Since - 1940

Open Access Journal
DOI No. https://doi.org/10.17605

ISSN 0368-4636
e-ISSN 2347-2537

Journal of the TEXTILE Association

VOL. 83 NO. 5 January-February, 2023

PACE

Professional Aftermarket Care for Excellence

- Technological Components
- Technological Parts
- PEKs
- Repair Services
- Customer Portal

LMW
Periyanaickenpalayam, Coimbatore - 641020, Tamil Nadu, India.
Website: https://www.lmwtmd.com/ | **Email:** info@lmwtmd.com | **Phone:** +91 73977 65924, 1800 212 3636


Higher productivity.
Better quality. Meet
the TCO 21!


FREECULTR
Premium Innerwear & Loungewear
- Made with sustainable fabric blends -
For Men & Women
-Featuring-
BreatheTech™
Visit Now - www.freecultr.com

since 1879

BOMBAY DYEING

(POLYESTER DIVISION)

AWARDED ASIA'S MOST TRUSTED COMPANY AWARD '2018


Certificate

2018

THE BOMBAY DYEING & MFG. CO. LTD.

Has Been Awarded

ASIA'S MOST TRUSTED COMPANY 2018

Awarded by:

IBC InfoMedia Pvt. Ltd.

INTERNATIONAL BRAND CONSULTING CORPORATION, USA

OEKO-TEX®

CONFIDENCE IN TEXTILES

STANDARD 100

08.JA.59644 HOHENSTEIN HTTI

Tested for harmful substances.

www.oeko-tex.com/standard100

PSF products are compliant to
ISO 9001:2015,
ISO 14001:2015,
BS OHSAS 18001:2007,
OEKO-TEX (Class-1) and
REACH pre-registered

OUR PSF PRODUCTS ARE MADE OF 100% VIRGIN POLYMER

- SUPER MICRO FIBRE
- SPUNLACE (SD & BLK)
- SUPER FIBRE
- LOW SHRINKAGE
- HIGH TENACITY
- SLICK
- SUPER HIGH TENACITY
- ANTIMICROBIAL
- OPTICAL WHITE (OPW)
- FLAME RETARDANT
- DOPE DYED BLACK
- JET BLACK
- HYGIENE
- TRILOBAL (SD & BLK)

~1736~
THE WADIA GROUP

Britannia	Bombay Burmah	NPL	Bombay Realty	Home & You	Go Air
SINCE 1918	SINCE 1863	SINCE 1954	SINCE 2011	SINCE 2015	SINCE 2005

THE BOMBAY DYEING & MFG. CO. LTD.
(POLYESTER DIVISION)
C-1, Wadia International Center, Pandurang Budhakar Marg, Worli, Mumbai 400 025, Maharashtra, INDIA.
Tel. +91 (022) 6662 0000 Extn. : 93055/93066 Fax : +91 (022) 6662 0004

SANJEEVANI
KAYA SHODHAN SANSTHAN, GOHANA
संजीवनी
काया शोधन संस्थान
A Unit of Swami Satyanand Charitable Trust
Naturopathy and Ayurveda Centre
प्राकृतिक चिकित्सा | आयुर्वेद | योग
TREATMENTS AVAILABLE AT SANJEEVANI
Naturopathy / प्राकृतिक चिकित्सा
Ayurveda / आयुर्वेद
Diet / आहार
Yoga / योग
Physiotherapy / भौतिक चिकित्सा
Panchkarma / पंचकर्म चिकित्सा
Meditation / ध्यान
Acupressure / एक्यूप्रेशर
Acupuncture / एक्यूपंक्चर
Mud therapy / मिट्टी चिकित्सा
Colon therapy / कोलन थेरेपी
Facilities Available
Organic Herbal Shopee
Beauty Parlour
Physiotherapy
Fitness Center
Badminton
Pathology Lab
Bicycles
Wi-fi
Swimming Pool
Table Tennis
Laundry
Book Your Stay Now!
BOOK BY QR CODE
info@sanjeevaniindia.org
www.sanjeevanikayashodhan.com
Near Shri Ram Sharnam Ashram, Jind Road, Gohana, Haryana
01263298004 | +919467700895 | +918607000895 | +918059800895

Printed at : S S Enterprises, Mumbai
Published by: Pavitra Publisher, Pune

JTA Abstracted by
Chemical Abstracts - USA | World Textile Abstracts-UK
Science Abstracts - India | Elsevier, Scopus-Netherland

Journal of the TEXTILE Association
TEXTILE SCIENCE | TECHNOLOGY | ENGINEERING | MANAGEMENT
ISSN 0368-4636
e-ISSN 2347-2537
JAN-FEB. 2023 VOLUME 83 NO. 5

CONTENTS

THE TEXTILE ASSOCIATION (INDIA)
702, Santosh Apartment, 7th Floor, Plot No.72-A, Dr. M. B. Raut Road, Shivaji Park, Dadar (West), Mumbai - 400 028
Tel.: 022-2446 1145 • E-mail: taicnt@gmail.com • Website: www.textileassociationindia.org

Indian Budget 2023 - Textile Industry Growth

Allocation of Rs. 4389.34Crores for Textile Ministry triggers the growth of textile industry and huge employment creations. Major focus of budget is the allocation of funds under AUTF as Rs. 900crores for the amended technology up-gradation of textile industry as compare to Rs. 600 crores in 2022 budget. PM – MITRA allocation fund is Rs. 200 to provide adequate facilities for skill Development of Textiles workers. Second largest fucus has been given to the national technical textile research and development as Rs. 450 Croes which will stand INDIA in technical textile export and reduction of import of it and the huge opportunity for technical textile industry growth. Budget priority is given to the extra long cotton crop yield by adopting a cluster-based approach with a public private partnership model using advanced technologies which can promote export of cotton yarn and manufacturing of value added garments.

Major allocation of budget is found for the upgradation, development of silk industry of huge amount as Rs 917.77 crores is the new area for the development and export of silk.

Jute industry also will also find the good scope as per allocation of funds. Emphasis has given for the handloom development and national handicraft development programme as Rs. 438 crores which will enhance our nation traditional cloth development area and employment generation. Textile cluster development scheme will help for the development of MSME textile industry also will promote the Atmanirbhar Bharat concept.

RoDTEP Scheme has been increased from Rs. 13,699 crore in 2022-23 to Rs.15,069 crore in 2023-24. Increase in import duty for textile machinery to 7.5% to encourage domestic manufacturing. (This might impact the industry adversely in near term as nearly 60% of machinery requirement is met through imports. This will increase the industry's need for more capital).

Dr. D. V. Raisinghani
Hon. Editor, JTA

Mr. R. K. Vij, President - TAI

Global Growth & the World Economics

I, as the President of The Textile Association (India), am delighted to see an august gathering at this prestigious event World Textile Conference-3 being organised in Ahmedabad, on a much larger scale and in a much broader format than our regular Annual Conferences.

The aim of the Conference is to provide an interactive opportunity, and to create a very positive atmosphere where the entire textile fraternity can take benefit by discussing, meeting and knowing each other and enhance our cumulative strength.

Under the leadership of our respected Prime Minister the time is not very far when India will become a manufacturing hub of textiles. Today the country is progressing at a very fast speed in all fields of textiles from raw materials to garments.

It is all due to favourable Govt. policies like PLI (Production Linked Incentive scheme), increasing textile export by different trade agreements, removing barriers for Indian professionals and securing imports of essential basic raw materials at international prices for manufacturing growth. New trade agreements have been signed with Australia, UAE.

Now, India is also one of the world's top nations in manufacturing and trading. Multinational Companies are selecting India as a manufacturing destination in line with China plus one global strategy.

India has signed 13 free trade agreements with countries such as Japan, Australia, United Arab Emirates, South Korea, Singapore, Thailand & Malaysia and is negotiating with the UK, UE and New Zealand. India might bring in $475 Billion in FDI over the next five years.

There are 4 strong areas where we should work together with Global Business. in the coming days.

1. After Covid pandemic, India emerged as a reliable source of Global Supply Chain. Global business Countries must consider incorporating India into their trade. All Indian States now are very eager to bring industries in their States by giving additional incentives.
2. Indian Industry is fully committed to meet the Global Partnership in the areas like, sustainable mobilizing, and the climate finance and for Green Infrastructure. It is to increase the share of renewable energy and use of electrical vehicles.
3. Research and Development, Innovation and Digitalization are a National priority of the future. We have to build a robust eco-system of research, innovation and technology in our country.
4. The Government is making huge investments in creating a world class transport and communication infrastructure. This will reduce overhead costs, access to International markets and higher customer retention.

We should look forward to partner with the world for finding solutions to meet global challenges and developing a better shared future. We must continue to invest in developing highly skilled, creative entrepreneurial, compassionate talent and more sustainable products and services in the new society.

All these will lead to better profits and higher employment.

"Earlier we were looking at the world, but now the world is looking at us".

Application of Multi-Criteria Decision Making (MCDM) Technique for Studying Tensile Properties of Himalayan Nettle Fibre

Sambaditya Raj*

Associate Professor& Head, Amity School of Fashion Technology, Amity University, Rajasthan

Abstract:

Natural fibres possess specific traits but some of these fibres are not capable to convert into yarn and thus developed into fabrics. The characteristics of fibres determine the spinning performance, the appropriate and suitable method of spinning and its blending possibilities with other fibres. Through this study the researcher has attempted to conduct various experiments and characterise the properties of Himalayan origin fibres like nettle, hemp, sisal and local wool as well as to study the spinnability of the locally available fibres and characteristics of fabrics woven in order to assess suitability in making apparels. Experiments resulted that Sisal was not found to be suitable, so it was discarded from the present study. Himalayan Nettle fibre along with Hemp and Local Wool was successfully converted into pure and blended yarn. In the present study, an attempt has been made to characterise the properties of those fibres and based on these, selection of fibres is made in a very judicious way to work with. The Multi-Criteria-Decision-Making (MCDM) approach was applied to select fibres among several alternatives, for the purpose of making yarn. Spinning of Nettle and Wool fibres into yarns were done through hand spinning system and also examining their characteristics with emphasis on tensile properties was the main concern. Attempt has also been made to weave fabrics out of yarns, so produced, and to study the characteristics of the fabrics woven in order to assess their suitability in making apparels.

Keywords: *Himalayan Nettle Fibre, Spinnability, Uttarakhand, Wool, Yarn*

Citation: Sambaditya Raj, "Application of Multi-Criteria Decision Making (MCDM) Technique for Studying Tensile Properties of Himalayan Nettle Fibre ", *Journal of the Textile Association*, **83/5** (288-293), (Jan-Feb'2023), https://doi.org/10.56716/4/1455

Article Received:25-10-2022, Revised: 07-12-2022, Accepted: 22-11-2022

1. Introduction

Many fibres are available in nature possessing some indigenous characteristics. Each of these fibres is not capable of being converted into yarn and subsequently into fabrics. Even if the fibres are converted into yarn those may not be useful in making apparel textiles. The characteristics of the fibres determine the spinning performance, the right and suitable method of spinning, its blending possibilities with other fibres. The properties of the yarn produced subsequently determine the behaviour of the fabrics woven out of these yarns [1, 2].

It has always become the topic of interest for the researchers to assess the spinnability of different fibres available from nature. The objective being sustainability, effective use of some fibres is particularly done when it is wild in nature. Moreover, the success lies in livelihood improvement of the people connecting with these fibres directly or indirectly. Nettle, sisal, hemp and locally available wool are some of the natural fibres available from Uttarakhand of the Himalayan region. Almora and Chamoli districts in Uttarakhand are very rich in producing Nettle fibre (Girardinia Diversifolia) [3, 4].

For promoting sustainable livelihood among rural women artisans, the researcher also conducted trainings for them. Wool being the main fibre available and therefore the main activity is also in the area of hand knit products and handwoven products. The basic raw material is got from Ludhiana because the local wool is not suitable for finer product and is only suitable for coarser product like carpet etc. As such the livelihood options are limited to woven skills and knitting skills workers and few axillary workers. The main areas of wool spinning and softening (processing) are left out.

In the present work an attempt has been made to characterise the properties of those fibres and based on these, selection of fibres is made in a very judicious way to work with. Spinning into yarns of Nettle, Ramie and Wool fibres in hand spinning system were done and to study their characteristics, emphasizing on tensile properties is the main concern. Attempt has also been made to weave fabrics out of yarns so produced and to study the characteristics of the fabrics woven in order to assess suitability in making apparels.

2. Experimental

2.1 Materials Used

Nettle fibre along with other three fibres namely Sisal, Hemp and local Wool, as detailed in Table1, have been used to conduct the present study. Nettle and Hemp fibres were collected from Uttarakhand Bamboo and Fibre Board, Dehradun; Sisal fibre was sourced from an NGO named Women's Development Organization, Dehradun and Himalayan Wool fibre was collected from another NGO, Chirag, Nainital. All the fibres were sourced from raw fibre stages.

**** Corresponding Author:***

Dr. Sambaditya Raj

Associate Professor & Head,Amity School of Fashion Technology, Amity University Rajasthan,Kant Kalwar, NH11C, RIICO Industrial Area, Rajasthan – 303 002

E-mail: rajsambo2008@gmail.com, rajsambo2000@yahoo.co.in

Table 1: Materials Used

Type of fibres	Source	length (mm)	Fineness (den)
Nettle	Uttarakhand Bamboo and Fibre Board, Dehradun	50.8 mm	17.08
Sisal	Dr. K. K. Sharma, Women's Development Organization, Dehradun	63.5 mm	57.79
Hemp	Uttarakhand Bamboo and Fibre Board, Dehradun	50.8 mm	17.96
Local Wool	Chirag Village: Simayal, P.O. Nathuwakhan, Nainital, Uttarakhand	50.8 mm	8.78

Source: Primary Data

3. Test Methodology for Fibres

a. Microscopic view of Fibres

Both cross sectional and longitudinal view of Nettle and other fibres under study have been taken with the help of Paramount Digital Projection (digivision) Prime Excel Microscope. Five numbers of snaps were taken and two of the most visible, clear one has been captured in each case. The diameter for each fibre has been measured using digivision software and recorded.

b. Measurement of tensile properties of fibres

Tensile characteristics of all the fibres were studied following standard test method; ASTM D 3822-01 [5] using 'Instron tensile testing machine', Model 3366, at a strain rate of 20 mm/min. The gauge length was kept at 20 mm and tension weight used was 3000 mg for all the samples. Before conducting the tests, proper jaw was selected and to avoid its slippage each fibre was initially mounted on a paper window and fixed first by an adhesive liquid, melamine formaldehyde and then by an adhesive tape. After mounting the paper window along with the fibre specimen between the two jaws of Instron, the two sides of the window were cut by a pair of scissors. A minimum of 50 tests were conducted for each sample and the average was taken.

c. Measurement of fibre fineness

Fibre fineness of Nettle and other fibres under study have been measured following standard test method ASTM D – 1577:2007. 50 tests were conducted and the average was taken [6].

4. Test Results and Discussion on Fibre Properties

The microscopic views of Nettle, Sisal, Hemp and Himalayan Wool fibre under this study are given in the figures 1 to 4.

Figures 1 to 4: Microscopic views of Nettle, Sisal, Hemp & Himalayan Wool Fibre

NETTLE

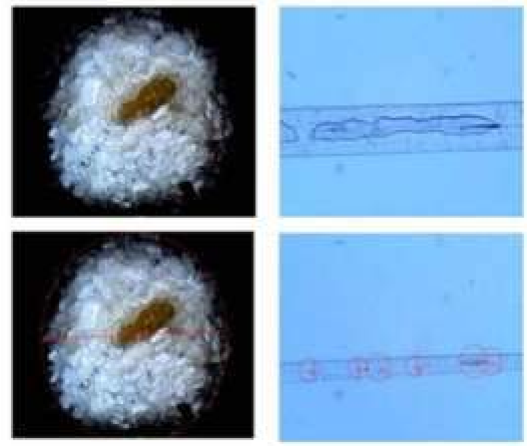


Figure 1

(a) – Cross section view of Nettle Fibre ***(b) - Longitudinal view of Nettle Fibre***

Sisal

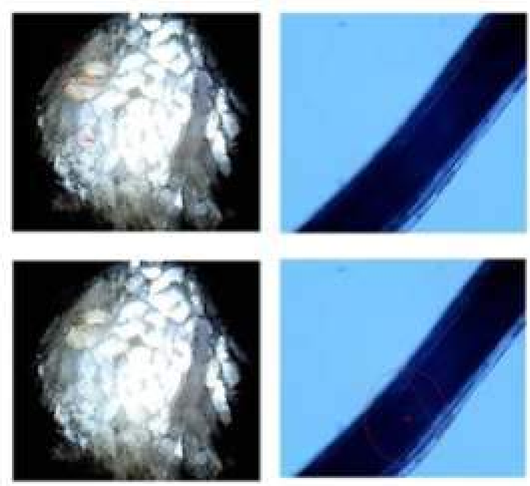


Figure 2

(a) – Cross section view of Sisal Fibre ***(b) - Longitudinal view of Sisal Fibre***

Hemp

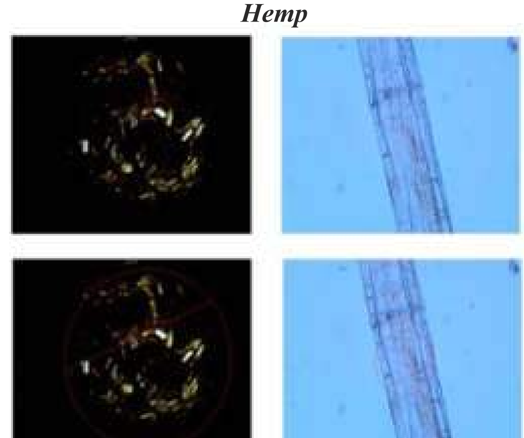


Figure 3

(a) – Cross section view of Hemp Fibre ***(b) - Longitudinal view of HempFibre***

HIMALAYAN WOOL FIBRE

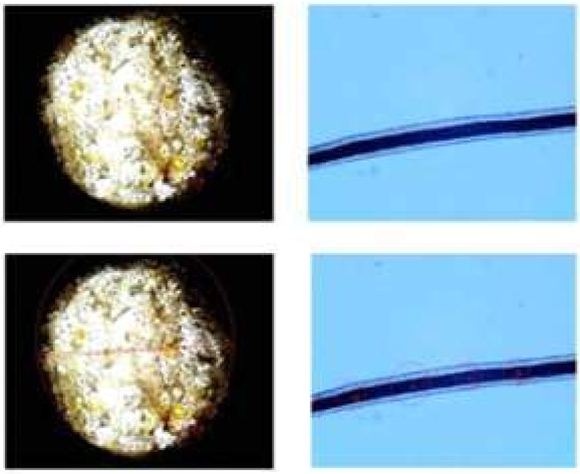


Figure 4
(a) – Cross section view of Local Wool Fibre *(b) – Longitudinal view of Local Wool Fibre*

It is clear from the microscopic views of Nettle fibre that it possesses a hollow core. The longitudinal view also confirms this. This unique feature of the fibre offers immense possibilities if fabric is made with this fibre. That fabric may find its application in warmth giving apparels since the hollow space provides accumulation of air which acts as a bad conductor of heat. On the other hand, when the hollow space provides accumulation of moisture, it provides comforts to wearer during summer. Therefore, the very distinguishing characteristics in the morphology of Nettle fibre have explored its possibilities to be used for making yarns and apparel in turn. Not much remarkable features in the morphological structure I was noticed in the case of Sisal and Hemp fibres, except that Sisal is having a rough surface as evidenced from its cross-sectional view which can provide better frictional resistance. Local wool showed surface having scale like any other kind of wool sourced otherwise. This causes a very well-known effect of 'Directional Friction Effect' (DFE). Blending of Nettle fibre with locally available wool were thought of as an option to work with. The measured diameter of all the fibres is given in Table 2 [7, 8, 9].

Table 2: Diameter of fibres

Parameter	Nettle	Sisal	Hemp	Wool
Diameter (micron)	5.118	9.740	7.407	4.510

Source: Primary Data

Results obtained from the tensile testing of the four fibres are given in Table 3. Tenacity, Breaking extension (%) and Initial modulus were thought to be very important properties for the use of fibres in textiles. Therefore, the obtained results of those properties are considered. The representative stress-strain curve of all those fibres have also been obtained and given in figures 5.1 to 6 [9, 10].

Table 3: Tenacity, Breaking extension (%) and Initial modulus

Name of the Fibres	Source	Staple length (mm)	Tenacity (g/den)	Breaking extension (%)	Initial modulus (g/den)
Nettle	Uttarakhand Bamboo and Fibre Board, Dehradun	50.8	2.73 (26.12)	2.39 (32.58)	75.15 (38.96)
Sisal	Dr. K. K. Sharma, Women's Development Organization, Dehradun	63.5	6.27 (27.79)	3.81 (25.88)	224.23 (33.73)
Hemp	Uttarakhand Bamboo and Fibre Board, Dehradun	50.8	6.03 (20.91)	4.04 (32.22)	17.28 (45.49)
Local Wool	Chirag, Village: Simayal, P.O. Nathuwakhan, Nainital, Uttarakhand	50.8	5.86 (22.88)	5.61 (26.48)	30.00 (18.40)

Note: Values within bracket shows the corresponding C.V%

It is observed from Table 3 that, the tenacity of Sisal fibre is highest (6.27 g/den) followed by Hemp (6.03 g/den), local Wool (5.86 g/den) and Nettle (2.73 g/den). This clearly tells that Sisal is being the strongest and Nettle being the weakest among four. The very crystalline nature of the Sisal fibre as evidenced from its remarkably highest Initial Modulus value (224.23 g/den) is considered to be the reason behind it. Although the Sisal fibre possesses the highest strength, still its suitability in making yarn out of this fibre is not acceptable particularly for apparel because it is very stiff in nature owing to very high modulus value. On the other hand, local wool possesses all favourable tensile properties in terms of good tenacity of 5.86 g/den and breaking elongation of 5.61%. Moreover, it has lowest initial modulus value, which means that it is not rigid & stiff. About two unconventional fibres Nettle and Hemp, it can be said that Hemp has a good tenacity in fact more than Wool and breaking extension less than wool. It is also not stiff enough as its initial modulus is lesser than wool. Nettle has a moderate tenacity, lowest extension and medium initial modulus value although it has recorded to have hollow core, considered to be an excellent property. C.V% in for all the parameters is towards higher side because all the fibres are natural [7, 11, 12, 13].

Therefore, apart from the properties of wool which has already established its position in textile manufacturing, other fibres like nettle, sisal and hemp do not exhibit all favourable tensile characteristics singly. Higher value of tenacity & extension and lower value of initial modulus are always desirable in textile usage. So far as the cost of raw material is concerned, its lower value is always acceptable. Here the characteristics are very much conflicting in nature for the fibres under study. Under this complex situation a suitable method is very much needed in order to select the fibres based on their suitability. their suitability [14, 15, 16].

Figures 5.1 to 5.4: Representative stress strain curves of Nettle, Sisal, Hemp & Local Wool Fibres

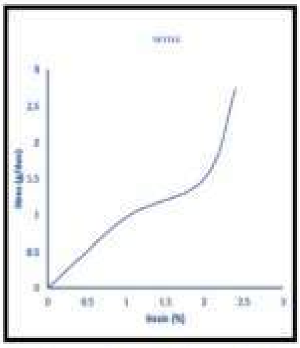


Fig.5.1: Representative stress-strain curve of Nettle

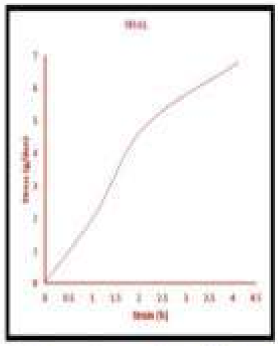


Fig.5.2: Representative stress-strain curve of Sisal

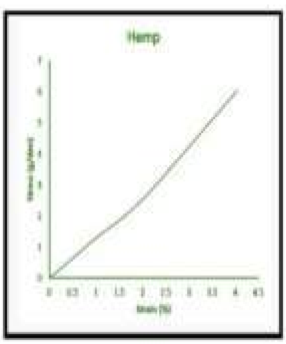


Fig.5.3: Representative stress-strain curve of Hemp

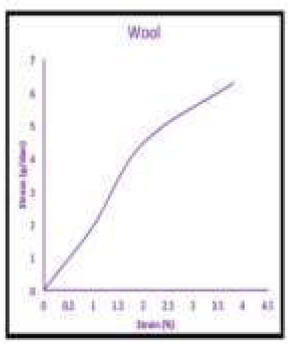


Fig.5.4: Representative stress-straincurve of Local Wool

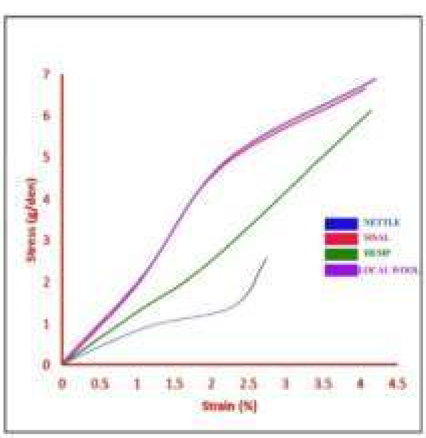


Fig. 6: Stress-strain curve of all fibres

Results obtained from the measurement of fibre fineness (denier) are given in Table 4. The results reveal that fineness is lowest for local wool followed by Nettle and Hemp. The fineness of Nettle and Hemp is almost same proving good compatibility in blending in that respect. The fineness of Sisal fibre is highest (57.79 den) and is more than 300% in comparison to Nettle and Hemp fibre. This value of fineness not in favour of giving yarn meant for apparel textiles. It can find some application in technical textiles. Therefore, in the context of fineness value of the fibres, acceptance of Local Wool, Nettle and Hemp fibre can be thought as potential raw material to produce yarn [15].

Table 4: Fineness (den) of fibres

Name of the Fibres	Linear density (den)
Nettle	17.08 (12.26)
Sisal	57.79 (15.44)
Hemp	17.96 (26.28)
Local Wool	8.78 (9.86)

Note: Values within bracket shows the corresponding C.V%

4.1 Material Selection (Selection of Fibres) through Multi Criteria Decision Making (MCDM) Technique

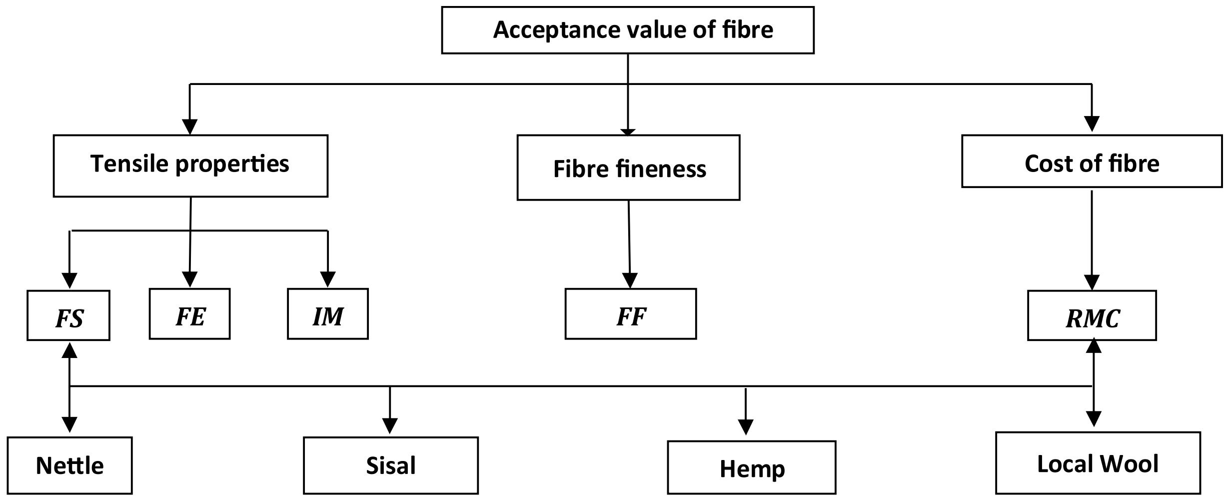
The selection of fibres among several alternatives, for the purpose of making yarn can be made through Multi-Criteria-Decision-Making (MCDM) approaches of operation research. As the properties of the yarn produced are directly dependent upon the properties of its constituent fibres, selection of fibres for manufacturing the yarns in scientific and judicious way is a matter of importance. Acceptance of a fibre for manufacturing yarns is generally done by its tenacity, elongation, initial modulus, fibre fineness and cost among many fibre parameters. In the present study, interest lies on selecting the optimal alternatives, here it is fibres among Nettle, Sisal, Hemp and Local wool. According to their preferential ranks under the presence of above-mentioned criteria using a multiplicative analytic hierarchy process (multiplicative AHP) of the MCDM method, best possible fibres have been taken to work with [17].

4.2 Hierarchy formulation for multiplicative AHP

The goal or objective of the present investigation is to determine the acceptance value of fibres among Nettle, Sisal, Hemp and Local wool for manufacturing yarns which can give fabrics in later stage meant for apparel use. So, the fibre properties criteria of this problem can be classified under three headings, namely tensile characteristics, fibre fineness and cost of fibre. Tensile properties can be divided into three sub-criteria, fibre tenacity (FS), breaking extension (FE) and initial modulus (IM) whereas fibre fineness and cost are solely represented by denier value (FF) and raw material cost (RMC) respectively [6, 18].

At the lowest level of the hierarchy, there are four alternatives of fibre types namely Nettle, Sisal, Hemp and Local wool which should be ranked according to their acceptance value. The schematic representation of the problem is depicted in fig. 7.

Figure 7: Hierarchical structure of fibre properties



4.3 Determination of criteria weights and ranking of alternatives

With respect to the objective of the problem, the pair-wise comparison matrix of three criteria is given in Table 5. Here the comparison is made according to Saaty's scale [18].

Table 5: Pair-wise comparison matrix of criteria with respect to objective

Criteria	Tensile properties	Fibre fineness	Cost of fibre	Geometric Mean (*GM*)	Normalized *GM*
Tensile properties	1	1/3	3	1.0000	0.2583
Fibre fineness	3	1	5	2.4662	0.6370
Cost of fibre	1/3	1/5	1	0.4055	0.1047

It can be inferred from Table 5 that fibre fineness property is essentially predominate over the cost parameter and moderately predominate over tensile properties whereas the dominance of tensile properties over cost parameter is moderate. The normalized *GM* column of Table 5 indicates that the fibre fineness properties of yarn have the most dominant influence with a relative weight of 0.6370. The relative weights of cost and tensile properties are 0.1047 and 0.2583 respectively. For the measurement of consistency of judgment, the original matrix is multiplied by the weight vector to obtain the product as shown below:

$$\begin{bmatrix} 1 & 1/3 & 3 \\ 3 & 1 & 5 \\ 1/3 & 1/5 & 1 \end{bmatrix} \times \begin{bmatrix} 0.2583 \\ 0.6370 \\ 0.1047 \end{bmatrix} = \begin{bmatrix} 0.7848 \\ 1.9355 \\ 0.3182 \end{bmatrix}$$

$$\text{Now, } \boldsymbol{\lambda max} = \left(\frac{0.7848}{0.2583} + \frac{1.9355}{0.6370} + \frac{0.3182}{0.1047}\right)/3 = 3.038511$$

The consistency in the pair-wise judgment is found to be justified as confirmed from calculating the consistency index (*RCI*) against corresponding number of alternatives (Table 6) [17].

Therefore,

$$CI = \frac{3.038511 - 3}{3 - 1} = 0.019256 \;\&\; CR = \frac{CI}{RCI} = \frac{0.019256}{0.58} = 0.033199 < 0.1$$
(acceptable)

Table 6: RCI values of different number of alternatives

M	1	2	3	4	5	6	7	8	9
RCI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45

In order to calculate the relative weights of sub criteria with respect to corresponding criteria, the pair-wise comparison between sub-criteria of tensile properties and the derived weight vectors are shown in Table 7. Then the global weights of sub-criteria are calculated by multiplying the relative weight of sub-criteria with respect to the corresponding criterion and the relative weight of criterion with respect to the objective. Hence, the global weight of tenacity is 0.3331×0.2583=0.0860; the global weight of breaking extension, and cost parameter are 0.5695×0.3331=0.1471, 0.0974×0.3331=0.0252 respectively [17].

Table 7: Pair-wise comparison of sub-criteria with respect to tensile properties

Tensile properties	Tenacity	Breaking extension	Initial modulus	*GM*	Normalized *GM*
Tenacity	1	1/2	4	1.2599	0.3331
Breaking extension	2	1	5	2.1544	0.5695
Initial modulus	1/4	1/5	1	0.3684	0.0974

CR=0

Therefore, according to the multiplicative AHP model, the equation to calculate the acceptance value of yarns (MI_{AHP}) becomes;

$$MI_{AHP} = \frac{FS^{0.0860}\, FE^{0.1471}}{RMC^{0.1047}\, FF^{0.6370}\, IM^{0.0252}}$$

The values of MI_{AHP} for Nettle, Sisal, Hemp and Local wool are calculated and shown in Table 8.

Table 8: Fibre properties and acceptance values

Types of fibre	Fibre tenacity (g/den)	Breaking extension (%)	Initial modulus (g/den)	Fibre fineness (den)	Cost of fibre (Rs./Kg)	MI_{AHP}	Rankings
Nettle	2.73	2.39	75.15	17.08	110.00	0.1115	3
Sisal	6.27	3.81	224.23	57.79	75.00	0.0597	4
Hemp	6.03	4.04	127.28	17.96	90.00	0.1258	2
Local wool	5.86	5.61	30.00	8.78	175.00	0.2010	1

The result from Table 8 shows that, Local wool fibre has maximum acceptance followed by Hemp, Nettle and Sisal fibres for spinning into yarns. Acceptance of both Hemp and Nettle fibres are almost same in this context. Sisal fibre although having very good strength and lowest cost, its ranking is lowest and thereby has least acceptance to be formed into yarn.

Hence, it is concluded that apart from local wool, Nettle and hemp fibres have the potentiality for spinning into yarn while Sisal fibre was discarded from the consideration [9].

5. Conclusion

Fibre selection which is an important aspect prior to production of any textile material has been done in the study in a very judicious and scientific way based on some key criteria of the materials used. Sisal was not found to be suitable, so it was discarded from the present study. Himalayan Nettle fibre along with Hemp and Local Wool was successfully converted into pure and blended yarn. Later it was possible successfully to weave five types of fabrics out of those developed yarns viz. Nettle × Nettle, Nettle × Wool, Nettle × Hemp, Nettle × Nettle/Wool, Nettle × Hemp/Wool. The performance of any textile material like fibre, yarn and fabric can be judged through evaluation by sophisticated testing instruments and analysing the test results obtained to arrive at any conclusion. Some important and essential tests of the fibres used, yarn developed and fabric developed have been performed in order to assess the suitability of the products to be used in apparels [9].

6. Acknowledgement

This is to extend my gratitude to all the officials of NITRA, Uttarakhand Bamboo and Fibre Board, Dehradun; Women's Development Organization, Dehradun and Chirag NGO as well as all the artisans for extending their valuable support and cooperation.

References:

[1] Determination of yarn strength parameters of yarns spun on cotton system, Indian Standard specifications, IS 1671:1977, SP: 15-1981, 54. New Delhi: Bureau of Indian Standards

[2] G. Huang, 'Nettle (Urtica cannabina L) fibre, properties and spinning practice'. The Journal of The Textile Institute, 96/1 (11-15), (2005), https://doi.org/10.1533/joti.2004.0023

[3] Klein W. 'Manual of Textile Technology', Vol. 1, UK; The Textile Institute: 2008

[4] S. K. Sett, A. Banerjee & A. Mukhopadhaya, 'Studies of Nettle (Girardinia Diversifolia) fibre blended Yarns'. Paper presented at the International Conference on Natural Fibers - From Nature to Market, Kolkata: 2015

[5] Standard test method for tensile properties of single textile fibres, Designation: D3822-01, Annual Book of ASTM Standards, vol. 07.01, 2005

[6] Standard test method for tensile properties of single textile fibres, Designation: D – 1577:2007, Annual Book of ASTM Standards, vol. 07.01, 2005

[7] S. Mukhopadhyay, R. Pal, V. Narula & M. Mayank, 'A Study of Interface behavior in sisal fibre composites – Single fibre pull out test'. Indian Journal of Fibre & Textile Research, 38 (87 – 91), (Mar'2013)

[8] Shanthi Radhakrishnan & Preeti A., 'Development of Fabric from Girardina Diversifolia Stem Fibres and its Blends', International Journal of Innovative Research in Science, Engineering and Technology, 4/11 (10499 – 10506); (Nov'2015)

[9] S. Raj, 'Evaluation of spinnability of some selected natural fibres of Himalayan origin for making yarns and their suitability in making woven textiles', A doctoral thesis (2017).

[10] S. Bharadwaj & S. Pant, 'Comfort properties of acrylic: Nettle fiber blend fabric', Man-Made Textiles in India, 43/5 (177 – 179), (2015)

[11] Method for determination of threads per unit length, Indian Standard specifications, IS 1963: 1981, New Delhi; Bureau of Indian Standards: 1981

[12] Standard test method for Linear density of yarn (yarn number) by the skein method, Designation: 1907-01, Annual Book of ASTM Standards, vol. 07.01, 2005.

[13] Standard Test Method for Mass per Unit Area (Weight) of Fabric, Designation: D 3776 – 96 (Reapproved 2002), United States: ASTM International

[14] Standard test method for Twist in single spun yarns by the untwist–retwist method, Designation: D1422-99, Annual Book of ASTM Standards, vol. 07.01, 2005

[15] Standard test method for Thickness of Textile materials, Designation: 1777-96 (Reapproved 2002), Annual Book of ASTM Standards, vol 07.01

[16] Standard Test Method for Breaking Strength and Elongation of Textile Fabrics (Grab Test), Designation: ASTM D5034 – 09 (2013), United States: ASTM International

[17] P. K. Choudhuri, 'Application of Multi-Criteria Decision Making (MCDM) Technique for Gradation of Jute Fibres', Journal of The Institution of Engineers (India): Series E: Springer Publication, (Jul' 2014), DOI:10.1007/s40034-014-0039-8

[18] Thomas L. Saaty. 'The Analytic Hierarchy Process'. New York: McGraw-Hill International: 1980

Effect of Finishing Wet Operation on the Functional Properties Imparted to Polyester Fabrics Loaded with Metal Oxides NPs

Samy E. Shalaby[1], Naser Gad Ahmed Al-Balakocy[1]*, Samiha. M. Abo El-Ola[1], & Margarita K. Beliakova[2]

[1]*Protenic & Manmade Fibers Department, National Research Centre, Dokki, Cairo, Egypt*
[2]*Preparation and Finishing of Cellulosic Fibers Dept., National Research Centre, Dokki, Cairo, Egypt*

Abstract:
The aim of the present study was to investigate the effect of wet processing operations on the functional properties of partially hydrolyzed, bleached, and dyed polyester fabrics decorated with TiO2, ZnO, and SnO2 nanoparticles (NPs). To study the effects of loading with NPs and sequences of finishing wet processes on the properties of fabrics, different trials have been carried out. The so decorated fabrics were characterized using SEM, EDX, and FT-IR. The results confirmed that, interactions occurred between the functional groups created on the finished polyester fabrics and each of the applied NPs. Moreover, the effect of loading and sequence of finishing wet operations on the functional performances of polyester fabrics was evaluated by estimating their antimicrobial efficacy and ultraviolet protection properties. The antimicrobial activity was tested against B. mycoides, E. coli, and C. albicans. The results reflected that, loading of polyester fabrics with TiO2 and ZnO NPs during or after finishing process using pad-dry-cure technique paves the way for imparting outstanding antimicrobial activity even after five washing cycles. Moreover, polyester fabrics finished by the suggested method acquired valuable ultraviolet protection factor (UPF). The approach is facile and benign to apply on industrial scale without cost investment.

Keywords: *Alkali Hydrolysis, Antimicrobial, Finishing, UPF PET and PET/C Blended Fabrics, TiO2*

Citation: Samy E. Shalaby, Naser Gad Ahmed Al-Balakocy, Samiha. M. Abo El-Ola & Margarita K. Beliakova, "Effect of Finishing Wet Operation on the Functional Properties Imparted to Polyester Fabrics Loaded with Metal Oxides NPs ", *Journal of the Textile Association*, **83/5** (294-202), (Jan-Feb'23), https://doi.org/10.56716/4/1448

Article Received:29-11-2022, Revised: 16-01-2023, Accepted: 19-12-2022

1. Introduction

Polyester fibers are considered one of the most widely used synthetic polymers in textile field. Unfortunately, these fibers and articles made from them have inferior qualities such as: low hydrophilicity, accumulation of electrostatic charges on their surfaces and limited susceptibility for dyeing with different classes of dyes. All these disadvantages are resulting from their high degree of crystallinity and having limited number of active functional groups. Therefore, these fibers cannot easily penetrate by dyes of large molecular dimensions and with anionic or cationic species [1-3].

Many recent approaches have been done to eliminate the inferior qualities or to impart polyester fibers desirable properties through physical or chemical methods [4-6]. The majority of these methods depend on activation of polyester by infusing functional groups such as carboxyl and hydroxyl within the surface of fibers, which are used later in the functional finishing and imparting polyester textiles a new and durable performance [7-10].

All these methods so far have not been used on a large industrial scale. The principal barrier to the commercial exploitation was the cost of these techniques: specific equipment, advanced technology, knowhow. While the use of chemical methods, in particular, partial hydrolysis using sodium hydroxide can be apply as a simple method for activating the surface of polyester fibers which already used effectively on the line of wet processes during scouring step [11-12].

Literatures showed an interested in finding a convenient method that could be used to produce polyester fibers decorated with chemically bonded NPs and at the same time applicable on the wet processing line on industerial scale. Some of these studies have already used alkali treated polyester fabrics, in the functional finishing with NPs. The results showed the success of this method in activating the surface of polyester fabrics and then the subsequent treatment with nano-metal oxides. The results showed that, the fabrics have acquired new qualities and noticeable enhancement has showed in their functional performance, also these qualities were durable [13-16].

Previously, the both effect of bleaching [17] and dyeing [18] wet processes were studied in the first and second parts respectively. In order to complete this study and give full panorama, the present article is aiming to investigate the effect of sequence of finishing wet process on the loading of TiO2, ZnO and SnO2 NPs. Furthermore, this study specifies the functional finishing performance of partially hydrolyzed, bleached and dyed polyester.

2. Experimental

2.1. Materials

PET (100 %) and PET/C blended (50/50) partially hydrolyzed and bleached woven fabrics (PET→H→B and PET/C→H→B) were used throughout this study. PET and

Corresponding Author:
Prof. Naser Gad Al-Balakocy,
Protenic & Manmade Fibers Department, National Research Centre, Dokki, Cairo, Egypt
E-mail: nasergad@yahoo.com

PET/C fabrics were kindly supplied by local Egyptian textile companies. These fabrics were partially hydrolyzed using the method described by Shalaby, et al 2007. Its carboxylic content (10.9 and 22.4 meq/100gr fabrics) respectively was determined according to the method listed in Shalaby, et al 2021.

2.2. Chemicals

- TiO_2, ZnO nano - emulsions and SnO_2 nano - powder (< 100 nm) were purchased from Sigma -Aldrich.
- Sodium hydroxide, Sedco finish SMA and nonionic detergent (dispersant agent) was purchased from Fluka and has been used as received.
- Microorganisms Bacillus mycoides (Gram - positive bacterium), Escherichia coli (Gram - negative bacterium), and Candida albicans (non-filamentous fungus) were used for estimation of antimicrobial potency of parent and treated samples. Microorganisms were obtained from the culture collection of the Department of Microbial Chemistry, Genetic Engineering and Biotechnology institute, National Research Centre of Egypt.
- Modified nutrient agar medium was used and is composed of the following ingredients (g/l): peptone (10.0), beef extract (5.0), NaCl (5.0) and agar (20.0). The pH was adjusted to 6.8. This medium was sterilized for 20 min. at 121°C under pressure.
- Disperse dye (Dianix Red CC Disperse), and reduction clearing agent (Sodium Hydrosulfite 1.0 g/l and Sodium Hydroxide 3.0 g/l), were kindly supplied by Misr Spinning and Weaving Elbedia Dyers, Kafr El Dawar - Alexandria, company. Dispersing agent was purchased from Fluka and has been used as received.
- Reactive dye (Prosion Red H E 7B) and soaping agent (Sera Fast), were kindly supplied by Dye Star company. Acetic acid, Dispersing agent, Sodium acetate, Sodium carbonate, non anionic agent, Sodium sulphate and sodium sulfite were purchased from Fluka and have been used as received.
- Sedco Finish SMA (silicon finish), was kindly supplied by local Egyptian textile companies (Misr Spinning and Weaving Elbedia Dyers, Kafr El Dawar - Alexandria, company).

2.3 Methods

2.3.1 Dyeing of PET Fabrics

Dyeing of PET fabrics was carried out using the method described in Shalaby, et al 2021.
PET→H→B→ D (Disperse)

2.3.2 Dyeing of PET/C Blended Fabrics

PET/C blended fabrics were dyed in two steps according to the method described in Shalaby, et al 2021.
PET/C→H→B→ D (Disperse → Reactive)

2.3.3 Finishing of Polyester Fabrics (Softening)

PET→H→B→D and PET/C→H→B→D fabrics have been immersed in finishing solution (Sedco Finish SMA) (20g/l). PET and PET/C fabrics samples were squeezed to pick-up 75 % increase, dried at 100°C for 60 minutes. and then cured at 160°C for 3.0 minutes.
PET→H→B→D→F
PET/C→H→B→D →F

2.3.4 Preparation of Metal Oxides NPs

0.5g of metal oxides (TiO_2, ZnO SnO_2) NPs (< 100 nm) were added in 1.0 liter of distilled water and subjected to sonication for 30 minutes at room temperature. Nonionic detergent was used as emulsifying agent to enhance the stability of the emulsion.

2.3.5 Loading Polyester Dyed Fabrics with Metal Oxides NPs (Before Finishing)

PET→H→B→D and PET/C→H→B→D fabrics have been loaded with NPs colloidal solution prepared according to the method (2.3.4). Then, the loaded fabrics finished by silicon according to method (2.3.3). The samples were in order to evaluate NPs adhesion to textiles; the loaded fabrics were repeatedly washed five washing cycles according to the standard AATCC test method (61-1989).
PET→H→B→D→ (TiO_2 or ZnO or SnO_2)NPs→F
PET/C→H→B→D→ (TiO_2 or ZnO or SnO_2)NPs→F

2.3.5 Loading PET Dyed Fabrics with Metal Oxides NPs (During Finishing)

PET→H→B→D and PET/C→H→B→D fabrics have been immersed in a finishing aqueous solution containing 20g silicon finish and 5g metal oxides NPs were added in 1.0 liter of distilled water and subjected to sonication for 30 minutes at room temperature. PET and PET/C fabrics samples were squeezed to pick-up 75% increase, dried at 100°C for 60 minutes. and then cured at 150°C for 3 minutes. The loaded fabrics were repeatedly washed five washing cycles according to the standard AATCC test method (61-1989).
PET→H→B→D→ [F+ (TiO_2 or ZnO or SnO_2) NPs]
PET/C→H→B→D→[F+ (TiO_2 or ZnO or SnO_2) NPs]

2.3.4. Loading Polyester Dyed Fabrics with Metal Oxides NPs (After Finishing)

PET→H→B→D→F and PET/C→H→B→D→F fabrics have been loaded with NPs colloidal solution prepared according to the method (2.3.4). The samples were in order to evaluate NPs adhesion to textiles; the loaded fabrics were repeatedly washed five washing cycles according to the standard AATCC test method (61-1989).
PET→H→B→D→ F→(TiO_2 or ZnO or SnO_2) NPs
PET/C→H→B→D→ (TiO_2 or ZnO or SnO_2) NPs→F

3. Analysis

3.1. Carboxylic Content

Carboxylic content was determined according to the method described by Shalaby, et al 2011 [19].

3.2. Antimicrobial Activity

Antimicrobial activity of fabrics loaded with NPs was quantified using shake flask method. In this method the antimicrobial activity of immobilized antimicrobial agents is determined under dynamic contact conditions according to ASTM standard test method 2143 (2001) .

3.3. Scan Electron Microscope (SEM)

Fabrics morphology was characterized by scanning electron microscope (SEM) (JEOL Model TSM T20).

3.4. Energy Dispersive X-ray (EDX)

Energy Dispersive X-Ray (EDX) mode was applied for the elemental composition analysis. Gold layer was deposited on the samples before analysis.

3.5. Fourier Transformation Infrared (FT-IR)

The chemical structure was determined using the Fourier transformation infrared (FT-IR) spectrometer, model NEXUS 670, NICOLET USA. The measurements were carried in the spectral range from 4000 cm-1 to 500 cm-1. Reflection percentage measurement technique was applied (R%). All investigated samples have the same area and weight.

3.6. Ultraviolet Protection Factor (UPF)

Ultraviolet Protection Factor (UPF) was determined using UV- Shimadzy 3101 P C spectrophotometer. It is a double beam direct ratio measuring system. It consists of the photometer unit and a PC computer. UPF factor was determined according to the method described in Australian/New Zealand standard AS/NZS 4399: 1996. UPF values were calculated automatically and classified according to table 1 [20].

Table 1 - Protection and classification according to AS/NZS 4399:1966

UVP	UPF
Excellent	40,45,50,50+
Very good	25,30,35
Good	15,20
Non- Rate-able	0,5,10

4. Results and Discussion

Different trials have been carried out to study the effect of the sequences of the finishing wet process operation on loading with NPs and the functional performance of partially hydrolyzed, bleached and dyed polyester fabrics loaded with NPs. To confirm the reaction actually had taken place between carboxylic groups created on polyester fabrics surfaces as a result of alkali treatment and each of the used NPs. This was carried out through Energy Dispersive X-Ray (EDX), Scanning Electron Microscope (SEM) and FT-IR measurements.

4.1. Scan Electron Microscope (SEM) and Energy dispersive X-ray (EDX)

The surface topographic investigation (EDX) was applied to investigate the presence of NPs on the surface of fabrics, were shown in fig. (1-2). The obtained results confirmed the existence of metallic Ti, Zn and Sn, irrespective of the mode and sequences of carrying out loading and finishing operations. The results presented by fig. (1-2) and tables (1-3) indicated the following:

i) The Images of the surfaces of PET and PET/C blended fabrics (Fig. 1-6) showed that treating dyed and finished fabrics with NPs leads to the appearance of a thin layer on the surface of the fibers differs In terms of thickness, depending on the site of the final finishing process: before, during or after the loading process with NPs.

ii) The presence of peaks of TiO2, ZnO and SnO2 in the EDX spectra, the intensity of which varies according to the location of the final finishing process of the fabrics before, during or after the NPs loading step and finally the type of fabrics being loaded (Fig. 1-2). There is no doubt that the presence of these peaks was one of the indications that confirmed a link between NPs and the surfaces of the fabrics under study.

iii) A partial alkali hydrolysis of the polyester fabrics proceed definitely on the fabric surface and amorphous regions, yielding soluble products such as short-chain oligomers (PET fibers) and glucose units (cotton fiber) (Al-Balakocy, et al 2013). This finding accompanied by an increase in the carboxylic content, and enhancement the attachment of the NPs which increase by increasing the amount of carboxyl groups (Table 1).

iv) The atomic percentage of TiO2, ZnO and SnO2 present on the surface of PET and PET/C blended fabrics that were dyed, finished and loaded with each of the TiO2, ZnO and SnO2 NPs exceeds their counterparts in the case of PET/C blended fabrics, and this trend remains prevalent even after five standard washing cycles (Tables 2-3).

