludge disintegration	[53]
Municipal sludge, VSS/MLSS 0.74	Ozone0.1 g O3/g TSS	Column reactor	36% disintegration of the sludge	[35]

Table 4: Color and COD removal in textile effluent by ozonation

Substrate	**Color removal%**	**COD removal %**	**Reference**
Dye	95-97	15-46	60
Toxic dye	100	60	61
Textile industry wastewater	91	33	62
Dyeing & finishing wastewater	95-99	60	63
Wollen textile dyeing wastewater	98-99	<40	64
Biotreated textile effluent	100	34-47	65
Textile effluent	98	37	66
Azo dye	100	50	67
Pretreated textile wastewater	97	43	68
Real textile wastewater	90	35	69

Farm to Fashion - Using Markets for Social Impact

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Abstract

The project titled "Farm to Fashion" aims to leverage an integrated handloom value chain in Ethiopia for employment, income multiplication, and social empowerment, with a focus on women. The intervention encompasses skilling, capacity-building, leadership training, and market development over the course of five years and aims to benefit 10,000 artisans directly and another 100,000 indirectly through financial inclusion and ancillary industry. The initial pilot is being carried out in Bahir Dar hosted by EiTEX, and is designed to be replicable within the country and eventually across East Africa. The initiative is a collaboration between Industree Foundation, Banglaore; ITC, Geneva; and Ethiopian stakeholders Women in Self Employment WISE, and the EDB (Enterprise Development Bureau of Amhara) and the Ethiopian Institute of Textile and Fashion Technology EiTEX.

Keywords- **Value Chain, Inclusive Enterprise**

I. Introduction

In populous countries such as Ethiopia and India, the key to sustainable growth lies in optimum utilization of the demographic dividend. Sadly, instead of being an asset, this dividend could fast become a liability and cause social unrest. Unemployment stares us in the face with every graduating batch adding to the numbers of poorly skilled workforce. While agriculture and informal work disguises the huge underemployment, the effects are still very evident. Finding jobs for all in the organized sector is not possible given the kind of per capita investment it would need, nor would it be sustainable.

In this scenario, building a handicraft based integrated value chain, attempts to improve incomes at the bottom of the pyramid by creating enterprise of the poor called the "Producers Company". The main premise of the model is using the available advantages, aggregating the resources of the poor and bringing in professional support to create a market-based intervention in the handloom sector.

II. Rationale

Economic significance of the sector: The handlooms sector is the second largest employer of rural families in the country after agriculture. The number of handloom enterprises in the country is estimated between 200,000 and 300,000 with almost 55% located in rural areas. It is a high priority sector for the government.

Sustainable job and income creation for households: The handloom value chain is conducive to sustainable job creation within and around small and medium-sized enterprises, counter-balancing industrial-scale development that necessitates dislocation or migration of workers to industrial zone dormitories.

Comparative advantage: Ethiopia has a longstanding tradition in handloom weaving with skilled craftspeople making products culturally linked to everyday use. Ethiopia has a domestic market demand for handloom products and which, unlike many countries in Africa, is not yet affected by large scale second-hand clothing imports from the west.

Scalability: There is both potential and a need for scalability in the handloom value chain. The value chain is fragmented with high cost inefficiencies due to the small scale of most enterprises, production of key inputs (e.g. yarn) being limited to industrial scale use, and limited awareness of the potential for market diversification.

III. Scoping Studies

The project was preceded by comprehensive scoping missions that selected Ethiopia as the best place to implement the project narrowing down on the suggested geographies and target groups. The scoping missions identified clear gaps as well as exciting possibilities. Special note has been made of resilience of the economic and social systems that have remained robust and functioning despite the political transitions vindicating the choice of the mission. The other major findings were:

- Handloom is the best area of intervention as it has a clear cultural and ethnic connect and has an immediate link to the bottom of the pyramid.
- Ethiopian handloom and cotton yarn production is impressive and commands an expanding market internally. Ethiopian handloom products, yardage and garments present an excellent range for the fashion-conscious consumer and the African design

communities, in Ethiopia, Africa and in the rest of the world.

- Home-based weaving community is the largest and most in need of professional help and it can best use the advantages of aggregation of raw material sourcing, accessing design inputs collectively – which the homebased weavers can't afford individually, as well as creating collective marketing strategies.

IV. INTERVENTION METHODOLOGY

Deep incubation & light handholding, 6C model

The *deep incubation* mode involves developing inclusive enterprises from the ground up by aggregating weavers and other actors across the value chain and providing them with a management layer. The professional management team would be formed by identifying local players who fit the profile of social entrepreneurs, training them, collectivizing them and providing marketing and design support, technological improvements and skilling for these teams to evolve into sustainable and "inclusive enterprises".

The *light hand-holding* mode is designed to support existing enterprises. Through capacity building, specific technological improvements and related skilling, and market development.

Industree's *6C framework* that is the basis of the above two modes constitutes of the following:

Channel:

-Sustainable B2B and B2C inclusive enterprises operating online and in brick-and-mortar retail outlets for local, regional, and international markets.

Construct:

-The creation of a branded, integrated farm-to-fashion value chain to add and capture value. This could be an overall umbrella brand or endorsement with sub brands from enterprises and/or product categories and customer segments.

-The enterprises involved could be fully integrated farm-to-fashion as well as partially integrated farm-to-yarn, yarn-to-fashion and fabric-to-fashion streams

-Professional apex entity to provide handholding to enterprises and aggregating buying and selling for greater economies and benefits

Create:

-Local design capability to produce ranges of apparel and home goods for different seasons and channels, and to collaborate with global designers for international markets.

Capacity:

-Implementation of skilling, capacity-building and leadership training programs. This would include hard skills training, soft skills training (financial literacy, lean manufacturing, market knowledge and design thinking, productivity improvement, business processes and entrepreneurship)

Connect:

-Institutionalized connect with markets and other social impact processes including policy level work at national and international for a for sustainable and equitable development.

6c's	What?	Why?	How?
Capacity	Build CAPACITY, productivity & competitiveness of the sector	To enable the sector to produce for modern domestic/ global, local/ premium markets at scale	Skilling
Construct	Aggregate creative producers to CONSTRUCT and own formal enterprises	To remove middlemen so that artisans regain ownership of their enterprise and products by gaining access to infrastructure needs/raw material	Through incubation of formal producer companies that access equity, enabling gradual capacity utilisation
Channel	Create direct CHANNELS for creative producers to sell	To provide new markets that associate high value to their products	Market linkages and professional supply chain management
Create	Enable creative producers to innovate and CREATE new designs and products using new technology	To design and produce what the customer wants	Design and product development
Capital	Raise CAPITAL for scaling up	To scale up artisan-owned companies to become national and global brands	Equity and debt for expansion
Connect	CONNECT artisans to digital solutions like online software and apps	To keep artisans relevant and connected to new markets	Online marketing platforms, digital finance and integrated online business software

V. SITUATION SPECIFICS

In the deep hand holding mode inclusive enterprises or producer owned companies are being set up. The first such company is located on the premises of EiTEX. The legal model of the enterprise has been evolved and adapted to Ethiopian Commercial Code and is being implemented as a three-tier structure of a national company, a regional company, and several local companies. The cascading structure of shareholding, with the local companies holding shares in the national apex company completes the loop and pushes the larger share of profit making at the end of the value chain, towards the bottom.

In the light hand holding mode, the project has launched a yarn bank with a subscription membership. The scoping study had identified shortages and fluctuating cost of inputs as one of the most critical issues for homebased weavers, who were not able to make most of the peak seasons for sale of traditional garments.

The subscription-based yarn bank will offer a transparent mark up above the mill rate. It will be able to lower the cost of inputs by aggregating the demand of the member weavers and the demand of the producer company, thereby getting lower rates. It will stock embroidery yarn for making "Tibeb" or the coveted border designs. Some of the colors that are most likely to disappear from the market during peak season would be stocked in advance and made available to members. This yarn bank is in the same workspace where the "producer company" is being set up and will have the benefit of demonstration effect on weavers who come to buy yarn and other materials and would be inspired to try the new machines. We would then step in to help them procure these and train them, and co-construct more such enterprises of weavers, spinners, tailors; thereby having a salutary effect on the eco-system.

Technical challenges are being met with collaborative efforts of EiTEX and technical team at Industree Foundation in India and solutions that are evolving are being documented to create a robust template for similar interventions in the country and rest of Africa.

