Since - 1940

ISSN 0368-4636
e- ISSN 2347-2537

Journal of the TEXTILE Association

VOL. 82 NO. 1 MAY - JUNE, 2021

RIETER

Make the Difference

Performance Optimization Services

Performance optimization services boost mill efficiency and reduce yarn production cost to give customers a competitive advantage. They help customers unleash the full potential of their spinning mills by offering short to mid-term solutions with immediate results and long-term perspectives.

www.rieter.com

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
MAY-JUNE 2021 VOLUME 82 NO. 1

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

Innovative Textile Materials and its Impact on Society

Industries have been striving continuously to develop and design innovative products and processes and textile industry is no exception. The textile industry has moved far from just being a supplier of mere finished products, to becoming source of solution to issues that affect society. The potential of textiles for fine engineering of their properties and flexibility in designing its structure makes it a material of choice for replacing materials such as steel, wood or even natural material like grass in certain applications. Emerging technologies such as microencapsulation, plasma, bio, nano and sol-gel technologies have given rise to many innovative products in textiles. Lighter, smarter, multi-functional fabrics with a range of engineered properties are being designed for health protection, safety and enhancement of human life. The introduction of smart and interactive textile materials such as shape memory materials (SMMs), phase change materials (PCMs), mechanical responsive materials, hydrogels, aerogels, chromic, conductive and piezoelectric materials having ability to sense the human body and external environment have revolutionized the health care system and enhanced the well being of an individual. Technology innovations have enabled complementary and conflicting functionalities to co-exist, without affecting the original properties of the modified fibres or fabrics. The whitepaper on the innovations carried out by various bodies under the aegis of Ministry of Textiles (2014) exhibits the significance of innovation for growth and development of the industry.

With the development of innovative techniques and materials, the onus for sustainable and environment friendly growth also lies with the industry. The textile industry being one of the most polluting industries is also working towards innovations for making textiles sustainable and environment friendly with the ability to recycle and reuse. The environmental load of petroleum-based fibres has shifted the focus towards exploring other natural alternatives like coffee, pineapple, lotus and hemp. The use of spacer fabrics in place of foam, corn to make biodegradable bags and manufacture of 3D shaped textiles to reduce waste and trims, exhibits the efforts of the industry towards sustainable innovation. An integrated approach of sustainable and high-tech functionality is needed to safeguard the environment and create a cleaner tomorrow.

Dr. Deepa V. Raisinghani
Hon. Editor

Acoustic Properties of Woven Fabrics – Part I : Influence of Physical Parameters and Mechanical Treatment

Dr. N. Gokerneshan[1]*, Ms. B. Padma[2], Ms. R. Haripriya[3], Ms. A. J. Abisha Raju[4], Dr. K. Sangeetha[5], Ms. Lakshmi Sudheer[6] & Dr. K. M. Pachiyappan[7]

[1]Department of Costume Design and Fashion, Dr. SNS Rajalakshmi College of Arts and Science, Coimbatore,
[2,3,4]Dr. SNS Rajalakshmi College of Arts and Science, Coimbatore
[5,6] Department of Textiles and Apparel Design, Bharathiar University, Coimbatore
[7]Department of Costume Design and Fashion, PSG College of Arts and Science, Coimbatore

ABSTRACT

The article comprehensively reviews the acoustic properties of wovens. In this part of the article, the effect of raising treatment and selected physical parameters of woven fabrics have been reviewed. Studies on fabrics with selected rib weaves using micro fibre polyester and regular polyester weft yarns that have been dyed, heat set and given raising treatment have been investigated for their effect on acoustic properties. In another study, the influence of physical parameters on the acoustic absorption properties have been considered. The acoustic absorption properties of selected types of woven fabrics having various structural parameters have been measured and evaluated. Multiple linear regression models have been established to characterize the relationship between acoustic behavior and various physical parameters. The findings reported in both the studies have been highlighted in this part of the paper.

Keywords: *Woven fabrics, Raising treatment, Acoustic absorption, Air permeability*

1. Introduction

During the past few decades a good deal of research has been done in the area of acoustics in textiles. The textiles for acoustics include wovens, knits and nonwovens. While a great deal of research has been focussed towards non wovens, considerable research has been done relating to wovens and knits. The amount of research conducted on sound absorption properties of woven fabrics in comparison to nonwoven and spacer textile fabrics is very limited [1]. Acoustical and sound absorption properties of woven fabrics have been studied. Woven fabrics having varying structural elements, such as weave type, weft yarn linear density, thickness created by layering of fabrics, yarn spinning system and depth of air space at the back of samples were tested. The sound absorption coefficient of woven fabrics is influenced by both density and porosity of fabrics. It was found that, plain fabric absorbed sound wave more than the other weave types. It was found that, finer weft yarn and higher thickness of fabric causes the noise reduction coefficient ~~or~~ (NRC) of the fabric to be increased. It was established that, fabrics woven using rotor-spun yarns exhibited the highest absorption in comparison to samples woven using ring-spun and compact yarns [2]. Sound absorption coefficient of woven fabric samples was determined via impedance tube method. Samples with various pick densities and yarn twist were used. The effect of fabric thickness was analyzed using three and six layered test samples. It was found that, noise reduction coefficient of three and six layered samples, woven at low pick densities showed significant increases in comparison to those woven at high pick densities. It was also established that samples woven with lower weft yarn twist absorb sound wave more efficiently. It was concluded that fabric air permeability can be used as a criterion of sound absorption behavior of woven fabrics [3]. A theoretical model for the oblique incidence sound absorption coefficient of thin woven fabrics backed by an air cavity is presented where the fabric is acoustically described by its specific airflow resistance and its surface mass density. The theoretical model is illustrated by an equivalent electrical circuit and validated in the case of normal sound incidence by experimental results obtained from impedance tube measurements on three fabric types. Measured and estimated absorption coefficients show excellent agreement, with mean value and standard deviation of the differences of 0.03 to 0.10. The model is therefore suitable for the design of new fabrics with an intended absorption coefficient [4].

A pile effect is produced during the raising process wherein several fibres on fabric surface get pulled out partly from the yarn structure. The fibres are pulled out from fabric surface by means of metal wires or teasels that are carried upon rotating cylinders on a raising machine. The fabrics thus processed on a raising machine tend to have softer feel, more thickness, bulkier, and with a hairy surface appearance [5,6]. The fibre ends protruding from raising treatment conceal the structure of the fabric and render a smoother surface. There could be the risk of fabric degradation and fly generation if raising effect is to be achieved in a single passage through the machine, which would need greater pulling forces. Hence, fabrics are made to go through repeated passages in the machine so as to achieve the desired raised effect without excessive mechanical stress. Because of their low weight and economical production costs fibrous materials can be considered prospective among different acoustic absorption materials. There have been reports of different acoustic absorbers made of fibrous materials, which comprise of acoustic wall coverings, acoustic barriers, fibrous ceilings, and passenger vehicle noise absorbers [7].

2. Influence of raising treatment

In order to improve the hand and aesthetic appearance of

All the correspondence should be addressed to:
Dr. N. Gokerneshan
Department of Costume Design and Fashion,
Dr. SNS Rajalakshmi College of Arts and Science, Coimbatore,
Email: advaitcbe@rediffmail.com

fabrics, raising process has been adopted over the years [8]. A number of studies have been conducted relating to the effect of the raising process on fabric hand, smoothness, and softness as per available literature [9,10]. Studies have been carried out on the fabric properties, particularly fabric handle of polyester fabrics through the finishing stages and it is revealed that raising improved the fabric handle. The findings of the subjective evaluation of raised woolen fabrics have been reported with regard to smoothness, softness, and stiffness. It was found that fabric smoothness and softness were clearly related to the amount of raise given to the fabrics. Besides the appearance and fabric hand, the raising process improves certain technical properties of fabrics. For instance, the created air pores within the increased volume of the fabric structure improve the thermal insulation and warmth of the fabric [11]. A tribological method has been described for studying the influences of raising and sanding on the surface properties of certain woven and knitted fabrics. As per the investigation, the hairs protruding from the fabric were longer after raising than after sanding it. A fibre mat is created over the fabric, wherein air has been entrapped. The influence of raising treatment on the thermal contact properties of knitted fabrics has been studied [12]. It determines the feeling when the human skin touches an object for a brief period of time. It was found that raised fabrics had a warmer feeling due to the entrapped air in the hairy and bulky structure. The comfort and some mechanical properties of raised denim fabrics have been studied. Based on the findings it was found that the thermal resistance of fabrics has been enhanced by raising. The air permeability also increased by raising. The results of the raised fabrics did not reveal any significant negative outcomes with respect to their mechanical performance. Roh et al. evaluated the effect of raising on the mechanical, comfort, and hand properties of artificial suede knitted fabrics made of nylon/polyester micro-fibers. There has been reduction in water vapour transmission after raising. However, there has been increase in the thermal resistance and water repellency of the artificial suede fabrics. Increasing the number of raising passes caused the suede to stiffen, but it kept the soft and smooth surface. In the sound absorption-related literature of woven fabrics, the effect of structural parameters on the sound absorption behaviour of woven fabrics has been investigated [13-15]. Barburski et al. performed acoustic tests on various woven fabrics. Dense fabric constructions of satin and double cloth weave showed better acoustical properties according to the results of the study. Segura-Alcaraz et al. reported the effect of the yarn density of woven fabric on the sound absorption performance. The highest sound absorption values were obtained from woven samples with higher yarn density. Soltani and Zerrebini also studied the sound absorption behavior of woven fabrics. The effective parameters havev been found to be fabric weight, density, and porosity. Plain weave fabric, having the highest density and the lowest porosity, absorbed more sound energy than the other fabric types in this study. In comparison with fabrics produced from ring and compact yarns the sound absorption of woven fabrics produced from rotor spun yarns is also found to be greater. This is because of the bulky structure of the rotor spun yarns. In another study by Soltani and Zerrebini, the effect of weft yarn twist on the sound absorption coefficient was investigated. There has been reduction in the sound absorption with increase in weft yarn twist.

A higher yarn twist increased the yarn compactness, which in turn reduced both the fabric cover and the number of voids in the yarns, which caused lower sound absorption values. Small voids are required in fibrous structures, since sound absorption in these structures mainly occurs due to frictional resistance between the fibers and air trapped in the pores that dissipates acoustic energy during sound wave propagation. Bulky and thick fibrous structures absorb more sound energy due to longer tortuous paths that offer more frictional resistance while sound waves pass through. As raised fabrics have surplus air pores in the raised surface and voluminous structures, they are capable of absorbing more sound energy than unraised ones. The upholstery industry has been looking for a good surface appearance and a soft hand, which are the two major features that raised fabrics inherently have. Hence raised fabrics find extensive utilization in home textile products, like curtains, furnishing, and decorative fabrics. Such fabrics are also capable of increasing the comfort of a room with regard to sound absorption. The influence of the raising process on the sound absorption behaviour of woven fabrics has been studied.

The influence of the number of raisingtreatments

In order to achieve various levels of raising effect, fabrics have been passed through the raising machine upto 3 times. SEM analysis has been used to study surface images of the basket weave fabrics containing micro-fiber weft yarns before and after each raising pass. There is an abrupt change in fabric surface texture after the first passage through the machine. The raised fabrics reveal projecting fibers of the weft yarns and surface warp yarns (vertical yarns). It can be observed that warp yarns of the fabric from one machine passage are more prominent compared with those of the two and three-passage fabrics. The surface images of the regular-fiber rib weave fabric before and after each raising pashas been studied using SEM. Even though the weave pattern at one pass is hardly visible because of the presence of some unraised fibers, the surface texture of the fabric is altered due to the raising action. The mass per unit area data for all test fabrics after each raising pass has been summarized. For the analysis of the mass per unit area values, an analysis of variance (ANOVA) F-test for independent groups was applied with a significance level (a) of 0.05. A LSD (least significant difference) test, which makes direct comparisons between individual groups, was run afterwards. In general there is an increase in the areal density of the fabrics between 1-6% after the first and second passages. The increment is significant statistically. In the event of the raising process the weft yarns are mostly pulled by metal wires and alter the position of the weft fibers vertically in relation to the fabric surface. The shrinkage in width arises from pulling forces exerted on the weft yarns which leads to change of weft direction. Hence it results in more material in a square area of fabric. It could be ascribed to increase in mass per unit area during the first and second passage. Whereas, it is observed that there is slight decrease in mass per unit area (maximum 3%) after the third passage. Beside the regular-fiber rib weave fabric, the decrease in mass per unit area after the third raising passage is statistically significant. It appears that during the third passage straight fibers on the fabric surface break away because of the pulling forces of the metal wires. There is a change in fabric thickness following every raising passage. Based on the findings, there is rise in the thickness of the fabrics after the first and the second raising passages. In all the types of fabrics studied, the maximum increase in thickness happens at the first raising passage. Whereas, the change of thickness appears insignificant for the third passage. For further analysis of the thickness values, a LSD test was applied following an ANOVA F-test with 0.05 to compare the means. The test results indicate that the thickness change of the fabrics after the third pass is insignificant, while the thickness increment after the first and the second raising passes is significant statistically. The weight and thickness values reported above are used to calculate the SVF of the fabrics.

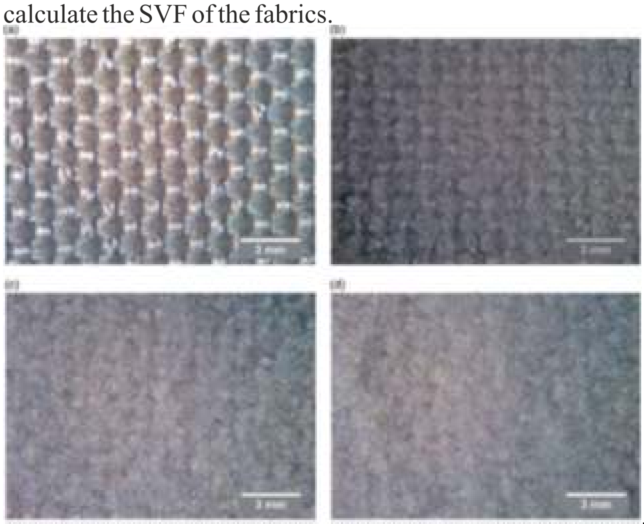


Figure 1 Surface images of regular-fiber rib weave fabrics before and after raising passes: (a) base fabric; (b) one-pass fabric; (c) two pass fabric; (d) three-pass fabric [16].

The SVF results of the fabrics after each raising passage have been determined. There is reduction in the ratio of solid (fiber) volume in the fabric structure following each raising passage. It is an anticipated outcome, as the raising process increases thickness and gives a voluminous characteristic to the fabrics. The decrease in SVF seems minimal after two passages. A LSD test was performed to all SVF data following an ANOVA F-test with a 0.05 to establish whether the experimental results have a significant difference. The reduction in SVF is considerable subsequent to the first and the second raising passages. Based on statistical findings the SVF values of the fabrics gone through two and three raising passages are found to be similar. It looks apparent that above two raising passages, the structural change that took place in the fabrics was small. The airflow resistivity results have been determined. Based on the findings, there is reduction in the airflow resistivity following every passage of raising. It seems that fabrics with higher SVF offer more resistance to passing air, since these fabrics are less porous. Further analysis is required to compare the airflow resistivity values of the two-pass and three-pass fabrics, in particular. Hence, a LSD test has been adopted to all airflow resistivity data following an ANOVA F-test with 0.05 to compare the means. Based on the statistical findings, the averages of the fabrics with double and triple raising passages do not vary considerably. But, the difference between averages is small in the case of rib weave fabrics weft yarns from regular fibers, with double and triple raising passages. Thickness, SVF, and airflow resistivity results together lead to the conclusion that beyond two passes raising does not change the voluminous characteristic and inner structure of the fabrics at all.

It has to be taken into account that the findings related to airflow resistivity in the case of the micro-fiber fabrics are higher in comparison with the regular-fiber-based fabrics. As anticipated, greater resistance to the air flow is created by thinner fibers. In the case of fabrics with matt weave the results of airflow resistivity are lower than those of the rib weave fabrics. The lesser resistance to air flow can be attributed to longer weave floats, fewer interlacements, and henceforth to more inter yarn spacing of the basket weave structure. In the case of fabrics having various passages of raising the results of sound absorption coefficient have been determined. It has been generally observed that at greater frequencies as the number of raising passages increases for all types of fabrics, the sound absorption coefficient increases. Whereas, at lower frequencies there is decrease in the sound absorption coefficient. It is also observed that fabrics having greater SVF (particularly base fabrics) exhibit highest sound absorption coefficient value at lower frequencies with a relatively narrow sound absorption curve. Another work reports similar result, wherein the sound absorption mechanism of the woven fabrics has been studied. Fabrics having higher densities (corresponding to higher SVF in this study) showed a sound absorption coefficient peak at lower frequencies, then the sound absorption decreased with the increasing frequency. This type of sound absorption behavior is mostly seen on resonant-type absorbers, such as membranes, which have normally very high SVF values compared to fibrous materials. Resonant-type absorbers dissipate the narrow frequency band of sound energy at relatively lower frequencies with a characteristic absorption coefficient peak. The resonant-type absorbers work on the principle of dissipating acoustic energy with structure vibration. With the effect of the raising process SVF, in other words, the solid fiber volume per unit volume of fabric decreases and, consequently, fabrics become more porous. Raised fabrics show mostly fibrous and porous material absorption characteristic curves in which sound absorption performance at higher frequencies is better. As the sound absorption results appear near to each other for the raised fabrics of two and three passages, it is necessary to have statistical comparison. A LSD test was run following an ANOVA F-test with a 0.05 to figure out if the sound absorption results of two- and three-pass fabrics are significantly different. Probability (p) values were calculated for the all sound absorption coefficient data between 1 and 6.1 kHz with 2.7 Hz intervals. From the statistical point of view, the influence of the first and second raising passages on the sound absorption results for all fabric types is significant for most of the frequency range.

Based on the findings, it is found that the sound absorption coefficients of the raised fabrics of two and three raising passages are almost equal over the complete range of frequency, statistically. But, exception has been considered in the case of the results of two- and three-raising passages for regular-fiber rib weave fabrics. The results of the sound absorption in the case of fabric having regular rib weave have been considerably affected by the third raising passage after the frequency of 3838 Hz. Owing to the close voluminous characteristic and inner structure of fabrics with two and three raising passages, the influence of the third raising passage on the sound absorption results of the fabrics is limited due to the close voluminous characteristic and inner structure of the two- and three-pass fabrics. Two passages of raising can be regarded as optimal with respect to the sound absorption performance of the fabrics produced in study considered.

The influence of the fiber and weave

Fabrics with various weave and yarn types and passed through two raising passages have been compared for sound absorption. The sound absorption coefficient results were compared between 1 and 6.1 kHz with 2.7 Hz intervals using a LSD test following an ANOVA F-test with a 0.05. Based on the statistical test findings the sound absorption of each fabric type are considerablly different over almost the complete frequency range. In the fabrics with double raising passages, it is evident that the sound absorption in the case of basket weave fabric with regular fibers is more at higher frequencies. Such kind of fabric has a lower solid material (fiber) volume than the total fabric volume (the lowest SVF of 0.164) and thus, has lower airflow resistivity, respectively. The more porous structure of this fabric type leads to better sound absorption performance at higher frequencies, which is a typical sound absorption behavior of fibrous and porous materials. Whereas, the sound absorption of rib weave fabric with micro-fibers is higher at lower frequencies among the two-passage raised fabrics. The ratio of solid/fibre material volume to the total fabric volume is found to be greater in the case of the micro-fiber rib weave fabric (the highest SVF of 0.263) and, thus, air flow resistivity is greatest in such kind of fabric. Owing to the greater solidity of the fabric structure it looks apparent that the resonance-type absorption mechanism is partly responsible for the lower frequency sound absorption. Because of the vibration of the sample in the resonance-type absorption mechanism sound energy dissipation takes place [16].

3. Influence of physical parameters of fabric

The effects of fabric porosity, areal density, and thickness on sound absorption behavior and air permeability were studied. It was found that there is a quadratic relationship between air permeability and the porosity of nonwoven fabrics. Furthermore, several theoretical models have been established to characterize the acoustical behavior of fiber felts and nonwoven fabrics, such as Delany–Bazley, Voronina, Miki, Garai–Pompoli, and Kino and Ueno [17-19]. But, such reported models are related to the properties of bulk fibrous materials that are unsuited for characterization of the acoustic absorption characteristics of woven fabrics. Owing to its aesthetic appeal woven fabric has largely been utilized in interior decorations. The acoustic absorption coefficient of woven fabric is relatively low, while the presence of an air gap can obviously improve acoustic absorption properties [20-22]. Presently, a number of investigations have directed their attention on the influences of fabric structural factors on acoustic absorption. For instance, Nute and Slater reported that the cover factor, thickness, and fabric weight contributed significantly to the acoustic absorption of woven fabric [23,24]. Shoshani and Rosenhouse further reported that the intrinsic parameters of woven fabrics have very weak effects on acoustic absorption coefficients in low frequency ranges ($f<500Hz$) but a significant impact at a high frequency ($f=4000Hz$)[25]. The acoustic absorption coefficient would also increase obviously in the low and medium frequency range ($250<f<1000Hz$) when there is an air gap behind the fabric [26]. The works of Soltani and Zarrebini indicated that the acoustical behavior of woven fabrics is mainly determined by areal density and porosity, and a plain fabric could absorb acoustic waves better than other weave types [27,28]. Fabrics woven from rotor spun yarns having lesser twist in weft yarn have the advantage of enhancing acoustic absorption. But, there are no confirmed empirical equations to explain the relation between acoustic absorption characteristics and structural factors of woven fabrics. In order to study the relation between fabric structural factors and properties multiple regression analysis has been widely used. For example, the tensile strength of plain-woven fabric has been predicted using multiple linear regression. Atmaca et al. studied the effects of various structural parameters on the air permeability of woolen fabrics. The findings show that weft–warp density, square mass, and porosity could determine 59% of the air permeability of fabrics with a regression coefficient of 0.593 as per multiple regression analysis. In addition, multiple regression analysis was also used to study the evaluation of fabric hand, the creep properties of nonwoven fabric, and the mechanical properties of cotton/spandex core-spun yarns. The acoustic absorption properties of woven fabrics have been investigated. The structural factors and acoustic absorption coefficients of 24 types of woven fabrics have been determined, and the multiple regression equations have been established. Further, 3 validated samples were used to verify the proposed model. It has been found that the established equations could predict the acoustic absorption coefficients of woven fabrics. The objective has been to explain the relationship between acoustic absorption properties and fabric structural factors. The study is expected to offer helpful guidance for the design of woven fabrics toward noise reduction applications.

Air permeability

Air permeability is a crucial aspect in fabrics. It relates directly to the differential pressure between either sides of test fabrics. But, during measurement, owing to the air flow through the fabric the fibers tend to get deformed. The air permeability values that have been measured can get affected by the deformation under various air differential pressure. The air permeability tests of woven fabrics at specified air pressures have been used with the objective of analyzing the influence of various differential pressures on the measured air permeability of fabrics. It is evident that there is gradual increase in air permeability, as the differential pressure increases. With good linear correlation coefficients of correlation higher than 0.97, it could be stated that the measured air permeability is strongly correlated to differential pressure. Hence, it can be concluded that the woven fabrics used in the investigation show good shape stability, and the measured air permeability values are affected insignificantly by air flow velocity. The air permeability tests at a differential pressure of 100 Pa have been used to study the acoustic absorption behaviour of the materials.

Influences of a single factor

Study has been carried out in relation to the acoustic absorption coefficients against thickness, diameter, perforation, weight, stiffness, and air permeability have been determined.. Also, the measured frequency spectrum ranging from 100 to 6300 Hz has been used to calculate average acoustic absorption coefficient. The coefficients of each frequency with a 2 Hz interval distance were taken, and the measured acoustic absorption coefficients of woven fabrics under different air gap conditions have been determined. The influence of thickness, diameter, weight, and stiffness on the acoustic absorption behaviour are insignificant, where the coefficient of correlation(R2) values are very low. The air permeability and perforation ratio relate closely to the measured acoustic absorption coefficient considering an air gap behind the fabric. But, in the case of absence of air gap behind the fabric the correlation coefficient is very low, where R2 is 0.086 and 0.110 for perforation ratio and air permeability, respectively. It can arise when the sound absorption behavior is very poor if woven fabric closely clings to the rigid back wall. Considering that the air gap distances are 1, 2, and 3 cm respectively, the correlation coefficients (R2) between the acoustic absorption coefficient and perforation ratio are 0.655, 0.729, and 0.686. Similarly, the correlation coefficients (R2) between the acoustic absorption coefficient and air permeability are 0.681, 0.696, and 0.687 for air gap distances of 1, 2, and 3 cm.

It has been found that the thickness of test fabrics ranged from 0.526 to 0.931 mm, and the weight ranged from 228 to 368 g/m2. For fibrous materials, the wavelength of an acoustic wave is greater than the thickness, and therefore it has insignificant effects on the acoustic absorption properties. Also, the correlation coefficients between weight and acoustic absorption are very low. The acoustic absorption behavior is different from that of nonwoven fabrics, where higher areal weights and thicknesses exhibit better acoustic absorption properties.

Studies have also been carried out relating to the influences of diameter and stiffness on acoustic absorption. The maximum diameter is found to be 0.584 mm, while the minimum value is 0.220 mm. The measured stiffness of test woven fabrics ranged from 49.60 to 275.56mN/cm. Also, it has been found that that the correlation coefficients between acoustic absorption properties and measured diameter or stiffness are very low. All the calculated correlation coefficients are lower than 0.15. Hence, it is inferred that diameter as well as stiffness do not significantly affect the acoustic behaviour of woven fabrics. According to reported studies, the stiffness of fibrous materials is closely related to the bending vibrations, thus contributing to the acoustic absorption. It is necessary to take into account the contribution of bending vibration mechanism to the acoustic absorption. The findings showed that stiffness does not significantly affect the acoustic absorption of woven fabrics. Hence, with regard to cross-stitched woven fabrics considering stiffness is only a negligible factor that affects the sound absorption considering its range lying between 49.60 to 275.56mN/cm.

The perforation ratio of the test fabrics ranged from 1.21% to 6.14%, and the air permeability at 100 Pa ranged from 401.5 to 887.8 mm/s. When air gap has been used the correlation coefficient is relatively low (R2<0.12). It could be reasoned that in absence of air gap the acoustic absorption coefficient of woven fabric is very poor. Hence, perforation and air permeability do not significantly affect the acoustic behavior. At air gaps of 1,2 and 3cms, the correlation coefficients between the acoustic absorption coefficients and the perforation ratio are correspondingly 0.655, 0.729, and 0.686. Hence, it can be inferred that the acoustic absorption properties of woven fabrics are mainly based on the perforation ratio. There would be a reduction in the coefficient of acoustic absorption by increase of the perforation ratio. Likewise, at the same air gap levels the correlation coefficients between the acoustic absorption coefficients and air permeability are correspondingly 0.681, 0.696, and 0.687. On the contrary, there is a gradual reduction in acoustic absorption coefficients due to rise in air permeability. This is consistent with nonwoven fabrics where the air permeability is closely related to the acoustic absorption coefficients. In the case of sheet fibrous materials, a relatively low air permeability proves useful to the incidence of acoustic waves, and the acoustic energy is consumed by the internal fibrous assemblies. The regression values between acoustic absorption coefficients and physical parameters have been determined.

Multiple factor regression

Here, all the structural factors have been taken into account in characterizing the acoustic absorption properties. Also, for prediction of the acoustic absorption coefficients of woven fabrics four regression equations have been established. A software has been used to obtain the multiple regression process. It has been used to study the relation between sound absorption and fabric factors [29]. Expressions of multiple factor regression models for various air gap conditions have been developed considering thickness, diameter, perforation, weight, stiffness, and air permeability with specified differential pressure. In the equation the plus in the front of the parameter indicates that it is positively correlated with sound absorption, while the minus means it is negatively related. A summary of predicted results based on established regression models for the test fabrics have been determined. The correlation coefficient is found to be relatively low in the absence of air gap. The multiple factor regression models predict the acoustic absorption properties of woven fabrics (R2>0.77) under different air gap conditions relatively well. The 95% prediction band of multiple factor regression models have been determined. It could be observed that most of the values fall into the prediction interval. Hence, it is effective to predict the acoustic absorption coefficients of woven fabrics with air gaps based on the structural parameters of woven fabrics.

Validation test

The acoustic characteristics of select number of woven fabrics have been investigated so as to validate the proposed multiple factor regression models. The physical factors of select test fabrics that include thickness, diameter, weight, stiffness, and air permeability, have been determined. In addition, optical images of the three samples have been obtained. The perforation ratios of select test fabrics are 5.03%, 2.59%, and 1.22%, while the diameters of perforated holes are 0.562, 0.427, and 0.215, respectively. The measured and predicted values of the validated fabrics and the prediction errors have been determined. In the presence of an air gap the predicted results agree well with the measured values of woven fabrics, where the prediction errors are less than 20% for the select test fabrics having various air gap distances (1, 2, and 3cm) [29]. But, in the absence of air gap behind the fabric, the prediction error is very high. The prediction error is 75.3% for one of the select test fabric, which can be due to the weak sound absorption due to absence of an air gap in fabric. In the case of the select test fabrics without an air gap, the acoustic absorption coefficient is poor and the prediction error is relatively high. It could be concluded that multiple regression models could well predict the acoustic properties of woven fabrics.

4. Conclusion

The mass per unit area, thickness, air permeability, and sound absorption coefficient of the fabrics given raising treatment were measured and surface images of the fabrics were taken. The solid volume fraction and airflow resistivity of the fabrics decreased significantly after the first and second raising passes. Increasing the number of raising passes up to two passes resulted in higher sound absorption (average increment of 20% at 5 kHz) in the higher frequencies at the expense of that in the lower frequencies. Sound absorption change beyond two passes was insignificant, though. The results demonstrated that raised fabrics having a lower solid volume fraction and airflow resistivity had better acoustical properties in the higher frequency region. The effective sound absorption frequency range of the fabrics can be altered from the lower frequency to the higher frequency region with the raising process. Multiple linear regression models have been established to characterize the relationship between acoustic behavior and various physical parameters. It has been found that the acoustic absorption properties were mainly determined by the air permeability. The decrease in perforation ratio and air permeability results in an increase of acoustic absorption properties of woven fabrics. Furthermore, three woven fabrics were used to validate the proposed multiple regression models. The established models could well predict the acoustic absorption properties of woven fabrics where the correlation coefficient is higher than 0.77 with air gaps of 1, 2, and 3 cm, respectively. It should be stated that these results are valid when the woven fabric is used alone, but are not suitable when the woven fabric is associated with porous materials.