Table 1: Carboxylic Content for PET and PET/C Blended Fabrics Before and After Treatment with NaOH

No.	Fabrics	Carboxylic Content (meq/100 gr. Fabric)
1	PET→B	2.95
2	PET→B→H	10.91
3	PET/C→B	4.99
4	PET/C→B→H	22.38

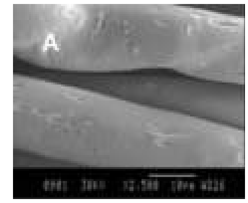
B= Bleached H= Hydrolyzed

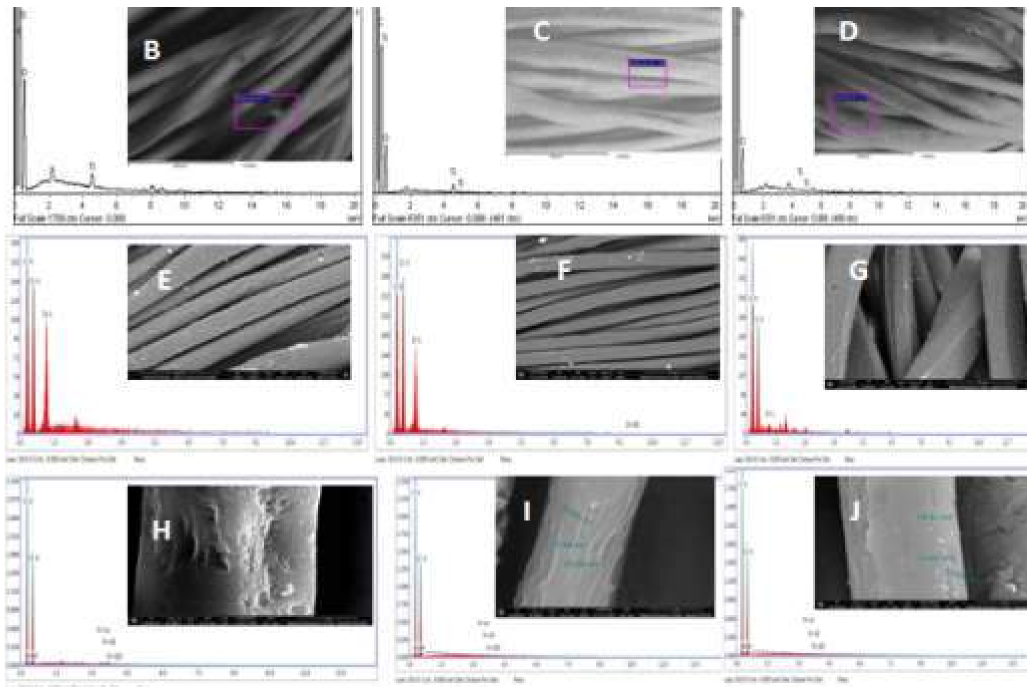
Alkali Treatment Conditions: [NaOH], 1.5 mol/l ; Duration, 60 min.; Temperature, 100oC; M: L Ratio, 1: 20.

Figure 1: SEM and EDX Micrographs of Bleached, Partially Hydrolyzed, Dyed and Finished PET Fabrics Loaded with TiO_2 NPs* (X2000)

[A] PET→B→H→D→F (Blank) [B] PET→B→H→D→TiO_2→F
[C] PET→B→H→D→F→TiO_2 [D] PET→B→H→D →(F+TiO_2)
[E] PET→B→H→D→ ZnO →F [F] PET→B→H→D→ F→ ZnO
[G] PET→B→H→D→(F+ ZnO) [H] PET→B→H→D→SnO_2→F
[I] PET→B→H→D→F→SnO_2 [G] PET→B→H→D→(F+ SnO_2)

*After Five Washing Cycles; AATCC Test Method (61-1989).





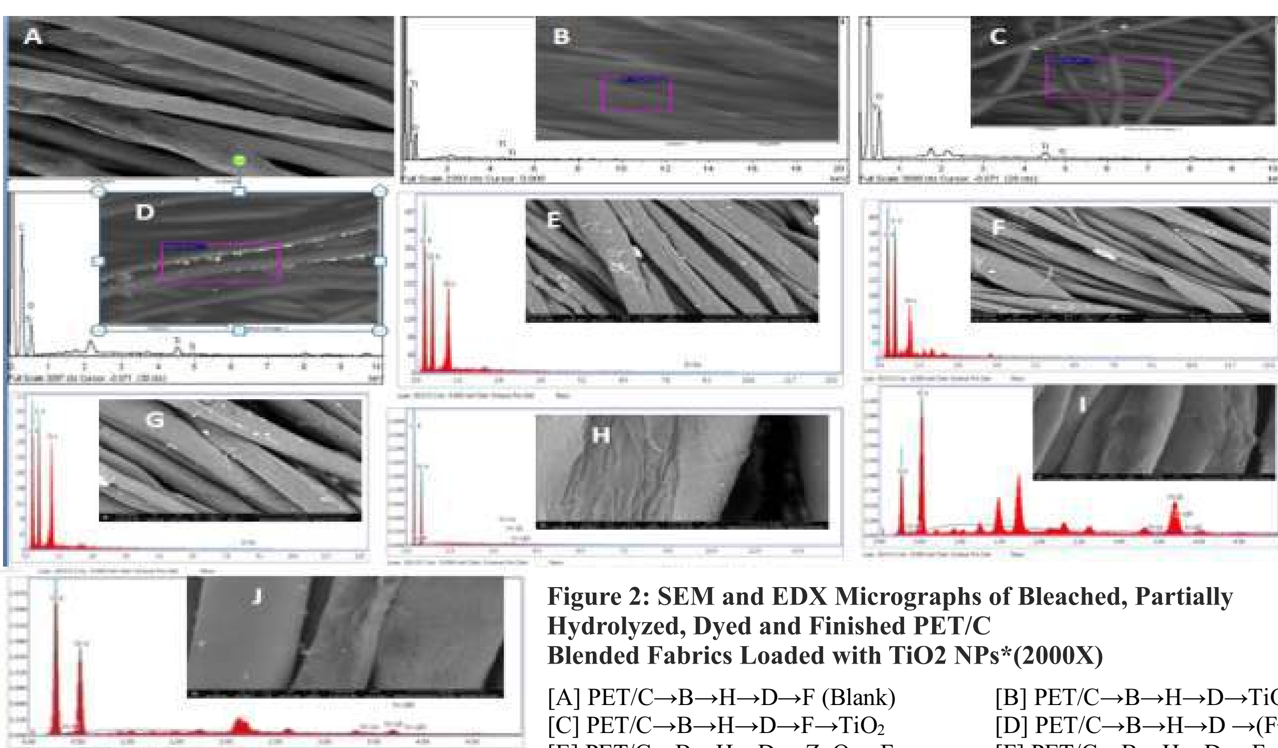


Figure 2: SEM and EDX Micrographs of Bleached, Partially Hydrolyzed, Dyed and Finished PET/C Blended Fabrics Loaded with TiO2 NPs*(2000X)

[A] PET/C→B→H→D→F (Blank) [B] PET/C→B→H→D→TiO_2→F
[C] PET/C→B→H→D→F→TiO_2 [D] PET/C→B→H→D →(F+TiO_2)
[E] PET/C→B→H→D→ ZnO →F [F] PET/C→B→H→D→ F→ ZnO
[G] PET/C→B→H→D→(F+ ZnO) [H] PET/C→B→H→D→SnO_2→F
[I] PET/C→B→H→D→F→SnO_2 [J] PET/C→B→H→D→(F+ SnO_2)

*After Five Washing Cycles; AATCC Test Method (61-1989).

Table 2: Ti, Zn and Sn Content on the Surfaces of Bleached, Partially Hydrolyzed, Dyed and Finished PET Fabrics Loaded with TiO2, ZnO and SnO2 NPs

No.	Fabrics	Contents (Atomic %) on the Surfaces of Fabrics of:					
		Ti		Zn		Sn	
		Number of Washing Cycles:					
		1*	5*	1*	5*	1*	5*
1	PET→B→H D→F (Blank)	0.00		0.00		0.00	
2	PET→B→H→ D→TiO_2→F	0.14	0.09				
3	PET→B→H→ D→ ZnO →F			0.04	0.02		
4	PET→B→H→ D→SnO_2→F					0.14	0.11
5	PET→B→H→ D→ (F+ TiO_2)	0.06	0.02				
6	PET→B→H→ D→ (F+ ZnO)			0.08	0.04		
7	PET→B→H→ D→ (F+ SnO_2)					0.25	0.14
8	PET→B→H→ D→F→ TiO_2	0.23	0.18				
9	PET→B→H→ D→F→ ZnO			0.04	0.02		
10	PET→B→H→ D→F→ SnO_2					1.00	0.09

B = Bleached H = Hydrolyzed F = Finished D = Dyed

* After 1 and 5 washing Cycles; AATCC Test Method (61-1989).

Table 3: Ti, Zn and Sn Content on the Surfaces of Bleached, Partially Hydrolyzed, Dyed and Finished PET/C Blended Fabrics Loaded withTiO2, ZnO and SnO2 NPs

No.	Fabrics	Contents (Atomic %) on the Surfaces of Fabrics of:					
		Ti		Zn		Sn	
		Number of Washing Cycles:					
		1*	5*	1*	5*	1*	5*
1	PET→B→H D→F (Blank)	0.00		0.00		0.00	
2	PET→B→H→ D→TiO_2→F	0.05	0.03				
3	PET→B→H→ D→ ZnO →F			0.07	0.04		
4	PET→B→H→ D→SnO_2→F					0.37	0.25
5	PET→B→H→ D→ (F+ TiO_2)	0.07	0.04				
6	PET→B→H→ D→ (F+ ZnO)			0.08	0.05		
7	PET→B→H→ D→ (F+ SnO_2)					0.78	0.57
8	PET→B→H→ D→F→ TiO_2	0.23	0.17				
9	PET→B→H→ D→F→ ZnO			0.06	0.04		
10	PET→B→H→ D→F→ SnO_2					1.00	0.04

B = Bleached H = Hydrolyzed F = Finished D = Dyed

* After 1 and 5 washing Cycles; AATCC Test Method (61-1989).

4.2. Fourier Transformation Infrared (FT-IR) (Tables 4-5)

(1) In the case of loading fabrics with TiO2 NPs

(A) PET fabric (Table 4):

a. The OH group reached a maximum value of 3502.6 cm-1 in case of fabrics treated with TiO2 NPs during final finishing, compared to 33000.7 cm-1 to parent fabric and the intensity of this group remained constant.

b. The position and intensity of >C=O group of all fabrics treated with TiO2NPs was not affected.

c. New bands appeared in the range from 723 cm-1 to 769.3 cm-1, which is the new bond (Ti—O—C).

(B) PET/C blended fabric (Table 5):

i. An increase in the wavelength of the OH group was observed in case of PET/C fabrics treated with TiO2 NPs. Also, there was no significant change in the intensity values of this group.

ii. The wavelength of the >C=O groups was not affected, while there was a slight decrease in the intensity values.

iii. New absorption bands appeared in the range from 722.8 cm-1 to 725.5 cm-1, which is the characteristic region of the new bond (Ti—O—C).

(2) In the case of loading fabrics with ZnO NPs

(A) PET fabric (Table 4)

1. No change occurred in the position of the OH group for all samples. The a maximum value was 3432.5 cm-1 in the case of fabrics treated with ZnO NPs before the final finishing, compared to 3428.8 cm-1 with parent fabrics.

2. The wavelength of the >C=O group reached its maximum value of 1734 cm-1 in the case of loading of ZnO NPs before the final finishing and decreased its intensity.

3. New bands with appeared in the range from 631 cm-1 to 633 cm-1 characterized to the new bond (Zn—O—C).

(B) - PET/C blended fabric (Table 5):

No change was induced in the wavelength of the OH group in the samples of the PET/C treated with ZnO NPs, while the intensity of these groups decreased and recorded its lowest value during loading fabrics with NPs and final finishing simultaneously.

2. A slight decrease was observed in both the wavelength and intensity values of the carbonyl group.

3. New bands located in the range from 654.8 cm-1 to 668.5 cm-1, which is (Zn—O—C) new bond

(3) In the case of loading with SnO2 NPs

(A) PET fabric (Table 4):

1. The position and intensity of COOH group was not affected by the treatment with SnO2 NPs.
2. Decrease in the strength of these groups when the loading was carried in the final finishing stage.
3. New band appeared in the range from 427.2 cm-1 to 436.8 cm-1 characterized to the bond (Sn—O—C).

(B)- PET/C fabric (Table 5):

1. Loading SnO2 NPs on fabric before the final finishing did not change the wavelength of the OH group.
2. Changing the place of the loading process leads to a significant decrease in the severity of this group.
3. A new absorption band appeared which is a distinct region for the (Sn—O—C) bond.

Table 4: FT-IR Absorption Bands of Bleached, Partially Hydrolyzed, Dyed and Finished PET Fabrics Loaded With TiO2, ZnO and SnO2 NPs*

No.	Fabrics	Absorption Bands of Functional Groups (>C=O —OH) Affected After Treatment with TiO_2 NPs				New Absorption Bands Appeared	
		>C=O		—OH			
		Position (Cm^{-1})	Intensity	Position (Cm^{-1})	Intensity	Position (Cm^{-1})	Intensity
1	PET→B→H→D→F (Blank)	1713.2	92.9	3300.7	99.7	-	-
2	PET→B→H→D+TiO_2→F	1712.3	91.3	3331.9	100.0	769.3	97.3
3	PET→B→H→D+ ZnO→F	1734.4	35.6	3432.5	86.0	633.5	67.6
4	PET→B→H→D+ SnO_2→F	1710.6	73.1	3327.6	60.1	427.2	87.9
5	PET→B→H→D→F→TiO_2	1714.2	92.9	3479.1	99.9	723.0	85.5
6	PET→B→H→D→F→ZnO	1732.8	35.4	3431.7	82.6	633.4	61.5
7	PET→B→H→D→F→ SnO_2	1710.6	39.4	3327.8	58.7	428.1	95.9
8	PET→B→H→D→(F+TiO_2)	1712.8	92.6	3502.6	99.7	724.1	86.1
9	PET→B→H→D→ (F+ ZnO)	1730.8	38.6	3431.7	76.0	632.6	60.8
10	PET→B→H→D→ (F+ SnO_2)	1710.6	81.3	3328.5	57.9	436.8	96.2

B = Bleached H = Hydrolyzed F = Finished D = Dyed

* After Five Washing Cycles; AATCC Test Method (61-1989).

Table 5: FT-IR Absorption Bands of Bleached, Partially Hydrolyzed, Dyed and Finished PET/C Blended Fabrics Loaded with TiO2, ZnO and SnO2 NPs*

No.	Fabrics	Absorption Bands of Functional Groups (>C=O —OH) Affected After Treatment with TiO_2 NPs				New Absorption Bands Appeared	
		>C=O		—OH			
		Position (Cm-1)	Intensity	Position (Cm-1)	Intensity	Position (Cm-1)	Intensity
1	PET/C→B→H→D→F (Blank)	1716.5	99.7	3317.3	99.5	-	-
2	PET/C→B→H→ D→TiO_2→F	1712.9	97.2	3337.8	99.4	723.1	91.3
3	PET/C→B→H→D→ZnO→F	1738.5	49.0	3432.7	54.6	668.5	19.4
4	PET/C→B→H→D→SnO_2→F	1710.6	83.5	3330.5	64.8	436.8	96.4
8	PET/C→B→H→D→(F+TiO_2)	1709.5	98.7	3326.0	98.4	725.5	93.9
9	PET/C→B→H→D→(F+ZnO)	1740.2	51.0	3431.3	46.8	654.8	18.6
10	PET/C→B→H→D→(F+SnO_2)	1740.2	51.0	3431.3	46.8	654.8	18.6
11	PET/C→B→H→D→ F→TiO_2	1713.3	94.5	3341.8	96.4	722.8	88.1
12	PET/C→B→H→D→ F→ZnO	1739.2	49.0	3431.8	47.3	657.2	17.9
13	PET/C→B→H→D→ F→SnO_2	1739.2	49.0	3431.8	47.3	657.2	17.9

B = Bleached H = Hydrolyzed F = Finished D = Dyed

* After Five Washing Cycles; AATCC Test Method (61-1989).

4.3. Antimicrobial Activity

1. Finishing of PET after loading with NPs leads to the fabrics acquiring a very good antimicrobial activity after washing 1 cycle. In the case of treatment with SnO2 NPs, the ability of these NPs is very modest (Table 6).

2. Loading PET fabrics with TiO2 and ZnO NPs, either simultaneously with or after the final finishing process resulting in acquiring the fabrics a superior ability to resist B. m, E. c, and C. a (Table 6).

3. Dyed and finished PET/C fabrics loaded with ZnO NPs resist both the influence of microbes and washing processes was closely related to the place of loading with NPs. It turned out that:

a. The highest ability to withstand the effect of both the microbes under study and the repeated washing processes are obtained after completing the NPs loading process during or after the final finishing of the fabrics. In general, the situation was not different when carrying out the NPs loading process before the final finishing of the fabrics.

b. Adding TiO2 and ZnO NPs in the finishing bath resulting in imparting the fabrics a high capabilities to withstand the influence of microbes and repeated washing processes.

Table 6: Antimicrobial Activity of Bleached, Partially Hydrolyzed, Dyed and Finished PET Fabrics Loaded with TiO2, ZnO and SnO2NPs, Determined by Shake Flask Method

No.	Fabrics	% CFU Reduction					
		B.m		*E. c*		*C.a*	
		Number of washing Cycles:					
		1*	5*	1*	5*	1*	5*
1	PET→B→H D→F (Blank)	0.0		0.0		0.0	
2	PET→B→H→D→TiO_2→F	100	100	100	84	100	24
3	PET→B→H→D→ZnO→F	88	81	79	70	87	83
4	PET→B→H→D→SnO_2→F	16	-	-	-	33	-
5	PET→B→H→D→(F+TiO_2)	100	84	88	68	45	24
6	PET→B→H→D→(F+ZnO)	100	98	100	91	88	82
7	PET→B→H→D→(F+ SnO_2)	70	-	24	-	53	-
8	PET→B→H→D→F→TiO_2	100	100	100	64	100	24
9	PET→B→H→D→F→ZnO	100	100	100	92	100	94
10	PET→B→H→D→F→ SnO_2	4.0	-	13.0	-	49	-

B = Bleached H = Hydrolyzed F= Finished D = Dyed

*After 1 and 5 Washing Cycles; AATCC Test Method (61-1989).

Table 7: Antimicrobial Activity of Bleached, Partially Hydrolyzed, Dyed and Finished PET/C Blended Fabrics Loaded with TiO_2, ZnO and SnO_2NPs, Determined by Shake Flask Method

No.	Fabrics	% CFU Reduction					
		B.m		*E. c*		*C.a*	
		Number of washing Cycles:					
		1*	5*	1*	5*	1*	5*
1	PET→B→H D→F (Blank)	0.0		0.0		0.0	
2	PET/C→B→H→D→TiO_2→F	100	100	76	54	72	52
3	PET/C→B→H→D→ ZnO →F	90	85	76	55	78	67
4	PET/C→B→H→D→SnO_2→F	20	-	0.0	0.0	41	-
5	PET/C→B→H→D→(F+TiO_2)	100	100	100	100	100	100
6	PET/C→B→H→D→ (F+ZnO)	100	100	100	100	100	100
7	PET/C→B→H→ D→(F+SnO_2)	20	-	0.0	0.0	53	-
8	PET/C→B→H→ D→F→TiO_2	100	100	100	100	100	100
9	PET/C→B→H→ D→F→ZnO	100	100	100	100	100	100
10	PET/C→B→H→ D→F→SnO_2	16	-	0.0	0.0	49	-

B = Bleached H = Hydrolyzed F= Finished D = Dyed

*After 1 and 5 Washing Cycles; AATCC Test Method (61-1989).

3.5. Ultraviolet Protection Properties

Loading dyed PET and PET/C fabrics with NPs before, during or after the final finishing leads to these fabrics gaining the ability to protect against ultraviolet rays.

Loading PET fabrics before, during or after the final finishing process characterized after being washed one cycle with excellent UPF protection factor (Table 8).

Loading PET/C blended fabrics dyed with NPs before the final finishing process leads to these fabrics gaining good classification, and the washing process didn`t lead to noticeable reduction in their values (Table 9).

The maximum UPF could be obtained for PET/C fabrics by treating them with NPs at the same time as the procedure was performed final finishing. It is worth noting that treating with SnO2 NPs acquire fabrics a very high ability to protect against ultraviolet rays that didn`t change after repeated washings.

Table 8: Ultraviolet Protection Factor (UPF) of Bleached, Partially Hydrolyzed, Dyed and Finished PET Fabrics Loaded with TiO_2, ZnO and SnO_2NPs

No.	Fabrics	Number of Washing Cycles:			
		1*		5*	
		UPF	UPF Rating	UPF	UPF Rating
1	PET→B→H D→F (Blank)	19.1	Good	16.7	Good
2	PET→B→H→ D→TiO_2→F	50+	Ex.	50+	Ex.
3	PET→B→H→ D→ ZnO →F	50+	Ex.	50+	Ex.
4	PET→B→H→ D→SnO_2→F	24.3	Good	21.1	Good
5	PET→B→H→ D→ (F+ TiO_2)	50+	Ex.	50+	Ex.
6	PET→B→H→ D→ (F+ ZnO)	50+	Ex.	50+	Ex.
7	PET→B→H→ D→ (F+ SnO_2)	23.5	Good	20.1	Good
8	PET→B→H→ D→F→ TiO_2	50+	Ex.	50+	Ex.
9	PET→B→H→ D→F→ ZnO	50+	Ex.	50+	Ex.
10	PET→B→H→ D→F→ SnO_2	25.0	V. Good	23.8	Good

B = Bleached H = Hydrolyzed F = Finished D = Dyed

* After 1 and 5 Washing Cycles; AATCC Test Method (61-1989).

Table 9: Ultraviolet Protection Factor (UPF) of Bleached, Partially Hydrolyzed, Dyed and Finished PET/C Blended Fabrics Loaded with TiO_2, ZnO and SnO_2NPs

No.	Fabrics	Number of Washing Cycles:			
		1*		5*	
		UPF	UPF Rating	UPF	UPF Rating
1	PET/C→B→H D→F (Blank)	19.1	Good	16.3	Good
2	PET/C→B→H→ D→TiO_2→F	18.6	Good	18.0	Good
3	PET/C→B→H→ D→ ZnO →F	22.0	Good	19.0	Good
4	PET/C→B→H→ D→SnO_2→F	12.1	Poor	-	-
5	PET/C→B→H→ D→ (F+ TiO_2)	50+	Ex.	28.3	V. Good
6	PET/C→B→H→ D→ (F+ ZnO)	50+	Ex.	39.0	V. Good
7	PET/C→B→H→ D→ (F+ SnO_2)	12.3	Poor	-	-
8	PET/C→B→H→ D→F→ TiO_2	23.8	Good	18.4	Good
9	PET/C→B→H→ D→F→ ZnO	37.0	V. Good	29.0	V. Good
10	PET/C→B→H→ D→F→ SnO_2	13.3	Poor	-	-

B = Bleached H = Hydrolyzed F = Finished D = Dyed Reac. = Reactive Dye

* After 1 and 5 Washing Cycles; AATCC Test Method (61-1989).

5. Conclusion

The aim of the present article was to investigate the effect of chemical finishing wet operation and its sequences on the functional performances imparted to partially hydrolyzed, bleached dyed and finished fabrics and loaded with TiO2, ZnO and SnO2 NPs. Characterization of the finished fabrics was carried out through SEM, EDX and FT-IR. The obtained results reveal that, TiO2, ZnO and SnO2 were chemically bonded to PET and PET/C blended fabrics, and that, the finishing wet operation had no effect on this electrostatic interaction between COOH groups and NPs. The antimicrobial activity of loaded and finished fabrics was tested. It had been found that, loading fabrics with TiO2 and ZnO during or after carrying finishing process paves the way for imparting outstanding antimicrobial activity even after five washing cycles, indicating that their excellent laundering durability. It was also found that the sequence of loading NPs after or during finishing wet operation highly affect the UPF values. Based on the abovementioned, one can conclude the feasibility of carrying out such modification on the wet processing line for PET and PET/C blended fabrics.

6. Conflict of Interest

The authors confirm that this article content has no conflict of interest.

7. Acknowledgements

The authors are grateful for financial support from the National Research Centre (Dokki, Cairo, 12622, Egypt) through the internal research project (ID: 10160001).

References

[1] N. G. Al-Balakocy, Chemical modification of polyethylene terephthalate (PET) fibres for better performance: A review article. Journal of the Textile Association, 75, 1, 7 - 221 (2014)

[2] M. Shabbir, J. N. Sheikh, Introduction to textiles and finishing materials. Frontiers of Textile Materials: Polymers, Nanomaterials, Enzymes, and Advanced Modification Techniques 4, (2020)

[3] A. Ketema and A. Worku, Review on intermolecular forces between dyes used for polyester dyeing and polyester fiber. Journal of Chemistry, (2020)

[4] A. Bartnik, H. Fiedorowicz, R. Jarocki, J. Kostecki, M. Szczurek, A. Biliński, O. Chernyayeva, J. W. Sobczak, Physical and chemical modifications of PET surface using a laser-plasma EUV source. Applied Physics A. 99, 4,831-6 (2010)

[5] M. Abdolahifard, S. H. Bahrami, R. M. Malek, Surface modification of PET fabric by graft copolymerization with acrylic acid and its antibacterial properties. International Scholarly Research Notices. (2011)

[6] L. Bech, T. Meylheuc, B. Lepoittevin, P. Roger, Chemical surface modification of poly (ethylene terephthalate) fibers by aminolysis and grafting of carbohydrates. Journal of Polymer Science Part A: Polymer Chemistry 1, 45, 11, 2172-83 9 (2007)

[7] S. E. Shalaby, N. G. Al-Balakocy, and S. M. Abo El-Ola, Alkaline Treatment of Polyethylene glycol Modified Poly (ethylene terephthalate) Fabrics. Journal of the Textile Association, May- June, 68, 1, 31-37 (2007)

[8] S. Hashemizad, M. Montazer, A. Rashidi, Influence of the surface hydrolysis on the functionality of poly(ethylene terephthalate) fabric treated with nanotitanium dioxide. J. Appl. Polym. Sci. 125, 1176 (2012)

[9] M. Montazer. and A. Sadighi, Optimization of the hot alkali treatment of polyester/cotton fabric with sodium hydrosulfite Journal of Applied Polymer Science, 100,6, 5049-5055 (2006)

[10] S. Hashemizad, M. Montazer, A. Rashidi, Influence of the surface hydrolysis on the functionality of poly(ethylene terephthalate) fabric treated with nano-titanium dioxide, J. Appl. Polym. Sci. 125 1176 (2012)

[11] D. Kowalczyk, S. Brzeziński, I. Kamińska, Multifunctional nano-coating finishing of polyester/cotton woven fabric by the sol-gel method. Textile Research Journal. 88, 8, 946-56 (2018)

[12] M. Mohammadi, L. Karimi, M. Mirjalili, Simultaneous synthesis of nano ZnO and surface modification of polyester fabric. Fibers and Polymers., 17, 9, 1371-7 (2016)

[13] S. E. Shalaby, N. G. Al-Balakosy, S. M. Abo El-Ola, M. K. Belakova, A. M. Elshafae, Functional Finishing of Polyester and Polyester Blended Fabrics with Zinc Oxide Nanoparticles". International Journal of Applied Chemistry, 10, (1), 77-94 (2014)

[14] N. G. Al-Balakocy, T. Hassan, S. Khalil, S. Abd El-Salam, Simultaneous chemical modification and functional finishing of polyester textiles. Research Journal of Textile and Apparel, 25, 3, 257-273 (2021).

[15] N. H. Ibrahim, B. M. Eid, M. A. Youssef, H. A. Ameen, A. M. Salah, Surface modification and smart functionalization of polyester-containing fabrics. Journal of industrial Textiles, 42, 4, 353-75 (2013)

[16] N. G. Al-Balakocy, Kh. El-Badry, T. M. Hassan, Multi – Finishing of Polyester and Polyester Cotton Blend Fabrics Activated by Enzymatic Treatment and Loaded with Zinc Oxide Nanoparticles. Journal of Applied Sciences Research, 9, 4, 2767 - 2776, (2013)

[17] S. E. Shalaby, N. G. Al-Balakocy, S. M. Abo – Ola, M. K. Beliakova, A. M. Elshafei, Effect of Wet Processing Operations on Functional Properties Imparted to PET Fabrics Loaded with Different Metal Oxides Nanoparticles Part I: Effect of Finishing on Properties Imparted to Bleached PET Fabrics loaded with TiO2, ZnO and SnO2 NPs, Egyptian Journal of Chemistry, 60, 6, 1045-1057 (2017)

[18] S. E. Shalaby, N. G. Al-Balakocy, M. K. Beliakova, A. M. Othman, Effect of Wet Processing Operations on The Functional Properties Imparted to Polyester Fabrics Loaded with Different Metal Oxides NPs Part II: Effect of The Different Sequences of Dyeing, Journal of Engineered Fibers and Fabrics, 16, 1-13 (2021)

[19] S. E. Shalaby, N. G. Al-Balakocy, M. K. Beliakova, O. M. Abdel-Fatah, A. M. Elshafei, One – Stage Method For Imparting Durable Antimicrobial Properties To Regular and Modified Polyester Fabrics, 5th International Textile Conference, Aachen – Dresden Germany, 24-25 November (2011).

[20] T. Gambichler, A. Avermaete, A. Bader, P. Altmeyer, K. Hoffman, Ultraviolet Protection by Summer Textiles. Ultraviolet Transmission verified by Determination of the minimal Erythematic Dose with Solar-Simulated Radiation, Br J Dermatol, 144, 484-489 (2001).

■ ■ ■

Effect of the Construction Elements on the Mechanical Properties of Military Clothes

Hafez S. Hawas[1]* & Doaa H. Elgohary[2]

[1]Department of Spinning and Weaving, Helwan University, Cairo, Egypt
[2]Dept. of Spinning and Weaving Engineering, Institute of Textile Research and Technology, National Research Centre, Dokki, Cairo, Egypt

Abstract:
Military clothes properties depend on a great extent of constructional parameters, methodology and machine conditions. Mechanical properties are very important properties, it affects on the durability of woven fabrics during use. Recently, there has been a growing realization that effective military clothing design requires greater consideration of comfort factors. Therefore, this research aims to investigate the relationship between different weft materials, weave structures and the mechanical and physical properties of produced military clothe fabrics.

For this objective, nine military samples were produced varying in weave structure (basket 2/2 & twill 2/2 & twill 1/3) and three different weft materials (viscose pcm, polyester pcm & bamboo). Tensile strength and elongation in both direction, abrasion resistance, tear strength in both direction and water absorbency of all the fabric samples were determined.

Two-way Anova statistical analysis was used to investigate the performance of textile materials and weave structures on different variables; also, the differences between means were analyzed using Tukey Honest Significant Difference test at p ≤ 0.05. The thermal conductivity and resistance tests were conducted for the sample (V4) manufactured with Viscose-PCM material for wefts & Basket 2/2 weave structure which achieved the highest rates of mechanical and physical properties according to radar charts result, the thermal conductivity and resistance of this sample reached to 0.03 Wm-1K-1, 0.01 m2.K/W respectively.

Keywords : *Bamboo, Mechanical properties, Military, Phase Change Material, Thermal Conductivity*

Citation: Hafez S. Hawas & Doaa H. Elgohary - "Effect of the Construction Elements on the Mechanical Properties of Military Clothes", *Journal of the Textile Association*, **83/5** (303-309), (Jan-Feb'2023), https://doi.org/10.56716/4/1449

Article Received:22-08-2022, Revised:08-10-2022, Accepted: 28-11-2022

1. Introduction

Technical textiles were a type of fabric materials and were widely manufactured for their execution and technical characterization unlike other types of textiles which were manufactured for aesthetic properties [1,2,3]. They were widely used in many different applications like military, medical field, agriculture, space craft and communications [4,2]

Technical textiles provide invaluable properties for military purposes, which are necessary for movement and struggle in a hostile environment [5]. They are used worldwide to provide protection from the hazards of battlefield to the military and paramilitary forces. Clothing being the first layer of protection for the weaver, forms an important protective measure in military operation against combat and environmental hazards [6]. Whiles the comfort has taken a secondary role after the protection as primary purpose [7].
Textiles are key components of much military equipment, and the organization of the armed forces as well as their operations are unthinkable without them. Textiles are used for uniforms, tents, sails, saddle pouches, caparisons, parachutes, early model aero planes, camouflage nets, dinghies, body armor and more besides [9,8].

Military garment is exposed to many of external influences, both during wearing and maintenance. The fabric is gradually worn by light, sweat, abrasion, bending and stretching until it deteriorates [10]. Military clothing systems normally have to resist greater strains than normal garments.[11] Adequate strength and durability are the pre-requirements for any engineering materials, simply because they must be strong enough to function [7].

The behavior of a textile material depends on the mechanical properties, tension, and load application methods. These mechanical properties are important considerations for engineering design fabrics which differ qualitatively from each other. Fabric structure and properties are important to resist permanent deformation under applied stresses and subsequent uses [12]. Mechanical properties are very important properties of woven fabric, it effects on the stress a textile material can withstand during use [13].

The thermophysiological comfort of clothing is defined as concerning the heat and moisture transport properties of clothing and the way that clothing helps to maintain the heat balance of the body during various levels of activity [14]. An up-to-date solution for thermal comfort control of garment is to use microcapsules containing phase change material (PCM). Phase change materials (PCM) are thermal storage materials that are used to regulate temperature fluctuations. As thermal barriers they use chemical bonds to store and release heat and thus control the heat transfer, e.g., through buildings, appliances and textile products [1,15,16,17,18,19].

Thermal properties of textile materials play a significant role in engineering design of clothes. The thermal conductivity is an important material property because it affects the heat

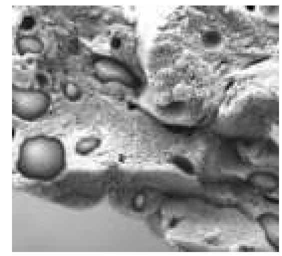
Corresponding Author:
Mr. Hafez S. Hawas
Associate Professor, Spinning and Weaving Dept., Faculty of Applied Arts, Helwan University, Cairo, Egypt
E-mail: Hafez_hawas2000@yahoo.com

flow in the material. Heat can be transferred from clothing to the environment to maintain its thermal balance through conduction, convection, and radiation [20]. Thermal conductivity is among important thermal properties of a fabric, which is also related to the breathability of the fabric. A fabric with a high thermal conductivity permits transfer of heat from a hot side, such as the human body to a cooler side such as the air on the other side of clothing. Thermal conductivities of textile structures in general vary from 0.033 to 0.10 W m-1 K-1 [21]. Thermal resistance is proportional to the fabric thickness, as stated in the following equation: {Thermal resistance = Thickness / Thermal conductivity} [14, 22, 23, 24]. The objective of this research was to analyze the mechanical and physical properties of military clothe fabrics with different yarn materials and weave structures to meet special requirements for military application.

2. Materials and Methods

This research clarifies the production of nine woven samples with different specifications, the samples were divided into three groups using various materials (viscose, polyester and bamboo) micro PCMs were incorporated into the polyester and viscose fibers, as shown in figure (1), three samples for each group using three different textile structures (Basket 2/2, Twill 2/2, Twill 1/3). Table (1) shows the produced samples specifications


(a)


(b)

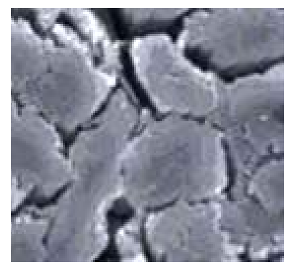

©

Figure 1: SEM of (a) Polyester PCM , (b) Viscose PCM and (C) Bamboo [25,26]

Table 1: Samples Specifications

Samples Code	Weave Structure	Warp Yarn Material	Weft Yarn Material	Warp Yarn Count Ne	Weft Yarn Count (Tex)	Fabric Density Ends * Picks)/inch	Mass per Unit Area (g/m²)[27]	Thickness (mm) [28]	Porosity
*P1	Basket 2/2	Cotton	Polyester	50/2	9	91*76	152.5	0.3	0.632
V4		Cotton	Viscose	50/2	16	91*76	152.7	0.3	0667
B7		Cotton	Bamboo	50/2	25	91*76	168.5	0.4	0.532
P2	Twill 2/2	Cotton	Polyester	50/2	9	91*76	173.7	0.4	0.685
**V5		Cotton	Viscose	50/2	16	91*76	213.2	0.5	0.721
B8		Cotton	Bamboo	50/2	25	91*76	211.2	0.5	0.531
P3	Twill 1/3	Cotton	Polyester	50/2	9	91*76	235	0.5	0.659
V6		Cotton	Viscose	50/2	16	91*76	161.8	0.4	0.736
***B9		Cotton	Bamboo	50/2	25	91*76	149.2	0.3	0.447
*P --- Polyester (PCM) ** V --- Viscose (PCM) *** B --- Bamboo									

2.1 Mechanical Properties tests

Seven mechanical testing were conducted for samples to examine its performance according to standard test methods and end use. Both breaking force, elongation and tear strength tests were performed at warp and weft directions using a universal testing machine according to ASTM D5035[29], for breaking force and elongation three reading were measured for each sample, while Tearing strength was applied according to ASTM D2261 [30], three replicates were measured for each sample highest five peaks forces were taken for each replicate, finally fifteen readings were taken for each replicate. Abrasion resistance of textiles were measured according to ASTM D4966,2012 [31]. Absorbency of Textiles were tested according to AATCC TM79–2000[32], three readings were taken for each sample and the average for all readings values were calculated.

2.2 Scanning Electron Microscope

Scanning Electron Microscope (SEM) instrument used to test the surface morphology of fabric sample as well as the fabric voids using an electron probe micro-analyser accelerating voltage 5 kV and magnification ranging from 100X to 1500X. The fabric sample was coated with gold in an S150A sputter (coated Edward, UK).

2.3 Thermal Conductivity

KES-F7 Thermo Labo was used. by constant thermal conductivity measurement, for measuring the ease at which heat transmitted from a heat plate with a temperature (30°C) through a sample to another heat plate with temperature (20°C). with (10°C) difference in temperature.

The physical and mechanical properties were examined at the Spinning and Weaving Engineering Department; also, some tests were performed at the Scientific Centre of Excellence for Textile Laboratories and Central Unit Analysis and Scientific Services at the National Research Centre.

2.4 Statistical analysis

All data were tabulated as mean as well as standard deviation values. ANOVA Two-way Measurements were used to show the significant effect between variables for samples at p ≤ 0.05, also differences between means were compared using Tukey Honest Significant Difference test (Tukey HSD test), both tests were examined using IBM® SPSS® (SPSS Inc., IBM Corporation, NY, USA) Statistics Version 22 for Windows.

3. Results and Discussions

Seven mechanical properties were performed to investigate the performance of nine woven samples as shown in table (2), mean values, standard deviation and Two-way Anova were presented and discussed at significant effect at P-value = 0.05, also the means compared using a Tukey Honest Significant Difference test at P-value = 0.05. Radar chart measured to show the best performance for samples according to end-use.

Table 2: Statistical Analysis for Variables

		Results							
Sample code	Weave structure	Breaking Load-warp (N)	Breaking Load-Weft (N)	Elongation Warp (%)	Elongation Weft (%)	Abrasion Resistance (No. of cycle)	Water Absorbency (Sec.)	Tear strength Warp (N)	Tear strength Weft (N)
P1	Basket 2/2	283.3(6.3)	634.1(26.9)	10.9(0.5)	29.4(2.5)	115.3(32.7)	50.3(2.1)	49.8(2.9)	51(10.2)
V4		285.8(7.8)	571.9(7.0)	11.9(0.3)	32.9(0.3)	50(0)	42.7(2.1)	30.9(2.2)	31.6(1.6)
B7		276.4(18.6)	293.9(9.8)	14.4(1.0)	17.4(0.5)	64(13.5)	54.7(3.8)	36.4(5.5)	30.2(1.1)
P2	Twill 2/2	301.7(9.1)	372.2(20.3)	14.5(0.1)	16.9(0.4)	87.3(24)	14.3(2.5)	67.9(4.2)	52.2(4.5)
V5		324.7(4.5)	609.1(7.3)	19.5(0.6)	19.4(0.9)	40(0)	7.3(1.5)	35.7(1.8)	50.2(3.9)
B8		284.2(7.2)	631.9(35.9)	16.5(0.3)	20.4(0.5)	35(8.7)	18.3(2.5)	37.9(3.3)	38.6(1.6)
P3	Twill 1/3	297.8(3.7)	282.8(21.8)	13.7(0.4)	17.0(0.8)	84.3(28)	9(1)	47.9(3.7)	26.7(2.7)
V6		292.4(13.8)	535.5(5.8)	13.3(0.5)	32.5(0.4)	110(28.2)	4.3(1.5)	31.7(1.6)	33.9(1.2)
B9		315.9(22.2)	674.0(20.2)	20.0(0.5)	18.3(0.5)	53.3(15.3)	14.3(3.1)	43.1(2)	67.7(5.7)
*P --- Polyester (PCM) ** V --- Viscose (PCM) *** B --- Bamboo									

( )-the values in parenthesis indicate the standard deviation

3.1 Mechanical Properties for Samples

3.1.1 Breaking Load

It was observed from the statistical analysis of two-way Anova of warp breaking load in Table (2) and Figure (2) that there was a significant effect for textile material at P-value (p=0.002), while there was no significant effect for weave structure at P-value (p= 0.292), on the other hand the interaction between textile material and weave structure there was a significant effect at P-value (p= 0.005). From the Tukey post Hoc test it was shown that for textile material there was a significant difference between (bamboo and polyester), (polyester and viscose). It was demonstrated for the effect of weave structure that there was no significant difference between all structures including (basket weave and twill 2/2), (basket weave and twill 1/3), (twill 2/2 and twill 1/3) respectively.

According to the statistical analysis of weft breaking load, it was observed from Table (2) and Figure (2) for textile material and weave structure that a significant difference was exist at P-value (p= 0.001), (p= 0.000) respectively. Furthermore, there was a significant difference effect for the interaction between textile material and weave structure at P-value (p= 0.000). It was obvious that form the Tukey's Test for Post-Hoc Analysis for textile materials that a significant difference occurred between (bamboo and viscose), (polyester and viscose) respectively. On the other hand, for weave structure a significant effect exists between all structures (Basket Weave and twill 2/2), (basket weave and twill 1/3), (twill 2/2 and twill 1/3) respectively.

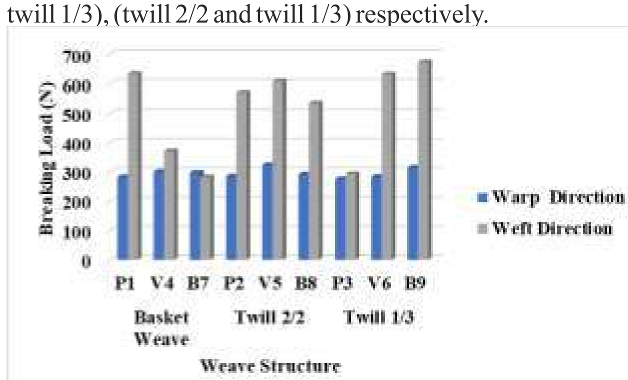


Figure 2: Breaking Load Test for Samples at Warp and Weft Direction

3.1.2 Elongation Variable

It was found from the statistical analysis of elongation at warp direction for textile material and weave structure as shown in table (2) and figure (3), that there was a significant difference at P-value (p= 0.000), (p= 0.000) respectively. Also, a significant difference occurred for the interaction between textile material and weave structure. On the other hand, the Tukey Honest Significant Difference test presented a significant difference between all textile materials (bamboo and viscose), (polyester and viscose), (bamboo and polyester). Furthermore, there was a significant difference between all weave structures (basket weave and twill 2/2), (basket weave and twill 1/3), (twill 2/2 and twill 1/3).

It was observed from the statistical analysis for weft elongation variable as shown in table (2) and figure (3), that a significant effect presented for for textile material, weave structure and the interaction between them at P-value (p= 0.000). It was seen from the analysis of Tukey post hoc test for textile material that a significant effect occurred between all materials, (polyester and viscose), (bamboo and polyester), (bamboo and viscose). On the other hand, a significant difference was existed between structures (basket weave and twill 1/3), (twill 2/2 and twill 1/3), (basket weave and twill 2/2).

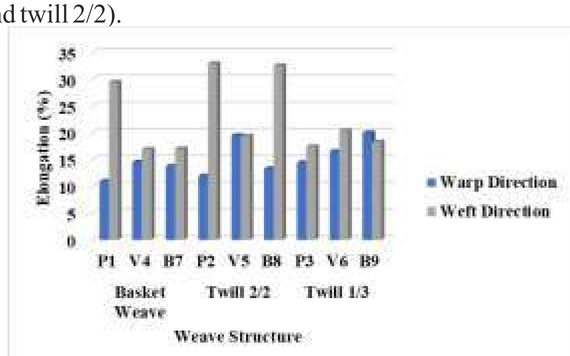


Figure 3: Elongation Test for Samples at Warp and Weft Directions.

3.1.3 Abrasion Resistance Variable

According to analysis of abrasion resistance as shown in figure (4) and table (2), it was found for textile material that a significant effect was existed at P-value (p= 0.020), while there was a significant difference between weave structures at P-value (p= 0.001). On the other hand, the interaction between materials and structures shows a significant difference at P-value (p= 0.017). It was observed from Tukey's Test for Post-Hoc Analysis for materials that no significant difference were occurred between materials (polyester and viscose), (bamboo and viscose), (bamboo and polyester). Also, a significant effect was presented between structures (basket weave and twill 2/2), (basket weave and twill 1/3) respectively.

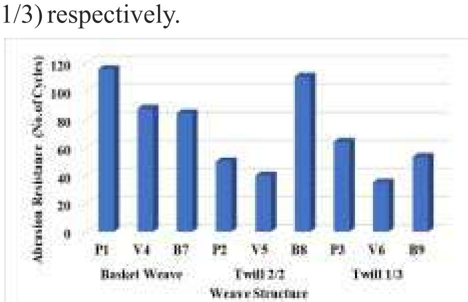


Figure 4: Abrasion Resistance Test for Samples.

3.1.4 Water Absorbency Variable

From the analysis of water absorbency variable, it was shown in table (2) and figure (5), that there was significant difference for materials and structures at P-value (p= 0.000), (p= 0.000), on the other hand, the interaction between materials and structures presented no significant effect P-value (p= 0.839). The analysis of the Tukey Honest Significant Difference test for materials observed a significant difference between all materials (bamboo and viscose), (bamboo and polyester), (polyester and viscose) respectively. Furthermore, a significant effect between textile structures were occurred (basket weave and twill 2/2), (basket weave and twill 1/3), (twill 2/2 and twill 1/3) respectively.

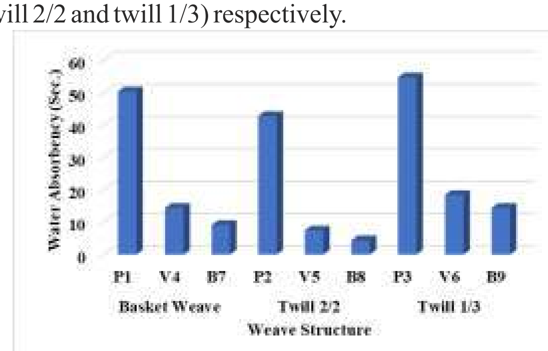


Figure 5: Water Absorbency Test for Samples.

3.1.5 Tear Strength

It was observed from the analysis of warp tear strength variable for weave structures and textiles materials as shown in figure (6) and table (2), there were a significant difference at P-value (p= 0.000), also the interaction action between structures and materials were obtained at P-value (p= 0.000). From the Tukey's Test for Post-Hoc Analysis, it was shown for textile materials that a significant difference occurred between (bamboo and viscose), (polyester and viscose). On the other hand, for structure, a significant effect was observed between (basket weave and twill 2/2), (basket weave and twill 1/3), (twill 2/2 and twill 1/3).

It was found from the analysis of weft tear strength that a significant difference occurred for weave structures and textile materials at P-value (p= 0.000), also a significant effect was existed for the interaction between weave structures and textile materials at P-value (p= 0.000), as shown in table (2) and figure (6). From the statistical analysis of Tukey post hoc test, it was seen that for textile materials there were a significant difference between all materials, furthermore a significant was observed between structures (basket weave and twill 2/2), (twill 2/2 and twill 1/3).

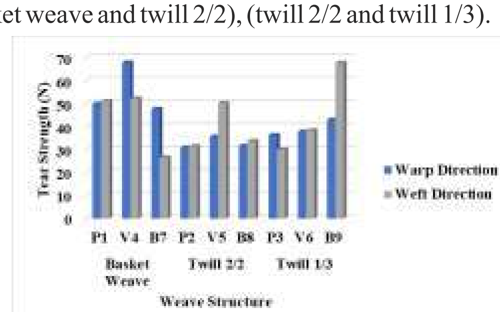


Figure 6: Tear Strength Test for Samples

3.2 Analyzing the mechanical Properties to Determine the Best Performance for Samples

The given results for mechanical and physical properties of samples were analyzed using radar chart, as shown in Figures (7,8,9) the radar area for each sample was calculated and the samples were ordered from best to lowest. From Table (3) it can be observed that, sample (V4) recorded the highest radar area while sample (B8) recorded the lowest radar area.

Table 3: Radar Chart Area Order

Sample Code	Radar Chart Area	Radar Chart Order	Sample Code	Radar Chart Area	Radar Chart Order	Sample Code	Radar Chart Area	Radar Chart Order
P1	43113.91	6	**V4**	56555.83	1	**B7**	53516.56	3
P2	39740.61	8	**V5**	48228.98	4	**B8**	39632.04	9
P3	40734.32	7	**V6**	47971.6	5	**B9**	53586.43	2

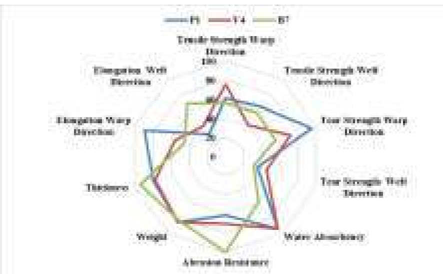


Figure 7: Radar Chart for Samples (P1, V4, B7) with structure Basket 2/2

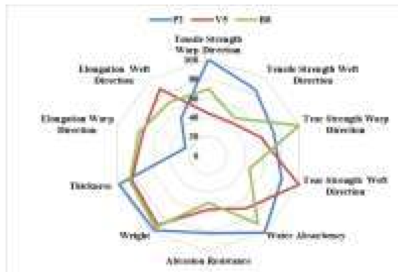
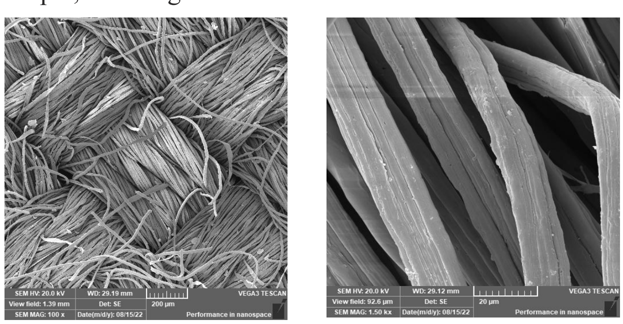


Figure 8: Radar Chart for Samples (P2, V5, B8) with structure Twill 2/2

Figure 9: Radar Chart for Samples (P3, V6, B9) with structure Twill 1/3

3.3 Scanning Electron Microscope

A scanning electron was performed for samples (V4) as presented in figure (10) and according to the radar chart result for best performance samples; the scanning was done to manifest the surface morphology of the manufactured sample, with magnification 100X and 1500X.



(a) 100x magnification *(b) 1500x magnification*

Figure 10: SEM images of (a) Viscose PCM sample with weave structure Basket 2/2

3.4 Thermal Conductivity

The sample which achieved a high mechanical and physical property according to the radar chart result as shown in table (10) were tested for studying the effect of Construction Elements on the thermal conductivity as shown in table (11).

Table 4: Thermal conductivity & resistant result of sample (V4) ±S.D

Samples Code	Weave Structure	Weft Yarn Material	Thermal conductivity ($Wm^{-1}K^{-1}$)	Thermal Resistant ($m^2.K/W$)
V4	Basket 2/2	Viscose PCM	0.03 ± (0.00153)	0.01± (0.0011)

From table (4) it was shown from the produced sample from Viscose pcm as weft material with weave structure basket 2/2 has recorded the thermal conductivity reached to 0.03 Wm-1K-1. The results of thermal conductivity can be explained by reviewing fiber morphology and its effect on contact areas between fabrics and skin [33]. As for the morphology, Viscose is less hairy, in addition to the low porosity of this sample as shown in figure (10) leads to decrease of trapped air in the fabric as a result the thermal conductivity increased and vice verses. Moreover, the plain-woven fabrics have higher thermal conductivity compared to twill woven fabrics [34].

4. Conclusion

The main objective of this paper was manufacturing a military clothes fabric and investigate the effect of research parameters (three weft materials & three weave structures) on the mechanical and physical properties, in addition to evaluate the thermal conductivity of the sample which achieve the best properties according to radar chart. From the results and statistical analysis concerned with the mechanical properties of produced military clothes fabrics evidently showed that:

From the statistical analysis of Two-way Anova, it was observed that all variables were significantly affected by textile materials, weave structures and the interaction between the textile materials and weave structures, except the weave structure for breaking load variable at warp direction at P-value (p= 0.292), also the interaction between textile materials and weave structures for water absorbency variable at P-value (p= 0.839).

From radar chart it can be concluded that, the best sample performance is (V4) with structure basket 2/2, manufactured with viscose material for wefts. Whilst the least sample performance is (B8) with structure twill 2/2, manufactured with Bamboo material for wefts.

From experimental work we conclude that there is an inverse relationship between porosity and thermal conductivity, in addition to the plain weave structure gives a high thermal conductivity.