VI. Conclusion

Gainfully employed individuals with regular incomes spend more on health, nutrition and education. Furthermore, leadership and decision-making roles at workplace are replicated within families. This means that women's economic empowerment leads to increased empowerment at home. As part of this initiative, social empowerment training will be given to women to take up leadership in their enterprises and giving them a platform to voice their concerns and take collective action on community issues. Through the 6C model, the project will create a self-owned ecosystem for sustainable livelihoods. Deep handholding support from professionals and mentors for the inclusive enterprises will assist in starting and scaling up operations, which will increase incomes and livelihoods in rural Ethiopia, particularly of women, who form a major part of the handloom value chain. The social impact of this initiative could be measured by the percentage of income spent on food and healthcare, as well as the number of women working in leadership and management roles in enterprises.

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[2] http://www.industree.org.in/resources/ wp-content/uploads/2016/08/Impact-Report-Web-file.pdf

[3] http://www.intracen.org/publication/SME-Competitiveness-Outlook-2015/- small and medium-sized firms are the 'missing link' to inclusive growth.

Study of Dyeability of Carbamated Cotton Fabric with Reactive Dyes

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Abstract

Cellulosic materials such as cotton are reasonably strong, hydrophilic, safe to living organisms, reproducible, recyclable, biodegradable, insoluble in water and in organic solvents. Carbamated cotton was prepared by pad-dry-cure method using urea. Dyeing of the carbamated cotton was done with Reactive Red HE3B dye which has an overall good fastness properties and brilliant shades requiring high amount of salt and alkali. The studies have been made to improve the exhaustion and reduce the use of large amount of salt and alkali through introducing a carbamate group to the substrate. Experiments showed the optimum operation for carbamation to be at 135°C of curing temperature, 400g/l of urea and 5 minutes of curing. Higher exhaustion, dye utilization and color yields could be realized on the carbamated cotton than that on the uncarbamated one in the conventional dyeing. Generally, modification of cotton fabrics by carbamation resulted in improved equilibrium exhaustion, improved dye utilization and reduced hydrolysis of reactive dyes with no effect on the wash fastness properties.

Keywords- **Carbamation, Urea, Cotton, Reactive Red HE3B, pad-dry-cure method**

I. Introduction

Dyeing of cotton fabric can be done with a range of dye types and nowadays, reactive dyes have been used very often and they are, by consumption, the most important textile dyes [1]. The high popularity of reactive dyes is based on producing brilliant and fast colors with a wide range of shades using various environmentally friendly procedures. Reactive dyes stand out from other dyes by their ability to make covalent bonds between carbon atoms of dye reactive group and oxygen atoms of cotton hydroxyl groups under alkaline conditions [2]. Reactive dyes are divided, according to the structure of a reactive group, in haloheterocycle and vinyl sulfone-based dyes, which react with cellulose through nucleophilic substitution and addition mechanisms, respectively [3].

The most important parameters affecting exhaustion and fixation of reactive dyes are temperature, salt concentration, alkali concentration, and a liquid ratio [4]. These are required to overcome the main drawback of reactive dyes which is low equilibrium exhaustion, due to low dye affinity for cotton, requiring high amounts of salt and alkali in the dyeing bath, which, when released into the water streams, produce disturbances in delicate biochemistry of water organisms.

There have been numerous physical and chemical procedures for modification of cellulose fibers to increase reactive dye exhaustion and fixation degree, saving electrolytes and minimization of ecological risks. The pretreatment to improve functionality and dyeing ability of cellulose fibers, using cationic agents, has attracted attention recently [2, 5-8]. The reason for such treatment is an improvement of cationic activities of cellulose fibers and reduction of electrostatic repulsion of negative ions resulting in a positive effect on the absorption of anionic dyes. The increased yield of reactive dye on cotton fabrics treated with a commercial cationic agent is explained by the positive surface charge of cationized cotton fiber [1]. Moreover, the introduction of amine groups in the cotton structure increases reactive dye yields due to an ionic attraction between cationic groups and reactive dye anions [9]. Dyeing of cationized cotton without salt indicated that reactive group type did not affect the dye yield on cationized cotton and colorfastness was not changed [2, 5, 10].

In this work, whether the extent of dye absorption of cotton fabric treated with a cationic agent, carbamation enhances the dyeing ability of cotton with reactive red HE3B (C.I. Reactive Red 120) dye is studied with treatment being given to the cotton cellulose after pre-activation with a caustic mercerization process.

II. Experimental

Materials

Plain weave cotton fabric (bleached) with the warp density 26 ends/cm, weft density 22 picks/cm, GSM 150 g/m^2, warp and weft way tensile strength 319N and 228N, warp and weft yarn count 20 Ne were used throughout the work.

Dye and Chemicals

Urea (Loba chemie pvt. Ltd., India), Sodium hydroxide, Barium hydroxide, Sodium sulfate, Sodium carbonate, Acetic acid (Alpha chemika, India), Reactive red HE3B (C.I. Reactive Red 120) dye were used in this research work.

Methods

a. Mercerization

Cotton woven fabric supplied as half bleached was subjected to mercerization for further accessibility of hydroxyl groups on cotton cellulose. Mercerization was done under 3% tension with the caustic soda concentration of 300g/l, the temperature in the range of 20 ºC to 25 ºC for mercerizing time of 60s. Once the operation has been completed the fabric was rinsed with water without removing the tension followed by neutralization by means of dilute acetic acid solution. The mercerizing efficiency was checked by barium activity number according to the AATCC test method 89-2003.

b. Carbamation

The mercerized cotton fabric (BAN = 141.2 ± 1.0) was subjected to carbamation using 100g/l, 250g/l and 400g/l amounts of urea by following Pad-dry-cure method; the prepared cotton fabric was impregnated using the padding liquor in a laboratory padding mangle. The pressure on the mangle was adjusted to give appropriate pick-up of greater than 85%. The samples were then pre-dried for 3 min at 100°C using a mini oven dryer/baker, and cured at 135°C, 160°C and 185°C for 1, 3 and 5 minutes. The proposed reaction mechanism is explained in Figure 1. The prepared carbamated samples were thoroughly washed with distilled water to purify it from the remains of urea finally air dried. The optimization was done with three-level factorial design using design expert 10 statistical software.

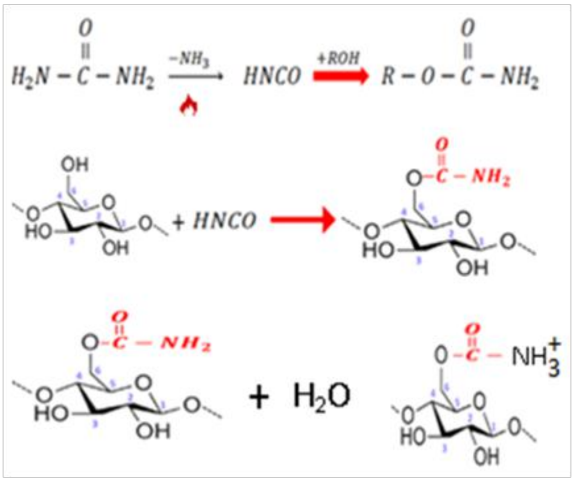

Figure 1 Proposed reaction mechanism

c. Dyeing

Dyeing of untreated (uncarbamated) and carbamated cotton were carried out using a laboratory Eco-IR dyeing machine available at EiTEX laboratory. Dyeing of uncarbamated cotton with Reactive Red HE3B dye was performed according to the procedure recommended by the manufacturer; 0.5% o.w.f. Reactive red HE3B (C.I. Reactive Red 120) dye (0.5% shade) was added to a room temperature dyebath. The fabric sample was then added and the bath was heated to 80ºC at a rate of 1.5 ºC/min. Before reaching to 80ºC, electrolyte (Na_2SO_4) of 40 g/l was added in two installments at 55ºC and 65ºC. After holding the temperature at 80ºC for 10 min, 3 g/l of sodium carbonate was added. The bath was then held at 80 ºC for 50min, cooled to 60 ºC at a rate of 2.5 ºC/min and then discarded (Figure 2a) [5]. Dyeing of carbamated cotton fabric was done with the absence of addition of electrolyte (Na_2SO_4) (Figure 2b).

