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Indian Textiles still rely on roadways 71% of freight transportation even after having Indian Railways as the 4th largest national railway system.

According to NITI Aayog, rail share in freight transportation in India has been declining since 1951. In 2020, it stood at nearly 18% as compared to road's share of 71%. Under the leadership of Hon'ble Prime Minister, Logistic Efficiency Enhancement Program (LEEP), under Gati Shakti Plan is designed to improve logistics efficiency using Infrastructure Solutions like building 35 multimodal Logistics Parks as well as introducing technological and digital solutions like goods tracking.

Logistics Parks will drive 10% reduction in transportation cost for the top 15 roads enabling freight movement on larger trucks and rail. The pollution levels, already at peak, are undoubtedly escalated by heavy duty vehicles plying on roads as they run on diesel. Heavy duty vehicles in India are not fuel efficient as compared like USA, China, and Europe. This has led to higher fuel consumption and higher fuel costs. Around 90% of road freight movement uses diesel as fuel.

Truck Productivity in India is low when compared to global standards. Trucks in India travel about 300 KM per day compared to the global average of 500-800 KM per day. The truck sizes are smaller; they are often over-loaded beyond their capacity and have empty running rates as high as 40%. These results in more drive to move the same amount of goods, causing high costs and higher emissions.

Average speed of freight vehicles on Indian roads is 25-30 KM/Hr., which is 50-60% lower than USA, this also adds freight cost. The quality of roads is also quite poor in India especially in tier-II & tier-III cities. Although with strong e-commerce growth in recent years, the network penetration to these areas has become way better than what it used to be, these locations still face delayed deliveries and misinformation of their deliveries.

Road congestion is a major problem in India, with no proper advance to the rules and norms of road construction as far as state and national highways are concerned. If the rail and water transportation is improved then the burden of the roads will be taken away by the other modes considerably, further resulting in timely delivery of goods from consumption hubs to the exact location of the customer.

Indian Textiles as on today

Indian textile industry is in expansion mode and should take the benefit of PLI, PM MITRA schemes along with other various Textile Policies which are offering the capital subsidy, support towards the land, plant & machinery and sustainable technology.

Ministry of Chemical & Fertilizer (Department of Chemical & petrochemical) to extend the date of BIS Norms for Polyester Fibre and Yarn for another six months as some of the Companies have not yet got the Licence. Extension will help the downstream industries to continue getting the raw material.

The Government is working on expanding the coverage of the Remission of Duties and Taxes on Exported Products (RoDTEP) scheme. TAI is following up for including RoDTEP benefits to those companies also who export textile products where raw material is imported under advance Licences. As on today RoDTEP benefits is only when you buy raw material locally and then export your goods.

The Government has also asked suggestions on the forthcoming Budget 2023-2024. TAI Centre will draft and suggest to the Govt. after taking the feedback from the stakeholders. TAI Centre is also speaking with the Government on the issues of Indian MMF, such as inverted duty structure, National Fibre Policy, adequate availability of raw material at international price at all levels from PTA and MEG till Garments, support and protection to the small power looms sector, provide R&D facilities, FTA negotiations with EU & UK infrastructure.

Good days are lying ahead and time has come to work in tandem with the Government to emerge again as the second largest exporter of Textile and Apparel products in the world within the next 2-3 years.
A Review on Breathable Fabrics Part – II: Fabric Construction

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Abstract:
Evaluation of breathable fabrics involves testing of resistance to water penetration and permeability to water vapour transmission, across the fabric. These inconsistent requirements are the demand of rainwear, sportswear, medical and workwear mainly developed by either coating or lamination. There are various test methods suggested, though the methods are standard guidelines, the real-life conditions are always different than test and one has to select the standard and norms for acceptance as per end use requirements. In this part of review, various test methods are discussed along with factor affecting the performance.

Keywords: Breathable textile, evaluation of breathability, moisture vapour transmission, resistance to water penetration


1. Introduction
Waterproof breathable fabrics and their assemblies are required for foul weather conditions; such applications involve survival suits, military protective clothing, surgical gowns and drapes, cleanroom wear; further, the products used for leisure or sport are trousers, cagoules, hats, gloves, rain wear etc. The waterproofness indicates the fabric is impervious to water and measured in terms of hydrostatic heads of water and anticipated results depends on end use applications. The term breathability refers to allow effective transmission of moisture vapour across the fabric. During use, moisture is generated by perspiration in microclimate – between skin and clothing, which should be transported to outside atmosphere across the fabric effectively. The heat is generated in the body during physical activities and cooling is attained by sweating. While evaporating, water absorbs latent heat from body, providing cooling effect. The details of work rate in physical activities and equivalent water evaporation, reasons for hyperthermia and hypothermia are explained in part – I of the review. Though the heavy physical activities are for short time, the fabric should be capable to transport the moisture quickly to avoid time being discomfort.

Clothing comfort sensation is determined by balanced process moisture vapour and heat exchange between body and atmosphere across the clothing. For the performance rating of fabric and clothing assembly, the testing for water resistivity and moisture transmission are carried out separately. However, in real-life conditions, it is expected that fabric should perform these functions simultaneously. In ambient conditions the variables such as temperature, relative humidity, water drop size and rate of raining, wind flow rate, angle and surface area of fabric facing to these adversities are uncontrolled. Even seasons, physical activities and rate of sweat vary time to time. Therefore, wide range of test methods are being developed and used for suitable end use applications, sometimes by varying test parameters. There is a vast scope to simulate real-life conditions with test parameters and develop test equipment suitable for explicit application.

2. Evaluation of breathability
Considering the adverse environmental conditions, the desired properties from breathable clothing are resistance to wind and water penetration, repellence to liquid water and permeable to water vapour along with mechanical strength. The assessment methods and factors responsible for performance are discussed one by one in subsequent sections. Apart from these properties, the clothing material is expected to perform well for tape seal-ability, abrasion resistance in dry and wet condition, strength of coating, good stability to multiple washings and dry cleaning operations, stability to autoclave cycles, dimensional stability, colour resistance, stain resistance, ambient to very low temperature flexibility, tearing strength, abrasion resistance, stiffness, hydrostatic resistance and adhesion of coated or laminated film to textile substrate along with environmental concerns; depending on end use applications. Breathability and resistance to water penetration is under scope of the paper and therefore these performance properties are discussed [1].

Such clothing manufacturers typically use two numbers system like 10,000/10,000; to rate the clothing performance. First number represents hydrostatic water head in mm. It measures waterproofness at equivalent pressure generated by water column in one sq. inch tube, when height of column of that number. The second number measures breathability in terms of grams of water vapour passed through a square meter of fabric in a 24 hours period. However, expression in terms of these numbers is not sufficient to compare different commercial products of different manufacturers; as there is a considerable variation in selection of test method, test parameters etc. If tests performed identically, one can conclude higher the number better the product performance.

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In case of waterproof fabrics, the pores, the spacing between warp and weft yarns and space between fibres within yarn, is either filled with coating chemicals or sealed by laminating films. This results into continuous fabric surface with no permeability to air or water. In case of water repellent fabrics, it is usually, treated with hydrophobic compounds and pores are not filled-up. This results into repellent water drop by roll-off mechanism however fabric shows permeability to air and vapours; further under pressure, water also pass across this fabric. For extreme weathering clothing, both fabrics are employed in assembly. Outer layer being water repellent and coated or laminated layer at inner side or at interlining inserts. Water repellent finished outer layer supports to improve waterproofness or penetration of water under shower. Therefore, while evaluating the performance of material the penetration of liquid water and is measured under either simulated rain condition (repellency) or penetration of water under pressure (proofness).

In real-life situation, the rain conditions are far different than testing conditions in laboratory. However, the variables include water drop-let size (<0.1 – 0.3mm), velocity (70 – 700cm.s−1), and kinetic energy (<0.01 – 346 J×10−6) of water droplet when it hits the textile substrate, angle of textile substrate and the temperature when it is actual raining. The water and fabric interaction results into either one or more phenomenon like repellency of water, wetting of surface at face side and / or back side, absorption and holding of water, transfer of water across the fabric and so on. However, when any test is performed there are explicit requirements – performance of material and implicit requirements – reproducibility of test. Therefore, one can select standard and reproducible conditions for test. The specifications for a specific product can be set as per degree of expectations to perform at desired end use applications.

There are numerous test methods are suggested and are being used, however the correlation between them is practically impossible because of wide variations in test parameters. The methods include:

1. Measuring wettability of fabric by means of contact angle. Contact angle more than 90° is considered as water repellent. Sometimes wettability may be measured in terms of time required to reduce contact angle to 90°.

2. Some test methods measure amount of water absorbed and hold by specimen when immersed partially or fully in water, wicking of water through capillaries. The physical form of fabric plays important role in results of such test methods.

3. Most commonly used test methods measure surface wetting and penetration of water under the influence of falling drops. The number, size, frequency and kinetic energy of drops; amount of water and time of exposure, specimen size and its angle for exposure also vary between tests. The test methods preferred commercially are Bundesmann rain test, AATCC spray test, drop penetration and impact penetration test.

4. The test method involved measurement of hydrostatic head required to force the water to penetrate the fabric. This is common test for testing waterproofness.

Some of the simulated rain test methods under the scope of waterproof breathable clothing are discussed below.

3.1 Bundesmann rain test

This test method is suitable for waterproof and rain wear material. When wearer is exposed to rain actively, the body creates abrasion underside the fabric which help to penetrate water through fabric. Bundesmann tester can provide an artificial rainfall to simulate raining under natural environment and test conforms to ISO 9865, BS EN 29865, DIN 53888 standards. The instrument consists of reservoir mounted at 1.5 m from the samples to be exposed to the rain. The deionised water is fed to the reservoir which has 300 number of identical nozzles produces drops of simulated rain.

The test specimens are mounted on cups having outer diameter of 10 cm and placed inclined at 15 to vertical as shown in figure 1. There are four cups, inside each cup there are cross wipers rotates underside of the fabric about 20 times per minute with friction pressure of about 2.5 N. ant water penetrated through specimen and collected in cup is measured. It is reported that water drop has a diameter of 0.64 mm and the terminal velocity of 540 cm.s-1 at fabric and corresponding kinetic energy of 2000 J × 10-6.

By keeping this in mind, one may attempt to set the specifications for desired end use product, as a maximum amount of water collected in cup for predetermined interval. Also, the amount of water absorbed by specimen can be expressed in percentage. In both the cases, average of four specimen is reported. This method is reproducible and mean deviation is reported to be 3 percent.
3.2 WIRA Shower test
Like Bundesmann test, WIRA shower test also measures the water penetration through fabric and absorption by fabric and adopted by British Standards (BS 5066). As shown in figure 2, predefined amount of water is placed in funnel and capillary output of funnel provides uniform flow of water to shower. Shower is made of polytetrafluoroethylene (PTFA) and on top of the perforated bottom plate, a filter paper is placed. This assembly produces uniform shower and well separated drops of water. specimen of 125mm×250mm size is mounted crease free on ribbed glass backing plate and placed on box below the shower. The box is inclined at an angle of 30° and distance of shower and specimen is 1 meter. The test specimen is exposed to shower for 7.5 min and after another one minute, sample is removed. Any water penetrated through test specimen is transferred to a measuring cylinder affixed below tap. The average of four specimens for a fabric sample is reported for either percentage absorption of water on mass basis (<20% for rain wear), volume of water penetrated through fabric (<120 ml for rain wear) or time taken for first 120 ml (should be >120 seconds for rain wear is recommended).