5. Funding

This work did not receive any specific grant from funding agencies either public or not-for-profit sectors.

References

[1] Elgohary D.H., Hafez S. Hawas, Enhancing the Comfort Properties of Military Clothing using Phase Change Materials (PCMs) and Bamboo, Journal of the TEXTILE Association, 82 (1), 26-34 (2021)

[2] Doaa H. Elgohary, Y.A. Abo El Amaim, The Influence of Using Different Textile Structures and Yarn Counts on the Mechanical Properties of Woven Sacks, Journal of the TEXTILE Association. 78 (5), (2018)

[3] Khalifa Tamer F., Technical Textile; Design &Methodology, International Design Journal, 3 (1), (2012)

[4] Elgohary D.H., Elshakankery M. H., Analysis of the Mechanical Properties of Kevlar 29 Woven Fabrics, Journal of the TEXTILE Association, 80 (6), 441-447 (2020)

[5] Kovacevic S, Gudlin Schwarz I, Durasevic V. Analysis of Printed Fabrics for Military Camouflage Clothing, FIBRES & TEXTILES in Eastern Europe, 20 (3): 82-86 (2012)

[6] Revaiah, R. G, T. M. Kotresh, and Balasubramanian Kandasubramanian. "Technical Textiles for Military Applications." The Journal of The Textile Institute, 111 (2) (2019): 273–308. https://doi.org/10.1080/00405000.2019.1627987.

[7] Eugene Wilusz, "Military Textile", Wood head Publishing Ltd and CRC Press LLC, (2008)

[8] Steffens, Fernanda, Sharon Erckmann Gralha, Iêda Letícia Ferreira, and Fernando Ribeiro Oliveira. "Military Textiles - an Overview of New Developments." Key Engineering Materials 812 (2019): 120–26. https://doi.org/10.4028/www.scientific.net/kem.812.120

[9] Galster, Kjeld, and Marie-Louise Nosch. "Textile History and the Military: An Introduction." Textile History 41 (1) (2010) , https://doi.org/10.1179/174329510x12646114289347

[10] Jana Švecová , Radka Lopourová , Martin Novotný, Antonin Havelka, Measuring Selected Properties of Materials of Military Clothing for their Possible Innovation , Fibres and Textiles 28 (4), (2021)

[11] Lijing Wang"Performance Testing of Textiles", Wood head Publishing Ltd and CRC Press LLC, (2016)

[12] Ranjit T., Rupesh P., Structural behavior of fabric design on mechanical properties of woven fabrics, Melliand international, 25 (1),83-85, (2019)

[13] Hafez Hawas, Y.A. Abo El amaim "Influence of Using Different Blend Ratios of Banana Fiber on the Mechanical Properties of Woven Fabrics", Journal of Architecture, Arts and Humanistic Science, 6 (21), (2021) .https://doi.org/10.21608/MJAF.2020.33552.1670

[14] Niles, Nilhan, and Vithursha Vijayarajah. "A Study of the Effect of PEG-1000 Phase Change Materials Coating on Selected Fabric Properties." Journal of Industrial Textiles 52 (2022): 152808372211230. https://doi.org/10.1177/15280837221123066

[15] El-Homossani M., Gawad M. A., Khalifa T. F., Hawas H. S., Achieving Optimum Thermal Comfort Properties for Automotive Seat Fabrics, International of Advance Research in Science and Engineering, 4(11), 424–435 (2015)

[16] Khalil E., Application of Phase Change Materials in Textiles: A Review, International Journal of Research & Review, 2 (5), 281-294 (2015). ISSN: 2349-9788

[17] Ponnapally T., Bathula T., Dornala G., Development of PCMs Based Textiles for Military Applications, International Research Journal of Engineering and Technology, 06 (03), 2107-2116 (2019)

[18] MedCrave, Thermo regulated clothing with phase change materials, Journal of Textile Engineering & Fashion Technology, 4 (5), 344–347 (2018)

[19] Fengzhi L., Penghao R., Influences of the PCM Microcapsules on Thermal Properties of the Garment, International Conference on Information Sciences, Machinery, Materials and Energy, 614-618 (2015)

[20] Siddiqui, MOR & Sun, D, 'Thermal Analysis of Conventional and Performance Plain Woven Fabrics by Finite Element Method', Journal of Industrial Textiles, 48 (4), 685-712, (2018)

[21] Kalaoglu-Altan, Ozlem Ipek, Burcak Karaguzel Kayaoglu, and Levent Trabzon. "Improving Thermal Conductivities of Textile Materials by Nanohybrid Approaches." iScience 25 (3), (2022), 103825. https://doi.org/10.1016/j.isci.2022.103825

[22] Uttam D. Objective measurement of heat transport through clothing. Int J Eng Res Dev, 2 (12), 43–47, (2012)

[23] Garg, Samridhi, Vinay K Midha, and Monica Sikka. "Studies on Thermal Comfort of Multi-Layered Fabric Assembly after Wetting with Sweat and Distilled Water." Journal of Industrial Textiles 52 (2022): 152808372211101. https://doi.org/10.1177/15280837221110105

[24] BS 4745. Determination of Thermal Resistance of Textiles, London: British Standards Institute, 1971

[25] http://www.outlast.com (Augest 2022)

[26] Hafez S. Hawa, Investigation of Comfort Properties of Bed Sheet Fabrics Using Different Weft Materials and Weave Structures, International design journal, 10 (4), 2020. https://doi.org/10.1016/j.isci.2022.103825/ 10.21608/idj.2020.113238
[27] ASTM D3776, 2002. "Standard Test Methods for Mass per Unit Area (Weight) of Fabric"
[28] ASTM D1777, 2002. "Standard Test Methods for Thickness of Textile Materials"
[29] ASTM D5035, 2011. "Standard Test Methods for Breaking Force and Elongation of Textile Fabrics (Strip Method)"
[30] ASTM D2261, 2002. "Standard Test Methods for Tearing Strength of Fabrics by the Tongue (SingleRip) Procedure (Constant -Rate-of-Extension Tensile Testing Machine)"
[31] ASTM D4966, 2012. "Standard Test Method for Abrasion Resistance of Textile Fabrics
[32] AATCC TM79, 2000 " Standard Test Method for Absorbency of Textiles"
[33] Nassar, Khalid Mansour; Mohsen;, Nahla; and Abou Taleb, Eman "Improving the thermal comfort properties of bamboo and bamboo blended fabrics for sports head scarves," International Design Journal, 10 (4), (2020)
[34] Umair, Muhammad, Muhammad Usman Javaid, Yasir Nawab, Madeha Jabbar, Shagufta Riaz, Hafiz Affan Abid, and Khubab Shaker. "Thermal Properties of Woven Fabric as a Function of Its Structural Parameters: Experimentation and Modeling." Research Journal of Textile and Apparel, 2022. https://doi.org/10.1108/rjta-10-2021-0123

Functional Properties of Polyester/ Bamboo & Polyester/ Cotton Blended Yarns & Knitted Fabrics

Shivam Pandey* & Rajiv Kumar

M. L.V. Textile & Engg. College, Bhilwara, (Raj.), India

Abstract

In the present work, influence of fibres type, blend & yarn count on different functional properties of Polyester/Cotton and Polyester/Bamboo blended fabrics have been studied. Three blend proportions of polyester/bamboo and polyester/cotton (80/20, 65/35, 50/50) are used to produce yarns of two linear densities (20s and 30s Ne), then twelve knitted fabric samples have been made from these yarns samples. However, increase in cotton content in the blend proportion enhances unevenness, imperfections & hairiness. Hairiness value reduces with increase in bamboo content in blend proportion. Polyester/ bamboo blended fabrics have higher value of abrasion resistance, air permeability, water vapour permeability and total absorbency rather than polyester/cotton blended fabrics. On the other hand, lower value of bursting strength, pilling resistance and vertical wicking is noticed in polyester/bamboo fabrics.

Keywords: *Abrasion, Air permeability, Bamboo, Cotton, Bursting strength, Fabric comfort, Moisture vapour transfer, Pilling, Whiteness Index*

Citation: Shivam Pandey & Rajiv Kumar, "Functional Properties of Polyester/ Bamboo & Polyester/ Cotton Blended Yarns & Knitted Fabrics", *Journal of the Textile Association,* **83**/5 (310-316), (Jan-Feb2023), https://doi.org/10.56716/4/1453

Article Received: 22-09-2022, Revised: 02-12-2022, Accepted: 25-11-2022

1. Introduction

IWith the great changes in technology in the last decade, the demands from fabrics have changed and the changes include clothing comfort which have psychological, sensorial and thermo-physiological comfort. It is now not only about style and durability. The main factors affecting comfort are fibre type, yarn properties, fabric structure, finishing treatments and clothing conditions [1, 2, 4]. The proportion of fibres in the blend plays a vital role and apart from it, the properties of blended yarns depends on the properties of the constituent fibres and their compatibility [3]. Moreover, it has been observed that the stronger component has to be blended at least by a certain proportion in order to enhance tensile properties [5, 8].

Also, bamboo cultivation does not require fertilizers, pesticides and chemical herbicides. To avail the positive attributes of the fibre and to achieve economy we have tried blending bamboo with polyester. The secondary reason for selecting this blend lies in the fact that when it is wet, bamboo fibre gets low tensile strength which decreases further [1].

Healthcare and hygiene sector is an important aspect of textile among other medical applications. Both disposable and non disposable items are produced such surgical gown, mask, surgical drape, sanitary napkins towels, gloves baby diapers, and so on used in hospitals. Bamboo fibre is highly water absorbent, able to take up three times of its weight of water that makes it ideal for processing into textiles. Bamboo fibre doesn't cause skin allergies since it has natural effect of sterilization, moisture vapour transmission property and easy drying and so its application in sanitary materials such as baby diaper, sanitary towels, absorbent pads and is found to increase [6, 7].

Corresponding Author:
Mr. Shivam Pandey
M. L.V. Textile & Engg. College, Pur Road,Bhilwara, (Raj)
E-mail: shivammlv@gmail.com

1.1 Objectives of the study are as follows

To find out influence of fibres type, blend & yarn count on different functional properties of Polyester/Cotton and Polyester/Bamboo blended fabrics.

1.2 Preparation of yarn samples

Polyester and its blend with Bamboo and Cotton fibres used for preparing yarns of 20s Ne and 30s Ne were spun from using different blend ratios (50:50, 65:35, 80:20) ., Polyester fibres were blended with Bamboo and cotton fibers manually in the ratio of Polyester: Bamboo (50:50, 65:35, 80:20) and Polyester: Cotton (50:50, 65:35, 80:20).

1.3 Preparation of fabric samples

From above blended yarns, twelve different fabric samples, using different count and blend on single jersey circular knitting machine and keeping same sett were prepared.

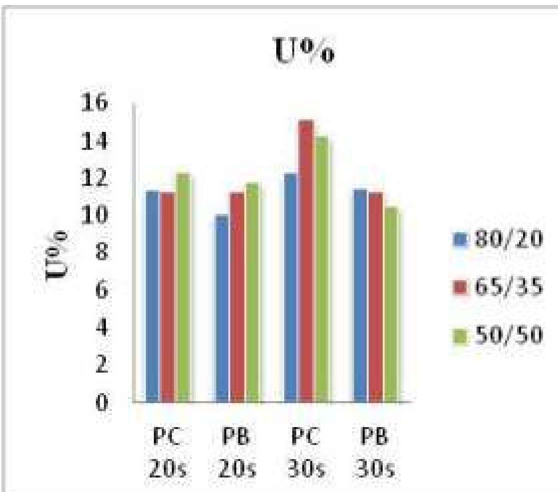
2. Result & Discussion

2.1 Yarn properties - U % & Imperfections

As linear density increases, unevenness & imperfections increases. The main reason of imperfections in the yarn is substantial variation in the numbers of fibres in the yarn cross section along the length. The increase in cotton content leads to increase in unevenness and imperfections. Polyester/Cotton blended yarns have 13% higher U% than polyester/bamboo blended yarns. As the yarn become finer the numbers of fibre in cross section decreased and the yarn imperfections increased [9]. Polyester/cotton blended yarns have 30% higher imperfections than polyester/bamboo blended yarns. Blend Percentage have a greater influence upon imperfections such as thick places and neps.

Table 1- U% & IPI of Polyester-cotton & Polyester-Bamboo blended ring spun yarn

Yarn count (Ne)	Blend	U %		Imperfections					
		Polyester-cotton	Polyester-bamboo	Polyester-cotton			Polyester-bamboo		
				-50%	+50%	+200%	-50%	+50%	+200%
20s	80/20	11.33	10.02	10.0	27.0	17.0	2.50	17.5	5.00
	65/35	11.25	11.27	2.50	47.5	15.0	3.50	22.5	25.0
	50/50	12.30	11.79	5.00	27.0	25.0	0.0	25.0	20.0
30s	80/20	12.24	11.42	30.5	25.0	41.5	15.0	27.5	22.5
	65/35	15.07	11.26	2.90	75.5	25.0	2.50	67.5	7.50
	50/50	14.23	10.45	8.50	37.0	77.5	0.0	45.0	42.5



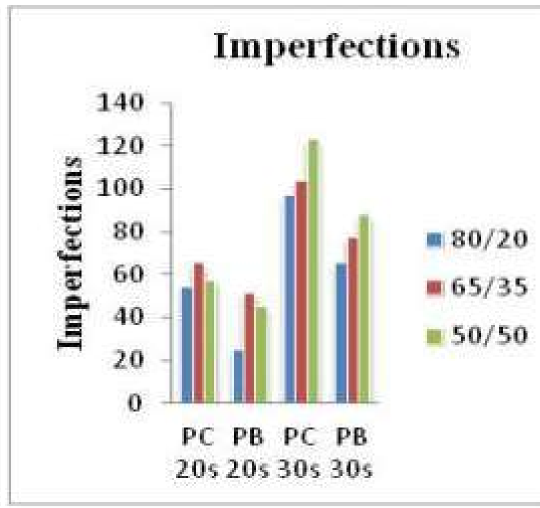


Figure 1: Variation in yarn unevenness & imperfections with count, blend & fibre type

2.2 Tenacity & Hairiness

As bamboo and cotton content increases, tenacity of the yarns reduces. It is also observed that as the proportion of bamboo fibre increases, the tenacity of the yarns improves compare to cotton. Polyester/bamboo blended yarns have 18% higher tenacity than polyester/cotton blended yarns. The breaking elongation of cotton fibre is much lower than the bamboo fibre, so cotton fibres are expected to reach the rupture point earlier during tensile testing of polyester-bamboo yarns [5].

As the proportion of bamboo fibre increases, the hairiness of the yarn gradually decreases when compared with cotton blended yarns, this is due to fibre flexural and torsional rigidity. The flexural and torsional rigidity of bamboo fibre is lower than that of cotton. Therefore, bamboo fibres are wrapped very easily in the yarn body thus the hairiness reduces with the increase in bamboo fibre proportion [5]. Polyester/bamboo blended yarns have 6% lesser hairiness than polyester/cotton blended yarns. A marked reduction is observed in hairiness with increase in linear density from 20s to 30s. As the yarn becomes finer, for the same blend proportion, the number of fibres reduces and probably this reduction happens in equal proportion in different length groups.

Table 2 - Hairiness, Tenacity & Breaking load of Polyester-cotton & Polyester-Bamboo blended ring spun yarn

Yarn Count (Ne)	Blend	Tenacity (GPT)		Hairiness (UT-5)		Breaking Load (Gf)	
		Polyester-Cotton	Polyester-Bamboo	Polyester-Cotton	Polyester-Bamboo	Polyester-Cotton	Polyester-Bamboo
20s	80/20	24.85	32.57	6.65	5.66	733.8	961.6
	65/35	22.70	28.17	6.91	6.23	670.4	831.7
	50/50	21.84	25.83	7.39	6.29	644.9	762.7
30s	80/20	30.23	31.15	5.69	6.10	702.9	613.1
	65/35	24.23	29.92	5.91	5.86	673.9	589.0
	50/50	21.00	28.94	6.53	6.68	413.4	569.6

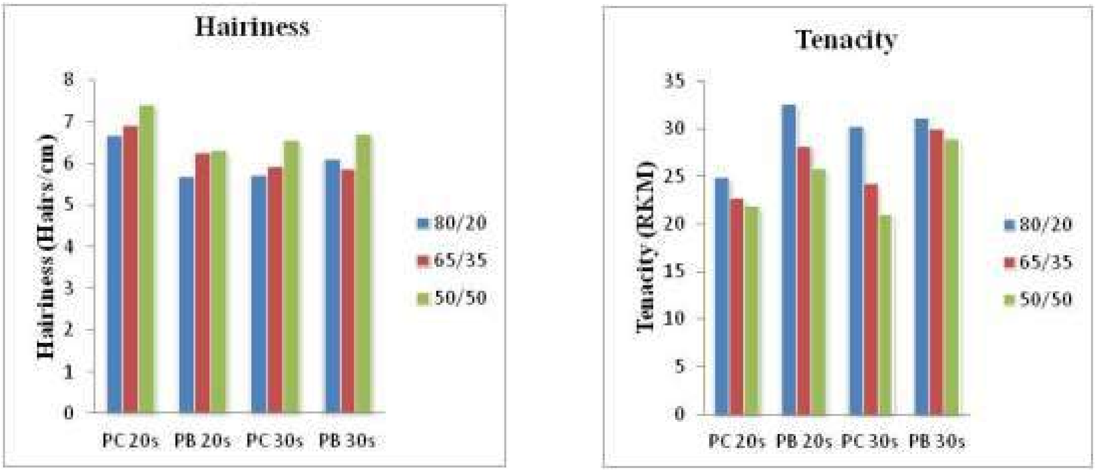


Figure 2 - Variation in yarn tenacity & hairiness with count, blend & fibre type

2.3 Bursting strength

The influence of yarn count, blend, fibre type on the bursting strength of the fabrics has been shown in Table-3. As shown in Fig-3 the bursting strength of the fabric reduces with increase in bamboo and cotton content in the blend. The bursting strength of the fabric depends on many parameters like fibre content, blend. The elongation at break point of the bamboo & cotton are lower than the polyester so a decrease in elongation in yarn will result in reduction in bursting strength [1]. The calculated value of "F" is greater than the table value which shows that there is a significant relationship between bursting strength, count and blend but not significant for fibre type at 5% level.

Table 3 - Variation in fabrics bursting strenght

Yarn Count (NE)	Blend	Bursting Strength (lbs/inch^2)	
		Polyester-cotton	Polyester-bamboo
20^s	**80/20**	170	152.5
	65/35	130	127
	50/50	125	110
30^s	**80/20**	120	115
	65/35	110.5	90
	50/50	99	80.5

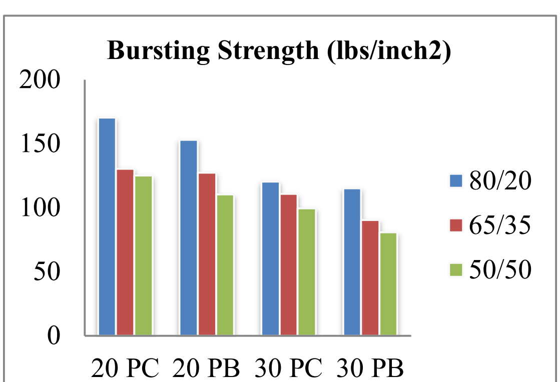


Figure 3 - Variation in fabrics bursting strength

2.3 Abrasion resistance

As shown in Fig.-4, the abrasion resistance of the fabric reduces with increase in bamboo and cotton content in the blend. It is observed that the weight loss% increases with increase in cotton and bamboo content and weight loss% is significantly higher in polyester- cotton blends with comparison to polyester-bamboo content. So resistance to abrasion is increased with the increase in bamboo fibre content in the blend [1]. Actually both bamboo and polyester fibre are good in terms of abrasion resistance because of their high elasticity. Finer count has more abrasion resistance as compare to the courser one this is due to yarn compactness, yarns of 30s count has more TPI than that of 20s, high level of twist helps to resist abrasion as the fibres can't easily pulled out of the yarn. The calculated value of "F" is greater than the table value which shows that there is a significant relationship between abrasion resistance, count and blend. The effect of blend is found to be significant but not significant for count & fibre type at 5% level.

Table 4 - Variation in fabrics weight loss (%)

Yarn count (Ne)	Blend	Weight loss (%)	
		Polyester-cotton	Polyester-bamboo
20^s	**80/20**	0.35	0.46
	65/35	0.58	0.91
	50/50	1.04	1.01
30^s	**80/20**	0.47	0.33
	65/35	0.82	0.61
	50/50	1.22	0.92

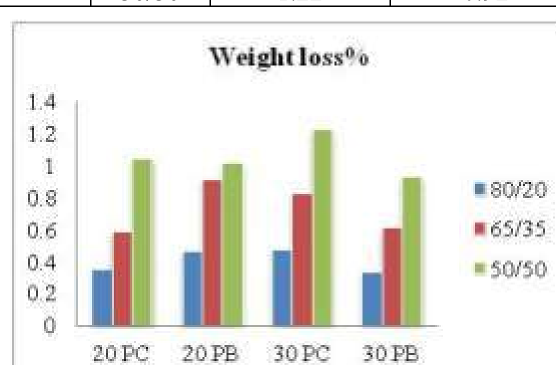


Figure 3 - Variation in fabrics bursting strength

3. Pilling

As shown in Fig.-5, it is observed that pills increase with increase in polyester content. This is due to high strength of the polyester fibre. As count become finer bigger pills become less but medium & small pills increases [10]. As yarn became finer, hairiness reduces; results in less pilling. Pilling resistance of fabric increases after finish, this is due to removal of protruding cellulosic fibre [11]. The table value of "F" at α = 0.05% confidence limit and 2 degree of freedom is "F" (table value). Calculated value of "F" is greater than the table value which shows that there is a significant relationship between pilling resistance, count and blend. The effect of count, blend & fibre type are found to be significant at 5% level.

Table 5 - Variation in fabrics pills/inch2

Yarn count (Ne)	Blend	Pills/Inch^2	
		Polyester-cotton	Polyester-bamboo
20^s	80/20	72	99
	65/35	55	89
	50/50	45	70
30^s	80/20	53	85
	65/35	45	70
	50/50	40	58

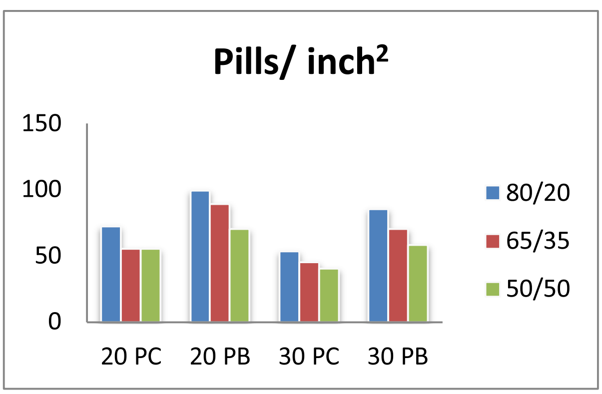


Figure 5 - Variation in fabrics pills/inch2

3.1 Air permeability

As shown in Fig.-6 the air permeability of the fabric increases with the increase in bamboo and cotton content in the blend and air permeability values are higher in bamboo blend compared to cotton blends. This can be explained in terms of enhanced rate of air flow as a consequence of the reduce bulk of bamboo majority yarn & bamboo majority yarns have lesser hairiness, which means that they offer less resistance to flow of air [3]. The air permeability of the cotton blended fabrics is slightly less when compared to bamboo blended fabrics. Calculated value of "F" is greater than the table value which shows that there is a significant relationship between air permeability, count and blend. The effect of fibre type is found to be significant but not significant for count & blend at 5% level.

Table 6 - Variation in fabrics air permeability

Yarn count (Ne)	Blend	Air permeability (cm^3/cm^2.sec)	
		Polyester-cotton	Polyester-bamboo
20^s	80/20	643.27	716.76
	65/35	649.22	686.29
	50/50	679.85	720.72
30^s	80/20	679.15	706.57
	65/35	695.86	683.45
	50/50	697.33	720.16

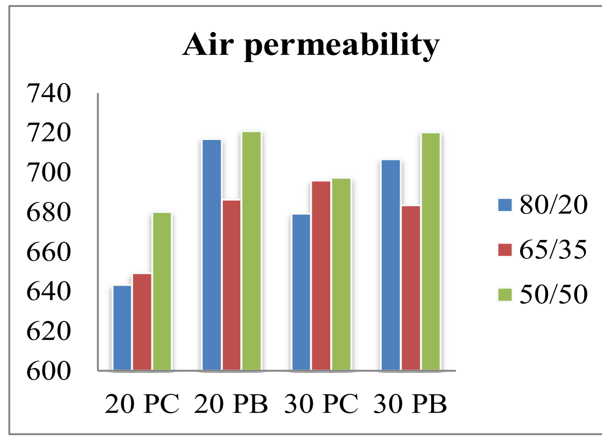


Figure 6 - Variation in fabrics air permeability

3.2 Water vapour permeability

As shown in Fig.-7, water vapour permeability of the fabrics increases with the increase in bamboo and cotton content and water vapour permeability is higher in bamboo majority blends compared to cotton majority blends. As the count of the yarn decreases, water vapour permeability of the fabrics decreases. The water vapour permeability of the fabrics is highly dependent on the micro porous structure and moisture regain of the constituent fibres. As cellulosic content increase in fabric, moisture regain of the fabric will increase causing higher diffusivity [12, 3]. Calculated value of "F" is greater than the table value which shows that there is a significant relationship between water vapour permeability, count and blend. The effects of blend & fibre type are found to be significant at 5% level but not signif***icant for count at 5% level.***

Table 7 - Variation in fabrics water vapour permeability

Yarn count (Ne)	Blend	Water Vapour permeability	
		Polyester-cotton	Polyester-bamboo
20^s	80/20	1142.72	1192.92
	65/35	1424.81	1477.40
	50/50	1716.47	1804.92
30^s	80/20	1047.09	1211.61
	65/35	1463.06	1353.09
	50/50	1685.39	1443.94

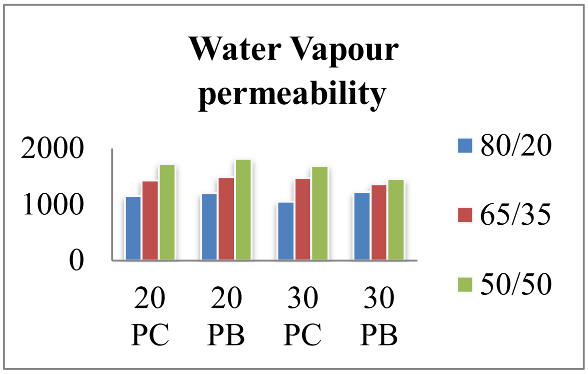


Figure 7 - Variation in fabrics water vapour permeability

3.3 Total absorbency

As shown in Fig-8 the absorbency of the fabrics increases with the increase in bamboo and cotton contents. Bamboo blended fabrics have higher water absorbency compared to cotton blended fabrics. Very remarkably the absorbency of P/C & P/B is improved by reducing yarn count, the significant increase indicate that the wet ability and penetrability of material to liquid improve due to the micro channels present in the fibre which transfer water through fibre.[3] Calculated value of "F" is greater than the table value which shows that there is a significant relationship between total absorbency, count and blend. The effects of blend, fibre type & blend are found not to be significant at 5% level.

Table 8 - Variation in fabrics total absorbency

Yarn count (Ne)	Blend	Total Absorbency (%)	
		Polyester-cotton	Polyester-bamboo
20^s	80/20	195	215.7
	65/35	218.74	221.14
	50/50	255.87	273.89
30^s	80/20	211.83	289.3
	65/35	287.72	319.92
	50/50	293.02	351.55

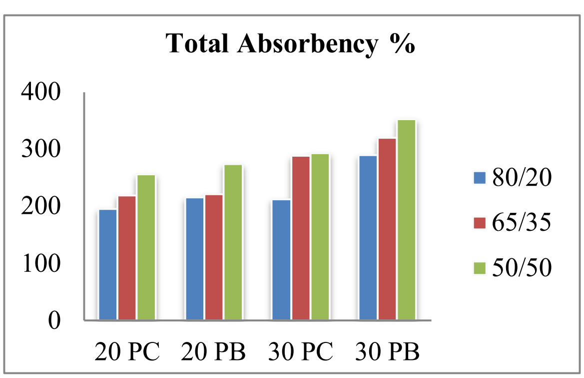


Figure 8 - Variation in fabrics total absorbency

3.4 Vertical wicking

The influence of count, blend, fibre type on the vertical wicking (wale wise & course wise) of the fabrics has been shown in Table 9 & 10. As shown in Fig. 9 & 10 the wicking of polyester/cotton blended fabrics is higher than the polyester/bamboo blended fabrics in wale wise wicking direction, while the wicking of polyester/bamboo blended fabric higher in course wise direction. This is due to the fact that the transfer of water is easier in wale wise direction, due to better capillary action in wale wise direction [1]. Vertical wicking reduces in both cases with the increase in count. Wicking increases with increase in bamboo content, this is due to the bamboo fibre retains the water absorption properties [1]. Calculated value of "F" is greater than the table value which shows that there is a significant relationship between wicking (wale wise), wicking (course wise), count and blend.

The effect of count & fibre type on wicking (wale wise) is found significant at 5% level but not significant for blend at 5% level.

The effects of fibre type on wicking (course wise) are found to be significant at 5% level but not significant for count & blend at 5% level.

Table 9 - Variation in fabrics wicking (15 min)

Yarn count (Ne)	Blend	Vertical Wicking(cm) (wale wise)	
		Polyester-cotton	Polyester-bamboo
		15 Min	15 Min
20^s	80/20	5.7	6.5
	65/35	5.3	6.6
	50/50	5.5	6.9
30^s	80/20	5.5	5.5
	65/35	5.0	5.9
	50/50	5.1	6.6

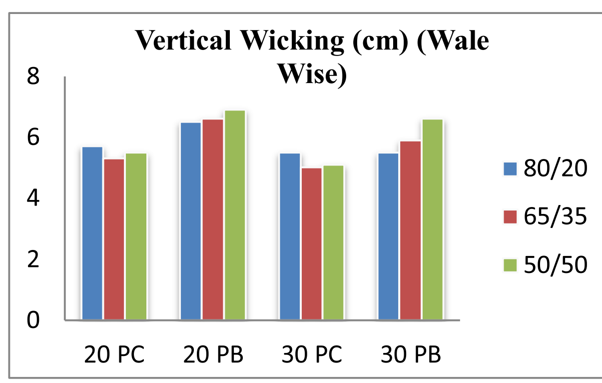


Figure 9 - Variation in fabrics wicking (15 min)

Table 10 - Variation in fabric wicking (15 min)

Yarn count (Ne)	Blend	Vertical Wicking(cm) (course wise)	
		Polyester-cotton	Polyester-bamboo
		15 min	15 Min
20^s	80/20	4.7	5.5
	65/35	5.0	6.0
	50/50	5.0	6.8
30^s	80/20	5.1	5.3
	65/35	4.3	5.3
	50/50	4.3	6.3

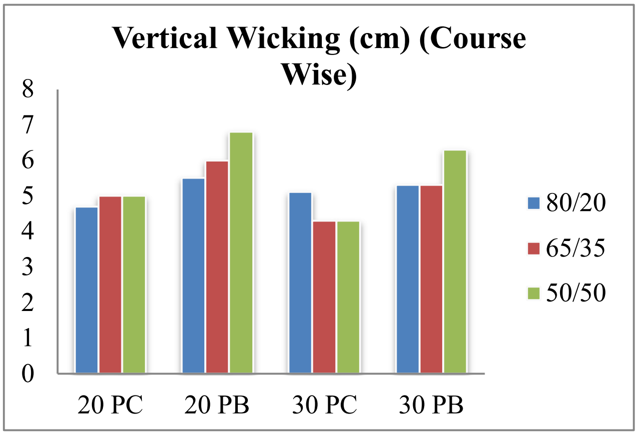


Figure 10 - Variation in fabric wicking (15 min)

3.5 Whiteness index

The influence of count, blend, fibre type on water vapour permeability of the fabrics has been shown in Table 11. As shown in Fig.11 whiteness of the fabrics increases with the decrease in bamboo and cotton content, whiteness is higher in polyester/bamboo blends compared to polyester/cotton blends, this is due to the fact that bamboo and cotton fibre are yellower than polyester or viscose [1]. So, as the bamboo content increases fabric yellowness increases and thus the whiteness index decreases. As the count of the yarn decreases, whiteness of the fabrics decreases. Calculated value of "F" is greater than the table value which shows that there is a significant relationship between whiteness index, count and blend. The effect of fibre type is found to be significant but not significant for count & blend at 5% level.

Table 11 - Variation in fabric whiteness Index

Yarn count (Ne)	Blend	Whiteness Index	
		Polyester-cotton	Polyester-bamboo
20s	80/20	56.64	59.31
	65/35	50.44	58.41
	50/50	49.62	57.24
30s	80/20	48.93	64.53
	65/35	48.84	64.26
	50/50	47.38	59.71

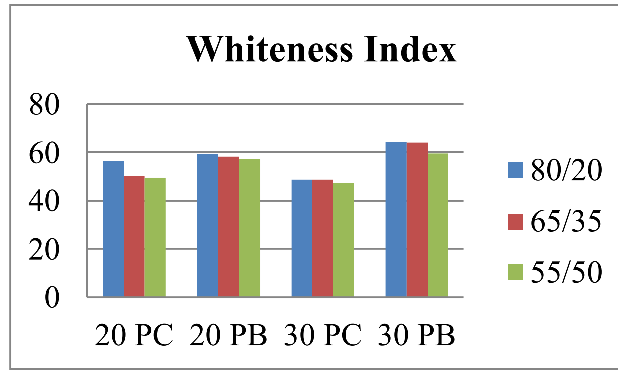


Figure 11 - Variation in fabric whiteness Index

4. Conclusion

Effects of Fibre

The polyester/bamboo blended yarns are different from polyester/cotton blended yarn in terms of their physical and mechanical properties. However, increase in cotton content in the blend enhances unevenness, imperfections & hairiness, in comparison to bamboo blended fabrics; on the other hand tenacity reduces. Tenacity increases with increase in bamboo content in blend proportion. Bamboo blended fabrics have higher values of air permeability, water vapour permeability, total absorbency, wicking and whiteness index rather than cotton blended fabrics.

Effect of Blend

With the increase in polyester content in blend, bursting strength and whiteness index increases. On the other hand pilling resistance, air permeability, water vapour permeability and total absorbency increase as bamboo and cotton content increases.

Effect of Count

As linear density increases bursting strength, abrasion resistance, water vapour permeability and whiteness index reduced. But pilling, air permeability, total absorbency and wicking increased.

For the apparel purpose 20s Polyester/bamboo is better compare to other fabric, this is due to its better tensile and moisture related properties.

References

[1] Sudipta S Mahish, A K Patra & Rashmi Thakur, "Functional properties of bamboo/polyester blended knitted apparel fabrics", Indian J Fibre Text Res, Vol.37, pp. 231-237, September 2012

[2] R. K. Nayak, S K Punj & K N Chatterjee, "Comfort properties of suiting fabrics", Indian J Fibre Text Res, Vol. 34, pp. 122-128, June 2009

[3] G.K. Tyagi, S.Bhattacharaya & G.Kherdekar,"Comfort Behavior of Woven Bamboo-Cotton Ring and MJS Yarn Fabrics", Indian J Fibre Text Res, Vol.36, pp.47-52, March 2011

[4] Ajay Rathod & Avinash Kolhatkar, "Analysis of Physical Characteristics of Bamboo Fabric", International J Res in Engg Tech, Vol.03, August 2014

[5] Abhijit Majumdar, Samrat Mukhopadhyay, Ravindra Yadav & Achintya Kumar Mondal,"Properties of ring-spun yarns made from cotton and regenerated bamboo fibres," Indian J Fibre Text Res, Vol.36, pp.18-23, March 2011

[6] L. Shanmugasundaram & R V Mahendra Gowda,"Development and characterization of bamboo and organic cotton fibre blended baby diapers," Indian J Fibre Text Res, Vol.35, pp.201-205, September 2010

[7] P. Kandhavadivu, R Rathinamoorthy & R Surjit,"Thermoregulatory characteristics of bamboo / lyocell union fabrics," Indian J Fibre Text Res, Vol.39, pp.386-393, December 2014

[8] C. Prakash1, G Ramakrishnan2 and C V Koushik,"Effect of blend ration on quality characteristics of bamboo/cotton blended ring spun yarn," Daffodil Int University J Sci Tech, Vol.7, January 2012

[9] M. Nawaz, N. A. Jamil, M. Iftikhar and B. Farooqi "How does open-end processing variable effect imperfections for different yarn count? ", Pakistan Text J, Vol. 23, March 2003

[10] I. C. Sharma, K. N. Chatterjee & A. Mukhopadhyay, "A Critical appraisal of pilling on polyester worsted fabric", Indian J Fibre Text Res, Vol. 21, pp. 122-126, June 1996

[11] H. Noreen, Mohd. A. Zia, "Optimization of bio-polishing of polyester/cotton blended fabric with cellulosed prepared from Aspergillus Niger", Indian J of Biotech, vol. 13, pp108-113, 2013

[12] P. Kandhavadivu, R Rathinamoorthi & R Surjit,"Moisture and thermal management properties of woven and knitted tri-layer fabrics," Indian J Fibre Text Res, Vol.40, pp.243-249, September 2015

■ ■ ■

Call for Articles

Journal of the Textile Association

Journal of the Textile Association (JTA) is open access bimonthly prestigious Peer Reviewed Journal. Blind Review Process is being followed to ensure the integrity of the blind peer review for submission to this journal. Every effort is made to prevent the identities of the authors and reviewers from being known to each other. For this the reviewer should not be from the same organization as that of the author. The author should submit three reviewers, which are related to the field of the subject paper with full contact details and reasoning for suggesting this reviewer.

JTA welcomes Original Manuscripts, Research Papers, Review Paper and Case Studies from the researchers, academicians and business people all around the globe. Especially we are publishing new and emerging areas of Textile Science, Technology, Engineering and Management. Your contribution of Research & Review Article is an honor for us. Follow the Guidelines.

Send to: jtaeditor@gmail.com

Cost Reduction Techniques for Growing Businesses: A Case Study with Polyester DTY Machine

Bibekananda Basu*
Retired GM, RIL Group, Silvassa & Textile Consultant

Abstract
Every Industry is facing cutthroat competition to survive in the domestic as well as in the global market and hence they are adopting lots of Cost cutting measures. To sustain in the Business world, it is highly necessary, but how? By simply reducing the staffs, reducing their salaries may create reverse effect. Staffs are to be motivated; Skills are to be developed, proper maintaining the relationship with the whole category of the employees, consider them as assets will improve the productivities. So, there should be right decision in the right direction for the Cost reduction process. New & newer value-added product developments, power saving, development of the machineries which can deliver better products at lower cost, enhance productivity, zero waste generation with recycle & reuse, strong R&D and sound Market research will lead the industries at profit making areas.

The Author has taken the case studies in the Polyester DTY machine which is now a booming Industry where all the possibilities of Cost cutting and enhancing the profitability are discussed. Those who are taking innovative measures rather than any short cut method are the gainers now a days. Too much cost reduction at the comfort of the workmen is also discussed.

Keywords: *Cost reduction, power cost, manpower utilization, DTY machine, value addition*

Citation: Bibekananda Basu, "Cost Reduction Techniques for Growing Businesses: A Case Study with Polyester DTY Machine", *Journal of the Textile Association,* **83/5** (317-320), (Jan-Feb2023), https://doi.org/10.56716/4/1454

Article Received: 18-10-2022, Revised: 22-12-2022, Accepted: 14-11-2022

1. Introduction

The cost control conception is not a new idea today but from the time of Industrialisation. It has become more essential as and when the Productivity cost increased, competition increased, and sales value decreased. Today, as there is tremendous industrial growth, obviously the profit margins are in decreasing order. But the survivors are there who could take the right decision at right time. A chunk of industries is always thought to reduce the staffs and their perks in the name of cost reduction which has become "penny wise pound foolish" at some times. It requires high strategic planning after discussing with the Plant people. The author has observed that "better to have one efficient and capable man than to have ten unfit men". That becomes more danger in most of the time. The case study in the DTY Plant has shown how best the cost reduction was done in gradual order with proper technical thought and plannings! It need to understand the potential possibilities of a manufacturing unit. (If it works in line with the best industry standard on all spheres).

Corporate Management information system is the backbone for achieving the best standard in the industry but even today, it is not given due importance. The industries must opt for the inventory control, quality of the raw materials, quality impact, production efficiencies (increase efficiency/ Utilisation%, minimise break downs, absenteeism), value loss due to the poor qualities, maintenance cost, power cost, water / utility costs, sewage & treatment costs, fuel/steam, packing cost etc. Try to reduce the travel costs, should have weekly/monthly progress report, and involve the floor level staffs for their contributions. All such factors will lead to cost control.[1] .

Corresponding Author:
Mr. Bibekananda Basu
Adjunct Faculty, Shri Guru Govind Singhji Institute of Engineering and Technology (SGGSIE&IT), Vishnupuri, Nanded – 431 606
E-mail: bibekananda.basu1502@gmail.com

2. How to Lower Business Expenses

Expense reduction requires serious thought and an organized approach so that you can reduce waste without impacting the quality of your services and products. At each stage of Production, proper auditing, vigilance, and quality checking should be done to find any leaking out of any product at any point.

2.1 What Is Cost Reduction? [2]

Cost reduction is the process of reducing unnecessary expenses to increase their bottom line. Methodologies and results vary from business to business. However, effective cost-cutting is a dynamic, continuous, and reflective process. Not to compromise with quality and production. But it's not as simple as one thinks. If anyone approaches cost reduction from an elimination-only mindset, it will miss out on a lot of other very useful strategies. Shockingly, it could end up badly effecting the business more. It would be a disaster.

2.2 Why Cost Reduction Fails [2]

In one word, it is because of the improper planning, lack in foresight ness, mission, vision, and strategic planning. If anyone goes for quick wins without a second thought, that will be a great losing aspect.

3. How to win the goal? [2]

1. Establish Goals.
2. Evaluate Business Expenses
3. Can ask Employees at any level. one can also encourage and reward their staffs for finding more efficient ways to work. Brain Storming
4. Outsource in proper planned way. (Should have skilled operators)
5. Reassess the Services and products
6. Replace unproductive staffs.
7. Reduce in- disciplined (maverick) staffs
8. Employees must work at full Potential to give best results. Understand which task they find engaging tweak rolls. (TOI.3.8.22)
9. Review the previous cost cutting measures and learn from it
10. Evaluate Potential Process Improvements
11. Ditch the legacy system
12. Invest in better and value-added products. Do the Market research very often! Don`t allow for stockpile up.
13. Automation whatever possible. Union is to be involved.
14. Develop / modify the present machineries for the higher production, better qualities, new product developments so that the organisation can reach to a higher goal. That will lead the organisation at higher profit stage wit lesser investments. (This paper discussed this subject for the Texturizing Industries)
15. Please go for the unbiased assessments of the staffs. Stop nepotism. A happy staff would take positive approach. It will lead to new ideas from them
16. Hire expert and consultants if the problems are not getting solved.
17. Be in touch with other Industries manufacturing same products.
18. Recycle the waste in upgrade. "No waste" concept should be added.
19. Proper Process Control, Process Audit to be done to have the 100% value realisation.
20. Have the proper skilled staffs. They should be properly trained to give the desired results. There is no place for the Lazy, timid and excuse giving and low IQ staffs. Promotions can be done based on KRA, innovations and quality of works.
21. The bosses should have the proper guiding attitude rather than to be a leg puller. (A majority of the bosses are scared to see the growing juniors)
22. Replacing dated appliances, lights, and fixtures with long-lasting, energy-efficient alternatives. Reduce the use of paper by going paperless.
23. Raw material procurements should be with proper planning. Avoid excess stock. Avoid pilferage. Before placing new purchase order, please ensure whether the same is available with other branches.
24. To follow proper Preventive Maintenance Schedule. Don`t go for the breakdown maintenance system or holiday maintenance, which will be penny wise pound foolish.
25. Reduce Meetings. (Boss is busy in a meeting, boss is busy, boss is in tour) – such conceptions are to be reduced. Whatever the case may be, the boss must be available for the guidance. No time to waste in the name of meeting. Make it short if at all necessary.
26. Work from Home: This can be implemented whatever possible as it will reduce the office expenses, Establishment Costs etc. "C" Suit can control from the Productivities from any distance through CCTV & Microprocessors. To some extent, it has got bad effect also.

All the above points are the general Conceptions for any organisation that how to take the Cost reduction methods to lead the organisation at profit making Stage. The Author has taken the case studies of the Texturizing Industries which is a very much growing industries with high business potentialities facing huge challenges and opportunities.

4. How to minimise cost in Texturizing process.

Direct savings:

4.1 Salary & wages.

Work with minimum workers and staffs. (i) Every operator must run two machines of 240 positions with splicing. (ii) An operator can attend 4 breaks / hour / machine and see that the breakage rate is not higher. In fact, if the machine and materials are perfect, then the breakage rate should be Zero. (iii) To attend a break, the whole operation must not take more than two minutes. (iv) The sensors must work actively and to see that in case of any breakage, there is no formation of lapping (v) The rest of the time he will check yarn path, keep the bobbins ready for next doff affixing sticker (vi) One side doff can be finished with 28 minutes. He can be helped by doffer gang or the nearing machine operator. (vii) In auto doffing machine, an operator is capable to handle as high 4 machines. In case of coarser denier, he can be allotted 3 machines.

The salaries are fixed as per the workload, for example it is higher for coarser denier and normal for the 100 den and below.

Figure 1 - Texturizing machine showing the Unit Disc and winding bobbin

Figure 2 -Texturizing Machine with creel, heater, and 3-deck winding bobbins

4.2 Waste control

It should not be more than 0.2.5% - 3%. (i) No yarn suction during threading. Receive a clean POY with knot and just thread it. Still 4-5 metres of yarn can go as wastage. See proper material handling and POY loading system with plastic cover. In case of edge damage of POY spools, a little suction is required. (ii) The loaders must have clear hands without ring, wristwatch, wrist ring etc which may damage POY spools if touched directly. (iii) There should not be any splice failure. Any failure requires a fresh threading which create wastage. (iv) No bottom generation: Put end cap at every POY spool while loading. The end caps are to be defect less. (v) The position of POY spools must be proper aligned. (vi) The separator plate at creel must be cleaned to avoid and splice failure. (vii) The cleaning of PTY Should be minimum. (viii) In spite of individual checking of PTY spools by hand to see bulk variation and intermingling, just take two -three meters of yarn from each bobbin lying on trolley. It will save wastages and manpower. (ix) TKD can be done for one PTY bobbins per POY spool. For example, if POY spool is of 15 KG and if PTY bobbin is of 5 KG, then TKD can be done 1:3 ratio. To hold the defective bobbins till it is rectified. (x) There are lesser % of wastages in the Auto doffing system. (xi) A skill operator can further minimise the waste%.

4.3 Savings in Electricity and power

(I) If Plant is AC, then 33-34 degree is good enough in summer. In Rainy season and in winter, AC can be put off. 1-degree temperature is equivalent to 1 lakh of rupee per day. Apart from above, the following measures can be adopted for Energy conservation.

- CFL/LED bulbs can be used. The height of the lights can be lowered. "Switch – off the lights when not required "should be the conception and to make awareness among all. Individual switch can be provided. To use Lamp shed. The LED Tube of 10 watt only can give more illumination. Instead of Tube lights of 40 watt and say for a shed of 100 tube lights, 50 tube lights with 10 watts are sufficient. Spot – Led tube lights can cover more areas.
- Regular Energy Audit is must.
- Solar heat, Windmills can be provided. Tree Plantation surrounding the Mills will cool the factory premises. Roof top can be provided.
- To put energy efficient exhaust fans in the suction system should be lighter.
- Interior finish, colour effects the illuminations.
- All the motors must have regular maintenance for energy savings.
- In modern construction, the ceiling height must not be too high.
- During daytime, roof top can be transparent to allow sunrays to penetrate.
- The close heaters are saving 15-20% power.
- There is the savings of about 300 unit per month per machine (280 positions) if the heater length is reduced by 20 cm (Both primary and secondary). But it depends on type of yarn. (Say 200 cm to 180 cm and 180 cm to 160 cm)
- Now a days all the heaters are heated by Dowtherm system rather than that of electrical heating system.
- 5% power savings are done of the shafts are Inverter driven.
- Capacitors can be used for the energy savings.
- By introducing 2B Shaft in the Text. Mc. the air pressures are reduced and that saving power cost.
- Oval shaped orifice of the jet can also save air consumption, but the terms apply.

4.4 Indirect savings

Short Term: (i) Need to increase machine speed as high as possible. Higher the product, higher is the profit. (Please refer: Techno Economic is High speed Texturising machine, published in Textile Trend Nov-2011) [3] (ii) The efficiency should be targeted to 99%. (Please refer the Project how to increase efficiency of Texturing machine, published MMFT. Sasmira Nov-2010) [4] (iii) The quality must be as high as 99%. (Iv) Proper Process Control at each stage is must. Please refer the article "Audit, a tool for quality improvements presented at International Textile Conference at KCT, Coimbatore on 16th December – 2011"[5] and that of "Process Control in Texturisation "presented at VJTI on 12th July 2013 in TEQUIP and in Sasmira 30th Sept`2014.[6] (vi) The PTY Spools size can be of higher side (as high as possible depending on cradle capacity, Carton size and or Jumbo packing size) It is better to have 6 kg PTY size with 8-12 degree tapering with proper hardness. Hence POY spool should be of 18 KG. (vii) Strict maintenance at an interval of 30 days for semi dull can be followed, but in case of higher speed say 900 mpm. and above, 25 days' gap is better. And 20-25 days maintenance schedule can be followed in case of FD, CD, Dope dyed which are better option. Please refer the publication "Better is the maintenance, higher is the production and quality, published in MMFT, Sasmira – Nov-2015 [7] (viii) Unit clean by brush at every shift, heater and cooling plate cleaning at regular interval is must. (ix) Floor clean, proper housekeeping will prevent in forming Stained packages and down gradations. (x) No PTY Package should be below 5-6 kg. All the bottoms must be rewind. (xi) A proper Creel maintenance will improve the efficiency by 3%. [8]

4.5 Indirect Saving: Long Term

(i) Automation (ii) Robot packing and material handlings (iii) Speed increase, (iv) No Breakage should be targeted. Today the breakage level has come down from 25 - 30 to 15-16 per day per machine due to the technical advancement. The New generation machine will run at a speed of 1200mpm with zero breakage and zero defect. (v) New generation machines are coming with new Pack formula, polymer, precision winding at POY/DTY level which will save huge defect and leads to high profit.

4.6 Training

(i) At the start of entry, proper training to operators and e ngineers are must. (ii) Then to see the right man at right place who can deliver maximum. (iii) Training to the trainers is also necessary. Please refer the publication "Training to the Trainers published International Journal of Multidisciplinary Research August – 2013 Vol-II, issue 5 (II).[9] (iv) Motivation to each employee is must with unbiased views.

Man. Material. Machine. Method and Managements are the right way to solve any problem. A proper analysis and thought at every stage will help you to bring down cost and enhance profitability.

5. Increase the spares life

It is found that the PU Disc life in increased from 2-2.5 years to 3 years if the shore hardness is increased from 85 to 90 for the same denier. Another 6-month life can be increased if the top layer disc is taken to bottom (1-4-1)

The apron life can be increased from 1.5 months to 2 months if the traverse length is increased from 15 to 20 mm. Thereafter, it can be reused at "output" zone after washing. More research are going on to increase the life.

Oil splashing can be avoided by putting covers over the oil rolls.

At packing stage, it is found that the Carton of 5 ply can take 60 kg and that of 7 plies can with stand more. The pallet packing with recycled materials is very popular now a days. Not to stack more than 1+ 4 cartons (each <60 kg) and that of pallets 1+1. Good quality of the paper tubes can be reused if found in acceptable conditions. Otherwise, it will be more disaster!! 3 ply boxes with 12 GSM during normal monsoon and that of 12.5 GSM during Monsoon give savings in cost. Pallet wrapping with 34-gauge plastic sheet during monsoon only will save huge amount. Customers are to be instructed to follow FIFO system.

6. Administrative Problems: Today, it is very difficult to get a skilled operator with proper dedications. The professionally managed Industries employ unskilled people, train them, and make them semiskilled and then skilled but they switch over to another Organisation with his branded image. The management`s policy required to be changed as per the situations. This leads the automation which are at the growing stage.

The factory owners expect higher returns with low investments and that becomes "penny wise pound foolish" method. It requires to change their attitude. During summer, the human efficiency is lost when the machine operators work at a tempt of 46degree!!

7. Conclusion:

Run the Industry with bare minimum cost, better quality, higher production, with right size of skill manpower, get higher profit are the motto today. At every stage, the Process control, expert opinion is the right way. No waste at any stage, whether it is hard waste, electricity, manpower is to be targeted. It is advisable not to go for quick return which may be another disaster. Motivation to the Employees help in reaching the target. The new generation machines (especially Barmag) are coming with high advance Technology which will save further.