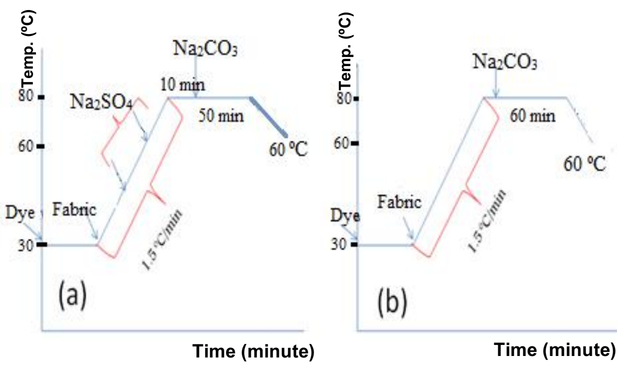

Figure 2 Dyeing cycle of uncarbamated cotton fabric (a), carbamated cotton fabric (b) (adopted from [5])

Determination of nitrogen content

The percentage of nitrogen present in the cotton fabric was measured in duplicate and used as an indicator of the level of carbamation. The analysis was conducted by kjeldahl method using sample mass of 10±2 mg, and the DS was determined using:

$$DS = \frac{162*N}{(14*100)-(43*N)} \qquad (1)$$

Where, N = specimen nitrogen content (%); 162 = molar mass (g/mol) of an anhydroglucose unit (AGU); 14 = molar mass of nitrogen (g/mol); 43 = net increment in molar mass (g/mol) of an AGU on substitution of a hydroxyl (–OH) by a carbamate ($-OCONH_2$) group.

Testing of exhaustion (%E)

Dye uptakes of both the treated and untreated cotton were measured by sampling the dye bath before and after the dyeing process. The absorbance of the diluted dye solution was measured at the wavelength of maximum absorption (λ_{max}) of the dye using UV-Visible spectrophotometer. Percent dye bath exhaustion E% was determined by using the following equation.

$$E\% = 100(1 - \frac{A_1}{A_0}) \qquad (2)$$

Testing of tensile strength

Tensile strength test was done by the ASTM D5035-textile strip method test.

Where A_0= absorbance of dye solution at λ max before dyeing and A_1= absorbance of residual dye solution at λ max.

Testing color strength (K/S)

The color strength of the dyed samples was determined as the K/S value calculated from the sample reflectance (R) at λ max using the following equation:

$$\frac{K}{S} = \frac{(1-R)^2}{2R} \qquad (3)$$

Where K is the Kubelka-Munk absorption coefficient and S is the scattering coefficient of the dyed sample at the wave length of maximum absorption.

Determination of fixation and total dye utilization

The extent of dye fixation of the Reactive Red HE3B (C.I. Reactive Red 120) dye on the treated and untreated cotton were determined by measuring K/S values of the dyed samples before and after soaping, from which the extent of dye fixation was calculated using the following equation:

$$F\% = \frac{C_2}{C_1}100 \qquad (4)$$

and total dye utilization using:

$$T\% = \frac{E\%*F\%}{100} \qquad (5)$$

Where T% = total dye fixed, C_1= K/S value of dyed sample before soaping, C_2= K/S value of dyed sample after soaping, and F%= degree of fixation of absorbed dye.

Testing of wash fastness

AATCC test method 61-2007 was followed for wash fastness test.

FTIR spectroscopy

The surface chemistries of untreated and treated (carbamated) cotton fabrics were evaluated by using Fourier Transform Infrared spectroscopy.

III. Results and Discussion

Carbamation

The optimum value for carbamation is found to be at 135ºC with the concentration of 400 g/l for the curing time of 5 minutes (Fig. 3), the DS result being 0.2829. The effect of the factors (concentration, curing temperature and curing time) on the responses (degree of substitution (DS) and Tensile strength) is shown in Fig. 4. From the figure it can be concluded that the DS increased with increasing concentration, curing temperature and curing time while Concentration has no effect on the warp way tensile strength, where increase in curing temperature and curing time has an effect on warp way tensile strength. The weft way tensile strength hasn't shown a significant change with all the factors (Concentration, curing temperature, curing time).

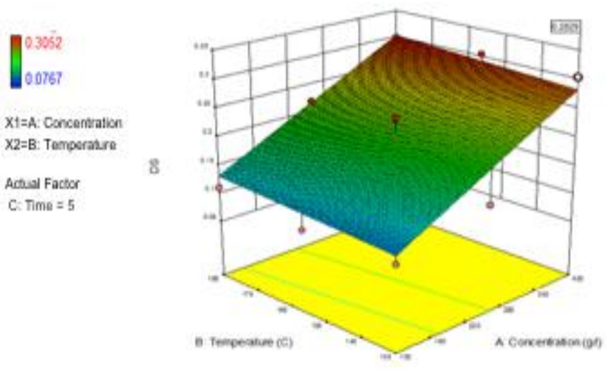

Figure 3 Response for optimum carbamation

Exhaustion (%E)

Dye exhaustion percentage of the carbamated cotton fabric is observed to be above 86.24%. The reason might be because there is less chance for hydrolysis of dyes due to absence of salt and use of mild alkali in the dye bath. The results are shown in the Table 1 and it is clear from the table that exhaustion value of the carbamated cotton fabric was 16.07% higher than that of the untreated cotton fabric. This may be explained by the fact that the electrical repulsion between the carbamated cotton fabric and anionic reactive dye is reduced [8]. On the other hand, by introducing the carbamate group which develops a quaternary ammonium group in the water, the cotton fabric would be cationized giving high substantivity for anionic reactive dyes because of attraction between the positive charge on the fiber and the negative charge on the reactive dye. Therefore, carbamation of pre-activated cotton cellulose with urea can increase the use percentage of Reactive Red HE3B dye.

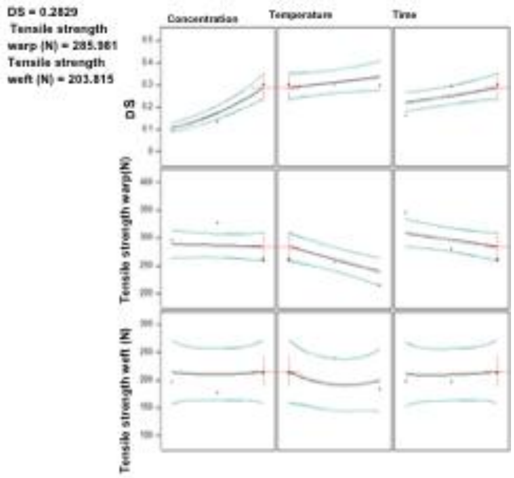

Figure 4 Effect of Concentration, Temperature and Time on the DS, Tensile strength warp and Tensile strength weft

Color strength (K/S)

The color depth of dyed cotton fabrics was evaluated in terms of K/S values from the Kubelka-Munk function (equation 2), where the reflectance R was measured with Gretag Macbeth coloreye 3100 spectrophotometer. Higher value of K/S indicates the higher dye uptake of the fabric.

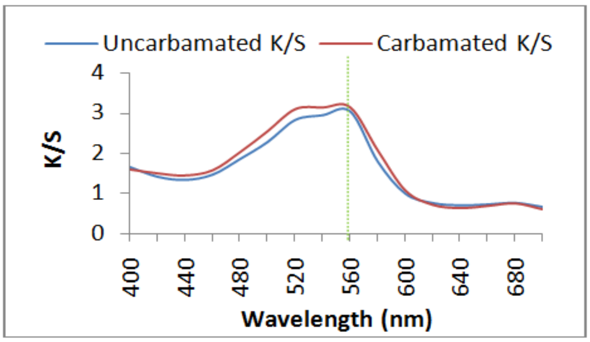

Figure 5 Color strength of carbamated and uncarbamated cotton fabric

The K/S value of the normal dyed cotton fabric was lower than the K/S value of carbamated cotton fabric (Fig. 5). This demonstrates that without exhausting agent and with mild fixing agent, carbamated cotton fabric react with dye molecule effectively, so that the dye uptake of the carbamated cotton fabric is higher than that of normal dyed fabric.

Dye fixation (%F)

Table 1 describes that the fixation value of the carbamated cotton fabric is higher than that of the untreated fabrics (normal dyed). This increased value is about 11.89% more than uncarbamated dyed cotton fabric. Fixation of the Carbamated cotton fabric was higher than that of the untreated cotton fabric under the same dyeing condition.

Table 1 Dyeing results of carbamated and uncarbamated cotton fabric

Treatment	Concentration	K/S before soaping	K/S after soaping	% E	% F	% T
Uncarbamated	2% (o.w.f)	4.6173	2.7155	74.3	58.81	43.7
Carbamated	2% (o.w.f)	4.7587	3.1314	86.24	65.8	56.75

Total dye utilization (%T)

Table 1 show that the total dye utilization (%T) of the carbamated sample is higher than that of normal dyed fabric. The carbamated fabric gives the %T value of 56.75%, which is 29.86% higher than that of uncarbamated cotton fabric.