3.3 Credit rain simulation tester
Waterproof and breathable fabrics generally coated or laminated when converted to garments by cutting and stitching, needle penetrates and create holes in fabric. This acts like weak link and water may penetrate through this. Therefore, proper way of construction or seam sealing is essential. The effectiveness of seams under rain is estimated by Credit rain simulator tester. The falling water-drops from jets of reservoir splits into random sized droplets when hits to wire gauze conical drop slitter. The seamed fabric sample is mounted over semicylindrical printed circuit board (PCB) below the drop splitter. When water drop penetrates through specimen, completes the circuit on PCB, as water contains small amount of minerals. The timer counts time from first drop falls on specimen to the penetration of water drop to complete circuit on board and also indicate the position of penetration as shown in figure 3.

3.4 AATCC 35 Rain test
The tester contains horizontal nozzle spray of water with specified number of holes and their size. In front of nozzle, test specimen is hold vertically and is backed by blotting paper as shown in figure 4. Water is fed to nozzle through a column of water maintained at constant height ranging from 60-240cm water gauge and severity of simulated rain is altered. The specimen is exposed to water spray through nozzle for 5 minutes. Any water penetrates the fabric causes increase in mass of blotting paper.

The performance of fabric is determined in terms of either the maximum water pressure at which no penetration occurs, the increase in amount of penetration with respect to pressure or minimum pressure required for penetration of >5g water and is known as breakdown.

3.5 Hydrostatic head test
Hydrostatic head is measure of resistance offered by test specimen to the passage of water. ISO 1420 B; AATCC 127 – 2, ASTM F 1670 standard use hydrostatic head test. The face side of the fabric us exposed to water and pressure on the water continuously increased at standard rate. The pressure at which water penetrates the fabric and drops observed on fabric surface. When the third drop of penetrated water observed, the corresponding water pressure in terms of centimetre water gauge is recorded. The circular specimen of 100 mm2 is clamped between gaskets over water chamber. Pressure on water is increased with control rate of either 10 or 60 cm head of water per min (1cm water head =98.0665 Pa). (Apparatus: figure 5). The average of observed pressure of 5 different specimen is reported for coated fabrics. The rate of increase of water head is controlled to achieved specified pressure as per end is requirement within a minute.
4. Water vapour permeability: [3, 5, 6]

The waterproof breathable fabrics are expected to exhibit zero air permeability or in other words they are wind-proof. The air permeability is defined as the volume of air in ml which is passed through 100 mm² of fabric in a second when pressure difference of 10 mm head of water was set across the fabric. There is no correlation between water vapour permeability and air permeability for different fabrics.

Water vapour permeability of clothing depends on many factors such as body temperature, perspiration rate, surrounding temperature, relative humidity, speed of wind etc. The clothing assembled for extreme weathering condition exposed to variety of conditions like temperature, wind, rain, sleet; further wearer physical activity varies like rest, walk, run, climbing or carrying material etc. The exact replica or real-life situation is difficult to simulate in test method. Different workers have designed variety of test methods and they vary with construction mechanism, test conditions and measurement parameters. The correlation between various test methods was carried out by many workers in the field. Some test methods are used as routine quality control and other are simulated to skin behaviour and developed for specific product and research.

4.1 Cup method

Generally, for routine test of measuring moisture vapour transmission cup method based on basic principles and is used. A shallow dish filled with distilled water is used as source of water and fabric to be tested is fixed on mouth of dish ensuring no gap between fabric and dish, as shown in figure 6 (a). The cup assembly is kept in standard atmosphere in upright position. After some time, when equilibrium is reached, the progressive loss in weight is considered as evaporation of moisture through fabric to be tested and reported as moisture vapour transmission in terms of gram of moisture transmitted through fabric per unit area per day. The results are influenced by various factors such as size of dish, depth of water in dish, gap between water surface and fabric to be tested, temperature and relative humidity in surrounding atmosphere. However, keeping all the conditions identical as per application requirements, one can compare performance of two fabrics.

British standard adopted this method with modifications. Dish diameter of 96mm and air gap between fabric and water surface in dish of 10mm are recommended. On the mouth of dish, a wire mesh is placed to support sample to avoid contact with water and wetting. The temperature of water in dish and surrounding is kept constant. It is assumed that this gap shall have saturated humidity after about one hour. The microclimate above the test specimen may become saturate and affects vapour transmission rate, therefore low velocity air current is achieved by placing multiple test assemblies on rotating platform. The test is carried out at 20±2°C at 65±2% relative humidity. The loss in weight due to water evaporation is expressed by extrapolating to grams per sq. m of fabric per day.

ASTM E 96 B is also modified cup method with minimum dish size 3000mm², the air gap in fabric and water surface of 19 mm is with air velocity of 2.8 m/s over the fabric surface. The relative humidity of 50% is to be maintained with preferrable temperature of 32.2°C.

Under some applications, water comes in direct contact with fabric, to evaluate such material, an option is provided to invert the assembly to keep water in contact with test specimen (ASTM E 96 BW). In the inverted cup test, to prevent the water in the cup from wetting the specimen, hydrophobic PTFE membrane is sealed over the mouth of the cup and then the test specimen is placed over the membrane using seal to prevent leakage. [Figure 6 (b)] The assembly is placed in inverted position in upper deck of wind tunnel. The test results are reported same as upright cup method.
The determination of permeance – the rate of moisture vapour transmission per unit difference vapour pressure across the test specimen provides performance of material. The results of test also expressed as ‘water vapour permeability index’, where the water vapour permeability of fabric is expressed as percentage of moisture vapour permeability of reference fabric tested simultaneously.

4.2 Desiccant inverted cup method

Water vapour transmission is measured as specified in JIS L 1099 B. In this method, the test assembly consisting a water vapour permeable cup (70 mm diameter and 92 mm height). A solution of potassium acetate (300 g in 100 mL water) is added in cup approx. two third of its volume and mouth is covered with PTFE membrane. Potassium acetate solution is used as desiccant that develops 23% relative humidity at one side of the fabric. The test specimen is mounted on PTFE film while the coated or laminated side facing outside. Another PTFE membrane is placed on specimen and sealed properly. Entire assembly in inverted form is placed so as to float on water container containing water at 23°C as shown in figure 6 (c).

The PTFE membrane keeps the specimen dry. Inside the cup the lower relative humidity is maintained by desiccant and outside is wet. Through membrane only moisture vapour will transfer inside across the specimen and thereby gain in weight is measured for 15 minutes is converted by calculating amount of moisture transferred per sq. meter per day. Inside the cup, humidity can be controlled using various desiccants like potassium acetate, calcium chloride, anhydrous calcium sulphate etc.

4.3 Dynamic moisture permeation cell (DMPC)

Water vapour permeability or diffusion resistance is measured using dynamic moisture permeation cell in accordance with ASTM F 2298. Specimen of 6 × 5 cm2 size is mounted in two identical metal flow cells as shown in figure 7.

A mixture of dry and moisture saturated nitrogen streams are allowed to pass over the top and bottom flow cells across the specimen, through separate flow controller. The relative humidity of stream is controlled by ratio of dry and saturated nitrogen. Humidity of 95% was maintained at top flow cell and 5% at bottom flow cell. There is no pressure gradient generated across the specimen and moisture transfer takes place through diffusion only. By measuring relative humidity at entry and exit of flow at given flow rate of 2 L/min and temperature 20°C, the water resistance to vapour diffusion is calculated; when system reached to steady state condition.

4.4 Sweating guarded hot plate

This method is simulated to sweating skin conditions. It measures evaporative resistance of fabric as specified in ISO 11092 B and ASTM F 1868 B. The test assembly consists of two layers of metal block heated electrically to constant temperature of 35°C. The upper layer is porous and bottom layer has channels to fed water to porous layer as represented schematically in figure 8.

The feeding of water is precisely controlled to maintain its level. Cellophane membrane – permeable to water vapour but impervious to liquid water, is placed on the upper porous layer and test specimen is mounted on membrane. The temperature of metal block and precisely maintained amount of water ensures the constant rate of evaporation. The setup is designed in such a way that the heat loss to the atmosphere is possible only through top layer of assembly and atmospheric conditions are maintained at 20°C and 40% relative humidity and an air current is allowed to pass over the surface of assembly. The heat loss is due to evaporation of water through the porous surface and is equal to the latent heat of water or corresponding electrical power consumption to maintain the block temperature at 35°C. An electrical power consumption is measured twice, one without and other with test specimen covering top of assembly on membrane, when steady state conditions are achieved. The difference between these two measurements is correlated with the heat loss or the mass of water transmitted through fabric in the form of vapour. This is used to estimate the moisture vapour permeability or resistivity and moisture vapour permeability index. The test method provides flexibility to choose values of the test parameters as applicable, however the estimation is carried out at steady state conditions. Total resistance to evaporative heat transfer provided by the fabric system and air layer is measured in terms of m2 Pa W−1.

Wide range of test methods are employed to evaluate MVTR however there are a lot of variation with respect to specimen size and time exposed to differential humidity; the relative humidity across the specimen; the temperature of evaluation; a presence of a layer of air on either side of fabric; in some test methods, sample is exposed to dynamic air flow however, the flow rate is different. Therefore, the numerical
values of test results also vary considerably and direct comparison is really difficult. Based on numerical ratings provided by fabric or clothing manufacturer it's challenging to choose correct material for specific end use.

Many workers tried to find the correlation between these test methods [5, 6]. It was reported that all the test methods give consistent results with acceptable coefficient variation. The upright cup and DPMC method showed higher correlation, however, the air layers in either side of specimen in both the test methods provide resistance to water vapour transmission and results are at lower amongst the test discussed above. These two test methods simulate the situation where fabric is dry and skin is normal to above normal hydrated by perspiration. The situation is slightly different in case of clothing meant for active sport wear with stretch to fit the body, where fabric is in direct contact with moisture saturated layer - skin. For such clothing inverted cup method provides close simulation. The care should be taken while using inverted cup method for fabric coated and laminated films with hydrophilic nature, which may swell in water and alter the rate of vapour transmission. The DMPC test is faster and can be modified to evaluate moisture vapour transmission at same humidity gradient at different levels of humidity, example, 50% gradient with 5-55%, 5-65%, 5-75% and so on, across the specimen; or different humidity gradient, like 10-50%, 5-65%, 5-95% across the specimen. The DMPC method also can be used to evaluate MVTR at different air pressure gradient to simulate real-life situation of windy atmosphere.

Desiccant inverted cup method (measuring MVTR) and sweating guard hot plat (measuring evaporative resistance) methods show good correlation with negative coefficient, as properties being measured are opposite in nature. These two methods offer higher numerical values. Sweating guard hot plate offers close simulation for eat and mass transfer conditions present in microclimate and atmosphere. Desiccant cup method required smaller sample size and conducted in shorter time; it doesn't require costly experimental set-up.