References

1. Gokarneshan N, Velumani K (2018). “Some Significant Advances in Spacer Fabric Technology for Newer Areas of Applications”. *J Textile Sci Eng* 8: 339. doi: 10.4172/2165-8064.1000339
2. Soltani P and Zerrebini M. “The analysis of acoustical characteristics and sound absorption coefficient of woven fabrics”, (2012). *Textile Research Journal* 82(9) 875–882.
3. Soltani P and Zerrebini M (2013). “Acoustic performance of woven fabrics in relation to structural parameters and air permeability”, *Journal of The Textile Institute*, 104:9, 1011-1016, DOI: 10.1080/00405000.2013.771427.
4. Reto P. “Sound absorption modelling of thin woven fabrics backed by an air cavity (2012). *Textile Research Journal*, 82(9) 864–874.
5. Matsudaira M and Matsui M. “Changes in the mechanical properties and fabric handle of polyester-fibre fabrics through the finishing stages”. *J Text Inst* 1992; 83: 144–155.
6. Bueno M-A, Viallier P, Durand B, et al. “Instrumental measurement and macroscopical study of sanding and raising”. *Text Res J*, 1997; 67: 779–787.
7. Tang X, Zhang X, Zhang H, et al. “Facile dip-coating process towards multifunctional nonwovens: Robust noise reduction, abrasion resistance and antistatic electricity”. *Text Res J*,. DOI: 10.1177/0040517517725120.
8. Tomasino C. “Chemistry and technology of fabric preparation and finishing”. *Raleigh, NC: North Carolina State University*, 1992.
9. Brooks KA. “Subjective assessment of wet-raised woollen fabric”. *J Text Inst* 1991; 82: 285–290.
10. Roh EK, Oh KW and Kim SH. “Effect of raising cycles on mechanical, comfort, and hand properties of artificial suede”. *Text Res J* 2014; 84: 1995–2005.
11. Sabir EC and Doba Kadem F. “Comfort and performance properties of raised and laminated denim fabrics”. *Fibres Text East Eur* 2016; 24: 88–94.

12. Gunesoglu S, Meric B and Gunesoglu C. "Thermal contact properties of 2-yarn fleece knitted fabrics". *Fibres Text East Eur* 2005; 13: 46–50.

13. Barburski M, Blaszczak JR and Pawliczak Z. "Influence of designs of weaves on acoustic attenuation of fabrics". *J Ind Text.* Epub ahead of print 9 April 2018. DOI: 10.1177/1528083718769945.

14. Segura-Alcaraz P, Segura-Alcaraz J, Montava I, et al. "The use of fabrics to improve the acoustic absorption: influence of the woven fabric thread density over a nonwoven". *Autex Res J* 2018; 18: 269–280.

15. Soltani P and Zerrebini M. "The analysis of acoustical characteristics and sound absorption coefficient of woven fabrics". *Text Res J* 2012; 82: 875–882.

16. Soltani P and Zarrebini M. "Acoustic performance of woven fabrics in relation to structural parameters and air permeability". *J Text Inst* 2013; 104: 1011–1016.

17. Fatih S and Yasemin D, "Investigating the effect of raising on the sound absorption behaviour of polyester woven fabrics", *Textile Research Journal* 2019, Vol. 89(23–24) 5119–5129.

18. Garai M and Pompoli F. "A simple empirical model of polyester fibre materials for acoustical applications". *Appl Acoust* 2005; 66: 1383–1398.

19. Kino N and Ueno T. "Improvements to the Johnson- Allard model for rigid-framed fibrous materials". *Appl Acoust* 2007; 68: 1468–1484.

20. Kino N and Ueno T. "Evaluation of acoustical and non acoustical properties of sound absorbing materials made of polyester fibres of various cross-sectional shapes". *ApplAcoust* 2008; 69: 575–582.

21. Tang X, Zhang X, Zhuang X, et al. "Acoustical analysis of corduroy fabric for sound absorption: Experiments and simulations". 2018: *J Ind Text,* 48(1)201.DOI: 10.1177/1528083717725912.

22. Tang X, Kong D and Yan X. "Facile dip-coating method to prepare micro-perforated fabric acoustic absorber". *Appl Acoust 2*018; 130: 133–139.

23. Kalinova K. "A nano fibrous acoustic system based on the cavity/membrane resonance principle". *Text Res J*, Epub ahead of print 22 December 2016. DOI: 004051751668528.

24. Nute ME and Slater K. "A study of some factors affecting sound reduction by carpeting". *J Text Inst* 1973; 64: 645–651.

25. Nute ME and Slater K. "The effect of fabric parameters on sound-transmission loss". *J Text Inst* 1973; 64: 652–658.

26. Shoshani Y and Rosenhouse G. "Noise absorption by woven fabrics". *Appl Acoust* 1990; 30: 321–333.

27. Shoshani YZ and Wilding MA. "Effect of pile parameters on the noise absorption capacity of tufted carpets". *Text Res J* 1991; 61: 736–742.

28.Soltani P and Zerrebini M. "The analysis of acoustical characteristics and sound absorption coefficient of woven fabrics". *Text Res J* 2012; 82: 875–882.

29. Xiaoning Tang1,2, Deyi Kong2 and Xiong Yan1, Multiple regression analysis of a woven fabric sound absorber, Text Res J, Vol 89, Issue 5, 2019, 855-866.ture related properties of hydrolyzed polyester fabrics*, Textile Chemists and colorist*, 16 (2) 48/35-54/41 (1984)

■ ■ ■

Comfort Properties of Plain Knitted Fabrics for Athletic Wear Applications

Meenu Munjal* & Dr. Dhirendra Sharma
MLV Textile & Engineering College, Bhilwara, Rajasthan

Abstract:
This work is focused on the investigation of the influence of fibre blend proportion and yarn structure on comfort properties of polyester/cotton plain knitted fabrics suitable for athletic wear. Comfort-related properties of the fabrics were determined and compared that included moisture vapour permeability, vertical wicking, and air permeability. In addition, fabric areal density and fabric thickness were also determined. In the present work, Polyester/Cotton weft knitted fabric samples were prepared with four blend proportions i.e. 100/0, 48/52, 65/35 and 0/100 spun Polyester/Cotton yarns. Moreover, 100% micro-denier multifilament polyester weft knitted fabric was prepared to understand the influence of yarn structure on fabric comfort properties. It is observed that micro-denier multifilament polyester fabrics show significantly higher wicking height as compared to equivalent spun yarns. In Polyester/Cotton weft knitted fabrics, with increase in cotton proportion, vertical wicking shows reducing trend.

Keywords: *Air permeability; comfort; knitted fabric; vertical wicking; water vapour permeability.*

1. INTRODUCTION

In recent times, there is a significant rise in interest in sports worldwide. The athletic apparel market occupies an important place in the total textile sector. The functional requirements of athletic wear and customer's expectations are increasing day by day [1]. Thermo-physical comfort and freedom of movement are the fundamental necessities of athletic wear, apart from dimensional stability, light weight, odour reduction etc [2]. Athletic apparel is clothing that is designed to be worn while working out, and are typically made of fabrics designed to wick moisture away from the skin, which helps keep the body cool and dry [3].

Knitted fabrics are preferred for athletic wear, as these fabrics have greater elasticity and stretchability as compared to woven fabrics [4]. The blend composition of yarn plays vital role in fabric moisture and air transmission properties. Proper selection of fibre, appropriate blend proportion, yarn and fabric structure and finally fabric finishing– all these factors contribute to the comfort properties of athletic wear. Much work has been reported on thermal comfort properties of knitted fabrics, however published data on the effect of yarn structure on moisture and air transmission properties of knitted fabrics is very less. This work investigates the influence of micro denier multifilament yarn and spun yarn structure on moisture and air transmission properties of knitted fabrics.

2. MATERIAL AND METHODS

Knitted fabric samples were produced using 34^{s}Ne polyester-cotton blended yarns and 1/155/288 micro-denier multi-filament polyester yarn. Single jersey, fabric samples were knitted with the same machine settings. The specimens were knitted with the same yarn tension and cam setting by using 30”diameter, 28 gauge circular knitting machine with loop length 2.8 mm. Before the measurements and tests, the samples were conditioned in standard atmospheric conditions for 48 hours. All tests were carried out in standard atmosphere. The specifications of fibre used and fabric samples prepared are given in Table 2.1 and Table 2.2 respectively.

Air permeability of the fabrics was measured on TESTEX TF 164 at a pressure of 127 Pa according to ASTM D737. Water vapour permeability was measured using cup method as per BS 7209 standard [9]. Vertical wicking was carried out on test samples of 200 mm×25 mm. The samples were immersed into the water container slowly and vertically up to 3 cm length. It was then left for 15 minutes, and the vertical wicking height was noted down [5]. The knitted fabric samples were measured for their thickness and areal density under standard atmospheric conditions. Ten observations were recorded for each fabric sample. The statistical software Systat 13.2 was used to analyse the results using one way ANOVA technique.

Table 2.1 - The specifications of fibre used

Property	Cotton	Polyester
Micronaire value	4.38	–
Maturity ratio	0.897	–
2.5% span length(mm)	28.08	–
Uniformity ratio %	82.2	–
Short fibre index	7.7	–
Strength(gf/tex)	30.1	–
Elongation%	5.6	–
Denier	–	1.5
Length (mm)	–	38

***All the correspondences shall be addressed to,**
Meenu Munjal
Asst Professor, MLV Textile & Engineering College,
Bhilwara-311001
Email : meenumunjal75@yahoo.com

Table 2.2 - The details of plain weft knitted fabric samples prepared

S. No.	Sample Code	Yarn structure	Blend proportion	Yarn fineness / denier per filament
1.	100 PMF	Microdenier multifilament	100% polyester	155 denier / 0.521
2.	100PS	Spun	100% polyester	156.3 denier
3.	65P	Spun	65/35 Polyester-cotton	156.3 denier
4.	48P	Spun	48/52 Polyester-cotton	156.3 denier
5.	100C	Spun	100% cotton	156.3denier

3. RESULTS AND DISCUSSION

All the fabric samples were tested for air permeability, vertical wicking and water vapour permeability. The results are presented in Table 3.1. Comfort is felt by human body when it is in balance with the environment. Air and moisture transmission are important aspects of comfort. When body is at rest or low activity, water vapour needs to be transmitted out but during high activity, liquid perspiration need to be transferred. So wicking property acquires more relevance for high activity sportswear, which is found be higher in case of hydrophobic fibre i.e. polyester fabrics and micro denier multifilament yarn structure. But during low activity, water vapour transmission is more relevant, which is found to be higher in case of hydrophilic fibre i.e. cotton due to sorption-transmission-desorption phenomenon. Moreover, water vapour transmission reduces with increase in fabric thickness as water vapour has to be transmitted to longer path in thicker fabrics.

Table 3.1 – Influence of yarn structure and blend proportion on comfort properties of plain knitted fabric.

Sample Code	Areal density (g/ m^2)	Fabric thickness (mm)	Air permea-bility (cm^3/cm^2-sec)	Wale wise Vertical wicking height (cm)	Water vapour permeabi-lity (g/m^2/day)
100 PMF	134.5	0.63	215.2	8.7	882.51
100PS	132.5	0.60	186.9	2.4	834.99
65P	128.7	0.59	176.1	2.1	838.43
48P	125.7	0.53	174.7	1.8	857.67
100C	125.2	0.52	170.2	1.4	875.72

Air permeability

Air permeability is the rate of air flow passing perpendicularly through known area under a prescribed air pressure differential between the two surfaces of material. Air permeability of textile materials depends on yarn, fabric structural variables and properties such as thickness, aerial density and porosity. Spacing of yarns is an important parameter that influences the openness of fabric structure since air flow takes place through inter yarn pores. The influence of yarn type and blend proportions on air permeability of the knitted fabric samples has been shown in Table 3.1 and Fig. 3.1. Air permeability is observed to increase as the polyester content in blended yarns increase. The observations may be attributed to reduction in yarn hairiness with increase in polyester content. As cotton content increases in yarn, yarn hairiness increases due to presence of short fibres.

As far as influence of yarn structure is concerned, micro denier multifilament yarns show higher air permeability in spite of higher thickness and areal density of fabric as compared to spun yarn counterparts. This may be ascribed to the structural features of micro-denier multifilament yarn.

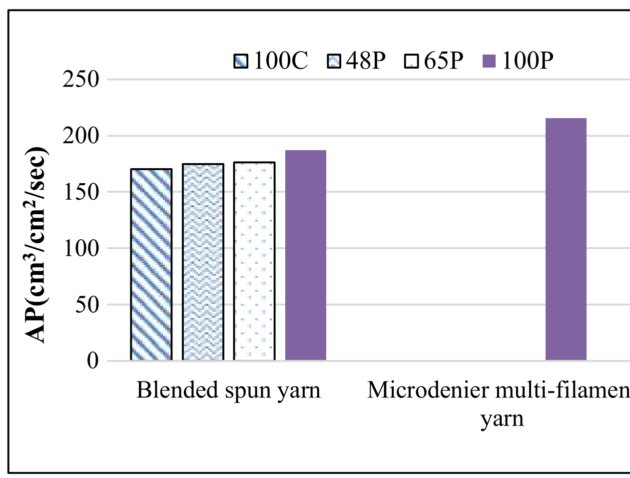


Fig 3.1 - Influence of polyester content and yarn structure on air permeability of weft knitted fabrics.

Vertical wicking height

The height of water rising on various fabrics was tested for wale wise direction and it is shown in Table 3.1 and Fig. 3.2. As the polyester content increases in the blended fabrics, vertical wicking height increases. It may be attributed to hydrophobicity of polyester fibres. When wicking takes place in a material whose fibres can absorb liquid the fibres may swell as the liquid is taken up, so reducing the capillary spaces between fibres, potentially altering the rate of wicking [9].

The wicking height was found to be significantly higher for micro denier polyester multifilament yarns as compared to spun counterpart. It may be ascribed to the fact that in case of spun yarns capillaries are not sufficiently water filled, or continuous, to start the transport mechanism.

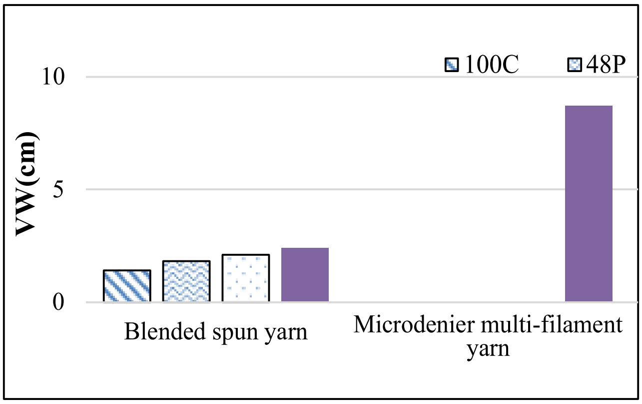


Fig. 3.2 - Influence of polyester content and yarn structure on vertical wicking height of weft knitted fabrics.

Water vapour permeability

The influence of the yarn structure and fibre composition of plain weft knitted fabrics on

water vapour permeability was investigated. From the results presented in Table3.1 and Fig. 3.3, it can be seen that the fabrics knitted from higher proportion of cotton have the higher water vapour permeability values. Water vapour can pass through textile material by following four mechanisms- [6] – diffusion, absorption- transmission – desorption, adsorption and migration of the water vapour along the fibre surface and transmission of water vapour by forced convection. The higher water vapour permeability of cotton fabrics may be attributed to sorption- transmission-desorption mechanism, as the regain of cotton is very high as compared to polyester and other factors such as yarn and fabric structure and environmental conditions are constant. Moreover the water vapour permeability of spun yarns was lower when compared to micro denier polyester multifilament yarns. It may be due to structural feature of micro denier polyester multifilament yarn.

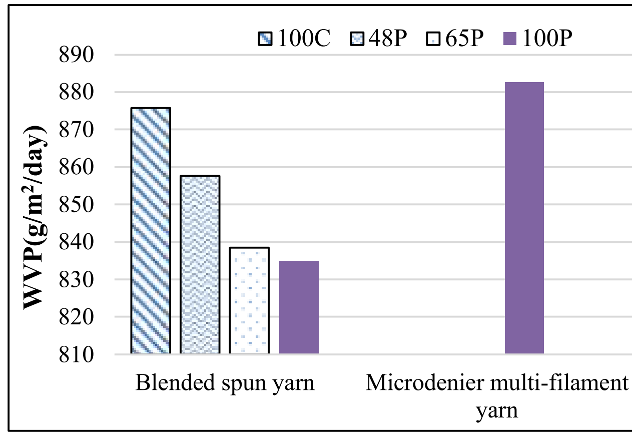


Fig. 3.3 - Influence of polyester content and yarn structure on water vapour permeability of weft knitted fabrics.

4. Conclusions

- Low activity requires apparel having good water vapour permeability but high activity sportswear needs to manage high rates of perspiration, so it should transfer liquid water from the body through higher wicking. Thus it can be concluded that cotton is comfortable in low activity whereas polyester is more comfortable during high activity.
- Moreover, micro-denier multifilament polyester fabrics show significantly higher wicking as compared to equivalent spun polyester knitted fabrics.
- Air and water vapour permeability of micro-denier polyester fabrics was also found to be higher than spun counterparts.

As far as effect of blend proportion is concerned, with increase in polyester content, vertical wicking increased, but air permeability and water vapour permeability reduces.

REFERENCES

1. Shishoo R., *Textiles in sports*, The Textile Institute, CRC Press, Woodhead Publishing Limited, **104**, (2005).
2. Munjal M; Sharma D, Performance Enhancing sportswear, *Journal of Textile Association*, **77**, (3), (2017).
3. Senthilkumar P & Sugandhi T, Influence of tuck stitch in course direction on thermal comfort characteristics of layered knitted fabrics, *Indian Journal of Fibre & Textile Research*, **44**, (6), 163 (2019).
4. Uttam D, Active Sportswear Fabrics, *International Journal of IT, Engineering and Applied Sciences Research*, **2**,(1),34, (2013).
5. Tyagi G K, Bhattacharya S & Kherdekar G, Comfort behavior of woven bamboo-cotton ring and MJS yarn fabrics, *Indian Journal of Fibre & Textile Research*, **36**, (3), 47 (2011).
6. Das B, Das A, Kothari V K, Fanguiero R & Araujo M, Moisture transmission through textiles, *Autex Research Journal*, **7**, (6),100(2007).
7. Kaswell E R, *Textile Fibers, Yarns, and Fabrics: A Comparative Survey of Their Behavior with Special Reference to Wool,* New York, (1953).
8. https://nptel.ac.in/noc/courses/noc18/SEM2/noc18-de05/
9. Saville B P, *Physical testing of textiles,* The Textile Institute, CRC Press, Woodhead Publishing Limited, **242**, (2002)

Vocal For Local: Applications of Banana Fibers into Textile Handicraft

Pavan Gupta*, Guddy Prajapati & Shradha Mantry
[1]Shri Vaishnav Institute of Textile Technology, Shri Vaishnav Vidyapeeth Vishwavidyalaya, Indore

Abstract
The textile handicraft industry in India represents the richness of the Indian heritage, culture, and tradition. Textile handicrafts industry in India is spread across the country especially in small towns of urban area and rural areas. In India, the textile handicrafts industry is a major income source for the village communities. Jute is one of the commercially used fiber for textile handicraft item especially in eastern India (West Bengal, Assam).

Dream of "Aatma Nirbhar Bharat" cannot be fulfil without "Vocal for Local". Therefore, Banana fiber has identified as local substitute of Jute fiber in central India (Madhya Pradesh and Maharashtra) and utilized to manufacture different decorative handicraft items such as Bangles, Potli Handbag, Flowerpot, Wall Hanging, and Fiber Doll. Further market survey was conducted through subjective rating assessment in terms of appearance, comfort, and cost in local area to evaluate the acceptability of these handicraft item. This paper included the manufacturing steps of each item along with the survey results of subjective assessment.

Keywords : *Textile handicraft, Natural bast fibers, Local for Vocal, Banana fiber.*

1. Introduction

"Handicraft is the second largest source of employment in the country, after agriculture". Indian Handicraft sector is world famous for its uniqueness, aesthetic value, beauty etc. and it has great demand in the International market [1-4]. Handicrafts can be defined as products which are produced either completely by hand or with the help of tools [5, 6]. In their product (may be ancient, revised traditional or fashionable), crafters transfer an area of their cultural heritage into forms, materials and work ways, similarly as their own values, philosophy of life, fashion and self-image. Craftspeople, conjointly known as artisans, possess technical data of materials and work ways. The materials utilized in the product are natural, industrially processed or maybe recycled [6]. Indian handicraft industry provides direct employment to over 35 million people an overwhelming majority of which belong to rural and more vulnerable society [7, 8].

The textile handicraft sector plays a significant and important role in the country's economy. It provides employment to a vast segment of craft persons in rural and semi urban areas and generates substantial foreign exchange for the country, while preserving its cultural heritage [9]. Textile's handicraft are passed down from one generation to another, connecting us to our families and communities, while the transmission of skills such as weaving and dyeing from parent to child [10]. The different textile handicraft products are Zari, Carpet, Rugs and Durries, Textile hand embroidery, Textile hand printing, diversified products, etc. [11].

Ecological textile resources such as bast fibers (Jute fiber, banana fiber, hemp fiber, etc.) are used to manufacture handmade products [12]. Jute is a ligno-cellulosic fiber extracted from the stem of Jute plant (genus Corchorus) and owing to its yellowish brown shiny appearance is popularly known as the Golden fiber. Traditionally, Jute is one of the majorly used fiber for manufacturing decorative handmade products such as espadrilles (casual shoes/footwear), fashion bags, jewellery, and floor coverings, etc [13].

Banana plant (*Musa* acuminate) not only gives the delicious fruit but is also provides useful textile fibres. After the fruit production, the trunk of the banana plant i.e., the pseudostem is thrown as agricultural waste to a great extent. The fibres are extracted mechanically from the outer sheath of these and used to make various products such as ropes and cordage, mats, Rugs, Sacks, handbags, basket, wall hangings, floor mats, etc but very less utilisation as compared to jute fiber due to low commercial extraction of banana fibers [14].

Jute is one of the commercially used fiber for making handmade products especially in eastern India (West Bengal, Assam). Banana fiber has identified as local substitute of Jute fiber in central India (Madhya Pradesh and Maharashtra). Therefore, banana fiber was utilized to manufacture different decorative handicraft items. Further market survey was conducted through subjective rating assessment in terms of appearance, comfort, and cost in local area to evaluate the acceptability of these handicraft item. This paper included the manufacturing steps of each item along with the survey results of subjective assessment. The main objective of this study is to explore the utilization of banana fiber for manufacturing the textile handicraft items and evaluate the acceptability in local market especially in central India.

2. Materials & Methods:

2.1 Materials

Banana fiber was used to making the handicraft products. Banana fiber was purchased from Shroff Industries, Khasra No.414/2, Sukhpuri Road, Jainabad, Burhanpur (MP), India, 450331.

2.2. Methodology

Five different decorative products were handmade using Banana fibre like Bangles, Wall Hanging, Flowerpot, Tray,

All the correspondences shall be addressed to,
Pavan Gupta
Shri Vaishnav Institute of Textile Technology, Shri Vaishnav Vidyapeeth Vishwavidyalaya, Indore
Email: pavangupta@svvv.edu.in

and Fiber doll. These products were prepared either directly by using fibres or by making the yarn from the fibres. Yarn from banana fiber was prepared using primitive technology that was used in old days in villages to produce yarn by hand. The count of the yarn was approximately 1 Ne.

Figure 2.1 - Yarn Formation Process –A) Banana fiber bundle, B) opening and straightening of Banana fiber, C) Takli for making yarn, D) Final handmade banana yarn.

2.2.1. Product Manufacturing:

A) Bangles:

Figure 2.2 - Handcrafted Bangles

Material required- Plain Bangle, Banana Fiber, Fevicol, Decorative Items.

Manufacturing process: Banana fibers were first straightened. Fevicol was applied on the surface of the plain bangle and after that banana fibers were wrapped on to the plain bangle in a circular motion. Product was kept for drying for some time and finally decorated using decorative items.

B) Potli Handbag:

Figure 2.3 - Handcrafted Potli Handbag.

Material Required- Banana Yarn (Count 1 Ne), Knitting Needles, Decorative Lace, Wool Yarn.

Manufacturing Process: Banana fibers were first straightened. Banana fibers were converted into yarn through handmade process as mentioned earlier. Then using these single yarns by a method of knitting (converting a single yarn into loop form by interlocking with each other to form a fabric structure) these Potli Handbags were formed. Lace and wool yarn were used finally to tie the opened surface of the bag and decorate the product respectively.

C) Flowerpot (Vase):

Figure 2.4: Handcrafted Flowerpot.

Material Required- Bottle (Glass), Banana Yarn, Decorative Stone, Wool Yarn, Fevicol.

Manufacturing Process: This Flowerpot was made using plain glass bottle in which the yarn made from banana fibre was wrapped around the bottle in circular motion from top to bottom. Fevicol was applied before wrapping so that yarn stick to bottle. After this, smaller flowers made by wool yarn using knitting needles were used to decorate the outer surface part of the flowerpot and decorative stones were also used to decorate it.

D) Wall Hanging:

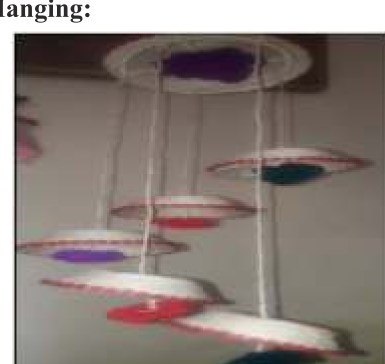


Figure 2.5 - Handcrafted Wall Hanging.

Material Required- Disposal Bowls, Banana Yarn, Fevicol, Wool Yarn.

Manufacturing Process: Disposal bowls were used as a base material on to which the banana yarn was wrapped after applying fevicol inside and outside surface of each bowl to handcraft the decorative Wall Hanging. Then rose flowers of wool yarn were prepared by knitting process to hang onto the bowl.

E) Fibre Doll:

Figure 2.6 - Handcrafted Fibre Doll

Material Required- Banana Fibre, Metal Wire, Newspaper, Fevicol, Scissor, and Color Paper.

Manufacturing Process: To make this fibre doll, Banana fibres were first straightened. Newspaper was wrapped around the metal wire using fevicol. Doll was created using the banana fibers and position of doll was set on the metal wire frame. Then color paper was cut and paste on to the doll to decorate it.

2.2.2. Market Survey:

To assess the acceptability in local area along with product viability and commerciality, preliminary market survey was conducted for these products individually using subjective rating method. Market survey was conducted taking participants of different gender and age. Major two criteria were assessed i.e., appearance and cost as these two criteria decide the acceptability of any handcraft product. For Bangles and Potli Handbag comfort criteria was also assessed as these two products touch the human body. Rating ranking was done as 5 for best acceptable and 1 for least acceptable.

3. Results & Discussion:

With the great effort and using primitive technology handicraft products were handmade. Due to natural brightness of banana fiber the appearance of handmade product found attractive and accepted locally. The average results of the market survey is summarized in table 2 irrespective to age and gender. Results showed that all the products are best accepted by the locality and there is great chance to explore the banana fiber not only for decorative handicraft but also for other textile applications.

Table 3.1 - Average rating of different handicraft products based on comfort, Appearance, and cost

S. N.	Product Name	Comfort	Appearance	Cost
1.	Bangles	4.6	4.8	4.6
2.	Potli Handbag	4.16	4.3	4.25
3.	Flowerpot	-	3.66	4
4.	Wall Hanging	-	4.7	4.7
5.	Fibre Doll	-	4.25	4.08

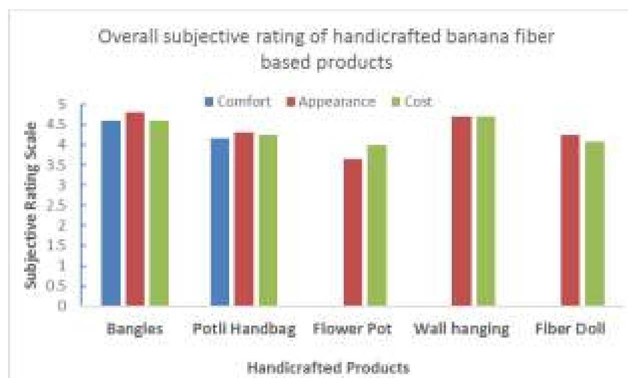


Figure 3.1 - Comparative analysis of product acceptance based on average retting

From the figure 3.1, it can be stated that all the handmade products are best accepted by the participants except the flowerpot but that is also happily accepted as average retting was 3.7 and 4 in terms of appearance and cost, respectively.

Table 2.1 - Details of market survey

S. N.	Product Name	Selling Price (Rs.)	Manufacturing cost (Rs.)	No. of Participants	Male	Female	Age Below 30 and above 15 years	Age Below 50 and above 30 years
1.	Bangles	35	20	20	4	16	8	12
2.	Potli Handbag	220	145	24	8	16	14	10
3.	Flowerpot	100	75	24	10	14	14	10
4.	Wall Hanging	200	130	20	6	14	10	10
5.	Fibre Doll	80	40	24	8	16	16	8

Product wise analysis was depicted in figure 3.2 to 3.6 in terms of gender and age based on comfort, appearance, and cost.