Wash fastness properties

Table 2 shows the wash fastness rating for carbamated and uncarbamated cotton fabric. It shows that there is no much difference between the carbamated and uncarbamated fabrics, confirming the effectiveness of dye fixation due to the introduction of carbamate group in the cellulose chain. So it can be mentioned from Table 2 that the carbamation have no effect on change in color and staining in comparison with uncarbamated dyed cotton fabric. It may be due to the formation of strong ionic bond between the fiber and dyes as it is equally good for the covalent bond that normally links the dye and fiber as explained by Montazer et, al [5]. The wash fastness depends upon the physical and chemical properties of the fiber, the class of the dyes and their forces of interaction, and their interaction with soap solution [12].

This could be explained based on the forces of repulsion and attraction expected to occur during the dyeing process. These forces arise due to the presence of free hydroxyl groups in cotton cellulose, anionic group present in Reactive Red HE3B (C.I. Reactive Red 120) dye, amino ions in introduced carbamate group. The presence of amino groups on carbamated cotton cellulose fibers reduces the repulsion between the free hydroxyl groups of cellulose and the anionic groups of dyes [11]. As a result, these carbamated cotton cellulose fibers show higher fixation.

Table 2. Wash fastness properties of carbamated and uncarbamated cotton fabric

Sample	Change in color	Staining on white					
		Acetate	Cotton	Nylon	Polyester	Acrylic	Wool
Uncarbamated	4	4-5	4	4-5	5	4-5	5
Carbamated	4	4	3-4	4-5	5	4-5	5

FTIR analysis

Since the properties of cotton cellulose carbamate material are one of the significant factors contributing to the dyeability of the material, differences between the cotton cellulose carbamate sample and uncarbamated cotton were evaluated to understand the chemical change that has taken place in carbamation (Figure 6). Carbamates of cotton cellulose were characterized by means of FTIR to ensure the reaction of hydroxyl groups with urea. A typical loss in transmittance band for the carbamated cotton is observed in the range 3600 cm^{-1} to 3300 cm^{-1} which is assigned to the (NH) [13] of the carbamate group. The stretch is not as broad or strong as it appeared in the uncarbamated cotton (OH-stretch) in this region. The transmittance band from 3300 cm^{-1} to 3000 cm^{-1} is very broad in the uncarbamated cotton which signifies the large numbers of –OH groups in the cotton [14], while this band is not as broad in the carbamated cotton; which indicates the reduction in –OH groups and these are replaced by the carbamate group. The transmittance peak at around 1100 observed on uncarbamated cotton disappeared on the carbamated cotton, which is attributed to the loss of –OH vibration in the carbamated cotton fabric. As well the reduction of hydroxyl peak at 3250 cm^{-1}, represents strong evidence for reaction of urea with the cotton samples.

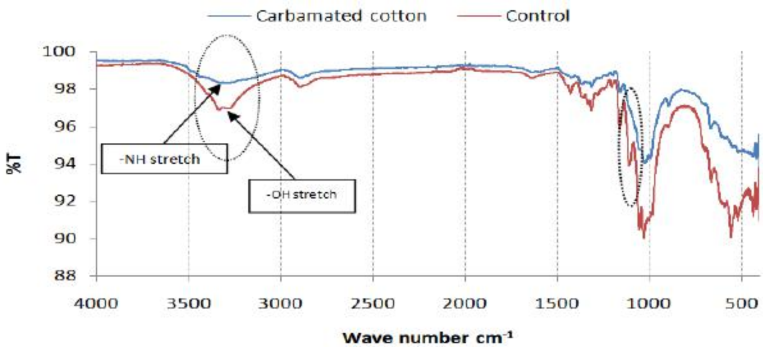

Figure 6 FTIR spectra of carbamated and control cotton fabric

IV. Conclusion

The effect of treating cotton with urea to introduce cationic group of carbamate on the dyeing performance was investigated. The optimum result for carbamation of cotton fabric with urea was found to be at 135ºC curing temperature with urea concentration of 400 g/l for 5 minutes. The carbamated fabric dyed with 0.5% shade Reactive Red HE3B dye, shows 24.15% higher exhaustion, 5.7% higher fixation and 41.8% higher total dye utilization value than that obtained by uncarbamated conventional dyeing method, and also exhibited similar washing fastness with the conventional dyeing method of uncarbamated fabric. By using this treatment method, the following advantages were observed; elimination of salt as an electrolyte, higher fixation of dye and less hydrolysis. It can be concluded that if a comparable or even higher results are achieved with DS of 0.2829, there is a likely chance of getting even higher results by increasing the DS. Therefore, needs studies to find out a way to introduce more number of carbamate groups.

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Jute Reinforced PLA Bio-composite for the Production of Ceiling Fan Blades

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Abstract

In this project work, jute fabric is used as reinforcement and PLA (poly lactic acid) film is the matrix by which composites are made by stacking of number of fabric layers in between the PLA films. For surface modification of the jute fabrics, different chemical treatments are carried out such as alkali, acetylation, silane treatment and treatment with maleic anhydride. The differently treated fabrics have been tested by Universal tensile tester machine and mechanical characterization is done. Accordingly, Alkali + Silane treated fabric shows the highest tensile strength and young's modulus followed by Alkali only treated. Alkali + Acetylation treated and Alkali + Maleic anhydride treated jute fabrics show poor tensile strength and young's modulus values. Compression moulding machine is used for composite blades making. With the use of the composite blades an average power savings of 15.65Watt has been achieved while the fan is operating at the maximum speed, which is 20% power reduction and due to this a minimum of 630 million Rupees or 63 croreRupees savings per annumwill be there if we use the blades in Delhi only.

Keywords: **Jute fabric, surface modification, compression molding, composite blades, power savings**

I. INTRODUCTION

Among the plant fibers, jute is the second most important bastfiber after cotton because of its easy availability at low cost. It is produced from plants in the genus Corchorus, family Tiliaceae. Jute fibers are composed primarily of the plant materials cellulose and lignin. Jute fibre stiffness comes because of the cellulose. It also gives strength and stability. But due to the hydrophilic properties of cellulose, compatibility with that polymer matrix is difficult because they have hydrophobic nature. For this basic reason different surface modification methods has to be there for the jute fibre so that the interfacial adhesion can be improved [2]. While reinforcing the fibre with the matrix material, the cellulosic hydroxyl groups on the fibre surfaces make both the physical and chemical bonds. To say that bond between fibre and the matrix is good, number and strength of bonds between the two materials has to be better [4].

Compared to the traditional polymers (Polypropylene, polystyrene & polyethylene), PLA has better mechanical properties like: tensile strength, tensile young's modulus, flexural strength, etc. besides the stated better mechanical properties, it has also its own drawbacks like poor toughness property and for those applications which needs Plastic deformation this poor property limits its use [7].The influence of chemical modifications on jute fibres has been studied and reported in different works. Amongst them are: latex coating, alkali treatment, monomer grafting, silane treatment, isocyanate treatment, permanganate treatment, acetylation, and so on. With the stated modification methods, improvements have been seen on the fibre matrix adhesion of the composites. Usually the need for modifications is for improvements on wettability and making compatible the reinforced fibre with the resin material so that the produced composite is going to be strong and durable [1]. The ceiling fan blades are usually made up of aluminum, steel, wood, etc. The ceiling fans have become a common appliance both in domestic and industrial applications.

Energy crisis and less availability of natural resources being the major challenge, selection of better material and effective manufacturing processes, can reduce both the power consumption and the manufacturing cost. Composite materials have found a wide range of application in replacing the conventional materials with enhanced strength and mould ability. Energy crisis is the major problem faced widely. Though wide range of researches is being laid in the areas of alternate energy sources, proper management of the available energy sources will contribute in controlling this energy crisis, particularly in high populous countries such as India. Ceiling fan being one of the vital electric appliance, consumes considerable electric power in most domestic and Industrial application. Imparting fibre reinforced composite blade in ceiling fans reduces the weight of the blade, thereby considerably reducing the power consumption. [16]

II. MATERIALS AND METHODS

Materials & Chemicals

Woven Jute fabric (1/1 plain fabric) and PLA (poly lactic acid) film were used. The following chemicals were used for chemical treatments and preparation of composites: NaOH,HCl,Aceticacid,Ethyl acetate,H2SO4,Amino propyl trimethoxysilane,Maleicanhydride,Acetone solvent, and Araldite epoxy.

Compression moulding machine,LCD Wind Speed Gauge Meter Anemometer & Thermometer,4 In1Digital Meter AC (80-260V/20A) Ammeter/Voltmeter/Power Meter/energy Meter are the equipment used for making of the composite blades and for testing the performance parameters.