Unfortunately, the Raw material cost has grown up 2.5 – 3 times higher and hence the conversion cost has gone higher by more than double in last 10 years. [Few examples for the increase in raw material cost from 2010 to 2021-22, - PT Rs. 8/- from 3/-, Power Rs. 2.5 /- to 5.50/ in (UT), anti-static oil from Rs. 42/- to now Rs. 118/-, Increased Labour Cost (place to place)]

References

[1] https://quandarycg.com/how-to-cut-costs-while-increasing-efficiency-in-your-business/[2] Ref:25 detailed cost reduction techniques for growing business by Kevin Shular – 14.08.21 Quandary consul fig group
[3] Techno Economic is High speed Texturising machine, published in Textile Trend Nov-2011) by B.Basu
[4] How to increase efficiency of Texturing machine, published MMFT. Sasmira Nov-2010), by B.Basu
[5] "Audit, a tool for quality improvements" International Journal of Social & Scientific Research (IJSSR), Vol – 03, Issue II, July- Sept `17. By B.Basu
[6] "Process Control in Texturisation "presented at VJTI on 12th July 2013 in TEQUIP Program and that of in Sasmira 30th Sept`2014., By. B.Basu
[7] "Better is the maintenance, higher is the production and quality, published in MMFT, Sasmira – Nov-2015, by B.Basu
[8] "How a proper Creel can improve efficiency by 3%". presented at SGGS, Nanded dated 10th &11th January 2014 under TEQUIP Program
[9] "Training to the Trainers published International Journal of Multidisciplinary Research August – 2013 Vol-II, issue 5 (II).by B.Basu

■ ■ ■

A Study on Progression of Sanganeri Block Print

Madhu Sharan*, Mitali Shah & Ayesha Chauhan

Dept. of Clothing and Textiles, Faculty of Family and Community Sciences, The Maharaja Sayajirao University of Baroda,

Abstract:

Background: Sanganer, a town in Rajasthan is known globally for its block printed textiles. The unique motifs and design configuration are the characteristics of this hand block printed textiles. Literature revealed that this technique of printing was developed between 16th and 17th century and is still popular. Even though there has been so much of technological development, political ups and down and societal changes, this art has survived without losing much of its original form.

Methods: This study was undertaken to study the progression of the printing and find out its strength which helped it in sustaining it over a period of time. For any art, the principle stakeholders are the artisans, retailers and consumers. For the study, data was collected from all the stakeholders i.e. artisans, retailers and consumers. Questionnaire was administered to all the participants after taking their consent. Data thus collected was organized, analyzed and concluded.

Results and conclusion: It was found that during Mughal period this art was at its peak as it had support of royal patronage. It declined during British Empire but survived after that. The receptivity of the artisans and manufactures for the consumer demand was the key factor for the survival with the ups and down in the popularity and the sale. Change in motifs, use of dyes, material and block while keeping the characteristics of the printing intact, was observed which lead to the survival and popularization of the art. Artisans from other states also have joined this art in Rajasthan.

Keywords: *essence, popularity, receptivity, survival*

Citation: Madhu Sharan, Mitali Shah & Ayesha Chauhan, "A Study on Progression of Sanganeri Block Print", *Journal of the Textile Association,* **83**/4 (321-325), (Jan-Feb2023' 2022),https://doi.org/10.56716/4/1447

Article Received: 16-09-2022, Revised: 107-12-2022, Accepted: 22-11-2022

1. Introduction

India has one of the finest textile traditions in the world with respect to dyeing, weaving and surface embellishment. The richness of its crafts is evident from the excavated findings of Harappa and Mohenjo-Daro in the Indus Valley, dated back to 5000 years. Textile printing is a well-diversified industry in India(1). There are several ways of textile printing including hand block printing. Hand block printing refers to the technique of creating pattern on the fabric by using carved wooden blocks covered with dyes which is repeatedly been pressed along a length of fabric. During initial year this industry was greatly influenced by the natural environment, such as: availability of water sources, abundant sun light, atmospheric humidity and the local herbs and flowers. Later on technological advancement was observed in the process. Sanganer printing has emerged as one of the art which has emerged as the most successful form surviving through many ups and down through its journey. This study includes the progression of this art over a period of time and factors responsible for the same.

2. Materials and methods

The study was case study of the Sanganer print, data collection was done from in and around Sanganer. The purposive sampling method was used where in artisans, retailers and customers were included. Study was divided into two phases.

***Corresponding Author :**
Prof. Madhu Sharan
Professor, Department of Clothing and Textiles, Faculty of Family and Community Sciences, The Maharaja Sayajirao University of Baroda, Vadodara
E-mail: sharan.madhu-ct@msubaroda.ac.in

Phase I: Data collection

Locale of the study was Sanganer. For data collection questionnaire was prepared and got validated. Separate questionnaires were prepared for artisans, retailers and customers. Keeping in mind the ethical concern consent of the participants was taken before the data collection through consent form. Those who consented to be the part of the study were included in the data collection. Total number of 30 participants were given the questionnaire. This was supported by the interview and photographs.

Phase II: Analysis of data and conclusion

Data thus collected through questionnaire, interview and pictures was organised, analysed and conclusions were derived.

The data thus obtained was supplemented with review of literature and conclusions were derived.

3. Results and Discussion

Printing in Rajasthan

During the 14th and 15th centuries some colourful printed fabrics were found from Rajasthan. According to literature, with the constant wars of Mughals and Marathas during that time, many printers migrated from Gujarat to Rajasthan. By the end of the 18th century this industry was fully developed under the royal patronage and became the finest art of Rajasthan. This printing was usually done by Chippa (comes from the word 'Chappna' means to imprint) community (2). They passed this craft skill down the generation, from parent to child. The major centres of traditional hand block printing in Rajasthan were Bagru, Barmer, Jodhpur, Pali, Sanganer. Over the time, each centre has developed its distinguished design, style and techniques (3).

Sanganer printing

Sanganer which is situated at a distance of 16 kilometres south of Jaipur has been a major centre for very fine block-cutting and printing since 18th century. It was famous for its fine hand block printing in subdued colors. Hand block printing was patronised by the royal family during Mughal period. Sanganeri hand block printed textiles and furnishings have been recognized to have a unique identity in manufacturing and in belonging to the area of Sanganer (4). The Sanganeri Print is visible from small flower motifs like stylised sunflowers, narcissuses, roses to flowers of luxuriant foliage like daturas, rudrakshas, and arkas.

Method of printing in Sanganer

The printing involves laying the fabric which is to be printed, on flat tables and impressions are made using the beautifully carved blocks. In case of direct printing, the block is dipped in the coloured dye and impressions are made. In case of resist dyeing, impression of an impermeable material (clay, resin, wax etc.) is made on the fabric, which is then dyed in the desired shade. The block image remains unprinted and reappears in reverse (5). This elaborate work needs expertly cut mirror images blocks to print the usually asymmetrical Mughal style designs. Although Sanganer is well known for producing fine block printed textiles on off white or pastel backgrounds, today a wide range of textiles are produced with both dark and pale grounds.

Traditionally natural and vegetable sources were used for dyes. But with the advent of synthetic dyes, things have changed, not necessarily for good. The ease of usage and the availability of synthetic dyes have replaced the vegetable dye in many cases (6).

The principal items printed here include sarees, dupattas, salwar-kameez, bed cover, curtains, scarves, and printed yardages (running cloth material), etc. Both local and imported cloth material are used. At present,' mulmul' (cotton voile), 'latha' (sheeting fabrics) and cambric etc. are sourced from Jaipur.

Beginning

Sanganeri printing gained high popularity during the 16th and 17th centuries in all European countries with its Calico prints and became one of the major exports of the East India Company. In Calico printing, the outlines were first printed, and then the colour was filled in. bold patterns and colours were used repeatedly in diagonal rows while printing (7). Sanganeri hand block printing witnessed the reign of Mughal, British and post-independence times and still managed to survive the ups and down.

As far as tradition goes, it is said that the great astronomer king- Sawai Jai Singh was responsible for giving impetus to this art of printing. He invited artists and craftsmen from different parts of the country to settle at Jaipur, mainly the zari workers from Surat and printers from Gujarat. He also brought some craftsmen from Malwa which is evident from Sanganer cotton prints which show an excellent combination of both of these traditions-the fineness of Malwa particularly of Sironj, and the lyrical quality of design from Gujarat (8). This combination is supported by geographical location also as Malwa is to the southeast of Sanganer and Gujarat is to the south in geographical proximity.

In Mughal time it has gained the delicacy and fineness of the motifs and under the royal patronage it has flourished extensively. According to John Irwin, “Gujarat's artisans suffered badly during the wars of Aurangzeb and later in the plundering raids of the Marathas. Many of the craftsmen migrated to seek more settled employment in Rajasthan and other parts of north-west India. (Dr. Ms. Chandramani Singh, Textiles and Costumes from the Maharaja Sawai Man Singh II Museum; Jaipur Printers; 1979)

During British rule in India, this art form has flourished as Calico printing in the Europe. But afterwards when taxes were levied to the hand block printing manufacturing and exports it lead to increase in the prices and decrease in the demand of the hand block printing products. Simultaneously, at that time screen printing was introduced which was cost effective and less labour intensive to produce. More products at cheaper rate were manufactured. But in such scenario also, Sanganer hand block printing still had its grip on the domestic as well as international market.

The major components of the block printing are its motifs, dyes used, material and block. To understand the progression of the hand block printing above components were studied and compared.

i. Motifs

Motifs have been an integral part of the Sanganer printing. It is the identification characteristic of this hand block printing. Delicate patterns and lines with vibrant colored designs were the defining factors for this printing technique (9). It was observed that many motifs have been added over a period of time. Initially the motifs were broadly divided into four categories on the size and appearance of the motifs as:

ii. Buti: used for the smaller motifs

iii. Buta: the bigger motifs

iv. Jal: the overall compact designs and

v. Bel: resembles the vines on the trees.

The traditional names were used by very few artisans today though they were using traditional motifs. Most of the design had been stylized to a certain extent to suit the fashion trends and orders so their traditional names were not used frequently. Within the classification, according to the modification certain names for motifs were popular (10). Some of the traditional names given to modified designs within the basic categories were-

a. Buti: Kachnar buti, Patasi buti, Turri ki buti, Kairi ki buti, Revadi buti,

b. Buta: Bad ka buta, Gulab ka buta, Dab buta,Jal: Kairi jal, Pan jal, Mor jal, Najla jal

c. Bel: Pardi bel, Sua bel, Gulab bel, Bel patra bel, Neem patti ki bel.

It was found that the size of motifs was very small therefore the blocks were difficult to handle and required special skills. But eventually the size of some of the motifs has been increased and were somewhat easy to handle.

Later on the change in the motifs was observed and it was found that the artisans were using different categories to explain the motifs. Later the motifs were divided in the following four categories:(Image 1)

d. Natural:

If the motif was inspired from nature and exact outline from the natural objects such as flowers, trees, fruits, climbers etc was used, then the motif was classified under natural motifs.

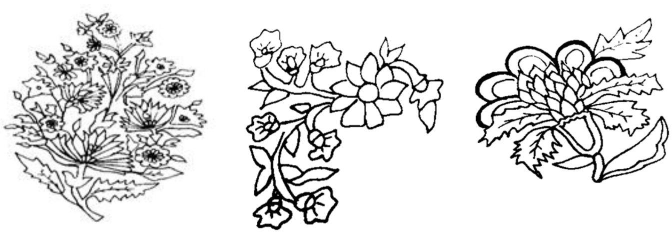


Image no.1: Natural Motifs

a. Stylized:

Stylized motifs had manipulation with line, either they were simplified or conventionalized to change the designs of the natural outlook.

Image No. 2: Stylized Motif

b. Geometrical:

Motifs created with pure geometrical shapes and their combinations were classified under geometrical motifs.

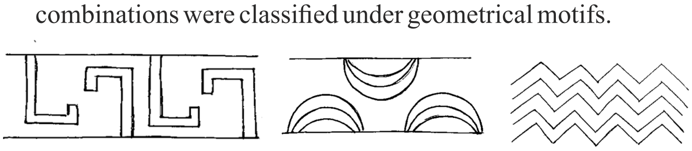


Image no.3: Geometric motifs

a. Customized

Motifs were made according to the requirements of the clients such as brand logo/name, verses from the holy books, quotes, cartoon characters etc.

The traditional motifs slowly faded away as new designs were the choice of the customers. New pattern observed was that a sample was provided by the client which the artisan copied, there was no specific classification for that and it was either known by its appearance for example angoor wala buta i.e. grapes bunch resembling motif or sometimes local names were used for motifs such as silli for lines, dana/rai for dots, parcha for big boarders, chaukdi for squares etc and thus new vocabulary was developed over a period of time. It was observed that there was addition of new motifs used for the printing and forms of motifs also changed. The consumer demand and technology played an important role in this change.

1. Dyes:

While presently, chemical dyes are mainly used for Sanganeri printing to meet the growing demand of unique colours from consumers. Traditionally for Sanganeri printing natural dyes were used. At present both vegetable and chemical dyes were used in Sanganer. Though the process of printing with chemical dyes was much easier and less complicated than that with vegetable dyes yet it was found that vegetables dyes were used more by many printing units. Chemical dyes used were Rapid, Indigo sol., Acramin, Naphthol dyes. The proportion of dye in the printing paste was based on the shade and colour required. The use of chemical dyes had provided a wide range of colours for the printed fabrics. With natural dyes limited colours were available. The colours most commonly used at that time were, black, red, maroon, pink, blue, and brown. Red and black were the most common colors used throughout the state of Rajasthan, followed by yellow and blue. The use of various colours in the printed fabric kept on changing according to the trends in fashion.

Table No.1: Sources for natural dyes

Sr. No.	Source	Colour obtained
1	Turmeric	Yellow
2	Indigo plant	Blue
3	Rust Iron	Black
4	Madder	Red
5	Madder with alum mordant	Red to pink
6	Catechu	Brown

Reasons found for switching to synthetic dyes were:

- Unlink synthetic dyes, the quantity of natural dye required was much more.
- Clothes made from natural dyes tend to fade
- The availability of raw materials that are used to make natural dyes can vary according to seasons but synthetic dye is available all year round
- Producing the raw material with which the natural dyes are made require large land areas for its production so it was costly affair.
- For export, special care was taken in selection of dyes to include only azo free dyes. These dyes were comparatively expensive than any other synthetic dye therefore it was used when demanded. There were no particular colours or colour combination used for a particular motif/design, it was either customized according to buyers' theme or by following market trend using forecasting sites such as WGSN forecast.

2. Fabrics:

Earlier only cotton fabric was used to print. Both handloom and mill made cotton fabrics such as poplin, cambric, muslin and mulmul were used. Sometimes fabric was also supplied by the customer. Silk and synthetic fabrics were not used at all mainly because the dyes used by the Sanganeri printers were not suitable for these fabrics. Moreover, another reason was that it could not be subjected to the harsh manufacturing conditions specially the high boiling temperature which was required in some of the processes. On the other hand, on cotton fabric had good absorption qualities for the dyes which were being used.

Cotton was still the top most priority for the printers for printing fabric as apart from its good dye absorption property it was also ideal for the summer season. Because of its cooling and sweat absorption property, it feels good on skin and was most demanded fabric by the customers. At present fabrics used in Sanganer has been divided on the basis of its fiber content and the weave of the fabric. Different cotton and cotton blends were used in Sanganer for printing which consisted of cambric, mulmul, and cotton blends such as polyester cotton and cotton- rayon.. Fabric with different weaves used were Chanderi, Kota doria. Chiffon was also used for printing which were made of silk fibers. Both cotton blends and silk fabrics were introduced later..

3. Blocks:

In olden days, the traditional blocks used by the Sanganer were recognized by their detailed carving. They were tiny in size. The wooden blocks for printing were either purchased from wood carvers or they were prepared on order. Majority of the units purchased blocks directly from the block makers rather than getting them specially prepared. Only few units were getting the blocks prepared by order. The blocks were mostly purchased from Sanganer and Jaipur or were ordered from Mathura or Farukhabad. Rosewood and Teakwood was used for blocks. The shape and size of the blocks depended upon the type of design made. For smallest, size of blocks used were 2”x 2” and the largest blocks were of 8”x 6 ½”. The wood used for making the blocks were Rose wood, Teak wood, Gudjan or Rodha (11). A number of blocks were required for the different colours used in a design. These blocks were mainly of three kinds; but depended on the number of colours used. The first was “rekh” or the outline block. Secondly, the “gad” or the ground colour block was used and lastly, the “datta” or the third colour block was used. Blocks were cleaned by just water and soft brush and left to dry. The blocks which were of no further use, were stocked away. They were never sold as they had a religious significance attached to them. A common belief existed among the owner and printers that since the blocks were a means of earning their living, they should never be sold or destroyed. But when the blocks became very old and were almost destroyed due to climate conditions, it was immersed in river. It was found that the blocks were used for decorative purpose also (12).

Over a period of time, the wooden blocks were majorly outsourced from the wooden block makers settled in Sanganer. Majority of the blocks were made on orders as most of the times designs were provided by the clients, sometimes even the blocks were also provided by the clients which they take back once the order was completed. Size of the block have gradually increased with time. Now-a-days less intricate designs were used with increased size of blocks. The size of the block ranged from 2”x 2” to 12”x12”. The most commonly used size was 8”x 8”. Traditionally blocks were very small and were difficult to handle. By the end of 1980, organized border of butta and butti combination, created need for bigger blocks. Also to compete with screen printing, the size of blocks increased almost four times to its original size.

The wood used for making the blocks was still the same i.e. rosewood and teakwood. The number of blocks required for printing a design varied according to the number of colour to be used in a design. The number of colours used for a design ranged from 1 to 8 colours in a motif. Same kinds of blocks i.e. Rekh, Gad and Datta were used to print a motif. Even though modern designs have come up, but old block has their own place and still used.

a. Metal (copper) block

b. Wooden Block

c. Rekh, Gad and Datta

Image 4: Blocks used for printing

4. Articles:

Since the artisans of Sanganer have worked for three types of people: nobility and courtiers, temple devotees and common people, their products catered for all the three sectors.

Initially the yardages were prepared and mainly used for turbans. Delicate floral prints were used during that time. Later on other products were added. Various articles being printed were sarees, bed covers, dress materials, quilt covers, table cloth, napkins and scarves. Bed covers and dress materials had gained a very high popularity all over India as well as in other countries too and thus all the units started printing it.

The product diversification has been increased with time. Now-a-days this material is used for producing fancy and utility articles such as handbags, wall hangings, footwear, jackets, table cloth/ runner, curtain, comforters has been included along with the products like sarees, dress materials, quilt covers, table cloth, napkins and scarves/duppata which were made earlier also. At present artisans sell their products in outlet i.e. they have their own factory outlet in Sanganer, and cater to retailers and wholesalers, brands such as Westside, Tata, Aditya Birla, FabIndia, Anokhi etc.

Reasons that have been observed for the existence of Sanganer hand block printed products were:

- Price of the products
- Variety in terms of design
- Products available in market
- Material used
- Durability
- Colour combination
- Aesthetic appeal
- Addition of new prints.

Majority of the consumer had purchased the products offline from the local markets or branded shops. In local market, they had purchased from retailers, artisans and exhibitions. Consumers found the price of the products moderate but online prices were a bit higher than that of local markets where the consumers could bargain and negotiate. The identification of the hand block printed products for consumers were the colours, motifs and design used.

Other factors in favour of the development of Sanganeri print were:

- Mass production
- Availability of labour
- Tourists
- Wood carver's availability
- Buyers provide designs
- Hereditary work
- Educated gen-next
- Adaptability to the changing trends
- Government initiatives to provide state and centre support to promote handicrafts
- Wider target markets
- Entry of entrepreneurs into e-commerce of handicrafts

Factors which worried the artisans:

- Lack of information about government schemes and policies
- Laid back attitude to work
- Lack of original ideas for design development
- Less interest of new generation to continue legacy of hand block printing
- Increase in no. of industries in Sanganer
- Use of synthetic dyes
- Screen printing

5. Conclusion

Sanganeri prints have reached to international market from its humble beginning as local art in Jaipur. This art always had support of royal patronage but also have face many troubles leading to decline.

- Earlier it was dispute between Mughals and Marathas.
- It flourished as the royal family of the Jaipur was the chief patrons but after independence the art almost died.
- It again revived during 70's owing to the efforts put in by person behind the movement for cottage industry like Kamla Devi Chattopadhaya.
- Then faced pollution charges which also was a setback to this.
- Adding to the progress, it has received GI index, which helped and will help in selling authentic products, getting recognition and wider market avoiding duplicate products under the tag of Sanageri print.

Adaptability to the demand was found to be the key for the sustainability and popularisation of the art.

References

[1] Baral, B. Block Printing- Sanganer http://www.dsource.in/resource/block-printing-sanganer/making-process (last accessed on 14/06/2021)
[2] Mathur, A. K. (2019) Socio-economic status of Chhipa: The Hand-block Printers of Sanganer, International Journal of Research in Social Sciences, 9(2), 1-11 Retrieved fromhttps://www.ijmra.us/project%20doc/2019/ IJRSSFEBRUARY2019/IJMRA-14333.pdf
[3] Ajrakh Block Printing https://worldofcrow.com/blogs/textiles-of-crow/ajrak-block-print (last accessed on 14/06/2021)
[4] Edwards, E. (2016) Block Printed Textiles of India Imprints of Culture, Niyogi Books Pvt. Ltd.
[5] A guide for industry practitioners engaged in hand printing http://www.handprintingguiderajasthan.in/ (last accessed on 14/06/2021)
[6] Block Printing https://www.utsavpedia.com/motifs-embroideries/hand-block-prints/ #:~:text=The%20hand%20block%20printing%20technique,as%20early%20as%203000%20BC.&text=The%20engraved%20patterns%20on%20the,style%20quotient%20originated%20in%20China. (last accessed on 14/06/2021)
[7] Gandhi, S.(15/05/2019) Exploring the Indian block print's rich culturalhistor
[8] https://www.vogue.in/content/history-of-block-prints-indian-textiles-designers
[9] -using-ajrakh-dabu-prints (last accessed on 14/06/2021)
[10] 8. Hand Block Printing https://thedesigncart.com/blogs/news/hand-block-printing (last accessed on 14/06/2021)
[11] Jain, R. and Hada, M. (2019, January) Past and present of hand block printing. Retrieved from https://www.fibre2fashion.com/industry-article/6741/past-and-present-of-hand-block-printing (last accessed on 14/06/2021)
[12] Kaur, J. (2017). Flora and Fauna Motifs in Sanganeri Print. International Journal of Manufacturing Research, 4(2), 1-5 Retrieved from https://www.researchgate.net/publication/330713229_Flora_and_Fauna_Motifs_in_Sanganeri_Print
[13] Sanghvi, S. (1982). A Study of the Sanganeri Printing, [Unpublished, Masters Thesis] The Maharaja Sayajirao University of Baroda, Department of Clothing and Textiles
[14] Trivedi, V. (2011). Traditional Knowledge of Wood Block Making Craft of Pethapur- A Case Study, [Unpublished, Masters Thesis] The Maharaja Sayajirao University of Baroda, Department of Clothing and Textiles

Journal of the TEXTILE Association

Synthesis of PLGA and its Fabrication for the Tissue Engineering by Electro and Melt Spinning

Savita H. Bansode*, Priyanka Vasant Khare & P. A. Mahanwar

Department Of Polymer and Surface Engineering, Institute of Chemical Technology, Matunga, Mumbai

Abstract:

Polylactic glycolic acid (PLGA) is the most important polymer in biomedical applications and the degradation kinetics is modified by the co-polymerization ratio of the monomer. In this interest, Biodegradable and biocompatible polymers are used in controlled drug delivery systems, in the form of implant devices for skin bone, and dental repairs. With microwave synthesis polycondensation, free and controlled radical polymerization, and ring-opening polymerization (ROP) can be done. The characterization of Polycaprolactone was done by Fourier Transform Infrared Spectrophotometer (FT-IR), scanning electron microscopy (SEM), the polymer interactions were checked by differential scanning calorimetric (DSC) and the XRD analysis was carried out to determine structural changes PLA/PCL nanofabrication done by electrospinning Technique for biomedical applications. PLGA synthesis is done by the conventional method, with the study of various parameters such as time, temperature, monomer, and catalyst ration. Important characteristics such as melting temperature, glass transition temperature, thermal stability, FTIR, and NMR were studied for this. These results helped to study the effect of monomer, and catalyst on reaction. The PLGA microparticles are one of the most successful new drug delivery systems (DDS) in labs and clinics. Because of their good biocompatibility and biodegradability, they can be used in various areas, such as long-term release systems and tissue engineering.

Keywords: *Biocompatible, Biodegradable, Electrospinning, Melt spinning, Polymerization, Synthesis*

Citation: Savita H. Bansode, Priyanka Vasant Khare & P. A. Mahanwar, "Synthesis of PLGA and its Fabrication for the Tissue Engineering by Electro and Melt Spinning", *Journal of the Textile Association,* **83**/5 (326-332), (Jan-Feb'2023), https://doi.org/10.56716/4/1452

Article Received: 22-05-2022, Revised:08-07-2022, Accepted: 11-10-2022

1. Introduction

Tissue engineering is the field that applies knowledge of life science and the principles of engineering toward the development, maintaining, or improving damaged tissue functions of the human being. Tissue engineering can act as a substitute for the extracellular matrix (ECM) and provide a substrate for cellular adhesion and organization [1, 14]. Thus, tissue engineering scaffolds have a strong resemblance to the natural ECM, which is comprised of nanometer-diameter protein fibers [2, 15]. Various polymeric nanofibers are used as material for scaffolds for tissue engineering applications such as; PHB (Polyhydroxy butyrate), Polylactic acid, Polycaprolactone, Polyglycolic acid, etc. [3]. There are five classes of biomaterials; metals, ceramics, polymers, synthetic polymers, and composites. In general, natural and synthetic polymers are used to replace skin; tendon, ligament, breast, eye, vascular systems, and facial tissues, there are different methods for nanofabrication: Self-assembly, phase separation, electrospinning and melt blowing. Electrospinning is one of the best methods for polymer nanofabrication studied in detail .

The electrospinning device consists of three main components: syringe pump, collector, and high voltage supply. A schematic representation of electrospinning is presented in Figure 1 [18, 19]. The method comprises of following steps: the polymer of which the nanofibers have to be produced is dissolved in solvents; the solution of the dissolved polymer is inserted into a syringe; the tip of the syringe needle is connected to a high-voltage power supply, and fibers are collected on the appropriate collector. The properties of fibers obtained by electrospinning affected by viscosity/solution concentration [20 -21], conductivity or charge density on fibers [22, 23], surface tension of electro spun fibers [24, 25], polymer molecular weight [26, 27], dipole moment and dielectric constant [28, 29, 30].

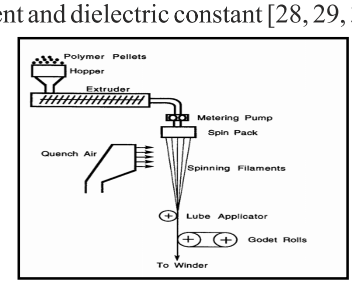


Figure 1 –Melt-spinning setup

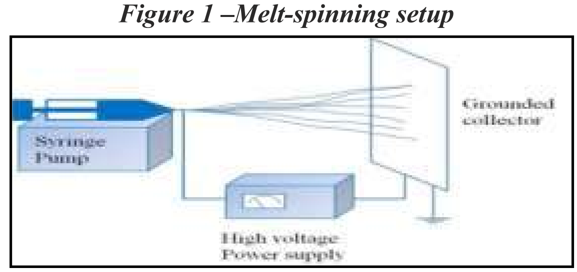


Figure 2 - Electrospinning setup

Melt spinning has a simple setup, where fibers from a molten polymer can directly be drawn continuously, avoiding the use of solvents. The fibers, temperature of spinning (extruder) and the rpm of take-up roll/ rotating disc, rate of cooling are the major factors affecting the melt-spun fibers [30].

****Corresponding Author :***

Ms. Savita H. Bansode
Department of Polymer and Surface Engineering, Institute Of Chemical Technology, Nathalal Parekh Marg, Matunga, Mumbai – 400 019
E-mail ID: savitabansode@gmail.com

2. Materials and Methods

2.1 PLGA Synthesis (Convectional synthesis)

Materials: Lactic acid 90% pure was purchased from Lobe chime, as a monomer. 97% pure Glycolic acid was purchased from Sigma Aldrich, as a monomer. Stannous Octoate 99% pure was purchased from Sigma Aldrich, as initiator and catalyst (it acts as both). Stearyl alcohol and Lauryl alcohol (reagent grade) from SD Fine Chemicals Pvt. Ltd used as co-catalyst. Lab-grade Silicon oil is used in thermocouple pockets.

Apparatus: Heating mental, Overhead stirrer, stirring rod with Teflon blade, vacuum setup, Nitrogen balloon, oil tube, thermometer, temperature sensor, thermocouple, thermometer pocket, four-necked round bottom flask, nitrogen (gas) purging tube, weighing machine, beakers, conical flask, pipette, water condenser, separating funnel, vacuum adaptor, stand, clamp, rubber bulk, join and bends, connector, stopper, Nitrogen balloon stand (ring clamp), fiber resistance fabric, petri dish, funnel, spatulas, glass stirring rod, Buchner funnel, wood blocks, rubber tube.

Procedure: Arrange apparatus according to setup. Place mechanical stirrer in central of four neck round bottom flask, and place it in heating mental. Nitrogen gas was purged from one neck with the help of a gas purging tube. Keep RPM speed nearly about 500. Vacuum should apply at an interval of time, after the temperature reaches 130°C, since oligomerization is started monomer will not be removed. Thermocouple place in thermometer pocket which filled with silicon oil and start heating. Lactic acid is added before glycolic acid because glycolic acid has higher reactivity compared to lactic acid. Add stannous octoate and/or Stearyl alcohol/ lauryl alcohol (co-initiator) after one hour (after oligomerization). To check the progress of the reaction we determine the acid value and/or saponification (sap) value. As the reaction proceeds acid value decreases and sap value increases. Also, determine the acid value of monomer and mixture after adding initiator and/or co-initiator.

Figure 3 - PLGA synthesis setup and Vacuum dryer

2.2 PLGA purification

Vacuum drying: Synthesized product PLGA was dissolved in chloroform and dried in a vacuum at 46°C after it keeps for cooling.

By using Desiccator: The product PLGA was cooled down and then dissolved in chloroform and subsequently precipitated into diethyl ether. The precipitated mixture was collected in a petri dish and dried in a desiccator using a vacuum. Vacuum applied by a vacuum pump.

Buchner funnel: The polymer PLGA was purified by first dissolving in chloroform followed by precipitating in methanol under the action of mechanical stirring. And the precipitate dries using a Buchner funnel in which a vacuum is applied to the arm.

2.3 Synthesis of PCL (Microwave synthesis)

Materials: The microwave method is used for the synthesis of Poly (Ɛ-caprolactone). Ɛ-caprolactone (Sigma Aldrich, India) was used as a monomer and stannous octoate (Sigma Aldrich, India) was used as a catalyst. Microwave synthesis of Poly (Ɛ-caprolactone) was done by adding a calculated amount of catalyst to a 5 mL monomer solution in Tetrahydrofuran as a solvent (THF, Sigma Aldrich, India).

Procedure: Microwave synthesis of Poly (Ɛ-caprolactone) was done by adding a calculated amount of catalyst to a 5 mL monomer solution in Tetrahydrofuran as a solvent (THF, Sigma Aldrich, India). The reaction conditions were varied and thereby synthesis was conducted in 4 different Runs. The synthesized polymer is characterized using gel permeation chromatography (GPC). The results obtained show that the polymer synthesized in Run 2 possesses Mn= ~10000 and Mw = ~ 30000 which is well in agreement with the report available in the literature. It is also observed that the polydispersity index (PDI) of the synthesized polymer is 2.9 which is also in agreement with the reported values in the literature [17]. Therefore, it is concluded that the polymer is properly synthesized.

Table 1 - Parameters of Polycaprolactone selected for the reaction

Sr. No.	Parameters			
1	Wattage	Temperature	Reaction Time	Catalyst
2	100	150	5	0.001
3	200	180	10	0.003
4	300	190	15	0.009
5	400	200	20	0.10

2.4 Melt Spinning

Apparatus: Melt spinning instrument, PLGA

Procedure: PLGA was dried in an oven for 40 min. to remove moisture from the polymer. About 200 grams of material PLGA are used for the fabrication process. The material was added to the spinneret in molten form. Optimized RPM (1200-1500) and Temperature (100-140°C) according to requirements. The polymer material is added through a hopper, the material was melted in a single screw extruder where heating plates are attached. The material will pass to the spinneret which is attached with a high-speed rotatory motor. PLGA melted in barrel then it passes through the nozzle to spinneret which rotates at high RPM.

2.5 PCL fabrication

Design Electrospinning Setup (zigzag aluminum collector), and Design needle collector

Design of electrospinning apparatus and Formation of polymer Nanofibers Electrospinning is a very simple process. It can be used for the fabrication of continuous nanofibers. The electrospinning device consists of three main components: syringe pump, collector, and high voltage supply. The needle and collector can be modified depending on the end application of polymeric fiber. Collector type also affects the strength of the fiber and the winding ability of the strand. We used ten syringes, with the help of a syringe pump, to produce fiber in a larger quantity, and voltage is applied to every needle. (Figure 4) .

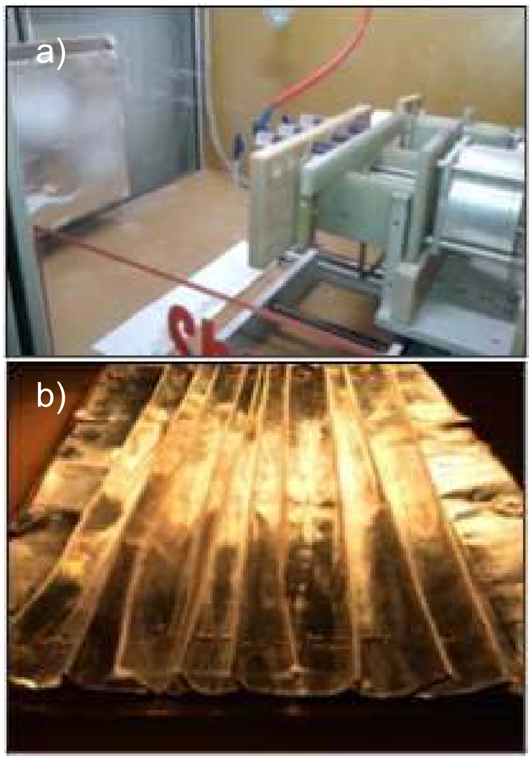


Figure 4 - Electrospinning Setup (a) syringe pump with needle and (b) zigzag aluminum collector resp

Procedure for Electrospun Nanofibers of PCL

The polymer is first dissolved in solvents, then the solution is inserted into a syringe. The tip of the syringe needle is connected to a high-voltage power supply. The solution acquires a charge when it is ejected through the needle, which causes it to gravitate toward the collecting plate, the collector acts as the template for the fibers to attach. Electrospinning Setup with the different collectors shows roller collator flat plate collector, for continuous production of fibers in Figure 4.

Optimized Parameters for Nanofiber Fabrication Polycaprolactone

Deposition height: 7cm from needle tip to receiving Plate, Polymer Concentration: 5 %, 10% 15% PLA in DMF with Acetone. Voltage applied: Vary as per conc. 10kv - 20kV.Deposition Patterning: Random Deposition (No patterning), Flow Rate: 0.5 ml -5ml per hr. Needle Diameter: 16-20 gauge.

2.6 Characterization of PLGA, PCL, and fibers

Fourier Transform Infrared (FTIR): The infrared absorption spectra were collected at 20°C from 4000 – 650 cm–1. The spectra were recorded on a Bruker spectrometer operating in the ATR (Attenuated Total Reflectance) mode.

Nuclear Magnetic Resonance (NMR): NMR samples have been prepared by dissolving the co-polymers in CDCl3 from Aldrich containing TMS at 0.05%. 1H spectra were obtained at 400 MHz Measurement has been performed at 300 K on a Bruker spectrometer. TMS was used as an internal reference.

Differential Scanning Calorimetry (DSC): The DSC equipment used, TQ instruments DCS Q100, was programmed to first heat the samples from room temperature -10°C to 200°C at a rate of 10˚C/min. An unsealed Aluminum sample vessel was used with nitrogen as the carrier gas at a flow rate of 20 mL/min. The mass of the analyzed sample varied from 5 to 10 mg. The DSC curve was the reference for determining the glass transition temperature (Tg) and phase transition temperature (Tm).

Thermogravimetry (TGA): TG analysis was carried out to measure the change in mass with an increase in temperature, thermal stability, and maximum degradation temperature for the samples. The test was conducted at a heating rate of 10˚C/min from 20˚C to 500˚C in an unsealed sample vessel under a nitrogen atmosphere with a flow rate of 20 mL/min. The equipment used was a PerkinElmer Pyric 1. The mass of the analyzed samples varied between 5 and 10mg.

Optical microscopy: Fiber diameter determined by using Olympus BX41 microscope with lens power of 20x and 50x.

3. Results and discussions

3.1 Synthesis of PLGA

PLGA successfully synthesized at 130°C temperature, in the ration of Lactic acid: Glycolic acid in 60:40, using stannous octoate as catalyst and Lauryl alcohol as co-catalyst in the 1.0 wt. % and 0.8 wt. % respectively. Reaction proceeds for 25 hr. at the mechanical stirring of 500 RPM.

Table 2 - Optimized parameter of PLGA

Monomer ratio (60:40) mol/mol	Lactic acid = 7.5 g Glycolic acid = 1.9 g
Sn (Oct)$_2$ (1.00%) wt.%	0.087 gm
Lauryl alcohol (0.8%) wt.%	0.052 gm
Time	25 h
Temperature	130°C
Acid value of lactic acid	561.00 mg of KOH/ g of sample
Acid value of glycolic acid	728.81 mg of KOH/ g of sample
Acid value at the start	563.50 mg of KOH/ g of sample
Acid value after 25 H	96 mg of KOH/ g of sample
Yield	89%

3.2 Purification process

- Vacuum drying: Synthesized product PLGA was dissolved in chloroform/ acetone, and dried in a vacuum at 46°C and 55°C. After that, it is kept for cooling.
- By using Desiccator: The product PLGA was cooled down and then dissolved in chloroform and subsequently precipitated into diethyl ether. The precipitated mixture was collected in a petri dish and dried in a desiccator using a vacuum. Vacuum applied by a vacuum pump.
- Buchner funnel: The polymer PLGA was purified by first dissolving in chloroform followed by precipitating in methanol under the action of mechanical stirring. And the precipitate dries using a Buchner funnel in which a vacuum is applied to the arm.

Table 3 - Effect of purification procedure on PLGA

Method	Vacuum drying	By using Desiccator	Buchner funnel
Conversion (%)	67	81	76
Reason	Some amount of PLGA (short chains) is also dissolved in a solvent.	Moisture and volatile component are easy to remove.	Filter mechanism

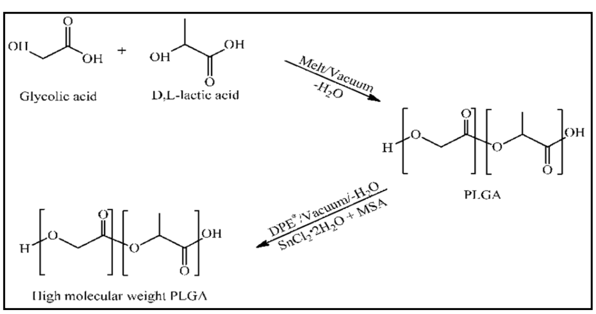


Figure 5 - PLGA synthesis route

3.3 Characterization of PLGA

Fourier Transform Infrared (FTIR)

The FTIR shows Characteristic bands of symmetrical and asymmetrical stretchings of CH2 and CH3 groups are presented between 2980 and 2850 cm-1. Similarly, bands of asymmetrical deformation of CH3 are presented in 1375 cm-1and CH2 in 1450 cm-1, with little decrease in intensity per decrease in the mass quantity of IR. The 1760 cm-1, in compounds with PLGA present, is seen in an acute and intense band, caused by the C=O bond stretching of the esters. The intensity is maintained in any composition and, is not visible in 100% IR. The 1185 cm-1 and the 1090 cm-1 are found to be bands relative to the C-O stretchings of aliphatic polyesters. The vibration of the IR C=C bond appears discrete at 1663 cm- 1.

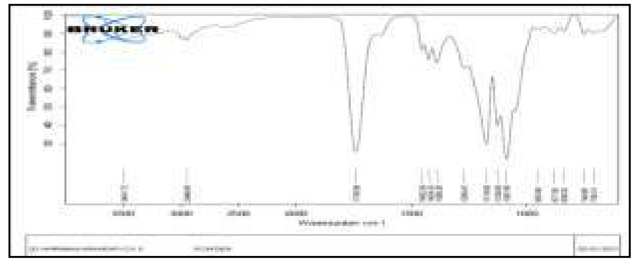


Figure 6- FTIR spectra for PLGA 60:40

Nuclear Magnetic Resonance (NMR): The methyl group (CH3) was adopted as a reference for the lactic acid monomer, with a peak of 1.66 ppm. Concerning the glycolic acid, the reference adopted was the peak observed for the methylene group (CH2), at 4.99 ppm.

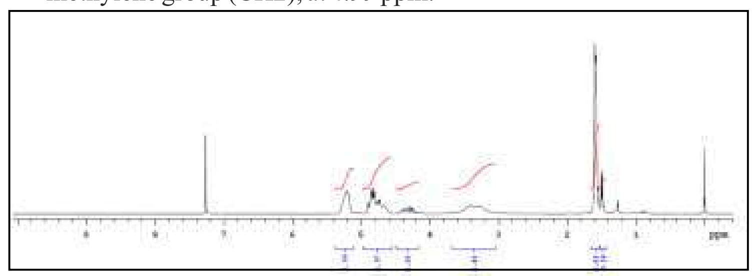


Figure 7 - NMR spectrum of PLGA 60:40

Differential Scanning Calorimetry (DSC)

The glass transition temperature was observed at 55.76°C and the melting temperature at 168.44°C. In the cooling cycle, the re-crystallization temperature is noted at 87.61°C.

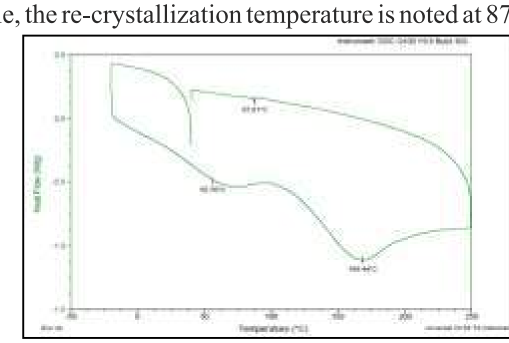


Figure 8 - DSC curve of PLGA 60:40 heating from -40 to 250°C

Thermogravimetry analysis (TGA)

Weight loss was 100% for PLGA and the respective values of Tonset and Tdeg. max was observed at 288.64°C and 325.60°C, heating was done from 30°C to 500°C.

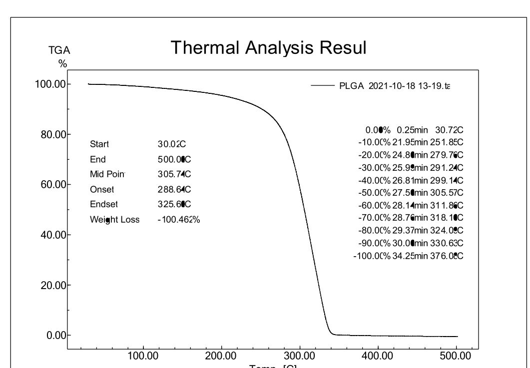


Figure 9 - TGA curve of PLGA 60:40 heating from 30 to 500°C

3.4 Characterization of PCL

Effect of Time, Temperature, and Wattage on PCL synthesis:

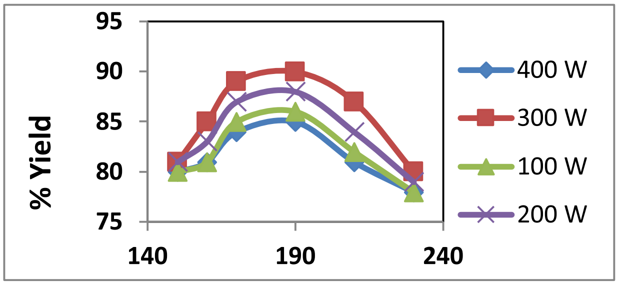


Figure 10 - Effect of reaction temperature and wattage on the synthesis of PCL Effect of reaction time

Table 4 - Effect of reaction temperature and wattage

Serial No.	Tempe rature	Wattage (W)	Catalyst concentratio n (g)
1	120	300	0.01
2	150	300	0.01
3	190	300	0.01
4	200	300	0.01

Fourier Transform Infrared (FTIR):

Fourier Transmittance Infrared Spectroscopy (FTIR) was used for the identification of polycaprolactone by measuring Transmittance from 500 to 4000 cm-1. In FTIR spectra of Polycaprolactone, peaks at 1720, 2940, and 2863 cm-1 verified the presence of Polycaprolactone.

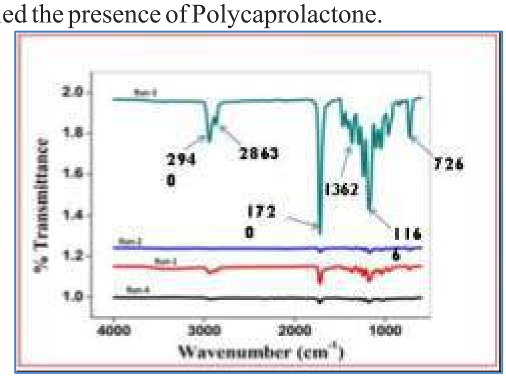
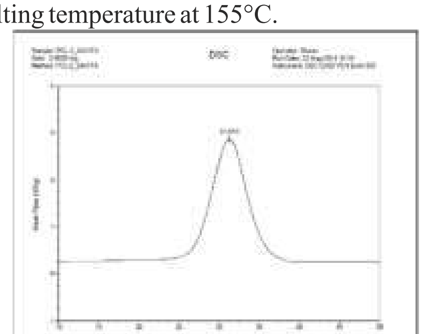


Figure 11 - Fourier Transform Infrared Spectrometry for PCL

Differential Scanning Calorimetry (DSC)

Glass transition temperature was observed at 67°C for PCL and Melting temperature at 155°C.



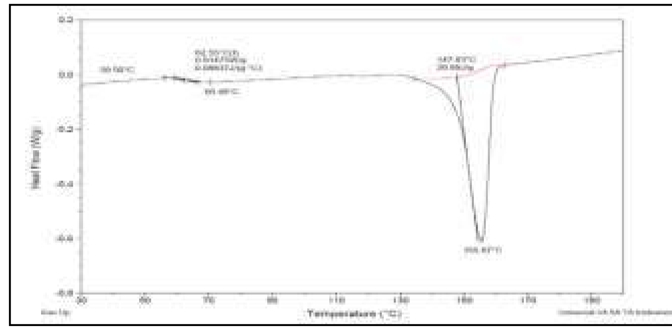


Figure 12 - Differential scanning calorimetry for PCL Nanofibers

X-ray diffraction (XRD) for PCL

X-ray diffraction (XRD) for PCL, The XRD analysis was carried out to determine structural changes. A normal focus diffractometer (Regaku Miniflex, Japan) source Cu target at 30 kV and was used with a scan rate of 3°/min. The data recorded in the range 20-500 and analyzed using Jade 6.0 software-ray diffraction patterns of synthesized PCL show sharp crystalline peaks at 21.3° and 23.8° which can be attributed to the crystallographic planes of the PCL crystal, respectively.

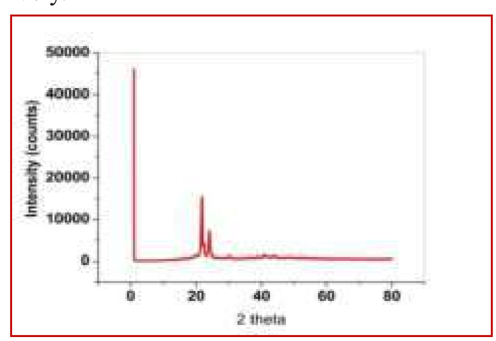


Figure 13 - X-ray diffraction (XRD) for PCL

3.4 Characterization of PLGA fibers

Optical microscopy

Fiber diameter was noted in the range of 21 µm. to 27 µm.

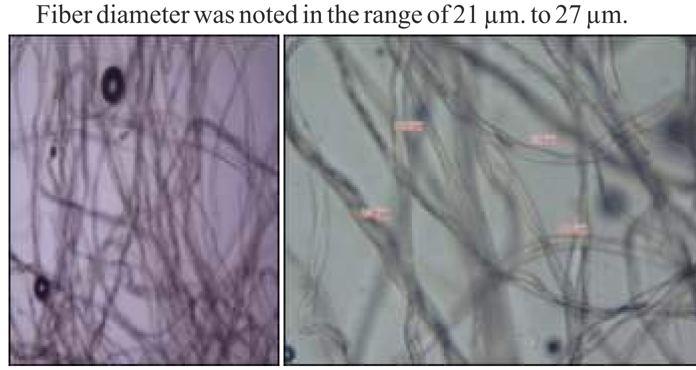


Figure 14 - Fiber diameter under lens power of 20x and 50x respectively

3.5 Characterization of PCL fibers

Scanning Electron Microscopy

A-Polarizing microscopy image of 5% PCL nanofibers.

B- Polarizing microscopy image of 20% PCL nanofibers.

Design of electrospinning apparatus for fabrication process shown in figure 19. C- SEM image of a Random 10% PLA nanofiber deposition. Electrospun 10% PLA nanofiber diameter was 329 to 500 nm. Scale bar = 1000x

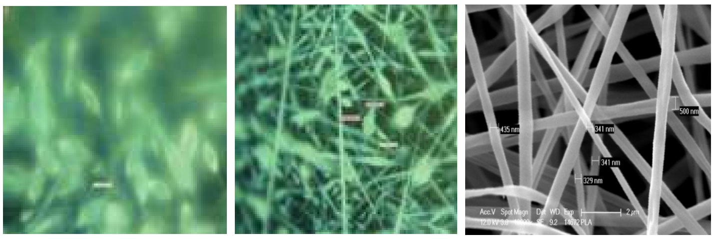


Figure 15 - PCL nanofibers by using electrospinning technique for 5, 10, 15, and 20% confocal images and scanning electrospinning microscopy images

4. Conclusion

PLGA polymers are good delivery carriers for the controlled administration of drugs, peptides, and proteins due to their biocompatibility and biodegradability. In general, longer-term release requirement. Also, for very long-term release (more than six months), semi-crystalline polymer with a high degree of crystallinity can be considered. Furthermore, multiple studies demonstrate that PLGA can easily be formulated into drug-carrying devices at all scales. Electrospinning is a very simple, versatile, and economic technique with many advantages for the fabrication of scaffolds for biomedical applications. Electrospinning has shown itself as a promising technology for the production of nanofibers which finds a great potential for its application in the biomedical field of tissue engineering.

5. Acknowledgments

I am very thankful to UGC for this work was financially supported and Institute of Chemical Technology and Prof. P. A. Mahanwar for valuable discussions, and CIRCIOT for SEM analysis.