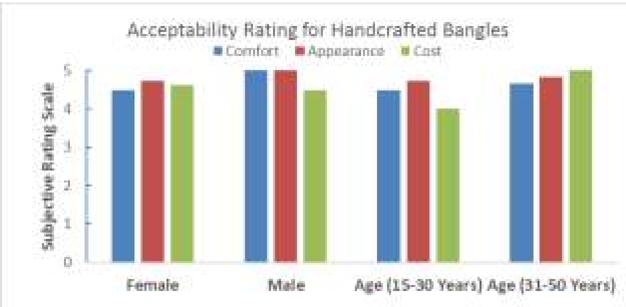


Figure 3.2 - Comparative analysis of handcrafted

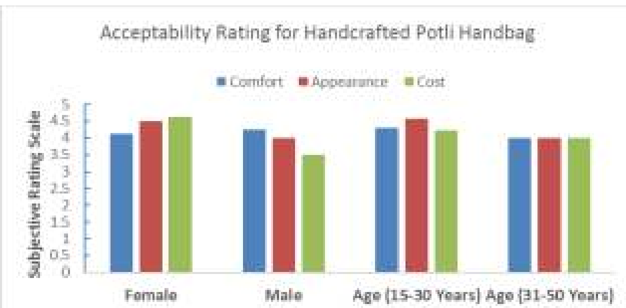


Figure 3.3 - Comparative analysis of handcrafted Potli Handbag

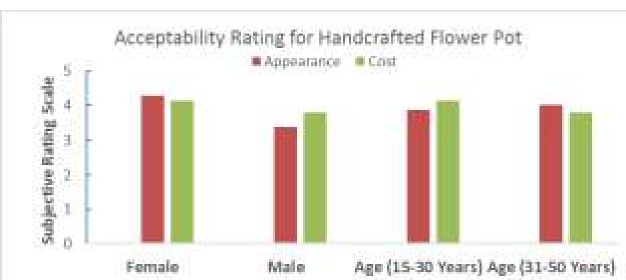


Figure 3.4 - Comparative analysis of handcrafted Flowerpot

From figure 3.2 to 3.6, it can be state that female best accepted all handcrafted product rather than male showed their inherent acceptability towards the decorative items while age group (31-50) irrespective of gender showed better acceptance than the age group (15-30).

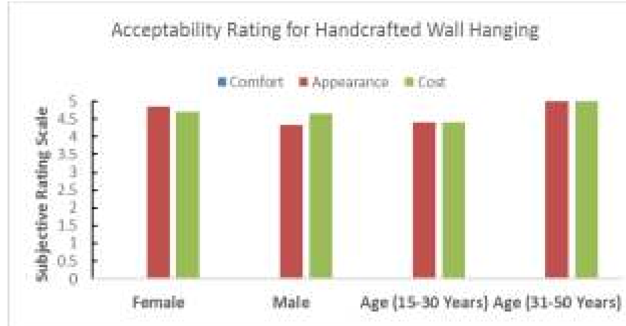


Figure 3.5 - Comparative analysis of handcrafted Wall

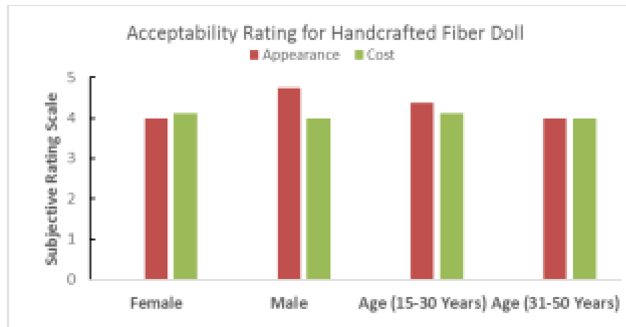


Figure 3.6 - Comparative analysis of handcrafted Fiber Doll

4. Conclusion

Textile Handicrafts is that sector of textile industry which uses textile material as resources. The Crafters or say artisans transfer an area of their cultural heritage, own values, philosophy of life, fashion and self-image, to develop this final product. There is a huge demand for Indian textile handicrafts products in the international market. But still there is a need to explore underutilized local textile resources such as Banana fiber. Therefore, Banana fiber was utilized to produce handcrafted items. Banana fiber in central India can be utilized as a substitute of jute fiber for textile applications especially in textile handicraft. Preliminary market survey indicate that local people happily accepted the banana fiber handcrafted products due to inherent luster and color of banana fiber. Further support from government and new startups will enhance the production and utilization of banana fiber utilization in commercial scale.

5. References

[1]. Vats, N., Indian Handicrafts and Globalization: A Review, *IOSR Journal of Humanities and Social Science,* **19** (1), 40-43, (2014).

[2]. Kumar, D., & Rajeev, P.V., Present Scenario of Indian Handicraft Products, *Asian Journal of Managerial Science,* **2** (1), 21-27, (2013).

[3]. Kapur, H., & Mittar, S., Design Intervention & Craft Revival, *International Journal of Scientific and Research Publications,* **4** (10), 1-5, (2014).

[4]. Kumar, D., Rajeev, P.V., & Tanty, G., A Literature Review of Ergonomics Factors in Handicraft Sector, *Siddhant-A Journal of Decision Making,* **19** (2), 98-101, (2019).

[5]. Jones, S., Woven Textile Crafts in Contemporary Commercial Contexts: Waving not Drowning, Textile, **17** (2), 110-119, (2019). DOI: 10.1080/14759756.2018.1473980

[6]. Shahinur, S., Hasan, M., Q., Saha, D.K., & Islam, M., Characterization on the Properties of Jute Fiber at Different Portions, *International Journal of Polymer Science,* **2015**, 1-6, (2015). DOI: https://doi.org/10.1155/2015/262348

[7]. Hashmi, S.K., Market for Indian Handicrafts, *Excel Journal of Engineering Technology and Management Science*, **1** (1), 1-7, (2012).

[8]. Kulkarni, V., & Konde, V. (2011). Pre-and Post-geographical Indications Registration Measures for Handicrafts in India, *Journal of Intellectual Property Rights*, **16**, 463-469, (2011).

[9]. Ministry of Textiles, Government of India, *Annual Report 2018-19*, 199-236.

[10]. Robertson, K., & Vinebaum, L., Crafting Community, *Textile*, **14** (1), 2-13, (2016). DOI: 10.1080/14759756.2016.1084794

[11]. Mohiuddin, A.K.M., Saha, M.K., Hossian, M.S., & Ferdoushi, A., Usefulness of Banana (*Musa paradisiaca*) Wastes in Manufacturing of Bio- products: A Review. *The Agriculturist,* **12** (1), 148-158, (2014).

[12]. Summerscales, J., Dissanayake, N.P., Virk, A.S., & Hall, W., A Review of Bast Fibres and Their Composites. Part 1- Fibres as Reinforcements, *Composites Part A: Applied Science and Manufacturing,* **41** (10), 1329- 1335, (2010).

[13]. Athalye, A. (2018). Jute-old World Fiber to New World Fashion*, Trends in Textile & fash Design,* **2** (5), 227-230, (2018). DOI: 10.32474/LTTFD.02.000147

[14]. Vigneswaran, C., Pavithra, V., Gayathri, V., & Mythili, K., Banana Fibre: Scope and Value Added Product Development. *Journel of Textile and Apparel, Technology, and Management*, **9** (2), 1-7, (2015).

■ ■ ■

Studies on Comfort Aspects of Khadi Fabrics Using Box and Behnken Design of Experiment Methodology

Dr. Debashish Mahalanobish[1] & Dr. Prabir Kumar Choudhuri[2]*
1.Associate Professor, Department of Design, Kala Bhavana, Visva-Bharati
2.Associate Professor, Textile Section, Department of Silpa-Sadana, Visva-Bharati

Abstract:
Khadi, a traditional fabric in India is hand-woven from hand spun yarns. It is a symbol of 'Fight for Freedom' and became the icon of 'Swadeshi movement' in India. It also symbolizes 'self-reliance'. Khadi sector plays an important role in rural economy of the country. Due its inherent characteristics it gives warmth in winter and cool in summer. Very little research work is recoded on the studies on comfort aspects of Khadi fabrics in a systematic and scientific manner. This paper deals with the studies on important comfort aspects of Khadi fabrics using Box and Behnken Design of Experiment considering three important weaving parameters; reed count, warp and weft yarn count at three levels of each. It is found that, the drape behavior, air permeability and thermal insulation of Khadi fabrics are largely correlated with the factors and their levels under consideration. The relation could be established with regression equations. The contour plot and response surface diagram are developed to understand the phenomenon. The finding of the study is found to be helpful in designing Khadi fabrics of desired comfort characteristics.

Keywords : *Air-permeability, Design of Experiment, Drape Co-efficient, Khadi, Thermal Insulation Value*

1. Introduction

Specialty of Khadi fabrics lies in the fact that it is hand woven fabrics made of hand spun yarns. There is also restriction in using variety of fibres to manufacture Khadi fabrics. Cotton, Silk, Wool are the majority in use whereas a very limited quantity of polyester fibre are used to manufacture Poly-Khadi fabrics. The characteristics of any woven fabrics are governed by the characteristics of constituent yarns and the structure of the fabrics generated due the mode of interlacement of the warp and weft yarns. Since the Khadi fabrics are hand woven out of hand spun yarns, its characteristics are very much inhomogeneous which is inevitable particularly due to the distribution of constituent fibres in yarn cross section and the distribution in twist. Therefore yarn count, twist, nature of fibre and structure of the fabrics play a major role to influence the fabric properties. The purpose of any woven fabrics meant for apparel is to provide comfort to the wearer along with some other important aspects like durability and extensibility.

Many a research has been conducted relating to the studies on fabric properties. In the domain of apparel textiles, researchers are also interested to study the effect of several fabric parameters on functional properties of fabrics. One of the important properties that attracted the attention of the designers, researchers, is the comfort aspect of woven fabrics. Clothing can be considered as a 'second skin' to human. To a wearer, it is the nearest mobile environment whose primary task is to protect the body against unsuitable physical environment by forming a barrier. Therefore, the human-being expects comfort from any clothing it wears which is a primary need and considered as complex phenomenon.

*** All the correspondences shall be addressed to,**
Dr. Prabir Kumar Choudhuri
Associate Professor,
Textile Section, Department of Silpa-Sadana, Visva-Bharati
E.mail: pkc1@rediffmail.com

Several researchers have looked into the essential need of clothing like comfort in several ways. Comfort has also been defined in several ways by researchers. According to Fourt and Hollies (1970)[1] comfort involves thermal and non-thermal components and is related to wear situations such as working, non-critical and critical conditions. According to Slater (1985)[2], comfort is a pleasant state of psychological, neuro-physiological and physical harmony between a human being and the environment. According to Hatch (1993)[3], comfort is 'freedom from pain and from discomfort as a neutral state'. The discomfort arises from the factors like; too hot, too cold, and odorous or stale atmosphere. Comfort conditions are those that do not cause unpleasant sensation of temperature, drafts (unwanted local cooling), humidity or other aspects of the environment to the wearer. The primary function of clothing is to protect the body against an unsuitable physical environment by forming a layer or layers of barrier.

However, clothing serves several other functions in human life such as decoration, social status, protection and modesty. At the interface between the human body and its surrounding environment, clothing plays a very important role in determining the subjective perception of comfort status of a wearer. Clothing is the aspect of our environment with which we are in closest contact and over which we have the most control. Textile designers, technologists have tried to manipulate the factors governing comfort aspects in order to obtain the desired comfort property of the fabric manufactured. Although some research works have been undertaken by scientists on comfort properties of Power-loom fabrics but only a very few papers are available for handloom fabrics and Khadi fabrics in particular.

Sonee N and Pant S (2014)[4] had undertaken a study to modify the stiffness and drape character of Khadi fabric with a view of garment making. Out of synthetic starch (revive) and synthetic resin (silicone) finished Khadi fabrics, revive caused increase in stiffness and drape co-efficient as compared to other. While application of silicone finish makes the fine cotton Khadi fabrics soft. They also observed the varying concentration of finishing agent and varying thickness of fabrics that has a relationship on stiffness and drape. According to them this can be exploited for the development of garments as special look fashion garment. Another study (2012)[5] was conducted by them wherein they had used acrylic as synthetic polymer-based resin, in place of revive. Acrylic treated Khadi fabrics showed better stiffness and drape than silicone treated fabrics which was confirmed through ANOVA (Analysis of Variance) statistic. Varying concentration of finish used on fabrics of varying thickness with an objective to design garments of varying look. Babel S and Kumawat M (2010)[6] conducted a study on value addition of Khadi bed linen from small width Khadi fabrics using computerized embroidery machine. Acceptance & market potentiality of the developed fabric was assessed through specially structured interview schedule of respondents randomly selected. This was found very much favourable as claimed by them. Khadi fabrics have already registered as comfort providing fabrics owing to the structural properties and material used. Chatterjee K N *et al.*, (2011)[7] has confirmed through a comparative study among Khadi, Handloom and Power-loom fabrics of similar type. Higher air permeability and lower bending length was observed for Khadi fabrics followed by Handloom and Power-loom fabrics. In order to introduce diversification in Khadi products, MGIRI (Mahatma Gandhi Institute if Rural Industrialization) (2013)[8] had nurtured rural lay-women as field trainer for designing new products from Khadi. Their attempt was directed towards enhancing of earnings and worthwhile supplementary employment.

On the other hand, only a very few research articles are available documenting in-depth study on comfort properties of Khadi fabrics. Though Khadi fabrics possess all necessary characteristics and offer tremendous possibilities provide comfort to the wearer as supposed from its inherent characteristics, literature hardly reports any systematic study on the effect of various important weaving parameters on comfort aspect of the fabrics and their optimization to produce most suitable fabrics except a very few attempts taken by researchers at very rudimentary level.

In the present work, an attempt has been made to conduct a scientific, in-depth and systematic study to explain the effect of different fabric parameters on comfort aspects of Khadi fabrics using Box and Behnken Design of Experiment (1960)[9] for three variables and three levels. The factors exclusively selected are reed count adopted (St), count of the warp yarn used (Ne) and count of the weft yarn used (Ne) as they influence the quality of the fabric produced.

2. Experimental

Material used

The Khadi yarns as detailed in Table 1 have been used to prepare the fabric samples.

Table 1 - Material used

Nature of fibre	Nature of yarn	Count	Nature of twist	Amount of twist (t.p.i)
Cotton	Pure Khadi yarn (plied)	$2/200^S$ Ne	Z on S	22.0 (7.5)
Cotton	Pure Khadi yarn (plied)	$2/150^S$ Ne	Z on S	18.6 (6.2)
Cotton	Pure Khadi yarn (plied)	$2/100^S$ Ne	Z on S	18.0 (5.8)
Cotton	Pure Khadi yarn (plied)	40^S Ne	S	22.0 (6.2)
Cotton	Pure Khadi yarn	60^S Ne	S	22.8 (8.1)
Cotton	Pure Khadi yarn	80^S Ne	S	29.4 (7.8)

Note: Values within bracket indicates respective C.V%

Sample Preparation

Preparation of Khadi fabrics sample

In order to prepare the fabric samples made of pure cotton Khadi yarn, the Box and Behnken model on design of experiment[9] for three variables and three levels was followed. Three variables used in this work being; reed count in Stock port system (St), warp yarn count (Ne) and weft yarn count (Ne). The actual levels of variables and the design matrix, generated using MINITAB 13 software are shown in Table 2 & 3 respectively.

Table 2 - Actual levels corresponding to coded levels

Variable	Coded level		
	-1	0	+1
Reed count (X_1), Stock port (St)	48	56	64
Warp count (X_2), Ne	2/100	2/150	2/200
Weft count (X_3),Ne	40	60	80

Table 3 - Design matrix as per Box and Behnken Design of Experiment Model

Run no.	Coded level			Un-coded level		
	Reed count (St) X_1	Warp Count (Ne) X_2	Weft Count (Ne) X_3	Reed Count (St) X_1	Warp Count (Ne) X_2	Weft count (Ne) X_3
1	-1	-1	0	48	2/100	60
2	+1	-1	0	64	2/100	60
3	-1	+1	0	48	2/200	60
4	+1	+1	0	64	2/200	60
5	-1	0	-1	48	2/150	40
6	+1	0	-1	64	2/150	40
7	-1	0	+1	48	2/150	80
8	+1	0	+1	64	2/150	80
9	0	-1	-1	56	2/100	40
10	0	+1	-1	56	2/200	40

Run no.	Coded level			Un-coded level		
	Reed count (St) X_1	Warp Count (Ne) X_2	Weft Count (Ne) X_3	Reed Count (St) X_1	Warp Count (Ne) X_2	Weft count (Ne) X_3
11	0	-1	+1	56	2/100	80
12	0	+1	+1	56	2/200	80
13	0	0	0	56	2/150	60
14	0	0	0	56	2/150	60
15	0	0	0	56	2/150	60

In order to prepare the fabric samples in each case, warping was done using vertical drum warping machine usually followed in Handloom industries. Pirns for each weft count yarn were made separately with the help of a charkha usually used in Handloom sector. Drawing of warp yarns were done through wire-healds (one end per eye) followed by denting as two ends per dent in the reeds of 48^S, 56^S and 64^S Stockport as per requirement of the design of experiment. Two heald-shafts were used to weave plain fabrics in handloom for all the 15 samples. After necessary looming work, weaving was carried out to make plain woven fabric samples of sufficient quantity in each case. Thus sample no. 1 was prepared using 48^S Stockport reed count, $2/100^S$ Ne warp and 60^S Ne weft Khadi yarn. In a similar way sample no. 2 to 15 were prepared following the combination of variables as laid down in Table 3.

Altogether 15 fabric samples of sufficient length were obtained.

Test Methodology

Measurement of linear density of yarns

Linear density of yarn was measured following standard method; ASTM D: 1907-01[10] with the help of a wrap reel and weighing balance. A minimum of 50 tests were conducted for each yarn sample and average was taken.

Measurement of twist of yarns

Yarn twist was measured by Untwist-retwist method on 'Eureka single yarn twist tester' following standard method; ASTM D: 1422-99 [11] using a tension of 1.5 gf/tex. A minimum of 50 tests were conducted for each type of yarn sample and average was taken.

Measurement of Thickness of fabrics

Thickness of the fabric sample was measured following standard method of testing; ASTM D: 1777-96 (2015)[12] with the help of Thickness tester, DIGITHICK using the following specification:

Pressure foot diameter 28.7 ± 0.02 mm, and Applied pressure 4.14 ± 0.21 kPa.

Fifty readings were taken at different places spreading over whole area of each cloth sample and the average value was taken.

Measurement of thread density of fabrics

The thread density i.e. ends per inch (e.p.i) and picks per inch (p.p.i) was found out with the help of a counting glass following standard method of testing IS 1963:1981[13]. One hundred readings for each parameter were taken at different places spreading over each fabric sample of $1m^2$ and the average value of ends per inch (e.p.i) and picks per inch (p.p.i) were calculated for each sample.

Measurement of cover factor of fabrics

Since all the yarns (warp & weft) of the fabric samples are made of cotton fibre and the fabrics are plain woven, based on the Peirce's cloth geometry[14] the cover factor of warp (K_1) and weft (K_2) were calculated using the formula:

$$\text{warp cover factor}(K_1) = \frac{\text{ends per inch (e.p.i)}}{\sqrt{\text{warpcount}}\ \text{(Ne)}}$$

$$\text{weft cover factor }(K_2) = \frac{\text{picks per inch (p.p.i)}}{\sqrt{\text{weftcount}}\ \text{(Ne)}}$$

Finally, the cloth cover %(K_C) was calculated using the relationship[14]:

$$\text{Cloth cover \% } (K_C) = [K_1 + K_2 - [K_1 \times K_2]/28] \times 100$$

Measurement of Drape behavior of fabrics

The drape behavior of the fabric samples was determined by calculating the drape co-efficient with the help of Drape meter following standard method of testing IS:8357[15]. Twenty experiments were conducted for each sample and the average was calculated.

Measurement of Air permeability of fabrics

Air permeability of the fabric samples were measured following standard method of testing ASTM D: 737[16] with the help of Air Permeability Tester, Model 9025, Make: United States Testing Co. Twenty such tests were conducted for each sample and the average was calculated.

Measurement of thermal insulation of fabrics ('Clo' value)[17]

SASMIRA thermal conductivity apparatus (electronic) based on guarded hot plate method was used to measure and compare the thermal insulation properties of fabric samples following the standard instruction prescribed in the instrument manual[17]. Thermostat was set at 50^0C and then guard box was switched on. Temperature was allowed to stabilize at 50^0C. After the stabilization of temperature, the hot plate was switched on. Once the temperature reached at 51^0C, thermostat became operational and temperature dropped to 45^0C. Samples were cut using round plate template and then placed on the hot plate. Once the temperature of the hot plate fall to 45^0C, sample was covered with round plate. Temperature was then allowed to rise to 51^0C. When temperature started falling down again, time taken for the hot plate to cool down from 50^0C to 49^0C was measured using a standard stopwatch. Minimum 10 observations were made for each sample to find out average cooling time and the average 'Clo' value (a measure of thermal insulation) was read from the graph of clo vs. time.

'Clo' value in turn may be converted to the more frequently used 'Tog' value using the formula: Tog = 0.645 × Clo. Higher 'Tog' value means lower thermal conductivity

Results and discussion

Characterization of fabric samples

The test results of fabric properties like thread density, cover factor and areal density as evaluated are presented in Table 4. Co-efficient of variation corresponding to each test result are calculated and also presented in parenthesis to show the variation.

Table 4: Fabric properties

Run no.	Combination of variables			Fabric properties				
	Reed count (St) X_1	Warp Count (Ne) X_2	Weft Count (Ne) X_3	Ends per inch	Picks per inch	Cover factor	Thickness (mm)	GSM
1	48	2/100	60	54 (0.57)	70.96 (2.94)	14.30	0.2098 (3.79)	95.58 (4.5)
2	64	2/100	60	70.8 (1.42)	61.36 (4.58)	15.10	0.2188 (5.81)	103.33 (3.2)
3	48	2/200	60	54.4 (1.51)	92.48 (5.23)	15.06	0.2096 (6.24)	99.46 (4.1)
4	64	2/200	60	73.2 (2.24)	84.48 (1.57)	15.38	0.1874 (5.48)	98.13 (3.8)
5	48	2/150	40	53.6 (1.53)	63.92 (3.43)	14.06	0.2506 (5.00)	117.54 (3.5)
6	64	2/150	40	69.2 (1.45)	59.04 (4.05)	14.66	0.2286 (4.68)	124.00 (3.6)
7	48	2/150	80	55.0 (1.87)	90.00 (4.63)	14.13	0.1922 (4.62)	87.19 (4.1)
8	64	2/150	80	73.6 (2.73)	82.08 (1.79)	14.89	0.1832 (5.34)	93.00 (5.2)
9	56	2/100	40	62.8 (1.60)	68.64 (8.06)	16.29	0.2604 (6.58)	116.25 (3.9)
10	56	2/200	40	63.2 (2.60)	78.64 (7.48)	15.95	0.2282 (5.21)	110.44 (4.7)
11	56	2/100	80	65.6 (1.25)	73.52 (3.45)	14.77	0.2174 (6.01)	94.29 (5.1)
12	56	2/200	80	64.8 (1.55)	96.96 (1.59)	14.81	0.1840 (5.81	87.83 (5.5)
13	56	2/150	60	63.6 (1.29)	76.24 (2.96)	14.60	0.2102 (3.53)	100.10 (4.6)
14	56	2/150	60	63 (1.34)	75.14 (2.80)	14.45	0.2115 (3.12)	102.25 (4.2)
15	56	2/150	60	64 (1.25)	76.85 (2.79)	14.69	0.2095 (3.33)	101.80 (4.8)

Values within bracket indicates respective C.V%

Studies on comfort aspects

In order to evaluate the relationship between the controlled experimental factors like reed count (St), warp (Ne) & weft count and the different comfort aspect liked drape behavior, thermal insulation value and air permeability as observed results, the response surface methodology, an empirical modeling technique has been used.

In a system involving three significant independent variables X_1, X_2, X_3, the mathematical relationship of the response on these variables can be approximated by the quadratic (second degree) polynomial equation:

$$Y = C_0 + C_1X_1 + C_2X_2 + C_3X_3 + C_{12}X_1X_2 + C_{13}X_1X_3 + C_{23}X_2X_3 + C_{11}X_1^2 + C_{22}X_2^2 + C_{33}X_3^2 \quad \text{...}(1)$$

Where, Y = predicted yield,

C_0 = constant, C_1, C_2 & C_3 = linear coefficients,

C_{12}, C_{12} & C_{12} = cross product coefficients,

C_{11}, C_{22} & C_{33} = quadratic coefficients

Depending upon the selection of terms like only linear, linear + square, linear + interaction in equation (1) the above mathematical model can be reduced into three separate equations like;

$Y = C_0 + C_1X_1 + C_2X_2 + C_3X_3$ …………… (2)
[Considering the linear terms only],

$Y = C_0 + C_1X_1 + C_2X_2 + C_3X_3 + C_{11}X_1^2 + C_{22}X_2^2 + C_{33}X_3^2$ ……….. (3)

[Considering the linear + square terms only],

$Y = C_0 + C_1X_1 + C_2X_2 + C_3X_3 + C_{12}X_1X_2 + C_{13}X_1X_3 + C_{23}X_2X_3$ ………..(4)

[Considering the linear + interaction terms only],

Multiple regression analysis in addition to ANOVA using MINITAB 13 software is done to obtain the coefficients based on best R^2 (adj) value obtained among above four equations.

The regression equations are evaluated through backward elimination method in which the factors are excluded based on their p-values at the level of 95%.

The experimental results of all 15 fabric samples for each type of comfort aspect i.e. drape behavior, thermal insulation value and air permeability are presented in Table 5. Using these results, the regression equations for different responses corresponding to each type of comfort parameter are developed and presented in Table 6. The given R^2 (adj) value corresponding to each equation depicts the strength of relationship between the factors and response. The contour diagram and response surface plot for different responses are also drawn with the help of MINITAB 13 software in order to visualize the influence of variables on response.

Table 5: Test results of comfort parameters

Run no.	Combination of variables			Comfort aspect		
	Reed count (St) X_1	Warp Count (Ne) X_2	Weft Count (Ne) X_3	Drape Co-efficient	T.I.V (Clo)	Air permeability ($m^3/m^2/min$)
1	48	2/100	60	0.565	1.54038	56.67
2	64	2/100	60	0.597	1.60333	38.34
3	48	2/200	60	0.564	1.54292	33.34
4	64	2/200	60	0.574	1.53067	29.45
5	48	2/150	50	0.601	1.64917	24.00
6	64	2/150	40	0.607	1.58708	20.00
7	48	2/150	80	0.530	1.57888	49.45
8	64	2/150	80	0.548	1.67617	32.78
9	56	2/100	40	0.600	1.60112	25.12
10	56	2/200	40	0.588	1.58542	21.10
11	56	2/100	80	0.554	1.59888	49.45
12	56	2/200	80	0.546	1.52840	38.01
13	56	2/150	60	0.579	1.64471	25.00
14	56	2/150	60	0.580	1.63471	25.5
15	56	2/150	60	0.578	1.65471	24.78

Table 6. Response surface equations for Comfort aspects of fabric samples

Parameter	Response surface equation	Co-efficient of Determination (R^2%)
Drape co-efficient	$0.614567 + 0.00103125X_1 – 0.00022X_2 – 0.0013625X_3$	90.45
T.I.V (Clo)	$0.238247 – 0.003054X_2 – 0.0003595X_1^2 - 0.0001078X_2^2 – 0.000094X_1X_2 + 0.000249 X_1X_3$	91.01
Air permeability ($mm^3/mm^2/min$)	$424.345 - 11.7685X_1 – 2.9729X_2 + 1.81844X_3 - 0.976107X_1^2 + 0.0129753X_2^2 + 0.01805X_1X_2$	94.30

Evaluation of drape behavior of fabrics

After the evaluation of drape co-efficient of the respective fabric samples of made as per the design of experiment, analysis has been performed for development of a model to get the desired regression equation (Table 6) and the resulted contour and surface plot; Fig.1(a) to 1(c).

It can be observed from the equation in Table 6 and from the Fig. 1(a) to 1(c) that, the drape co-efficient of the fabrics increases with the increase in reed count. Increase in reed count increases the ends per inch in the fabrics. More thread density in the fabrics makes the fabric stiffer giving higher value of drape co-efficient. The drape co-efficient value also increases with the decrease in value of warp & weft count. As the count of both warp and weft increases which means the yarns becomes finer, there will be lower value of drape co-efficient favouring more fabric fall. Fabric made of finer yarns has higher flexibility, lesser stiffness to drape better.