III. METHODOLOGY

A. Jute fabric surface treatments:

Table 1 Characteristics of untreated jute fabric

Ends/inch	Picks/inch	GSM	Density (g/cm^3)
10	9	251	1.42

Alkali treatment

5% w/w NaOH solution is prepared using sodium hydroxide pellets and distilled water. Then the fabric is dipped in NaOH solution for 1hour separately. After 1 hour, fabric is washed with 1% HCl solution for neutralization. Finally, it is washed with distilled water. Fabric is then kept in hot air oven for 3 hours at 70°c to hinder the water content.

Alkali treatment + Acetylation

The alkali treated jute fabric is then treated with acetic acid for 1hour at room temperature and then thoroughly washed with distilled water and dried.

Alkali treatment + Silane treatment

A solution of 0.5 wt% silane coupling agent [3-(2-aminoethyl amino) propyl trimethoxysilane] was prepared in acetone. Acetone was used in preference to water to promote hydrolysis to take place with the moisture on the surface of the fibres rather than within the carrier. It also promotes swelling of the fibre and so increases the fibre surface area exposed to treatment and the Alkali treated jute fabric is then immersed in the solution for 45 min. After treatment, fabric is removed from the solution and dried in oven at 650c for 1h. Finally, the fabric is thoroughly washed with water to remove chemical residues until a pH of 7 is obtained and then dried at room temperature.

Alkali treatment + Maleic anhydride treatment

In maleic anhydride treatment, the alkali treated jute fabrics were surface treated for 5 min with 1% solution of maleic anhydride dissolved in toluene solvent at 55ºC. After treatment, fabrics were washed in toluene to remove extra MA. The fabrics were then dried for 6 h followed by oven drying at 60°C.

B. Characterization Techniques

Evaluation of tensile properties of fabrics

Breaking strength and elongation of fabrics were tested on Universal testing machine following ASTM D 5035:1995 using load cell of 1000N. Five specimens were tested for each sample. The testing conditions are: Width: 5cm; Thickness: 2mm; Length: 20cm; Gauge length: 7.5cm; Loading rate: 300mm/min.

Evaluation of tensile properties of composites

Tensile stress (MPa) and breaking extension of composites were tested on a Zwick tensile testing machineby following ASTM D 3039. A load cell of 50 KN was used. The testing conditions are: Width: 25mm, 20mm; Thickness: 2mm, 3mm, 4mm & 5mm; Length: 175mm; Gauge length: 100mm; Cross head speed: 2mm/min

Testing of Inter-laminar shear strength of composite

By using Zwick/Z010 shear strength tester, inter-laminar shear strength of composite specimens was tested following ASTM D2344/D2344M – 16 using load cell of 5KN. The testing details are:

Thickness: 2mm; Width: thickness*2= 4mm; Length: thickness*10= 20mm; Span length: thickness*4= 8mm; Cross head speed: 2mm/min

Measurement of air velocity of fans

An LCD wind speed gauge Anemometer was used for measuring the air velocity (ft/min) of fans (both Usha and the composite blade) running at different speeds starting from the minimum to the maximum. Readings were taken at the tip (edge) part of the blades, where maximum air velocity is there and to get the actual readings data has been recorded just after completion of 3 minutes.

Measurement of power consumption of fans

Power consumptions of fans were measured using 4 in 1 Digital meter Ac (80-260V/20A). By using the wiring diagram at the back of the meter, 1st and 4th terminals of the meter are loaded to the power conductors of the fan's regulator switch and through 20 A load current, 2nd and 3rd terminals of the meter are connected to the voltage supply of the regulator switch. Finally, the fan regulator has been switched on and readings are taken at different speeds.

IV.RESULTS AND DISCUSSION

Tensile properties of jute fabrics

The tensile strength and young's modulus of un-treated and chemically treated fabrics are given and compared in Fig 1. The breaking extension (%) at maximum breaking load has been compared for the differently treated and untreated jute fabrics and the result shows jute fabrics treated with Maleic anhydride and Acetic acid exhibits highest breaking extension (%) and this is due to the fact that many constituent fibres in the fabric slips rather than catastrophic failure when breaking load is applied on the fabric and do not contribute for the load sharing, and hence, the fabrics show a lower breaking strength and tensile strength values. On the contrast, Alkali+Silane treated jute fabrics show the lowest breaking extension (%) value because of the catastrophic failure of the constituent fibres which in turn contributes for the load sharing and hence a highest breaking strength and tensile strength values.

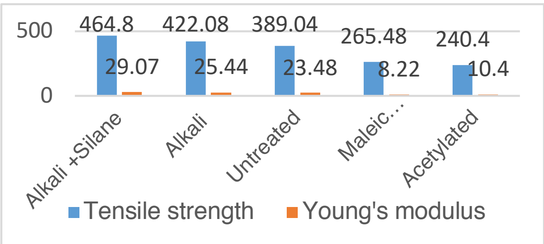


Fig. 1 Tensile properties of untreated and treated fabrics

Alkali+Silane treated jute fabrics exhibits a higher tensile strength and Young's modulus followed by alkali only treated jute fabrics (Fig.1). So for making of composite specimens with different fibre volume fractions and weights, jute fabrics treated with Alkali+Silane were only considered.

Mechanical Characterization of Composite Samples

Three composite specimens made from Alkali + Silane treated jute fabrics as reinforcement by 60:40 fibre volume fraction to matrix volume fraction and with five layers of jute fabrics have been tested and results are compared with that of aluminum alloy 1050 H14, which is a potential candidate for making ceiling fan blades.

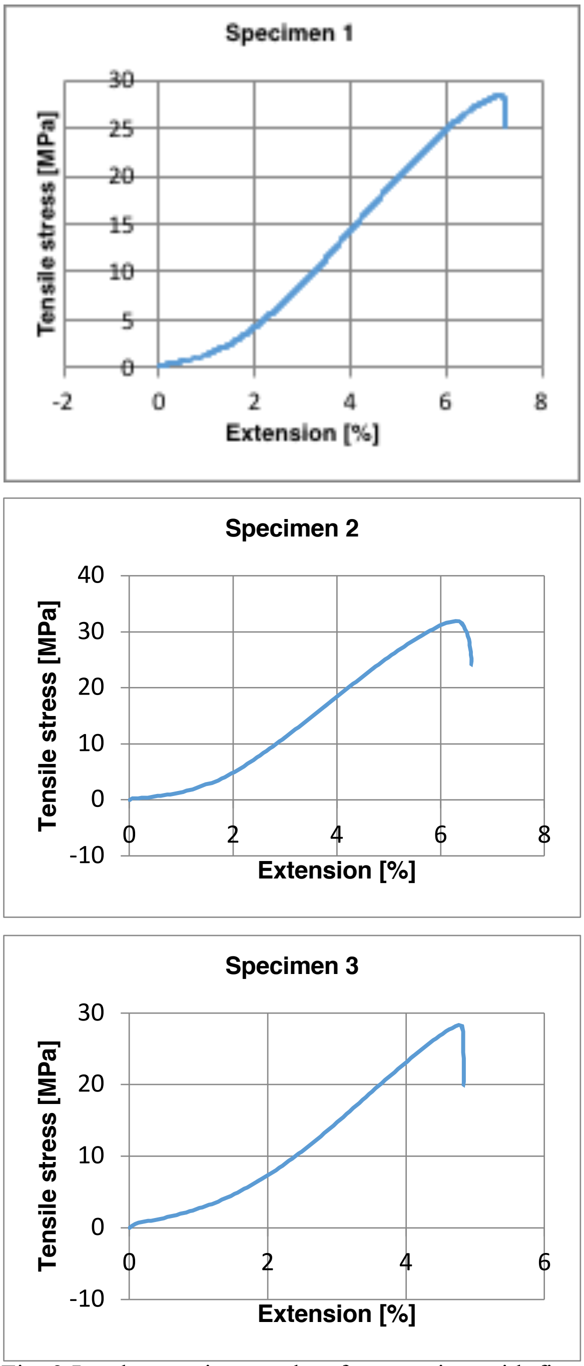


Fig. 2 Load-extension graphs of composites with five fabric layers (fibre volume fraction: 60%)

Another four samples of the composite having the same volume fractions but only increasing the number of fabric layers to ten have been tested and compared and below the data is shown in figure 3 and Table 3.