References

[1] C. Chong, Y. Wang, A. Fathi, R. Parungao, P. K. Maitz, and Z. Li, “Skin wound repair: Results of a pre-clinical study to evaluate electropsun collagen–elastin–PCL scaffolds as dermal substitutes.,” Burns, vol. 45, no. 7, pp. 1639–1648, 2019, doi: 10.1016/j.burns.2019.04.014

[2] Armentano, M. Dottori, E. Fortunati, S. Mattioli, and J. M. Kenny, “Biodegradable polymer matrix nanocomposites for tissue engineering: A review,” Polym. Degrad. Stab., vol. 95, no. 11, pp. 2126–2146, 2010, doi: 10.1016/j.polymdegradstab.2010.06.007

[3] C. B. Benatti et al., “Bioreabsorbable polymers for tissue engineering: PLA, PGA, and their copolymers,” Mater. Biomed. Eng., pp. 83–116, 2019, doi: 10.1016/b978-0-12-816901-8.00004-3

[4] Z. Sheikh, S. Najeeb, Z. Khurshid, V. Verma, H. Rashid, and M. Glogauer, “Biodegradable materials for bone repair and tissue engineering applications,” Materials (Basel)., vol. 8, no. 9, pp. 5744–5794, 2015, doi:10.3390/ma8095273

[5] P. A.Gunatillake and R. Adhikari, “Biodegradable synthetic polymers for tissue engineering,” Eur. Cells Mater., vol. 5, pp. 1–16, 2003, doi:10.22203/eCM.v005a01

[6] J. S. Bello, I. Cruz-Maya, P. González-Alva, M. A. Alvarez-Perez, and V. Guarino, “Electro- and nonelectro-assisted spinning technologies for in vitro and in vivo models,” Nanomater. Theranostics Tissue Eng., pp. 175–204, 2020, doi:10.1016/b978-0-12-817838-6.00007-3

[7] D. H. Tan, C. Zhou, C. J. Ellison, S. Kumar, C. W. Macosko, and F. S. Bates, “Meltblown fibers: Influence of viscosity and elasticity on diameter distribution,” J. Nonnewton. Fluid Mech., vol. 165, no. 15–16, pp. 892–900, 2010, doi:10.1016/j.jnnfm.2010.04.012

[8] K. Morikawa, M. Green, and M. Naraghi, “A Novel Approach for Melt Electrospinning of Polymer Fibers,” Procedia Manuf., vol. 26, pp. 205–208, 2018, doi: 10.1016/j.promfg.2018.07.028

[9] B. Raghavan, H. Soto, and K. Lozano, “Fabrication of melt spun polypropylene nanofibers by Forcespinning,” J. Eng. Fiber. Fabr., vol. 8, no. 1, pp. 52–60, 2013, doi: 10.1177/155892501300800106

[10] T. Sato and T. Taniguchi, “Multiscale simulations for entangled polymer melt spinning process,” J. Nonnewton. Fluid Mech., vol. 241, pp. 34–42, 2017, doi: 10.1016/j.jnnfm.2017.02.001

[11] E. Zhmayev, D. Cho, and Y. L. Joo, “Nanofibers from gas-assisted polymer melt electrospinning,” Polymer (Guildf)., vol. 51, no. 18, pp. 4140–4144, 2010, doi: 10.1016/j.polymer.2010.06.058

[12] R. Chandra and R. Rustgi, “BIODEGRADABLE POLYMERS,” Prog. Polym. Sci., vol. 23, no. 97, pp. 1273–1335, 1998

[13] N. R. Khan and V. K. Rathod, “Microwave assisted enzymatic synthesis of speciality esters: A mini - review,” Process Biochem., vol. 75, pp. 89–98, 2018, doi: 10.1016/j.procbio.2018.08.019

[14] X. Niu, Q. Feng, M. Wang, X. Guo, and Q. Zheng, “In vitro degradation and release behavior of porous poly(lactic acid) scaffolds containing chitosan microspheres as a carrier for BMP-2-derived synthetic peptide,” Polym. Degrad. Stab., vol. 94, no. 2, pp.176–182, 2009, doi:10.1016/j.polymdegradstab.2008.11.008

[15] V. Frenz, D. Scherzer, M. Villalobos, A. A. Awojulu, M. Edison, and R. Van Der Meer, “Multifunctional polymers as chain extenders and compatibilizers for polycondensates and biopolymers,” Tech. Pap. Reg. Tech. Conf. - Soc. Plast. Eng., vol. 3, no. July, pp. 1678–1682, 2008

[16] T. C. R. Silva, B. C. O. Cardoso, M. E. S. R. e Silva, R. F. S. Freitas, and R. G. Sousa, “Synthesis, Characterization, and Study of PLGA Copolymer in Vitro Degradation,” J. Biomater. Nanobiotechnol., vol. 06, no. 01, pp. 8–19, 2015, doi:10.4236/jbnb.2015.61002

[17] K. Avgoustakis, “Polylactic-Co-Glycolic Acid (PLGA),” Encycl. Biomater. Biomed. Eng. Second Ed. - Four Vol. Set, no. Scheme 2, pp. 2259–2269, 2005, doi:10.1201/b18990-216

[18] A. Krzyzaniak, M. Leeman, F. Vossebeld, T. J. Visser, B. Schuur, and A. B. De Haan, “Novel extractants for the recovery of fermentation derived lactic acid,” Sep. Purif. Technol., vol. 111, pp. 82–89, 2013, doi:10.1016/j.seppur.2013.03.031

[19] C. E. Astete and C. M. Sabliov, “Synthesis and characterization of PLGA nanoparticles,” J. Biomater. Sci. Polym. Ed., vol. 17, no. 3, pp. 247–289, 2006, doi: 10.1163/156856206775997322

[20] X. Zhang, D. A. MacDonald, M. F. A. Goosen, and K. B. McAuley, "Mechanism of lactide polymerization in the presence of stannous octoate: The effect of hydroxy and carboxylic acid substances," J. Polym. Sci. Part A Polym. Chem., vol. 32, no. 15, pp. 2965–2970, 1994, doi: 10.1002/pola.1994.080321519

[21] V. Botvin, A. Latypov, N. Ponarin, and A. Filimoshkin, "Synthesis of glycolide by catalytic depolymerization of glycolic acid oligomers modified by polyhydric alcohols," J. Phys. Conf. Ser., vol. 1145, no. 1, 2019, doi: 10.1088/1742-6596/1145/1/012019

[22] A. Komesu, M. R. W. Maciel, and R. M. Filho, "Separation and purification technologies for lactic acid - A brief review," BioResources, vol. 12, no. 3, pp. 6885– 6901, 2017, doi: 10.15376/biores.12.3.6885-6901

[23] A. Komesu, P. F. M. Martinez, B. H. Lunelli, R. M. Filho, and M. R. W. Maciel, "Lactic acid purification by reactive distillation system using design of experiments,"Chem. Eng. Process. Process Intensif., vol. 95, pp. 26–30, 2015, doi:10.1016/j.cep.2015.05.005

[24] Z. Lazarova and L. Peeva, "Solvent extraction of lactic acid from aqueous solution," J. Biotechnol., vol. 32, no. 1, pp. 75–82, 1994, doi: 10.1016/0168-1656(94)90122-8

[25] T. Ghaffar et al., "Recent trends in lactic acid biotechnology: A brief review on production to purification," J. Radiat. Res. Appl. Sci., vol. 7, no. 2, pp. 222–229, 2014, doi: 10.1016/j.jrras.2014.03.002

[26] Y. Selim and I. Inci, "Extraction of Glycolic Acid from Aqueous Solutions by Amberlite LA-2 in Different Diluent Solvents," J. Chem. Eng. Data, vol. 54, no. 10, pp. 2791–2794, 2009, doi: 10.1021/je800722a

[27] I. Inci and H. Uslu, "Extraction of glycolic acid from aqueous solutions by trioctyl methylammonium chloride and organic solvents," J. Chem. Eng. Data, vol. 50, no. 2, pp. 536–540, 2005, doi: 10.1021/je049677i

[28] J. Bojda, E. Piorkowska, G. Lapienis, and A. Michalski, "Crystallization of star-shaped and linear poly(L-lactide)s," Eur. Polym. J., vol. 105, no. May, pp. 126–134, 2018, doi: 10.1016/j.eurpolymj.2018.05.017

[29] X. Song, Z. Bian, Y. Hui, H. Wang, F. Liu, and S. Yu, "Zn-Acetate-Containing ionic liquid as highly active catalyst for fast and mild methanolysis of Poly(lactic acid)," Polym. Degrad. Stab., vol. 168, p. 108937, 2019, doi: 10.1016/j.polymdegradstab.2019.108937

[30] E. Wojtczak, P. Kubisa, and M. Bednarek, "Thermal stability of polylactide with different end-groups depending on the catalyst used for the polymerization," Polym. Degrad. Stab., vol. 151, no. March, pp. 100–104, 2018, doi: 10.1016/j.polymdegradstab.2018.03.003

Influence of Silane Based Quat on Different Properties of Cellulosic and Blended Fabrics

Kushal Desai* & Bharat Patel
Department of Textile Chemistry, Faculty of Technology and Engineering, Kalabhavan,The M. S. University,Vadodara

Abstract:
In this research, an attempt has been made to investigate the effects of silane-based quaternary ammonium compound (2-Hydroxyethoxydimethoxysilyl) (QAC) on Cotton (C), Polyester/Viscose (P/V), and Polyester/Cotton (P/C) blend fabrics. The treatment enhances the physical properties such as tensile strength and crease recovery angle of treated C, P/V, and P/C fabrics compared to the untreated counterpart of the same. It also improves the abrasion resistance and pilling of the fabrics. The treatment reduces the bending length and drape ability of P/V and P/C fabric. The water absorbency of QAC treated fabrics was reduced by 94 - 95 % (wicking behavior) concerning control fabrics respectively. The P/V fabric after QAC treatment becomes water penetration fabric that requires more time for top and bottom surface wetting with very low spreading speed, with reduced bottom wetted radius. The P/C fabric after the treatment becomes a very good moisture management fabric. But cotton fabric after the treatment becomes water penetration fabric with a marginal drop in overall moisture management properties.

Keywords: _Comfort properties, MMT, Quaternary ammonium compound, Silane based, Uniform fabrics_

Citation: Kushal Desai & Bharat Patel, "Influence of Silane Based Quat on Different Properties of Cellulosic and Blended Fabrics", _Journal of the Textile Association,_ **83/5** (333-339), (Jan-Feb2023), https://doi.org/10.56716/4/1451

Article Received: 15-05-2022, Revised: 27-07-2022, Accepted:06-10-2022

1. Introduction :

In tropical countries like India, sweating bad odor on textiles is a common problem for the wearer, especially living in coastal cities. This has aggravated due to polyester-rich blends and also global warming. Consumers are looking for garments free of bad odor at the end of the day so that the frequency of washing would be reduced apart from the comfort factor. The problems caused by microorganisms have been widely aired in the media in Western Europe & North America and the medical textile sector, In particular, has welcomed the greater applicability of antimicrobial finishes to stem the presence of the microorganism. Many processes have, therefore, been reported in the literature to impart durable antimicrobial finish to textiles by introducing cationic sites, which is known as "Cationisation". Introducing amino groups or quaternary ammonium groups via its hydroxy group can cationize cotton [1-3].

Recently, natural fibers are modified to improve their mechanical and chemical properties and also to overcome the deficiencies present in the fiber. In cotton generally, it can be done by either blocking in the functional group already present in the fiber or by introducing of new functional group [1-3]. Other important aspects of chemical & mechanical modification of cotton are to achieve shorter dyeing time, lower temperature of dyeing, normal salt or no salt to exhaust the bath, neutral pH fixation of modification fiber etc [4,5]. A detailed study on the antimicrobial efficacy of QAC treated textiles are available but very little work has been reported on the effect of QAC treatment on the mechanical and moisture management properties of cotton and its blends [6-9].

In the present investigation, an attempt has been made to evaluate the effect of a QAC; silane-based quaternary ammonium compound (zycrobial) treatment on the physical properties of Polyester/Viscose (P/V), Polyester/Cotton (P/C) blend, and 100% Cotton (C) fabric by standard methods of testing and the changes in the moisture management property on moisture management tester (MMT) using AATCC TM195-2009 standards.

2. Materials

2.1 Fabrics

The three types of fabrics were selected for uniform fabrics namely, Polyester/Viscose (P/V), Polyester/Cotton (P/C) blend, and 100% Cotton (C). The detailed specifications for fabrics are given in Table 1.

Table 1 - Specification of Various Fabrics

Specification	Fabrics		
	P/V	P/C	C
Weave	Plain	Plain	2/1 Twill
Blend (%)	80/20	67/33	100% C
GSM	175.24	119.57	246.77
EPI/ PPI	58/50	100/76	78/53
Count/Denier	416/380	161/155	14.8/11.5
Width (cm)	148.5	92	152
Thickness (mm)	0.38	0.30	0.62

2.2 Chemicals

The QAC; silane-based quaternary ammonium compound

***Corresponding Author :**
Mr. Kushal Desai
Department of Textile Chemistry, Faculty of Technology and Engineering, Kalabhavan, The M. S. University of Baroda, Pratapgunj, Vadodara – 390 001
E-mail: desai.kushal911@gmail.com

(zycrobial) material supplied by Zydex industries limited, Vadodara. Other chemicals i.e. acetic acid, R-77, and sodium carbonate used in this experiment were of analytical grade and used without further purification.

2.3 Experimental methods

The experimental plan was based on the application of QAC on P/V, P/C, and C fabrics by pad–dry- cure method.

2.3.1 Application of QAC on uniform fabrics

The application of QAC on fabrics was one by padding technique. In pad application, the fabric immersed in liquor containing the required amount of QAC agent (zycrobial- 30 gpl and 50 gpl) and passes through the padding mangle at 2.5 kg/cm2 pressure using laboratory two bowl padding mangle. The fabric was subsequently dried and cured at room temperature.

2.4 Testing and Analysis

The QAC treated fabrics were analyzed for the change in their physical properties by slandered techniques of testing. The treated and untreated specimens were conditioned at 65 ± 2 % relative humidity and 27 ± 2°C before testing each physical property.

2.4.1 Thickness test

The thickness of treated and untreated fabrics was measured on the thickness tester as per ASTM D5729 standard.

2.4.2 Tensile strength

Lloyd LRX (Lloyd Instruments Limited, Hampshire, UK) mechanical test device was used for the assessment of tensile strength of treated and untreated samples. The tensile force was applied with a speed and a gauge length of 300 mm/min and 200 mm, respectively. Each tensile test was performed under pull to break test setup on Lloyd Instrument using ASTM D5035-06 R08 standard.

2.4.3 Stiffness (Bending length)

The stiffness in terms of bending length of treated and untreated samples was measured as per ASTM D1388-2007 standard using a Prolific stiffness tester (India).

2.4.4 CRA (Crease Recovery Angle)

The test specimen (2×1 inch) was folded and compressed under the controlled condition of defined force to create a folded angle. The specimen was then suspended in an instrument for a controlled recovery; the recovery angle was then examined. The test was performed as per ASTM D 1295-67 using a Sasmira crease recovery angle tester.

2.4.5 Tear strength

The Elmendorf tearing tester was used for testing tear strength as per the standard ASTM D1424-09. The average force required to continue a tongue-type tear in a fabric is determined by measuring the work done in tearing it through a fixed distance. The fabric samples were cut in both warp and weft ways. The specimen was held with two clamps, stationary and moveable, and for tearing it by the fall of the pendulum due to the force of gravity. The augmenting weight taken was 6400gm. Tearing strength was calculated by multiplying pointer reading to weight.

2.4.6 Abrasion resistance

Abrasion resistance is the ability of a fabric to resist surface wear caused by flat rubbing contact with another material. Abrasion results are one of several means of comparing fabrics for a particular application. The testing process requires samples of the test fabric to be pulled taut in a frame and held stationary. Individual test specimens cut from the warp or weft directions are then rubbed back or front using an extra-fine Emery cloth J297 UE as the abradant. The endpoint is reached when appreciable wear is reached. The abrasion tester we used here is made by Henry Bayer and Co. S.A, Zurich; Model -1952-53. In this instrument abrasion surfaces wrapping with sandpaper are used to abrade the fabric samples. A counter was used to count the number of abrasions. The tester used in this experiment was an electrical tester with automatic stop motions i.e. the motor of the tester is switched off as soon as a hole appears or the specimen breaks.

2.4.7 Pilling test

The determine the tendency to form pills, test specimens were taken from the fabric sample are rubbed against each other under controlled conditions and the appearance of the test specimen after rubbing for 5hr. at 60 rpm is compared against the standard rating. The pilling test (IS-10971-1984) on IKON pilling box Tester.

2.4.8 Drape test

The test was performed as per the IS-8357/1977 (BTRA Drape meter 30). The drape is defined as the area covered by the shadow of the draped specimen expressed as a percentage of the area of the annular ring of fabric. The drape and drape ability are terms for that property of textile materials, which allows the fabric to orient itself into graceful holds or pleats when acted upon by the force of gravity. Hence a fabric is said to have a good draping quality when the configuration is pleasing to the eye.

3. Results and Discussion

Changes in physical and comfort properties of the treated fabric in terms of their thickness, tensile strength, tear strength, stiffness, drape ability, pilling, abrasion, crease recovery angle, and moisture management was analyzed and reported in this section.

3.1 Influence of QAC treatment on the physical properties of uniform fabrics

3.1.1 Influence on the thickness

Table 2- Thickness of QAC treated and untreated fabrics

Fabric	Treatment	Thickness (mm)
P/V	Untreated	0.38
	QAC Treated	0.38
P/C	Untreated	0.30
	QAC Treated	0.30
C	Untreated	0.62
	QAC Treated	0.62

It can be seen from the results given in Table 2 that the thickness of fabric before and after the QAC treatment remains the same. It may be due to the quaternary amine compound group react with the polymer chain itself, therefore there was no superficial deposition or coating layer formed on the material which can increase the thickness of the material.

3.1.2 Influence on tensile strength

Table 3 - Tensile strength of QAC treated and untreated fabrics

Fabric	Treatment	Warp / weft	Load (kgf)	Percentage Strain
P/V	Untreated	Warp	116.66	24.39
		Weft	96.58	34.03
	30gpl QAC Treated	Warp	119.10	25.24
		Weft	99.47	35.40
P/C	Untreated	Warp	68.97	25.26
		Weft	50.08	25.20
	30gpl QAC Treated	Warp	71.52	25.91
		Weft	51.02	26.21
Cotton	Untreated	Warp	94.12	21.07
		Weft	53.59	13.48
	30gpl QAC Treated	Warp	99.09	21.59
		Weft	56.09	14.03

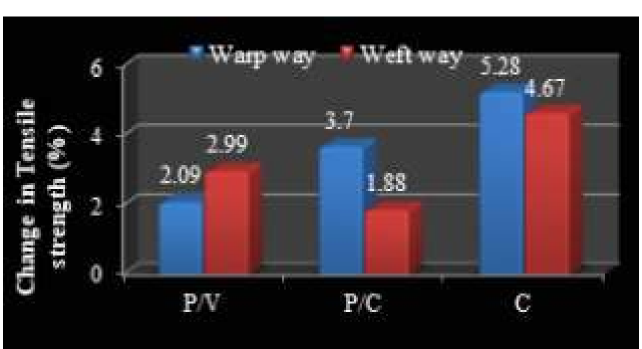


Figure 1 - Effect of QAC treatment on tensile strength of the fabric

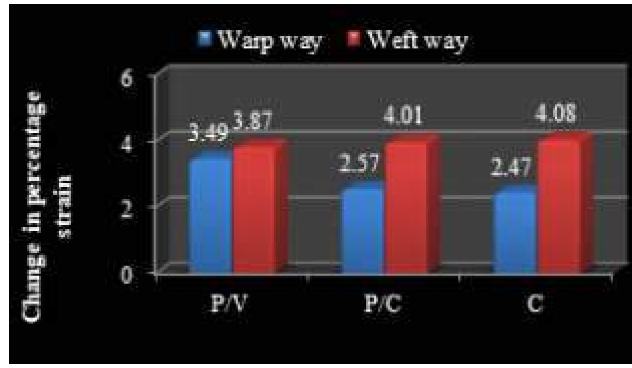


Figure 2 - Effect of QAC treatment on percentage strain of the fabric

The tensile strength (dry) and elongation at break of untreated as well as QAC treated fabrics are represented in Table 3 and Figure 1, 2. From the results, it can be seen that the treatment improves the tensile strength of the fabric. The treatment with the quaternary amine group leads to a slight improvement in the tensile strength as well as elongation at break10. Such improvement may reflect the QAC effect on the individual and blended textile fabric. The improvement in the tensile and elongation of fabric is attributed due to the ionic cross-linking nature as it may bring the cellulose chain closer to each other, hence, an increase in the tensile strength is observed. For example, the tensile strength increases from 94.12kgf for the untreated fabric to 99.09kgf for the cotton fabric treated with QAC in a warp way. However, the change in improvement in values of tensile strength and percentage strain varies (Figure 1 & 2) for cotton to P/V fabric. Such differences in the values of tensile strengths in warp and weft direction could be associated with variation in blend proportion and also with the class of fiber in the blend.

3.1.3 Influence on bending length

The bending length is directly proportional to stiffness. The stiffness of the P/V, P/C, and 100% cotton fabric in warp and weft way was evaluated and shown in Table 4.

Table 4 - Bending length of untreated and QAC treated fabrics

Fabric	Treatment	Warp / weft	Average Overhang length (cm)	Bending Length (cm)
P/V	Untreated	Warp	4.02	2.01
		Weft	4.36	2.18
	30gpl QAC Treated	Warp	3.84	1.92
		Weft	4.20	2.10
P/C	Untreated	Warp	3.84	1.92
		Weft	3.76	1.88
	30gpl QAC Treated	Warp	3.62	1.81
		Weft	3.64	1.82
Cotton	Untreated	Warp	4.30	1.72
		Weft	3.40	1.70
	30gpl QAC Treated	Warp	4.06	1.63
		Weft	3.20	1.60

From the results given in Table 4 and Figure 3, it can be seen that the fabric becomes slightly softer after QAC treatment. Almost 3-6 % increase in softness was observed in all fabrics treated with 30 gpl QAC and minimum bending length was observed in the cotton sample compared to the P/V sample.

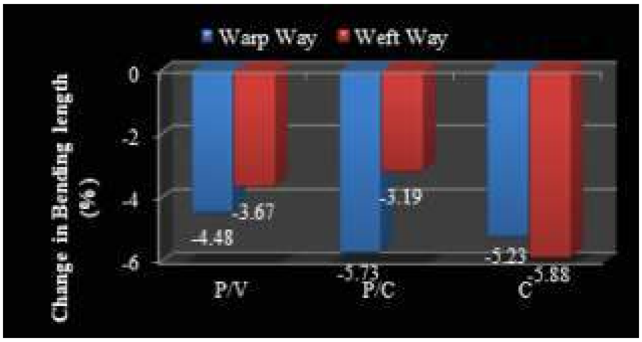


Figure 3 - Effect of QAC treatment on the stiffness of the fabric

3.1.4 Influence on crease recovery angle

The result shown in Table 5 and Figure 4 indicates that the QAC treatment increases the crease recovery angle irrespective of the class of fabric selected for the treatment.

Table 5 - Crease recovery angle of untreated and QAC treated fabric

Fabric	Treatment	Warp/weft	Average (°)
P/V	Untreated	Warp	127
		Weft	151
	30gpl QAC Treated	Warp	138
		Weft	167
P/C	Untreated	Warp	135
		Weft	121
	30gpl QAC Treated	Warp	146
		Weft	130
Cotton	Untreated	Warp	73
		Weft	90
	30gpl QAC Treated	Warp	91
		Weft	113

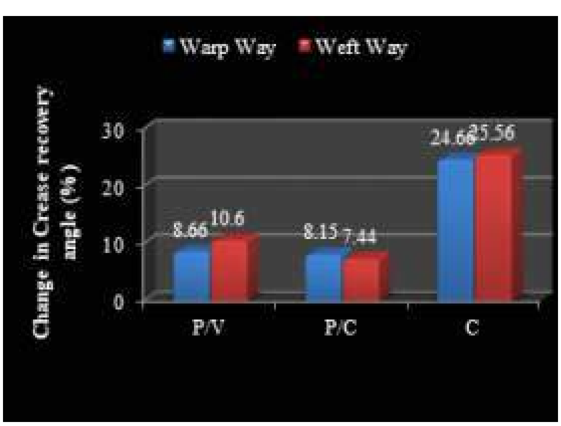


Figure 4 - Change in crease recovery angle of treated P/V, P/C, and cotton fabric

The bending elasticity seems to be of the greatest importance in the phenomenon of creasing. Creases appear when the material is distorted in such a manner that part of it is stretched beyond its small power of elastic recovery. The bending of the fibers which takes place during creasing leads to an extension of the fabric on the upper surface and compression on the under surface. The crease recovery angle of fabric increased with the treatment with a 30gpl concentration of QAC compared to the untreated sample of the respective fabric. The crease recovery angle of QAC treated P/V and P/C blend fabric were good as seen from Figure 4 while that of 100% cotton fabric was found excellent.

3.1.5 Influence on tearing strength

The average force required to continue a tongue-type tear in a fabric is determined by measuring the work done in tearing it through a fixed distance. The tearing strength of fabric samples in both warp and weft ways was calculated by multiplying pointer reading to weight. The results in average pointer reading and tear strength are given in Table 6. The change percentage of tear strength due to the treatment was shown in Figure 5. The QAC treated samples of P/V and 100% cotton samples shows an increase in tear strength by 4% and 15% respectively compared to their untreated counterpart. On the other hand, the tear strength was found to decrease in the case of P/C fabric by 12 to17% compare to its untreated sample.

Table 6 - Tearing strength of QAC treated and untreated fabric

Fabric	Treatment	Warp / weft	Avg. Pointer reading	Tear strength (gms)
P/V	Untreated	Warp	62.4	3993.6
		Weft	51.0	3264.0
	30gpl QAC treated	Warp	67.4	4313.6
		Weft	58.6	3750.4
P/C	Untreated	Warp	33.6	2150.0
		Weft	24.6	1574.0
	30gpl QAC treated	Warp	29.4	1882.0
		Weft	20.2	1293.0
Cotton	Untreated	Warp	38.4	2458.0
		Weft	32.6	2086.0
	30gpl QAC treated	Warp	42.4	2714.0
		Weft	34.0	2176.0

Figure 5 - Effect of QAC treatment on tearing strength of the fabric

3.1.6 Influence on abrasion resistance

Abrasion is the ability of a fabric to withstand the loss of appearance, life, or surface through the destructive action of surface, wear, and rubbing. Fibers in use are subjected to a variety of different forces, which are repeated many times until finally, the fibers wear out. The abrasive wear of materials depends to a certain extent on the construction of yarn and fabric. Table 7 and corresponding Figure 6 illustrate the effect of QAC treatment on P/V, P/C and cotton fabrics.

Table 7 - Average abrasion strokes for untreated and QAC treated on fabrics

Fabric	Treatment	Average Abrasion stroke
P/V	Untreated	214
	QAC Treated	348
P/C	Untreated	141
	QAC Treated	78
Cotton	Untreated	136
	QAC Treated	101

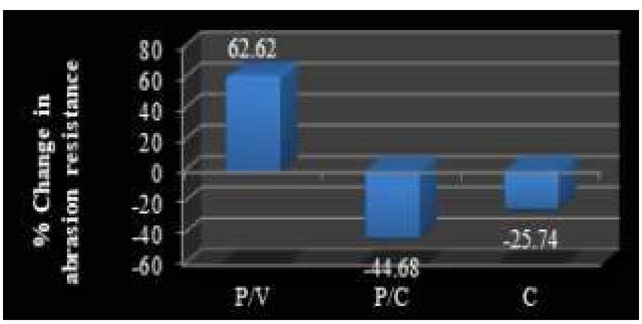


Figure 6 - Change in abrasion resistance of QAC treated fabric

The abrasion resistance of the QAC treated sample was found excellent in the case of P/V fabric, whereas the same property was found decreased in the case of P/C and 100 % cotton fabric treated with QAC compared to their respective counterpart.

3.1.7 Influence on pilling of the fabric

Pills were counted on each specimen and the result in terms of ratting according to the standard scale is shown in Table 8.

Table 8 - Rating of pilling of untreated and QAC treated fabric

Fabric	Treatment	Rating
P/V	Untreated	0
	30 gpl QAC Treated	2
P/C	Untreated	0
	30 gpl QAC Treated	2
Cotton	Untreated	1
	30 gpl QAC Treated	2

Table 8 reveals that the treatment reduces pilling formation on the surface. Results indicate that the treatment with a 30gpl concentration of QAC improved the pilling property of fabrics irrespective of the class of fabric. The QAC treated fabrics show ~30 pills whereas untreated fabric shows more than 80 pills in all the fabric. The results of pilling can further be supported by observing treated and untreated fabric surfaces, where the surface of the treated fabric seems to be very smooth and free from loose fiber or hairiness.

3.1.8 Influence on drape ability

Table 9 - Drape Coefficient of QAC treated and untreated fabric

Fabric	Treatment	Drape Coefficient (F)
P/V	Untreated	0.60
	QAC Treated	0.53
P/C	Untreated	0.55
	QAC Treated	0.52
Cotton	Untreated	0.63
	QAC Treated	0.64

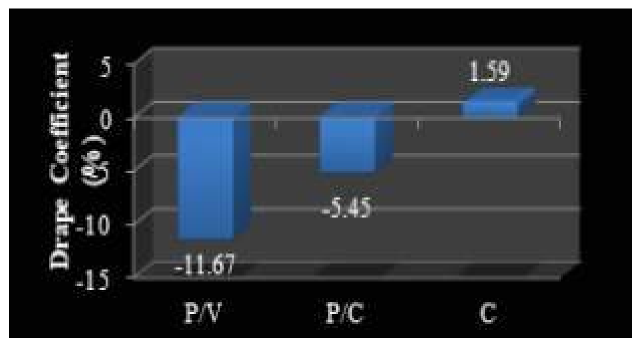


Figure 7 - Effect of QAC treatment on drape ability of the fabric

The drape is a unique property that allows a piece of fabric to be bent in more than one direction with double curvature. Fabric drape ability may be described as a degree of the deformation of fabric to orient itself into folds in more than one plane when the fabric is partially supported by other objects. The drape ability of each specimen five times was measured, from which we calculated the mean value of each parameter for each specimen. The change in the drape ability of the specimen is shown in Figure 8. In the analysis of the drape profile, it was noted that the small value of the drape coefficient shows better drape ability and the large value of the drape coefficient indicates the bad drape ability of the fabric. It implies that the QAC treated fabric shows improvement up to 12% in drape ability of P/V fabric and 5.5% in P/C fabric but there was no significant change observed in the drape ability of 100% cotton fabric.

3.2 Influence of QAC treatment on the comfort properties of uniform fabrics

3.2.1 Influence on absorbency

The water absorbency of QAC treated and untreated fabric samples were measured as per the standard AATCC test method. Results for the same are presented in Table 10 and Figure 8. From the results, it is found that the treatment drastically reduces the water absorbency of all the fabric samples. The QAC reacts with the intermolecular structure as well as forms a second layer on the surface of the fabric which may resist immediate penetration of water droplets, which increased the time to travel and get water molecules absorbed, inside the fabric structure. The results presented in Table 10 show that due to the application of QAC wicking length was reduced, that is for a fixed time the length traveled by water was reduced in treated samples.

Table 10 - Wicking length of QAC treated and untreated fabric

Fabric	Treatment	Average length (mm)
P/V	Untreated	121
	30gpl QAC treated	5
P/C	Untreated	102
	30gpl QAC treated	5
C	Untreated	94
	30gpl QAC treated	5

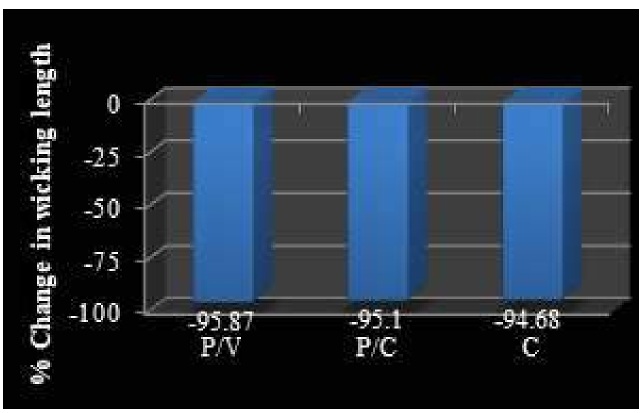


Figure 8 - Effect of QAC treatment on wicking length of the fabric

From the results, it can be safely interpreted that the treatment makes the fabric hydrophobic.

3.2.2 Influence on moisture management

Fabrics treated with QAC were analyzed for their moisture behavior. The untreated P/V fabric shows overall excellent moisture management property with a 4.5 rating means the fabric requires less time for top and bottom surface wetting with high spreading speed. The P/V fabric after QAC treatment becomes water penetration fabric with a rating of 2 means the fabric requires more time for top and bottom surface wetting with very low spreading speed, with reduced bottom wetted radius.

The moisture management property of P/C fabrics before and after QAC treatment. The untreated P/C fabric shows overall excellent moisture management property with a 4.5 rating means the fabric requires less time for top and bottom surface wetting with high spreading speed. But after QAC treatment the top surface wetting time increased to 120 seconds compared to 2 seconds required by the fabric before the treatment. The data indicate the P/C fabric after QAC treatment becomes water penetration fabric with a rating of 4 means the fabric requires more time for top surface wetting with 0 spreading speed and 0 bottoms wetted radius. However, the fabric requires less time for bottom surface wetting and according to the MMT analysis system, the high one-way transport index of the tested fabric is considered a very good moisture management fabric.

Cotton fabric was also tested for its moisture management behavior. From the results, it can be seen that the untreated cotton fabric shows overall good moisture management property with a 3 rating means the fabric requires less time for top and bottom surface wetting with good spreading speed. The cotton fabric after QAC treatment becomes water penetration fabric with a marginal drop in overall moisture management property i.e. rating of 2.5; means the fabric requires a little more time for top and bottom surface wetting with low spreading speed, with reduced bottom wetted radius.

4. Conclusion

A silane-based quaternary ammonium compound can be applied to uniform fabrics i.e. cotton, polyester/cotton, and polyester/viscose blend fabric by economical pad-batch technique.

The treatment enhances the physical properties such as tensile strength and crease recovery angle of treated cotton, P/V, and P/C fabrics compared to the untreated counterpart of the same. It also improves the abrasion resistance and pilling of the fabrics. The treatment reduces the bending length and drape ability of P/V and P/C fabric.

The water absorbency of QAC treated fabrics was reduced by 94 - 95 % (wicking behavior) concerning control fabrics respectively. The P/V fabric after QAC treatment becomes water penetration fabric that requires more time for top and bottom surface wetting with very low spreading speed, with reduced bottom wetted radius. The P/C fabric after the treatment becomes a very good moisture management fabric. But cotton fabric after QAC treatment becomes water penetration fabric with a marginal drop in overall moisture management property.

With the advent of new technologies, the growing needs of the consumer in the wake of health and hygiene can be fulfilled without compromising the issues related to safety, human health, and the environment.

5. Acknowledgment

The authors are thankful to Mr. J. Sridhar (Vice President-Textile), Mr. P. Pandey, and Ms. S. Vijay of Zydex Industries for extending their support to complete this research work.

References

[1] J. Shore, 'Cellulosics Dyeing'; Society of Dyers of Colorists, Manchester, U.K.; 1995.
[2] S. P. Misra, 'A Text book of Fibre science and Technology'; New age international publication, New Delhi: 2000: pp.14.
[3] R. B. Chauhan & D. P. Chattopadhyay, "Cationization of cotton for improved dyeability", Colourage, annual (1998) 127-133.
[4] S. R. Karmakar, "Modifying the dye-ability of cotton by chemical treatment", Colourage, annual (1991) 43-50.
[5] Dr. V. A. Shenai , 'Textile fibres', Sevak Publication, Ed. 3: Vol-I: 1996.
[6] B. H. Patel, R.D.Pachauri & K.U.Desai, "Changes in cotton treated with choline chloride", The Indian Textile Journal, 124(10) (2014) 74-78.
[7] B. H. Patel, R.D.Pachauri & K.U.Desai, "Effect of salt in the dyeing of choline chloride pretreated cotton with reactive dyes", Cotton Bangladesh, 14(2) (2014) 22-24.
[8] W.D.Schindler & P.J.Hauser, 'Chemical finishing of textiles', chapter-15 :2004 : pp. 165.
[9] B.H.Patel, "Improved dyeability of cotton by chemical modification", The Indian Textile Journal, 115(1) (2005) 41-46.
[10] S.P. Rowland & MAF Brannan, "Introduction and removal of durable creases in wrinkle-resistant cotton fabric", Textile Research Journal, 40 (1970) 607–613.

■ ■ ■

To Study Contribution of Surface Finishes to Needle Punched Non-Woven Properties

Atul Dhavale*, M. C. Burji & Rohit Shinde

Dept. of Textile Engineering, D.K.T.E Society's Textile & Engineering Institute, Ichalkaranji (M.S.)

Abstract:

In recent years nonwoven textiles are acquiring major stake in technical textile application because of it physical and functional properties. The technical developments in polymer, nonwoven processing & fabric finishing have significant impact on fabric properties. Characteristic like greater air permeability, greater specific area, and smaller pore size with its controllable distribution benefits nonwovens to its diversified application range in technical textile area. These characteristics help nonwoven to have highest market share near about 90% out of total.

Resent development in technologies and different challenges faced by world and human beings demands additional features of nonwoven. To fulfill these challenges different surfaces finishes are applied to nonwovens to enhance the properties of it. A calendaring is a type of mechanical finish given to nonwoven which is very oftenly applied to improve properties. So an attempt was made to study contribution of calendaring to change in nonwoven properties which very much useful for its behavior as a filter media.

Analysis of properties before and after calendaring was done by using paired t- test shows that calendaring has significantly affecting on properties like thickness, air permeability, pore size. Calendaring reduces thickness, air permeability and pore size of fabric while bursting strength increases.

Keywords: *Calendaring, Needle Punched, Testing, T-Paired Analysis Test*

Citation: Atul Dhavale*, M. C. Burji & Rohit Shinde, "To Study Contribution of Surface Finishes to Needle Punched Non-Woven Properties", *Journal of the Textile Association,* **83/5** (340-343), (Jan-Feb'2023), https://doi.org/10.56716/4/1459

Article Received:14-07-2022, Revised: 08-09-2022, Accepted:09-11-2022

1. Introduction :

The nonwoven industry is one of the rapidly developing industries in the world. For the past 30 years, it has been exhibiting an average growth of about 8% and is expected to sustain this rate of growth for the next ten years [1]. Man-made fibres completely dominate nonwovens production, accounting for over 90% of total output. According to a study by Tecnon Ltd, the world usage of fibres in nonwovens production is:

- Polypropylene 63%
- Polyester 23%
- Viscose Rayon 8%
- Acrylic 2%
- Polyamide 1.5%
- Other Specialty Fibers 3% [2]

Needle punching is a nonwoven process by which the fibres are mechanically entangled to produce a nonwoven fabric by repeated penetration of barded needles through a preformed dry fibrous web [3, 4]. Calendaring is a mechanical finishing technique which can be applied to nonwovens made of cellulose, protein and synthetic fibres. The fabric is subjected to a smoothing and a squeezing activity when passed through these rollers. When the nonwoven is passed through the calendar rollers, it is subjected to an extremely uniform pressure along the entire width of the rollers [1].

Corresponding Author :
Prof. A. J. Dhavale
Assistance Professor, Department of Textile, Textile and Engineering Institute, Rajawada, Ichalkaranji – 416 115
E-mail: ajdhavale@gmail.com

Calendaring process increased the resistance to air flow & resulted in reduction of actual permeability's, which may be due to the increase in the packing density of nonwoven media resulting in less open space & higher resistance to air flow. Increase in fabrics weight per unit area means more number of fibres per unit area acting against the flow of air, resulting in decrease in air permeability values. [5, 6] Calendared nonwoven fabrics has lower thickness, porosity and characteristic opening pore size with regard to only the needled nonwoven fabrics. The density of the calendared nonwoven fabric is greater than that of the needled nonwoven fabrics. [7,8]. The advantages of the calendaring process is the water permeability of calendaring polypropylene geotextile decreased in the narrow interval compared to only needle punched polypropylene geotextile, which is important in practical use. [9,10]. The mass per unit area of the needle-punched geotextile after the calendaring process has increased due to a decrease in length and an increase in the diameter of the fibres in geotextiles[11]. Bursting strength increased with the increase in calendar roller pressure and later it became more or less constant. It increased with the increase in calendar roller temperature and subsequently decreased during later stages. It decreased with the increase in calendar roller speed [12].

2. Material

The needle punched hybrid nonwoven material was manufactured with proportionate mix of polyester & polypropylene. The table below gives details of fibre used and its specifications.

Table 1 - Fibre Specification

Specifications	Polyester	Polypropylene
Density	1.38 gm/cc	0.9 gm/cc
Denier	3d	3d
Denier	6d	6d
Staple	64 mm	64mm

3. Method

A RSM method was used to optimize the process parameters with a minimum number of experiments, as well as to analyze the interaction between the parameters. [4] In present work, three independent variables were chosen for the statistical experiment design as Fiber Denier, Fiber Density, Fabric GSM (Gram per Sqr. Meter). The range and level of the factors varied accordingly to the experimental design. These three variables together with their respective ranges were found to be critical parameters for Nonwoven Fabric thickness, Air permeability and Bursting Strength. To optimize number of trials Response Surface-Box-Behnken design with three center points were used.

Nonwoven fabric samples were produced in D.K.T.E.'s Centre of excellence in nonwovens, Ichalkaranji. The polyester and polypropylene fibre were mixed in proportion to produce in needle punch nonwovens on Trutzschler, machine. Needle punched nonwoven fabric manufacturing consists of carding, web formation and web bonding. Total fifteen samples were manufactured and details of it are as follows:

Table 2 - Behnken experimental design with the independent variables

Sr. no.	Denier of fibre	Density of fibre (gm/cc)	Composition	GSM
1	3	1.155	50 % poly 3d + 50 % pp 3d	200
2	3	1.38	100 % poly 3d	160
3	4.5	0.93	50 % pp 3d + 50 % pp 6d	200
4	6	0.93	100 % pp 6d	160
5	4.5	1.555	25% poly 3d + 25% pp 3d +25% poly 6d+25% pp 6d	160
6	4.5	1.38	50 % poly 3d + 50 % poly 6d	200
7	6	1.555	50 % poly 6d + 50 % pp 6d	120
8	6	1.555	50 % poly 6d + 50 % pp 6d	200
9	3	0.93	100 % pp 3d	160
10	4.5	1.38	50 % poly 3d + 50 % poly 6d	120
11	4.5	1.555	25% poly 3d + 25% pp 3d +25% poly 6d+25% pp 6d	160
12	6	1.38	100 % poly 6d	160
13	4.5	1.555	25% poly 3d + 25% pp 3d +25% poly 6d+25% pp 6d	160
14	3	1.555	50 % poly 3d + 50 % pp 3d	120
15	4.5	0.93	50 % pp 3d + 50 % pp 6d	120

A produced needle punched non-woven material was tested for thickness, air permeability, bursting strength, pore size & porosity properties and results were recorded for before and after calendaring. The machine used for mechanical finishing or calendaring has following.

Table 3 - Calendaring machine specification

Hot Calendaring Machine	Yamuna Private Limited
Pressure	2 kg/cm^2
Speed	10 MPM
Temp	180^{0}C
Cylinder diameter	31”
Pressure roller diameter	6”

Figure 1 - Calendaring process & Material

4. Result & Discussion

The data obtained from sample testing was statistically analyzed by applying t-Test: paired two sample for means. Paired 't'test is used to test the means of two paired measurements, such as before & after calendaring, to check there is significant difference or not [6].

4.1 Thickness

Thickness of calendared & non calendared material was tested on Digital Thickness Gauge- SDLATL ATLAS tester as per standard ASTM D5729 and results are plotted below.

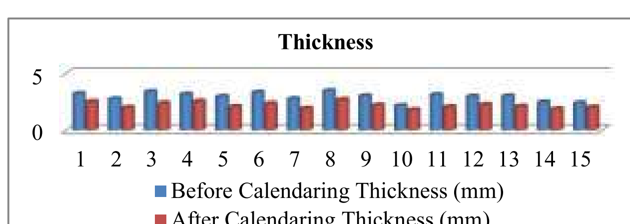


Figure 2 - Effect of calendaring on thickness

Analysis of results used 't-Test: paired two samples for means' get mean & variance of both type of samples i.e., thickness of before and after calendaring respectively 2.9408 - 2.192 & 0.142 – 0.067. A statistic't' value is 14.22 & t critical one tail value is 1.76 indicate that the absolute value is greater than t critical one tail value, so the null hypothesis is rejected. This means that fabric thickness values differ significantly before & after calendaring. So calendaring process significantly impacts on thickness of needle punched non-woven fabric. After the calendaring thickness of all samples were reduced by 25% due to material compression.

4.2 Air Permeability

Air permeability of before & after calendared material was tested on TEXTEST FX3300 III tester as per standard - ASTM METHOD – D737 and results are plotted below.

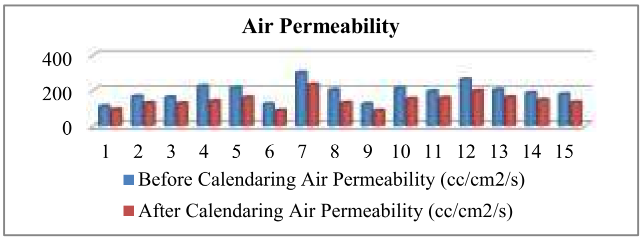


Figure 3 - Effect of calendaring on air permeability

Analysis of results using 't-Test: paired two samples for means' get mean & variance of both type of samples i.e., air permeability of before and after calendaring respectively 191.68 – 141.92 & 2760.36 – 1623.46. A statistic't' value is 10.56 & t critical one tail value is 1.76 indicate that the absolute value is greater than t critical one tail value, so the null hypothesis is rejected. This means that fabric air permeability's values differ significantly before & after calendaring. So calendaring process significantly impacts on air permeability of needle punched non-woven fabric. After calendaring air permeability of all samples is decreases. Calendaring process increased the resistance to air flow & resulted in reduction of actual permeability's, which may be due to the increase in the packing density of nonwoven media resulting in less open space & higher resistance to air flow. Increase in fabrics weight per unit area means more number of fibre per unit area acting against the flow of air, resulting in decrease in air permeability values. After calendaring air permeability of all samples was reduced by 26%.

4.3 Bursting Strength

Bursting strength of calendared & non calendared material was tested on Digital Bursting Strength Tester as per standard ASTM D6797 and results are plotted below

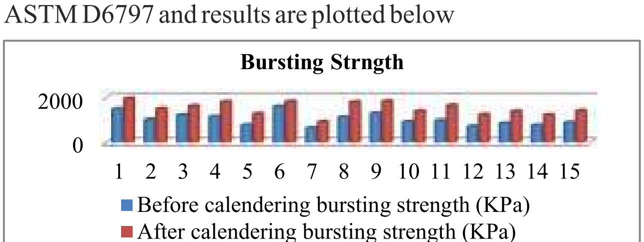


Figure 4 - Effect of calendaring on Bursting strength

Analysis of results using 't-Test: paired two samples for means' get mean & variance of both type of samples i.e., bursting strength of before and after calendaring respectively 1033.65 – 1529.80 & 80127.51 – 85864.30. A statistic't' value is 15.19 & t critical one tail value is 1.76 indicate that the absolute value is greater than t critical one tail value, so the null hypothesis is rejected. This means that fabric bursting strength values differ significantly before & after calendaring. So calendaring process significantly impacts on bursting strength of needle punched non-woven fabric. As the weight per unit area of the calendaring material are increased, means more number of fibers per unit area, i.e. packing density is increased. Bursting strength increased with the increase in GSM. Bursting strength increased with the increase in calendar roller pressure as well as temp. After calendaring bursting strength of all samples was increased by 48%.

4.4 Pore Size

Pore size of calendared & non calendared material was tested on Capillary Flow Porometer CFP 1300 tester as per standard ASTM E1294 and results are plotted below.

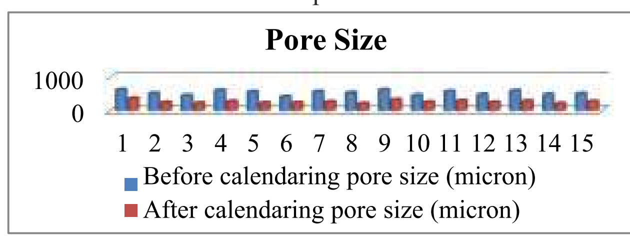


Figure 5 - Effect of calendaring on Pore size

Analysis of results using 't-Test: paired two samples for means' get mean & variance of both type of samples i.e., pore size of before and after calendaring respectively 530.57 – 263.59 & 4216.85 – 2000.71. A statistic 't' value is 22.83 & t critical one tail value is 1.76 indicate that the absolute value is greater than t critical one tail value, so the null hypothesis is rejected. This means that fabric pore size values differ significantly before & after calendaring. So calendaring process significantly impacts on pore size of needle punched non-woven fabric. After calendaring pore size of all samples was reduced by 50% Due to calendaring the material is compressed. Basically packing density is increases.

4.5 Porosity

The porosity is defined by the ratio of free space to fibre in a given volume of fabric. Porosity or void fraction is the measure of the void spaces in a filter fabric. It is a fraction of the volume of void over the total volume of the filter fabric, between 0 and 1 or as a percentage 0% to 100% and result are plotted below.

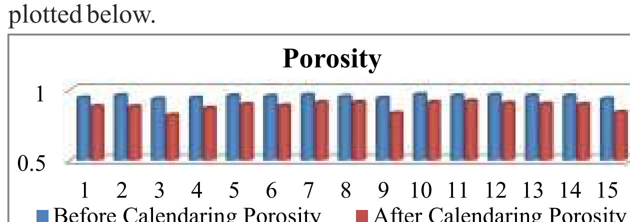


Figure 6 - Effect of calendaring on porosity

Analysis of results using 't-Test: paired two samples for means' get mean & variance of both type of samples i.e., porosity of before and after calendaring respectively 0.9512 – 0.8838 & 0.000088 – 0.00099s. A statistic 't' value is 10.96 & t critical one tail value is 1.76 indicate that the absolute value is greater than t critical one tail value, so the null hypothesis is rejected. This means that fabric porosity values differ significantly before & after calendaring. So calendaring process significantly impacts on porosity of needle punched non-woven fabric. After calendaring porosity of all samples were reduced by 7% due to decreasing thickness.

5. Conclusion

Present work investigates contribution of calendaring on nonwoven properties change which is very much useful in understanding their behavior as a filter media. A calendaring of needle-punched fabric has significant effect on physical properties like thickness, porosity and functional properties air permeability, bursting strength. Due to mechanical finishing like calendaring, there is a reduction in thickness by 25%, air permeability by 26% pore size by 50 % and porosity by 7% of fabric while bursting strength increases by 48%.

References

[1] T. Karthik, R. Rathinamoorthy & C. Praba Karan, "non-woven-process, structure, properties and applications," woodhead publishing India in textiles, 2016, ISBN: 978-93-85059-12-4

[2] S.J.Russell, "Handbook of nonwovens," woodhead publishing in textiles, 2007, ISBN-13:978-1-85573-603-9

[3] Md. Abu Sayad, "Needle punching method for non-woven", https://textileapex.blogspot.com/2014/09/needle-punching-method-nonwoven.html

[4] L.A.Sarabia, M.C.Ortiz ,"Response Surface Methodology", Chemical and Biochemical Data Analysis Volume 1, 2009, Pages 345-390, https://www.sciencedirect.com/science/article/pii/B9780444527011000831

[5] Emel Cincik & Emirhan Guanydin, "The Influence of Calendaring Parameters on Performance Properties of Needle-Punched Nonwoven Cleaning Materials Including R-PET Fibre," The Journal of the textile institute,17 march 2016, http://dx.doi.org/10.1080/00405000.2016.1161694

[6] https://www.jmp.com/en_in/statistics-knowledge-portal/t-test/paired-t-test.html

[7] Kopitar Dragana, Zenun Skenderi & Tatjana Rukavina, "Impact of Calendaring Process on Nonwoven Geotextile Hydraulic Properties," Textile research journal, January 2014

[8] P C Patel & V K Kothari, "Relationship Between Properties of Fibres and Nonwoven Fabrics," Indian journal of fibre & textile research, vol.26, December 2001

[9] Kopitar Dragana, Zenun Skenderi & Tatjana Rukavina, "Influence of Pressure On Water Permeability & Characteristic Opening Size of Non-Woven Geotextile," Journal of fibre bioengineering and informatics, 6:1 (2013) 103-115

[10] Vinay Kumar Chauhan, Sanjoy Debnath & Bharti Singh, "Optimizing Bursting Behavior of Calendaring Needle-Punched Polyester Fabrics," Journal of the textile institute, 02 feb 2011

[11] Vinay Kumar Midha, "Study of Stiffness And Abrasion Resistance Of Needle-Punched Nonwoven Blankets," Journal of the textile institute, 02 feb 2011

[12] l. Holme, P. V. K. Lee & A.K. Mehrotra, "The Calendaring of Needle-Punched Fabrics Part I: Single-Pass Calendaring Treatments," The journal of the textile institute, 25 Nov 2008

[13] Vinay Kumar Midha & A. Mukhaopadyay, "Bulk & Physical Properties Of Needle-Punched Non-Woven Fabrics," Indian journal of fibre & textile research, vol.30, June 2005

[14] Kopitar,et.al, "Study On The Influence Of Calendaring Process On Thermal Resistance Of Polypropylene Nonwoven Fabric Structure," Journal of fibre bioengineering and informatics, 2014, 7,1-11

[15] Burcak K. Kayaogle, "Characterization of air permeability behavior of needle-punched nonwoven fabrics," Journal for textile and clothing technology, Vol.6, Zagreb, January-June 2012

[16] G Thilagavathi, N Muthukumar, S Neelakrishnan and R Santhosh Egappan, "Development of Polyester Needle-Punched Nonwoven Fabrics for Filter Press Applications," Journal of industrial textile, 2018

[17] Sanjoy Debnath & M. Madhusoothanan, "Compression Creep Behavior Of Polyester Needle-Punched Nonwoven Fabrics," The journal of the textile institute, 18 April 2012

[18] S. Ghosh & L. Chapman, "Effects of Fibre Blends and Needling Parameters on Needle punched Moldable Nonwoven Fabric," Journal of the textile institute, 30 March 2009

[19] Guocheng Zhu, Dana Kremenakova, Yan Wang, Jiri Militky, "A Permeability of Polyester Nonwoven Fabrics," AUTEX Research journal, vol.15, no 1, March 2015Natural Areca fibres and their composites", In Workshop on Natural fibre Composites, Research Gate, 2008 July, Vol. 2

■ ■ ■

Basalt Fiber Reinforced Material for Radome

Hireni Mankodi*[1] *& Shiza Parmar**[2]

[1] *Department of Textile Engineering, the M.S University of Baroda, Kalabhavan, Vadodara, Gujarat, India*

[2]*Research Scholar, Dept. of Textile Engineering, Gujarat Technological University, Ahemdabad, Gujarat, India*

Abstract:

The environmental awareness spread out throughout the world needed to resolve current environmental issues using more sustainable products. Basalt is a high performance material, which can common extrusive volcanic rock formed by decompression, melting of Earth's mantle. Which have properties like thermal performance, high tensile strength, good electromagnetic properties, and resistance to acid, radiation, UV light, vibration, impact load and recyclable. The attempt has been made to develop basalt composite for radome application. With the help of the hybridization concept, it is possible to tailor the desirable properties of materials to meet specific requirements. The work has been focused on the combination of basalt fibers in hybrid laminates for radome application. The basalt fiber provides 10% higher absorption of electroma

gnetic radiation and absorption of forces; additionally basalt fibers distinguish in excellent resistance to UV radiation, corrosion and organic effects. Also basalt and glass fibers have been considered for comparative analysis, where it has been found that basalt laminates give better physical and mechanical properties than glass fiber. The Basalt preform and hybridization of basalt preforms improves the mechanical properties of laminate. The hybridization of preforms or introducing PPF layer between preforms improves the adhesion between layers. The hybrid material layers in laminates, which provides required engineering properties, including in-plane stiffness, bending stiffness, strength, and coefficient of thermal expansion. Radomes protect radars and other antenna systems from various environments. The radome must allow the transmission of electromagnetic waves and radio waves. In designing radome electromagnetic as well as mechanical properties of radome are equally important.