5. Performance of waterproof breathable material
There are various reasons for moisture vapour transmission including material characteristics, temperature, vapour pressure etc. Therefore, it is essential to study the effect of various parameters including test conditions on performance in terms of moisture vapour transmission rate of various fabrics.

Various water proof breathable fabrics use to construct sportswear and foul weather clothing and evaluated under various environmental conditions [7]. The samples were PU coated, cotton Ventile, microfibre fabric, PTFE laminated, PU laminated and hydrophilic laminated fabrics with various GSM and thickness. The water vapour permeability of these specimen was measured using dish method at range of temperature keeping air gap of 2mm. For all the sample initial rate of water vapour transfer was higher for first six hours after which it reduced and followed linear path with respect to time. For all the fabric samples, the rate of water vapour transfer observed was ranked as decreasing order as microfibre fabric, cotton Ventile, PTFE laminated, PU laminated, Hydrophilic laminated and PU coated. In general, the author found that tightly woven fabric allows greatest water vapour transport followed by laminated at then coated material. Also, he observed water repellent finish improves vapour permeability. Water vapour diffuse through interspace between the fibres and interstices of yarns, which provide space for air. He also observed that vapour transport is affected by thickness of the fabric and air permeability within the same group.

When water vapour transfer was measured at various air temperature from 0 to 20°C, it was concluded that the difference between water vapour transportation amongst various fabric was minimum and as air temperature increases to 20°C, the difference amongst various samples was increased. However, for any individual fabric the rate of moisture vapour transfer is greatly affected by the difference between vapour pressures across the fabric then the difference of temperature.

The experimental conditions were also optimised in a set of experimentations, where air gap between fabric sample and water layer in dish was varied from 5 – 20 mm. In general, it was concluded that as air gap increases, the amount of moisture vapour transferred from the fabric decreases. This was attributed to the resistance offered by air layer in air gap for diffusion of moisture vapour. However, the reduction in moisture vapour transmission is not similar to the entire specimen under investigation.

The experimentations were carried out at temperature gradient where water temperature in dish was kept at 33°C which is normal skin temperature and air temperature varied from +20°C to –20°C. It was observed that, the difference in water vapour pressure across the test specimen is not only criteria for vapour permeability. At temperature 0°C and below, the condensation of water vapour was observed, and the liquid water deposition disturbed the flow of vapour across the fabric. Also, different types of specimens exhibited differently when compared with results obtained without temperature gradient at steady state moisture vapour permeability.

The effect of windy conditions on moisture vapour transmission was studied through the various fabric specimen used for sportswear applications using dish method [8]. Water temperature in dish was maintained at 33°C and air gap of 2mm below the fabric surface to be tested. The air was allowed to blow parallel to the fabric surface at the speed up to 10 m/s and predetermined air temperature was maintained (range used: 0 - 20°C). It was observed water vapour transmission increases with decrease in temperature of air.
Further, as wind speed increases, the vapour pressure difference increases across the fabric and result into more vapour transfer.

Variety of fabrics including range of coated, hydrophilic and hydrophobic membrane laminated fabrics using dish method under temperature gradient were studied [9]. The water used in dish was at 33°C and ambient temperature of air was about 20°C and 7°C with wind velocity of 0.5 m/s. In these experimental conditions also, similar observations were found. Compared to isothermal conditions, temperature gradient showed more water vapour transmission.

A study [10] of comparison between various test methods for moisture vapour permeability of various waterproof breathable fabrics with wide range of operating conditions was carried out. It was found that the results varied with method to method. For hydrophilic coating material, the moisture vapour permeability was observed humidity dependent. The vaporization was higher when fabric was adjacent to wet surface and was lower when tested in relatively dry air. The transmission water vapour through textiles and its condensation in clothes, at high altitudes was studied [11]. Water vapour diffusion coefficient depends on temperature and pressure, therefore, care for both shall be taken while designing the clothes for high altitude. Water vapour resistance offered by clothes increases in lower temperature conditions of high altitudes. However, effect of pressure on water vapour resistance is more significant than the temperature. This resistance decreases and allow vapour permeability considerably with lower pressure. The detailed evaluation revealed that though the vapour permeability increases at higher altitude due to lower pressure; at lower temperature, air becomes saturated at lower moisture content, in case moisture vapour pressure increases inside clothing, the condensation takes place. Once condensation takes place, it reduces temperature of body causing adverse effects. It was suggested that [12] more moisture vapour transfer is possible through polyurethane under isothermal conditions and hydrophilic laminates exhibit the same under non-isothermal state.

6. Summary
A lot of work has been carried out to achieve waterproof and breathable fabric for various extreme weathering conditions and also to achieve comfort in work wear. Mechanical and chemical means were developed for waterproofness as well as breathability. For the evaluation various methods have been developed and modified. However, there is still tremendous scope for improvement, correlation with respect to specific product selection, membrane or coating formulation choice, and simulate with real-life conditions such as high-altitude clothing, medical application, sport wear and work wear; and is appealing to researchers.

References:

The Textile Association (India)
Membership Fees

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*Plus 18% GST
A Study on Fitting Problems Faced by Men in Traditional Ready-to-Wear (Lower Wear) Garments

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Abstract:
Fit refers to how well a garment conforms to the three-dimensional human body. Good fit is crucial to customer satisfaction. However, it is often easier to find clothes according to colours, prices and style that one likes than a well-fitted garment. The effect of a stunning design, gorgeous fabric and exquisite workmanship are destroyed if the finished garment doesn’t fit well to the intended wearer. The main objective of this study is to identify the fitting problems faced by male consumer in traditional Ready-to-Wear lower garments and to view the preference and satisfaction of male consumers towards Rajasthani Traditional Ready-to-Wear lower garments. Traditionally men’s wears in Rajasthani apparels are Pyjama, Jodhpuri pants, and Dhoti pants. The study was divided into two age groups 18-35 years and 36-60 years. The consumer survey was conducted to collect the data through questionnaire method.

Keywords: Dhotis, Fit, Jodhpuri pants, Pyjama, Rajasthani Traditional Garments


1. Introduction
Men’s traditional clothing in India nowadays consists of fusion of western and Indian styles such as Sherwani with trousers or dhoti with different styles. Traditional Indian clothing such as the Kurta has been combined with jeans/dhoti pants to form part of casual attire. Well-fitted garments are defined as those that are comfortable to wear, allow sufficient ease for freedom of movement, conform to present day fashion and are also free of wrinkles, sags or bulges.

Clothes are not only used to cover and protect our bodies; today, clothes are used to identify oneself. Clothes communicate personality, stand point, group belonging etc. Not all garments give clear and complete signals about the wearer’s self-identity, since the interpretation depends on the viewer [1]. Ready-to-wear garments are designed to provide consumers with pre-assembled apparel, in a range of standard sizes, designed to fit the average consumer. By this definition, people whose measurements are not within the average-size will experience difficulty with fit, either in part or in totality, when they wear standard size garments. As a result of fit problems experienced by consumers outside the standard size range, mostly prefer made-to-measure garments. From the consumer’s point of view, the ‘Fit’ of the clothing is the most important attribute. The fit of a garment is how it conforms to your body structure. The desired fit in clothing changes with fashion [2]. The high prevalence of dissatisfaction with business clothing indicates shortcomings in the ready-to-wear offerings available to male consumers. There is no link between clothing interest level and reporting rate of clothing issues, future studies of fit and sizing issues do not need to take into account the effect of interest on the accuracy of their results [3]. The trouser manufacturers develop their own size charts, manufacture trousers and sell them in the stores. Some of the graded sizes were selected for construction of trousers for wear trials to get feedback on the fit and comfort of the new developed trousers [4]. The main objectives of the research were:

- To identify the problems faced by men in traditional ready-to-wear lower garments from the age groups of 18-35 years and 35-60 years.
- To collect information regarding the satisfaction of male consumers in regards with men's traditional ready-to-wear lower garments.
- To access the preference of male consumers towards men's traditional ready-to-wear lower garments.

2. Material & Methods
Locale of the study: The study was conducted in Jaipur with the method of random sampling.

Sample size: The total sample size of the respondents was taken as 200.

Sample selection: The research was done by selection of multi-stage sampling method in which consumer survey was conducted with random sampling in area sampling. The male consumers were chosen randomly.

Data Collection: Both the primary and secondary data collection methods were considered. The primary data was collected through a questionnaire designed exclusively for the study. The secondary data was collected through journals, articles, and internet.

Analysis of Data & Interpretation: After the collection of the desirable data through questionnaire, the data was be analysed and the final result was evaluated through the transferring the data to the excel sheet. Then the data was evaluated by putting the desirable and suitable tests.
3. Results & Analysis

From the above study one can conclude that majority (55% and 47%) of respondents of age group 36-60 years and 18-35 years feels that the length of garment is too long in fi for the garment; whereas 20% and 21% respondents of age group of 18-35 years and 36-60 years have faced problem with the minor difference that the length of the garment is too short in ready-to-wear pyjamas which are available in the market.

The study shows that majority (39% and 34%) of respondents of age group 36-60 years and 18-35 years feels that the round waist of the garment is too loose according to the fit; whereas 27% and 20% respondents of age group of 36-60 years and 18-35 years have faced problem with the round waist of the garment as it is too tight in ready-to-wear pyjamas available in market.

Thirty percent respondents of age group 36-60 years and twenty three percent respondents of age group 18-35 years have experienced fit problem at round hip of the garment as it is too loose for the wearer; whereas compared to 28% respondents of age group 36-60 years only 26% respondents of the age group 18-35 years have faced problem at round hip of the garment as it is too tight in ready-to-wear Pyjamas.

From the above figure one can conclude that 31% and 29% respondents of age group 36-60 years and 18-35 years have experience fit problem at ankle area of the garment as it is too loose; whereas the majority of 38% and 37% respondents of age group 18-35 years and 36-60 years have faced problem with the minor difference in the ankle area in ready-to-wear Pyjamas as it is too tight.

The above figure shows that majority (36% & 27%) respondents of age group 36-60 years and 18-35 years have experience fitting problem at knee area of the garment as it is too loose; whereas compared to 31% respondents of age group 36-60 years, the majority of 43% respondents of the age group 18-35 years have faced problem in the knee area in ready-to-wear Pyjamas as it is too tight.

The above figure depicts that 23% of respondents of age group 36-60 years and 21% of age group 18-35 years have experience problem with the crotch line of the Pyjama as it is too long; whereas 33% and 27% respondents of age group 36-60 years and 18-35 years have faced problem in the knee area in ready-to-wear Pyjamas as they are too short.

The above figure depicts that majority (36%) respondents of both the age group of 18-35 years and 36-60 years have experience fitting problem at thigh area of the garment; whereas 32% and 31% respondents of the age group 18-35 years and 36-60 years have faced problem with the minor difference in the thigh area in ready-to-wear Pyjamas, as they are too tight.
Majority (33% and 29%) of respondents of age group 18-35 years and 36-60 years feels that the round waist of the garment is too loose; whereas compared to 39% respondents of age group 18-35 years only 33% respondents of the age group 36-60 years have faced problem with the round waist of the garment as it is too tight in ready-to-wear Jodhpuri pants.