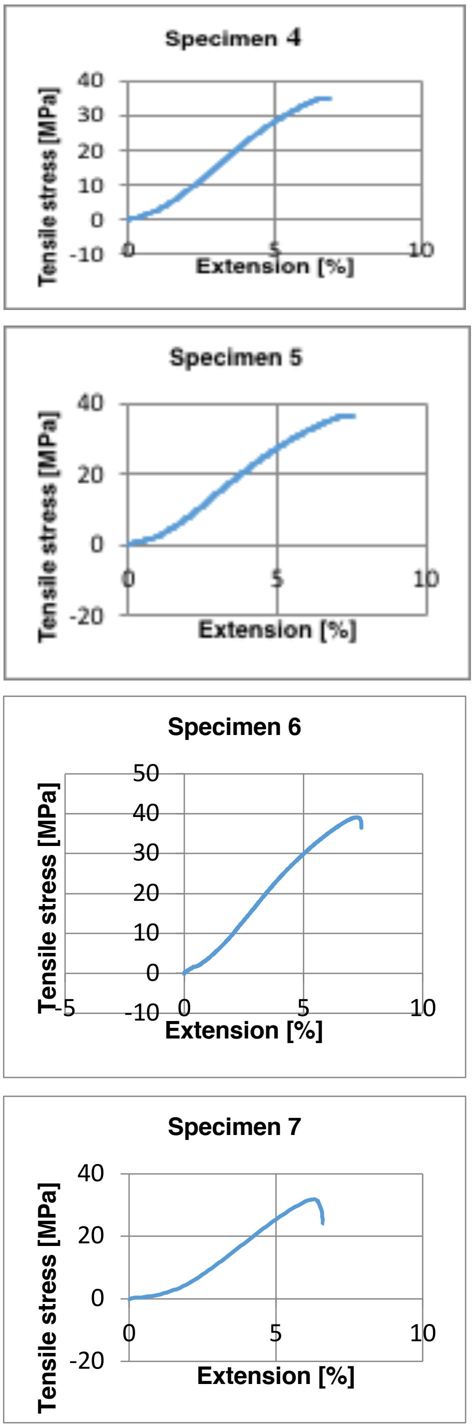


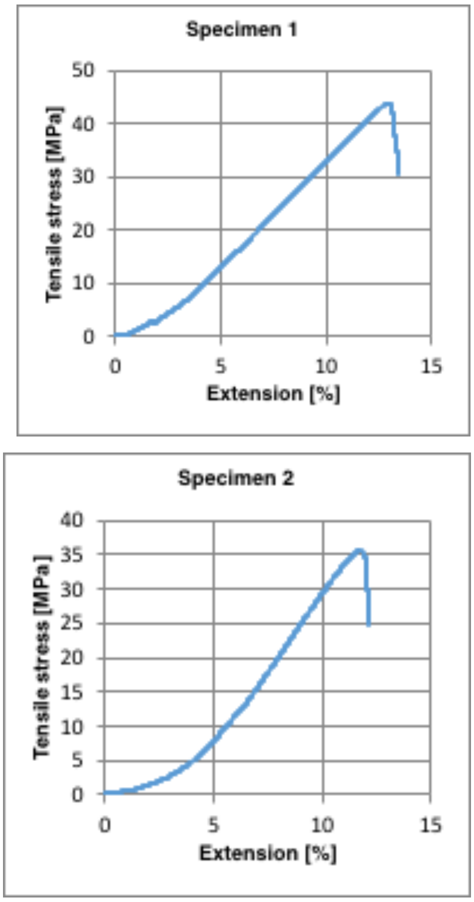
Fig. 3 Load-extension graphs of composites with ten fabric layers (fibre volume fraction: 60%)

Table 2 Tensile Properties of Aluminum Alloy 1050 H14

Material	ρ (g/cc)	E (GPa)	Tensile strength (MPa)
Aluminium Alloy 1050 H14	2 .8	52	105-145

Tensile Test of Composite Blades (70% Fibre Volume Fraction & sixteen fabric layers)

150 g weighing composite blade made from Alkali + Silane treated jute fabrics as reinforcement by 70:30 fibre volume fraction to matrix volume fraction and with sixteen layers of jute fabrics have been tested and results are compared with that of aluminium alloy 1050 H14, which is a potential candidate for making ceiling fan blades.



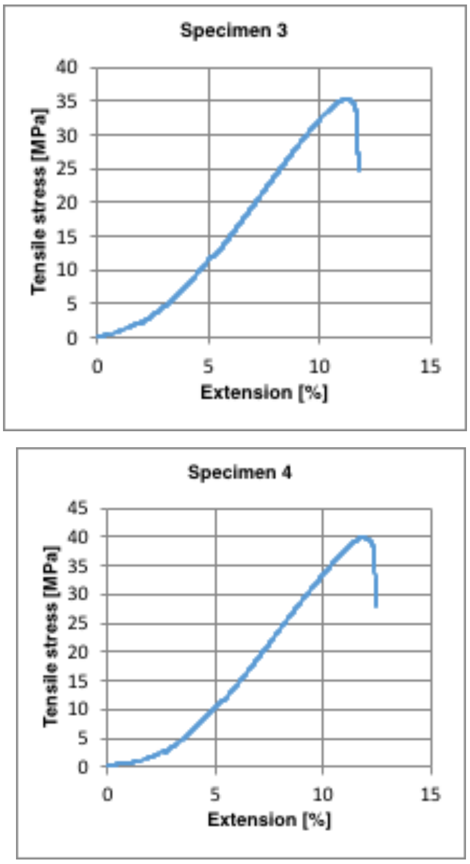
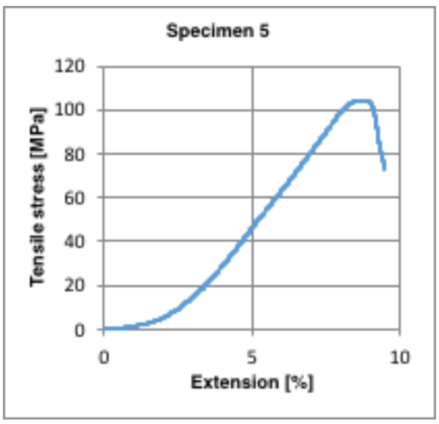


Fig. 4 Load-extension Graphs of composites with sixteen fabric layers (fibre volume fraction: 70%)

Tensile Test of Composites (50% Fibre volume fraction & twelve fabric layers)

150 g weighing composite blade made from Alkali + Silane treated jute fabrics as reinforcement by 50:50 fibre volume fraction to matrix volume fraction and with twelve layers of jute fabrics have been tested and results are compared with that of aluminum alloy 1050 H14, which is a potential candidate for making ceiling fan blades.