Keywords: *Basalt, Electromagnetic, Hybridization, Radome, Sustainable*

Citation: Hireni Mankodi & Shiza Parmar, "Basalt Fiber Reinforced Material for Radome", *Journal of the Textile Association,* **83/5** (344-348), (Jan-Feb' 2023), https://doi.org/10.56716/4/1483

Article Received:12-11-2022, Revised: 18-12-2022, Accepted:28-02-2023

1. Introduction :

The hybridization concept, it is possible to tailor the desirable properties of materials to meet specific requirements [1-4]. The E Glass and carbon fibers are renowned fibers used for composite for different industrial applications. When compared with glass fiber, carbon fiber and aramid fiber, basalt fiber have good mechanical properties, acid-alkali resistance, excellent electrical properties, high electromagnetic wave permeability, non-conductive, and excellent sound insulation [5-7]. Based on the above advantages, the combination of basalt fiber and substrate can enhance the composite laminates properties. The basalt fiber provide 10% higher absorption of electromagnetic radiation and absorption of forces, additionally basalt fibers distinguish in excellent resistance to UV radiation, corrosion and organic effects. They are comparatively inexpensive, environment friendly, and ecologically harmless [8-12]. Basalt fibers can be considered as a prospective type of reinforcing material for composites because it is having better physical and mechanical properties than E Glass fiber. It was found in the literature review that mainly hybrid composite research focused on the use of E Glass with various other fibers, but very little work is reported on the use of Basalt fiber in hybrid composites. Also environmental awareness spread out throughout the world needed to resolve current environmental issues using more sustainable products. Considerable interest in sustainable materials the new development of basalt composite materials is triggered nowadays. Hence this study approaches multidisciplinary design and optimization to involve both aspects simultaneously. In this paper only dielectric properties of basalt composite have been discussed.

***Corresponding Author :**

Ms Shiza Parmar

GTU Research Scholar, A/11, Sardar Park Society, Near C.N.I. Church, Maninagar (E), Ahemdabad – 380 008

E-mail:shiza.das@gmail.com

2. Basic Problem

The Radomes are large dome-shaped structures which protect the radars from the bad weather conditions but at the same time allow the electromagnetic signals to be received by the radar without any distortion or attenuation. The service life of a radome wind load is the most important load for the design and analysis of strength and stability of the structure. On the other hand, good electromagnetic performance of a radome also requires optimum electrical characteristics at the operating frequency band. The radomes composite materials are manufactured from E Glass, quartz, and aramid. The majority of fiber reinforced composites are made with E Glass fibers. The E Glass fiber is toxic and non-renewable [13]. To replace or reduce the use of the E glass and make the composite is today's need. Aramid fibers are stronger than E Glass fibers; they are having problems with moisture absorption and poor compressive strength [14].

3. Basic Concept

The radome is an essential component that protects the radar against the rain, pollution, dust, temperature etc as shown in Fig 1.

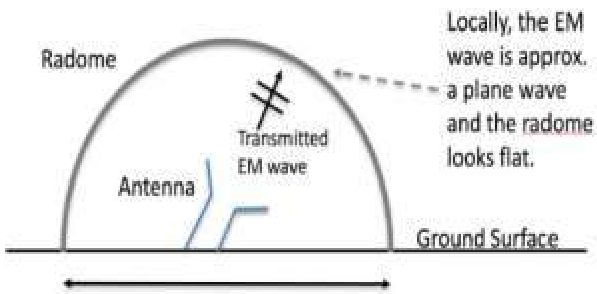


Figure 1: Concept of Radome [15]

In order to understand the electromagnetic (EM) wave propagation in a material it is important to know the material constitutive parameters, such as, permittivity, permeability and conductivity. These constitutive parameters characterize the EM properties of the material. From these parameters, special care must be taken in selecting the radome material with optimum relative permittivity (Er) or dielectric constant (Dk). Signal fade or "loss" occurs either by the reflection of the electromagnetic waves at the boundary of radome structure or due to multiple reflections within the radome material itself. This is mainly due to the difference in dielectric constant (Dk) of the radome relative to air. The dielectric constant (Dk) represents the reflective, as well as the refractive, properties of a material. In general, the electromagnetic signal can be thought of as "slowing down" as it moves through the radome when compared with air. The EM wave propagation and interaction with respect to material is shown in Fig 2.

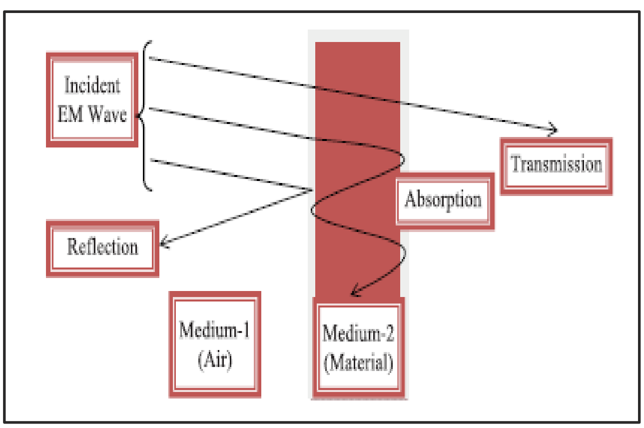


Figure 2: Electromagnetic wave Material Interaction [16]

4. Material and Methodology

4.1 Material Selection

The selection of materials was done with the aim of best suited properties for radome application. This selection includes the procurement of preform as reinforced material where Basalt Woven, Polypropylene (PP) /Basalt Woven, PP Non Woven fabric has been taken as preforms. Taking preforms and its combinations laminate has been prepared using epoxy and polyester resin. The physical properties of performs as list in Table 14.2 Preparation of Laminates

Properties	Basalt Preform	PP / Basalt Preform	PP Non Woven Preform
Fabric Count (Ends/cm X Picks/cm)	6 X 5	4 X 6	-
Fabric Width (cm)	100	130	-
Fabric Weight (g/m2)	300	168	382
Fabric Thickness (mm)	0.27	0.25	1.36

The Vacuum assisted resin transfer molding (VARTM) is likely the most common acronym of all used in the discussion of low pressure closed mold reinforced composite molding. The often used VARTM acronym is most accurately applied to the process of vacuum infusion, that is where the composite is molded using a rigid mold to provide part geometry and a thin flexible membrane over the fiber, with outer atmospheric pressure compressing the fiber tight against the rigid mold surface. The set up shown in Fig. 3 following procedures have been followed for preparation to make laminate by Vacuum Assisted Resin Transfer Molding Process (VARTM).

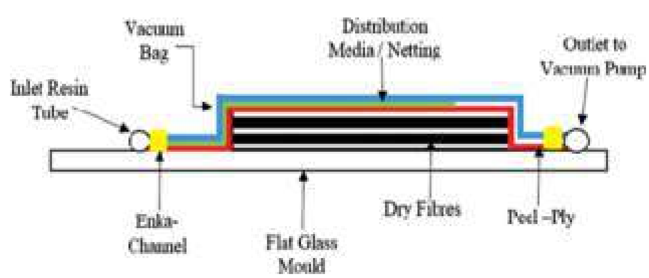


Figure 3 - VARTM process [17]

Textile preforms were cut into 400 mm X 400 mm. After that a 16 layers of preform and accompanying materials such as release films, peel plies, perforated coil, and distribution mesh are laid on the tool surface. The preform is sealed with a vacuum bag and the air is evacuated by a vacuum pump. The liquid resin with hardener is infused into the preform until complete impregnation. Curing and de-molding steps follow the impregnation to finish the product. Laminates were cured at room temperature for 24 hours.

4.3 Dielectric properties

The Radome material performance mainly checks based on its dielectric Properties. Dielectric properties are defined in terms of dielectric constant and dielectric loss factor. There are different measuring techniques to determine the dielectric properties. They can be divided into two categories Resonant and Non Resonant Methods. The prepared laminates have been evaluated using both methods. The main significance of using these two methods is discussed. The dielectric resonant cavity method presented here has only recently been developed, but has shown significant potential in this area.

Resonate cavity technique provides more accurate results than broadband techniques but its results are for one frequency, thus requiring a significant measurement effort when a wide range of frequency response is to be derived. The cavity perturbation technique has been used widely for measuring dielectric properties because of its simplicity, easy data reduction, quick measurement, accuracy and high temperature capability [18-20]. Cavity perturbation measurements can be highly accurate and are practically advantageous in the determination of relative permittivity of dielectrics with a small loss tangent where this technique differs from the others due to its high sensitivity. Non resonant methods are exploited when general knowledge of a material's electromagnetic properties over a range of frequencies is desired. A vector network analyzer measures the magnitude and phase of multiple frequencies at the same time. In vector analysis, the magnitude and phase of each impedance are measured independently, and the results are combined to calculate the impedance of the network. Vector network analyzers are used to quickly and accurately validate the performance of RF components and devices.

i. Resonant Methods:
Resonant methods are limited by measurement on single/discrete frequency points, but are very accurate. These methods are used when accurate knowledge of a material's electromagnetic properties at a specific frequency or at several discrete frequencies is needed. Accuracy and sensitivity are the key advantages of resonant methods.

The cavity perturbation technique (CPT) has been used widely for measuring dielectric properties Cavity perturbation measurements can be highly accurate and are practically advantageous in the determination of relative permittivity of dielectrics with a small loss tangent where this technique differs from the others due to its high sensitivity. In the cavity perturbation technique, when a small sample of dielectric material is introduced into a resonant cavity, the frequency of resonance (~f) is changed by a small quantity as well as the quality factor (Q-factor) of the cavity. These effects on the circuit parameters are usually quantified which results in the measurement of the dielectric properties of the sample. The test method used per ASTM D2520 is cavity perturbation method which is highly suitable for measurement of dielectric properties of low dielectric constant and low loss materials.

ii. Non Resonant Methods
Non resonant methods are exploited when general knowledge of a material's electromagnetic properties over a range of frequencies is desired. This measurement can be performed over a wide range of frequencies, but is normally used to observe the behaviour of EM waves.

A vector network analyzer (VNA) consists of a signal source, a receiver and a display. A vector network analyzer measures the magnitude and phase of multiple frequencies at the same time. Vector network analyzers typically use a technique called vector analysis to measure the impedance of a network. In vector analysis, the magnitude and phase of each the impedance are measured independently and the results are combined to calculate the impedance of the network.

5. Result and Discussion

The six laminates prepared of Basalt and its combination as given in Table 2.The dielectric loss EM wave absorbers and underlying loss mechanism investigation are of great significance to unveil EM wave attenuation behaviour and guide for novel dielectric loss material design. However, current research focuses more on materials used for radome. The dielectric constant and loss tangent together specify the transmission efficiency of a radome combined with an antenna system, where both together are ideally measured at the intended operating frequencies. CPT was conducted at test frequency 2.61 GHz with resonant cavity 86.36mmX43.18mmX230mm. VNA test was conducted at temperature 23°C with the help of Anritsu Vector star network analyzer.

Table 2: Dielectric Properties of Laminates at 10 GHz

Laminates	16 layer Combination	Thickness in mm	Dielectric Constant CPT	Dielectric Loss Tangent CPT	Dielectric Constant VNA	Dielectric Loss Tangent VNA
LB_E	Basalt fabric with Epoxy resin	4.09	4.768	0.003922	1.885	0.02
LB_P	Basalt fabric with Polyester resin	3.64	4.659	0.007598	3.554	0.013
LB_{EPPY1}	Basalt fabric + PP/ Basalt fabric +Basalt fabric with Epoxy resin	4.17	3.765	0.018194	3.735	0.0049
LB_{EPPY2}	PP/Basalt fabric + Basalt fabric + PP/Basalt fabric with Epoxy resin	3.06	3.197	0.028495	1.386	0.0097

Laminates	16 layer Combination	Thickness in mm	Dielectric Constant CPT	Dielectric Loss Tangent CPT	Dielectric Constant VNA	Dielectric Loss Tangent VNA
LBEPPN1	Basalt fabric +PP nonwoven fabric+ Basalt fabric +PP nonwoven fabric + Basalt fabric with Epoxy resin	7.27	3.173	0.044469	1.866	0.006
LBEPPN2	Basalt fabric +PP nonwoven fabric+ Basalt fabric +PP nonwoven fabric + Basalt fabric + PP nonwoven fabric + Basalt fabric +PP nonwoven fabric + Basalt fabric with Epoxy resin	7.29	2.935	0.032947	3.043	0.0039

The result obtained by VNA method as shown in Fig.4. The result represents the influence of fiber content on the value of dielectric constant of basalt reinforced hybrid composites. It was observed that the dielectric constant decreases with decrease in the basalt fiber content. The highest dielectric constants were exhibited by the pure basalt with epoxy matrix material. The composites, dielectric constant depended on the contributions of interface, orientation, atomic and electronic polarizations in the material. In unsaturated polyester, the dielectric constant was low compared to epoxy since it had only instantaneous atomic and electronic polarizations. While considering only dielectric constant LBEPPY1 gives the lowest value. But for radome application dielectric constant and dielectric loss tangent both should be lower which is exhibited by LBEPPY2.

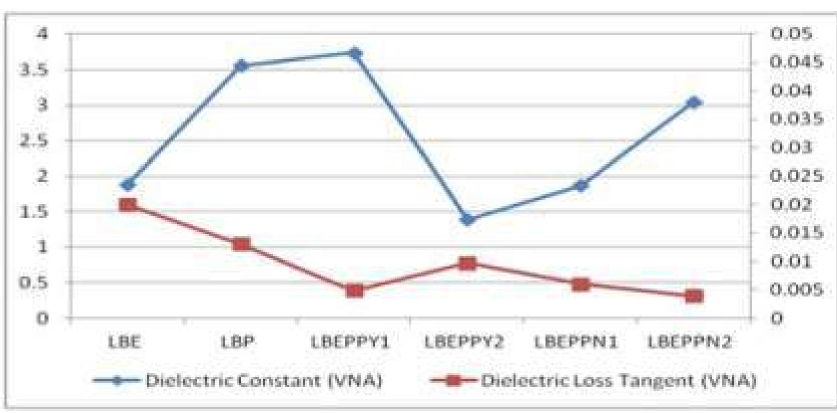


Figure 4: Laminates Dielectric Properties by vector network analyzer (VNA)

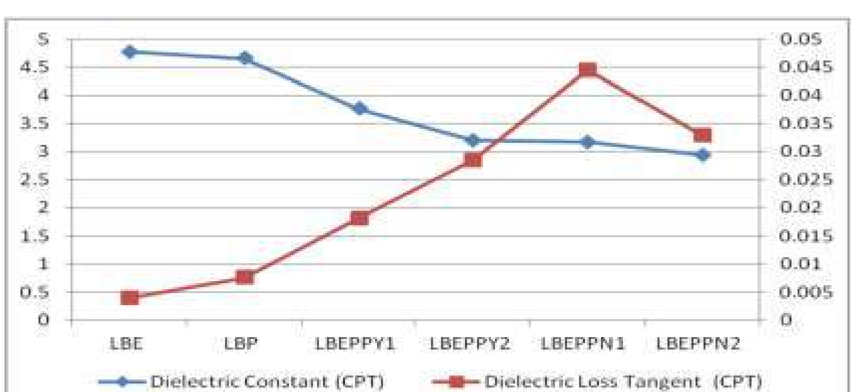


Figure 5: Laminates Dielectric Properties by cavity perturbation technique(CPT)

The result obtained by CPT method as shown in Fig.5 In this the influence of fiber content on the dielectric constant of basalt reinforced hybrid composites shows a similar trend with the VNA method. It was observed that the dielectric constant decreases with decrease in the basalt fiber content. LBEPPN1 gives better results for dielectric constant, while considering dielectric loss tangent it shows a reverse trend. As dielectric constant and loss tangent both are equally important parameters one should consider not the best values but both values should be minimum. Therefore, CPT method also give better result for sample LBEPPY2 laminate.

6. Conclusion

The composites are used as radomes due to the high strength and weight ratio, good mechanical and dielectric properties and weather resistance. In the nutshell, the dielectric properties of basalt reinforced hybrid composites were assessed using resonant and non resonant methods. Both the methods have their own advantages but results show that for application of radome, materials with lower dielectric constant and dielectric loss tangent are preferred. Hence from the experimental results hybrid laminate LBEPPY2 preferred over 100% Basalt laminate for radome application.

References

[1] P. Mallick. 'Fiber-Reinforced Composites Materials, Manufacturing, and Design', 3rd ed. New York; CRC Press: 2007

[2] S. Khalili, V. Daghigh and R. Eslami Farsani, "Mechanical behavior of basalt fiber-reinforced and basalt fiber metal laminate composites under tensile and bending loads", Journal of Reinforced Plastics and Composites, 30/8 (2011) 647-659.

[3] V. Vasiliev and E. Morozov. 'Advanced Mechanics of Composite Materials and Structures', 1st ed. Oxford; Elsevier: 2007

[4] S. Chandra, Yerramalli, M. Anthony and Waas, "Compressive behavior of hybrid composites", In 44th AIAA/ASME/ASCE/AHS structures, structural dynamics, and Material Conference, Norfolk, (2003) 1-9

[5] P. Chaphalkar and A. Kelkar, "Classical laminate theory model for twill weave fabric composites", Composites Part A: Applied Science and Manufacturing, 32/9 (2001) 1281-1289

[6] V. Dhand, G. Mittal, K. Rhee, S. Park and D. Hui, "A short review on basalt fiber reinforced polymer composites", Composites Part B: Engineering, 73 (2015) 166-180

[7] H. Jamshaid and R. Mishra, "A green material from rock: basalt fiber – a review", The Journal of The Textile Institute, 107/7 (2015) 923-937

[8] T. Czigany, J. Vad and K. Poloskei, "Basalt fiber as a reinforcement of polymer composites", Periodica Polytechnica Ser. Mech. Eng., 49/1 (2005) 3-14

[9] C. Colombo, L. Vergani and M. Burman, "Static and fatigue characterisation of new basalt fibre reinforced composites", Composite Structures, 94/3 (2012) 1165-1174

[10] Alexander and B. Augustine, "Free Vibration and Damping Characteristics of GFRP and BFRP Laminated Composites at Various Boundary Conditions", Indian Journal of Science and Technology, 8/ 12 (2015) 1-7

[11] H. Jamshaid, R. Mishra, J. Militky and S. Hussain, "Basalt Hybrid Woven Textile Materials For Advanced Thermal Applications", Indian Journal of Fibre and Textile Research, 44 (2019) 56-64

[12] A. Palmieri, S. Matthys and M. Tierens. 'Concrete Solutions,Basalt fibers: Mechanical properties and applications for concrete structures', 1st ed. CRC Pres: 2009: pp. 1-6

[13] S. Feih, A. Thraner and H. Lilholt, "Tensile strength and fracture surface characterisation of sized and unsized glass fibers", Journal of Materials Science, 40/7 (2005) 1615-1623

[14] P. Reddy, D. Anuradha and S. Nikhil, "A Study and Modeling of High Pressure Radome with Uwb Frequency Coverage in Submarine Communications", Research Inventy: International Journal of Engineering And Science, 5/7 (2015) 49-62

[15] Balanis C. 'Advanced Engineering Electromagnetics', 2nd ed., New York: John Wiley and Sons:2012: pp.180-185

[16] S. Dasgupta, "Polymer Matrix Composites for Electromagnetic Applications in Aircraft Structures", Journal of the Indian Institute of Science, 95/3 (2015) 275-296

[17] C. Tan, A. Azmi and N. Muhammad, "Delamination and Surface Roughness Analyses in Drilling Hybrid Carbon/Glass Composite", Materials and Manufacturing Processes, 31/10 (2015) 1366-1376

[18] A. Kumar and G. Singh, "Measurement of dielectric constant and loss factor of the dielectric material at microwave frequencies," Progres in Electromagnetics Research, 69 (2007) 47–54

[19] G. Schaumburg and H. W. Helberg, "Application of a cavity perturbation method to the measurement of the complex microwave impedance of thin super- or normal conducting films," Journal de Physique III, 4/5 (1994) 917–927

[20] M. C. Dimri, S. C. Kashyap, and D. C. Dube, "Electrical and magnetic properties of barium hexaferrite nano particles prepared by citrate precursor method," Ceramics International, 30/7 (2004) 1623–1626

■ ■ ■

A Review of Development of Waterproof Breathable Garments

Abhishek Kumar[1], Manpreet Manshahia[1]* & Jyoti Aggarwal[2]

[1]Amity School of Fashion Technology, Amity University, Noida

[2]Institute of Home Economics, University of Delhi, New Delhi

Abstract:

Waterproof breathable garments are functional garments made with the aim of protecting its wearer from getting wet while being air permeable, making it comfortable for the users. The method of joining the panels is an important aspect in developing a waterproof breathable garment, since regular stitching might not be efficient for these garments because during the process needle holes are formed which provides passage for water to penetrate inside the garment and thus failing to pursue its aim as a functional garment. These garments are assembled using a variety of modern techniques instead of regular stitching. In this article, available literature on the fabrics used for waterproof breathable garments and different assembling techniques to turn these fabrics into garments are examined. Study findings will assist in selecting appropriate fabrics and seaming techniques to create waterproof breathable garments, and serve as a basis for future research.

Keywords: *Coating, Hydrophilic, Hydrophobic, Membrane, Seams, Waterproof Garment*

Citation: Abhishek Kumar, Manpreet Manshahia & Jyoti Aggarwal, "A Review of Development of Waterproof Breathable Garments", *Journal of the Textile Association,* **83/5** (349-355), (Jan-Feb' 2023), https://doi.org/10.56716/4/1457

Article Received: 14-09-2022, Revised: 01-11-2022, Accepted: 15-10-2022

1. Introduction :

Waterproof breathable garments are functional garments and the term 'functional' refers to something that is designed to be practical and useful rather than appealing. The essential criterion for garments in a wet environment is that they keep the user dry by being resistant to water penetration. The chemical composition of the solid surface, its roughness, porosity, and the presence of other molecules on the surface all have an impact on the garment's capacity to resist wetting [1]. Some examples of waterproof breathable garments are leisurewear, active sportswear, swimwear, rainwear, skiwear, mountaineering garments, special protective military clothing, functional work wear, survival suits, fireman garments and surgical garments [2-5].

The 15th century saw the first recorded effort to develop water-repellent protective garments. Sailors attempted to infuse their garments with linseed oil, animal fat, or wax during the time [6]. Rubber was used to "proof" clothes for the first time between 1790 and 1830; the term "to render cotton, linen, and woollen cloths, etc., waterproof" appears in multiple patents by Peal, Macintosh, Hancock, and others. In the early 1820s, Charles Macintosh established a rubber factory and named a fabric after himself. It was a waterproofed fabric in which rubber creates an air and water-impermeable flexible coating on a fabric [7]. Unfortunately, the way rubber was handled retains many of the same characteristics as rubber in its original state: it stiffens when cold and becomes sticky when heated, neither of which are desirable characteristics for a wearable item. It also smelled awful, and the manufacturing process was quite hazardous. It wasn't until around 1843, when Thomas Hancock developed the vulcanisation method in which natural rubber is heated and combined with sulphur under controlled conditions that it became truly practicable to use [8]. However, the requirements of protective garments have competing features, meaning that meeting one constrains the accomplishment of the other. The waterproof fabrics blocked the pores in the fabric, making it impenetrable for water but they also trapped the vapour molecules inside the garments making it unbreathable and difficult to wear for longer duration [9]. It resulted in development of waterproof breathable fabrics.

Another important aspect in developing waterproof garments which differs it from regular garments is the assembling technique which is used to join the fabric panels. The main function of a seam or a joint is to distribute stress uniformly from one piece of fabric to the other, preserving the fabric assembly's overall integrity [10]. Usually stitching is the method used for assembling the garments, but it is not effective for waterproof garments as it requires a needle to penetrate through the fabric panels and staple the panels together using the sewing threads. However, the needle holes formed during this process which aren't covered completely during the process and leave enough space for water to penetrate inside. Thus, compromising the functional requirements of the garments. To overcome this problem different alternative techniques are used to prepare the seams of waterproof breathable garments.

2. Waterproof Breathable Fabrics

Breathability is an important aspect of comfort for the users as a good breathable garment transports the sweat away from the body. The skin's production of sweat is critical for body temperature regulation. The typical human core temperature is 37oC, and the skin temperature is between 33oC and 35oC, depending on the circumstances. Death occurs when the core temperature rises above threshold levels of around 24°C and

***Corresponding Author :**

Dr. Manpreet Manshahia

Amity School of Fashion Technology, Amity University,

Sector - 125 Gautam Budh Nagar, Noida - 201 313 UP,

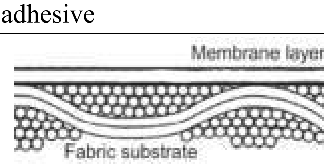
45°C. The lower temperatures of 34oC and 42oC can produce confusion and seizures. If the patient is involved in a risky sport or activity, the results could be disastrous. The body delivers some cooling during physical exercise by creating insensible perspiration. If the water vapour cannot escape to the surrounding atmosphere, the relative humidity of the microclimate inside the garment rises, causing an increase in the insulating air's thermal conductivity and making the garments uncomfortable. Hypothermia can occur in extreme circumstances when the body loses heat faster than it can produce it, such as when physical activity has ceased, resulting in a drop in core temperature. The body is unable to cool at the same pace as heat is created if perspiration cannot evaporate and liquid sweat is formed. Hyperthermia can occur during physical exercise, for example, as the body's core temperature rises. Garment must allow the flow of water vapour from perspiration at the rates required by the activity conditions if the body is to maintain the physiologically required temperature [11]. Breathable waterproof fabrics provide a strong resistance to liquid water penetration while remaining permeable to water vapour [12, 13].

In 1879 Thomas Burberry invented that waterproofing and breathability can be achieved by employing tightly woven materials like gabardine [8]. Ventile was the first effective waterproof breathable fabric. It was developed in 1940 during World War II in England for military purposes, and in 1943 they began its mass production [6]. Membranes and coatings are used to produce more effective waterproof breathable fabrics. In 1969, W. Gore brought a revolutionary change in the field of waterproofing material by developing Gore-tex membrane which is a film of polytetrafluoroethylene (PTFE) also known as Teflon. It provides a breathable waterproof material. PTFE membrane is hydrophobic in nature and has pores 20,000 times smaller than size of water drop, thus it doesn't allow the water droplets to penetrate inside the fabric, but it is 700 times larger than water vapour molecule allowing the water vapour to get out and making it comfortable for the user. It also provides protection from wind penetration and is resistant to extreme temperatures [12]. Similar membranes are made by other companies using microporous polyvinylidene fluoride (PVDF) cast directly upon the fabric. However, body oils, particle dirt, pesticide residues, insect repellents, sun tan lotion, salt, and residual detergent and surfactants used in cleaning; have all been suspected of weakening the membrane's waterproofing and permeability to water vapour. To limit the impacts of contamination, microporous membranes commonly incorporate a layer of hydrophilic polyurethane [11]. Coated waterproof breathable fabric is obtained by applying polymeric material to one surface of the fabric. [14]. Table 1 presents the different methods of obtaining waterproof breathable fabrics, their application procedure, typical view and structures [6, 11, 12, 14].

These fabrics can be divided into three categories from the standpoint of structure. The first type is a densely woven cotton fabric that has been appropriately proofed; when wet, the cotton fibres swell to further seal the fabric structure and resist water penetration. The second kind, called microporous, is made of a laminated or coated cloth with minute pores all over that permit water vapour to diffuse through and lessen liquid water penetration. The third type of waterproof breathable structure are hydrophilic, created with the help of a polyurethane basis that has been chemically altered by adding polyvinyl alcohols and polyethylene oxides. These have a chemical affinity for water vapour, which allows water vapour to diffuse through the polymer's amorphous areas. Thus, they absorb water vapour on one side and re-evaporates it on the other, keeping liquid water from penetrating. To achieve adequate vapour permeability, flexibility, durability, and insolubility in water and dry-cleaning solvents, the hydrophilic and hydrophobic components of the polymer system must be balanced optimally [11].

When it comes to the development and utilization of microporous and hydrophilic membranes and coatings, smart breathable fabric and fabric based on biomimetics are also demonstrating their promise. Smart breathable fabrics are based on shape memory polymer and Phase Change Material (PCM). Shape memory polymer-based materials prevent the loss of body heat by limiting the passage of heat and vapour at low temperatures. Conversely, at high temperatures, they transport more heat and water vapour from inside clothes to the outside than regular waterproof breathable fabrics. The PCM does not directly control how

Table 1: Different methods of obtaining waterproof breathable fabrics

Method	Densely Woven Fabrics	Membranes	Coatings
Application Procedure	Tightly woven long staple cotton yarns in an Oxford weave	Bonding ultra-thin polymeric films to the fabric using added adhesive	Applying polymeric material to one surface of the fabric
Typical View			
Structure	Densely woven porous	Microporous and Hydrophilic	Microporous and Hydrophilic

much water vapour may travel through a cloth, but its integration improves thermal and moisture management. The PCM is enclosed in small plastic spheres with diameters of only a few micrometres. These PCM microcapsules are either permanently encased in PU foams or fibres or coated on the surface of textile structures. Through the finishing process, the micro-capsulation renders the PCM-containing microcapsules reliable and secure. When the PCM transitions from a solid to a liquid state, heat is absorbed and released, respectively. A NASA research programme used these fabrics in the astronauts' space suits to give enhanced thermal protection against the high temperature variations in space in the early 1980s [4].

Biomimetics is the imitation and modification of biological mechanisms to create useful artificial objects. The foundation of the trademarked "Lotus effect" is high hydrophobicity. The foundation of the accomplishment is the inclusion of roughness and the repositioning of hydrophobic particles like lotus leaf. When a leaf tilts at a slight inclination, the contact angle increases and a sphere-shaped droplet rolls off. Nano Reactants with a carbon fluorine base were used as the hydrophobic substance. Under the brand name Stomatex, Akzo Nobel is promoting a product that is based on the way that stomata on leaves open and release moisture as needed depending on the environment. When moisture is produced at a higher rate, the closed-cell neoprene foam with a stomata-like aperture at the top aids in releasing it. When the user is at rest, the foam returns to its passive state [4, 15].

3. Techniques used to Assemble Waterproof Breathable Garments

Assembling techniques are very important to make a garment. The objective of these assembling techniques or seams is to make a three-dimensional garment by joining two-dimensional fabric panels [16]. Waterproof and water-resistant garments require special types of seaming techniques to join the panels of the garment because conventional sewing is not effective for these garments as stitching causes needle holes which allows passage for the water to penetrate inside the garment thus, compromises with the functional requirement of the garment [17-19]. There are various alternatives of preparing waterproof seams that are used to overcome this issue such as; seam sealing using seam tape, welding technique and bonding technique. The appropriate seam is used as per the application area of the waterproof fabric.

3.1 Conventional Sewing

Although conventional sewing is not an effective method to prepare a waterproof or water-resistant seam, with some modification of lap seam it is possible to prepare waterproof seam using traditional sewing technique. The main issue with traditional sewing is that it forms needle holes which allows water to penetrate inside the garment but if a lap seam is used to join the different panels of the garment together in which the stitches do not penetrate all the panels together and the holes formed while stitching do not extend entirely through the garment [20]. Thus, it does not provide a clear passage for the water to penetrate inside the garment. The construction of this lap seam is presented in Figure 1. A lap seam provides better seam strength in comparison to superimposed seams [21]. This provides a waterproof seam but the thick edges formed due to construction of the seam makes an uneven surface at the joints of the garment and form a thick and bulky seam which affects the feel of the garment making it uncomfortable for the wearer. Also, thick edges visible from outside makes the garment aesthetically dull.

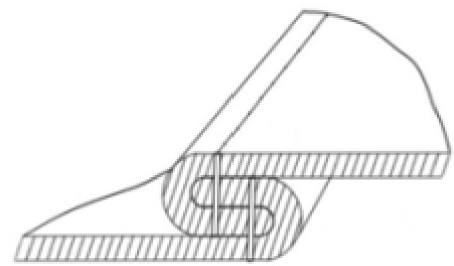


Figure 1: Lapped Seam

Macit [22] compared the seam strength and water permeability values of seams prepared by lock stitch, lock stitch with seam tape and ultrasonic welding and concluded that the seam strength of lock stitch is significantly higher than ultrasonic welding technique but the water permeability value is considerably low. Oh et al. studied the seams made by straight stitch, overlock stitch, flatlock stitch without an overlap and with seam sealing, flatlock stitch with an overlap, flatlock stitch with both overlap and seam sealing, zigzag and flatlock stitch, zigzag and flatlock stitch with seam sealing, glue and blind stitch and glue and blind stitch with seam sealing [23]. It was quite evident from the results of the experiment that seams which consisted of multiple needle holes and were made without the help of any seam sealing or glue such as overlock, flatlock without an overlap, and zigzag and flatlock stitches performed poorly in comparison to straight stitch.

3.2 Seam Sealing Tapes

Another method of using conventional stitching to prepare waterproof seam is by applying seam sealing tape over the traditional stitched seam so that it covers the needle holes created during stitching [24]. Use of seam sealing tapes on stitched seams increases the water resistance properties of seam significantly [23]. These seam sealing tapes are made of woven material which contains a thermoplastic adhesive coating on one side which gets activated when hot air at a precisely controlled temperature is applied to the hot melt adhesive, after which it is applied over the fabric seam under pressure. After cooling down, a strong bond is formed which prevents the water from penetrating through needle holes [25]. Systematic changes in taping temperature and feeding speed had a considerable impact on the seam quality. Setting inappropriate parameters may result in a loss of waterproofness and seam strength [19].

Apart from conventional stitching, seam sealing tapes are also used over welded seams for reinforcement and smooth finish. Tapes are available in single, double or triple layers and are used according to the application of seams [26]. Single layer seam sealing tapes are used for waterproof garments prepared using welded seams from PVC and PU materials and are manufactured directly by welding and seam sealing machines. Double layer tapes are used over the seams prepared using traditional stitching to cover the needle holes. Triple layer tapes are used on thick or heavy-duty fabrics. They are usually made of nylon/polyester backer fabric, a PU waterproof primer film with a hot melt adhesive film on top and offer excellent dry-cleaning resistance and washability [16].

The seam prepared with seam tape provides better results in terms of seam strength, seam slippage and water permeability than the ultrasonic technique, although the air permeability of seams reduces by a certain amount [22, 26, 27]. The seam creates an uncomfortable feeling regardless of the seam direction for the wearer and also affects the draping and bending resistance of fabric since the seam joint becomes stiff due to application of seam tape [28-30].

3.3 Welding Techniques

Welding techniques were the milestone in preparing seams without sewing; coming into existence in 1942 but its use for commercial purposes has seen a rise in the new millennium. It was a breakthrough in preparing seams as it provided high functional utility seams with better aesthetic appearance and avoiding issues like seam puckering, yarn breakage during stitching and missed stitches. This technique can be used on thermoplastic fabrics or with the help of thermoplastic coating or film. The welding seam is prepared by applying heat energy. Heat, speed and temperature are the three key factors required for using welding technology. Speed controls the rate at which fabric passes through the system so that the thermoplastic content of fabric gets heat for an appropriate amount of time. Pressure is used to complete the molecular bond between the panels of waterproof fabric by compressing the heated thermoplastic materials together during the sealing process [31-34].

Dielectric welding and rotary welding are the two most common kinds of fabric welding. In dielectric welding the fabric panels are kept stationary on a base plate and die is lowered onto them. Both the panels are joined together when the thermoplastic coating melts due to heat which is provided by a timed pulse of radiofrequency energy sent between the die and the base plate. Once the panels are joined, the die is lifted and new panels are kept for welding. Unlike dielectric welding, in rotary welding fabric panels move through the welding area with the help of a pair of drive wheels. Heat is provided just before the fabric panels passes between the drive wheels with help of hot air, heated metal wedge or other sources. The panels join when the welding pressure is applied while passing through the drive wheels [35]. The schematic diagram of dielectric welding is presented in Figure 2 and examples of rotary welding are shown in Figure 3.

There are five major techniques based on the source of heat commercially used in modern time to prepare welded seams:

- Hot air welding
- Hot wedge welding
- Ultrasonic welding
- Radio frequency welding
- Laser welding

All of these above mentioned methods have their own advantages and disadvantages which is mentioned in Table 2 [22, 25, 29, 31-41]. The major disadvantage of using welding technique is that the fabric strength can deteriorate by as much as 60 % and the seam strength may be around 50 % of a sewn seam [17, 21].

Table 2: Different types of welding techniques used for preparing waterproof seams

Technique	Source of Heat	Welding Parameters	Advantages	Disadvantages
Hot Air Welding	Hot air nozzle	• Roller Pressure • Speed • Temperature • Hot Air Flow	• Low maintenance • High speed	• Emission of fumes
Hot Wedge Welding	Metal wedge	• Roller Pressure • Speed • Temperature	• Concentrated heat • No fumes • Smooth seams	• Low in speed and high maintenance cost than hot air welding
Ultrasonic Welding	Mechanical vibrations	• Roller Pressure • Speed • Vibration Amplitude • Style of Wheel	• Energy conservation • Potential of precise automated assembly • Cost efficient • High speed Smooth seams	• Lower seam strength • Use is limited to a certain thickness of fabrics as fabrics beyond the certain strength will get burned and below the strength will get liquefied • Bursting strength decreases after washing

Technique	Source of Heat	Welding Parameters	Advantages	Disadvantages
Radio Frequency Welding	Electrode	• Power • Electrode Pressure • Welding Duration	• Compliance with regulatory and environmental standards • Cost efficient	• Can only be used on materials with polar groups in their molecular structure • An additional conductive-composite implant is required at the joint contact for joining nonpolar material, which will increase the cost • Shortfall in the waterproof properties' endurance when used repeatedly over time
Laser welding	Laser energy	• Roller Pressure • Speed • Laser Energy	• Flexible seams • Smooth seams	• Health and safety risks for operators • Increased energy cost

Apart from conventional stitching, seam sealing tapes are also used over welded seams for reinforcement and smooth finish. Tapes are available in single, double or triple layers and are used according to the application of seams [26]. Single layer seam sealing tapes are used for waterproof garments prepared using welded seams from PVC and PU materials and are manufactured directly by welding and seam sealing machines. Double layer tapes are used over the seams prepared using traditional stitching to cover the needle holes. Triple layer tapes are used on thick or heavy-duty fabrics. They are usually made of nylon/polyester backer fabric, a PU waterproof primer film with a hot melt adhesive film on top and offer excellent dry-cleaning resistance and washability [16].

The seam prepared with seam tape provides better results in terms of seam strength, seam slippage and water permeability than the ultrasonic technique, although the air permeability of seams reduces by a certain amount [22, 26, 27]. The seam creates an uncomfortable feeling regardless of the seam direction for the wearer and also affects the draping and bending resistance of fabric since the seam joint becomes stiff due to application of seam tape [28-30].

3.3 Welding Techniques

Welding techniques were the milestone in preparing seams without sewing; coming into existence in 1942 but its use for commercial purposes has seen a rise in the new millennium. It was a breakthrough in preparing seams as it provided high functional utility seams with better aesthetic appearance and avoiding issues like seam puckering, yarn breakage during stitching and missed stitches. This technique can be used on thermoplastic fabrics or with the help of thermoplastic coating or film. The welding seam is prepared by applying heat energy. Heat, speed and temperature are the three key factors required for using welding technology. Speed controls the rate at which fabric passes through the system so

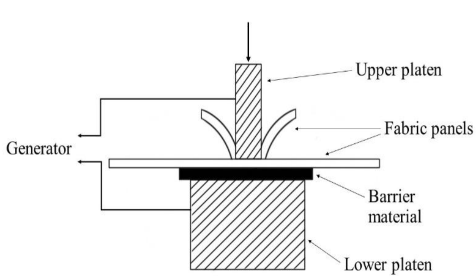


Figure 2: Radio Frequency Welding

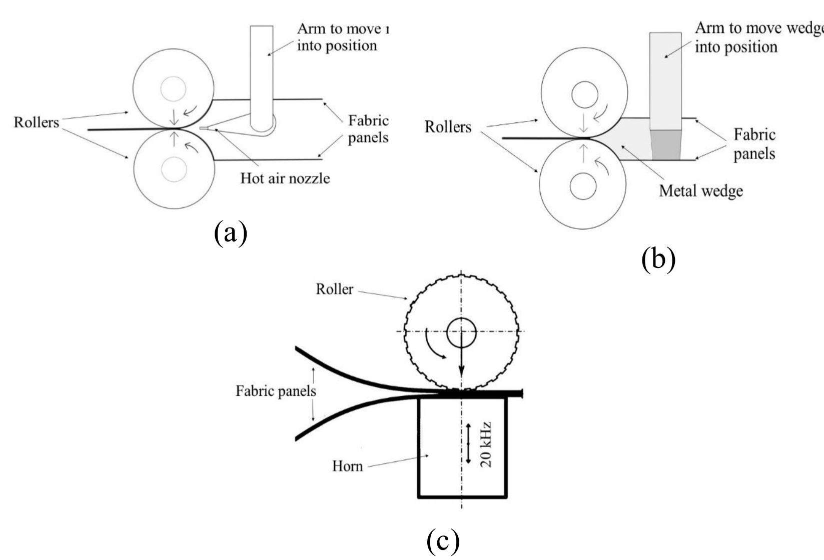


Figure 3: (a) Hot Air Welding, (b) Hot Wedge Welding, (c) Ultrasonic Welding

3.2 Bonding Technique

In recent times the use of bonding technique is increasing in the manufacturing of functional garments due to various advantages which it brings to the product and production in comparison to conventional sewing [21]. It's a physical-chemical process. Chemical/ liquid glue bonding or thermoplastic film is used in bonding techniques. Bonding occurs by applying adhesive between two layers of materials and providing an appropriate amount of heat, pressure and moisture. The heat and pressure activate the adhesive layer resulting in melting of film which penetrates inside the fabrics and fills the irregularities of surfaces to create a bond between the fabric layers after cooling [25, 34, 42, 43]. Polyurethane adhesives are considered as one of the best adhesives used for textiles due to their excellent adhesive properties, fast curing properties, chemical and heat resistance [44].

Bonding strength of the seams depends upon the fabric structure, bonding parameters, tensile characteristics of thermoplastic films, structure mobility, bond peeling velocity and fabric bearing surface [45]. Smooth surfaces guaranties better adhesive bond in comparison to uneven surface [46]. Since the fabric is made up of yarns thus its surface is irregular so the quality of bonding depends upon the structural characteristics of fabric such as density and yarn thickness [47]. Sufficient adhesion between the textile surfaces is important for durability. The temperature also needs to be precise to create a good bonded seam as too high temperature will affect the dimensional stability while too low temperature may cause bond failure [25, 42].

It is the most reliable method of preparing waterproof seam as it offers flat, slimmer and less abrasive seams with feeling of low friction to the user, seamless appearance and weight of the garment is less in comparison to sewn garments due to the reason that only one fabric panel have seam allowance instead of both the panels as in case of stitching [43, 45]. However, the production cost of the product is considerably high [21].

References:

[1] J.W. Rowen & D. Gagliardi, "Properties of Water-Repellent Fabrics", Journal of Research of the National Bureau of Standards, 38 (103-117), (1947)

[2] G.R. Lomax, "Breathable polyurethane membranes for textile and related industries", Journal of Materials Chemistry, 17 (2775-2784), (2007)

[3] Holmes, DA. 'Waterproof breathable fabrics' In: Horrocks, AR., Anand, SC. (Eds.), Handbook of Technical Textiles, first ed., Woodhead Publishing Limited in Association With the Textile Institute, Cambridge: 2000: pp. 282–315

[4] A. Mukhopadhyay & V.K. Midha, "A review on designing the waterproof breathable fabrics part I: fundamental principles and designing aspects of breathable fabrics", Journal of Industrial Textiles, 37(3) (225–262), (2008)

[5] Textiletoday.com.bd [Internet]. Textile Today Bangladesh [updated 2016 December 4; cited 2022 October 2], http://www.textiletoday.com.bd/waterproof-breathable-fabrics-technologies-and-practices-2/

[6] J. Williams, "In the Textile Institute Book Series, Waterproof and Water Repellent Textiles and Clothing"; 1st Ed., Woodhead Publishing: 2018

[7] C.M. Blow, "Recent Developments in the Deposition of Rubber on to Textile Fibres", The Journal of the Society of Dyers and Colourists, 55/7, (1939)

[8] Vam.ac.uk [Internet]. V&A Blog [updated 2015 April 8; cited 2022 October 2], https://www.vam.ac.uk/blog/textiles-and-fashion/a-very-brief-history-of-staying-dry/

[9] H. Klug & M. Gorlt, "Piece of Garment", United States Patent, US 9,066,545 B2, (2015)

[10] JO. Ukponmwan, A. Mukhopadhyay & KN. Chatterjee, "Sewing Threads", Textile Progress Institute Journal, 30:3-4, (2000)

[11] Fibre2fashion.com [Internet]. Fibre2fashion [published 2006 December; cited 2022 June 8], https://www.fibre2fashion.com/industry-article/923/waterproof-breathable-fabric

[12] A.V. Porav, "Gore-Tex and Sympatex Textile Waterproofing", Fascicle of Textiles, Leatherwork, XII (160-165), (May 27-28, 2011)

[13] J. Hu, "In Woodhead Publishing Series in Textiles, Fabric Testing", 1st Ed.; Woodhead Publishing: 2008

[14] S. Kanjana & G. Nalankilli, "Smart, Waterproof, Breathable Sportswear - A Review", Journal of Textile and Apparel, Technology and Management, 10/3 (1-13), (2018)

[15] S.B. Vhanbatte, B. Thakur & R.L. Gotipamul, "A Review on Breathable Fabrics Part – I: Fabric Construction", Journal of the Textile Association, 83/2 (82-87), (2022)

[16] S. Radhakrishnan & D. Kumari, "Seams for Protective Clothing–An Overview", World Journal of Textile Engineering and Technology, 3 (16-23), (2017)

[17] C. Mesegul and G. Karabay, "Usage of Fusible Sewing Threads to Improve the Waterproof Property of Seams", Medžiagotyra, 26/4 (498-504), (2020)

[18] S. Ashour, G. Gabr & Z. Megeid, "Investigating the effect of Joining Techniques on Waterproof and Comfort Properties", International Journal of Scientific & Engineering Research, 8/11, (1319-1327), (2017)

[19] S. Kara & S. Yeşilpınar, "A research on the waterproofness of seam lines of protective clothes", V. International Technical Textiles Congress, (2012)
[20] J.D. Grazia; "Waterproof Seam"; United States Patent Office; 3,090,047; (1963)
[21] N. Seram & T. Nandasiri, "A Comparison between Bonding and Sewing: Application in Sports Performance Wear", Journal of Academia and Industrial Research, 3/8 (343-345), (2015)
[22] A. Macit & B. Tiber, "Evaluation of some physical performance properties of ultrasonic seaming, conventional seaming and sealing adhesive tape on waterproof polyester woven fabrics with polyurethane membrane", Journal of the Textile Institute, (2021)
[23] H. Oh, K. Oh & S. Park, "A study of the improvement of foam material sealing technology for wetsuits", Fashion and Textiles, 6/25, (2019)
[24] W. Jeong & S. Kook An, "Seam Characteristics of Breathable Waterproof Fabrics with Various Finishing Methods", Fibers and Polymers, 4 (71-76), (2003)
[25] P. Jana, "Assembling technologies for functional garments — an overview", Indian Journal of Fibre & Textile Research, 36 (380-387), (2011)
[26] S. Kara & S. Yeşilpınar, "Comparative Study on the Properties of Taped Seams with Different Constructions", Fibres & Textiles in Eastern Europe, 29/2(146) (54-60), (2021)
[27] S. Golomeova & G. Demboski, "Performance of Garment Seams Strengthened with Thermoplastic Stitched Rainforced Tape", International Scientific Journal "Machines. Technologies. Materials.", XI/11 (545-548), (2017)
[28] N. Seram & D. Cabon, "Investigating the possibility of constructing different seam types for clothing using ultrasonic", International Journal of Clothing Science and Technology, 25(2) (90-98), (2013)
[29] M. Yasue & M. Kamiya; "Joining Structure for Waterproof Fabric"; United States Patent; 5,885,679; (1999)
[30] V. Bansal & J.P. Lenox; "Waterproof Breathable Garment with Tape-Free Seams"; United States Patent; US 8,782,812 B2; (2014)
[31] K. Herzer, "Joining of Textiles besides Sewing", Techtextil Texprocess, (2014)
[32] S. Jevšnik, S. Eryűrűk, F. Kalaoğlu, B. Kayaoğlu, P. Komarkova, V. Golombikova & Z. Stjepanovič, "Seam properties of ultrasonic welded multilayered textile materials", Journal of Industrial Textiles, 46/5 (1193-1211), (2017)
[33] M. Seif & M. Nasr, "A Comparative Study of Assembling Methods of Nonwoven Bags Traditional Sewing vs Welding Seaming", International Journal of General Engineering and Technology, 5/6 (2278-9936), (2016)
[34] K. Boles, "Examination of Alternative Fabric Joining Techniques Compared to Traditional Sewing", McNair Scholars Research Journal, 5/1, (2012)
[35] P. Viorica & C. Sunhilde, "Ultrasonic Assembly [Review]", Annals of the University of Oradea Fascicle of Textiles-Leatherwork, 16(1) (83-86), (2015)
[36] I. Jones & G. Stylios, "In the Joining Textile, Principle and Application", 1st Ed.; Philadelphia; Woodhead Publishing Series in Textiles: 2013
[37] R. Nayak & R. Padhye, "The use of laser in garment manufacturing: an overview", Fashion and Textiles, 3/5, (2016)
[38] S. Yesilpınar & S. Bahar, "Ultrasonik Dikis Makinaları", Tekstil Maraton, 80 (9-17), (2005)
[39] Erez-therm.com [Internet]. Erez [updated 2020 June 2; cited 2022 October 2], https://erez-therm.com/welding-thermoplastics/
[40] M. Troughton, "In the Handbook of Plastics Joining, Radio Frequency Welding", 2nd Ed., William Andrew Publishing: 2009: pp. 57-63
[41] D. Ujević, S. Kovačević & S. Horvat-Varga, "Analysis of High-Frequency Artificial Leather Welding as a Function Analysis of High-Frequency Artificial Leather Welding as a Function of Seam Quality", Fibres & Textiles in Eastern Europe, 19/ 4(87) (94-100), (2011)
[42] Ž. Jakubčioniene & V. Masteikaitė, "Investigation of Textile Bonded Seams", Medžiagotyra, 16/1 (76-79), (2010)
[43] G. Busilienė, E. Strazdienė, V. Urbelis & S. Krauledas, "The Effect of Bonded Seams upon Spatial Behaviour of Knitted Materials Systems", Medžiagotyra, 21/2 (271-275), (2015)
[44] A. Pizzi & K.L. Mittal, "In the Handbook of Adhesive Technology, Revised and Expanded", CRC Press: 2003
[45] G. Mikalauskaitė & V. Daukantienė, "Investigation of the Influence of Bonding and Thermal Ageing Duration on the Peeling Strength of Knitted Materials' Bonds", Medžiagotyra, 26/2 (225-232), (2020)
[46] T.R. Simmons, K. Liu, R. Paroli, A.H. Delgado, J.D. Irwin & D. Runyan, "Effects of Welding Parameters on Seam Strength of Thermoplastic Polyolefin (TPO) Roofing Membranes", In Proceeding of the North American Conference on Roofing Technology, (56-68), (1999)
[47] Ž. Jakubčioniene, V. Masteikaitė, T. Kleveckas, M. Jakubčionis & U. Kelesova, "Investigation of the Strength of Textile Bonded Seams", Medžiagotyra, 18/2 (172-176), (2012)

■ ■ ■

Analysis of Different Yarn Properties Produced from Diverse Blend of Fibres and Spinning Systems

Toufiqua Siddiqua[1]*, Towfic Aziz[2], Md. Sakhawat Hossain[3] & Md. Ariful Hossain Faisal[4]

[1]Dept. of Yarn Engineering, Bangladesh University of Textiles, Tejgaon, Dhaka, Bangladesh
[2]Matam Multi-Fiber Mills Ltd., Bharadoba, Valuka, Mymensingh, Bangladesh,
[3]Square Textiles Ltd., Saradaganj, Kashimpur, Gazipur, Bangladesh,
[4]Square Textiles Ltd., Mascot Plaza, Uttara Dhaka, Bangladesh,

Abstract:
Blending fibers to produce yarn is more popular nowadays due to its quality and processing performance in the following stages. In addition, the properties of fabric made from blended yarn also become better than that of conventional ring-spun yarn. Furthermore, the popularity of blended yarn is increasing day by day, though there exist various yarns produced from numerous new along with modern spinning systems. Vortex spinning is a modern spinning system, and it has brought a revolutionary change in yarn properties in terms of hairiness handling compared to conventional ring-spun yarn. In this work, three yarns of a count of "30's Ne" count were produced by blending cotton-polyester fiber in a conventional ring and air vortex spinning system as well as cotton-flax fibers in a ring spinning system. During the work, the blending ratio was kept constant (60/40). Fiber properties were tested by High Volume Instrument (HVI) and Advanced Fiber Information System (AFIS). After getting yarn from ring and Murata vortex, spinning system properties were tested by Auto sorter, Electric Twist Tester Mag-YOY52, Uster Evenness Tester 6, Automatic wrap reel, Electronic Lea Strength Tester, (Model: TYT-03C), and Mesdan Strength tester AUTODYN 300. All yarn properties were analyzed by One way of ANOVA. It has been found that cotton-polyester blend yarn produced in ring spinning systems is superior in quality over others because it has better irregularity %, IPI, CSP, tenacity, and elongation. On the other hand, the vortex produced yarn with low hairiness compared to others.