![Figure 3.2.2: Problem in round hip of the Jodhpuri pants (n=200)](image)

From the above result it can be can analyzed that 34% and 32% respondents of age group 36-60 years and 18-35 years have experienced fit problem with round hip of the garment as it is too loose; where only 27% and 25% respondents of age group 18-35 years and 36-60 years have faced problem with the round hip of the garment as it is too tight in ready-to-wear Jodhpuri pants.

![Figure 3.2.3: Problem in Ankle of the Jodhpuri pants (n=200)](image)

Both respondents of the age groups 18-35 years and 36-60 years have experience equal fitting problem of 35% at ankle area of the garment as it is too loose; where as compared to majority of 39% respondents of age group 18-35 years only 37% respondents of the age group 36-60 years have faced problem with the ankle area in ready-to-wear Jodhpuri pants as they are too tight.

![Figure 3.2.4: Problem in knee of the Jodhpuri pants(n=200)](image)

The above figure depicts that 25% and 22% respondents of age group 36-60 years and 18-35 years have experience fitting problem at knee area of the garment as it is too loose. The majority of 46% respondents of the age group 18-35 years 43% of 36-60 years have faced problem in the knee area in ready-to-wear Jodhpuri pants as they are too tight according to the fit of the garment.

![Figure 3.2.5: Problem in crotch line the Jodhpuri pants (n=200)](image)

Above figure highlights that 26% and 24% respondents of age group 36-60 years and 18-35 years have experience problem with the crotch line of the Jodhpuri pants as it is too long for the wearer. The majority of 42% and 40% respondents of age group 18-35 years and 36-60 years have faced problem with the crotch line in ready-to-wear Jodhpuri pants as they are too short for them and is not suitable for them to wear.

![Figure 3.2.6: Problem in Thigh of the Jodhpuri pants](image)

The above study shows that majority of 41% and 39% respondents of age group 36-60 years and 18-35 years have experience fit problem in thigh area as too loose; where as compared to 33% respondents of the age group 18-35 years only 28% respondents of age group 36-60 years have faced problem in the thigh area of garments in ready-to-wear Jodhpuri pants, as they are too tight and at time they are about to tear out while wearing it and is very uncomfortable.

![Figure 3.3.1: Problem in round waist of the Dhoti pants (n=200)](image)

With comparison to 14% respondents of age group 36-60 yrs only 7% respondents of age group 18-35 yrs have experienced fitting problem with round waist as it is too loose in garments which are available in the market; where as compared to 16% respondents of the age group 36-60 yrs only 11% respondents of age group 18-35 yrs have faced problem in round waist area of the garment as it is too tight in Dhoti pants.
From the above study one can analyze that in comparison to 14% respondents of age group 36-60 years only 9% respondents of age group 18-35 years have experienced fit problem with round hip of the garment as it is too loose to wear which gives them ill effect to the wearer; where as compared to 15% respondents of age group 36-60 years only 11% respondents of the age group 18-35 years have faced problem with the round hip of the garment as it is too tight in Dhoti pants.

The least 3% respondents of age group 36-60 years and 2% respondents of age group 18-35 years have experienced problem with the crotch line in Dhoti pants as it is too tight in Dhoti pants.

The majority (50% and 44%) of respondents in age group of 36-60 years and 18-35 years have suggested that the body measurements should be improved so that they can find proper and good fit for the garments which can enhance their overall personality; whereas compared to 43% of age group of 36-60 years only 34% in age group of 18-35 years feels that the market should provide them wide range of sizes so that they can select the fit according their body type.

The above figure also depicts that the side seam allowances for adjustment according to the fit of the wearer was also selected by the majority (39% and 25%) of respondents of age group 36-60 years and 18-35 years as they could do alteration according to themselves.

Clear information on the size labels is the least chosen factors by respondents (25% and 24%) in age group of 36-60 years and 18-35 years as it hardly matters when they buy the clothes for themselves whereas compared to 34% respondents of age group of 36-60 years only 24% respondents of age group of 18-35 years suggested to localized the sizing labels according to the Indian standard size measurement chart.

4. Conclusion
The study fulfilled the purpose that fit plays the major role in clothing satisfaction and it can be concluded the consumers have faced problem in various areas of Pyjama, Jodhpuri Pants and Dhoti. In lower traditional ready-to-wear garments, consumers have faced with the long length of Pyjama and Jodhpuri Pants, whereas it was also observed that ankle and knee are mostly tight in both the garments which is inconvenient in wearing and has major possibility of tearing. Consumers have also faced problem with loose thighs in Pyjama and Jodhpuri Pants. Most of the consumer experienced tight round waist and short crotch line in Jodhpuri Pants which is not at all comfortable for them while sitting. No problems were experienced by majority of consumers in Dhoti. The study also indicated that the majority of consumers of age group of 18-35 years get more satisfied by fashion goods, in relation to quality, price, goods with big brand names, as advice from the salesman and after sale services as compared to age group of 36-60 yrs.
References
Microbial Dyes for Textiles: A Sustainable Alternative to Synthetic Dyes

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Abstract:
The textile and dyeing industry have been utilizing synthetic dyes to color a range of fabrics from time immemorial. However, with increasing awareness about environmental hazards, pollution, consumer safety and health issues, there is an escalating demand for development of natural dyes that are biodegradable and safe for human use. A plausible alternative for synthetic dyes are microbial dyes which have bacterial, fungal and lichen origin and are safer to use in comparison to the synthetic dyes. Microbial dyes owing to their eco-friendly biodegradable properties are exceeding expectations in terms of sustainability. They also offer several other advantages over the traditional synthetic dyes in terms of ease and lower cost of production and in addition, properties such as UV protection and antimicrobial properties. The present review outlines the different types and properties of microbial dyes that have potential for use in the textile industry and how they compare against the extensively used synthetic dyes. The review also highlights some interesting commercial applications of microbial dyes and discusses the potential they hold in changing the outlook of the textile industry in future.

Keywords: Antimicrobial, Biopigments, Biotechnology, Colorfast, Eco-friendly, Microbial dyes

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1. Introduction
Dyes and dyestuffs are used intensively within textile industries. About 100,000 commercially available dyes exist and over 7×10^5 tons of dyestuff are produced annually [1]. It is a prerequisite for the industries to add hues to their product in order to make them appealing and increase its market value for which certain dyes and pigments are used (both natural and synthetic dyes). These dyes give color to the article by adhering to the surface and the chemistry of the dye reveals that either by the phenomena of physical adsorption or mechanical retention, they form covalent bonds with metals or salts [2]. The synthetic dyes used in textile industries are hazardous towards our health because of their carcinogenic properties, they can also induce allergies or due to presence of strong acids or alkalies as catalysts they can cause toxic reactions that are perilous to the environment [3]. Moreover, in the course of preparing textiles, a huge amount of dyestuff is channeled into the nearby water bodies resulting in water waste that eventually contributes to pollution of the environment. Thus, the need of the hour is to switch to more sustainable and eco-friendly alternatives to these synthetic and chemical dyes. Plant based natural dyes are again coming up as one of the solutions to curb this problem. However, as they are limited by the large amount of space and time required for their preparation, variation in seasonal availability and low yield, making it difficult to meet the high demands of the textile industry. In this regard, microbial based natural dyes are emerging as a promising solution. These require comparatively less time and space for productivity and work well with both synthetic as well as natural fibers [4]. In the present review, we will highlight various sources of microbial dyes, their comparison with synthetic dyes, commercial status and future prospects.

2. Diverse Sources of Microbial Dyes
Microorganisms including many types of bacteria, fungi, algae and protozoa are the most versatile tools in biotechnology to produce a variety of molecules including enzymes, antibiotics, organic acids and pigments. Microbial products serve as potential alternatives to many synthetic products. Microorganisms produce a wide variety of stable pigments such as carotenoids, flavonoids, melanins, prodigiosins, quinones, and verubramins and have higher yields than fermentation products of plants and animals [5]. Microbial biopigments have tremendous applications in various leading industries like food, textile, waste management, cosmetics, pharmaceutical and many more. Microbial pigments offer several advantages over plant based pigments in terms of availability, stability, cost efficiency, labour, yield and easy downstream processing [6]. Most importantly, the stable and sustainable nature of microbial dyes makes them attractive alternatives to synthetic dyes.

3. Bacterial pigments used in textile industry
A vast array of bacteria is potential producers of pigments which are used in the textile industry. Biopigments produced by bacteria have immense applications as natural dyes to impart stable colors to various grades of textiles. Chromobacterium violaceum, Janthinobacterium lividum, Chromobacterium lividum and Pseudoalteromonas luteoviolacea produce pigments which are used for dyeing textiles and good dyeing results have not only been obtained in connection with natural fibers such as silk, wool and cotton, but also with synthetic fibers such as nylon. A bluish purple pigment was also isolated from Janthinobacterium lividum, and it is used for dyeing in textiles [4]. A blue color pigment isolated from Streptomyces coelicolor is also used for dyeing in textiles. A yellow color pigment isolated from Chryseobacterium sp. is used to dye fabrics such as natural...
It can be observed that there are majorly three types of pigments viz. prodigiosin, violacein and melanin. Although natural dyes have more affinity for synthetic fabrics, bacterial dyes can stably dye a broad variety of fabrics including cotton fabrics too. They have a significant degree of fastness to light and wash.

There are various advantages of using bacterial pigments. Firstly, bacteria are highly versatile and productive over other sources. They have a short generation time and can be produced in bulk. Thus, their upscaling and fermentation is inherently faster. Secondly, downstream processing of bacterial pigments is also simple and cheap. They can be extracted using simple liquid-liquid extraction techniques. In addition to these advantages, some bacterial pigments have antimicrobial, anti-cancer and anti-diabetic properties. Of these properties, application of antimicrobial bacterial pigments to certain textiles such as those used in hospitals will have a significant advantage as it would decrease the chances of nosocomial infections. It can also be used to dye garments made for babies and for patients allergic to chemical dyes. One of such bacterial dyes, prodigiosin has already been reported to inhibit both Escherichia coli and Staphylococcus aureus. Prodigiosin is an attractive red colored pigment produced mainly by Serratia sp. It is a cell associated pigment which is considered as a multifunctional secondary metabolite as it has anti-bacterial, anti-parasitic, anti-fungal, anti-diabetic and anti-cancer properties. It is being used to dye a variety of textile materials such as cotton, nylon, polyester, muslin, silk and wool. Owing to its potential anti-microbial activity it can be used to dye special textiles with specific protection against some pathogenic microorganisms [8]. Another violet colored bacterial pigment, violacein, produced by Chromobacterium violaceum also possesses anti-fungal, antibacterial, antiparasitic activity. Synergistic effect of this pigment with silver nanoparticles has also been documented to impart excellent antimicrobial properties against pathogens such as Staphylococcus aureus, Escherichia coli and Candida albicans [9].

Furthermore, melanin, produced from Streptomyces sp. has been applied to dye wool. This dark brown color dye gives highest color strength value and excellent fastness properties of washing, perspiration and light to both dyed and printed wool fabrics [10].