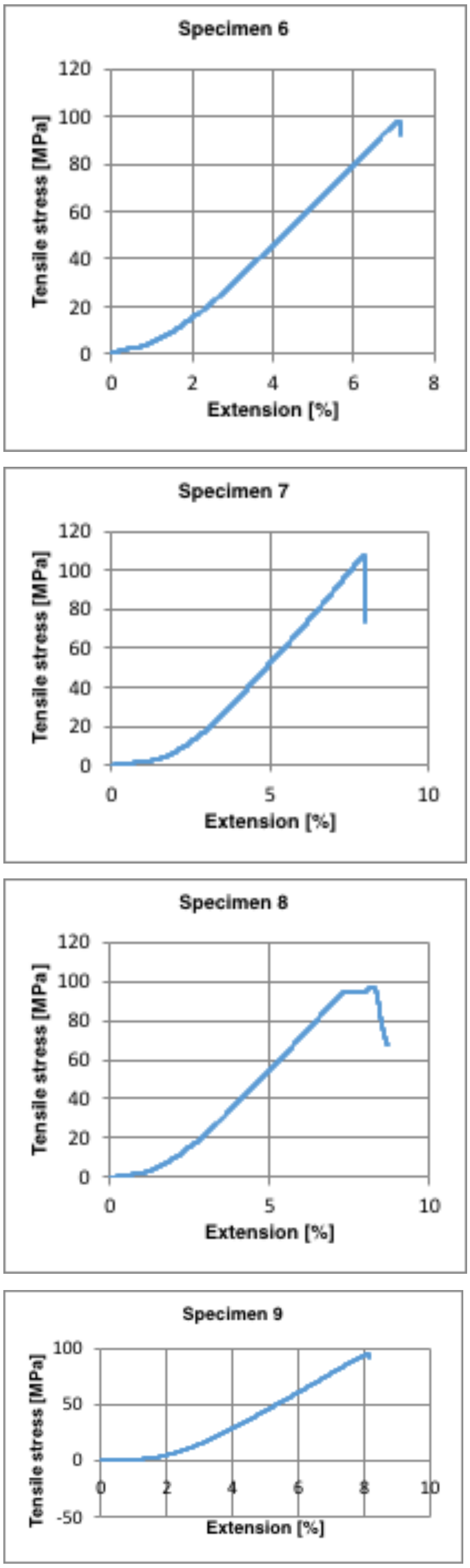
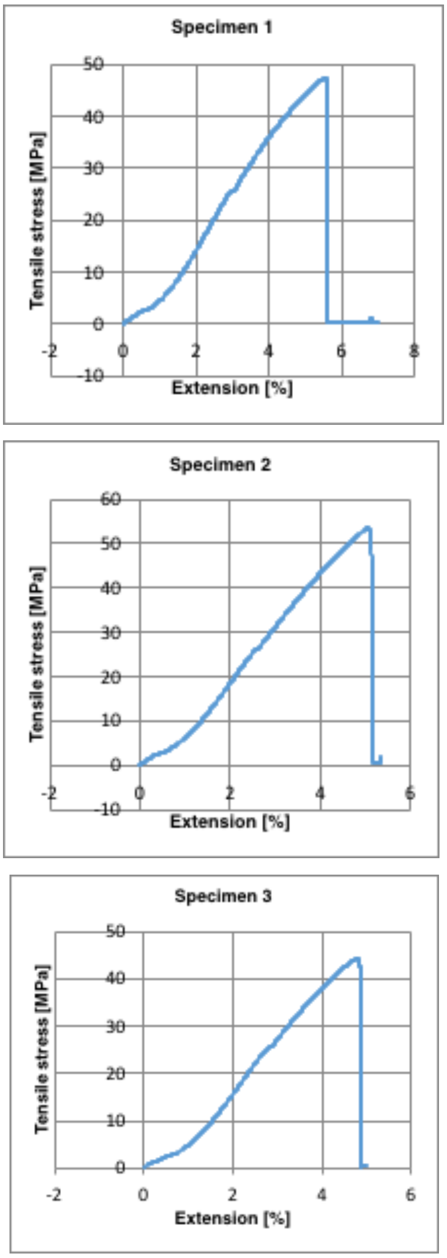


Fig. 5 Load-extension graphs of composites with twelve fabric layers (fibre volume fraction: 50%)

Tensile Test of Composites (50% Fibre Volume Fraction and Six Fabric layers)

75g weighing composite blade made from Alkali + Silane treated jute fabrics as reinforcement by 50:50 fibre volume fraction to matrix volume fraction and with six layers of jute fabrics have been tested and results are compared with that of aluminum alloy 1050 H14, which is a potential candidate for making ceiling fan blades.



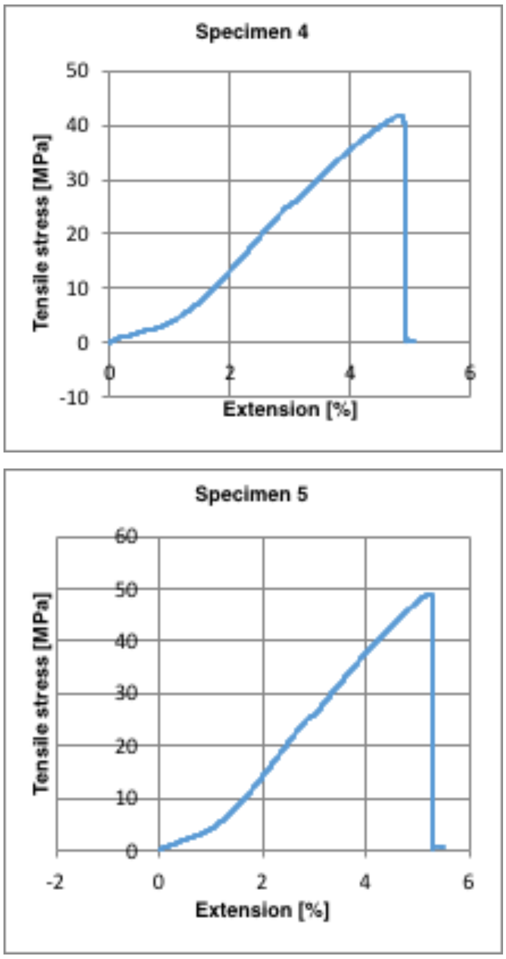


Fig. 6 Load-extension graphs of composites with six fabric layers (fibre volume fraction: 50%)

Referring from Table 3, tensile strength achieved for composite blades made with 50:50 fibre volume fraction weighing 150g is most comparable with the Aluminum alloy 1050 H14 but it is still heavier blade so composite blades made with 50:50 fibre volume fraction weighing 75g has been chosen as the composite blades because it is lightest one although it has a tensile strength value which is half of that of the aluminum alloy.

Table 3 Summary of comparisons of tensile strength of composites with Aluminum blade

S/No.	Material	Tensile strength (MPa)	Strain at failure (%)	Br. Load (N)
1	Composite blade with 60:40 fibre volume fraction	36.075	7.1	2167.5
2	Composite blade with 70:30 fibre volume fraction	38.7	12.4	3870
3	Composite blade with 50:50 fibre volume fraction weighing 150g	**99.12**	8.26	7929.6
4	Composite blade with 50:50 fibre volume fraction weighing 75g	**47.1**	5.1	1886
5	Aluminium Alloy 1050 H14	**105-145**	-	-

Short Beam Shear Strength Tests for Composite Blades Made with 50:50 Fibre Volume Fraction Weighing 75g

Short beam shear tests are often used to assess inter-laminar shear strength (ILSS) and to compare the effects of fiber surface treatment on the fiber matrix adhesion. A total of 9 composite specimens made from both treated (Alkali+Silane) and untreated jute fabrics having the same dimensions have been tested and results are also compared (referred to tables 4 & 5).

Table 4 Summary of short beam shear strength tests for Alkali+Silane treated jute fabric composites with six fabric layers (fibre volume fraction: 50%)

S/no.	Thickness, t (mm)	Width, w (mm)	Max. load, P_{max} (N)	Displacement (mm)	Short beam strength, F^{sbs} (MPa) $F^{sbs} = 0.75*(P_{max}/t*w)$
1	2	4	101.19	2.01	9.48
2	2	4	95.5	1.45	8.95
3	2	4	99.72	1.53	9.35
4	2	4	90.86	1.34	8.52
5	2	4	86.55	2.45	8.11
Average	**2**	**4**	**94.764**	**1.756**	**8.88**

Table 5 Summary of short beam shear strength tests for untreated jute fabric composites with six fabric layers (fibre volume fraction: 50%)

S/no.	Thickness, (mm)	Width, (mm)	Max. load, P_{max} (N)	Displacement (mm)	Short beam strength, F^{sbs} (MPa) $F^{sbs} = 0.75*(P_{max}/t*w)$
1	2	4	79.52	1.8	7.45
2	2	4	68.77	1.45	6.45
3	2	4	76.01	1.42	7.13
4	2	4	67.61	1.58	6.34
Average	**2**	**4**	**73**	**1.56**	**6.84**

So from the test results given in the tables (4&5) the composite specimens made with Alkali+Silane treated jute fabrics shows higher ILSS (inter-laminar shear strength) of 8.88 MPa and composite specimens made with untreated jute fabrics shows a lower value of 6.84MPa. A 23 % improvement on the shear strength is observed, because of the treatments.