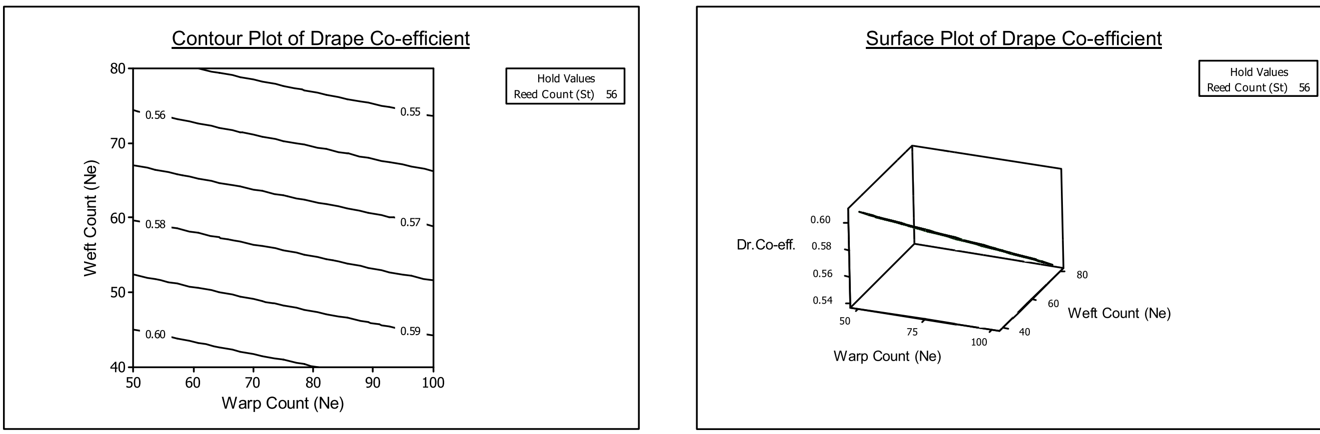


Fig. 1(a). Effect of warp count and weft count on Drape co-efficient at constant reed count of 56s Stockport

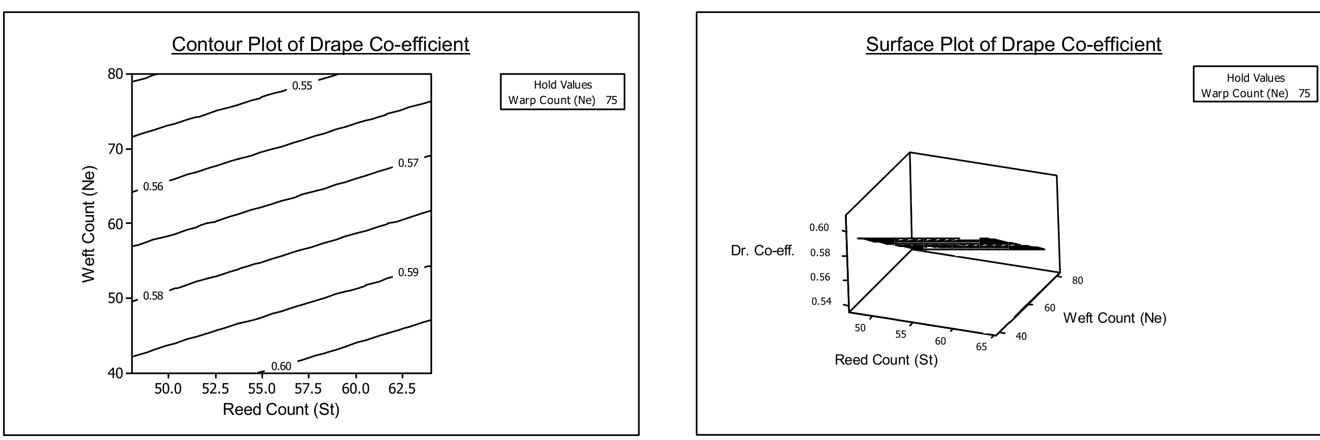


Fig. 1(b). Effect of reed count and weft count on Drape co-efficient at constant warp count of 75^{S}Ne

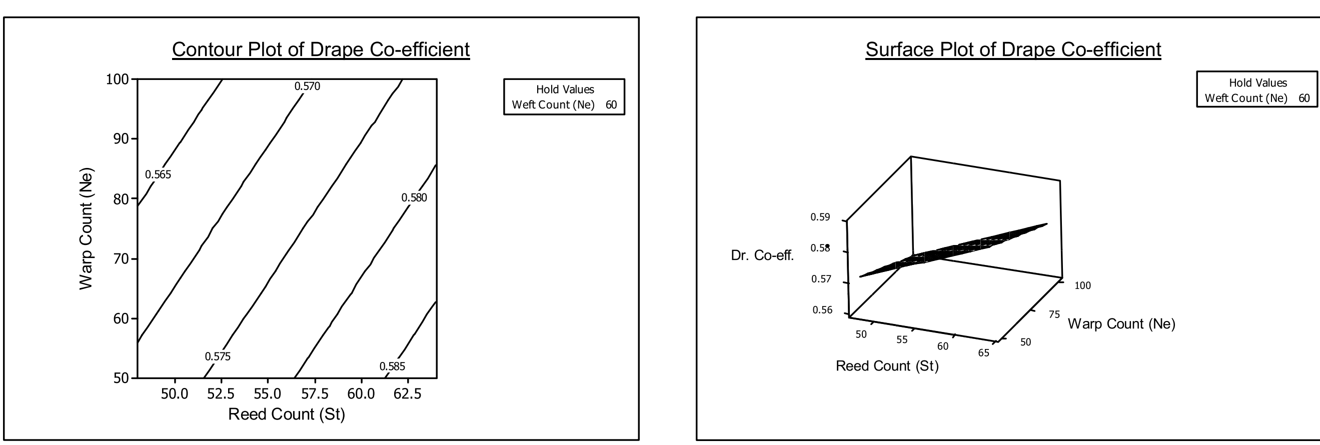


Fig. 1(C). Effect of reed count and warp count on Drape co-efficient at constant weft count of 60^{S}Ne

Evaluation of Thermal Insulation Value (T.I.V) of fabrics

Following to the evaluation of Thermal Insulation Value (T.I.V) of the respective fabric samples in the design of experiment, analysis has been performed for development of a model to get the desired regression equation and the resulted contour and surface plot in Fig. 2(a) to 2(c).

The regression equation model developed is shown in Table 6 based on the results obtained from the fabric samples as per experimental design. It is found that the equation is a quadratic one which is very complex. The thermal insulation of fabric is not very simple phenomenon to explain with main effects only, rather some interactive effects are also responsible to govern this property of the fabric. It can be observed from the equation and also the Fig. 2(a) – 2(c) that reed count and warp count have negative impact on thermal insulation of fabric. This may be explained as; since the count of warp yarn becomes finer and the reed count becomes denser, the available void spaces in the fabrics become less, entrapping less amount of air causing lower value of T.I.V which makes the fabric subsequently less thermally insulated.

On the other hand, there is also an interactive positive effect of reed count and weft count. Higher reed along with finer weft yarn increases the T.I.V of fabrics as evident from the equation and surface plot & contour diagram. Higher reed count causes more warp density. During weaving, when a finer weft yarn is interlaced through higher number of warp threads per unit length, its crimp height increases marginally. This results in increase in thickness of the fabric causing better thermal insulation of the fabric.

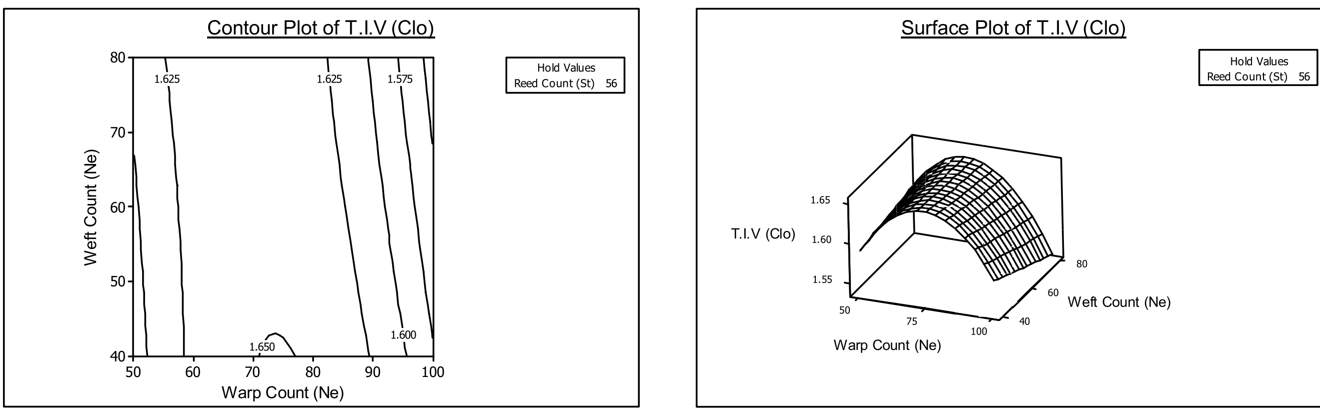


Fig. 2(a). Effect of warp count and weft count on T.I.V (Clo) at constant reed count of 56s Stockport

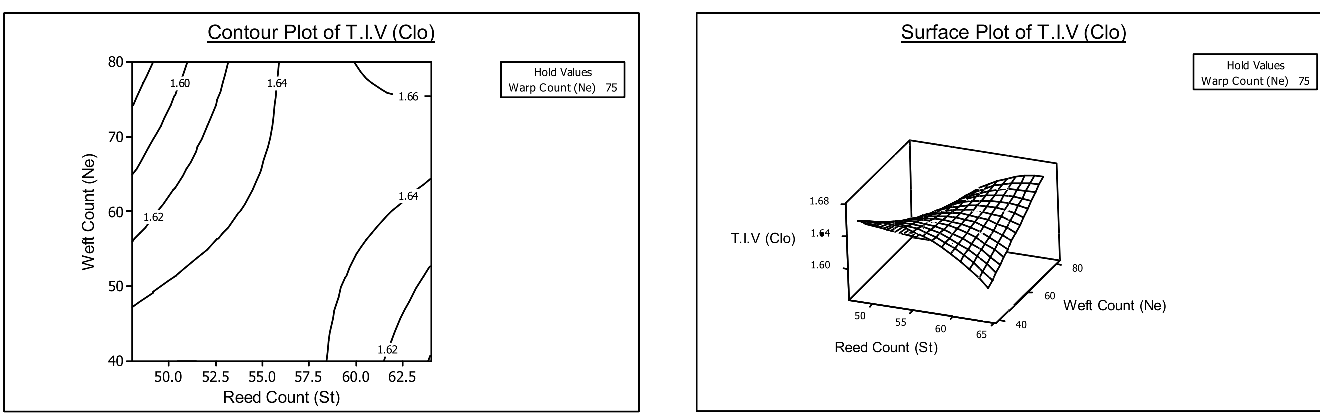


Fig. 2(b). Effect of reed count and weft count on T.I.V (Clo) at constant warp count of 75^{S}Ne

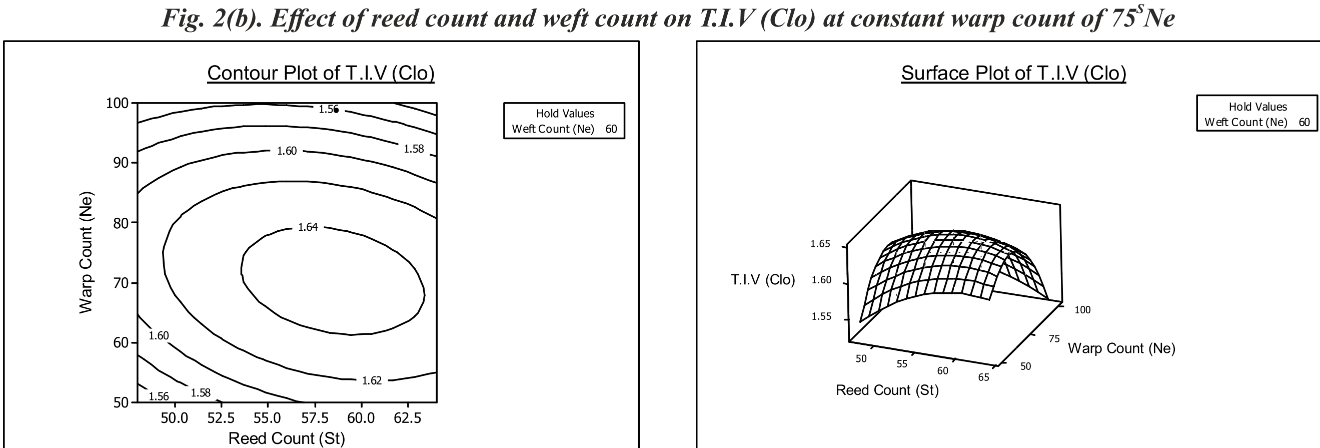


Fig. 2(C). Effect of reed count and warp count on T.I.V (Clo) at constant weft count of 60^{S}Ne

Evaluation of Air permeability of fabrics

The Air permeability being one of the important comfort parameter was evaluated for the respective fabric samples obtained as per the design of experiment and analysis has been performed for development of a model to get the desired regression equation and the resulted contour and surface plot in Fig. 3(a) to 3(c).

The regression equation model developed is shown in Table 6 based on the results obtained from the fabric samples as per experimental design. It is found that the equation is a quadratic one based on the best value of R^2 (94.30%). It is seen that, the regression equation developed here is a quadratic one containing square and interactive terms in addition to linear terms. It is evident from the equation and also from the curve in Fig. 3(a) – 3(c) that, the air permeability decreases with the increase in reed count (St) at fixed warp and weft count (Ne). Increase reed count facilitates increase in ends/inch which in turns offers more resistance to allow the air to pass through fabric. It is also evident that the air permeability increases as the warp count becomes coarser. In coarser yarn, there are more number of fibres and more inter fibre spaces are available to pass the air at constant reed count and weft count. More interesting phenomenon is the interactive effect of reed count and warp count. Their interaction has a significant effect on air permeability. It is clearly visible from the Fig. 3(c) that, coarser warp yarn while drawn through reed count of lower value (St), gives better air permeability. This may be due to lesser warp density in the fabric. However, the effect of reed count is appeared to be more than any other factor of warp & weft count. The contour and surface plots also reveal that, air permeability increases as the weft becomes finer. This is more prominent for lower reed count. Lesser ends per inch with finer weft may result to generate more inter yarn spaces allowing higher air to pass through and hence higher air permeability value.

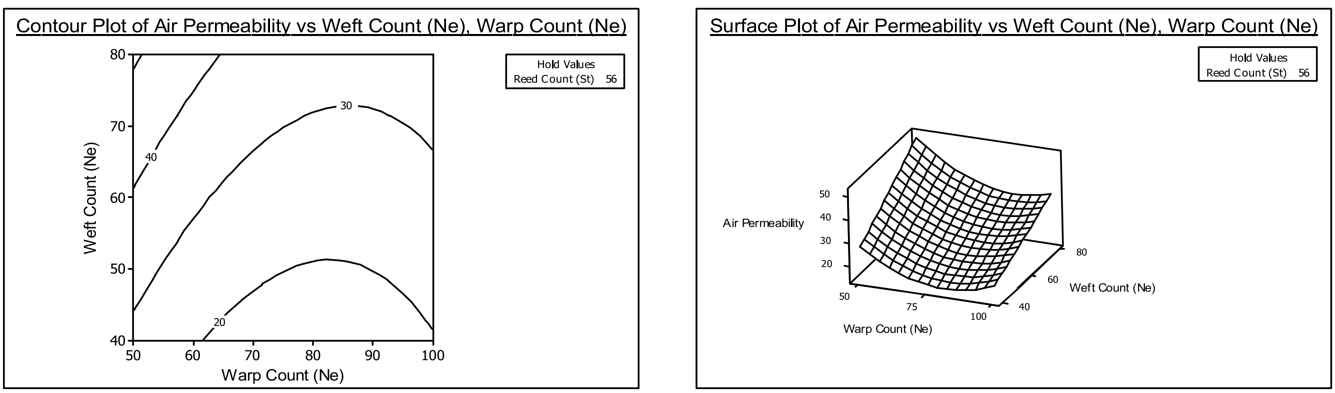


Fig. 3(a). Effect of warp count and weft count on Air permeability ($mm^3/mm^2/min$) at constant reed count of 56s Stockport

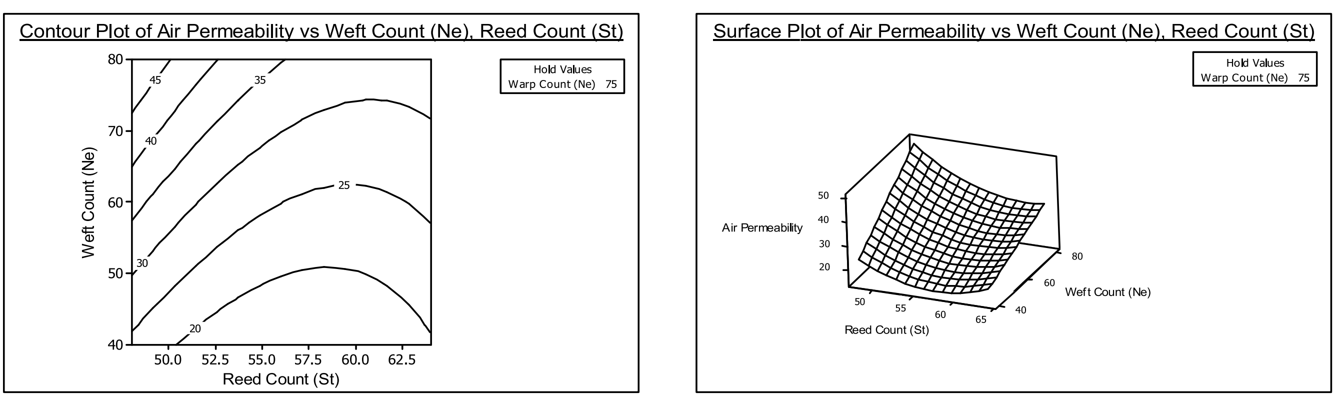


Fig. 3(b). Effect of reed count and weft count on Air permeability ($mm^3/mm^2/min$)at constant warp count of 75^SNe

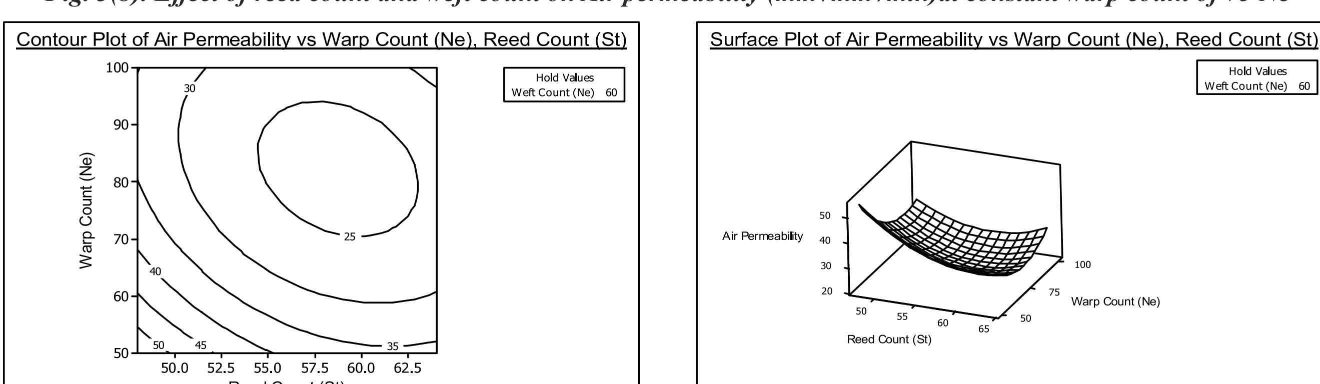


Fig. 3(c). Effect of reed count and weft count on Air permeability ($mm^3/mm^2/min$) at constant weft count of 60^SNe

3. Conclusions

The following conclusions may be drawn from the present study

a. The relationship between factors and responses can be well established & explained using Box and Behnken Design of Experiment methodology.

b. The important comfort parameters like Drape, thermal insulation and air permeability of Khadi fabrics taken under investigation are influenced by three important factors like reed count (St), warp count and weft count used to weave the fabrics.

c. The regression equations have been developed taking reed count, warp count and weft count as independent variable and each of the comfort parameter (drape, thermal insulation and air permeability) as dependent variable with a very high degree of association.

d. The generated surface and contour diagrams are well justified.

e. The findings of the study will help to design Khadi fabrics of desired comfort characteristics.

Reference

[1] Fourt and Hollies, *Clothing: Comfort and Function*, ISBN 13:9780824712143, (Dekker (Marcel) Inc., U.S.), 1970.

[2] Slater K, *Human comfort*, ISBN: 0398051283, (Springfield, III, U.S.A), 1985.

[3] Hatch, *Improving comfort in clothing*, (Woodhead publishing, The Textile Institute, U.K), 2011.

[4] Sonee Noopur and Pant Suman, A comparative study on the effect of finishing agents on stiffness and drape of khadi fabrics, *International Journal of Engineering Research and Applications*, 4(2) (2014) 47–52.

[5] Sonee Noopur and Pant Suman, Effect of Resin Finishing on Stiffness and Drape of Khadi Fabric, *Indian Journal of Applied Research*, 1(9) (2012) 214–216.

[6] Babel Sudha and Kumawat Monika, Redefining khadi bed linen with cad embroidery, *Asian Journal of Home Science*, 5(2) (2010) 336–338.

[7] Chatterjee KN, Das D, Kavita & Nayak RK, Study of Handle and Comfort Properties of Poly-Khadi, Handloom and Powerloom Fabrics, *Man-Made Textiles in India*, 39(Oct.) (2011) 351-358.

[8] Mishra SP, Das LK, Bansod, Gujar U, Bhalshankar Sujata P and Kale PB, Nurturing Lay-Women as 'Field Trainers', *International Journal of Scientific and Research Publication*, 3(7) (2013) 1-7.

[9] Box GEP and Behnken DW, Some New Three Level Designs for the Study of Quantitative Variables *Technometrics*, 2(4) (1960) 455-475.

[10] 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.

[11] 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.

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

[13] Method for determination of threads per unit length, *Indian Standard specifications*, IS 1963:1981, (Bureau of Indian Standards, New-Delhi).

[14] Booth JE, *Principles of Textile Testing* (Heywood Books, London), 1968, 282, 273.

[15] Method for determination of Drape of fabric, *Indian Standard specifications*, IS: 8357:1981, (Bureau of Indian Standards, New-Delhi).

[16] Standard test method for Air Permeability of fabric, Designation: ASTM D: 737, *Annual Book of ASTM Standards, vol 07.01.*

[17] Manual, Thermal conductivity apparatus (Electronic), SASMIRA, Mumbai, India, 1997.

Enhancing the Comfort Properties of Military Clothing using Phase Change Materials (PCMs) and Bamboo

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

[1]Department of Spinning and Weaving Engineering, Textile Industries Research Division, National Research Centre, 33 El Bohouth st., Dokki, P.O.12622, Cairo, Egypt.

[2]Department of Spinning, Weaving and Knitting, Faculty of Applied Arts, Helwan University, Cairo, Egypt.

Abstract

Comfort properties considered the most important property that depends on chosen the final product according to different parameters especially for apparels. The main role of phase change materials (PCM) was to release and store energy according to chemical bonding through the phase mutation. The aim of this work was to investigate the performance of textile materials and weave structures on the manufactured military textiles by performing a four comfort properties. In this research three groups of woven fabrics were manufactured, three textile materials (polyester, viscose, bamboo) for weft materials were used, warp count and material were constant for all samples. The micro PCMs were incorporated into the polyester and viscosefibers, one textile material for each group with three weave structures (plain 2/2, twill 2/2, twill 1/3).

The achieved results for the laboratory measurements were statistically analyzed using ANOVA Two-way Repeated. It was indicated that the four comfort properties were significantly affected by both textile materials and weave structure at P-value ($P < 0.05$). Scanning electron microscope and differential scanning calorimetry tests were conducted according to radar chart area results. This research was addressed to analyze the comfort properties of thermo-regulating textile materials with different yarn materials and weave structures in order to meet special requirements for military application.

Keywords: *Bamboo; Comfort; Differential Scanning Calorimetry; Encapsulated; Phase Change Material*

1. Introduction

Comfort illustrates the relation state between human and the surrounded environment in three states physiological, physical harmony and psychological. Special types of fabrics are produced to achieve the optimum body (desire-requirements) in order to feel comfort and be able to select the proper end use for the manufactured fabrics [1, 2, 3, 4, 5, 6]. There are several factors affecting thermos-physiological comfort including type of fibre used, yarn characterization, weave structure and finishing process [1].

From the most important characteristics for woven fabrics to achieve comfort property is water vapour transmission through fabrics which depends on choosing the end use (application). Fabrics are engineered to meet (reach) different uses with various characteristics. As the fiber has a great ability to absorb water or moisture from the body skin that help to keep the skin dry. A various rate results of transmission were obtained depending on the standard test methods used [3, 7, 8].

The transfer of heat through textiles is adjusted through different mechanisms conduction and convection. Transportation of heat is divided into two portions, first is the dry heat which transfer from the skin when the fabric material occurred in direct contact with the body skin which is the conduction mechanism, vice versa for wet heat in which the convection mechanism occurred by transferring of moisture from the body skin through the fabric layers [3,4,7,5].

All the correspondences shall be addressed to,
Dr. Doaa H. Elgohary
Department of Spinning and Weaving Engineering, Textile Industries Research Division, National Research Centre, 33 El Bohouth st. (Former El Tahrir St.), Dokki, P.O.12622, Giza, Egypt. Email : d_ego44@hotmail.com

Air permeability efficiency is depended on the total size of both voids and pore size. Hairy fibers and fabrics have a good heat and moisture insulation efficiency than the smooth ones this can be interpreted due to the air volume within fabric [8].

Technical textiles are a type of fabric materials that are widely manufactured for their execution and technical characterization unlike other types of textiles which are manufactured for aesthetic properties [9]. Some parameters affecting the designed technical textiles in order to achieve the end use properties including yarn materials and counts, weave structure, yarn twist factor for either warp or weft [10].Technical textiles are widely used in many different applications like military, medical field, agriculture, space craft and communications [11, 12, 13].

The first development of phase change materials of microcapsules technology inside of textile materials was in 1987 [14]. Phase change materials are compounds that have the ability to store energy during heating process and release energy during cooling process. The phase change can be converting from one state to another, either from liquid to solid or from solid to liquid. The role of phase change materials in textiles are depending on both time and temperature. When the temperature is rising up heat the microcapsules of PCM respond by absorbing the heat and storing energy which is called latent, despite of falling the temperature down the microcapsules act to release temperature to act in solid state [15, 16, 17, 18, 19, 20, 21, 22]. On the other hand, latent heat is the most adequate way for improving the thermal execution for clothes during the change from one state to another according to conditions of temperatures [23, 19].

Phase change materials are conducted into textiles in various forms like lamination, coating, bi-component synthetic fiber extrusion, encapsulation, finishing and melt spinning, etc,,, [24, 21, 25].. Furthermore, phase change materials are used in various applications including solar and civil engineering, heat pump, aerospace suits and textile scope particularly technical and smart textiles [26, 27]. The objective of this research was to analyze the comfort properties of thermo-regulating textile materials with different yarn materials and weave structures in order to meet special requirements for military application.

2. Materials and Methods

A research-based study was done for the manufactured samples with various specifications, as illustrated in Table, three different materials (polyester-pcm, viscose-pcm and bamboo) with three different weft yarn count (80, 148 and 221) Denier respectively. The micro PCMs are incorporating into the polyester and viscose fibers, as shown in Figure 1.1. Warp yarn count was constant for all samples 106 Denier, three weave structure were used for each material, warp density was constant for all samples 36 ends/cm, while weft density varied between 30 or 40 according to each sample, as illustrated in Table 1.1.

Figure 1.1: SEM of Outlast® for (a) Polyester and (b) Viscose [28].

Table 1.1: Characterization of Samples

Samples Code	Warp Yarn Material	Weft Yarn Material	Warp Yarn Count (Denier)	Weft Yarn Count (Denier)	Fabric Density (Ends * Picks)/cm	Weave Structure	Mass per Unit Area (g/m^2)[29]	Thickness (mm) [30]
S1	Cotton	Polyester-pcm	106	80	36*40	Plain 2/2	153	0.3
S2		Polyester-pcm		80	36*40	Twill 2/2	153	0.3
S3		Polyester-pcm		80	36*40	Twill 1/3	149	0.3
S4		Viscose-pcm		148	36*30	Plain 2/2	174	0.4
S5		Viscose-pcm		148	36*30	Twill 2/2	162	0.4
S6		Viscose-pcm		148	36*30	Twill 1/3	169	0.4
S7		Bamboo		221	36*30	Plain 2/2	235	0.5
S8		Bamboo		221	36*30	Twill 2/2	213	0.5
S9		Bamboo		221	36*30	Twill 1/3	211	0.5

*Note: Yarn counts for (cotton, viscose and bamboo) were converted into denier count

2.1. Comfort Properties Conducted for Manufactured Samples

Laboratory tests were performed according to standard conditions during 24 hr according to ASTM D 1776 [31] to investigate the performance of produced samples in order to achieve the specifications of military textiles.

2.1.1. Water Vapour Permeability for Fabrics

This test was carried out using cup method according to the British standard BS 7209:1990 [32].

2.1.2. Air Permeability for Fabrics

This test was carried out by using The Digital Air Permeability Tester M021A (SDL ATLAS) according to the American Standard Specification of ASTM D737 [33].

2.1.3. Stiffness of Fabric

Stiffness was performed using JIKA (TOYOSEIKI) according to ASTM D 1388 [34].

2.1.4. Ultraviolet protection factor (UPF)

A UV-VIS Spectrophotometer instrument was used to measure the ultraviolet protection for the manufactured samples, the UPF test was conducted to show the transmittance or blocking of ultraviolet radiation through the samples, the test variable was performed according to AATCC-183 test method [35].

2.2. Differential Scanning Calorimetry (DSC)

This test was carried out by using shimadzu dsc-60 instrument, according to the American Standard Specification of ASTM E793 [36].

2.3. Scanning electron microscope (SEM)

Scanning electron microscope was conducted for manufactured samples using a scanning electron probe micro analyzer (type T-scan)– Czech Republic at accelerating voltage 5kV. The samples were prepared at approximately

1×1cm; the samples were marked with permanent marker in order to identify the samples. The samples were stained at separate equipment using a gold material, after staining step the samples were transported to the scanning electron probe micro analyzer.

2.4. Samples Statistical analysis

All the output results were presented and tabulated as mean values with their standard deviation, the significant difference between comfort properties were analyzed using ANOVA Two-way Repeated Measurements. The difference between textile materials and weave structures were statistically analyzed using Tukey post hoc test, all statistics were done using IBM® SPSS® (SPSS Inc., IBM Corporation, NY, USA) Statistics Version 22 for Windows, The level of significance was assigned at P value=0.05.

3. Results and Discussions

After the manufacturing of nine woven fabrics, comfort properties were conducted for all samples, the average of results values were calculated, presented and discussed. Radar chart was applied to investigate the performance of the samples in an order from best to lowest according to radar area.

3.1. Samples Comfort Properties

From the statistical analysis of Table 3.1 and Figure 3.1 for water vapour permeability variable, it was indicated that there was a significant effect for the weave structures and textile materials of the test variable at P-value (p=0.000), (p=0.001) respectively and the interaction between the textile materials and weave structures were highly significantly affected at P-value (p=0.000), as determined by Two- way Anova repeated.

According to a Tukey post hoc test for textile materials it was showed that there was a significant difference between bamboo and polyester, bamboo and viscose at P-value (p=0.009), (p=0.001) respectively, while the relation between polyester and viscose was non-significant at P-value (p=0.560). For weave structure Tukey post hoc was revealed that (plain 2/2, twill 2/2), (plain 2/2, twill 1/3) and (twill 2/2, twill 1/3) were significantly affected at P-value (p=0.000), (p=0.000) and (p=0.014) respectively.