Keywords: *ANOVA, blend, cotton, flax, Murata vortex spinning, polyester, ring spinning*

Citation: Toufiqua Siddiqua, Towfic Aziz, Md. Sakhawat Hossain & Md. Ariful Hossain Faisal, "Analysis of Different Yarn Properties Produced from Diverse Blend of Fibres and Spinning Systems", *Journal of the Textile Association,* **83/5** (356-362), (Jan-Feb' 2023), https://doi.org/10.56716/4/1456

Article Received: 05-08-2022, Revised: 10-10-2022, Accepted: 16-11-2022

1. Introduction :

Nowadays, the textile business creates a lot of employment though it faces massive competition and pays a certain amount of tax to machine producers. The clothing industry largely depends on traditional ring spinning systems for yarn [1]. Cotton fiber spinning has three different spinning systems available: conventional ring sinning system, open-end spinning system, and Murata Vortex spinning [2]. Spun yarn properties depend on its constituent fiber and spreading in a cross-sectional body. Different spinning systems affect yarn structure and the intricate connection between fiber and yarn construction. The conventional ring spinning system produces yarn where fibers are firmly intertwined. On the other hand, modern spinning systems such as rotor, air-jet, and friction make yarn scarce a tangle of fiber. It is happened due to the geometrical difference in yarn construction [3]. There is an establishment that ring, rotor, and air-jet machine draft affect tensile properties of yarn [4]. Process parameters have a significant influence on the physical properties of the yarn. Therefore, it is crucial to understand the structure and its effect on the physical properties of yarn produced from different spinning systems because every spinning system shows exceptional yarn properties [5]. There were continuous efforts to modify existing ring spinning systems to improve technology, including automation and developing process capabilities for some decades [6].

Corresponding Author :
Mrs. Toufiqua Siddiqua
Assistant Professor, Dept. of Yarn Engineering, Bangladesh University of Textiles, Tejgaon Industrial Area, Dhaka - 1208, Bangladesh
E-mail: toufiquaku@gmail.com

Murata Vortex Spinning is a new technology to produce a yarn different from the conventional ring, open-end, and air-jet spinning systems. The main advantage of this spinning system is that it produces yarn with a higher speed than other spinning systems [7]. Flax is a natural fiber and has a long history but the elasticity properties are low [8-9]. Flax can be spun in two systems a dry system and wet (boiling and bleaching of fiber) system [10]. A blending of fiber is done to reduce cost with an acceptable quality of yarn [11]. Blend yarn of natural and manufactured fibers is popular in underwear, socks, hygienic textile products, and composite because of some essential characteristics such as non-irritating, anti-bacterial, anti-allergic, good ultraviolet ray protection, and better moisture absorption and desorption capability [12]. Polyester cotton blend is typical in the blending trend. This blended yarn has better advantageous properties than pure cotton and polyester yarn [13]. The blended yarn of cotton and polyester fiber is more common in apparel production due to some factors like better evenness, a reduced amount of pilling and static charges, and good processing performance [14].

2. Materials

Flax, polyester, and three cotton fibers, such as one Spanish and two Tajikistan fibers, were used to produce yarn in this thesis work. The origin of polyester fiber is Indonesia, and flax fiber is Egypt. Polyester fiber's cut length, fineness, and strength are 32mm, 1.2den, and high, respectively. Flax and cotton fibers properties were tested using High Volume Instrument (HVI) and Advanced Fiber Information System (AFIS). Fibers were kept in standard atmospheric condition about 48hours before testing. Test results of all fibers are given below.

Table 1: Fiber properties from HVI

Fiber Properties Name	Spanish Cotton Fiber	Tajikistan Cotton Fiber-1	Tajikistan Cotton Fiber-2	Flax Fiber
SCI	158	142	145	91
MIC Value	4.76	5.14	5.24	7.59
Moisture (%)	7	6.3	6.8	6.5
Maturity Ratio (-)	0.87	0.78	0.89	0.97
UHML (mm)	28.94	29.33	29.08	36.07
UI (%)	83.3	84.56	82.98	74.9
SFI (%)	8	7.8	8.1	5.7
Strength (GPT)	38.6	33.8	36.2	42.2
Elongation (%)	6.7	6.2	5.8	2.6

Table 2: Fiber properties from AFIS

Fiber Properties Name	Spanish Cotton Fiber	Tajikistan Cotton Fiber-1	Tajikistan Cotton Fiber-2	Flax Fiber
Neps (Cnt/g)	159	169.5	153.2	580
Neps Size (µm)	702	654.5	717.5	748
SCN (Cnt/g)	9.5	9.5	5	197
SCN Size (µm)	1033.2	1050	1474	1046
SFC (n) (%)	12.85	12.3	11.45	71.8
UQL (w) (mm)	29.7	31.5	30.8	18.4
5% (mm)	33.9	34.6	35.15	22.4
Fineness (mtex)	176	181	184	205
IFC (%)	5.5	5.85	4.8	6.2

2.1 Experimental

Three blended yarns of the exact count of 30's Ne KH (Card Hosiery) were produced in-ring and vortex spinning systems. The blend ratio of those yarns is shown below;

Table 2: Fiber properties from AFIS

Sample Name	Description	Spanish Cotton Fiber (%)	Tajikistan Cotton Fiber-1 (%)	Tajikistan Cotton Fiber-2 (%)	Flax Fiber (%)	Polyester Fiber (%)	Total Fiber in Yarn (%)
CVC Ring Spun Yarn	Chief Value of Cotton (CVC) yarn produced from ring spinning system	60	-	-	-	40	100
CVC Vortex Spun Yarn	Chief Value of Cotton (CVC) yarn produced from Murata vortex spinning system	-	60	-	-	40	100
Cotton-Flax Blended Yarn	Cotton-Flax (CF) yarn produced from ring spinning system	-	-	60	40	-	100

Three mixing samples of fibers were prepared by hand according to the percentage mentioned in table number 3 as well as they were processed in a ring and vortex spinning system. The first and third blended samples were dealt with in the card process of ring spinning system considering with almost same settings whereas the second sample was processed in vortex spinning system. Rovings were fed to the ring frame where spindle speed: 16500 (CVC Ring Spun Yarn) & 10000 (Cotton-Flax Blended Yarn), TPI: 20.16 (CVC Ring Spun Yarn) & 25.85 (Cotton-Flax Blended Yarn). Drawn sliver were fed to Vortex spinning frame of model 870 II while delivery speed: 400 m/min, pressure: 0.50MPa and TPI: 19.78 to produce yarn. Wastage percentage of CVC Ring Spun Yarn, CVC Vortex Spun Yarn and Cotton-Flax Blended Yarn was kept at 11.75, 15.09, and 26.47, correspondingly.

After collecting the samples from both ring and vortex machines, the ring yarns were wound on a cone in the winding machine, where the vortex machine automatically provided a cone. The winding speed for CVC Ring Spun Yarn was kept at 1200m/min, and for Cotton-Flax Blended Yarn, it was 950 m/min.

3. Results

All the packages were then conditioned to standard atmospheric conditions for about 48 hours. Yarn evenness, imperfection, and hairiness properties were tested using Uster Evenness Tester 6, and the testing speed was kept at 400 m/min and carried out for 1 min. Some other properties like count strength product (CSP) by using Automatic wrap reel, (Model: TYT-02) and Electronic Lea Strength Tester, (Model: TYT-03C, Testing Standard- ASTM-D157812256), Mesdan Strength tester AUTODYN 300 and TPI by using Electric Twist Tester Mag-YOY52 were also tested.

During the CSP calculation sample length for testing, strength was 120yds. Single yarn strength tester machine works on a constant rate of elongation (CRE) principle, and during the testing of single yarn strength, sample length and clamp speed was kept 645mm and 500 mm/min. Properties of yarns are listed below-

4. Discussions

4.1 Yarn Irregularity

Irregularity means the weight per unit length difference because of variation in fiber assembly. It is expressed in two terms named Um% or CVm % [31]. It is seen from figure 1 that CVm% of Cotton-Flax Blended Yarn shows the highest value and CVC Ring Spun Yarn the lowest and the values are 20.73 and 14.72 respectively. It is probably due to the characteristics of the fibers. Flax fiber is more uneven than cotton and polyester fiber; that's why Cotton-Flax Blended Yarn is more irregular. On the other hand, CVC Vortex Spun Yarn remains middle position. It happens because the high draft has to give on the vortex yarn, as it is produced from sliver directly.

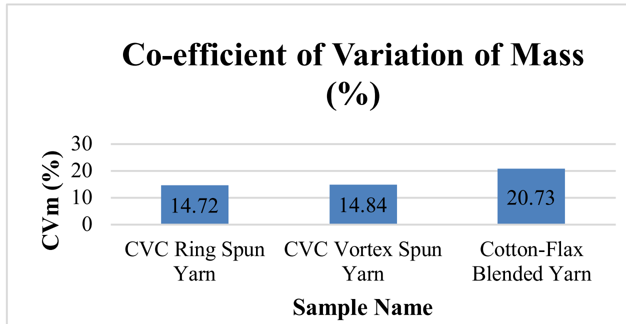


Figure 2: Yarn imperfection index

4.3 Yarn Hairiness

Fiber dispersal transversely in the yarn body affects yarn hairiness. Yarn hairiness has a significant effect on fabric properties. Figure 3 shows that CVC Vortex Spun Yarn demonstrates better results. On the other hand, Cotton-Flax Blended Yarn displays the worst result, and CVC Ring Spun Yarn expresses medium location. The highest and lowest value is 6.43 and 5.6, consequently. CVC Vortex Spun Yarn reveals the best result among the three because this may be possible due to the wrapping fiber of vortex yarn that wraps around the core, whereas in ring spinning system, yarn consistently remain in contact with balloon control ring that

Table 4: Different yarn properties

Sample Name	Unevenness (%)	CV_m (%)	Thin Place (-50%)/Km	Thick Place (+50%)/Km	Neps (+200%)/Km	Imperfection Index (-)	Hairiness (-)	CSP (Ne*lb)	Tenacity (RKM)	Elongation (%)
CVC Ring Spun Yarn	11.22	14.70	217	70.83	53.50	343	6.22	2531	19.7	8.77
CVC Vortex Spun Yarn	11.96	14.80	25	217.50	101.33	344	5.60	1770	13.1	7.74
Cotton-Flax Blended Yarn	16.77	20.70	596	2457	1838	4891	6.43	2061	12.5	5.53

creates friction cause hairiness. During the processing of vortex yarn, the wrapping fibers wrap the inner fibers so they can't come out to the yarn surface, thus reducing hairiness. The hairiness is higher in Cotton-Flax Blended Yarn due to its stiffness property. Due to higher stiffness, flax fibers want to reach the yarn surface, thus increasing hairiness. Also spinning triangle is an essential factor.

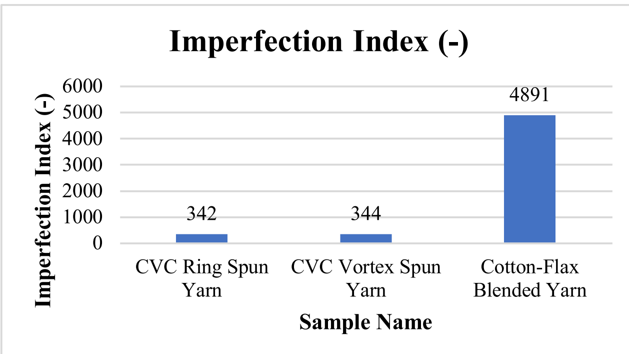


Figure 2: Yarn imperfection index

4.3 Yarn Hairiness

Fiber dispersal transversely in the yarn body affects yarn hairiness. Yarn hairiness has a significant effect on fabric properties. Figure 3 shows that CVC Vortex Spun Yarn demonstrates better results. On the other hand, Cotton-Flax Blended Yarn displays the worst result, and CVC Ring Spun Yarn expresses medium location. The highest and lowest value is 6.43 and 5.6, consequently. CVC Vortex Spun Yarn reveals the best result among the three because this may be possible due to the wrapping fiber of vortex yarn that wraps around the core, whereas in ring spinning system, yarn consistently remain in contact with balloon control ring that creates friction cause hairiness. During the processing of vortex yarn, the wrapping fibers wrap the inner fibers so they can't come out to the yarn surface, thus reducing hairiness. The hairiness is higher in Cotton-Flax Blended Yarn due to its stiffness property. Due to higher stiffness, flax fibers want to reach the yarn surface, thus increasing hairiness. Also spinning triangle is an essential factor.

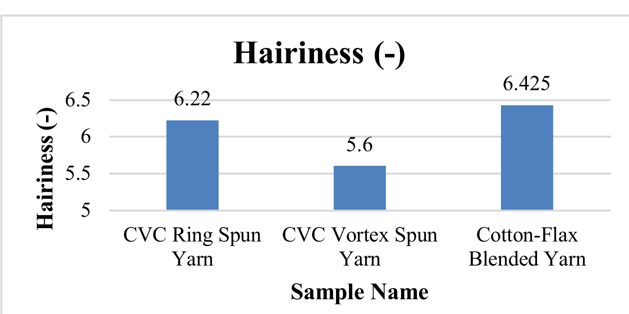


Figure 3: Hairiness of yarn

4.4 Yarn Strength

Yarn strength is an essential factor in consideration with serviceability in the end product. It is expressed in two ways, single yarn strength named tenacity and count strength product (CSP). It is realized from figures 4 & 5 that CVC Ring Spun Yarn displays maximum values, and CVC Vortex Spun Yarn shows bottommost values both in CSP as well as tenacity. It is perhaps due to the orientation of fiber in yarn. In ring-spun yarn, the fibers are more oriented than vortex yarn; another cause is the migration of fibers from core to sheath and vice-versa.

On the other hand, in ring-spun yarn, all the fibers from core to surface get the twist, which doesn't occur in vortex yarn. As all the fibers in ring-spun yarn get a twist, the fibers in the yarn body get higher orientation and migration; that's why the bundle strength in CVC Ring Spun Yarn and Cotton-Flax Blended Yarn is higher than CVC Vortex Spun Yarn. The reason behind the strength difference between CVC Ring Spun Yarn and Cotton-Flax Blended Yarn is the strength of the polyester fiber is higher than the flax fiber.

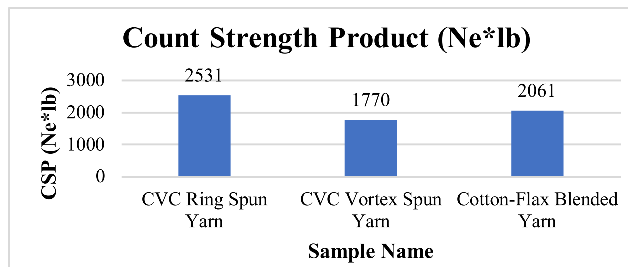


Figure 4: Count strength product of yarn

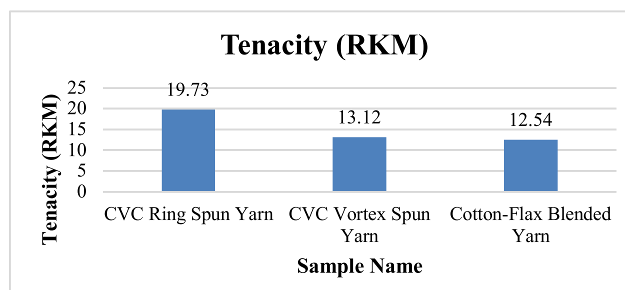


Figure 5: Yarn tenacity

4.5 Yarn Elongation

Yarn elongation has an impact on further processing and the end product. The elongation percentage of the three samples is shown in figure 6. CVC Ring Spun Yarn exhibits supreme value, CVC Vortex Spun Yarn medium and Cotton-Flax Blended Yarn lowermost value. This is because of the soft nature of cotton and polyester fiber. However, Cotton-Flax Blended Yarn is also produced in ring frame machine, exhibits low elongation because of the stiffness property of flax fiber.

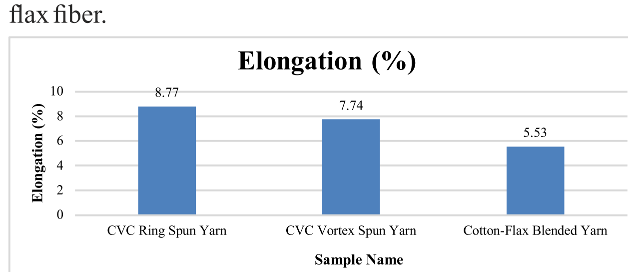


Figure 6: Elongation of yarn

4.6 Statistical Analysis

One-way ANOVA (Analysis of Variation) was accomplished for all properties of the three yarns by using Microsoft Excel 2013. The tests were carried out at alpha level 0.05. P-value is 0.00 for all ANOVA test results that indicate remaining variation within the samples.

Table 5: P-value of ANOVA test result

Yarn Properties Name	*P-value*
CV_m (%)	0.00*
Imperfection Index (-)	0.00*
Hairiness (-)	0.00*
Tenacity (cN/tex)	0.00*
Elongation (%)	0.00*

Therefore, before concluding, it is necessary to perform Post-Hoc Analysis, which was completed through Microsoft Excel 2013 with t-test: Two-sample Assuming Equal Variances. The reason behind choosing t-test: Two-sample Assuming Equal Variances is this is not a test for hypothesizing that one means greater or less than the other. It is a way to know whether they are different or ask are they different either way up or down, so choosing the to test two-tailed term t-test and assuming that they have equal variance.

4.7 Post-Hoc Analysis

The alpha level used for comparison was 0.0167 (Bonferroni correction), as the comparison number was three. The results are given below-

Table 6: Result of t-test

Yarn Properties	P(T<=t) two-tail Between		
	CVC Ring Spun Yarn and CVC Vortex Spun Yarn	CVC Vortex Spun Yarn and Cotton-Flax Blended Yarn	Cotton-Flax Blended Yarn and CVC Ring Spun Yarn
CV_m (%)	0.59	0.00*	0.00*
Imperfection Index (-)	0.96	0.00*	0.00*
Hairiness (-)	0.01*	0.00*	0.04
Tenacity (RKM)	0.00*	0.43	0.00*
Elongation(%)	0.01*	0.00*	0.00*

There is no statistically significant difference between CVC Ring Spun Yarn and CVC Vortex Spun Yarn in the case of CVm (%), and imperfection index (-), between CVC Vortex Spun Yarn and Cotton-Flax Blended Yarn in case of tenacity, and between CVC Ring Spun Yarn and Cotton-Flax Blended Yarn in case of hairiness because values are higher than 0.0167 (Bonferroni correction). However, others show the reverse pattern.

5. Conclusion

To sum up, it can be said from different test results that CVC Ring Spun Yarn demonstrates the best result among three samples. All the results are better without hairiness properties. The probable cause of this performance is that cotton and polyester fibers are comparatively even in nature and have good fiber orientation in the yarn body due to the better draft distribution in the ring-spinning system. CVC Vortex Spun Yarn performs good results than Cotton-Flax Blended Yarn, excluding strength. Vortex yarn quality is inferior to CVC ring yarn may be the higher draft in the spinning frame as the yarn is produced from sliver. The reason behind the low performance of Cotton-Flax Blended Yarn is that it may be the irregularity and stiffness properties of the fiber itself.

From statistical analysis, it is seen that although ANOVA test results show a significant difference for all samples. Nonetheless, t-Test: Two-Sample Assuming Equal Variances confirms that CVC Ring Spun Yarn and CVC Vortex Spun Yarn have a quality level near to each other. On the other hand, there are significant differences with Cotton-Flax Blended Yarn with those samples. Therefore, CVC ring-spun yarn is the best within three.

6. Acknowledgment

The authors' thanks are due to the Bangladesh University of Textiles, Matam Multi-Fiber Mills Ltd., and SQUARE Textiles Ltd. For providing their support and facilities for this work.

References:

[1] H. A. Begum, T. Siddiqua, A. Kalam, M. Mazed, and A. B. Siddique, “Modification of Adapter in Auto Cone Winding Machine for Better Performance,” International. Journal of Recent Technology and Engineering, 8/6 (2761–2768), (2020)

[2] A. K. Soe, M. Takahashi, M. Nakajima, T. Matsuo, and T. Matsumoto, “Structure and Properties of MVS Yarns in Comparison with Ring Yarns and Open-End Rotor Spun Yarns,” Textile Research Journal, 74/9 (819–826), (2004)

[3] G. K. Tyagi, A. Goyal, and R. Chattopadhyay, “Physical characteristics of tencel-polyester and tencel-cotton yarns produced on ring, rotor and air-jet spinning machines,” Indian Journal of Fibre and Textile Research, 38/3 (230–236), (2013)

[4] A. Kumar, S. M. Ishtiaque, and K. R. Salhotra, “Analysis of spinning process using the Taguchi method. Part IV: Effect of spinning process variables on tensile properties of ring, rotor and air-jet yarns,” Journal of Textile Institute, 97/5 (385–390), (2006)

[5] W. O. YOU HUH, YOUNG RYUL KIM, “Analyzing Structural and Physical Properties of Ring, Rotor, and Friction Spun Yarns,” Textile Research Journal, 72/2 (156–163), (2002)

[6] M. Krifa and M. D. Ethridge, "Compact Spinning Effect on Cotton Yarn Quality: Interactions with Fiber Characteristics," Textile Research Journal, 76/5 (388–399), (2006)

[7] H. G. Ortlek, F. Nair, R. Kilik, and K. Guven, "Effect of spindle diameter and spindle working period on the properties of 100% viscose MVS yarns," Fibres and Textiles in Eastern Europe, 16/3 (17–20), (2008)

[8] T. Jackowski, B. Chylewska, D. Cyniak, J. Czekalski, and L. Jackowska-Strumillo, "Modelling of the relationship between feeding sliver structures and parameters of cotton/linen blended yarns," Fibres and Textiles in Eastern Europe, 11/2 (12–17), (2003)

[9] N. Dhirhi, R. Shukla, N. B. Patel, H. Sahu, and N. Mehta, "Extraction method of flax fibre and its uses," Plant Archive, 15/2 (711–716), (2015)

[10] W. Cierpucha, R. Kozłowski, J. Mańkowski, J. Waśko, and T. Mańkowski, "Applicability of flax and hemp as raw materials for production of cotton-like fibres and blended yarns in Poland," Fibres and Textiles in Eastern Europe, 12/3 (13–18), (2004)

[11] B. Azzouz, M. Ben Hassen, and F. Sakli, "Adjustment of Cotton Fiber Length by the Statistical Normal Distribution: Application to Binary Blends," Journal of Engineered Fibers and Fabrics, 3/3 (35-46), (2008)

[12] G. Pralkash, C, Ramakrishnan and C. V Koushik, "Effect of Blend Ratio on the Quality Characteristics of Bamboo / Cotton Blended Ring Spun Yarn," Fibres and Textiles in Eastern Europe, 19/6 (38–40), (2011)

[13] P. D. Baykal, O. Babaarslan, and R. Erol, "Prediction of strength and elongation properties of cotton/polyester-blended OE rotor yarns," Fibres and Textiles in Eastern Europe, 14/1 (18–21), (2006)

[14] R. F. Q. A. N. M. S.A. MALIK, A. TANWARI, U.SYED, "Blend Yarn Analysis, Part-I, Influence of Blend Ratio and Break Draft on Mass, Hairiness and Physical Properties of 15 tex PES-CO Blended Ring Spun Yarn.pdf." Taylor & Francis Group, LLC, 9 (197-206), (2012)

■ ■ ■

Sustainable Business Models for Fashion and Textile Industry

*Geetha Pandey**

Srishti Manipal Institute of Art, Design & Technology, Yelahanka New Town, Bangalore

Abstract:

The fashion and textile industry has recently been in discussion for its negative environmental impact and the pandemic has further accelerated this issue the industry is facing. Sustainability has become a major topic of discourse on various platforms and the fashion industry is still struggling to meet the sustainable goals, especially in consumption and production. This paper analyses how there is a need to bring a paradigm shift in the way consumption and production of fashion goods is done and evaluate different sustainable business models if the fashion industry has to successfully achieve SDG 12. Data collected from reliable and research-based secondary resources helped to frame the findings which focus on initiatives of better waste management and the longevity of the product life cycle by bringing it back into the loop of consumption.

Keywords: *Fast Fashion, R's of sustainability, Recycle, Reuse, Sustainable business models*

Citation: Geetha Pandey, "Sustainable Business Models for Fashion and Textile Industry ", *Journal of the Textile Association,* **83/5** (362-366), (Jan-Feb' 2023), https://doi.org/10.56716/4/1460

Article Received: 19-06-2022, Revised: 20-08-2022, Accepted: 09-10-2022

1. Introduction :

The industry suffered one of the worst years in 2020 where consumption patterns shifted, supply chain was disrupted and the need for a more sustainable initiative to survive the future has become prominent. The industry contributes to 8-10% of global CO_2 emissions produced and consumes 79 trillion litres of water per year. 20% of the water pollution is caused by the dyeing and finishing processes of making textiles [12].

In the last two decades, there has been a drastic shift in the consumption pattern which has almost doubled to 13 kgs from 7 kgs per person. Textile production has doubled to meet the consumption demand of almost 100 million tonnes and more. The majorities of the textiles goes to the landfill or are burnt and just about 15% of it is recycled [20].

These numbers clearly show that there is an urgent need to commit to sustainable production and consumption which is particularly an important criterion of SDG 12 goals. The current production and consumption pattern has a substantial effect on accomplishing the UN Sustainable Development Goals (SDGs). There is an immediate necessity to address the usage of natural resources, alternate strategies that help prolong the life cycle of the product, waste management both at the production and consumption stage. Therefore, it is necessary that both producers and customers become aware of the environmental, social, economic impact of the current practices of production and consumption in the fashion industry.

The current linear model of fast fashion of make-use-dispose has changed the way people buy and use clothing. Fast fashion is a term used to describe the readily available, inexpensively made fashion of today [2]. The industry has moved away from the traditional 4 season's model and consumers are being spoilt for choices. The rise in globalization has led to a drastic shift in supply chain management, manufacturing process, and sourcing of materials.

These numbers indicate the urgency with which there is a need to formulate sustainable initiatives and strategies that are needed for the textile and fashion industry to move from a linear model of production and consumption to a circular model. "A circular economy is an industrial system that, restorative or regenerative by intention and design" [7]. It involves designing products that can be made again and again empowering the systems with renewable energy. It brings a shift in the way the 'end-of-life' concept is seen with focus on using renewable energy, reducing the use of toxic chemicals in the production process which will help in the reuse and restoration of textiles and fashion products [5].

The paper aims to understand better how sustainability can be integrated within the fashion and textile industry. This integration has to be implemented in different areas covering from field to end of life of the product and how business models can promote longevity of clothes and allow to reuse, recycle clothes and materials.

2. Pilot study

Pilot study is undertaken to understand the impact of fast fashion on the ecosystem and the growing need for sustainable practices that will help keep the product and material in the product lifecycle loop. Further primary research through field trips, interviews and case studies of practices within the unorganized sector is studied to understand their model.

Corresponding Author :
Ms. Geetha Pandey
Associate Dean- Academics/ Faculty, Srishti Manipal Institute of Art, Design & Technology, 40/D Marilingiah Building 2nd Cross Rd, Yelahanka New Town, KHB Colony, Bengaluru – 560 064
E-mail: geetha.pandey@manipal.edu, pandeygeetha@gmail.com

3. Results and Discussion

3. 1. Existing Fashion Business Models

3.1.1 Fast Fashion Model

The scale of impact of fast fashion due to consumer demand and globalization of the supply chain has been a topic of discussion for some time now. Fast fashion is defined as a business model, offers customers new trend-led collections frequently at a low price' [15].

The fashion market is highly competitive and the constant demand means that the retailers have to extend the seasons frequently to provide an entire range of merchandise in their store as quickly as in a few weeks. The shorter life cycles, higher profit margin, and cheap prices indicate a practice of 'here today gone tomorrow" [1].

Fast fashion retailers like Zara, H&M, and Forever 21 are able to provide trends at a faster pace through an extensive supply chain. In essence, the retailers of fast fashion are able to pull off greater variety allowing more choice to the consumers at a low price [13].

It's not just the retails and brands that seem to be contributing to fast fashion cycle. The impact is visible in the unorganized sector as well. On visiting the local weaver's community in Yelahanka area of Bangalore, it was found that that a six-yard saree could be made in less than half the time on a power loom when compared to a saree being made on handloom which would take anywhere between 1-2 days to make. Observations and discussions with the weavers showed that the pandemic has hit this sector hard and the handloom weavers are struggling to meet ends.

Fig. 1 model clearly shows that in the present scenario the fast fashion strategy focuses on shorter lead times increasing the stock at the shop floor at a much faster rate.

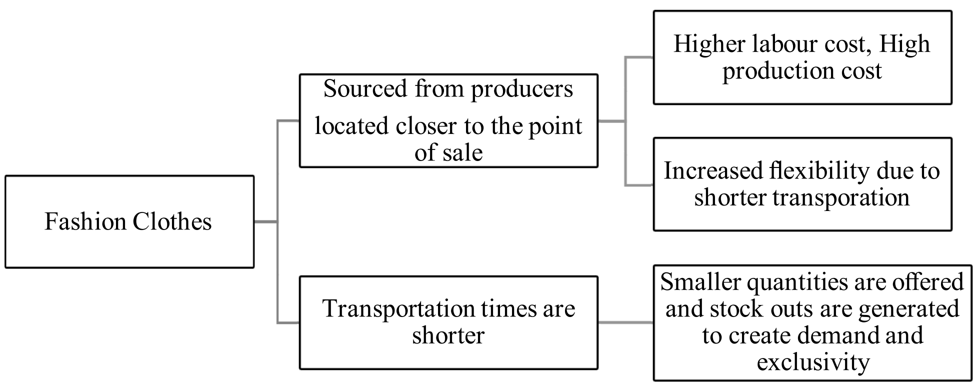


Figure 1: Fast Fashion Strategy

3.1.2 Traditional Fashion Model

Increasing globalization and digitization are responsible for the faster introduction of trends and many of the fast fashion companies use the fast fashion strategy to offer more variety of products and be flexible to consumer demand. Looking at fast fashion from the consumer's perspective is an important element. These consumers want products immediately. Fast fashion follows basic economic laws as they are still considered economic goods a higher price leads to lower Sustainability demand and a higher income leads to higher demand [26].

From the fig. 2 model, it was observed that large quantities are purchased to prevent stock –outs rather than producing quantities to meet the needs of the market.

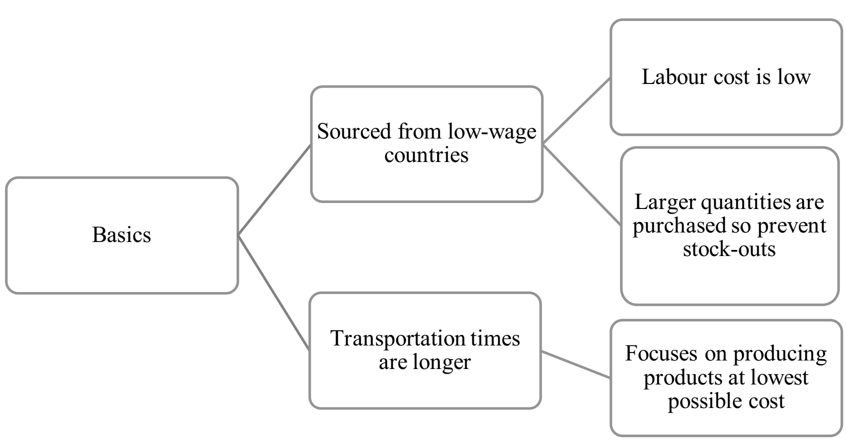


Figure 2: Traditional Strategy for Procurement

3. 2. Sustainable Fashion Models

Sustainable fashion model has varied definitions and is synonyms to terms including slow fashion, ethical, green, and eco- fashion. Sustainable fashion can be defined as fashion clothing, footwear, and complementary accessories that are produced, sold, and used in a sustainable manner with a focus on both environmental and socio-economic aspects [3]. Every stage right from the field to store is continuously improved upon. End of life is extended by following 4 R's of sustainable strategy which is detailed in table below:

Table 1: 4 R's of Sustainable Business Strategy

Sustainable practices	Definition	Methods	Modes of facilitation/ Types	Synonym terms
Reuse	Refers to means by which the life of the product is prolonged by transferring ownership.	Swapping, exchange, mending, renting, borrowing	Online platforms, exchange cafes, Swap cafes, charities, clothing libraries, second hand shops, flea market and garage sales	Collaborative consumption, product-service system, commercial sharing systems
Recycling	Refers to repurposing of pre and post consumption textile waste for use in new textile or non-textile products.	Recycling routes are mechanical and chemical and include recycling of fibres, fabric, polymer	Down cycling- recycling materials into rags, low grade blankets which is lower in cost and quality than original value. Upcycling – recycling materials which are higher in value and quality compared to original product. Product can be recycled to make another product (open loop) or make similar product (close looped).	Recycling, upcycling, multiple life cycles
Repair	Mending or repairing the whole or part of the garment to ensure longevity of product.	Preventive mending, visible mending, patching, replacement	Repair cafes, community repair events, repair/mending workshops	Restoring, Mending, Salvaging
Reduce	Value generated mainly by consumer behavior, minimizing waste in pre and post consumption phase.	Buy less, Less is more, minimalist, buying quality that last longer	Slow fashion, Lowsumerism, Capsule wardrobe, educational campaigns to raise awareness	Slow fashion

Table 2: Evaluation of the Sustainable Strategies

Sustainable practice	Environmental Impact of production	Impact of consumption
Reuse	+	+
Recycling	+	+
Repair	+/-	+
Reduce	+	+

Textiles consist of multiple materials blended together which makes recycling difficult. Though less is more is ideally the need of the hour, reuse and recycling are alternate solutions to address the issue of the linear model of make-wear-dispose of clothing.

Reuse can be defined as using the textiles again for the same purpose for which it was made whereas recycling is defined as the use of the textiles for creating recycled materials [6]. Overconsumption is an integral part of the waste generated in the fashion industry. Over the last decade, there has been a growing need for looking at ways how to create alternate usage for textiles and fashion.

Research of consumer attitudes towards disposal by Sabine Weber [25] showed that the majority of consumers are more likely to be a part of reselling, swap, second-hand clothing more for the reason of removing unwanted textiles rather than for the environmental benefits.

Recently there has been a good demand for second-hand clothing on online platforms. There are several reasons for this boom showing that there has been a shift in how consumers see second-hand clothing now. It has become more acceptable, trendy, and popular. In comparison to other industries like paper, glass with increased recycling rates, there are limited improvements in terms of waste management in the textile industry [8].

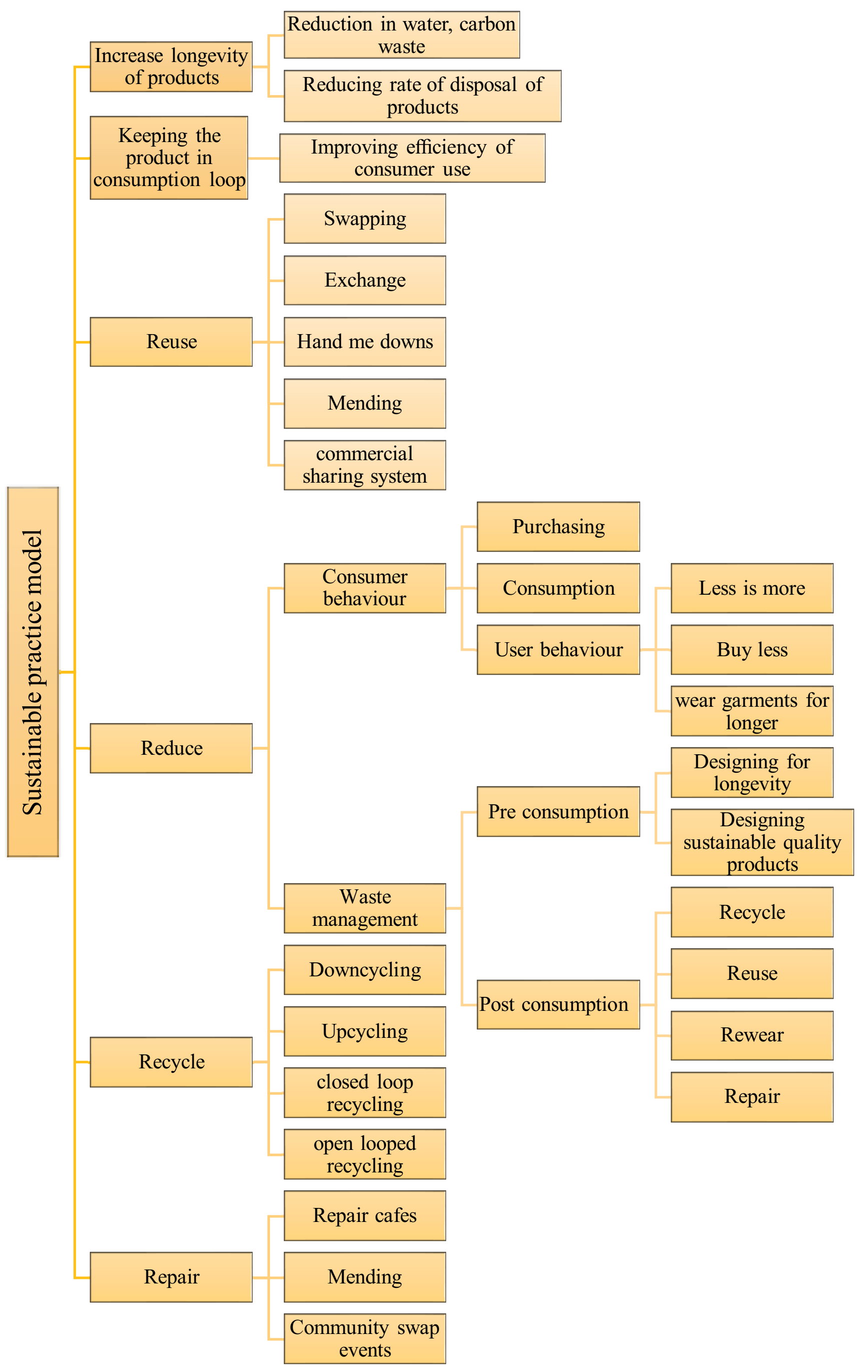


Figure 3: Mapping of Sustainable Business Practice Models

4. Conclusion

There has been a tremendous increase in the consumption of fashion and textile products. This has led to an increase in textile waste. Most of the waste either find their way to the landfill or is incarcerated and very little is reused or recycled. There is a need to look at alternative sustainable solutions to create a circular fashion. To achieve a circular economy and deviate from the make-use-dispose culture, it is important to consider the need for using textiles and fabrics that are sustainable, eco-friendly and can be brought back into the loop of consumption. From the various case studies, it was clear that sustainable business models that help create awareness about sustainable materials and products are the need of the hour.

References:

[1] Bhardwaj, V., & Fairhurst, A, 'Fast fashion: response to changes in the fashion industry', The International Review of Retail, Distribution and Consumer Research, 20(1), 165–173, 2010 https://doi.org/10.1080/09593960903498300

[2] Bick, R., Halsey, E., & Ekenga, C. C, 'The global environmental injustice of fast fashion', Environmental Health, 17(1), 92, 2018, https://doi.org/10.1186/s12940-018-0433-7

[3] Brydges, T., Retamal, M., & Hanlon, M, 'Will COVID-19 support the transition to a more sustainable fashion industry?', Sustainability: Science, Practice and Policy, 16(1), 298–308, 2020, https://doi.org/10.1080/15487733.2020.1829848

[4] Diddi, S., & Yan, R.-N, 'Consumer Perceptions Related to Clothing Repair and Community Mending Events: A Circular Economy Perspective', Sustainability, 11(19), 5306, 2019 https://doi.org/10.3390/su11195306

[5] Ekins, P., Domenech, T., Drummond, P., Bleischwitz, R., Hughes, N., & Lotti, L, 'The Circular Economy: What, Why, How and Where' In Background paper for an OECD/EC the workshop series "Managing environmental and energy transitions for regions and cities, 2019

[6] Ekström, K. M., & Salomonson, N, 'Reuse and Recycling of Clothing and Textiles—A Network Approach', Journal of Macro marketing, 34(3), 383–399, 2014, https://doi.org/10.1177/0276146714529658

[7] Ellen MacArthur Foundation, 'A New Textiles Economy: Redesigning Fashion's Future, In www.ellenmacarthurfoundation.org/publications, 2017

[8] Hole, G., & Hole, A, 'Recycling as the way to greener production: A mini review', Journal of Cleaner Production, 212, 2018, https://doi.org/10.1016/j.jclepro.2018.12.080

[9] Islam, M. M., Perry, P., & Gill, S, 'Mapping environmentally sustainable practices in textiles, apparel and fashion industries: a systematic literature review', Journal of Fashion Marketing and Management: An International Journal, 25(2), 331–353, 2021, https://doi.org/10.1108/JFMM-07-2020-0130

[10] Kamis, A., & Farah Najwa Ahmad Puad, 'Environmentally Sustainable Apparel: Recycle, Repairing and Reuse Apparel', The International Journal of Social Sciences and Humanities Invention, 5(1), 2018, https://doi.org/10.18535/ijsshi/v5i1.04

[11] Khan, M. M. R., & Islam, M. M, 'Materials and manufacturing environmental sustainability evaluation of apparel product: knitted T-shirt case study', Textiles and Clothing Sustainability, 1(1), 8, 2015, https://doi.org/10.1186/s40689-015-0008-8

[12] KIRSI NIINIMÄKI (Ed.), 'Sustainable Fashion in a Circular Economy', In Aalto University School of Arts, Design and Architecture, 2018

[13] Linden, A. R., 'An Analysis of the Fast Fashion Industry', Senior Projects Fall, 2016, https://digitalcommons.bard.edu/senproj_f2016/30

[14] Nicole Thompson, 'Textile Waste & The 3R's: Textile Waste Strategy Recommendations for The City of Toronto', In York University, 2017

[15] Peters, G., Li, M., & Lenzen, M., 'The need to decelerate fast fashion in a hot climate - A global sustainability perspective on the garment industry', Journal of Cleaner Production, 295, 126390, 2021, https://doi.org/10.1016/j.jclepro.2021.126390

[16] Piribauer, B., & Bartl, A., 'Textile recycling processes, state of the art and current developments: A mini review', Waste Management & Research: The Journal for a Sustainable Circular Economy, 37(2), 112–119, 2019, https://doi.org/10.1177/0734242X18819277

[17] Rouch, D. A, 'Fashion and clothing textiles: how to reduce the environmental and social impacts', Working Paper No. 20, 2021, Clarendon Policy & Strategy Group, Melbourne, Australia

[18] SAJN Nikolina, 'Environmental impact of the textile and clothing industry What consumers need to know', European Parliamentary Research Service, 2019

[19] Sandin, G., & Peters, G. M, 'Environmental impact of textile reuse and recycling – A review', Journal of Cleaner Production, 184, 353–365, 2018, https://doi.org/10.1016/j.jclepro.2018.02.266

[20] Shirvanimoghaddam, K., Motamed, B., Ramakrishna, S., & Naebe, M., 'Death by waste: Fashion and textile circular economy case', Science of The Total Environment, 718, 137317, 2020 https://doi.org/10.1016/j.scitotenv.2020.137317

[21] Thorisdottir, T. S., & Johannsdottir, L, 'Sustainability within Fashion Business Models: A Systematic Literature Review', Sustainability, 11(8), 2233, 2019, https://doi.org/10.3390/su11082233

[22] UK Cooperative Extension Service, 'Clothing Repair', University of Kentucky, College of Agriculture, 2007

[23] Ütebay, B., Çelik, P., & Çay, A, 'Textile Wastes: Status and Perspectives', Waste in Textile and Leather Sectors. IntechOpen, 2020, https://doi.org/10.5772/intechopen.92234

[24] Villa Todeschini, B., Cortimiglia, M., Callegaro-de-Menezes, D., & Ghezzi, A, 'Innovative and sustainable business models in the fashion industry: Entrepreneurial drivers, opportunities, and challenges', Business Horizons, 2017, https://doi.org/10.1016/j.bushor.2017.07.003

[25] Weber, S., Lynes, J., & Young, S. B., 'Fashion interest as a driver for consumer textile waste management: reuse, recycle or disposal', International Journal of Consumer Studies, 41(2), 207–215, 2017, https://doi.org/10.1111/ijcs.12328

[26] Zhang, B., Zhang, Y., & Zhou, P, 'Consumer Attitude towards Sustainability of Fast Fashion Products in the UK', Sustainability, 13(4), 1646, 2021, https://doi.org/10.3390/su13041646

IMPRESSIONS OF INDIA ITME 2022

Mr. Gurudas Aras

Mr. Gurudas Aras

Mr. Aras holds a Bachelor's degree in Textile Engineering securing First rank with distinction, Master's degree by research and a post-graduation in Marketing Management, all from Mumbai University. He is an alumnus of VJTI.

Mr. Aras retired in March 2021 as Director-Textile Engineering group from A.T.E. group. During his long tenure of 40 years at A.T.E. group he was instrumental in bringing many European leading textile machinery manufacturers to company's fold and made A.T.E. an "End-to-End Solution provider".

Mr. Aras is now an independent director on the board of directors of 3 group companies of Rossari Biotech Ltd, a leading textile, agro and specialty Chemicals Company. Mr. Aras is Strategic Advisor and member of the Advisory Board of the German group ITA from Aachen. He is also strategic advisor to Yamuna Machine Works, Rabatex Industries and Piotex Ventures.

Mr. Aras is a member of the Board of Studies of Textile Manufactures department at VJTI and also member of it's the Advisory Group. He is on the editorial board of textile magazines ITJ and JTA. He regularly writes articles and blogs on contemporary issues related to Indian textile Industry, which are very popular amongst the readers.

In the year 2018, Mr. Aras received the 'Service Gold Medal' from the Textile Association of India for his contribution to the textile industry.

India ITME 2022, the 11th edition of the exhibition, was held after a gap of 6 years from 8th to 13th December, 2022 at India Mart Exhibition Limited (IEML) Venue at Greater Noida.

Some key highlights of the exhibition

- Excellent infrastructure at the venue spread over 235,000 sq. mtrs. with largely spread area, 6 entry/exit gates, ample parking space , 3 conference halls, well designated service areas
- Well organized show by India ITME Society, so far, the best one
- Parallel to the show many events and activities were planned like new machinery launches, Symposiums, CEO Meet, Technology awards, B2B meetings, Wildlife photography exhibition and Alumni meets
- 1,10,000 visitors from 73 countries, 1000+ exhibitors with 3130 machines on display on the show and 76 new product launches

Some noteworthy innovations/new technologies

This ITME exhibition was very special since 76 new products innovations were launched by machinery makers, which is by far the highest number at any ITMEs held so far.
I am covering briefly some of the noteworthy innovations exhibited by some companies at ITME. The focus is more on the innovative technologies launched by the Indian machinery manufacturers.