4. Fungal Pigments used in textile Industry

Fungi are a versatile group of microorganisms that can serve as a valuable source of pigments for the textile industry. Several pigments from fungi have been shown to have the potential for dyeing different types of fabrics ranging from wool, nylon, acrylics and silk [2]. These fungal pigments show tremendous versatility in chemical structure such as carotenoids, polyketides, azaphilones, quinones, anthraquinones, flavins, melamins etc. [2]. Venil et al have reviewed the different fungal pigments isolated from diverse genera of fungi [2]. Fungi can be easily cultivated on a large scale and fungal pigments can be easily extracted using simple procedures. Hence, fungal pigments produced commercially can serve as cheap, eco-friendly biodegradable alternatives to synthetic pigments. Table 1 includes the various fungal pigments shown to have potential in the textile industry.

Fungal dyes have been used to dye a range of fabrics such as leather and cotton, nylon, polyester, wool and silks [2]. The fungal pigments offer the advantage of color fastness which is the primary requirement for dyeing fabrics. The fabrics dyed with fungal pigments show fastness after washing and remain intact even under conditions of prolonged sunlight and rain washing [2]. The fungal pigments also show stability to heat, light, pH and temperature [11, 12, 13]. A remarkable group of pigment producing fungi is the wood rotting fungi isolated from natural environments. Several of these wood-sapting fungi have been shown to produce pigments that showed potential in preliminary tests [14]. The extraction of these novel pigments however need dichloromethane that may be a health and environment hazard and safer methods for their extraction need to be developed. Similarly, a red pigment has been isolated from an endophytic fungus, Nigrospora aurantiaca CMU-ZY2045, that can be used for dyeing cotton fabrics [15].

Several biotechnological approaches have been used to produce pigments from fungi [16]. Many fungal pigments offer interesting features such as absorption of UV light, thereby offering UV protection to the skin of the user [17]. Several fungal pigments also show antimicrobial activities [18][19].

5. Lichen Based Dyes

Lichens are a beautiful symbiotic amalgamation of algae and fungi. For over 4000 years lichen dyes have been used to coloring materials, particularly shades of purple have been extracted from the lichens over the years, generally called false shellfish purple or orchil or archil dyes which were derived from Rocella fuciformis D.C. and Rocella fuciformis D.C. The lichen dyes were obtained by the process of fermentation of the lichen extracts in the presence of modifiers like ammonia and air [20]. Methods like cow urine method, ammonia fermentation method (AFM), boiling water method (BWM) dimethyl sulphoxide extraction method (DEM) were employed for extraction of dyes from lichens. These extraction methods helped in procuring purple, pink, yellow, brown, orange, and green hues. In addition to the different hues the fabric dyed with lichen dyes had a specific odour attributed to it [20]. Lichens can dye natural fibers of all kinds, such as wool, silk and synthetic fibers, and plastic buttons and animal hides and substantially do not require any mordant or fixatives due to the presence of ammonia and nitrogen in them. Lichens are easily available in the environment as they grow on tree trunks, over rocks and stones, and during sample collection process they are thoroughly washed to get rid of all the contaminations and the pigment producing parts are severed for further extraction of the dyes. It is advised to only use naturally available lichen for dyeing and the whole thallus should not be harvested in an effort to protect their natural habitat [20].
6. Microbial Dyes vs Synthetic Dyes

As more and more microbial dyes are being identified and studied, it is time that the textile industry realizes their potential and innumerable advantages over the extensively chemically synthesized dyes. First and foremost, they are eco-friendly and hence are a great replacement to the synthetic dyes, most of which are non-biodegradable. Millions of tons of synthetic dyes and their precursors are discarded as effluents by textile industries every year [21]. A great concern is the persistence of these in the environment for years to come. This calls for the development of eco-friendly alternatives to synthetic dyes in the textile industry.

Use of synthetic dyes and mordants that are used to enhance the dying process leads to a lot of environmental pollution which poses major health hazards that can be easily circumvented by the use of microbial dyes. Certain microbial dyes such as those isolated from lichens, in fact, do not require any mordants to be taken up by fibers, thereby further reducing the need for chemical mordants [20].

Microorganisms are a promising reservoir for bio pigments that offer a range of hues that can be attained on natural as well as man-made fibers [4]. Interestingly, microbial pigments produce different color tones in different textiles. The same pigment may give a different color tone on natural and synthetic fibers based on their affinity to these different fibers [19] [22]. Their ability to dye a range of fabrics and color fastness of fabrics dyed by using them make them a lucrative replacement to synthetic dyes. These are also cost efficient in addition to being easily available with higher yields and are more stable than the plant sourced dyes [6]. Production and dyeing processes of these microbial dyes are water efficient too, as in conventional dying procedures a huge amount of water is used [5].

It is also important to assess the toxicity of pigments to understand how safe they are for use. Many synthetic dyes may have long term toxic effects or can be a cause of allergies and cancer [23]. This calls for the development of safe nontoxic dyes isolated from natural sources. Several studies involving cytotoxicity tests have been performed to analyze the toxicity of fungal pigments [24]. Most microbial dyes tested showed extremely low levels of toxicity, which makes them a favorable choice over synthetic dyes [25]. In addition, several microbial dyes show antimicrobial properties that make them lucrative for dying hospital appaels, sheets [26]. Some also possess antioxidant and anti-inflammatory properties [27].

Despite having these characteristics, microbial dyes and pigments still lack somewhere in meeting the needs of the textile industry. One basic reason for this can be that clothes cover the skin and therefore, they are directly related to it. In rare cases, microbial dyes can cause allergies and infection to skin [28]. Another important limitation is irregular fixation shown by these compounds, even with the use of mordants. Also, because these are still in the developing process and microbial dyes have not properly established in the market, there is a lack of standardized industrial dyeing procedures tested for this type of compounds. So in order to raise industrial production of microbial dyes and pigments for textile applications, there is an urgent need to rectify such issues of testing of dyeing methods suitting conditions and requirements of the textile industry [29]. Certain steps and processes like fermentation, cell growth, and nutrient content can act as limiting factors for production of microbial pigments. To overcome this, selection of appropriate strains, growing conditions, nutrients provided, substrates etc. needs to be standardized further [15]. Increasing pigment yield and biomass yield impart another challenge because of being negatively correlated. This develops the need to study the relationship between biomass and pigment production. Genetic engineering techniques are one good solution to overcome this challenge. But again, proper study and testing are needed to be done before applying any technique for marketing purposes. Some microbial dyes are less stable and offer a limited range of hues.

Another hurdle in the use of microbial dyes is the co-production of toxic compounds along with the useful pigment, limiting their application and preventing regulatory approval. These toxic compounds can be harmful in so many ways, hence, there must be some ways to reduce or bring their yield to zero for production of only desired pigment. Several fungal pigments from Trichoderma sp., Thermomyces sp., P. purpurogenum, P. niczynskii have been tested and found to be safe and non-toxic having broad scope in the textile industry [2]. Optimization of various parameters such as temperature, pH, substrates and dissolved oxygen during the time of pigment extraction can help overcome most of these limitations. This has been proven the easiest and most basic way for overcoming these challenges.

7. Commercial status of microbial dyes in textile industry

The market of microbial dyes, though in its infancy, is already making a place in the market with demands from various textile industries worldwide. The need for developing sustainable and eco-friendly solutions for dyeing textile material is shifting the trend of big fashion houses to use microbial dyes in place of synthetic dyes. Innovative designers like Natsai Audrey Chieza are already using Streptomyces coelicolor to dye their unique products such as a tie-dye T-shirt with shades of red, pink, purple and blue. Streptomyces coelicolor produces pink to red colored prodigiosin dye and actinorhodin, a water-soluble molecule which majorly gives blue color. Its color depends on pH. Deep magenta color can also be produced from it as a combination of prodigiosin and actinorhodin dyes [30].

Colorifix’s Innovation, another England based textile brand, aims to reduce water pollution by using microbial pigments. They are using biotechnology tools to engineer bacteria to produce a diverse spectrum of dyes. In addition, they are also saving on a large amount of water and chemicals used to isolate bacterial pigments by directly coloring the fabric by bacteria. They grow the bacteria on the fabric and then heat the fabric leading to lysis of bacterial membrane and release of the colored dye. This is followed by washing the dyed fabric to remove the remnants of bacteria [31].
On similar lines, another French startup company, PILI is into producing and using a new generation of renewable microbial colors. Their production process, though still in trial stage, projects to use 80% less water and produce 90% less carbon emissions, than conventional dye-making methods [32]. Vienna Textile Lab also fabricates organic bacterial colors to dye a variety of fabrics as they also believe that chemical dyeing is the most polluting aspect of the global fashion industry and it should be replaced by more sustainable alternatives such as these microbial dyes [33]. Another established fashion brand, Kukka is successfully running a Living color biodesign project to potentially use bacteria as dye factories to color their products. They are producing various shades of purple pigment violacein from Janthinobacterium lividum, the pink to red colored carotenoid pigment from Arthrobacter agilis and yellow pigment from Micrococcus luteus [34]. It’s not just bacteria, the future of fashion is also being supported by algal pigments. An Israeli firm, Algalife, is growing non-toxic dyes with algae. They are turning algae into healthy dyes in a clean system. These algae-based dyes and fibers are not only eco-friendly but are also good for our skin and body [35].

With a large number of fashion houses realizing the importance of use of microbial dyes, soon the commercial demand of microbial dyes will constantly be on a rise.

8. Future Prospects
Biotechnology based approaches to improved pigments production is a burning area of research. As more and more pigment production biopaths in microorganisms are now well understood, it will soon be possible for scientists to make guided genetic manipulations in microorganisms to synthesize the fungal metabolites (some of which are pigments) of their interest. Genetic engineering approaches have also been applied for improved production of pigments in fungi [36]. Interestingly, fungal pigment production can also be metabolically engineered in an organism that generally does not produce the pigment naturally. Organisms such as S. cerevisiae, that are simple to grow, well understood and cost much less in industrial fermentations can thus be engineered to produce pigments of choice [37]. Blue pigment producing bacteria such as Streptomyces coel has been genetically modified to produce a polyketide which exhibits bright yellow color [38]. Recent reports have also shown the possibility of production of the dye indigo widely used in the textile industry, from metabolically engineered E. coli and Corynebacterium glutamicum [39] [40]. Genetic engineering approaches can also be applied to strain improvement and process development for microbial dyes.

An important deterrent in the production of microbial dyes at industrial scale is the high cost of instruments, chemicals and processing procedures. Some of the media components used for growing microorganisms have high cost and the cost of production can definitely be brought down through the use of agricultural and industrial waste as substrates for growth of bacteria and fungi. There are many recent reports where these waste materials have been used for production of pigments from fungi. Wastes such as whey and coconut water medium jackfruit and durian seeds, sugarcane and corn bagasse and grape waste [2] have been used in various studies for production of fungal pigments. This would bring down the cost of production as well as solve the problem of disposal of these wastes.