So, based on the above stated mechanical characterizations of the different composite blades the one that shows the comparatively better properties and lightest one has been chosen and below in table 6 the weight and dimensions has been compared with the existing Usha fan blades

Table 6 Comparison of weights and dimensions of existing (Usha) fan and the composite blades made with 50:50 volume fractions

Weight of each blade (g)		**Width (in.)**		**Length (in.)**		**Thickness (mm)**	
Existing Usha fan	Composite blade	Existing (Usha fan)	Composite blade	Existing Usha fan	Composite blade	Existing (Usha fan)	Composite blade
250	**75**	**5**	**4**	**18.8**	**10**	**1**	**2**

C. Performance of the Composite Fan Blades

The following technical parameters have been assessed and compared:

- Air velocity in ft/min,
- Air delivery in cfm,
- Power in watt and
- Service value in cfm/watt

Table 7 Summary of air velocity (ft/min) and air delivery (cfm) at maximum speed for composite blades (with six fabric layers &fibre volume fraction: 50%)

Speed	**Air velocity (ft/min)**			**Air delivery (CFM)**			**Blade surface area (ft^2)**	
	Usha fan blades weighing 250g	**Composite blades weighing 75g**		**Usha fan blades weighing 250g**	**Composite blades weighing 75g**		**Usha fan blades weighing 250g**	**Composite blades weighing 75g**
		10.13^0	**12^0**		**10.13^0**	**12^0**		
5	**713**	**836**	**846**	**357**	**251**	**254**	**0.5**	**0.3**

Table 8 Comparisons of power consumption of Usha fan blade and the composite blade (with six fabric layers &fibre volume fraction of 50%)

Speeds	**Power consumption (Watt)**			**Average Power savings (Watt)**	**Average % age power reduction**
	Usha fan blades weighing 250g	**Composite blades weighing 75g**			
		10.13^0	12^0		
1	14.4	14	13.6	0.6	-
2	34.8	36	35.8	-	-
3	52.5	45.8	45.7	6.75	13
4	57.8	58	56.3	0.65	-
5	**77.8**	**60.6**	**63.7**	**15.65**	**20**

D. Monetary Savings:

As it is stated above (referring table 8), by using the composite blades there is a 15.65W power savings which is 0.01565Kw. Let in Delhi we use ceiling fans for 8 months per year for 12 hours a day. That is the fan will be on 12 hours a day for 240 days.

So the energy savings will be calculated as:

0.01565Kw *12hr * 240 days

=45.072 KWh/fan/year

For domestic use the electricity tariff in Delhi is about 4Rs/KWh. So, 180.3 Rs/fan/yearwill be saved.

Population of Delhi is around 20,000,000. Assuming that one family has four members, we have about 5,000,000 families. But from these families, those that can afford to buy ceiling fans be around 70 %. Then, the number of families who can afford to buy a ceiling fan is 3.5 million. Let, to the minimum 1 family has only 1 fan in home, so we are going to have a minimum of 3.5 million ceiling fans in Delhi.

So the monetary savings will be calculated as;

180.3Rs*3,500,000= 630 million Rupees or 63 crore Rupees savings per annum will be there.

Table 9 Comparisons of service value (cfm/watt) of Usha fan blade and the composite blade (with six fabric layers &fibre volume fraction of 50%) at maximum speed

Speed	**Service value (cfm/watt)**		
	Usha fan blades weighing 250g	**Composite blades weighing 75g**	
		10.13^0	**12^0**
5	**4.58**	**4.14**	**4**

So from the table (Table 9), service values for the composite blades are a little bit lower than the Usha fan blades due to the lower air delivery values of the composite blades that are because of the lower surface area of the blades.

E. Cost Analysis:

The composite blades are made with 50:50 fibre volume fractions, so the Wfibre = 53 &Wmatrix = 47. To produce composite blades weighing 75 g the following amounts of fabrics and matrix will be needed:

0.53*75g=40 g of fabric and 0.47*75g=35 g of matrix

1 layer of jute fabric having dimensions of 10*25 cm2 or 250 cm2 weighs about 6.6 g so 40 g of fabric will come about 6 layers. So to produce a blade with the stated dimensions and weight we need to have about 6 jute fabric layers.

Raw material cost

Jute fabric

1m2 jute fabric costs about 150Rs and the composite blades have dimensions of 10*25 cm2 or 250 cm2. So,

10,000cm2 = 150Rs

250cm2 = 3.75Rs (1 layer) so for 6 layers it will be 22.5Rs.

PLA matrix

1 kg of the matrix costs about 400Rs, but to produce a blade we need to have 35 g of it so the cost will be 14Rs.

Chemicals cost

NaOH

5 % of 40 g =2 g of it is needed,

5kg NaOH= 1405Rs

2 g= 0.562Rs

HCl

1 % of 40 g = 0.4 ml of it is needed,

500 ml= 100Rs

0.4 ml=0.08Rs.

Aminopropyltrimethoxysilane

0.5 % of 40 g= 0.2 g of it is needed,

500 g= 12,150Rs

0.2 g= 4.86Rs

Acetone

1 % of 40 g= 0.4 ml of it is needed,

2.5 L = 846Rs

0.4 ml= 0.14Rs

Araldite epoxy

About 6 g of it is needed to bond one composite blade with the metal plate,

180 g= 250Rs

6 g = 8.33Rs

Manufacturing cost

Motor power of moulding machine: 3000 W.

Let's convert this number to kilowatts by dividing by 1000, to get 3 kW.

To produce one blade 8 minutes is needed,

Let's convert 8 minutes, into hours by dividing by 60, so 8 minutes is 0.133333 hrs.

The moulding machine that has been on for 0.133333 hours, have consumed

3 kW*0.133333 hours = 0.4 KWh of energy.

For non-domestic use the electricity tariff in Delhi is 5Rs / KWh,

Finally, since energy costs 5.00Rs/kW-hr, the device will cost:

0.4 KWh*5Rs/KWh = Rs. 2

So, total cost = raw material cost + chemicals cost + manufacturing costs

= (22.5+14+0.562+0.08+4.86+0.14+8.33+2) Rs

Total cost = Rs. 52.5 per blade

So one composite blade costs about 52.5 rupees which is lower as compared with the price of one aluminum blade which costs about 100 to 150Rs.

V.CONCLUSION

For the production of jute fabric reinforced PLA composite, chemical modifications of the fabrics were carried out as, alkalization, acetylation, silane and maleic anhydride treatments. The differently treated fabrics have been characterized. Jute fabrics treated with 5 % alkali followed by 0.5 % Silane treatment shows the highest tensile strength, young's modulus, specific tensile strength and specific young's modulus followed by fabrics treated with 5 % alkali only. The untreated jute fabrics show lesser tensile strength and young's modulus. 5 % Alkali treated+ Acetic acid treated with an MLR of 1:20 shows the poorest tensile strength and 5 % Alkali treated+1 % Maleic anhydride treated fabrics shows the poorest young's modulus. From the breaking strength-elongation graph it is observed that the elongation at break percentage is found to be much highest in 5 % Alkali+1% Maleic anhydride and 5 % Alkali + Acetic acid treated with an MLR of 1:20 treated fabrics. This is because these two differently treated fabrics exhibits lower tensile strength values and when the fabric is breaking the constituent fibres slips rather than catastrophic failure which of course contribute for the load sharing. Besides the changes in the mechanical properties, Colour changes have also been observed after chemical treatments. The Alkali treated fabric gets darkened, Acetylated and maleic anhydride treated jute fabrics gets brightened/faded because of further purification on the removal of hemicelluloses, lignin and cellulosic components from the fibre after alkali treatment and that of Silane treated jute fabric colour gets into dark golden.

So, composite blades were prepared from jute fabrics treated with Alkali+Silane on a compression molding machine at a temperature of 1900c, with a pressure of 15 bars for 8 minutes followed by air cooling at room temperature. The composite blades were prepared at three different fibre volume fractions; 50:50, 60:40 and 70:30. The samples were tested for tensile-and shear-strength as per ASTM standards and also compared with the existing aluminum blade, Aluminum Alloy 1050 H14.The composites which showed better and comparable mechanical properties have been chosen as the blades. Composite blades with 50:50 fibre volume fractions and having a weight of 75g and a thickness of 2mm was found to be the lightest and showed a tensile strength of 47.1 MPa (referring to Table 3 and fig. 6), which is half of the value of the aluminum alloy and having an ILSS (Inter-laminar shear strength) value of 8.88MPa (referred in Table 4) has been chosen as the composite blades. By performing surface modifications of the jute fabric, the ILSS value has been increased from 6.84MPa to 8.88MPa which is 23% increment on the shear strength.

The composite blades are made with average pitch angles of 10.130 and 120. The performance parameters have been tested and compared with Usha ceiling fans. An air velocity of 836 and 846 ft/min and an air delivery of 251 and 254 CFM were achieved for the composite blades with the pitch angles of 10.130 and 120 respectively (referring to Table 7). From the results it can be seen that the air velocity of composite blades is higher than Usha ceiling fans which has 713 ft/min but due to the reduced surface area of the composite blades i.e .0.3ft2, the air delivery is lower than Usha fans which is 357 CFM having a higher blade surface area of 0.5ft2.

An average power savings of 15.65Watt has been achieved with the use of the composite blades while operating at the maximum speed of 5 (referred in Table 8), which is about 20% power reduction and due to this a minimum of 630 million Rupees or 63 crore rupees per annum can be saved if we use the blades in Delhi only.

The total cost to produce one composite blade is calculated to be 52.5Rs, which is lower as compared with the price of one aluminum blade which costs about 100 to 150 Rs.

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