SPINNING

1) TRUETZSCHLER

TC19i intelligent Card

- Self-optimizing card
- Gap Optimizer T-Go results in very precise settings even in changing production conditions
- 40% reduction in yarn imperfections
- Up to 2% raw material savings

TC021 – New Generation Comber

- Automatic piecing optimization technology with Intelligent cooling system and automatic greasing
- Speed up to 600 nips/minute

2) RIETER

Autoconer X6

- Latest splicer with optimum quality
- Multi-link system and Multi- lot (handling different yarn counts)

Rieter Autoconer X6

Spin-it-again

- Solution for integration of recycled raw material into yarn production

ROBOspin

- Piecing robot for ring spinning

3) SAURER

AutoSpeed Roving frame

- Fully integrated automation. Turbo doffing - less than 2 minutes doffing time
- RoWeClean converts residual roving into fibres- used as soft waste in blow room

Saurer Roving Frame

Auto-Airo Airjet spinning

- Independent drive and piecing for each spindle
- Spindles on both sides (70% space savings)

Saurer Auto-Aro Airjet Spinning

4) LAKSHMI MACHINE WORKS (LMW)

RAP- Smart Ring frame Auto- Piecing

- Manpower reduction up to 60%

LAW 60 Autowinder

- Direct link feed system with Easy plug and play modules
- Winding speed up to 2000 mpm

LAW 60 Autowinder

LJS 9 Jet Spinning

- Double sided machine up to 200 positions with Delivery speed up to 550 mpm
- Individual piecing and individual drives

LJS 9 Jet Spinning

5) MURATA

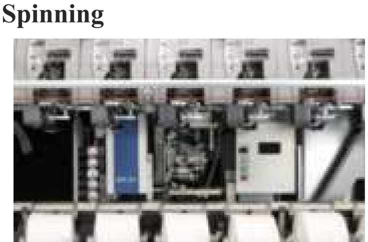
Process Coner II FPRO EX 10

- Diverse package shape range
- Stretch Air Splicer for core spandex yarn (CSY)

Murata Process Coner

VORTEX 870 EX Airjet Spinning

- Speeds up to 550 mpm
- Possible to run 100% Polyester and Poly-Cotton blends



Murata Vortex Airjet

6) SAVIO

Proxima Smartconer

- Smart Changer – fastest bobbin change unit
- Smart Booster- bobbin unwinding system-stabilized unwinding
- Smart Tensioner- low yarn breaks, better yarn quality
- Smart Jointair- fastest splicing cycle and smart tail withdrawal

Savio Proxima Smart Coner

WEAVING PREPARATION

1) RABATEX INDUSTRIES

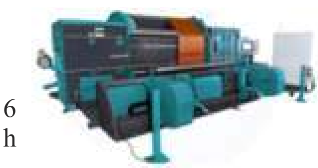
Complete Fabric Sampling Solution

- 1st time made in India Sampling Solution having Mini Sample Warper
- Single End Cone-to-Cone Sizing machine and Sample Rapier Weaving machine

Single End Sizing Machine

Advanced Sample Warper

- Speed up to 1000 mpm
- Rotary Creel with 16 packages with Synchronized yarn laying



RABATEX Advance Sample Warper

Advanced Sectional Warper

- Laser sensor for yarn built-up measurement & Online length measurement
- Closest to yarn delivery to avoid cross-over ends

RABATEX Advance Sectional Warper

2) PRASHANT

Robotic Sectional Warper

- Complete leasing function by robots
- Time saving results in 50% increased productivity, Space saving by 35%

Eco-friendly Indigo Sheet Dyeing machine with Nitro chamber

- Saves the water consumption by around 50%, Chemical saving around 15-20% &Space saving of 10%

Prashant Indigo Sheet Dyeing

WEAVING & KNITTING

1) TSUDKOMA

ZAX001 neo - Fastest Airjet Loom

- Running at 2300 rpm with low vibration with low power and air consumption
- 40% reduction in warp and weft stoppages

Wider width Rapier Loom

- 340 cms width weaving machine capable of running at high speed of 1000 rpm

2) SHIMA SEIKI

"WHOLEGARMENT" making machine

- Entire piece is 3 dimensionally produced on the knitting machine
- Eliminates expensive, time-consuming post-production labour

Shima Seiki WHOLE GARMENT Machine

PROCESSING

1) YAMUNA - 3 New products launches at the show

Multi-layer Stenter Yamuna-Alea (In collaboration with Alea, Italy)

- 1st Indian made Multi-layer Stenter
- 10 chambers machine in a 3 chamber space at 6 chambers operating cost with high productivity with energy efficiency and enhanced finishing quality

YAMUNA ALEA Multi-Layer Stenter

Open-width Knits Singeing machine

- Fabric singeing with minimal tension

YAMUNA Open Width Singeing Machine

Open width Knits Compactor

- 1st Indian made open width Compactor,
- Controlled shrinkage due to Rubber belt + Compactor combination and controlled tension & minimal stretch in knit fabric

YAMUNA Open Width Knits Compactor

2) KUESTERS CALICO

High-intensity Ceramic Burner

- 3 singeing positions with Temperature controlled cooling system

Kuesters Calico High Intensity Burner

Super-Flush Efficient Washer

- Short distance guide rollers to ensures creaseless fabric transport
- Less liquor requirement

3) MENZEL INDIA

Pulsation Drum Washer

- Pulsation effect in washing at higher efficiency and with water saving

Opti-Dip

- New applicator with multiple dips, useful for heavy and dense fabrics

4) COLORJET

EARTH SEREIES DIGITAL PRINTER – Pigment printing solution

- Water based pigment ink used with a binder for fixation to fabric
- Pre and Post treatment not required resulting in water and energy saving
- Polymerization at 160 degrees temp. after printing provides excellent colour fastness and print quality

COLORJET Earth Series Digital Printer

Metro NXT – Industrial production digital printer

- High production capacity up to 9000 sq.mtr/day
- Efficient Ink Supply System with 32 printing heads of Kyocera delivering sharp prints

COLORJET Metro NXT Industrial Digital Printer

5) EMBEE

Acumen & Signature – Rotary printing machines

- High production output up to 90 mts/min with high quality printing with Automatic repeat setting and unique head lifting system and Multi repeat printing head
- Options of Closed bearing multi repeat (Acumen) and Open bearing (Signature)

Smart Color- Colour kitchen

- First time- Made in India – replacing imports
- Fully automatic paste and colour dispensing

While there were new technology launches and new technologies exhibited by many companies at the show, only some of the noteworthy of them are covered in this article.

CONCLUSION

- India ITME 2022 had been a very well organized event, the venue was comparable with the best in the world like Milan, Frankfurt, Barcelona and Hannover.
- "Make in India" theme was very much in prominence
- Lot of import substitute products and technologies were seen
- Major themes noticed at the exhibition had been:
- Automation and robotics
- Recycling
- Resource saving (raw material, energy, water, chemicals)
- Eco-friendly and sustainable technologies

Mr. Bharat Trivedi

Rupee Trade and Vostro Mechanism

Bharat Trivedi, Manager-Exports, Colorant Limited

The rupee trade mechanism refers to a trade arrangement where two countries use their own currencies for conducting trade transactions instead of using a third currency such as the US dollar. In this mechanism, the importing country pays for the goods and services in its own currency, and the exporting country receives payment in its own currency.

For example, if India imports goods from Sri Lanka, the payment for those goods will be made in Indian rupees (INR) and Sri Lanka will receive payment in Sri Lankan rupees. This eliminates the need for both countries to convert their currencies into a third currency such as the US dollar, which can often be expensive due to transaction fees and currency conversion charges.

Importance

1. Economic growth: India is one of the fastest-growing economies in the world, and its currency is an important indicator of the country's economic health. The rupee trade allows foreign investors to participate in India's growth story by investing in Indian stocks and bonds denominated in rupees.

2. Export/import transactions: As India is a major exporter of goods and services, the rupee trade plays a crucial role in facilitating international trade transactions. Companies engaging in cross-border trade with India rely on foreign exchange markets to hedge against currency fluctuations and manage their foreign exchange risk.

3. Foreign investment: Foreign investors can use the rupee trade to invest in Indian assets like stocks and bonds, thereby supporting the country's economic growth. In addition, the Indian government has relaxed foreign investment rules in recent years, making it easier for foreign investors to participate in the Indian economy.

4. Exchange rate stability: The rupee trade can help stabilize exchange rates by providing liquidity and price transparency to foreign exchange markets. This can help reduce volatility and facilitate international trade and investment.

Limitations:

While it can offer some benefits, such as reducing the cost of foreign exchange and promoting bilateral trade between India and other countries, it also has some limitations:

1. Limited acceptance: Not all countries or businesses are willing to accept the Indian rupee as a form of payment. This can limit the scope of rupee trade and make it difficult for Indian businesses to expand their operations globally. As of today only 18 countries accepted this mechanism.

2. Exchange rate risk: When engaging in rupee trade, businesses may be exposed to exchange rate risks if the value of the rupee fluctuates significantly against other currencies. This can lead to financial losses and affect business profitability.

3. Limited availability of hedging tools: Hedging tools, such as currency futures and options, may not be as widely available for the Indian rupee as they are for other major currencies. This can limit the ability of businesses to manage their currency risks effectively.

4. Limited financial market infrastructure: The Indian financial market infrastructure may not be as developed as that of other major economies, making it difficult for businesses to access financing or manage their financial risks.

5. Regulatory restrictions: The Reserve Bank of India (RBI) imposes certain restrictions on rupee trade, such as limits on the amount of money that can be remitted abroad for business purposes. These restrictions can limit the ability of Indian businesses to engage in international trade and expand their operations globally.

How will Trade in Rupee work?

The rupee trade will be done through “Vostro Account”. The trade in rupee typically refers to the use of the Indian rupee (INR) as the currency for conducting trade transactions. In general, trade in rupee can be conducted in two ways:

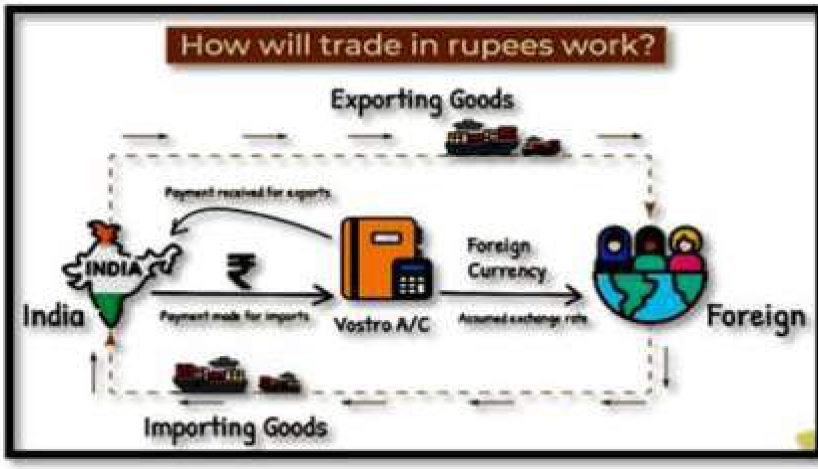
Settlement in INR: In this mode of trade, both the buyer and seller agree to settle the transaction in INR. The exporter sends the goods to the importer, and the importer pays the exporter in INR. This type of trade is beneficial for both parties as it eliminates the need for currency conversion and reduces transaction costs.

Rupee-Denominated Trade Finance: In this mode of trade, a financial institution provides trade finance to the exporter or importer in INR. The exporter or importer repays the loan in INR along with any interest or fees charged by the financial institution. This type of trade finance is beneficial for both parties as it eliminates the foreign exchange risk and provides access to funding at competitive rates.

In order to facilitate trade in rupee, the Indian government has entered into currency swap agreements with various countries. These agreements allow Indian businesses to transact in local currency with businesses in the other country, thereby reducing transaction costs and increasing trade volumes. Additionally, the Reserve Bank of India has relaxed regulations on the use of the INR for cross-border transactions, making it easier for businesses to conduct trade in rupee.

What is a “Vostro” account and how will it work?

The term "Vostro" comes from Latin and means "yours." A Vostro account is an account that a correspondent bank holds



on behalf of another bank or financial institution.

A Vostro account is a type of bank account used in international trade. It is an account in which a correspondent bank holds funds on behalf of a foreign bank. The foreign bank has the right to instruct the correspondent bank on how to disburse the funds, but the correspondent bank is responsible for actually carrying out the instructions.

In a Vostro account relationship, the correspondent bank acts as a custodian of the funds and performs various banking services for the foreign bank, such as processing wire transfers, collecting and paying checks, and providing account statements. The foreign bank, in turn, may use the Vostro account to receive payments from its customers, make payments to its suppliers, or hold funds in a foreign currency.

The Vostro account relationship is governed by a contract between the correspondent bank and the foreign bank, which outlines the terms and conditions of the account, including fees, account maintenance requirements, and other details.

The correspondent bank may require the foreign bank to maintain a minimum balance in the account or provide collateral to cover any potential losses.The Vostro account allows foreign banks to conduct international transactions more efficiently and cost-effectively, while also providing a level of security and transparency in the movement of funds.

Overall, the "Rupee trade" using Vostro account is a win-win situation for both countries, as it provides numerous benefits and strengthens their relationship. It promotes economic growth, regional integration, and investment, which are crucial for the development of both countries.

Reference:

https://economictimes.indiatimes.com, https://www.thehindu.com, https://www.wikipedia.org

Mr. Bharat Trivedi completed his MBA (International Trade) from International School of Business Management. After completing his Master of Commerce from North Maharashtra University, he started his career with Angiplast Pvt. Ltd, Ahmedabad and also served various companies in various positions for more than 22 years. At present, he is working with COLORANT LIMITED as Manager-Exports. The Company is engaged in Manufacturing and Exporting of Reactive Dyes.

He played a vital role in achieving exponential growth for the company's exports which led COLORANT LIMITED to various awards and recognition from various trade bodies and organizations for its performance in export.

Mr. Trivedi has travelled to more than 10 countries and his responsibilities developed a greater understanding for Reactive Dyes markets globally.

He has delivered many talks on International trade and export management. He attended many international exhibitions and technical seminars during his career path.

M.: 9099020852

E-mail: mktg@colorantindia.com

TAI - MUMBAI UNIT

Report on the Lecture on “BUDGET HIGHLIGHTS 2023”

The Textile Association (India), Mumbai Unit organized the Lecture on “Budget Highlights 2023” on Wednesday, 8th February, 2023, at the office of TAI, Mumbai Unit.

The lecture was conducted by Mr. Darshan M. Pathak, Leader, HD Valstand Advisors. He has experience of working in Deloitte and NHBS. He has led many assignments of various Corporates, Banks and NBFC's.

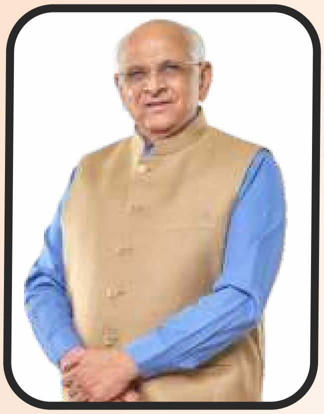
Mr. Pathak gave the highlights of the 2023 financial budget in a very simplified manner and highlighted the points related to the textile industry. He covered the following points.

- Important highlights on the Textile Sectors focusing on the budget allocation to the various industries, boards, and development programs along with guidance on "How to read the Budget”.
- Analysis of the allocation of funds to ATUFS, Central Silk Board, National Textiles Mission, PM Mitra and such other schemes.
- Benefits of RODTEP, ROSCL, and Revamping the Credit Guarantee Scheme under the Credit Guarantee Fund for MSME(CGTSME).
- Analysis of the Exports of Textiles, Garments, Man-made Textiles, Carpets, Woven Fabrics, Jute, and other similar products to various countries.
- Understanding of the Slabs rates Old Tax Regime, New Tax Regime (Existing) and New Tax Regime (Proposed).
- Analysis of the latest amendments in The Income Tax Act, in the Finance Budget 2023-2024.

Mr. Haresh B. Parekh was the Convenor of this lecture. Mr. Rajiv Ranjan, President, TAI, Mumbai Unit welcomed the speaker and participants. Mr. A. V. Mantri, Hon. Secretary, TAI, Mumbai Unit proposed the Vote of Thanks.

The lecture was very successful and was attended by around 35 participants. The response to the session was very enthusiastic. There was excellent interaction between speaker and the participants.

WORLD TEXTILE CONFERENCE – 3



Shri Bhupendrabhai Patel
Hon'ble Chief Minister, Govt. of Gujarat

Smt. Darshana V. Jardosh
Hon'ble Union Minister of State
Ministry of Textiles & Railways, New Delhi

Shri R. K. Vij
President-The Textile Association (India)

Shri T. L. Patel
Conference Chairman & Vice President - TAI

Shri Mahendrabhai G. Patel
Hon. Gen. Secretary,
The Textile Association (India)

Shri H. S. Patel
President- The Textile Association (India)
Ahmedabad Unit & Member of Parliament

Supported by

iNDEXTb
INDUSTRIAL EXTENSION BUREU
(A GOVT OF GUJARAT ORGANISATION)
ISO 9001:2000 Certified

World Textiles – Redefining Strategy

On 25th & 26th February, 2023
Dinesh Hall, Ahmedabad

The Textile Association (India) organized First World Textile Conference (WTC) in 2011 at Mumbai; 1st International Asian Textile Conference (ATC) in 1991 and 7th International Asian Textile conference (ATC) in 2003 in New Delhi; Global Textile Congress 2015 with the support of Thailand in 2015 at Bangkok, Thailand; Second World Textile Conference (WTC2) in 2016 at Mumbai; South Asia Textile Summit in June, 2017 at Mumbai; First Global Higher Education Conclave "Global Innovators and Researchers Conclave (2018) at Murthal (Haryana) and First CEO Conclave 'Investment and Partnership Summit (2019) at Hyderabad.

After the grand success of the all the conferences and after COVID 19 pandemic crises, once again TAI take up the challenge of organizing the World Textile Conference -3 during 25th & 26th February, 2023 at Dinesh Hall, Ahmedabad on the theme 'World Textiles – Redefining Strategy'.

Conference on the day one 25-02-2023, inaugurated with lightening of the lamp by the worthy hands of Chief Guest of the event Hon'ble Shri Bhupendrabhai Patel, Chief Minister, Govt. of Gujarat, Guest of honor Smt. Darshana V. Jardosh, Union Minister of State for Textiles & Railways, India. The dignitaries on the dais present on the occasion were Shri Uday Gill, Indorama Ventures Global Services Ltd.; Shri Punit Lalbhai, Executive Director, Arvind; Shri R. K. Vij, President, The Textile Association (India); Shri T. L. Patel, Vice President, The Textile Association (India); Dr. P. R. Roy, Diagonal Counseling (India); Shri H. S. Patel, Member of Parliament (MP) & President, The Textile Association (India) – Ahmedabad Unit and Shri Mahendrabhai G. Patel, Hon. Gen. Secretary, The Textile Association (India).

Chief Guest Hon'ble Shri Bhupendrabhai Patel inaugurated by lightening the lamp

The dignitaries on the dais present on the occasion

Shri R. K. Vij, President, The Textile Association (India) welcomed the Chief Guest Hon'ble Shri Bhupendrabhai Patel, Chief Minister, Govt. of Gujarat and the Guest of Honor Smt. Darshana V. Jardosh, Union Minister of State for Textiles & Railways, India has been felicitated with offering floral bouquet and the Memento. Also other dignitaries were welcomed and felicitated with the floral bouquet and Memento.

Shri Uday Gill, Executive Director- of Indorama, shares how Indorama functions in a most elegant way of producing clean energy and textiles. Indorama is moving from Traditional to Value base Textile and Textile brands. He suggests not simply copying the practices of mass production as in China rather than moving towards a value base. He tells us to go for Green Textiles, Circularity, Biobased process, and finally, the people's attitude.

Shri Punit Lalbhai, Executive Director, Arvind Mills, in his Keynote address, opines that Manmade Fibre Textiles are becoming increasingly sophisticated and prominent. Production Linked Incentive by the Ministry of Textile is also expected to boost both

Shri R. K. Vij welcoming Chief Guest, Guest of Honour and other dignitaries

Shri R. K. Vij felicitating with floral bouquet and the Memento to the Hon'ble Shri Bhupendrabhai Patel

Shri H. S. Patel (M.P) felicitating to the Guest of Honour Smt. Darshana V. Jardosh

Shri T. L. Patel felicitating with floral bouquet and the Memento to Shri Uday Gill

Shri M. G. Patel felicitating with floral bouquet and the Memento to Shri Punit Lalbhai

Shri H. S. Patel (M.P) felicitating with floral bouquet and the Memento to Dr. P. R. Roy

Shri Punit Lalbhai presenting his Keynote address

Shri Uday Gill addressing his views

Manmade and Technical Textiles. Manufacturing of Garments should be on primary focus so that major Buyers can source textiles and garments from India.

Circular Fashion and Innovation should be a continual process for sustainability followed by Training and Talent Development at all levels as a need of the hour.

The Textile Association (India) felicitated with the Awards for achieving excellence in the area of productivity, innovations, research and developments in textiles and the academics who have contributed tremendously. Awards were issued by the worthy hands of Chief Guest Hon'ble Shri Bhupendrabhai Patel, Chief Minister, Govt. of Gujarat.

Dr. Seshadri Ramkumar receiving the award from the hand of C. M. Hon'ble Shri Bhupendrabhai Patel

Dr. Seshadri Ramkumar, Professor, Texas Tech University (USA) has been honored with Honorary Membership of TAI with the Gold Medal and the Certificate for his yeoman contribution towards the growth of the textile industry and the research fields.

He has been credited with creating Technical Textiles revolution in India, which played a vital in India becoming self-reliant in developing PPE products during this COVID-19. He has received the highest award for research and academic efforts by the world's largest textile related professional association, Textile Association India with its Honorary Fellowship.

Dr. M. S. Parmar receiving the award from the hand of C. M. Hon'ble Shri Bhupendrabhai Patel

Dr. M. S. Parmar, Director, Northern India Textile Research Association (NITRA), has been conferred with the Fellowship of the Textile Association (FTA) for his significant contribution in research and the development in the academic field.

Presently he is the Director as working at NITRA for the last 28 years in various capacities. His main areas of are Textile Chemistry, Protective Textiles, unconventional fibres, and Quality Control of Textiles.

He has been involved in various consultancy and training projects. He has framed many QRs /specifications for Military and paramilitary forces.

Shri H. S. Patel receiving the award from the hand of C. M. Hon'ble Shri Bhupendrabhai Patel

Shri Hasmukhbhai S Patel, President, The Textile Association (India) – Ahmedabad Unit and the Member of the Parliament (MP), has been awarded with TAI Service Gold Medal (Instituted in the Memory of Hon. Maj. R. P. Poddar) in recognition of his services to the Textile Association (India).

Shri Hasmukhbhai was elected as a MLA during 2012 to 2017 from Amraiwadi Vidhansabha, Gujarat. Once again he was elected as a MLA during 2017 to 2019 from Amraiwadi Vidhansabha, Gujarat. Mr. H. S. Patel is since June 2019 to till date is a MP (Member of Parliament) from Ahmedabad East Constituency, Gujarat.

Dr. Ashwin I. Thakkar receiving the award from the hand of Hon'ble Shri Bhupendrabhai Patel

Dr. Ashwin I Thakkar, Vice President of The Textile Association (India) – Ahmedabad Unit and Head of Department of textile Technology, L. D. College of Engineering, Ahmedabad has been awarded with TAI Service Memento (Instituted by Shri H. A. Shah) for his services to the Association at Unit level.

He has 5 years of industrial experience and more than 34 years of Academic experience. In 1988 he joined the Textile Department, L D College of Engineering, as lecturer. Since 2011 he has been Head of the Department. His core areas include Weaving, Garment, Technical Textile, PPC etc.

Shri Rajiv Ranjan receiving the award on behalf of Shri V. A. Bhajekar from the hands of Hon'ble Shri Bhupendrabhai Patel

Shri V. A. Bhajekar, Managing Director, Global Organic Textile Standard (GOTS) has been awarded with TAI Service Memento (Instituted by Shri J. J. Randeri) for his services to the Association at Unit level.

He joined Global Standard GmbH, a non-profit organization registered in Germany appointed Shri. Bhajekar as their Director, Standards Development & Quality Assurance. Shri. Bhajekar has the responsibility of technically and administratively running the globally acclaimed Global Organic Textile Standard (GOTS), now in version 6.0 and keeping the standard current and updated. Since 2018, He is one of two Managing Directors of GOTS.

Office Bearers and the Members of TAI Ahmedabad Unit receiving the Best Unit award from the hands of Hon'ble Shri Bhupendrabhai Patel

The Textile Association (India) – Ahmedabad Unit has been awarded the Best Unit Award (Instituted by Shri H. C. Jain) for their all round best performance & activities done by the Unit during the year.

Ahmedabad Unit has established a hat-trick record of winning awards for continuous 3 times. It has created history by achieving distinct milestone of winning award continuously. They have won the prestigious award overall for 10 times. These Awards have been declared and bestowed upon Ahmedabad Unit on the basis of the overall performance and activities done by Ahmedabad Unit

Shri Punit Lalbhai receiving the award from the hand of C. M. Hon'ble Shri Bhupendrabhai Patel

Shri Punit Lalbhai, Vice-Chairman & Executive Director of Arvind Limited has been awarded with Young Industrialist Award for his significant excellent contribution for the growth of textile industry as a young Entrepreneur.

He leads Arvind's Manufacturing business which include core Textiles, advanced Materials, Engineering & agribusiness. He also spearheads initiatives in sustainability, CSR and innovations at Arvind.

Then the Chief Guest of the event Hon'ble Shri Bhupendrabhai Patel, Chief Minister, Govt. of Gujarat, and the Guest of honor Smt. Darshana V. Jardosh, Union Minister of State for Textiles & Railways, India, delivered their views.

Smt. Darshana V. Jardosh, Union Minister of State for Textiles & Railways, India delivering her speech

Smt. Darshana V. Jardosh, Union Minister of State for Textiles & Railways, India delivering her speech

Union Minister of Textile, Smt. Darshana V. Jardosh, categorically mentions that India is also very much with other Natural Fibres like Jute, Silk, and wool which have a massive potential for growth. Besides, Govt. has taken various growth strategies to promote high valued Textile, Technical Textiles, and Handicraft, which have a high potential for future growth and employment. Today, India has become one of the largest exporters of Face masks and Personal protection kits.

In the Inaugural speech Hon'ble Chief Minister, Gujarat, Shri Bhupendrabhai Patel, referring to the state budget, highlights the significant allocation of funds to Education, Infrastructure, Health, and Agriculture, which are primarily responsible for the economic and industrial growth of the state.

Hon'ble Shri Bhupendrabhai Patel, Chief Minister, Govt. of Gujarat delivering his inaugural speech

Hon'ble Shri Bhupendrabhai Patel, Chief Minister, Govt. of Gujarat delivering his inaugural speech

Shri T. L. Patel, Conference Chairman & Vice President TAI addressing the gathering

Dr. P. R. Roy, Conference Knowledge Partner addressing the gathering

After that Shri T. L. Patel, Conference Chairman & Vice President of The Textile Association (India) briefed about the World Textile Conference-3. A video of the TAI Ahmedabad and TAI Central activities and the journey was displayed.

Then Dr. P. R. Roy, Diagonal Consulting (India) briefed on the conference theme and the program of 2 days conference. He clarifies Redefining the Strategy as the way of thinking to change strategy to achieve competitiveness in this changing scenario for which the industry may get the right direction for sustainability and growth.

So, the process must be more than random and be structured and prioritized. Though Man-made textile is expected to grow faster and become popular worldwide, Cotton continues to have its Glory.

Shri Mahendrabhai Patel, Hon. Gen. Secretary, TAI proposing the Vote of thanks

At the end of the inaugural function a National Anthem performed

At the end of the Inaugural function, Shri Mahendrabhai G. Patel, Hon. Gen. Secretary, The Textile Association (India) proposed the vote of thanks and then a National Anthem was performed.

Thereafter, after the short break, Technical Sessions started.

Technical Session II on First Day (25-02-2023)

Speakers:

Mr. R. D. Barhatt: Joint Commissioner of Industries, Govt. of Gujarat

Mr. Uday Gill: Executive Director, Indorama Ventures Limited, Thailand

Dr. Bryan Hoynes: Senior Technical Director, Kimberly Clark Corporation (USA)

Mr. Tony Fragnito: President, Inda (USA), North American Nonwoven – Key Challenges & opportunities

Shri Uday Gill is presenting his topic

Shri Haresh B. Parekh felicitating to Shri Uday Gill

Shri Uday Gill, shares how Indorama functions in a most elegant way of producing clean energy and textiles. Indorama is moving from Traditional to Value base Textile and Textile brands. He suggests not simply copying the practices of mass production as in China rather than moving towards a value base. He tells us to go for Green Textiles, Circularity, Biobased process, and finally, the people's attitude.

Shri R. D. Barhatt is delivering his Paper

Shri Ved Prakad Gupta felicitating Shri R. D. Barhatt With Memento

Shri R. D. Barhatt, while referring to Gujarat Textile Policy 2012/13, mentions the establishment of an additional 25 lakh spindle capacity, which, in turn, has become the driving force for the development of weaving, knitting, and Processing across the state of Gujarat.

Shri Bryan Hayens delivering his presentation

Shri Kamal Mishra felicitating Shri Bryan Hayens With Memento

Shri Bryan Hayens, shares various ongoing issues in Textile and Non-woven areas. Only 9% of plastic in the USA could be recycled in the last 70 years. Every minute 3 lakh Diapers are incinerated in the landfill of USA. They have adopted Machine Learning to carry out overall Process Hazard Analysis to overcome these issues.

Shri Tony Fragnito is presenting his paper

Shri D. K. Singh felicitating Shri Tony Fragnito with Memento

Shri Tony Fragnito, expresses the views of non-woven textiles in North America for over 260 varieties. The ongoing recession in the USA will drive many industries to go away. The cost of Green Textiles is becoming higher and higher. For India, the potential area of non-woven textiles would be Automobiles and Infrastructure. But regulatory pressure will continue.

Session III:

Speakers:

Mr. Subhash Bhargava: Managing Director, Colorant Ltd., Dyes & Chemicals

Mr. R. D. Udeshi: President, Reliance Industries Ltd.

Mr. Anil Jain: Jain Cord Industries Ltd.

Shri Subhash Bhargava is presenting his paper

Dr. V. D. Gotmare is felicitating Shri Subhash Bhargava with Memento

Mr. Subhash Bhargava, suggests adopting New Sustainable Management System with 3Ps, Profit-People-Planet. Without Profit, can one sustain? He means adopting Nano-technology, Bio-discharge, etc., to overcome environmental issues besides the approach of adopting Zero Discharge Facilities, which are existed at least 3 Textile units out of 4 in the country.

Shri R. D. Udeshi is presenting his paper

Shri Ashokkumar D. Patel is felicitating to Shri R. D. Udeshi with Memento

Shri R. D. Udeshi, was referring to the expected 4 to 5 % incremental requirement of Textile Fibre globally, Mr. Udeshi raises a question, "Is there any alternative of Polyester to fulfill this incremental requirement of textile fiber?" While talking about sustainability and environmental issues, he affirms that 80-90% of PET bottles are recycled in our country. Still, much R&D work is yet to be done in Bottle manufacturing. Many are yet to be done in Technical Textiles, precisely when 40% of textiles are the Technical Textile worldwide as against only 10% in India. But, a need of the hour is to collaborate with Industries, Government, and R & D for sustainability and growth.

Shri Anil Jain delivering his presentation

Shri Rajeshkumar Shah is felicitating to Shri Anil Jain with Memento

Mr. Anil Jain, shares his views on ongoing water crises where 75% of water is consumed by Agriculture alone, followed by the People and Industry. Talking about the sustainable practice in the Textile Industry for a more fantastic future, he strongly suggests exploring the possibility of using Re-cycled Sewerage Treated Water for the industry.

Session IV:

Speakers:
Shri Manmohan Singh: Chief Marketing Officer, Birla Cellulose (Aditya Birla group)
Ms. Michelle Salg: Product Manager Fabric, Uster Technologies, Switzerland
Shri Rajesh N. Pande: TSi Power Ltd. Baroda

Shri Manmohan Singh delivering his paper

Shri Harishchandra Shah felicitating Shri Manmohan Singh

Shri Manmohan Singh, shares the practice of Birla Cellulose on their sustainable business practices and sustainable Textile Brand of Viscose fiber with a Circular Economy. They have sustainable, top-rated Textile brands like Livaeco™ by Birla Cellulose, Birla Modal™, Birla Excel™, Birla Viscose™, Birla Spunshades™, and others.

Ms. Michelle Salg presenting her paper

Shri Ashokkumar Patel is felicitating Ms. Michelle Salg

Ms. Michelle Salg, discusses their Fabric Inspection Model and how the Integrated Machine Inspection process supersedes the limitation of human capabilities in achieving accuracy.

Shri Rajesh N. Pande is delivering his presentation

Shri Bhogibhai Patel felicitating to Shri Rajesh N. Pande with Memento

Shri Rajesh N. Pande, explains how a static voltage regulator with precession can regulate the process efficiently.

Session V:

Speakers:

Mr. Niraj Bansal: Sieger Spintech Equipments Pvt. Ltd., Textile Industry Automation
Dr. Vijay Gotmare: Sustainability in Textile, Apparel & Fashion industry
Prof. Seeram Ramakrishna: NUS, Singapore, Circular Economy & Textile Industry

Shri Niraj Bansal presenting his paper

Shri Hitesh Trivedi is felicitating to Shri Niraj Bansal with Memento

Mr. Niraj Bansal, discusses the need for Automation towards minimizing Space, Manpower and establishing integrated data for better monitoring, control, and waste reduction. While giving an example, he says Customized modern cone packaging can replace the operating cost of 40 persons by engaging only two persons.

Dr. V. D. Gotmare presenting his paper

Shri Harish A. Patel felicitating to Dr. V. D. Gotmare with Memento

Prof. Vijay Gotmare, discusses sustainability in the Textile, Apparel, and Fashion Industries. It explains how the recycling process is happening in different parts of the world, from the waste of, Fibre, Yarn, Fabric, Textile Auxiliaries, Apparel, and various laminated textiles. He explores the possibility of developing startups and innovative Textiles out of this waste.

At the end of the first day Sessions, an Eternity Fashion Show was organized by the Students of Institute of Fashion Technology, IPS Academy, Indore.

Designers with Student Models

Designers with Student Models

Designer s with Student Models

Designer s with Student Models

Mrs. Vij is felicitating the Principal of Fashion Institute Ms. Priety Sarva

Group photo with Designers and the Students of the Institute

Technical Session I on Second Day (26-02-2023)

Speakers:

Mr. Hans Gerhard Wroblowski: Area Sales Director, Manforts Textile Machine GmbH & Co., Germany

Mr. Noishas Desai: Bitacel Silicons Limited

Mr. R. Hariharan: Nestling Technologies India (P) Ltd.

Shri Hans G. Wroblowski delivering his presentation

Shri Harishchandra Shah felicitating Shri Hans G. Wroblowski with Memento

Mr. Hans Gerhard Wroblowksi, talks about India and what is next for the Textile Machinery. In India, it is the 2nd largest polluting industry, where 1 Kg of cotton to process needs 2000 liters of water. He suggests stopping the principle of mass production and Fashion Mania. He advises adopting updated technology driven by new standards and sustainable products and processes. Modernization with a Stenter with high heat recovery, use of Block Chain for Supply chain Management, adopting Smart sensors, Data capturing Information systems, and finally with Teamwork will be an appropriate approach to achieving success and sustainability.

Shri R. Hariharan is presenting his paper

Shri D. I. Patel felicitating to Shri R. Hariharan with Memento

Mr. R. Hariharan, discusses the Purity of Cotton and removing contamination using I-Scan from the Farming stage to the final Spinning. This system of i-Scan can also identify idle spindles, End breaks, Doffing status, Maintenance activities, and overall monitoring for efficient working.

Session II:

Speakers:

Mr. Joerg Bauersachs: Head of CCI Technical Services, Cotton Council International

Mr. Mandava Prabhakar Rao: Chairman, NSL Textile Ltd.

Mr. Arunkrishna Srinivasan: Director, Jaylakshmi Textiles (P) Limited

Dr. Jaywant Irkhede: Textile & Clothing Industry in South Africa

Shri Joerg Bauersachs presenting his paper

Shri Harish A. Patel felicitating to Shri Joerg Bauersachs with Memento

Mr. Joerg Bauersachs, explains American Cotton's benefits regarding fiber quality and profitability. Cotton USA also provides services like Buying process, exploring increased spindle speed, Technology survey, Field survey, and follow-up visits, besides organizing training for the Technicians.

Shri Arunkrishna Srinivasan delivering his presentation

Shri K. Gandhiraj felicitating Shri Arunkrishna Srinivasan with Memento

Shri Arunkrishna Srinivasan, initiates a talk on cotton, which is expected to get more demand. However, he suggests giving priority to adopting updated technology to increase productivity instead of going for expansion.

Dr. Jawant Irkhede is presenting his paper

Shri Rajesh Shah felicitating to Dr. Jaywant Irkhede with Memento

Mr. Arunkrishna Srinivasan, initiates a talk on cotton, which is expected to get more demand. However, he suggests giving priority to adopting updated technology to increase productivity instead of going for expansion.

Dr. Jayant Irkhede, explains various schemes and financial supports for those who want to set up an enterprise in South Africa.

Session III:

Speakers:

Dr. Seshadri Ramkumar: Prfessor, Texas Tech University (USA)

Mr. Samir Agarwal: Arvind Limited

Dr. Seshadri Ramkumar is presenting his views

Mr. D. K. Singh felicitating Dr. Seshdri Ramkumar with the Memento

Dr. Seshadri Ramkumar, explains how he developed the required Face Mask during Covid-19. He describes how a new project can be developed i.e., the incremental development of a product. He also demonstrates a product developed by him on technical textiles.

Shri Samir Agarwal is delivering his presentation

Mr. Yogesh Mahajan felicitating Mr. Sanir Agarwal with the Memento

Mr. Samir Agarwal, discusses Trends in Global Denim. In India, it is now nearer to overcapacity. Besides, there is an expected recession in the world.

Session IV: Panel Discussion

Moderator: Dr. Seshadri Ramkumar: Professor, Texas Tech University (USA)

Panelist - Dr. Hireni Mankodi: Technical Textile Research & Development

- Mr. Hemant Dave: Technical Textile & Nonwooven Cunsultant
- Mr. Amit Agarwal: Chairman ITTA
- Mr. Navneeet Singh Sodhi: Partner, Gherzi Textil Organization, Switzerland

Dr. Hireni Mankodi addressing her views

Shri Haresh Parekh felicitating Dr. Hireni Mankodi with the Memento


Shri Hemant Dave is presenting his views


Mr. V. D. Zope felicitating Mr. Hemant Dave with the Memento

Shri Amit Agarwal is presenting his views

Shri Ashokkumar Patel felicitating Shri Amit Agarwal with the Memento

Shri Navneet Singh Sodhi is presenting his paper


Shri B. P. Mistri felicitating to Shri Navneet Singh Sodhi with the Memento

Session V: Valedictory Address

Valedictory Chairman: Dr. Chandan Chatterjee, Executive Director ADS Foundation & Former Director C.E.D., Govt. of Gujarat.

L to R.: Mahendrabhai G. Patel, Mr. T. L. Patel, Dr. Chandan Chatterjee, R. K. Vij and Dr. P. R. Roy

Mr. R. K. Vij is welcoming Dr. Chandan Chatterjee

Dr. Chandan Chatterjee delivering his Valedictory speech

Shri H. S. Patel and Shri R. K. Vij is felicitating Dr. Chandan Chatterjee

Dr. Chandan Chatterjee mentioned that the World Economy is still in crisis… Rising interest and Ukraine Crisis persist. Asia has a direct impact on a slowdown of external demand. Russia, Indonesia, the UK, and Germany are also expected to face output loss significantly along with the rising cost of Food and Fuel. Technology advancement and their adoption and commercialization are becoming increasingly critical for their sustainability and competitiveness.

Global Textile is one of the most significant growing segments and is, therefore, expected to face a new challenge in this economic crisis. A need is, therefore, felt to redefine the growth strategy in this context of World Textile.

Further he summarized as under

- Production of Cotton will be almost stable, whereas the world over, there will be incremental growth in Manmade Textiles.
- Manufacturing garments are expected to be the driving force for the overall growth of Textiles. Also, buyers can source fabric and Apparel from one place.
- Skill development and training for the talent should be a continuous process.
- Industries need to move for Circular Economy and Sustainable Textiles.
- Before expanding, the industry should explore adopting energy-efficient and modern technology to increase productivity.
- The focus should be more and more towards highly valued products and products like Technical Textiles targeting the need of mainly Automobile, Healthcare, and Infrastructure sectors.
- Optimizing natural resources like water, power, etc., is essential to achieving competitiveness.
- Post Covid, overall, there is an indication of improvement in industries. Still, an increased rate of interest and the ongoing Russia- Ukraine war may negatively impact countries like India.
- Ongoing environmental issues, including threats of climate change, biodiversity reduction, groundwater depletion, and pollution textile industry, one of the largest polluting industries, will face regulatory pressure in the country and abroad.
- Overall, the address was confined to various strategic changes at different levels to achieve competitiveness and to look at the process and steps for the Textile Industry to be future-ready and sustainable.

Shri Mahedrabhai G. Patel in his vote of thanks expressed sincere thanks to all the Sponsors, Advertisers, Delegates, G. C. Members, Office Staff of Central & Ahmedabad, All the TAI Units and Press & Media for their support and the cooperation to make this Conference a grand success.

National Anthem is performed

View of the audience

At the end of 2 days conference a National Anthem was performed.

Overall World Textile Conference -3 was a memorial grand success event and highly appreciated by the participants, speakers, sponsors and the industry stalwarts. There were more than 800 delegates attended.

Supported by

Supported by

AHMEDABAD UNIT

SPONSORS

LEAD SPONSOR

INDORAMA VENTURES

DIAMOND SPONSOR

G20 INDIA

iNDEXTb
INDUSTRIAL EXTENSION BUREAU
(A GOVT. OF GUJARAT ORGANISATION)
ISO 9001 : 2015 Certified

GOLD SPONSOR

ARVIND
FASHIONING POSSIBILITIES

TSI POWER

JC
RC VELVET
JAIN CORD

BRONZE SPONSOR

monforts | USTER® Think quality | COLORANT® Quality is Colorant | NESTLIND

Birla Cellulose | Bhilosa | SIEGER | COTTON USA | SKAAT®

CO - SPONSOR

KGP KOTAK GINNING & PRESSING INDUSTRIES PVT. LTD. | JAYALAKSHMI TEXTILES | MOKSHA | COLOURS INDIA INC | rimtex® Sliver Management Systems | tai AHMEDABAD UNIT

Jaydeep Cotton Fibres Pvt. Ltd | Lakshmi Lakshmi card clothing | KHOSLA PROFIL PVT LTD. Solutions that keep you ahead. | STRATA | SEKHANI | The DML Group

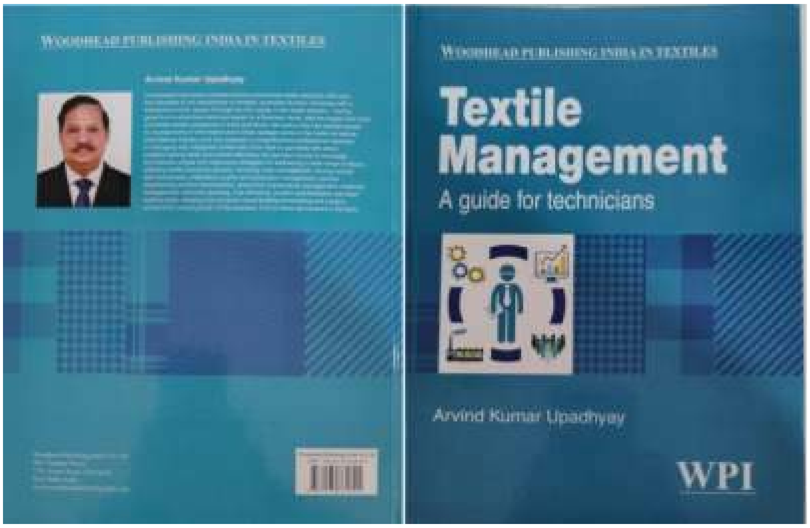
Ajay Cotspin INDUSTRIES | RIETER | oerlikon | FILATEX INDIA LIMITED | colourtex® World Class Dyestuff Company | GROZ-BECKERT

Britacel | AALIDHRA | NSL TEXTILES Cotton to Clothing | TRÜTZSCHLER | PASHUPATI® GROWTH WITH VISION | JK Bodal Chemicals Ltd.

MEDIA PARTNER

TECOYA TREND & J.T.A.

New Book – "Textile Management – Guideline for Technicians"



Mr. Arvind Kumar Upadhyay, during his more than four and a half decades of work experience in the international textile Industry in various positions from "Apprentice Supervisor" to "Business Head", he has realized that a technician is not a complete manager without an understanding of commercial and financial aspects of the business.

It is commonly observed that even after decades of working in the industry. Most of the technician's remain unaware about essential features of business.
Main topics covered in the book: Basic accounting, budgeting, preparation of projects, sales & marketing, auditing, profit & loss accounts, risk management, import & export, cost saving, case studies and suggestions for Indian textile industries etc.

The objective of this Book is to provide the relevant and useful guidelines about critical business aspects of textile Industries. The author has tried to cover important concepts of business in a brief and simplified yet practical way through examples in the form of reports, formats, & figures related to respective subjects.

Author believes that the book will provide the readers with the necessary basics tools to understand the overall management of a Textile manufacturing company and help technicians to transform themselves as techno commercial managers.

It may not only help to expedite the career development of students, individual technicians and managers working in the industries, but may also contribute towards a strong apparatus for the larger benefits of the Textile Industry as a whole.

Publisher: Wood Head Publishing India, Delhi (Mr. Ravindra Saxena) +91981-104-0727
E-mail: editorial@woodheadpublishingindia.com

About the Author:
Mr. Arvind Kumar Upadhyay has very wide experience and knowledge. He has worked in various reputed Textile Industries on Executive Capacities. He worked as CEO in Uniworth Textile Ltd, Nagpur; President & COO in Indoworth Textile Limited, Nagpur (A P Lohia Group of Company); President & COO in Digjam Ltd, Jamnagar (S K Birla Group of Company); President Operations in Reid & Taylor, Mysore; Vice president Manufacturing in OCM India Ltd, Amritsar; Chief Operating Officer in S. Kumars Nationwide Ltd (SKNL), Dewas; Business Head in Ken Knit Group of Industries, Eldoret (Ex Raymond), Kenya; Business Head in Bhojsons Industries PLC, Lagos, Nigeria; PCH in International Textile Industries, Lagos Nigeria and DGM Production, Sr Manager in Raymond Ltd. Thane.

THE TEXTILE ASSOCIATION (INDIA)

Central Office

Shifted to:

702, Santosh Apartment, 7th Floor, Plot No. 72-A,
Dr. M. B. Raut Road, Shivaji Park, Dadar (West),
Mumbai – 400 028 INDIA
Tel.: +91-22-2446 1145, Fax: +91-22-2447 4971
E-mail: taicnt@gmail.com
Website: www.textileassociationindia.org

SIDT organized a Guest Lecture Session at its Campus

SIDT's Center for Sustainability Studies (SCSS) in association with INVIYA® Spandex Business, Indorama India Private Ltd. organized an Industry Interaction session at its campus on February 9th, 2023.

Mr. Shalendra Vasudeva, Chief Marketing Officer, INVIYA® Spandex Business, Indorama India Private Ltd., was the speaker for this guest lecture session. He spoke on the topic "Understanding the Importance and Multipurpose end use of Spandex/Elastane in the Textile Industry".

Mr. Shalendra Vasudeva, Chief Marketing Officer, delivering his presentation

Mr. Shalendra Vasudeva, Chief Marketing Officer, delivering his presentation

The session was opened by Dr. Krishnendu Datta, Dean at Sasmira's Institute of Design & Textiles (SIDT), who welcomed the various dignitaries present at the event. Dr. Manisha Mathur, Joint Director, presented a memento to the speaker. This was followed by a very insightful and interactive session by the speaker.

In his detailed PowerPoint presentation, Mr. Vasudeva discussed trends & opportunities in the textile and apparel industry, and the growing consumer demand for spandex. He discussed the key drivers including the shift in consumers seeking premium offerings and upgrading their choices, the rise in e-commerce sales, New Product Developments in Spandex with Cotton, Polyester, Nylon, and Cellulose fibers, and the increasing awareness about eco/sustainable fashion.

Joint Director Welcoming Mr. Shadendra Vasudeva

Team SIDT & Team INVIYA® Spandex Business

Mr. Vasudeva updated about the complete range of specialty products that their company offers e.g. ECOModa100™ (100% Recycled Spandex for a Better World), STOLID® (Full-Dull Spandex for Specialty Apparels), SnugFit® (Super Comfort Spandex for Hygiene Applications) and INVIYA® (High-Quality Spandex for Multipurpose end uses).

To make the students understand the practical application of spandex, the INVIYA® team displayed a few samples of fabrics and spools which aided the students to get a better understanding of the product.

The session was attended by the students of Fashion Designing, Textile Designing, Textile Technology, and Merchandising.

The insightful session concluded with a Q&A session and a vote of thanks to the speaker. Dr. Krishnendu Datta, Dean at Sasmira's Institute of Design & Textiles (SIDT), thanked Mr. Shalendra Vasudeva for accepting to be a speaker for this session.

Liva partnered with Miss Universe 2023

Liva partnered with Miss Universe 2023 as the official fabric sponsor; participants wore Liva capes in the swimsuit round

Aditya Birla Group's fabric brand Liva partnered with the 71st Miss Universe, held at New Orleans, US, as the official fabric sponsor. This year, LIVA personalized the delegate's fashion with its fabric, the way they want to design and express. In this new element of the competition, all the 90 delegates across the world wore LIVA capes during the swimwear round in the competition.

This is the first time in the history of Miss Universe that capes were introduced in the contest, with the countries' have freedom to design them basis their creative sensibilities.

“We are proud to be a part of a global event and represent a fabric made in India on an international platform. We are elated and excited to see our fluid fabric being draped around the most beautiful women at such a prestigious pageant”, says Sree Charan, Vice President, Head of Branding.
This collaboration echoed out the need of circular and sustainable fashion, and also about strengthening awareness around fluid fashion like Liva, that embodies the message of “LiveYourFlow”, at the most prestigious pageant of the world.

“The Miss Universe Organization is thrilled to have LIVA Fluid Fashion join us as the official fabric sponsor for the 71st MISS UNIVERSE® Competition. Our delegates from around the globe are elated to wear these beautiful fabrics for the swimwear round, during which they will don capes hand designed by artisans from their home countries as a method of self-expression. The LIVA fabrics will serve as a blank canvas coverup, which will be used to ultimately spread awareness about the delegate's culture or issues that are present in their home countries,” said Amy Emmerich, the CEO of Miss Universe Organization.

Liva Miss Diva who represented India at the competition, Divita Rai donned her Liva outfit as well, placing herself in top 16 finalists amongst other delegates. Miss USA, R'Bonney Gabriel was crowned as the new Miss Universe 2022 by her predecessor, Miss Universe 2021, Harnaaz Sandhu from India.

TENCEL teamed up with INTIMASIA to exhibit the future of Intimate Wear Industry

Lenzing's flagship Textile Brand for lyocell and modal fibers - TENCEL™ teamed up with INTIMASIA to exhibit the future of Intimate wear segment across the nation. After four successful editions of INTIMASIA, TENCEL ™ fiber brand once again came back to support the intimate wear industry. The event took place from 20th - 22nd February 2023 in Mumbai, Maharashtra.

TENCEL™ INTIMASIA covered 1,20,000 square feet and include 200+ renowned brands, 100+ Raw Material Suppliers, 15,000+ Retailers & Distributors, and 500+ delegates. TENCEL™ INTIMASIA turned the wheel of innovation and started a conversation about the future of the intimate wear apparel industry, making it South Asia's largest B2B fashion expo in the intimate wear category. Retailers, distributors, wholesalers, and potential business owners were seen rushing to this cutting-edge intimate-wear apparel expo from India. Through strategic placement and deft timing, this event is targeting Mumbai, the city with the highest per capita spending in India. TENCEL™ INTIMASIA 2023, which took place at the Bombay Exhibition Centre, has welcomed sizable attendees of 15,000 visitors from across India.

During the tradeshow, the audience was eager to connect with the Indian experts in intimate wear for the latest offerings, innovations, and trends. The event presented products, services, and technology relevant to the entire production chain, serving as the undisputed gateway to offer exceptional quality and a one-stop selling and sourcing platform. Products from the following categories were displayed: lingerie, underwear, sleepwear, loungewear, swimwear, beachwear, yoga wear, activewear, children's innerwear, athleisure, shapewear, maternity wear, leggings, sportswear, thermals, socks, hosiery, and handkerchiefs. In addition to other products, participating suppliers demonstrated fibres, yarns, elastics, lace, packaging, mannequins, retail software, display solutions, and machines. TENCEL™ INTIMASIA also showcased product demonstrations, collection debuts, and networking events throughout its three-day trade fair to bring together producers, wholesalers, suppliers, retailers, and other industry experts.

Panel Discussion Intimasia Tencel 2023

Intimasia Tencel 2023

Yusuf Dohadwala, Chief Organizer and CEO of Intimate Apparel Association of India said that "INTIMASIA's grand success has set a new milestone for the Hosiery & Knitwear Industry with record participation both in exhibitors & visitors. The Show further displayed India's preparedness in increasing exports for the intimate wear industry and replacing China soon. The Indian Innerwear & Comfort wear segment is currently valued at 60,000 Crores and expected to reach 90,000 Crores by 2026 giving tremendous growth opportunities."

Talking about the show and the brand, Avinash Mane - Commercial Director, of Lenzing fibers (TENCEL™) South Asia said, "Due to the softness and skin friendliness, our fibres go well with products for intimate wear. We make sure that the fibres are of superior quality so that anyone can use these fibres to manufacture intimate wear. We believe in expanding the Indian intimate apparel market, and INTIMASIA is a great step towards it. We hope that people got the best out of this trade show as it was a great platform for networking as well."

Apart from product displays, several Panel Discussions took place where Industry experts like Mr. Avinash Mane - Commercial Director, Lenzing fibers, Mr. Ritesh Sharma - Head - Brand & Retail, R-Elan, Mr. Dinesh Keswani - Business Development, Creora, and Mr. Rajkumar Agarwal - MD, SVG Fashions graced the event

TENCEL ™ brand, the title sponsor of the event also exhibited its innovations at the trade show. It has been seen that the lyocell and modal fibres sold under the TENCEL ™ brand have seen a phenomenal demand in the Indian intimate wear market. Made from sustainably harvested wood using eco-friendly manufacturing techniques TENCEL™ fibers are used in numerous highly specialized applications, they may be found in the collections of many recognized brands and leading designers. They are recognized for their superior comfort and smoothness, as well as for their capacity to regulate temperature and for high color vibrancy. Underwear and high-quality lingerie benefit tremendously with the use of TENCEL™ Intimate cellulosic fibres. The fiber's smooth surface has a delicate character that gives it a scarcely perceptible feel. The fibres also effectively absorb moisture, creating a less favorable environment for the growth of bacteria, improving the sanitary properties of fabrics while also adding long-lasting softness and improved breathability.

Even many national and international brands have adopted TENCEL™ modal and lyocell fiber which offer more value than existing fibers like cotton and are becoming more cost competitive in the market. These fibers are now hugely popular among emerging and existing domestic brands to offer the product to Indian consumers at an affordable rate.

Appeal to TAI Members

You are requested to update your contact details to enable us to update the mailing details

You can fill up the form online

https://textileassociationindia.org/membership/online-form/

Regd. No. R. N. 11386/57 (Formally Textile Digest)