Microbial dyes are biodegradable, organic and eco-friendly in nature which makes them gentle to both the environment as well as safe for human use. Due to this reason their use has been encouraged in food, pharma, cosmetics industries [8]. Microbial strains are easy to manipulate, their life expectancy can be altered in accordance to our requirements, and with microbial dyes one gets the opportunity and liberty to design a strain in reference to their needs and the demand of the product. Microbial dyes are a more sustainable alternative in textile dyeing in terms of resource (one single culture can go a long way) and management (requires less time and space) as well. Microbial dyes are a plausible imperishable alternative, and need to be embraced and employed to provide the world population with a sustainable way into the future. With growing awareness about usage of environment friendly dyes as well as stricter rules and regulations against use of synthetic dyes, the microbial dyes are indeed a boon to textile industries.

9. Acknowledgment
The authors would like to thank the management of Shaheed Rajguru College of Applied Sciences for Women, University of Delhi. The authors would also like to thank Ms. Arunima & Ms. Bhavna for their contribution.
Air-Permeability and Water Absorption of Typha Wet Laid Nonwovens for Technical Application and Tencel Socks

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Abstract
The Comfort properties in terms of air-permeability and water absorbency of nonwovens are very important for some technical applications like health care and hygiene in medical textiles. Typha fibers extracted through chemical retting process & wet laid nonwovens prepared with different GSM. Two parameters mainly measured i.e. air-permeability and water absorption capacity of nonwoven fabrics; also thicknesses of different nonwoven fabrics assessed and have correlated their effect by change of factors. The fiber retting parameters such as chemical concentration & treatment time and nonwoven particulars i.e. fiber length & GSM, their effect on air-permeability and water absorption capacity studied. From the experimental evaluation it was found that the fiber length and GSM have significant effect on air-permeability; water absorption capacity for all GSM nonwovens found to be same i.e. 400-500%. Sinking time of nonwoven webs 50sec for 100gsm and 2minutes for 250gsm and nonwovens bonded with SLN binder have found to be 20minutes.

Keywords: Typha Angustifolia, Nonwoven, Diameter, Air-permeability, Water absorption capacity,


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1. Introduction
The utilization of nonwoven fabrics made from natural fibers has increasing contemporary world and have numerous applications in the field of technical textiles. There are many reasons to choose natural fibers for technical applications, mainly due to environmental concern [1,2]. Also the researchers are working on many unconventional fibers for their rich availability, eco-friendly and also to control on usage of synthetic fibers for specific applications.

Typha fibers extracted from leaf blades of Typha plant, which will grow and abundantly available in water ponds/wet lands. There are various methods available for fiber extraction such as mechanical method, dew and water, enzymatic & chemical etc. In chemical method the fiber yield approximately in the range of 30-40% on w/w basis [3]. In general fiber yield will vary by type of retting and extraction particulars such as treatment time, temperature & chemical concentration also the type of material i.e. fiber source. Natural fiber wet laid nonwovens (NFWLN) made for the various applications like hygiene, acoustic, composites, insulation, automotive and geo-textiles etc. [4, 5, 6, 7, 8].

Evaluation of the performance characteristics of NFWLN will be depends upon end product functional requirements. For hygiene applications it is very important to know about the water absorbency and permeability. These are directly influenced by fiber diameter, fabric thickness or GSM, fiber cut length and more. In the previous works, natural fibers like flax, jute, hemp and banana were used for making sanitary products[9], Also used wood pulp [10]. They have evaluated antibacterial properties, water retention & absorption, GSM, pore size distribution and air-permeability.

In the present work, describes the chemical retting process of Typha fibers with optimized extraction parameters, optimization based on fiber diameter and single fiber tensile strength. These fibers were taken for the preparation of wet laid nonwovens with various combinations. A flow chart of conversion process from fiber extraction to nonwoven making was shown in Figure1. The various nonwovens have been evaluated their thickness, air-permeability, water absorbency and sinking time. From the statistical analysis a study was carried out to see the effect of various parameters/factors on above said comfort properties.

Figure 1: Process flow chart for fiber to nonwoven

2. Material and Methodology
2.1 Material
Typha fibers with the lengths of 10mm, 20mm, 30mm extracted from Typha leaves using chemical retting method (sodium hydroxide). A perforated mesh screen used for web
making and SLN binder has been used for fiber bonding. From the extracted fibers wet laid nonwovens fabrics were made with different fabric densities to measure the air permeability.

2.2 Wet laid nonwoven fabric making process

The fabric preparation process involves majorly four steps i.e. fiber extraction, opening, web making and web bonding. Fresh Typha leaves were collected and dried, further these leaves chopped manually with required cut length. Sodium hydroxide was used for the fiber extraction with 20&30gpl concentrations and 240&300min of treatment times respectively. After extraction dried fibers opened in drum carder for the individualization and to reduce the fiber bunches. Opened fibers subjected in water to prepare homogenous mixture of fiber slurry for making a uniform wet laid web, hence the fabric areal density. Figure 2 illustrates the detailed process of making Typha fiber wet laid nonwoven fabrics. The prepared web was chemically bonded with acrylic binder, after the application of binder solution webs are dried at 90°C and cured 130°C about 6-10min to fix the binder on the fabric. The process of web making and application of binder on to wet laid web was shown in Figure 3.

![Figure 2: A complete preparation process of Typha fiber wet laid nonwoven fabrics](image)

![Figure 3: Wet laid nonwoven fabric making process: (a) Web making,](image)

![Figure 3: Wet laid nonwoven fabric making process: (b) Chemical bonding by means of spraying technique](image)

3. Methodology

A preliminary study was conducted to fix the NaOH concentration and Treatment time for the present study. Here three levels (i.e. 10, 20 & 30 grams per liter) of concentration and four levels (i.e. 180, 240, 300, 360minutes) of treatment times were selected and total twelve combinations made for the optimization. After the fiber extraction of respective combinations the fiber tensile strength was measured to optimize the above said two factors. It was found that the tensile strength of 20gpl NaOH with 240 & 300 minutes treatment time got 125Mpa & 179.82Mpa and 30gpl with 240 & 300 minutes treatment time got 106.03Mpa & 122.69Mpa respectively. Since these combinations observed highest tensile properties, in the present study 20 & 30gpl of NaOH and 240 & 300minutes of treatment time for the extraction of fibers were selected.

A total of four factors were selected with different levels shown in Table 1. From the selected factors and levels a total of 48 combinations prepared using a multilevel full factorial design.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Fiber type</th>
<th>Sodium hydroxide concentration (gpl)</th>
<th>Extraction / Treatment time (minutes)</th>
<th>Fiber cut length (mm)</th>
<th>Fabric GSM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Typha</td>
<td>20</td>
<td>240</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>30</td>
<td>300</td>
<td>20</td>
<td>150</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>-</td>
<td>-</td>
<td>30</td>
<td>200</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>250</td>
</tr>
</tbody>
</table>

3.1 Characterization:

i. Fiber diameter

Fibers extracted from the various combinations were assessed using their diameter and fiber swelling behavior treated with distilled water at Radical RXL-4T optical microscope with 4X magnification.
ii. Nonwoven Fabric thickness

Fabrics thickness of all the nonwoven was evaluated using fabric thickness tester as per the standard method of ASTM D5729-97.

iii. Air permeability

Air permeability is a property of a material, in which penetration ability of air through the fabric can be measured in cm3/s/cm2. The applications of nonwoven fabrics such as hygiene products, air filters, air cooling pads, pillows, duvet covers and insulation materials it is important to know the performance in terms of air permeability. For example, the efficiency of filtration is directly connected to air permeability. Also in case of air cooling pads, the cooling efficiency is directly related to permeability of air through it [11]. The change in air-permeability of various densities of wet laid nonwoven fabrics assessed by air-permeability tester as per the standard test method of ASTM D737[12].

iv. Water absorption capacity

Nonwoven fabrics have several applications in the textile sector, some are air cooling pads, hygiene goods in medical textiles, and cleaning cloths etc. As per the application point of view it is important to evaluate the water absorption capacity of a prepared nonwoven, based on this the performance of the nonwoven can be decided. This test is used to measure the total amount of water absorbed by the nonwoven fabric [13]. The specimen of 100×100 mm2 measured dry weight then the specimen is immersed in water of depth 20cm for 20minutes ± 30sec. Then the immersed specimens was taken out from the water, shaken ten times manually and hang it for 2minute to remove excess amount of water and measured wet weight to calculate the total water absorption percentage.

Percent water absorption = \[
\frac{\text{Mass of water absorbed by the specimen}}{\text{Original mass of the specimen}} \times 100
\]

v. Sinking time

Sinking test is to measure time taken for sinking the specimen in distilled water. For the test all the samples has prepared into 25 × 25mm size.

4. Result and Discussion:

4.1 Fiber diameter

There are four combinations made by using the factors such as sodium hydroxide & extraction time for the retting of fibers from Typha leaf. The longitudinal view of fibers observed under microscope for the measurement of fiber diameter. The fiber mean diameter and mean diameter CV% given in Table 2. It was observed that, the diameter decreases while increasing the concentration of sodium hydroxide and extraction time. This is due removal non-fibrous content and impurities by increase in concentration and time.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>NaOH concentration, Retting time</th>
<th>Fiber mean diameter (µm)</th>
<th>Mean diameter CV%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20gpl, 240min</td>
<td>131.467 ±30</td>
<td>10.4461</td>
</tr>
<tr>
<td>2</td>
<td>20gpl, 300min</td>
<td>118.5936 ±35</td>
<td>15.6442</td>
</tr>
<tr>
<td>3</td>
<td>30gpl, 240min</td>
<td>113.2332 ±38</td>
<td>15.4193</td>
</tr>
<tr>
<td>4</td>
<td>30gpl, 300min</td>
<td>105.6777 ±35</td>
<td>17.566</td>
</tr>
</tbody>
</table>

Also it is observed that at 30gpl with 300min extraction time, there was a rising of fibrils from the fiber due to more removal of non fibrous content which is shown in Figure 4.

Figure 4: Longitudinal view of Typha fibers of various retting conditions, A] 20gpl, 240min B] 20gpl, 300min C] 30gpl, 240min D] 30gpl, 300min

The extracted fibers also evaluated the change in diameter of fiber (observation made at same place) treating with water, starting with 1 minute time interval up to 15minutes later, every 5minutes interval until the no change in diameter observed. The fiber diameter changed within a minute around 30%, 1min to 15min 8%, and then from 15min to 30min 7% diameter increased; in an overall 45% increased its diameter from diameter of 115.5µm at specific area.

4.2 Fabric thickness

Nonwoven fabric thickness is measured at 20different places of each sample using fabric thickness testing apparatus and evaluated mean fabric thickness. The mean thickness of the fabrics correlated with the chosen factors of the experiment, the interaction plots for fitted means shown in Figure 5.