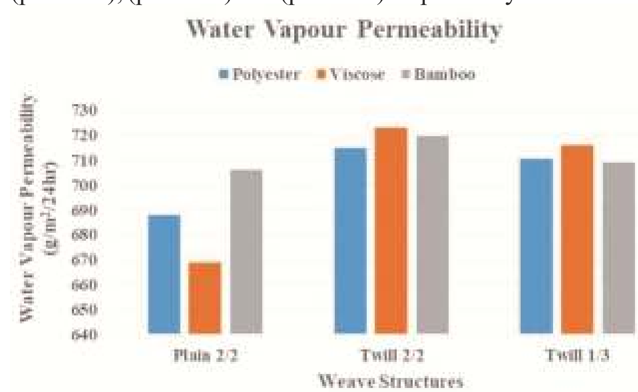


Figure 3.1: Water Vapour Permeability for Samples

Table 3.1: Water Vapour Permeability Results

Test Variables	Weave Structure	Materials 1	Materials 2	Materials P-value	Mean	F-value	P-value	Material * Structure F-value	Material * Structure P-value
		Mean ± S.D.							
Water Vapour Permeability	Plain 2/2	687.7 ± 5.0	668.7 ± 5.5	706.7 ± 6.7	687.7^a	113.702	0.000	21.803	0.000
	Twill 2/2	714.7 ± 5.5	723.2 ± 2.5	719.6 ± 5.0	719^c				
	Twill 1/3	711.3 ± 1.5	715.5 ± 5.0	709.2 ± 0.6	712.1^b				
	Mean	704.6^a	702.3^a	711.9^b					
	F-value	10.6							
	P-value	0.001							

a–c Means with different superscripts differ ($p < 0.05$). Probability of significant effect due to the difference in materials and structures.

For Air permeability variable, it was shown from Table 3.2 and Figure 3.2 it was significantly affected by both the textile materials and weave structures at P-value (p=0.000) and according to the interaction between the textile materials and structures there was a high significant difference at P-value (p=0.000), as demonstrated by Two- way Anova repeated.

Tukey post hoc was revealed for textile materials, although the relation between bamboo and polyester was non-significant at P-value (p=0.718), the relation between bamboo and viscose, polyester and viscose at P-value (p=0.000). For weave structures of Tukey post hoc it was demonstrated the relation between all structures was highly significant at P-value (p=0.000).

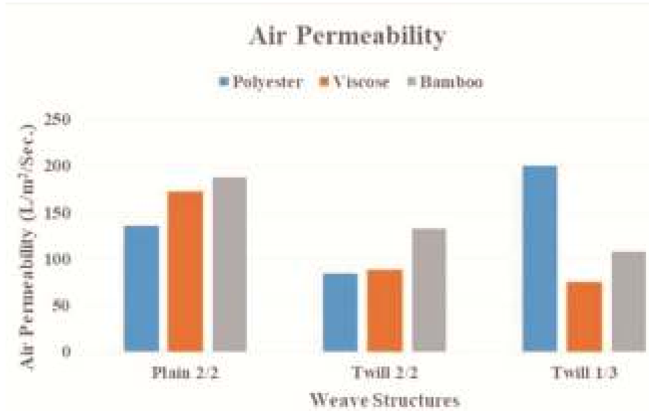


Figure 3.2 : Air Permeability for Samples

Table 3.2: Air Permeability Results

Test Variables	Weave Structure	Materials			Mean	F-value	P-value	Material * Structure	
		1	2	3				F-value	P-value
		Mean ± S.D.							
Air Permeability	Plain 2/2	136 ± 6.4	172.7 ± 6.1	187.3 ± 6.4	165.3^{c}	248.619	0.000	192.070	0.000
	Twill 2/2	84.3 ± 2.3	87.9 ± 5.6	132.3 ± 3.1	101.5^{a}				
	Twill 1/3	200 ± 5	74.3 ± 1.4	107.5 ± 10.8	127.3^{b}				
	Mean	140.1^{b}	111.7^{a}	142.4^{b}					
	F-value	70.782							
	P-value	0.000							

a–c Means with different superscripts differ ($p < 0.05$). Probability of significant effect due to the difference in materials and structures

It was shown from Table 3.3 and Figure 3.3 that stiffness at both directions warp and weft for all samples was significantly affected with both the weave structure and the textile materials used at P-value (p=0.000), also the interaction between the textile materials and structures has a significant effect at P-value (p=0.000), as demonstrated by Two- way Anova repeated.

It was observed from the Tukey post hoc of warp stiffness for textile materials that there was no significant difference between bamboo and polyester at P-value (p=0.211), despite of the relation between bamboo and viscose, polyester and viscose at P-value (p=0.003), (p=0.000) respectively, while for weft stiffness there was significant difference between bamboo and polyester, bamboo and viscose at P-value (p=0.000), although there was no significant effect between polyester and viscose at P-value (p=0.929).

For the textile structures of warp stiffness and according to Tukey post hoc test it was revealed that there was significant difference between plain 2/2 and twill 2/2 at P-value (p=0.004), between plain 2/2 and twill 1/3 at P-value (p=0.001), in spite of there was no significant effect between twill 2/2 and twill 1/3 at P-value (p=0.842). While for stiffness at weft direction there was no significant difference between plain 2/2 and twill 2/2 at P-value (p=0.478), although both structures (plain 2/2, twill 1/3) and (twill 2/2, twill 1/3) were significantly affected at P-value (p=0.000).

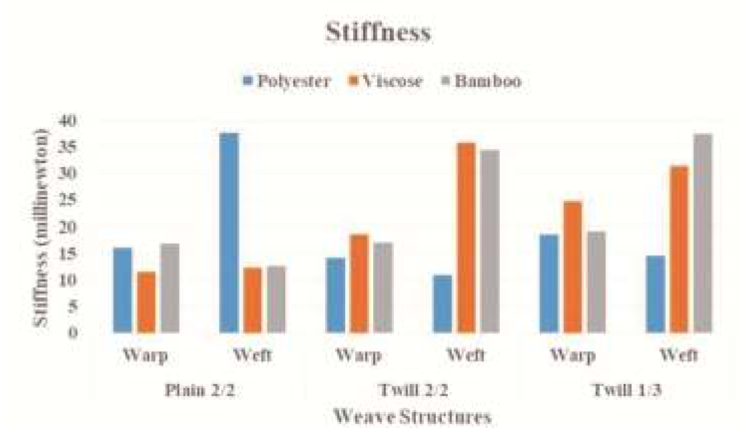


Figure 3.3: Stiffness for Samples

Table 3.3: Stiffness Results

Test Variables	Weave Structure	Materials 1 (Mean ± S.D.)	Materials 2 (Mean ± S.D.)	Materials 3 (Mean ± S.D.)	Mean	F-value	P-value	Material * Structure F-value	Material * Structure P-value
Warp Stiffness	Plain 2/2	16.1 ± 6.9	14.2 ± 4.1	18.5 ± 3.0	16.3[a]	11.056	0.001	30.363	0.000
	Twill 2/2	11.4 ± 4.4	18.5 ± 11.2	24.6 ± 10.9	18.2[b]				
	Twill 1/3	16.9 ± 3.8	17.1 ± 5.1	19.2 ± 2.9	18[b]				
	Mean	14.8[a]	16.6[b]	20.8[a]					
	F-value	16.427							
	P-value	0.000							
Weft Stiffness	Plain 2/2	37.6 ± 23.2	10.9 ± 3.8	14.5 ± 6.7	21[a]	28.551	0.000	52.965	0.000
	Twill 2/2	12.2 ± 3.6	35.8 ± 18.0	31.3 ± 20.3	26.4[a]				
	Twill 1/3	12.7 ± 5.2	34.4 ± 29	37.4 ± 20.4	28.2[b]				
	Mean	20.8[a]	27[a]	27.7[b]					
	F-value	17.529							
	P-value	0.000							

a–b Means with different superscripts differ ($p < 0.05$). Probability of significant effect due to the difference in materials and structures

It was observed that from Table 3.4 and Figure 3.4 that the UPF variable was significantly affected by textile structures and materials at P-value (p=0.000), and the interaction between the weave structures and textile materials were significantly affected at P-value (p=0.000), as determined by Two- way Anova repeated.

According to Tukey post hoc test for textile materials it was clear that all materials were significantly affected at P-value (p=0.000), also for weave structures there were a significant difference for all structures (plain 2/2, twill 2/2), (plain 2/2, twill 1/3) and (twill 2/2, twill 1/3) at P-value (p=0.005), (p=0.005), (p=0.000) respectively.

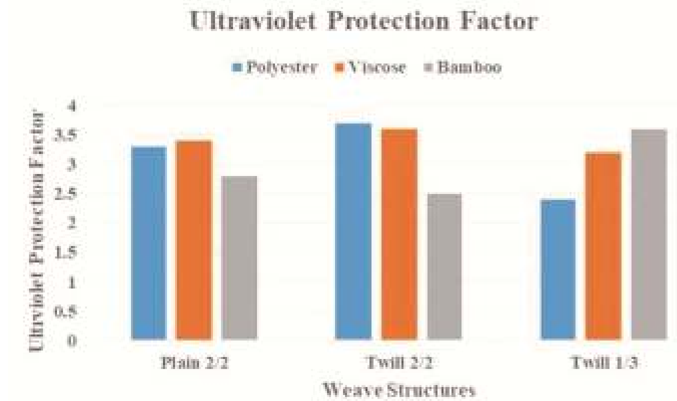


Figure 3.4: Ultraviolet Protection Factor for Samples

Table 3.4: Ultraviolet Protection Factor Results

Test Variables	Weave Structure	Materials			Mean	F-value	P-value	Material * Structure	
		1	2	3				F-value	P-value
		Mean ± S.D.							
Ultraviolet Protection Factor	Plain 2/2	3.3 ± 0.1	3.4 ± 0.1	2.8 ± 0.1	3.2^b	27.000	0.000	349.500	0.000
	Twill 2/2	3.7 ± 0.1	3.6 ± 0.1	2.5 ± 0.1	3.3^c				
	Twill 1/3	2.4 ± 0.1	3.2 ± 0.1	3.6 ± 0.1	3.1^a				
	Mean	3.2^b	3.4^c	3a					
	F-value	129.0							
	P-value	0.000							

a–c Means with different superscripts differ ($p < 0.05$). Probability of significant effect due to the difference in materials and structures

3.2. Ultraviolet protection factor (UPF)

From the statistical analysis of Table 3.4, it was indicated that sample 2 using polyester material and twill 2/2 textile structure recorded the highest value for UPF, while sample 3 recorded the lowest results using polyester material and twill 1/3 textile structure.

3.3. Analyzing the Comfort Properties to Determine the Best Performance for Samples according to Radar Chart

The given results for comfort properties of samples were analyzed using radar chart, as shown in Figure (3.5), (3.6), (3,7) the radar area for each sample was calculated and the samples were ordered from best to lowest. It was observed from Table 3.5 that sample 6 recorded the highest radar area while sample 2 recorded the lowest radar area.

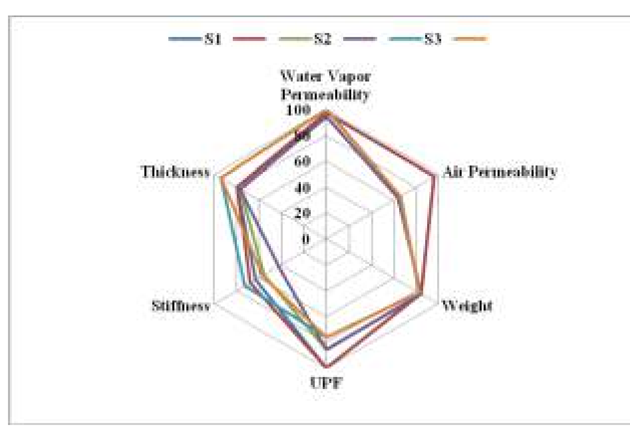


Figure 3.5: Radar Chart for Samples 1, 2 and 3

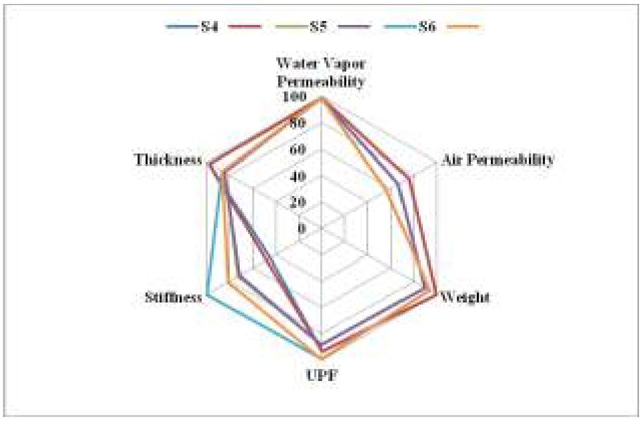


Figure 3.6: Radar Chart for Samples 4, 5 and 6

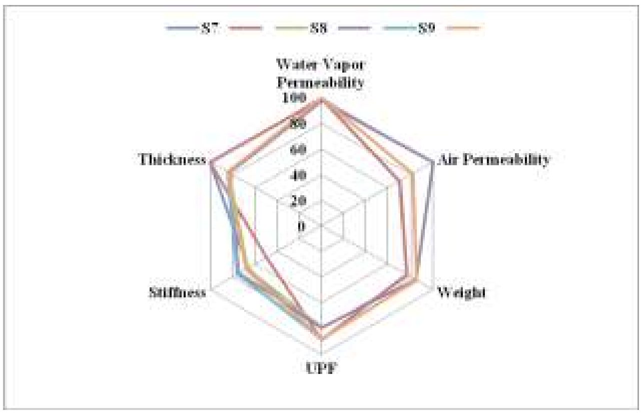


Figure 3.7: Radar Chart for Samples 7, 8 and 9

Table 3.5: The order of Manufactured Samples from Best to Lowest

Samples Code	Radar Chart Area
S6	44755.2
S1	44372.5
S8	43136.6
S9	42338.6
S4	41988.1
S5	40367.9
S7	39037.7
S3	37808.9
S2	33342.1

3.4. Differential Scanning Calorimetry

Differential Scanning Calorimetry test was performed for samples 6 and 1 according to the radar chart result for best performance samples; the heat analysis was done to examine the thermal behavior. The samples are prepared in hermitically sealed aluminium sample pans. Testing is performed under constant N_2 flow. Test conditions consist of cooling to –10°C, isothermally holding for one minute then heating from –10°C to 50°C at 5°C/min., isothermally holding for one minute at 50°C, then cooling from 50°C to –10°C at 5°C/min. The heat storage capacity of the micro capsulated samples 6 and 1 were 11.76 J/g and 2.82 J/g respectively, as shown in Table 3.6. The thermal capacities per square meter were calculated by the following equations:

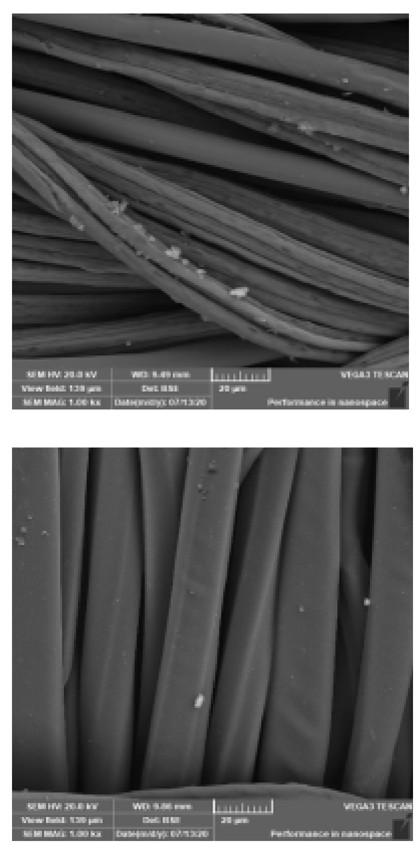
Table 3.6: Differential Scanning Calorimetry Test Results

Sample code	Latent heat (j/g)	Thermal capacity per square meter (j/m^2)
S6	11.76	1987.4
S1	2.82	431.46

It is clear from table 3.6, that the sample 6 which produced from viscose have recorded the highest rates to the thermal capacity followed by sample 1 which produced from polyester. This is owing to physical properties of Viscose which has high percentage of amorphous fibers followed by Polyester leads to an increase in the heat absorbent capacity of Viscose more than Polyester. In addition to the Phase change materials in the form of microcapsules were located inside mono-component viscose fibers during wet spinning process, on the other hand polyester fibers used a melt spinning process by producing a multi-component fiber comprises a phase change material core, and a sheath from polyester material surrounds the core member. Therefore viscose yarns gave more heat capacity than polyester yarns [37,38].

3.5. Scanning Electron Microscope (SEM)

A scanning electron was performed for samples 6 and 1, as presented in Figure 3.8 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 1000X. Figure 8 illustrates a number of fibers with smooth surface for both samples.



(a)

(b)

Figure 3.8: Scanning Electron Microscope for Samples 6 (a) and 1 (b)

4. Conclusion

The aim of this research was to investigate the impact of comfort properties on the manufactured samples. Four comfort properties were performed for all samples; the results were presented, tabulated and discussed. Two- way Anova repeated statistical analysis showed that the four comfort properties were significantly affected by both textile materials and weave structure at P-value ($P < 0.05$) for all samples. Radar chart show that sample six followed by sample one was the best performance samples. Scanning electron microscope and Differential Scanning Calorimetry were conducted according to the radar chart area results, in which the scanning electron microscope show the surface morphology of samples 6 and 1, furthermore, for differential scanning calorimetry show that sample 6 manufactured from viscose have recorded the highest rates followed by sample 1 which produced from polyester. This can be concluded as the Phase change materials in the form of microcapsules were located inside mono-component viscose fibers during wet spinning process, while polyester fibers used a melt spinning process by producing a multi-component fiber comprises a phase change material core, and a sheath from polyester material surrounds the core member. Finally, viscose yarns gave more heat capacity than polyester yarns.

4. Funding

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

References

[1] Islam M., Rokon A.A., Rubel M.C., Ahmed M., Islam A., Investigation on Comfort Properties of Conventional Cotton and Organic Cotton of Knitted Fabric Structures, *Manufacturing Science and Technology*, **2**(3), 62-66 (2014). DOI: 10.13189/mst.2014.020303.

[2] Afzal A., Ahmad S., Rasheed A., Ahmad F., Iftikhar F., Nawab Y., Influence of Fabric Parameters on Thermal Comfort Performance of Double Layer Knitted Inerlock Fabrics, *AUTEX Research Journal*, **17** (1), 20-26 (2017). DOI: 10.1515/aut-2015-0037.

[3] Das S., Study on Comfort Properties of Different Woven Fabric, *International Journal of Management and Applied Science*, **2** (8), 57-61(2016). ISSN: 2394-7926.

[4] Scacchetti F.A.P., Soares G.M.B., Chemical Characterization and Thermal Comfort Properties of Cotton Finished with Phase Change Materials and Antimicrobial Agents, *Cellulose Chemistry and Technology*, **53** (3-4), 363-371 (2019).

[5] Chinta S.K., Gujar P.D., Significance of Moisture Management for High Performance Textile Fabrics, *International Journal of Innovative Research in Science, Engineering and Technology*, **2** (3), 814-819 (2013). ISSN: 2319-8753.

[6] Jhanji Y., Khanna S., Manocha A., Comfort Characteristics of Textiles - Objective Evaluation and Prediction by Soft Computing Techniques, National Conference on Advances in Engineering, Technology & Management, *IOSR Journal of Computer Engineering* (IOSR-JCE), 42-47. e-ISSN: 2278-0661, p-ISSN: 2278-8727.

[7] Saha P.K., Haque A., Islam T., Paul D., Saha J.K., A Study on Thermal Comfort Feeling Properties of 60%/40% and 80%/20% Cotton/Polyester and 100% Cotton Fleece, *Journal of Textile Science & Fashion Technology*, **4** (3), 1-5 (2019). DOI: 10.33552/JTSFT.2019.04.000586.

[8] Classen E., Comfort testing of textiles, Advanced Characterization and Testing of Textiles, The Textile Institute Book Series, Woodhead Publishing, Elsevier, 2018, 59-69. ISBN: 978-0-08-100454-8.

[9] Basuk M., Choudhari M., Maiti S., Adivarekar R.V., Moisture Management Properties of Textiles and Its Evaluation, *Current Trends in Fashion Technology & Textile Engineering*, **3** (3), 0050-0055 (2018). DOI: 10.19080/CTFTTE.2018.03.555611. ISSN: 2577-2929.

[10] Elgohary D.H., Abo El Amaim Y.A., Taha G.M., Reda S.M., Evaluation the Impact of UVB Radiation on different High Performance Fabrics Treated with Nanomaterials, *Egyptian Journal of Chemistry*, **62**(12), 1-10 (2019). DOI: 10.21608/ejchem.2019.11040.1709.

[11] Elgohary D.H., Abo El Amaim Y.A., The Influence of Using Different Textile Structures and Yarn Counts on the Mechanical Properties of Woven Sacks, *Journal of the TEXTILE Association*, **78**(5), 301-308 (2018). ISSN 0368-4636.e-ISSN 2347-2537.

[12] 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). ISSN0368-4636. E- ISSN 2347- 2537.

[13] Fayed, A.I.H., Abo El Amaim, Y.A., Elgohary, D.H., Enhancing the Performance of Cordura and Ballistic Nylon using Polyurethane Treatment for Outer Shell of Bulletproof Vest, Journal of King Saud University- Engineering Sciences, (2021). https://doi.org/10.1016/j.jksues.2021.02.001.

[14] Shin Y., Yoo D., Son K., Development of Thermoregulating Textile Materials with Microencapsulated Phase Change Materials (PCM). IV. Performance Properties and Hand of Fabrics Treated with PCM Microcapsules, *Journal of Applied Polymer Science*, 97, 910–915 (2005). DOI 10.1002/app.21846.

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

[16] Kanimozhi B., Ramesh Bapu B.R., Sivashanmugam M., Enhancement of Solar Thermal Storage System using PCM, *National Journal on Advances in Building Sciences and Mechanics*. **1**(2), 48-52 (2010).

[17] Fredi G., Dorigato A., Pegoretti A., Multifunctional glass fiber/polyamide composites with thermal energy storage/release capability, eXPRESS Polymer Letters, **12** (4), 349–364 (2018). https://doi.org/10.3144/expresspolymlett.2018.30.

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

[19] Khan A., Pervez N., A Study on Phase Change Material with Reference to Thermal Energy Storage by Using Polyethyleneglycol-1000 to Create Thermo-Regulating Fabric, *International Journal of Textile Science*, **4**(3), 53-59 (2015). DOI: 10.5923/j.textile.20150403.01.

[20] 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).

[21] 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). e-ISSN: 2395-0056. p-ISSN: 2395-0072.

[22] Lin S., Phase Change Materials' Application in Clothing Design, *Transactions of the Materials Research Society of Japan*, **37**(2), 103-106 (2012).

[23] Arjun D., Hayavadana J., Thermal Energy Storage Materials (PCMs) for Textile Applications**,** *Journal of Textile and Apparel, Technology and Management*, **8** (4), 1-11 (2014).

[24] Ghosh S., Bhatkhande P., Encapsulation of PCM for Thermo-Regulating Fabric Application, *International Journal of Organic Chemistry*, 2, 366-370 (2012). http://dx.doi.org/10.4236/ijoc.2012.24050.

[25] Onofrei E., Rocha A. M., Catarino A., Textiles Integrating PCMS – A Review,. LVI (LX), f. 2, 2010, Buletinul Institutului Politehnic din Iaşi. Electrotehnică, Energetică, Electronică, 99-110 (2010).

[26] Iqbal K., Khana A., Sunb D., Ashrafa M., Rehmana A., Safdara F., Basitd A., Maqsood H. S., Phase change materials, their synthesis and application in textiles—a review, The Journal of the Textile Institute, **110** (4), 625–638 (2019) .https://doi.org/10.1080/00405000.2018.1548088.

[27] Mondal S., Phase change materials for smart textiles – An overview, Applied Thermal Engineering. Xxx, xxx–xxx (2007). doi:10.1016/j.applthermaleng.2007.08.009.

[28] http://www.outlast.com (September 2020).

[29] ASTM D3776 **"**Standard Test Methods for Mass per Unit Area (Weight) of Fabric**"** (2020).

[30] ASTM D1777 **"**Standard Test Methods for Thickness of Textile Materials**"** (2020).

[31] ASTM D1776/D1776M, **"**Standard Practice for Conditioning and Testing Textiles**"(**2020).

[32] BS7209 "Specification for Water Vapour Permeable Apparel Fabrics" (1990).

[33] ASTM D737 "Standard Test Methods for Air Permeability of Textile Fabrics" (2012).

[34] ASTM D1388 "Standard Test Methods for Stiffness of Fabrics" (2012).

[35] AATCC 183 "Transmittance or Blocking of Erythemally Weighted Ultraviolet Radiation through Fabrics" (2004).

[36] ASTM E793 "Standard Test Method for Enthalpies of Fusion and Crystallization by Differential Scanning Calorimetry" (2001).

[37] Mattila H. R., Intelligent Textiles and Clothing, Woodhead Publishing Limited and CRC Press LLC, (2006).

[38] 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).

■ ■ ■

A Wearable Technology in the Field of Medical Textile - Intelligent Functional Clothing

Ms. Swapnil Kulshrestha & Mr. Siddharth Phalke

Textile Manufacturers Department, Veermata Jijabai Technological Institute (VJTI), HR Mahajani Road, Matunga, Mumbai

Abstract:

For the direct interaction of the body with its medical analysis through textile, Intelligent Functional Clothing (part of SFIT - Smart Fabrics and Interactive Textiles) comes into action; where technology meets medical textile to make medication continuous, direct and faster. The manufacturing of Intelligent Functional Clothing is done by connecting hair like thin electrodes and microprocessors with the appropriate textiles. Currently an external source of energy is used for its working which adds a tedious task of removing and attaching this source for recharging and for washing since it breaks the monitoring flow. Hence, there is a need of generating a medium which is also repetitively washable. In the busy lifestyle of this era and the growing rate of diseases, many miss out on routine checkups. So, making Intelligent Functional Clothings (IFCs) for personal health records and making it user-friendly enough is the solution. With pros, there are cons which are to be overcome by advancement in this field. But the biggest challenge it is facing is sustaining itself in the market of wearable technologies. By resolving these issues and gaining the trust of the consumers on this product, the sector of Intelligent Functional Clothing is bound to flourish.

Keywords: : *IFC, Intelligent Functional Clothing, Medical Textiles, and Textile Technology.*

1. Introduction:

The wearable industry gained momentum in the 2000s, but a handful of 20th century technologies are the originators of wearable technology. Wearables have evolved to become a global industry worth $27B from the emergence of wearables in the 1970s. If you apply the following two-part criteria for defining a wearable device, you can see that the wearable marketplace dates back to the 1970s. Wearables must be marketed to serve many industries. [1]

1.1 History of Wearable Technology:

Evolution of wearable technology went about gradually and slowly over the years as shown fig.1.1, from 1975 to today. This is explained below:

- Comfortably worn on the body for extended periods of time
- Use of independently powered sensors or microcomputers to process information. In addition to the notable reduction of size of the wearables device over time, from the Sony Walkman's 0.5 lb. to the 0.3 ounce Fitbit Zip, the "smart" component of wearables.

In the last 10 years, "smart" wearables have advanced in two primary areas:

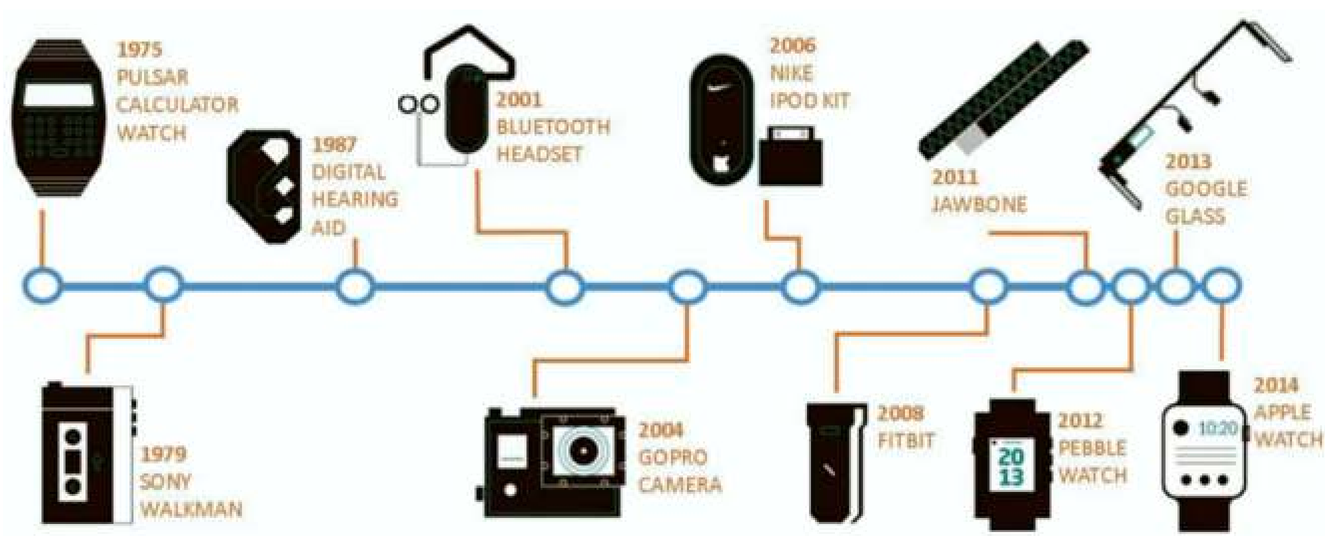


Figure 1.1: Evolution of the Wearable Market Industry[2]

- The ability to collect personal data (Nike iPod, GoPro)
- The ability to provide Real Time data insights to users (Fitbit, Jawbone, Pebble)

These advancements, coupled with the ubiquity of smartphones, have primed the market for smart, wearable, personal devices such as the Apple Watch. However, notable

***All the correspondence should be addressed to:**
Ms. Swapnil Kulshrestha
Email : kulshresthaswapnil05@gmail.com
Mr. Siddharth Phalke
Email : siddharth.sp45@gmail.com

missing from the current timeline are smart clothing products. Until recently, technology and cultural and market conditions have not been aligned to support the adoption of smart clothing. Hence now finally, an increase in the smart clothing market is seen. Intelligent functional Clothing has been growing in the market but still there are a lot of advancements to be done and lots of cons to be overcome. An integral part of SFIT (Smart Fabrics and Interactive Textiles) is Intelligent functional Clothing which also has a lot of scope but still there are a lot of advancements to be done and lots of cons to be overcome.[1]

In this paper, the main objectives are studying:

- Recent trends and application in the field of wearable technology.
- To know the need for personalising IFCs.
- To know the advancements needed in the current market production of IFCs.
- To know the manufacturing methods of these IFCs.
- To learn about the market of IFCs.