From the fully nested analysis of variance (Table 3) depicts that the factors such as chemical concentration, retting time and fiber length have no significant effect on fabric thickness. This is due to no moderate change in mass per unit volume (i.e. mass of fibers occupied in unit area), whereas, the fabric thickness has increased by increase in GSM. The mean fabric thicknesses 1.235 mm, 1.856 mm, 2.379 mm & 2.989 mm for various fabric GMSs such as 100, 150, 200 & 250 respectively.
From the fully nested analysis of variance (Table 3) depicts that the factors such as chemical concentration, retting time and fiber length have no significant effect on fabric thickness. This is due to no moderate change in mass per unit volume (i.e. mass of fibers occupied in unit area), whereas, the fabric thickness has increased by increase in GSM. The mean fabric thicknesses 1.235 mm, 1.856 mm, 2.379 mm & 2.989 mm for various fabric GSMs such as 100, 150, 200 & 250 respectively.

Table 3: Analysis of Variance for Mean nonwoven fabric thickness

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical concentration (gpl)</td>
<td>1</td>
<td>0.2232</td>
<td>0.2232</td>
<td>2.140</td>
<td>0.281</td>
</tr>
<tr>
<td>Treatment time (minutes)</td>
<td>2</td>
<td>0.2086</td>
<td>0.1043</td>
<td>0.310</td>
<td>0.742</td>
</tr>
<tr>
<td>Fiber cut length (mm)</td>
<td>8</td>
<td>2.6950</td>
<td>0.3369</td>
<td>0.560</td>
<td>0.803</td>
</tr>
<tr>
<td>Error</td>
<td>36</td>
<td>21.6414</td>
<td>0.6011</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>47</td>
<td>24.7682</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.3 Air-permeability interpretation

The mean diameter of extracted fibers is given in table 2, finer fibers extracted while increase in chemical concentration. Nonwoven fabrics made with these fibers have measured air permeability and it was found that the fabrics made with finer fibers found high mean air permeability the main effects plot shown in Figure 6. This is because of low fiber packing density observed using finer fibers compared to coarser fibers and creates more air gaps it leads to higher air permeability. But their effect was small due to less variation in diameter i.e. the maximum difference in diameter among all combinations is about 25.79 µm.

The effect of fiber length on air permeability found significant, by increasing the fiber length in nonwoven air permeability also increased and 10mm fiber length nonwovens got low air permeability. The shorter fibers (10mm) dispersed homogeneously in water, because shorter fibers are easy to individualize and while web formation these dispersed fibers are laid randomly & closely on the permeable screen [14]. For longer fibers (30mm) creates more open space, this is because of fiber grouping/entanglement in nonwoven. As per as GSM concern higher the mass per unit area found lower air permeability vice versa. An interaction plot has shown in Figure 7. Also the significant effect of all selected parameters evaluated using full nested ANOVA, it was clearly evident that fiber cut length and fabric GSM shown significant effect, Table 4. The chemical concentration and treatment time were not significant.
Figure 7: Interaction plots with all factors for Air-permeability

Table 4: Analysis of Variance for Air permeability CC/Sec/Sq. Cm

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical concentration (gpl)</td>
<td>1</td>
<td>6917.921</td>
<td>6917.921</td>
<td>0.219</td>
<td>0.664</td>
</tr>
<tr>
<td>Fiber cut length (mm)</td>
<td>4</td>
<td>126359.590</td>
<td>31589.897</td>
<td>6.956</td>
<td>0.001</td>
</tr>
<tr>
<td>Fabric GSM</td>
<td>18</td>
<td>81746.842</td>
<td>4541.491</td>
<td>30.647</td>
<td>0.000</td>
</tr>
<tr>
<td>Treatment time (minutes)</td>
<td>24</td>
<td>3556.446</td>
<td>148.185</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>47</td>
<td>218580.799</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.4 Percent water absorption

All the prepared nonwovens measured their water absorption capacity. In Figure 8 Typha nonwoven fabric samples kept under water to absorb maximum possible amount of water for the water absorption studies. It was found that, the Typha nonwoven fabrics holding the water up to 4 to 5 time more (i.e. 400% to 500%) on its dry weight of fabric.

Figure 8: Typha nonwoven for water absorbency test

4.5 Sinking test

Typha nonwoven fabrics with different GSM of non-bonded and bonded was evaluated sinking time in seconds as per standard test procedure. The test was carried out for all the non-bonded and bonded samples. From the test, observations made that the non-bonded fabrics sinks in the water between 50seconds to 2minutes and bonded fabrics have taken more time to sink in water i.e. 20minutes ±2minutes. Non-bonded fabrics sinking times of various fabric densities (g/m2) i.e. 100, 150, 200, 250 are 50sec, 70sec, 90sec & 120sec respectively. In case of bonded fabrics the rate of water absorption was very slow due to covering of binder particles on the fiber surface and the reduction of fabric porosity.

5. Conclusion

The comfort properties of Typha nonwoven fabrics can be described from air-permeability and water absorbency. Using optical microscope the diameter of fibers estimated. A notable change observed i.e. diameter and fibrillation, the low diameter (105.6777 ±35µm) fibers extracted with increase in chemical concentration and treatment time. At 30gpl chemical concentration with 300min time found more fibrils on fiber. Nonwovens made with different combinations have no significant effect on fabric thickness. The main effect of air-permeability for the samples made with 30gpl, 30mm fiber length & 100 gsm fabrics shows highest air-permeability 278cc/sec/sq.cm. From the analysis it was found that fabric GSM and fiber length have significant effect on air-permeability. Since the Typha is a natural fiber, the percentage of water absorption was about 400 to 500% for all GSM ranges. As per as sinking time of Typha nonwoven web found to be 50sec for 100GSM web and 2minutes for 250GSM webs. For bonded nonwovens it was found that 20min ±2 for all fabric densities. The Tensile & compressional properties of wet laid nonwoven fabrics can be studied further with varying GSM, binder types and binder concentration etc.
References


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6. Contact No. (Landline & Mobile No.)
7. E-mail ID

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Or sent it to
taicnt@gmail.com
1. Introduction
Moisture management properties of the clothing material is very essential as it plays a major role in transporting liquid moisture from the human skin to the outer environment to maintain high level of comfort to the wearer. This moisture management character is very essential for the clothing such as intimate apparels, sportswear, and active wear where the dissipated moisture vapours and liquid moisture (perspiration) needs to be transported from the skin to the outer environment for dry feel [1]. If the moisture is not transported, it creates sticky feel and increase the friction between skin and the fabric which restricts the body movement and results in lesser performance of the players. The selection of fabrics for these applications must be carried out with maximum caution to provide comfort. The capability of a fabric to regulate transport of moisture is called moisture management of textile fabric [2].

Different combinations of fibre types, yarn types and fabric structures were developed and involved in designing sports and active wear. Many researchers have studied the influence of material, yarn and fabric structure on comfort properties. The liquid moisture management property of fabrics is a complex property which includes the absorbent ability, absorption speed and evaporation of the fabric with the type of fibre and fabric structure effects the properties of final fabric produced [3, 4]. Blending of various fibres in different proportion is carried out to improve the qualities of performance and aesthetic values of the fabrics.

The effect of linear density, blend ratio and fabric type on moisture management behaviour of bamboo knitted fabric and stated that the fabric thickness influence the liquid transport and bamboo content affects the absorption rate and drying property [5, 6, 7]. The effect of count of the yarn on wicking behaviour has recorded that the wicking is directly proportional to yarn count [8]. The wicking property of yarn in the vertical wicking method and in-plane wicking method and found that increase in yarn fineness is reduces the in-plane wicking [9]. The wicking of knitted fabric under deformations and stated that the multidirectional deformation increases the wicking area [10]. All the literature review states that the type of fibre, yarn and fabric plays a vital and dissimilar role in clothing comfort. However, only limited studies are available recording the comfort properties of plain and its derivative structures, even though these are commercially receiving significance.

In the present study, it is proposed to study the moisture management behaviour of the natural and manmade cellulosic fabrics produced using plain and its derivative knit structures.

2. Materials and Methods
2.1. Materials
The 30s Ne of 100% Cotton, 100% Bamboo, 100% Modal, 100% Tencel, 50 / 50 Cotton / Bamboo, 50 / 50 Cotton / Modal, 50 / 50 Cotton / Tencel yarns were used for producing the samples. All these seven yarns were used in producing 3 knitted structures namely single jersey (knit), Single pique (Knit and tuck) and Honeycomb (knit and float) which is presented in Figure 1.

![Figure 1 - Knitted structures of fabrics produced [11]](image)
2.2. Methods

Knitted fabrics were produced using Mayer and Cie knitting machine of 24-inch gauge, 24-inch diameter and 72 feeders with 0.3-inch loop length for assessing moisture management behaviour of the fabrics. Table 1 shows the specification of the developed fabric.

<table>
<thead>
<tr>
<th>S. No</th>
<th>Sample Code</th>
<th>Fibre Type</th>
<th>Knitted Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CHC</td>
<td>100% Cotton</td>
<td>Honeycomb</td>
</tr>
<tr>
<td>2</td>
<td>CSJ</td>
<td>100% Cotton</td>
<td>Single pique</td>
</tr>
<tr>
<td>3</td>
<td>CSP</td>
<td>100% Cotton</td>
<td>Single jersey</td>
</tr>
<tr>
<td>4</td>
<td>BHC</td>
<td>100% Bamboo</td>
<td>Honeycomb</td>
</tr>
<tr>
<td>5</td>
<td>BSP</td>
<td>100% Bamboo</td>
<td>Single pique</td>
</tr>
<tr>
<td>6</td>
<td>BSJ</td>
<td>100% Bamboo</td>
<td>Single jersey</td>
</tr>
<tr>
<td>7</td>
<td>C/BHC</td>
<td>50% Cotton-50% Bamboo</td>
<td>Honeycomb</td>
</tr>
<tr>
<td>8</td>
<td>C/BSP</td>
<td>50% Cotton-50% Bamboo</td>
<td>Single pique</td>
</tr>
<tr>
<td>9</td>
<td>C/BSJ</td>
<td>50% Cotton-50% Bamboo</td>
<td>Single jersey</td>
</tr>
<tr>
<td>10</td>
<td>MHC</td>
<td>100% Modal</td>
<td>Honeycomb</td>
</tr>
<tr>
<td>11</td>
<td>MSP</td>
<td>100% Modal</td>
<td>Single pique</td>
</tr>
<tr>
<td>12</td>
<td>MSJ</td>
<td>100% Modal</td>
<td>Single pique</td>
</tr>
<tr>
<td>13</td>
<td>C/MHC</td>
<td>50% Cotton-50% Modal</td>
<td>Honeycomb</td>
</tr>
<tr>
<td>14</td>
<td>C/MSP</td>
<td>50% Cotton-50% Modal</td>
<td>Single pique</td>
</tr>
<tr>
<td>15</td>
<td>CMSJ</td>
<td>50% Cotton-50% Modal</td>
<td>Single jersey</td>
</tr>
<tr>
<td>16</td>
<td>THC</td>
<td>100% Tencel</td>
<td>Honeycomb</td>
</tr>
<tr>
<td>17</td>
<td>TSP</td>
<td>100% Tencel</td>
<td>Single pique</td>
</tr>
<tr>
<td>18</td>
<td>TSJ</td>
<td>100% Tencel</td>
<td>Single pique</td>
</tr>
<tr>
<td>19</td>
<td>C/THC</td>
<td>50% Cotton-50% Tencel</td>
<td>Honeycomb</td>
</tr>
<tr>
<td>20</td>
<td>C/TSP</td>
<td>50% Cotton-50% Tencel</td>
<td>Single pique</td>
</tr>
<tr>
<td>21</td>
<td>C/TSJ</td>
<td>50% Cotton-50% Tencel</td>
<td>Single jersey</td>
</tr>
</tbody>
</table>

2.2. Measurement of Moisture Management Properties

The moisture management properties of the fabrics were assessed with AATCC 195-2009 using SDL Atlas Moisture Management Tester. The sample size of 8-inch by 8-inch is prepared from the conditioned fabric and positioned in the MMT tester which contains concentric moisture sensors. Synthetic sweat is fed on the top surface of the fabric to measure the moisture related properties. Based on the liquid transmitted, the following indexes are calculated and graded.