2. Recent developments and applications in the field of Wearable Technology

The application of these new technologies made a profound social impact not only on the employees but also the location of those employees in clothing production. The world of apparel is very different today, as the designers are taking inspiration from modern gadgets and amalgamating clothes and technology to come up with apparel that are awe-inspiring and techno-savvy. Different applications and technology used in the respective applications are given below:

1. Counter-surveillance fashion is becoming more common. The common phrase used to describe such clothing is stealth wear. Such clothes are designed to protect the wearer from detection and surveillance. There are hoodies and cloaks available under this category. The special clothing uses reflective and metallic fabric, which is generally used in protective gear for firefighters. In practice, this limits the wearer's visibility to aerial surveillance vehicles employing heat-imaging cameras to track people on the ground.[2]
2. The solar energy concept, a solar bikini has been created that contains fine strips of photovoltaic film which is stitched on with a conductive thread. The suit produces a five volt output that, via the attached USB connector, can recharge gadgets like the iPod.[2]
3. More similar innovations easily available in the market are deodorizing fabrics, insect killer clothing, breathable fabrics, hazard warning clothing, functional sportswear, medical and safety wear, anti-stress wear etc. They use stimuli sensitive materials in fabrics that respond to external factors like changes in temperature. Thus there are also sweat proof garments in the market that adjust according to changes to the outer temperature.[2]
4. The use of ThermoChromic materials (TCM) is also seen in many applications. Such materials respond to the changes in environmental temperature by changing the colour of the fabric to suit the external climate. Similarly, there are Phase Change Materials (PCM) in fabrics, that soak up the heat energy when it changes from solid to liquid state and discharges heat energy when it reverts back, which gives a temporary cooling or heating effect on the clothing layer and keeps the wearer comfortable.[2]
5. Colour Changing Fabrics are also very common these days. These fabrics are developed by integrating chromic materials within the fabrics. Chromic materials change colour based on changes in atmospheric condition. The reversible change in colour of these fabrics is termed as chromism. The chromic materials are classified on the basis of stimulus: ThermoChromic (Heat), PhotoChromic (Light), Iono Chromic (pH value), ElectroChromic (Electricity), PiezoChromic (Pressure), Solvate Chromic (Liquid), Carsol Chromic (Electron beam). Among these categories, thermo chromic and photo chromic materials are most commonly used and are also commercially viable.[2]
6. Another addition to the range of smart fabrics is conductive and composite textile. This range includes wearable electronics. Also known as e-apparel, here electronics are added to the textile. The modern day micro-system technology is constantly improving and there are tinier components available that are merging intelligence with more exclusive products. More recently, a newer tech has been developed by a British company that makes it easier to remove zippers, buttons, fastenings, tags, logos, linings and other materials from the used garment without damaging the surrounding fabric. Garments essentially fall apart on command, making it easier to recover and reuse pure fibres.[2]
7. Major Smart Shirts and Smart Undergarments which can monitor heart rate viability, anaerobic threshold, fitness and stress levels,etc., use a clip-on box to record data and it is integrated in the garment. Although the sensors are hidden and invisible from top, the downside of these is that the clip-on box has to be removed before washing and for charging.[3]

3. The need to personalise IFCs

In this busy running lifestyle, the rates of diseases, heart attacks and sudden deaths have increased rapidly. Cardiovascular disease is a leading cause of global mortality, accounting for almost 17 million deaths annually or 30% of all global mortality. In developing countries, it causes twice as many deaths as HIV, malaria and TB combined. It is estimated that about 40- 50% of all cardiovascular deaths are sudden cardiac deaths (SCDs) and about 80% of these are caused by ventricular tachyarrhythmias. Therefore, about 6 million sudden cardiac deaths occur annually due to ventricular tachyarrhythmias. The survival rate from sudden cardiac arrest is less than 1% worldwide and close to 5% in the US. And the main risk factors behind this increasing death rate are lack of exercise, inappropriate diet, stressed lifestyle and smoking. It is suggested that after a certain age, one should go for routine checkups, but a survey by the International Journal of Technical Research and Application shows that only 22% of the population goes for routine checkups.[4]

Now, to solve this problem, imagine if one does not have to go to the doctor physically, but the medical reports of the heart patient are sent to the doctor virtually. But again, people are not ready to accept this, so the idea is to basically fit the measuring devices in a normal breathable fitted t-shirt which never goes out of fashion. When people start accepting these Wearable Health Checkup Tees (WH T-Shirts), the market would be ready to accept the Full Body Monitoring suits (FBM Suit) strictly for medical purposes and having much more functions and monitoring than the WH T-shirts.

4. Why do we need an advancement in the field of IFCs:

Although there is an existing market of IFCs, we need some advancements as the current IFCs are facing some issues.[5]

There is a need for a new development and a plan as well to overcome the problem faced by IFCs like:

a. Design and technical difficulties:

Many creative ideas are difficult to achieve because of fabric constraints and technological backwardness. Applying theory to practical application is difficult in itself.

b. Cost efficiency.

As we go into more advanced and efficient levels of integration and the use of more tiny and microprocessor implants, the cost increases. At the same time, making it more fashion forward and comfortable are two aspects which themselves need attention.

c. Security issues.

Since the system works on processors, applications, programming-based systems, it could leak information to unwanted sources if not programmed properly. Technology always has its loopholes but must be covered on the basis of the application it is used for.

d. Lack of trust of people.

Gaining the trust of the people is the key requirement for any product to expand its market. But people prefer going to the doctors physically rather than trusting some device left to monitor all by itself. And with an issue like monitoring health, people do not like taking risks.

e. Difficult to promote in the market.

For any new product to become familiar with people, it takes years and ages. Marketing also becomes difficult when it is a new product and it has a lot of competition with lack of trust in the product itself.

f. Lack of fashion-oriented designing.

The main objective here is to achieve a certain function. Hence, the fashion aspect is usually overlooked and not paid attention to. Also, because of the functional integration, there are a lot of design limitations for the product development.

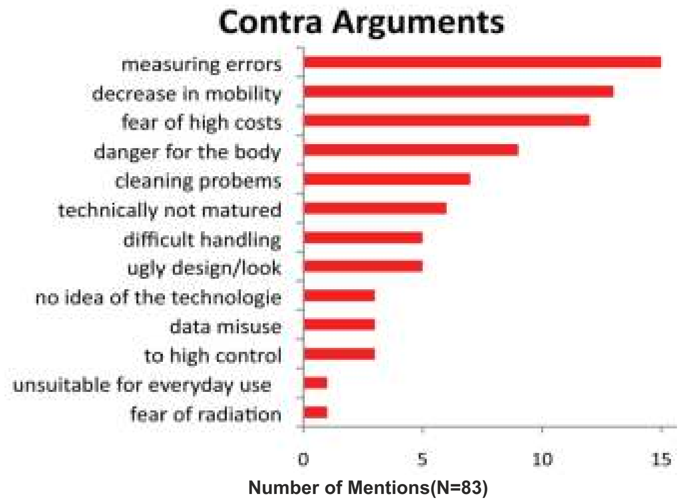


Figure 4.1: Problems faced by IFC[6]

More cons of IFCs and the degree to which it upsets the customers are given in the fig.4.1:

Since, the problem exists more in the acceptance in the market and the restrictions while manufacturing the IFC itself, the idea is to come up with something effective which is acceptable to the people and is efficient in its working too. But, there are multiple aspects that need to be considered while manufacturing an IFC.

5. Manufacturing of IFCs

The evolution of technical textiles takes cues from the electronics and photonics industries. The integration of sensor arrays and plastic optical fiber (POF) creates an extension of functional fabrics commonly known as smart textiles. At its core, technical textile manufacturing is a vast landscape of advanced yarn systems combined with textile formation techniques. The complete construction can be further transformed through lamination, coatings and composite methods.[6]

Depending on their use, smart fabrics are created by fusing together fibers and technology. These fibers include conductive yarns and polymers, shape memory polymers, encapsulated phase change materials, fiber optics, and other small electronics. They may also use external additions, such as:

- Sensors
- Chemical treatments
- Thermochromic dyes

These materials interact with one another along with external stimuli — such as temperature, light or pressure — creating a transfer of energy. Once activated, the functional fabric responds depending upon the textile's function.

According to Textile Institute (2006), smart clothing is located in the intersectional province of design research, physiology, and textile technology as shown in fig.4.1.

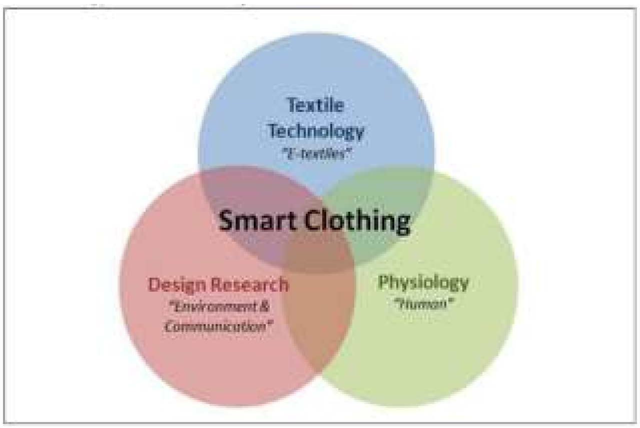


Figure 5.1: Multidisciplinary Approach to Smart Clothing[7]

6.1 Research Aspects

There are some aspects to be studied while making of the IFCs:

6.1.1 Design Research:

Design research focuses on product development issues and includes the objectives of environment and communication. The product development process is important because redesign costs become higher as the process goes closer to production, while costs to change designs remain lower in development stages.

There are some factors to be considered when Design Research for any IFC is done:

a. Product development -

It takes seven steps to identify users' needs and develop a product to meet identified needs. Functional clothing development process is in contrast with conventional clothing development in terms of the location of core stages. Generally, clothing products start with market needs and go through product- oriented processes where critical decisions are made in the design and evaluation phase. The overall process for functional clothing is not very distinguishable from the typical clothing design framework. However, the information-gathering stage focusing on the needs and preferences of the target customer has much more emphasis in functional design.[7]

b. Thermal comfort -

The body constantly generates heat from the metabolism and loses this heat to the environment. A balance must be maintained between the rates of heat production and heat loss. Discomfort becomes apparent when the body feels too hot or too cold. Thermal balance is closely related to the transport or conservation of heat and moisture throughout the garment system.[7]

c. Tactile material -

The interaction between fabric and human skin will stimulate various sensory receptors on the skin and may cause uncomfortable feelings such as tickle, itch, prickle, and abrasion of the skin. For the clothing, overall tactile feeling is more related to pressure and comfort which includes heaviness and tightness rather than prickliness, itchiness, and roughness.[7]

d. Mobile comfort -

The ease of movement is dependent on garment design and the relative size between body and clothing. High stretch fabrics have provided opportunities for the functional clothing to accommodate both tight-fitting and body movement. Mobility within clothing is reduced as technological function increases. If wearable technology incorporates bulky and stiff areas, they must be situated at specific locations on the body in order to avoid the abrasion and preserve mobility. [7]

e. Fashion -

The apparel is one of the products highly appealing to the aesthetic preference of the user. Aesthetically pleasing design is an integral part of the success in the fashion and apparel industry. Although technical aspects have strong influences in smart clothing development, we cannot expect the fashion industry to adapt itself to technology. Before we start designing smart clothing, we must ask ourselves which should be a decisive factor, form (style or fashion) or function (technical performance or technology).[5]

f. Degree of technological integration -

Until every part of technology can be made out of textile material without any functional limitation, technical components cannot be completely integrated into the clothes. To empower the appearance, technology must be simplified and invisible as much as it can. If technology is not invisible, it should have an attractive appearance and become fashionable accessories of the clothing such as a button or a zipper.Hence, degree of integration increases from pocket integration to integration of material into the textile material itself as shown in fig.6.1.1.[7]

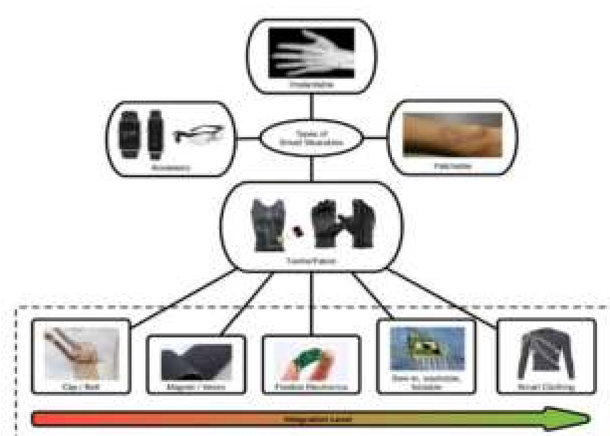


Figure 6.1.1.: Degree of integration[8]

6.1.2 Physiology:

Since these IFC's are to analyze and monitor the human body, there is a need to know about the human body. Only then it is possible to design wearable tech in order to gather the required data from the places to be analyzed (For e.g., An EKG vest needs to collect data from particularly 12 points on the chest and the back). Also, it is necessary to study about the radiations and the ill effects caused by the electronics used on the body, since it will be held very close to the skin. Hence, it becomes important to study about the human body and the data that must be collected in order to understand what all parameters are to be measured for knowing about any abnormal body behavior.

6.1.3 Textile Technology:

Textile Technology, the word itself suggests two parts:

a) The textile material to be used:

1) Whether the material to be used composes of:
- A single type of yarn
- A plied yarn with 2 or more textile yarns.
- A plied yarn with non-conductive and conductive thin wire.

2) The type of fabric to be used (Knitted, Woven, Non-woven)

b) Technology used behind manufacturing the IFCs and the electronic devices or chips or implants used for measuring the different body parameters. Some of them are given in Table.6.1.3.

TECHNOLOGY	FUNCTION	INTEGRATION
Optical Fibre	Signal Transfer	Woven
Processor	Data Transfer	Pocket
Electrode	Cardiopulmonary Signal	Implanted
Piezoresistive Sensors	Respiratory Data and Body Movement	Pocket
Temperature Sensors	Skin Temperature	Sewn on lining
Repiband	Respiratory Data	Sandwiched in between linings

6.2 Energy Sources:

Currently the energy sources majorly used are external sources such as batteries and cells which are to be recharged and removed while washing. This hinders the continuous body monitoring process. Also, this adds a negative point to the IFC and obstructs it from using it in a daily routine busy lifestyle. Hence, we need some inbuilt washable energy source.

There are 2 inbuilt sources which can be used:

a. Kinetic Energy: Kinetic Energy will be produced by the rubbing of the inner side of the cloth with the body when it is in the motion or any movement is done. Sensors will sense the movement and the heat produced due to rubbing and the heat energy will be converted to electrical energy.

b. Thermal Energy: Thermal energy will be produced by the thermal gradient between the body temperature and environment. The temperature sensors will sense the heat and convert this thermal energy into electrical energy.[9]

6.2.1 Turning Kinetic energy from body into thermal energy

In order to maintain a healthy lifestyle the average person is supposed to walk 10,000 steps a day. In other terms, the average person should be traveling five miles by foot every twenty-four hours (Parker-Pope, New York Times). This equates to a lot of human motion. In fact, in order for the average adult to be capable of transporting himself this far he is supposed to eat about 2,000 calories. However, depending on the person's basal metabolic rate, amount of physical activity and thermal effect of food, this number is subject to change (Discovery, Fit and Health). Their bodies virtually function as energy converters but instead of converting solar energy into electric energy for instance, they are converting energy from food into kinetic energy. The kinetic energy can be harnessed; much like some hydropower technologies harness water movement. A way to convert this kinetic energy into electric energy is through piezoelectricity. By applying a mechanical stress to a piezoelectric crystal or material an electric current will be created and can be harvested.[10]

6.2.2 Turning Body heat into electricity

The idea of converting the human body's energy into electricity has tantalized scientists for years. A resting male can put out between 100 and 120 watts of energy, in theory enough to power many of the electronics you use, such as your Nintendo Wii (14 watts), your cellphone (about 1 watt) and your laptop (45 watts). Eighty percent of body power is given off as excess heat. But only in sci-fi fantasies such as the Matrix film series do you see complete capture of this reliable power source. Recent developments in nanotechnology engineering promise to usher in lots more body-powered devices. The basic technology behind the concept of turning body heat into electricity is a thermoelectric device. It is usually a thin conductive material that exploits the temperature difference between its two sides to generate electricity, known as the Seebeck effect. Such devices can work in reverse, meaning if you were to apply electricity to the device, one side would get extremely cold and the other extremely hot. There's even greater potential in improving the efficiency of thermoelectric generators.[11]

While ThermoElectric(TE) technology has been used in military and aerospace applications for decades, new TE materials and systems are being developed to generate power using low or high temperatures waste heat, and that could provide a significant opportunity in the near future. These systems can also be scalable to any size and have lower operation and maintenance cost.[12]

6.3 A lead for an innovative solution:

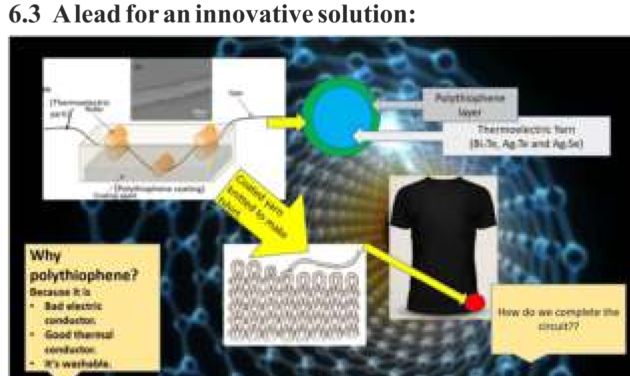


Figure 6.3.1.: Making of Fabric

It is true that IFCs are 'Interlooping Threads of Technology' serving the fundamental function of monitoring the body behaviour but it will be successful only when it is able to fulfill the basic demands of a comfortable apparel. Comfort is difficult to achieve in functional textile applications, hence is lacking in the existing models of IFCs. So, the basic requirements of the fabric for making IFCs are: breathability, heat absorption, energy conversion (heat/kinetic energy to electrical energy, as seen in 6.2), electrically conductive on the inside but electrically insulated from the outside, flexibility and stretchability.

Hence a material which can convert thermal energy to electrical energy is needed, so it has to be a Thermoelectric material-based yarn (which are also made from Bi_2Te_3 or Ag_2Te or Ag_2Se)[9]. But this if worn directly against the skin, will transfer current to the body as well. Hence, it is needed to coat the thermoelectric yarn with a material, as shown in fig.6.3.1., which allows heat transfer but is a bad conductor of electricity[13]. Such a material is Polythiophene with a melting point of 350 degree Celsius. The main advantage being it is washable. Then, polythiophene coated thermoelectric yarn is knitted to make a body fitting t-shirt. The result would be a t-shirt which would convert thermal energy to electrical energy, and the next step is transfer of this electrical energy.

The micro sensors or chips are embedded with pocket integration and are joined to the hem of the shirt with straight flexible Silver yarns as shown in figure.6.3.2.

Silver yarns should be used because it is highly conductive. It is used for obtaining small distance accuracy in all the electronic devices. It is highly conductive on low voltages and also is crisp when it comes to low current transmission.

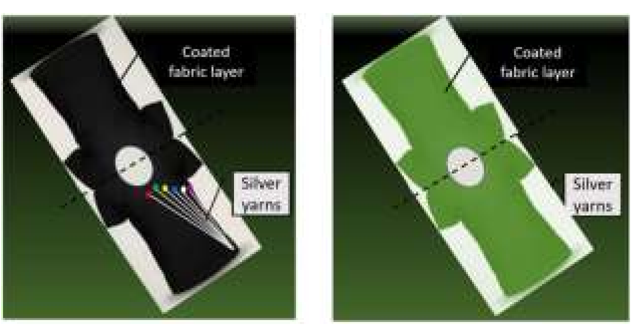


Figure 6.3.2: Making of garment

The Sensors receive data, it transmits the data to the hem of the t-shirt. The hem of the t-shirt will be connected to a transmitter which sends the data to the app which sends signals and notifications if anything abnormal is seen. It will also send timed reports for routine checkup to the concerned doctor. The key sensors used for the WH T-Shirts are:

- 3 axis accelerometer
  a) Heart Rhythm.
  b) Breathing Pattern.
- Breathing Sensors
  a) Expansion and contraction of Ribcage.
  b) Stress level.

7. Market size of Smart Clothing

The 2015 global smartphone market is an impressive $399 billion, but pales in comparison to the clothing market with $1.2 trillion in garment sales. For 2019, this gap is predicted to widen to $520 billion smartphone sales and a whopping $2.2 trillion in garment sales.[14]

Given the pervasiveness and continual growth of the clothing market, you would assume that merger of wearable technology with clothing would be an obvious area for market expansion. However, growth in this area is predicted to be slow with smart clothing accounting for less than 1% of the market as shown in fig.7.1..

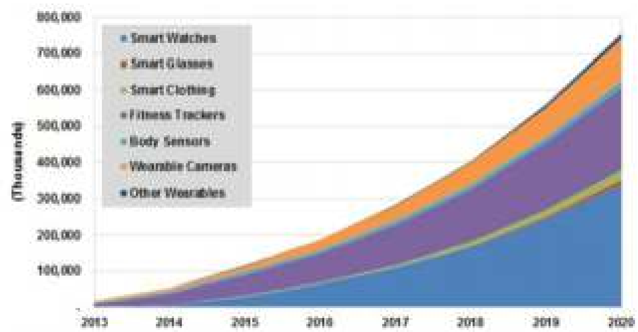


Figure 7.1: Cumulative Wearable Device Shipments by Device Category, World Market: 2013-2020[14]

The slow adoption might be due to a lack of obvious use cases for consumers starting with a basic lack of public awareness. Although recent Google searches show "Smart clothing" increasing in popularity, users still are not largely aware of the market offerings.

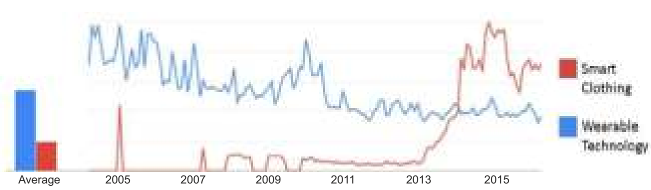


Figure 7.2: Growing trend of Smart Clothing over Wearable Technology from 2005-2015[14]

The slow adoption might be due to a lack of obvious use cases for consumers starting with a basic lack of public awareness. Although recent Google searches show "Smart clothing" increasing in popularity, users still are not largely aware of the market offerings.

The idea shown above in section 6.3 will succeed in increasing the market of Intelligent Functional Clothing as it takes care of the market issues existing currently and customer needs by focusing on:

1. Comfort:

Create the right partnerships with sensor companies. This will be crucial because clothing sensors have unique requirements such as waterproof, wash ability, and comfort. Hence, using polythiophene for wash ability and water probability and knitted structure for comfort is necessary. If the IFC's are not comfortable against the skin, people will reject it after the first use and the market won't grow. Hence, comfort plays a vital role in the acceptance of the clothing.

2. Energy Source:

The first step is to create partnerships with clothing designers and manufacturers to develop a truly wearable product. Plugging in the clothing into the wall will not be an option for charging. The clothing will need to be treated like clothing and not like a piece of electronic equipment. Here's where the inbuilt energy sources like kinetic and thermal sources can be used.

3. Fashion:

Usually the smart clothing is functional but not fashionable, which gives it a negative edge in the marketing sector. Hence, working on the design of the FBM suits and the WH tees and making it fashion forward is the need of the hour.

4. Accuracy:

Only if these IFC's are accurate, they can be used in the Medical sector. Also making it accurate will help in gaining the trust of the customers.

5. Cost Efficient:

A well-made product is never successful if it is out of the customers reach, as it can become a dream of a normal wage customer but never a need in their daily lives. So, making it cost efficient is the first step to growing business.

8. Summary

IFC is a sector of Wearable Technology and the medical monitoring aspect has been discussed in the paper. There are various technologies integrated with textiles to make IFCs like solar energy, counter servilliency, stimuli sensitive responsive barriers, thermochromic concept and Internet of Things,etc. But seeing the urgent need of personalising health monitoring and making routine checkups a part of the daily lifestyle, another technology integrated textile is made, known as Intelligent Functional Clothing(IFCs).

IFCs are manufactured by many manufacturers but some aspects like cost efficiency, security issues, lack of trust from consumers, ugly design,etc., make it difficult to gain market. The manufacturing of these IFCs cover various aspects like Design Research, Physiology, Textile technology,etc. But the need of the hour is to make a medium of inbuilt washable energy source as the products manufactured right now are very cumbersome. So the 2 mediums to generate energy from the human body and clothing interface are using the thermal gradient and using the friction energy generated by rubbing of layers. So the concept of using thermoelectric yarns and knitting it and integrating technology by use of silver yarns can be used to make a fashion forward daily wear t-shirt.

The product will be a success only when areas like comfort, energy source requirements, fashion forward design, accuracy and cost efficiency are covered while manufacturing the IFCs. Ultimately, the design and versatility of the big data processing platform from connectivity of clothing, integration of environmental sensors and the analytics capabilities that are custom made for each domain will determine market success. Also the increase in the curve of Smart Clothing over Wearable Technology shows the acceptance of Smart Clothing or IFCs, hence opening opportunities for IFCs to develop.

Acknowledgement

We would like to express our deepest appreciation to the one who provided us the possibility to complete this paper. A special gratitude, we give to our senior professor at VJTI, Dr. S.P.Borkar, whose contribution in stimulating suggestions and encouragement, helped us to coordinate well and complete our paper with expert supervision.

References

1. Alex Hanuska, Bharath Chandramohan, Laura Bellamy, Pauline Burke, Rajiv Ramanathan, Vijay Balakrishnan, Smart Clothing Market Analysis, *Journal by Berkeley Engineering*, 4-8, (2017).
2. Technology opening new vistas in fabric innovations| Article, *Bluesign*, **1**(1), 1, 2014.
3. Michael Sawh, The best smart clothing: From biometric shirts to contactless payment jackets, *Wearable-Smart Clothing Wearable Technology Feature,* **1**(4), 1, 2018.
4. Rahul Mehra, Global public health problem of sudden cardiac death | Article, *National Library of Medicine*, **40**(11), 1, 2007.
5. J. McCann and D. Bryson, Smart Clothes and Wearable Technology| Book, *Woodhead Publishing Series in Textiles*, **1**(2), 70-100, 2009.
6. Smart Textiles: The Future of the Fabric Industry | Blog, *Apex Mills*, **1**(11), 1, 2019.
7. Minyoung Suh, Kate Carroll, Nancy Cassil, Critical view on smart clothing product development, *JTATUM Journal of Textile and Apparel Technology and Management*, **6**(9), Issue 4, 5-15, 2010.
8. Anne Kathrin Schaar and Martina Ziefle, Smart Clothing: Perceived Benefits vs. Perceived Fears, *RWTH Aachen University*, **10**(1), 601-606, 2011.
9. Agency for Science, Article- Harnessing body heat to power electronic devices, *Technology and Research (A*STAR) Singapore*, **1**(11), 2018.
10. Cary Hairfield, Harnessing Kinetic Energy from Humans| Original Paper, *Sustainability.williams.edu,* **1**(5), 3, 2013.
11. Wikipedia, Thermoelectric effect, *Online Encyclopedia*, **1**(5), 1, 2021.
12. Osman Can, Ozcanli, Turning Body Heat Into Electricity, *Forbes*, **1**(6), 1, 2010.
13. Qian Wu and Jinlian Hu, Edited by Patricia Aranguren, Thermoelectric Textile Materials | Chapter, *Bringing Thermoelectricity into Reality*, **2**(11), 25-28, 2017.
14. Tiago M. Fernández-Caramés and Paula Fraga -Lamas, Towards The Internet of Smart Clothing: A Review on IoT Wearables and Garments for Creating Intelligent Connected E-Textiles, *MDPI-Publisher of Open Access,* **7**(12), 1-4, 2018.

Dr. Arun Mahadevrao Thakare

Dr. Arun Mahadevrao Thakare is a B.Sc, B.Sc Tech, Ph.D Tech. in Textile Chemistry from UDCT (now ICT, Mumbai). He has a wide experience of last 29 years of working in Textile Mills such as Mafatlal, Premier, Oswal FM Hammerle, Morarjee Brembana, Welspun etc.

Furher he has Academic experience of 3 years as HOD Textile Chemistry division in Textile Institute.

Mr. Thakare has published 7 papers in National and 1 in International Textile. Also he has published papers 2 times in Textile Conferences.

Mobile: 7066034863
Email:
arun.thakare1709@gmail.com

Cotton Yarn Dyed Shirting Fabric - Technical Aspects

Dr. Arun M. Thakare

Abstract:
In today's Global market situation in Cotton Shirting Fabric quality Piece Dyed Fabric / Printed fabric and Yarn Dyed fabric varieties are available as manufactured in many textile mills in world.

Yarn dyed fabric having good market for Men's Shirting Tops for Women's wear and for kids and some fashion wear uses.

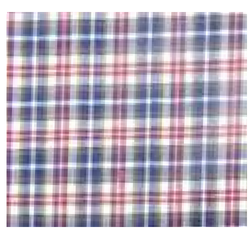
In India today and tomorrow good market potential for yarn dyed shirting fabric. Many branded shirting in our domestic market and also in Global market. Major brands M&S, Walmart, USA Polo, Benneton, Zodiac, Colour Plus, Black Berry and many.

Textile Composite mills in India are producing Piece Dyed, Printed, Yarn Dyed in various counts in cotton as per customer's requirements. Count varies from 24s, 30s to 80s, 100s, 2/120s, 2/200s i.e. from coarser to very fine variety valuable shirting fabric.

Description:
Starting production of yarn dyed fabric, main Raw material is Cotton Yarn.

Yarn Quality
To select yarn quality as per end use of fabric, i.e. whether for Stripe, Checks, Chambray, 100 % Colour woven (warp and weft yarn dyed), Fil A Fil, Dobby design fabric .

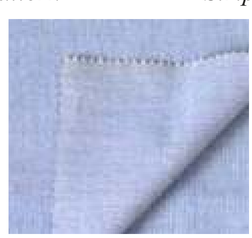
Some fabric patterns are shown herewith:



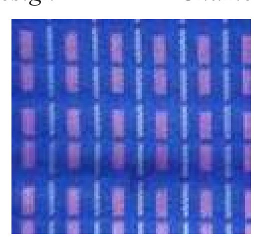
Checks Pattern

Stripe Design

Chambray Quality



Fil A Fil Fabric Design

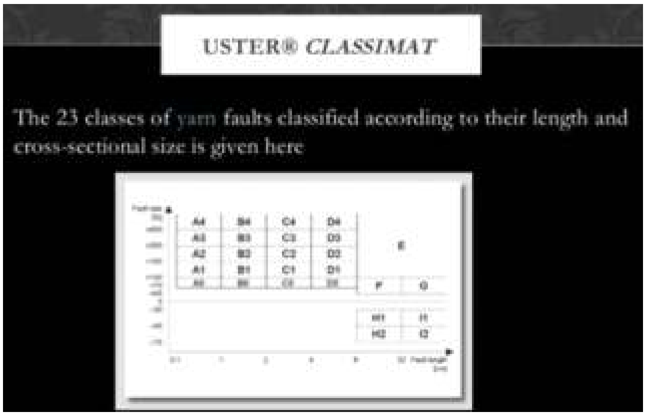


Dobby Design

While selecting Yarn quality, to consider following parameters:

- Yarn RKM ie strength - Min 21
- % Elongation - 4.8 to 5
- U % and its CV % - < 9.5
- Hairiness Index - <1.5 to 2
- Imperfection level -depend on count and quality Say 50s - < 35-45, 90s - < 60, 2/200 - <45
- Classimat faults, to consider long thin and thick places- lower the better
- Yarn appearance board to compare with ASTM board, A B C D - it should be A or B as per fabric quality requirement

Classimat Details are shown below



Total Faults

Short thick faults	-	A1 + B1 + C1 + D1
Long thick faults	-	E + F + G
Thin faults	-	I1 + H1

Objectionable faults

Obj. Short thick faults	-	A4 + B4 + C3 + D2
Obj. Long thick faults	-	E + G
Obj. Thin faults	-	I2

For say Fil A Fil, Chambray, 100 % warp and weft yarn dyeing quality, yarn quality is very important to have good RKM value, less classimat faults, i.e. less long thin and thick places, good yarn appearance i.e. A grade. Abnormal yarn quality will affect fabric appearance i.e. neps, thick, thin places are visible, affecting fabric appearance; customer will not accept such fabric.

Some Yarn dyed fabric construction are given

Warp x Weft	Ends and Picks per inch
50 x 50s	150 x 80
50 x50s	164 x 76
60 x 60s	128 x 106
60 x 60s	186 x 87
2/80s x 2/80s	144 x 78
2/170s x 2/170s	168 x 116
2/200s x 2/200s	214 x 120

QA have to consider as above while selecting yarn for specific quality, looking at the end use and customer brand.

Yarn dyed fabric before bulk production, following route to follow:

1. Desk loom route
2. Yardage / Blanket route
3. CAD route

Desk Loom route – for making desk loom, as per customer order, as per std sample given by customer technical design department will inform on shades to be dyed to LAB. Technical Lab Manager have to check and will dye yarn skeins as per quantity given by Designing team. After matching all shades perfectly, Manager to check shade and then send yarn skeins to Designing department.

First yarn skein to convert form yarn to cone on winding m/c.

After that such cones are used for warp and weft to weave Desk loom sample, on the availability of Desk loom m/c or CCI loom in the department".

M/c photo is shown below of CCI loom.

CAD Route: Customer sometimes send standard as per CAD earlier developed by Unit creative designing team. Normally at unit level various CAD designs in different pattern are developed using CAD CAM software, looking at the CAD design. Technical Designing, mentioned shade nos. from Yarn shade library and to ask LAB to dye accordingly and then make desk loom or Yardage as per customer need.

Sometimes customer can accept Desk loom, and give bulk order considering Desk loom. Some customers mostly branded ones ask for Yardage of length 10 to 25 meter length.

LAB to match the shade perfectly of Desk loom, Yardage all shades and QA as independent of production have to take decision as per customer Standards sample. If not matching, need to redo the process.

LAB have to select Reactive or Vat dyes (class of dyes as per customer need),considering non-metameric recipe, so as to match in light cabinet in D65, TL 84, as specified light source by customer .Fastness of shades is important. Should be tested in LAB, accordingly proper dyes must be selected, also to consider mercerization fast dyes.

Below are given some factors which affects desk loom not matching

- Some Yard dyed skein is not matched by shade development team in lab
- Picks in desk loom is different than standard, though shade is ok, picks difference causes desk loom matching problem
- Uneven picks difference in chambray sample
- Shade ref given by Technical designing department, sometimes not matching as per standards
- Shade ref. given from shade library by Shade development team, or technical designing team member is not correct i.e. not matching as per standards
- Whiteness in std sample and in desk loom sample is different in whiteness value and tone, causing look different of desk loom

- Weave of Desk loom is slightly different than Std sample
- In CAD desk loom ref. given below CAD (Colour palate), though dyed shade is matching to it, but overall look is not matching to CAD cutting
- Construction difference in std and desk loom sample
- Sometimes std given with different design, only for colour ref., though shade matched with it, due to different design, overall look could not get matched.

Thus need to consider all above factors while matching desk loom sample perfectly to satisfy customer.

- ➢ Other route to submit samples to customer is yardage/ blanket of 5 to 40 meters as per customer's need. It is processed as per bulk process route before bulk production. It is useful for Garment maker to check all properties, do wearer trial to access fabric appearance at Garment stage.
- ➢ Once bulk order is received, in yarn dyeing with Reactive or Vat dyes, as per different shades lots to be dyed and then tested for shade and fastness in LAB/ QA. QA testing on fastness of Mercerization is important, otherwise in process mercerisation, colour may bleed and affect fabric.
- ➢ In LAB while matching shade, non-metameric recipe to be selected, and mercerization fast dyes. It should match in light cabinet in D65, TL 84 light source or other light as specified by customer. Checking outside is technologically not correct and outside light may cause different tone look of shade.
- ➢ QA department has to do the testing on Levelness of dyed package, wrt top bottom variation. To make hose of one yarn dyed package, by making baby cones at different layers from top to bottom.
- ➢ Levelness checking is very important, otherwise any package variation will cause fabric defect of weft way band, streaky appearance in fabric of warp dyed shade.

Yarn dyed different shades as per design, after warping beam of particular colour, is taken to Sizing m/c with sizing recipe as below:

Chemical	-	Size UCF 4
Water (on weight of size)	-	1:7
Temperature	-	95 Deg C
Time	-	3 min.

Speed of Sizing m/c 40-45 mpm, with moisture content 7 %

Especially Chambray, 100 % Colour woven and F A F quality, level dyeing is very much essential, thus checking critically at each stage in yarn dyeing, i.e. package density, its weight, loading on carrier, rewinding before issue to preparatory, bottom removal from each packages as per variation if any observed. Then while running in weft on loom, should run with 4 feeders with different size packages for weft Chambray, 100 % yarn dyed fabric quality.

LAB and QA work is very important on matching, testing and approvals, it will make RFT in producing yarn dyed shirting fabric process. It will also cause quick delivery to fabric inspection department and packing as per company lead time, customer delivery time. This will cause customer meet their Garment making and its delivery as per Customer Requirement, to make customer delight, and likely to get order again.

Above article is based as per my Textile Industry working Experience in Technical Services department.

Interview with Mr. Vilas V. Gharat, President TAI - Mumbai Unit & Managing Director - Gharat & Associates

In these times of Covid-19 Pandemic and increasing focus on health & safety, the role of the industry is maintaining sustainability and maintains the standards of their manufacturing products. **Mr. J. B. Soma,** Hon. Ass. Editor & Publisher of JTA, took the opportunity to deliberate with you on the current plans to overcome from this pandemic.

Mr. Vilas Gharat is working as a Managing Director, for Gharat & Associates, having over 50 years' experience in manufacturing function in all composite sectors of Textile Industry. Out of which more than a decade in Operations and HR with emphasis in Business Process Consulting,

Mr. Gharat is having specialization in various fields of textile value chain like;

- Change Management, Business Development and Project Management; Project Management, Business Development; Supply Chain Management; Resource Allocation; Process Reengineering; Change Management, Production and Business; Planning Function and Training and Mentoring CEO's etc.

He has wide experience in:

- Business Consultant for Oswal Hammerle, for their upcoming state of art technology plant for manufacture of sophisticated yarn dyed shirting project, primarily catering to the needs of international garment manufacturers. This is a Joint Venture project of Oswal group and F.M. Hammerle (Austria)
- His previous assignment involves restructuring and transformation of a large Textile units
- He worked with various executive capacities as Executive Director -Suvin Advisors Pvt Ltd.; Senior President in S Kumar's., Technical & Commercial Advisor in J. K. Cotton Mills, Senior President in Morarjee Brembana Ltd., Birla's in Indonesia, Oswal Hammerle, Bhojsons, Nigeria etc.

Awards:

Mr. Gharat was awarded with **Best General Manager Award** in MSTC - National Award for energy conservation for Simplex Mills & MSTC and **Best Vendor Award** from Johnson & Johnson.

Mr. Gharat was awarded with **FTA** by The Textile Association (India) in 1999.

Mr. Vilas Gharat is President of The Textile Association (India) - Mumbai Unit during 2017-2019 and 2019-2021.

Q.: How are we mobilizing our content and expertise to support the global fight against corona virus?

Ansr: It is more than one-year entire world is facing very difficult phase & trying all possible measures for survival. We Indians are definitely much better in controlling virus & stabilizing Indian economy. I have been reaching to ground level workforce in Textile Industry by video calling & sending solutions to their issues -both professional & personal. I am still doing online counselling to workers & staff who are in factory and making them to follow heath guidelines & SOP in respective operation.

We have been advising people not to waste time in media & unsupportive messages but follow only Govt. guidelines received through proper authorities. We have been educating workforce regarding living healthy life & advising them to take care of their family members.

Q.: How has the worldwide lockdown impacted the textile & apparel industry? What are the immediate concerns and key takeaways?

Ansr: Lockdown impact on textiles & apparel industry worldwide is definitely huge & many reputed brands have reduced their operations. No one is trying to add anything in wardrobe but trying to reduce by discarding old garments. It has given spurt to used garment sale in many backward countries -backward areas.

The demand has been shifted to anti-virus garments with innovative fashion designs. The concept of use & throw is been followed by young generations. The safety is more preferred than durability hence to reduce cost over engineering of product is not necessary.

Similarly, many companies changed their product to medical textiles as per present quality requirements and it is the key for sustaining & survival of business.

Q.: Any comparison on how differently the Indian textile industry got affected compared to the world?

Ansr: I do not have statistics but in general many reputed companies in India accepted challenges & changed mind set of people to make products as per present requirements of customers. The PPE kits or masks are excellent examples of Indian Textile Industry's achievements. Many Indian companies are catering to domestic requirements & exporting to needy countries. We have seen there is shortage of medical equipment but no shortage of medical garments in India. Compared to European Textile Industry we are better & will be doing excellent, provided we change our products. Government active support is very necessary to control raw material prices so that we can be competitive in international markets. Indian textile technocrats are capable of handling all such issues provided top management is proactive & supportive.

Q.: How critical would be the reduction of trained manpower on fronts like manufacturing, warehousing, supply chain etc for the businesses?

Ansr: We can do everything online except manufacturing hence skilled workforce is very important for any business. Unfortunately, in today's situation no importance is given to skilled workforce working on shopfloor. All staff members are allowed to work from home but shopfloor workforce is suffering in all such lockdowns. Very few companies have taken care of their workers.

The category of skilled workforce is been totally neglected by Govt, & Entrepreneurs. It has resulted in migration of skilled workforce to different locations or different job profiles for their survival. We have seen many people walked down to their native place but no help is provided.

It will be very difficult to get those skilled workforces when business will have excellent opportunities. We have created this critical situation by neglecting such workforce. I am sure that it will be difficult for top management to take advantage of business in view of shortage of skilled workforce.

Q.: How can textile and apparel companies better manage their workforce and supply chain amid current situations?
Ansr: As mentioned above everything can be done online except manufacturing hence retention of skilled & loyal workforce is very important. We need to dismantle pyramid management structure to flat so that major cost of salary & wages will be under control. It will help shopfloor workforce to get correct information & we will get many useful / innovating ideas from them. Similarly, ongoing training schemes should be implemented through professional trainer. Earlier there was training institute in Parel (Damodar Hall) who were giving training only to textile operators.

Olden days all textile mills had their workers & staff accommodation in mill premises with reasonable rent & hence there never used to be shortage of skilled hands. Govt. & Mill owners should create such infrastructure to avoid migration of skill workforce.

Q.: Based on consumer preferences, how are businesses going to get altered? What role will technology have in it?
Ansr: As mentioned above preference will be given to only virus protective garments on online sale. Buying cloth & stitching garment may be only for occasions. The personal safety will be more preferred than durability of garments. The return policy by many online sellers has given booster to business & hence online selling will be major change.

The fashions will be changed according to living guidelines set due to pandemic & life styles at all levels of costumers.

The role of technology will have to create innovative products at regular interval with better features & lower cost. Take example of mobile phone companies who are changing product features with new concepts & innovations.

Q.: Are there any positive outcomes of the current crisis if at all for the textile industry?
Ansr: As long as human beings are wearing garments the industry will not die but may get some set back if not changed as per time. According to me Indian Textile Industry has great future ahead provided we tap new markets & products such as Technical Textiles requirement. We need to enter into product which we are importing till date.

As infrastructure such as roads & dams are in pipelines, we must produce Geo Textiles which we are importing.

Medical textile is also immediate global need & we have already developed skills to make as per international standards. In short we need to come out of our old culture & change according to market requirements timely.

Q.: There is a lot of talk about reviving businesses to arrive at the new normal. Is there any thought process towards this at the company level or collectively as an industry?
Ansr: There are many webinars or seminars but what is percentage that it is implemented. There are many consultants or advisors who are making excellent presentations & resorts at very high cost. But very few are assisting implementation on shopfloor.

I have offered my services online with just Rs.11,000/- per month & 10% of savings due to our advice or customize reporting systems which we create.
You may contact us on vilasgharat@gmail.com

Q.: Which countries have fared well in offering stimulus to the textile industry? Where is India lacking?
Ansr: No comments on other counties but we Indians are capable of resolving all issues for better business provided - We stop bureaucratic working & adopt flat managements with proactive approach. We only depend on Govt. concessions or Policies. Let us face challenges & resolve through our expertise instead of blaming Govt. Policies. We should represent our cases to Govt. but should not dis continue our efforts.

Q.: By when are you expecting the revival process to commence and what is your recovery model?
Ansr: No comments but only recovery model is adopt changes for self-survival by keeping your mind open & positive.

Q.; What is the road ahead for the textile & apparel industry in India?
Ansr: Be positive & accept all changes for your survival. It is difficult to predict but keep your mind open to face all changes, Indian industry will have better days ahead.

Q.: What is your opinion on how the organizations react on this pandemic, when entire manufacturing activity is slowed down?
Ansr: According to me very few reacted positively & wisely.

Q.; What should be the priorities in the New Year 2021?
Ansr: You need to change according to time & retain skill workforce to face all challenges ahead. Change management working style to adopt changes timely.

A radical leap in fabric inspection

Uster Q-Bar 2 becomes the unique formation monitoring system

The best way to avoid off-quality is simply not to make it. Uster Q-Bar 2 introduces a radical leap in fabric inspection. It monitors the fabric additionally at the earliest point – the critical stage in fabric formation – with automatic, in-line inspection. Identifying problems here brings enormous benefits, preventing defects and enabling weavers to deliver constant quality and stay competitive in the market.

Q-Bar 2 is best described as a formation monitoring system, because of its ingenious positioning directly at the interface of warp and weft threads. That allows rapid response as soon as a defect appears, avoiding long-running or repeating faults. Alarm and stop signals alert the operator to correct problems immediately – and early detection reduces second quality and material loss, as well as minimizing the need for post-production checks. For weavers, these advantages represent genuine and long-awaited innovations with a positive impact on both productivity and quality.

Formation monitoring

Weaving defects can have various root causes, so Uster Q-Bar 2 provides different algorithms to identify specific defects and their causes. This inbuilt knowledge can prevent defects within the weft insertion cycle.

Its enhanced detection position in the fabric formation zone means the warp is monitored even before it is traversed by the weft – a truly unique benefit. It allows detection of incorrect warp positions, missing warp, loose warp ends and even pattern irregularities.

Another important innovation is the control of weft irregularities. By monitoring each inserted weft in the formation area, Q-Bar 2 primes users to react to weft irregularities at the earliest possible stage. At this point, it can detect weft-related defects such as double picks, broken weft or slubs and loops. "Formation monitoring is the answer to market requests. Weavers demand zero defect standards, increased sustainability by waste reduction and they want to produce the fabric meeting specific quality requirements," says Michelle Salg, Product Manager Fabric Inspection at Uster.

Total supervision

Defects that become visible only in the woven fabric are the nastiest threat. Often, it's too late when defects such as reed marks, dirty yarns or floats are spotted – but it can't happen with Uster Q-Bar 2. Its fabric inspection algorithms detect even 'invisible' defects in the fabric. It's the simple solution to improving fabric yield by automated formation monitoring.

Q-Bar 2 also monitors critical machine units in the formation zone. If there is a problem here, the system makes it easy to identify and eliminate it, preventing further defects and again maximizing fabric yield.

Another element of the total supervision provided by the formation monitoring system is its special focus on the selvedge area. This is not only critical for an efficient weaving process, it is also important in further process steps. Specific algorithms detect irregularities in the selvedge, as well as broken leno – but also identify any pattern defects. Continuous pattern monitoring flags up incorrect patterns at the earliest stage, so the loom can be stopped and the problem fixed before many meters of fabric are wasted.

Last but not least, the system has a permanent eye on the fabric width, an essential factor for further processing. For this reason, Q-Bar 2 provides continuous width measurement of the woven fabric, from loom setup to full roll.

Designed for users

The technology in this new formation monitoring system is impressive, but Q-Bar 2 is highly developed in many other aspects too. Its attractive industrial design is also ergonomic, so users have easy access to all important parts. Weavers appreciate its simple installation on existing weaving machines. And operators like the integrated LEDs used by Q-Bar 2: system status is indicated and the positions of detected defects shown by red lights. The improved hardware platform is capable of handling high loom speeds and is ready for future innovations.

First-quality production, to customer specifications, is the overall goal. That is especially important in demanding applications such as industrial and safety textiles.

In apparel and home textiles too, it is vital to avoid seconds and minimize waste fabric. "Independent of the fabric application, Uster Q-Bar 2 is a game-changer. For the first time, weavers can actually prevent weaving defects instead of only reacting to them," says Salg.

For more details, please contact:

Edith Aepli
On behalf of Uster Marketing Service
Uster Technologies AG
Sonnenbergstrasse 10
8610 Uster
Switzerland
Phone +41 43 366 38 80
Mobile +41 79 91 602 91

A.T.E. joins hands with SMIT to promote rapier looms

In a development that will provide momentum to the modernisation of the Indian textile industry, A.T.E. and SMIT S.r.l. have entered an exclusive partnership for the promotion of SMIT's advanced rapier looms in India.

SMIT, a weaving machine manufacturer based in Italy since 1938, is globally renowned for its advanced rapier looms. A.T.E. is a leader and a one window solution provider in textile engineering across the textile value chain, with 80+ years of experience.

SMIT rapier looms are reputed for their versatility, high productivity, superior quality fabric production, and capability to handle a wide range of weft material and yarn counts. Other notable features of SMIT weaving machines include the custom made self-retaining grippers which are easily adjustable and remain stable while weaving. SMIT rapier looms include rapier weft insertion optimised for home textiles, garments, terry towels, and customised solutions to produce special technical fabrics.

2FAST

FAST stands for Flexible Advanced Shuttleless Technology. SMIT's high speed weaving machine 2FAST can handle diverse fabric applications such as apparels, home textiles, and technical textiles. 2FAST unleashes the full potential of free flight of the rapier and helps achieve the best fabric construction at the highest speed with the lowest stress for yarn – thanks to the longest beating time among machines of this kind!

2FAST is the most compact loom in the market today, with simple and low, strain-free access to the front of the loom. Additionally, the 'robust design' methodology employed by SMIT guarantees the longest machine life and the lowest spare parts consumption.

A.T.E. is committed to provide the latest technology solutions to the Indian textile mills and its partnership with SMIT is yet another step in this direction.

"This partnership fills a major product gap of looms in our portfolio. With our deep domain knowledge and our excellent relationship with customers, I am confident that we will be able to strengthen SMIT's presence in India. We are excited to present SMIT to the Indian market from May 1", said Mr Navin Agrawal, Business Head, Fabric Forming Division. Mr Agarwal further added that A.T.E. also plans to offer comprehensive services for SMIT machines that include after-sales service support, an electronic centre, stock and supply of spare parts, and training.

"We are very proud to announce the partnership between SMIT and A.T.E. Enterprises Private Limited. A.T.E.'s decades of industry expertise, undisputed market leadership, and professional team of specialists will empower SMIT and SANTEX RIMAR GROUP to rise to new challenges and together reach new heights in the textile landscape. Looking forward to a fruitful and long-lasting partnership, we are sure that with A.T.E., we will take full advantage of the restart of the Indian and global economies after the pandemic challenge." commented Enrico Valsecchi, Sales Director of Smit.

Challenging Times - Requirements of the Textile Industry for enterprise software

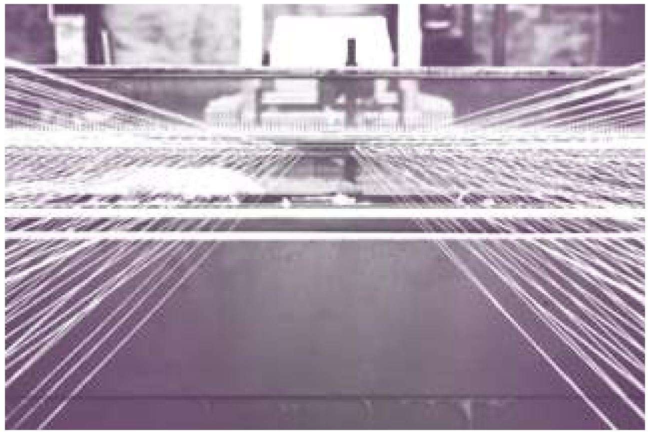
Author: istock.com/sorendls

The special characteristic of the textile industry is that it works with a very large variability and variety. This is because customer requirements are diverse and each order is special, which has a strong impact on production. This is additionally reinforced by the current situation.

Thus, especially in the quotation, order and production phases, a completely different system is needed than in other industries. The system to be set up must have an extremely flexible structure and be capable of producing fast solutions. The most important requirement for an enterprise solution is therefore to be able to set up a mechanism that can map and manage precisely this diversity and variability - using methods such as variants and assortments, for example. Other defining requirements of the industry are traceability, critical paths and good quality control phases.

The most important feature that companies therefore expect from an enterprise resource planning system is the ability to create a solution that is integrated with the variety of products and the rate of change of products. Each order contains many details: location, assortment matrix, sequence details, accessory details are always different. It is necessary to merge all these details within the ERP system. If the company uses the standard structure of the ERP system for this, it will be left behind quickly. For example, it is important to be able to respond to order requests as quickly as possible.
For this reason, the company must have a system that can be

built according to product structures rather than standard structures. To do so, it is very important to have an integrated ERP system that produces flexible and fast solutions. Especially in current times, textile companies that can best adapt to current needs and market fluctuations have an advantage. Systems that do not offer freedom of movement do not have an easy time succeeding in the textile industry.


iStock 864536328 Violett

color management, which is so important for fabrics, should also be appropriately mapped and available for use in the ERP. An application in the area of bills of materials, for example, where a color recipe can be created and tracked according to the fabric batch, is beneficial here. It should also be possible to monitor the dyehouse management processes via the system and to transfer the color recipes created directly to the machines. In addition, an application for capacity planning can provide support here, according to which the capacity of the dyeing boilers, the sequential dyeing of the colors and the tub washes can be taken into account accordingly. It can therefore be seen that a flexible, integrated and fast structure is crucial for textile companies.

A flexible, integrated and fast structure is crucial

The industry can be treated under two different focuses: Garments/Apparel and Fabrics. Basic processes needed in the garments/apparel area include product information form, assortment management, accessory management, critical path and marker planning. In fabrics, color management, pattern management, composition management and mix & match processes need to be set up in the system.

With an enterprise resource planning product with a very flexible structure, users can manage business processes much more easily and quickly. In the best case, the enterprise solution thus optimally adapts to the textile industry with its two main focuses and is optimized based on the needs and experiences of many textile companies. Thus, applications and basic structures such as product tree, route, work order management, material card, product configurator are already included in the standard as far as possible.

An additional advantage is provided by clear application screens (UI), which enable users to realize their processes in a simple and fast way. Other modules and applications that facilitate the special work in the textile industry are also useful: With an MRP module, for example, the traceability of orders can be maximized through customer-specific processes. If there is a fabric or accessory that needs to be purchased specifically for a customer's order, this can be tracked as its relation to the order can be clearly identified. A link to cost management is also helpful, allowing users to directly calculate a cost and create a quote directly from the product. This offers companies a major speed advantage. The enterprise software should also be able to map the special needs in the area of fabrics: When the company starts producing a job, for example, not all the requirements for the product are clear from the start, as usual.

Thus, all preparations that are necessary in this process should already be plannable in the system. A contract management application also supports the management of many business processes and it is possible to observe which operations are carried out in which part and what is the degree of completion of the project. A supplier portal via which information can be entered and controlled via the system also provides valuable support here. The topic of

More efficiency required

Particularly with regard to marker-making, users want to be able to enter fabric layers and batch information and use this information to track how many fabric layers are laid, which batch is used and which semi-finished products are produced. The system should receive information about which parts of the garment product are currently being produced. Approval processes and planning processes are also an issue that can be served by an assortment matrix in the system.

In addition, one of the important issues in the industry is the critical path. With the critical path, which covers the entire process from the start of production to delivery to the customer, all processes such as procurement, cutting, sewing, packaging and delivery of materials can be monitored step by step with dates. A project management module is useful for this. A variant structure also helps to manage product diversity. Variations such as size, color and height can be easily resolved within the variant. A special point for companies working in the textile industry, especially in the apparel sector, is the time study. The user wants to know how long a product is produced and define and track this with all its part details.

The role of IIoT

Meanwhile, Industrial Internet of Things (IIoT) technologies can be used very effectively in the textile industry. Dyehouse integrations, quality control testing processes, production results and tracking, scale integrations, and RFID barcode integrations can be successfully designed and used by IIoT systems. Thanks to suitable IIoT solutions, users can communicate with machines directly from the system. The systems are put into operation without human intervention and the prescriptions collected by the machines are transferred to the ERP system without errors. For example, IIoT technologies are intensively used in the winding and quality control of produced materials. Information such as meters and kilograms coming from the equipment is used.

When the product is manufactured, all the criteria that determine its characteristics are transmitted from the system, while quality control is performed for the final product. In addition, IIoT solutions enable instant monitoring of machines by the system. Thus, in the case of a machine in the dyeing plant, it is possible to immediately see at what stage of which washing it is in. This allows the margin of error to be determined and improves speed and efficiency by allowing the ERP system to communicate directly with the machines about this and many other issues.

Especially in the area of fabrics Industry 4.0 technologies are already strongly used, in the area of apparel production it is still less common. The textile industry has complex business processes and needs special solutions. When selecting their software, textile companies should therefore make sure that the software manufacturer understands the industry and can adapt to the business processes and offer fast solutions.

A special focus is on the particular dynamics of the market, which must be withstood and for which the appropriate innovations must be developed again and again. Solutions that already incorporate the experience of customers from the textile industry into their product and are thus leaders in the industry are suitable for this. Necessary applications and modules, integrated in a single system, offer great added value. The offer of additional, also integrated, Industry 4.0 technologies helps companies to achieve a holistic, fast, integrated and flexible software service. For example, with the right solution, textile companies can feed in data from devices, use a Big Data solution to manage and report on the data collected due to product diversity, and connect to an ERP that can work fully integrated with all other solutions and provide end-to-end solutions. This makes companies robust to dynamic market developments and strengthens efficiency and speed.

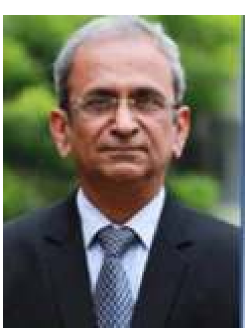
For more information, please contact:

Mr. Mukul Bodhare
Product Marketing Officer / Marketing
Canias ERP Pvt. Ltd.
E-mail: mbodhare@canias40.com
Website; www.canias40.com

SOMALWAR'S NIKALAS MAHILA MAHAVIDYALAYA

Creative Junction Lecture Series organized by Nikalas Mahila Mahavidyalaya

Department of Textile Science and Fashion Design of Nikalas Mahila Mahavidyalaya, Nagpur organised the series of guest lectures titled **'Creative Junction'**. The idea was to overcome the monotony posed by the prevailing COVID-19 pandemic situation, Expert speakers from the field of Textile and Fashion Industry shared their valuable insights in the series with the students of the department. 'Creative Junction' lecture series was really a good opportunity for the students of Fashion and Textile department of Nikalas Mahila Mahavidyalaya, Nagpur to interact with experts from industry. The motto of this series was also to shed off negativity and hone the students' creative skills.



Prof. Deepak Kulkarni

Prof. Deepak Kulkarni, former Principal and Head, Dept. of Textile Manufactures, Govt. Polytechnic Nagpur interacted with the students through a very interesting presentation on **'Career Opportunities in Textile and Fashion Industries'.** Prof. Kulkarni motivated students by sharing success stories of experts in the field who changed their lives through systematic career planning and hard-work.

These successful personalities are the famous icons in their domain of work. In his presentation many useful tips on career planning, SWOT analysis, personality development and success mantra were shared. He explained the concepts of Fashion and Textile industry through anecdotes which helped the students to connect with the concept with much ease.

In his second lecture in the series 'Creative Junction', Prof. Kulkarni delivered an interesting talk on **'Khadi- a Sustainable Textile Material'.** He explained the significance of Khadi as an eco friendly product and its manufacturing process in detail. With some interesting and useful facts about this Khadi fabric, Prof. Kulkarni sparked interest in the minds of young, inquisitive students. He also showcased through his presentation, how Khadi fabric is setting the stage for India to become a world leader of socially responsible, sustainable fashion. Students were made aware of Khadi contribution in the battle against Covid-19.

Dr. Pravin Ukey

Second in the series, **Dr. Pravin Ukey,** Assistant Prof., Dept. of Fashion Technology, DKTE's Textile and Engineering Institute, Ichalkaranji interacted with students on **'Indian Textile and Clothing Industry'.** With his immense experience in industry, teaching and publication, he made the session very lively and informative.

Dr. Ukey explained the working of Textile and clothing industry, major issues associated with the industry, production processes and also the initiatives taken by government to promote the industry. Dr. Ukey's presentation created good interest among the students and the faculty about the working of the industry.

Mr. Atik Sheikh, Senior GM (Marketing) Mohan Industries was also invited to share his knowledge with the students as a guest speaker in the series on **'Key Skills up-gradation for**

Mr. Atik Sheikh

future career'. Being a working professional in the field of Textile and having dealt with many products, he gave valuable guidance to the students so as to improve their professional skills required for working in the industry.

In his presentation, he covered points such as meaning and importance of skills, key professional skills 2030, skills to get a job, how to identify personality strength, career path based on interest groups, handling hurdles and career mentoring. Students were motivated by his knowledge and experience.

Ms. Nikita S. Chaudhary

Ms. Nikita Shivhare Chaudhary, an entrepreneur in the field of fashion made an impressive presentation on **'My 10 steps Fashion Design Process'.** She very well explained the process of fashion design, She explained how designers get inspired from different things and how this conceptual designing is done. Ms. Nikita inspired students for theme based designing and product development.

'Creative Junction' has instilled interest, motivation and optimism regarding their chosen field among the students. **Dr. Seema Somalwar,** Principal of Nikalas Mahila Mahavidyalaya always focuses on the creative development of students. Her pedagogy involves bridging the gap between theoretical knowledge and practical learning experiences. The Creative Junction series was launched keeping this vision in mind.
The feedback received from students is very encouraging and positive. "It was really an enriching experience and the lecture series was extremely helpful in developing creative temper. It was an amazing learning experience."

This series was conceptualized and executed under the able guidance of the Head of the Department, **Dr. Rajashree Bapat** who, with her immense experience in the field spearheaded this unique initiative.

The sessions were hosted by **Mrs. Archana Lande, Mrs. Shilpa Vishwarupe** and **Mrs. Shubhangi Bhatkule**, Assistant Professors of the department of Textile and Fashion. Technical support for 'Creative Junction' was provided by **Mrs. Vaishali Lande,** Training and placement in charge of the department. **Dr. Sayali Pande Asstt.** Prof. provided the media support.

RIETER Ensuring Competitiveness Through Technology

- **Ring spinning with G 38 and ROBOspin sets new standards in automation**
- **COMPACTapron takes yarn strength to new heights**
- **ESSENTIAL offers new features with smarter insights for better decisions**
- **ROBOdoff automates doffing to save time and money**
- **SSM's new winder NEO-YW delivers more efficiency and sustainability**
- **Graf's new cylinder wire and flats enhance lifetime and quality**

Rieter has doubled down on its R&D efforts since the onset of the pandemic to accelerate the development of its suite of intelligent and automated machines and systems so customers can manufacture yarns more profitably, efficiently and sustainably. This also empowers mill owners to respond flexibly to fast-changing markets.

Ring Spinning with G 38 and ROBOspin Sets New Standards in Automation

Rieter's proven ring spinning machine G 38 with up to 1 824 spindles, equipped with the fully electronic drafting system and the industry's first fully automated piecing robot ROBOspin sets new standards in terms of automation and flexibility. This powerful combination makes it easy to produce standard, special, and compact yarns thanks to the best-in-class compacting devices COMPACTdrum and COMPACTeasy. COMPACTapron completes Rieter's family of compacting devices, taking yarn strengths to new heights thanks to its unique 3D technology that guides the fibers smartly through the compacting zone.

Novibra's HPS 22 spindle, which is available for ring and compact spinning, offers the best price performance across all applications with spindle speeds reaching up to 22 000 rpm. It caters to a pressing need on the Chinese and other markets.

ESSENTIAL Offers New Features with Smarter Insights for Better Decisions

Rieter's ESSENTIALmonitor, one of the modules of its all-in-one digital monitoring system, has new features that offer smarter insights into the mill's operations so owners can fully unlock the mill's potential.

ROBOdoff Automates Doffing to Save Time and Money

Manual doffing is cumbersome, time consuming and costly. Available on the rotor spinning machine R 37 as an option and on R 35 and R 36 as an upgrade, ROBOdoff automates the changing of packages, replacing full packages with an empty tube that is prepared along each side of the machine so that the spinning process can continue seamlessly. ROBOdoff significantly helps to save time and money.

New Spinning Rotor and CHANNELinsert Boost Production

The new rotor 31-XT-BD and the CHANNELinsert 28 can boost rotor yarn production by up to 6% for both knitted and woven applications. It is even possible to use lower quality

Rieter's ring spinning machine G 38 equipped with the fully automated piecing robot ROBOspin sets

COMPACTapron completes Rieter's family of compacting devices takes yarn strengths new heights

raw materials while achieving constant production output.

SSM's New Winder NEO-YW Delivers More Efficiency and Sustainability

The NEO-YW offers clear benefits for dye package winding and rewinding of filament yarns and features the brand-new online backpressure system for low and high package densities. Together with the firmly established thread laying system fastflex and tension control technology digitens it guarantees the best dyeing results and unwinding properties.

Graf's New Cylinder Wire and Flats Enhance Lifetime and Quality

The latest innovations from Graf include the new card cylinder wire P-1940S and the flexible card flat resist-O-top C-60. The cylinder wire delivers consistent sliver quality irrespective of the incoming cotton fibers' trash content and extends the lifetime by more than 10% thanks to the robust design with increased blade width. In addition, the flexible flat resist-O-top C-60 reduces imperfections by up to 15% for fine count yarn spinners.

Rieter's family of components which spans Bräcker, Graf, Novibra, and Suessen, helps extend service life while enhancing quality and consistency.

Technology Competence – Supporting the Industry's Circularity Journey

With a mere 1% of used garments being recycled and 73% going to landfill, the textile industry faces mounting pressure to become more circular.

Rieter is leveraging its expertise to support the industry's ambitions, with a recent study showing it is possible to spin not only rotor but also ring yarns of varying quality out of recycled clothes on a Rieter system. The semi-automated rotor spinning machine R 37 for example delivers promising yarn qualities thanks to improved waste extraction, closing the loop faster.

Visit ITMA Asia + CITME 2021 National Exhibition and Convention Center, Shanghai, China, from June 12 to 16, 2021 in hall 8 at booth C07.

ESSENTIAL's new features offer smart insights into the operation of a spinning mill

ROBOdoff automating package changes on the rotor spinning machine R 37

Oerlikon Nonwoven meltblown technology in demand across the globe

Schleswig-Holstein Minister President visits Neumünster, Germany

Since the outbreak of the coronavirus pandemic, the worldwide demand for protective masks and apparel has resulted in a record number of new orders in the high doubledigit millions of euros at the Oerlikon Nonwoven business unit of the Swiss Oerlikon Group. From the manufacturing site in Neumünster, Germany, the hightech meltblown systems with their patented ecuTEC+ nonwovens electro-charging technology are meanwhile be exported all over the world. For the very first time, a contract has now been signed with a business in Australia. Today, Schleswig Holstein's Minister President Daniel Günther was won over on site by the technology of a 'global player'. Rainer Straub, Head of Oerlikon Nonwoven, was thrilled, stating: "The machines and systems for manufacturing manmade fiber and nonwovens solutions from Neumünster enjoy an outstanding reputation throughout the world. It is especially in this crisis that the technology from Schleswig-Holstein has proven itself to be absolutely world-class."

In addition to a tour of the meltblown system and its assembly and production facilities, the visit by Minister President Daniel Günther had one purpose above all: the dialog between politicians and business. Rainer Straub, Head of Oerlikon Nonwoven, and Matthias Pilz, Head of Oerlikon Neumag, jointly expressed their thanks for the support that Oerlikon has repeatedly had the fortune to experience over the past months and years in Schleswig Holstein and looked to the future full of hope. "As a result of our additional investment at the site here in Neumünster is this in our new technology center that will be completed by the end of this year or in our new logistics center that is already operating. We, as one of the region's largest employers, are continuing to move forward, supported by a State Government that is also focusing on both promoting industry and business and on advancing an efficient training and educational system, as innovation is only possible with outstanding engineers", stated Matthias Pilz. And Rainer Straub directed his appeal specifically at the Minister President: "Treat education and training as a priority. Ultimately, they will secure the future of Schleswig-Holstein as a center of excellence and manufacturing!"

Five-million-euro digitalization program

Daniel Günther, the incumbent Minister President of Schleswig-Holstein since 2017, immediately responded, making reference to one of the Federal State's current training initiatives: "The State Government is supporting higher education institutions and students in the present coronavirus crisis.

With a five million euro digitalization program, we are investing on the long-term digitalization of our higher education institutions. With this, we are overall creating a future for young people, particularly also for those who could very well go on to invent the next generation of manmade fiber systems."

And the Minister President was just as impressed by the willingness and readiness with which Oerlikon has been providing high level support since the beginning of the COVID-19 pandemic to master the present challenges as he was with the company's meltblown technology itself. Rainer Straub explained: "When, at the beginning of the pandemic in February, demand for protective face masks in-creased rapidly, we at Oerlikon Nonwoven responded immediately. We ramped up all the available production capacities here in Neumünster in order to quickly manufacture nonwovens for producing face masks using our laboratory systems. As a result, we have been able to make a small, regional contribution to covering demand. In parallel, we have pulled out all the stops in order to systematically further expand our skills as machine and system builders so as to cater to the initially expected, and now also continuing, global demand for meltblown systems as quickly as possible."

The Oerlikon Nonwoven meltblown technology

Leading meltblown technology

The Oerlikon Nonwoven meltblown technology with which nonwovens for protective masks can also be manufactured, among other things is recognized by the market as being the technically most efficient method for producing highly separating filter media made from plastic fibers. The capacities for respiratory masks available in Europe to date are predominantly manufactured on Oerlikon Nonwoven systems. "Ever more manufacturers in the most diverse countries are hoping to become independent of imports.

Therefore, what we are experiencing in Germany is also happening in both industrialized and emerging countries throughout the world", commented Rainer Straub. In addition to China, Turkey, the United Kingdom, South Korea, Austria and numerous countries in both North and South America, Australia and not least Germany will for the first time also be among the countries to which Oerlikon Nonwoven will be delivering machines and equipment before the end of 2021.

For further information:
André Wissenberg
Marketing, Corporate Communications
& Public Affairs
Tel. +49 2191 67 2331
Fax +49 2191 67 1313
andre.wissenberg@oerlikon.com

TRÜTZSCHLER

Truetzschler's launched new card TC 12 card in India

Truetzschler India launches the new high speed, high quality, less maintenance card: TC 12

Truetzschler India launches the new high speed, high quality, less maintenance card: TC 12.

The TC 12 is an innovative new generation card that offers attractive benefits for spinners. It builds on the success of the hugely popular TC 10 card to offer even higher quality, productivity and precision with reduced maintenance requirements.

The Truetzschler TC 10 card was launched in 2016 – and there are now several thousands of these cards running in India. Within just five years, the TC 10 has captured the hearts of spinners across this important market with its unique range of value-adding features. Now, innovators at Truetzschler have developed a next-generation card that offers exciting opportunities for spinners to further boost their quality, productivity and efficiency. It's called the TC 12. The TC 12 was created as a part of Truetzschler's constant focus on exploring the potential for state-of-the-art technologies to solve key challenges for the textile industry.

Carding machines, for example, require a lot of care in order to keep delivering outstanding quality at high rates of productivity. Settings need to be maintained and regular maintenance is necessary. These tasks are time-consuming and need a highly skilled operator. That's why our R&D teams focus on creating breakthrough solutions like the TC 12 to minimize interference and maximize the availability of carding machines.

Truetzschler Card TC 12

Standard key features of the TC 12 include:

- **Redesigned licker-in zone:** New cleaning elements below the licker-in offer a combing bar and a precision mote knife system that enable controlled extraction of trash with minimum lint loss. This also ensures the re-orientation of fibers on the licker-in surface, which enables better opening when processing man-made and sticky cottons.
- **New 8-point settings for flexible bends:** The TC 12 features eight flexible bends, which enables more precise basic settings between flat tops and cylinder. This basic setting is installed by our specialists and never requires any further readjustments, even during wire changes or maintenance.
- **T-LED:** A next-generation display on the TC 12 card uses the latest LED technology, which makes it visible to the operator even from far away. It displays a visualization of operating parameters to enable operators to avoid malfunctions and reduce downtime.
- **Improved Precision Flat Setting (PFS) system:** A new PFS system empowers spinners with a setting range of 40/1000 inch instead of 8/1000 inch. This is more than enough to perform all required operations without altering the basic settings of the card. The basic setting system, with eight flexible bends, also allows closer gauges, which leads to superior and more consistent carding performance.
- **New web doffing and sliver forming:** The improved web doffing offers several benefits. The card is equipped with transverse sliver take-off, with a pair of maintenance-free belts. This enables better control when collecting web at high speed. A semi-automatic piecing unit is also a standard feature in this card. It is activated through the touch of a button and offers quick threading aid for the operator.
- **DISC MONITOR:** The TC 12 includes a sensor called the DISC MONITOR. It was designed for quality monitoring in draw frames with a delivery speed up to 1,000 meters per minute. It ensures stable levelling behavior and quality monitoring, while also cutting the operating cost of the card by reducing compressed air consumption by 90 percent.
- **New can changer:** A new and more compact system is offers can change speeds of up to 300 meters per minute. It is delivered as a pre-assembled unit, which enables fast installation, and is available with 1,000-millimeter diameter and a height of up to 1,500 millimeters. The new can filling system also saves space and is more efficient than a typical rotary can changer.
- **Multi-touchscreen:** A new monitor offers an improved interface between operator and machine. For the first time, it includes a multi-touch technology that makes operation as intuitive as using a smartphone or tablet device.
- **Improved doffer suction unit:** A new unit provides increased efficiency for the suction of short fibers. This improves the yarn values in terms of winding cuts and Classimat, while also offering better post-carding heat management.

- **Improved lip suction seals:** A redesigned sealing system offers improved cleaning efficiency, reduced maintenance and improved life of suction ducts.

Optional features for the TC 12 card include:

- **TC-WCT WASTE CONTROL System:** This proven system in the blow room is now also part of the TC 12 card, optimizing carding waste in the licker-in zone. Customers can use a touchscreen to choose between Economy, Intensity, and Balance mode. The system can increase raw material yield and minimize waste by up to 2 percent.
- **T-MOVE 2 with Jumbo Can:** The T-MOVE 2 system further enhances the can filling capacity of our existing Jumbo Can with 1,200 millimeter can diameter. After each can rotation, the coiler head shifts its position by a few centimeters – so that the first layer of card sliver is fed into the can, and then the second layer is fed in 4 centimeters from the can's rim. As a result, the sliver is deposited in a way that creates less mounting of material at the core hole, which reduces pressure on the sliver and improves coiling quality. It also increases can capacity by up to 8 percent compared to the previous version of T-MOVE.
- **MAGNOTOP:** The MAGNOTOP system further simplifies the operation and maintenance of the flat system, while improving yarn quality by increasing precision. No investments are required for a flat workshop, and operational costs are lower.

Conclusion

The card is the most influential part of the entire spinning process for determining and controlling yarn quality parameters. The new TC 12, in the working width of 1 meter, is able to operate at high speed while maintaining the outstanding quality levels that spinners demand. Its innovative features simplify maintenance requirements and cut the related downtime, making the TC 12 an ideal choice for future-facing spinners in India and around the globe.

EASY MASK - Sustainable industry collaboration by KARL MAYER GROUP

Sustainable industry collaboration between Indorama Ventures, DyeCoo and STOLL, a brand of the KARL MAYER GROUP

As we enter the second year of the worldwide COVID-19 pandemic there is a continuing need for masks. While face masks help greatly in mitigating the spread of the virus and protecting the wearer, they also contribute to environmental problems such as waste and pollution.

EASY MASK is a collaborative initiative between Indorama Ventures, DyeCoo and STOLL to produce a fashionable mask with a sustainable mind-set throughout the whole production process - starting from the yarn production and followed by the dyeing, design and production.

With the advanced technologies of the three companies, the mask does not just eliminate waste, but also reduces the use of water and energy. The design approach ensures that all components can be easily removed and re-used for other masks.

Deja™ recycled polyester

Deja™ is the sustainable recycled polyester brand from Indorama Ventures. The polyester performance yarn is made from 100% post-consumer recycled PET bottles and can be used for a multitude of home and apparel applications. The yarn is independently certified and traceable, with full transparency across raw material and processes including GRS, Ecomark, RCS, Oeko-Tex 100 and Reach.

Locally sourced 100% post-consumer rPET products offer a low-carbon footprint and closed loop solution. Deja™ is 100% recyclable at the end of use and can be repeatedly re-processed without harmful emissions or discharges to create new high value-added products.

CO2 Dyeing

The Deja™ recycled yarn is afterwards dyed with the innovative supercritical Carbon Dioxide textile dyeing technology by the Dutch company DyeCoo at CleanDye factory. The sc-CO2 dyeing machines can dye yarns or fabric rolls in a closed-loop process without using water and process chemicals, thereby producing any wastewater. By using only the pure non-toxic Corangar dyestuff made by Colourtex, in combination with sc-CO2 that 95% reclaimed in the machine, textile dyeing has less of an environmental impact compared to traditional dyeing technologies. As Carbon Dioxide has the same quality every day and over the whole world the technology is reliable and reproducible.

Design and Production

The sustainable product advantages achieved through the use of Deja™ recycled polyester and CO2 dyeing technology are further enhanced with the design and production method.

EASY MASK is a fresh approach to reinterpret a traditional medical facemask from a design perspective. It is a 3D knitted and playful kinetic object that expands and collapses easily. It is simple to use and comfortable to wear; be it over the face or around the neck. The design approach allows customization, on-demand production, and reduces production waste to below 1%. Integrated ventilation increases breathability. Whilst it does not protect the wearer from infection it limits the spread of viruses.

Both the production method, as well as the design itself, takes environmental and sustainable aspects into account. The seamless production method eliminates cut and sew and reduces waste material whilst offering customized on-demand production to lessen product surplus. Washing at 60°C makes repetitive use possible. All mask components (metal bar, knitted strings and adjustment tube) can be easily removed and re-used for other masks.

The mask is knitted on a STOLL CMS 530 HP B E 7.2 machine, but can also be knitted on other types of STOLL machines. This allows for flexible local production independent of the machine park.

About Indorama Ventures

Indorama Ventures Public Company Limited, listed in Thailand (Bloomberg ticker IVL.TB), is one of the world's leading petrochemicals producers, with a global manufacturing footprint across Europe, Africa, Americas, and Asia Pacific. The company's portfolio comprises Combined PET, Integrated Oxides and Derivatives, and Fibers.

Indorama Ventures products serve major FMCG and automotive sectors, i.e. beverages, hygiene, personal care, tire and safety segments. Indorama Ventures has approx. 24,000 employees worldwide and consolidated revenue of US$10.6 billion in 2020. The Company is listed in the Dow Jones Emerging Markets and World Sustainability Indices (DJSI). Indorama Ventures is headquartered in Bangkok, Thailand with global operating sites in

EMEA: The Netherlands, Germany, Ireland, France, UK, Italy, Denmark, Lithuania, Poland, Czech Republic, Luxembourg, Spain, Turkey, Nigeria, Ghana, Portugal, Israel, Egypt, Russia, Slovakia, Austria, Bulgaria

Americas: USA, Mexico, Canada, Brazil

Asia Pacific: Thailand, Indonesia, China, India, the Philippines, Myanmar, Australia

Indian weaving industry prefers beams from KARL MAYER warp preparation

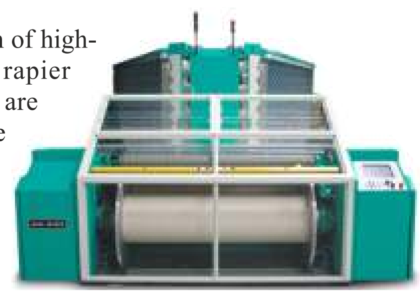
The textile industry witnessed a slowdown due to the pandemic in 2020. Towards the latter half of 2020, however, a sudden rise in demand for home textiles overseas and from the domestic market spurred weaving units to install a large quantity of weaving machines; many of existing units were able to fully utilise their weaving capacities.

Over the past years, there has been a significant increase in shuttleless looms in the country due to the demand for quality fabrics and also favourable government policies for the power loom sector. While it appears as though the future looks bright for weavers in India, most micro, small and medium enterprises (MSMEs) are under pressure to upgrade the technologies they use, both improving quality while cutting costs to remain competitive. This has forced individual units to band together and form strategic alliances or become part of a common cluster so that they are able to reap the cost advantages of economies of scale.

Shuttleless weaving in India continues to grow with high speed air-jet and rapier technologies. Weavers are also looking at other technologies to gain a competitive edge. Two additional, notable technological developments related to weaving include KARL MAYER's PROSIZE® and WARPDIRECT®.

Highest warp beam quality for maximum efficiency in weaving mills

Thanks to India being a spinning hub of fine, compact, and coarser cotton yarns, Indian bed linen and terry towels are in great demand in overseas markets. Most KARL MAYER machines in India are installed in major weaving clusters like Ichalkaranji and Erode, where many of India's quality fabrics are produced.



WARPDIRECT Gesamtmaschine BENIMG 4046

The latest generation of high-speed air jet and rapier weaving machines are used to produce diverse range of articles, which require high quality warp beams for best results. This is where KARL MAYER's PROSIZE® and WARPDIRECT® outshine the competition: KARL MAYER's beam warping machines ensure the exact same warping length for all warp beams, uniform thread tensions and an even winding structure. KARL MAYER's sizing machines apply the size to the threads homogeneously over width and length but without affecting the elasticity and with low water and chemical requirements. In addition to this, the price-performance ratio of KARL MAYER's products is just right.

“Today, customers are aiming for high quality and productivity from sizing units. For many of warp qualities they are running sizing machines at a speed of 140 to 150 metres per minute and achieving daily production targets of 100,000+ metres or 10+ tons from KARL MAYER's PROSIZE® or ISOSIZE sizing machines.” says Mr Navin Agrawal, Vice President, A.T.E. Enterprises.

During the pandemic, when travel was severely restricted, A.T.E. and KARL MAYER were able to finalise a number of orders through online meetings alone. This shows the customers' trust in KARL MAYER and A.T.E.

Dr. T. V. Sreekumar Appointed as Director of BTRA

Dr. T. V. Sreekumar

The Bombay Textile Research Association (BTRA) is proud to announce the appointment of Dr. T. V. Sreekumar as Director in the place of Dr. A. K. Mukhopadhyay, who was retired recently.

Dr. T. V. Sreekumar completed his Ph.D. in Fibre Science & Polymer Technology from Department of Textile Technology, Indian Institutes of Technology Delhi and Post-Doctoral Research from Georgia Institute of Technology, Atlanta, USA. He has over 25 years of experience in senior management, technology strategy, research and development, teaching, testing and quality assurance in Academic, Chemical, Material and Textile Industry. He is a winner of Technology Day Titanium Medal and certificate from Scientific Advisor to Defence Minister. He has published 28 research papers in reputed international journals, 2 book chapters, more than 3500 citations for the papers published and inventor of 21 patents. He had opportunity to work and publish with 1996 Chemistry Nobel Prize Winner, Prof. Richard E Smalley.

He was invited for giving lectures at various reputed universities and organizations such as United Nation Head Quarters New York, Deakin University Australia, Georgia Institute of Technology USA, Indian Space Research Organization (ISRO), Indian Institute of Science (IISc), Indian Institute of Technology (IIT), DRDO and several other Indian Engineering Colleges / Universities. He is an INAE-AICTE Distinguished visiting Professor.

His wealth of knowledge and proven track record in the areas of Material Science, Polymer Science, Fibre Science, wet spinning, melt spinning, Carbon fibre, Acrylic Fibre, CNT Fibre, Specialty polyester, cost reduction etc. will assist BTRA to grow and expand in the newer area of textile technology.

For further information, please contact:
The Bombay Textile Research Association
E-mail: director@btraindia.com, info@btraindia.com

Grasim Industries and Nanliu Enterprise Co. Ltd, donates 50,000 masks in M.P.

Grasim Industries and Nanliu Enterprise Co. Ltd, Taiwan collaborate to donate 50,000 masks in Nagda, MP

Grasim Industries Limited, a flagship company of the Aditya Birla Group, has recently collaborated with Taiwanese nonwoven manufacturing firm Nanliu Enterprise Co. Ltd. to donate 50,000 masks in Nagda. The partnership comes at a crucial juncture during the COVID-19 pandemic, a global crisis that has impacted millions of people worldwide.
Grasim Industries Limited's CSR team initiated the distribution of the three-layered high quality masks manufactured by Nanliu Enterprise, at Nagda and the surrounding villages. Mr. Samir Gupta MD – Business Coordination House – BCH, representing leading nonwoven associations in India facilitated this CSR activity.

The locations included Govt. Civil Hospital – Nagda, Indubhai Parekh Memorial Hospital, Govt. Primary Health Centres, Govt. Anganwadis, ASHA workers, Sarpanches/Sachiv of nearby villages, Govt. College, Secondary High Schools, SDM Office, Civil Court, and Police stations, among others.

At Nagda, Grasim has undertaken several measures to combat COVID-19. Among these include creating COVID-19 awareness, RTPCR testing, Vaccination, disinfection spraying in rural and urban areas, distributing masks, food packets, grocery kit, providing medicine/healthcare for the benefit of thousands of villagers.

At Nagda, the CSR projects are operational in 55 villages, where the company reaches out to 2.15 lakh people every year.

Visco+ –innovative vacuum filter for IV setting

Under vacuum, the new BB Engineering large-area filter produces a ho-mogeneous, pure melt with a targeted IV setting for instance, for returning polyester production waste to the melt flow, but also for achieving a homogeneous viscosity in the case of virgin material.

BB Engineering has expanded its melt filter portfolio to include a patented large-area vacuum filter designed especially for processing polyester waste. The so called Visco+ filter is already known as the key component of the BB Engineering VacuFil recycling system. Now, it is also available as a separate and easily integratable upgrade component for existing systems. Within this context, the uses of the Visco+ are by no means limited to just decontamination. Here, the Visco+ offers the following solutions:

- IV homogenization: if an existing production system is struggling with IV fluctuations, the Visco+ is able to actively intervene and balance out any irregularities;
- IV increase: if the final viscosity is insufficient when processing recycled materials, the Visco+ can increase the IV without the negative impact of long residence times.

In this way, the Visco+ enables fast and flexibly-controllable viscosity build up and reliable viscosity monitoring of the polyester melt using a to date unique, patented process. Depending on the intended end use, the melt can be adjusted to the further processing procedure in a targeted manner. The requisite melt properties above all the intrinsic viscosity, but also the purity and homogeneity are achieved in a reliable and reproducible manner and can also be adjusted during ongoing operation.

The BB Engineering process is both completely new and super-efficient. As a melt filter, the Visco+ operates like a liquid-state polycondensation unit. A maintenance intensive reactor or a deposit prone stirring unit is not required. Moisture is removed from the PET in the filter, which in conjunction with an adjustable residence time results in the desired IV increase in the vacuum. This enables a controlled IV build-up of up to 30%. The intrinsic viscosity is the central quality figure in PET recycling and rPET processing. It determines the melt performance in the downstream production process and the properties of the end products.

The intrinsic viscosity is continually monitored by means of an integrated viscosity measurement unit and reliably adjusted in the event of deviations (caused by disparate input qualities, for ex-ample). At the same time, the filter provides an enormous material surface compared to the volume and continuously renews this. To this end, contamination can be removed particularly effectively from the starting material by means of automatically-regulated high-performance vacuum (1-30 mbar).

The result is a pure, homogeneous melt with controllable IV values and consistent quality. For this reason, the Visco+ is particularly suitable for recycling PET waste that is to be reused for high-end products.

For further information, please contact:

Mrs. Pia Kürten
Marketing
kuerten.pia@bbeng.de
www.bbeng.de

FORTHCOMING EVENTS

ITMA ASIA + CITME
Date : 12th to 16th June, 2021
Venue : National Exhibition and Convention Center, Shanghai, China
Website : http://www.itmaasia.com

ITM 2021
Date : 22nd to 26th June, 2021
Venue : Tuyap Fair Convention and Congress Centre, Beylikduzu, Istanbul
Website : www.itmexhibition.com

Yarnex – India International Yarn Exhibition
Date : 01st & 03rd July, 2021
Venue : Pragati Maidan, Delhi
Contact : S.S. Textile Media Pvt. Ltd.
826, 9th cross, 10th Main Rd, 2nd Stage,
Indiranagar, Bengaluru - 560 038 Karnataka
Tel. : +91-80-25214711, 41151841
Mob. : +91-9845446570
E-mail : sstm@textilefaiarsindia.com
Website : www.textilefairsindia.com

FILTECH 2021
Date : 23rd to 25th August, 2021
Venue : Cologne, Germany
Website : https://filtech.de

Shanghaitex – 20th International Exhibition on Textile Industry
Date : 23rd to 26th November, 2021
Venue : SNIEC, Shanghai (Pudong)

ITME India Exhibition 2021
Date : 08th to 13th December, 2021
Venue : IEML, Greater Noida
Contact : India ITME Society,
1210, Dalamal Tower, A Wing, 12th Floor,
211, Nariman Point, Mumbai – 400 021
Tel. : +91-22-4972 4603 / 2202 0032 / 2285 1579
Mob. : +91-9820507570
E-mail : itme@india-itme.com
Website : https://itme2021.india-itme.com/

Every effort is made to ensure that the information given is correct. You are however, advised to re-check the dates with the organizers.

ADVERTISEMENT INDEX

Advertise in JTA	Cover 1	S. KUMARS LIMITED	P 18
RIETER	Cover 2	TRUTZSCHLER INDIA	Cover 4
Promote your Brands	Cover 3		

Redg. No. R. N. 11386/57 (Formally Textile Digest)