- Wetting time (WT): The time taken for the fabric surface to get wet after the supply of liquid moisture. It will be calculated for top surface and bottom surface separately.
- Absorption rate (AR): It is the rate of absorption of liquid moisture by the fabric sample. It will be calculated for top surface and bottom surface separately.
- Spreading speed (SS): It is the speed of the liquid spreading along the surface of the fabric to reach its maximum wetted radius. It will be calculated for top surface and bottom surface separately.
- Maximum wetted radius (MWR): It is the measure of maximum spread of liquid along the surface of the fabric in radial direction from the source of liquid input. It will be calculated for top surface and bottom surface separately.
- Accumulative one-way.
- Transport Index (AOTI): It is the measure of difference in the moisture accumulated in the top and bottom surface of the fabric.
- Overall Moisture Management Capacity (OMMC): It is the measure of overall moisture management capacity of the fabric samples tested.

3. Results and Discussion

3.1 Effect of Fiber Type and Structure on Wetting Time

Figure 2 represents the time taken for wetting the top and bottom surfaces of the fabrics in seconds soon after the start of the test [12]. From the result, it is seen that the wetting time for the top and the bottom surface differs. In common, the wetting time of the bottom surface is higher than the top surface of the fabrics except modal fabrics. This time difference is due to time taken for travelling from the top surface to the bottom surface, through the thickness of the fabric. But in the case of modal fabric, it very quickly wetted on either side of the fabric.

When comparing between the different types of fibres, modal fabrics showed lesser wetting time than cotton, bamboo and Tencel fabrics. The wetting time of the fabric is having a directly relation with the absorbency property. When these fibres are blended with cotton, the wetting time got affected. From the result it can be observed that wetting time cotton bamboo blended fabrics reduced from 4 to 3 minutes. But in the case of modal and Tencel blended fabric, the wetting time got increased. This is mainly because of greater proportion of cotton in the blended fabrics. At the same time the thickness of the fabric increases, the wetting time also increases [13].
higher than the top surface of the fabrics. The reason for this is that major part of the liquid is distributed/settled at the bottom surface. The results of absorption rate are similar to the results of wetting time where the cotton and bamboo fabrics showed higher rate than other fabrics, because of its hydrophilic nature. When compared to above mentioned fabrics Modal, Tencel and its blend fabrics showed lower rate. The type of fibre used in the fabric is one of the main influencing factors of the absorption rate and it is evidenced from the results shown in the Figure 3. When comparing the structures of the fabrics, the order of absorption rate of the fabrics is Single Jersey (SJ) > Single Pique (SP) > Honeycomb (HC). The obtained trend of absorption rate based on the fabric structure is because of the fabric structure, GSM and its thickness.

3.2 Effect of Fiber Type and Structure on Maximum Wetted Radius

The maximum wetted radius (MWR) of the fabrics was measured by providing equal amount of liquid as input for wetting the surfaces and is represented in Figure 4. Generally, the liquid given as input radiates in multi-direction and this measure indicates the effectiveness of fabric in transporting the liquid along its surface. In connection to the results of absorption rate, as the major portion of liquid settled at the bottom surface of the fabric, it gets transported on the same side and hence the result of maximum wetted radius obtained [14].

When comparing the structures, the spreading speed is higher in the single jersey fabric than Single pique and honeycomb structures. The alternate knit and tuck stitches (pique structure), knit and float stitches (honeycomb structure) interrupts the smooth and continuous flow of liquid and reduces the water liquid spreading speed.

3.2 Effect of Fiber Type and Structure on Fabrics Accumulative One-Way Transport Index and Overall Moisture Management Capacity

Accumulative one-way transport index (AOTI) is the measure of difference in the amount of moisture accumulated between the top and bottom surface of the fabric. The fabrics produced from cotton, bamboo, Tencel and its blends shows positive results which indicates that the amount of moisture on the bottom surface is higher than top surface. At the same time modal and its blended fabrics obtained a negative AOTI which shows that the amount of moisture on the top surface is higher than the bottom surface. The results presented in Figure 6 indicate that the modal fabrics hold moisture rather than transporting to the other side of the fabric for faster evaporation.

When comparing the structures, the spreading speed is higher in the single jersey fabric than Single pique and honeycomb structures. The alternate knit and tuck stitches (pique structure), knit and float stitches (honeycomb structure) interrupts the smooth and continuous flow of liquid and reduces the water liquid spreading speed.
The Overall Moisture Management Capability (OMMC) is the result obtained from the combined effect of the absorption rate, one-way liquid transport index and liquid spreading speed which is presented in the Figure 7. When the rating obtained are compared with the grade scale, all the fabrics ranges between fair to very good [12]. From the obtained results, the bamboo fabrics exhibit low OMMC value. This is due to minimum thickness of bamboo fabric than other fabrics.

![Figure 6 - Accumulative one-way transport index of the samples](image1)

![Figure 7 - Overall moisture management capacity of the samples](image2)

Majority of the fabrics have a lesser wetting time and higher absorption rate. For the direct overall evaluation of moisture management properties of the fabrics, Table 2 gives the classification of fabrics produced.

<table>
<thead>
<tr>
<th>S. No</th>
<th>Sample Code</th>
<th>WT</th>
<th>AR</th>
<th>MWR</th>
<th>SS</th>
<th>AOWI</th>
<th>OMMC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>CHC</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>2.</td>
<td>CSP</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>3.</td>
<td>CSJ</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>4.</td>
<td>BHC</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>5.</td>
<td>BSP</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>6.</td>
<td>BSJ</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>7.</td>
<td>MHC</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>8.</td>
<td>MSP</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>9.</td>
<td>MSJ</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>10.</td>
<td>THC</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>11.</td>
<td>TSP</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>12.</td>
<td>TSJ</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>13.</td>
<td>C/BHC</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>14.</td>
<td>C/BSP</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>15.</td>
<td>C/BSJ</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Classification of fabric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast-absorbing and slow-drying fabric</td>
</tr>
<tr>
<td>Fast-absorbing and slow-drying fabric</td>
</tr>
<tr>
<td>Moisture-management fabric</td>
</tr>
<tr>
<td>Fast-absorbing and slow-drying fabric</td>
</tr>
<tr>
<td>Fast-absorbing and quick-drying fabric</td>
</tr>
<tr>
<td>Moisture-management fabric</td>
</tr>
<tr>
<td>Fast-absorbing and quick-drying fabric</td>
</tr>
<tr>
<td>Moisture-management fabric</td>
</tr>
<tr>
<td>Fast-absorbing and quick-drying fabric</td>
</tr>
<tr>
<td>Fast-absorbing and quick-drying fabric</td>
</tr>
</tbody>
</table>

*Table 2 - Rating of the samples*
It is clear from the Table 2 that all the fabric falls under the classification which is suitable for clothing purposes. In specific Modal fabric and its blends are graded as moisture management fabric which can be most suitable for sportswear, and active wear designing purposes. Among the three structures, single jersey works effectively in moisture management, and it can be utilised when other types of fabrics are required to be used.

4. Conclusion
The moisture management properties were assessed to identify the fabric which can provide high level of comfort. The moisture management property of fabrics varies with type of fibre used and fabric structure. Modal fibre showed shortest wicking time, longest radius of wicking and high spreading speed and graded as moisture management fabric. Tencel, bamboo and cotton stand in the next range of moisture management behaviour. Single jersey fabrics showed excellent behaviour of transportation of moisture through its surface without any hindrance. Single pique and honeycomb stand next where the travel of liquid need to take different path in each stitch.

References
3. Summary

The problem of environmental stress exists and will not go away by magic. The impact of new technologies and techniques like as ultrasonic and microwave technology, ozone treatment, and enzymatic processing on the long-term viability of wet processing operations has been explored in this paper. However, even in the laboratory, the new processes are still encountering difficulties, necessitating further research and development to make them a viable alternative to traditional processing. These sustainable technologies would reduce the environmental impact, resulting in energy savings, reduced water consumption, and the replacement of harsh chemicals in manufacturing textile materials.

References

Evaluation of Flame Retardancy

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Abstract:
Flame retardancy is one of the most important property withstand by the textile materials. It is necessary to test the flame retardancy of the material before deciding their end uses. There are several methods determined for testing flame retardant property of textile material. This revive consists of different methods by which we can study the flammability/flame retardant property of material. Vertical flammability, horizontal burning test, inclined flammability test limiting oxygen index (LOI) and BS5438 tests series are the some common methods by which we can study flame retardancy of fabric. Also we can study how to measure the char length of material. However LOI values of some common fibres are added to this article with their significant effects to the flame.

Keywords: Evaluation, flammability, LOI, testing methods, textile materials


1. Introduction
Generally, generation of heat and transfer of heat is nothing but flammability. Flammability have different action on different textile materials [1]. Flammability is the tendency of material to burn with flame. The materials which easily get reacts with flame are flammable. However the materials which ignite on flame but self-extinguishes on removal from the flame are flame resistant material. And the materials which do not burn but melts are called flame retardant material [2]. In this paper we are dealing with the flame retardancy and the different test methods which are being used to test the flame retardancy of textile materials. This paper gives an instant view on the testing of flame retardancy of textile fabrics.

These methods are useful to measure how easily the materials get ignited and in what way they react with the flame. Fire testing laboratories various tests on textile samples to determine the fire resistance, flame spread, reaction to fire and flash point [3]. These properties explain nature of materials according to flame retardancy. In international markets, there are some regulations having the import and sale of most products, including flammability standards such as the EU Toy Safety Directive 2009/48/EC. Most of the consumer markets have similar regulations. Therefore, manufacturers and suppliers must go for fire testing laboratories to test the products according to there, expectations [3].

There are several methods used to test the flame retardancy of the textile material. Following are the few test methods which discuss about the flame retardancy of the textile material.

2. Vertical Flame Test
This method is based on vertical flame test which is being used for evaluating flame resistance of all types of textile materials [4]. This test explains the characteristics of sample material after the test flame has been removed. Indirectly this determines the rate at which the material burns [3].

2.1 Principle
A suitable piece of fabric is suspended vertically and ignited by the flame on both sides of the material. After the ignition period is over, note down the ignition period, the char length, after flame & afterglow characteristics [4].

2.2 Preparation of Apparatus
- Gas pressure is adjusted to 17.2±1.7 kPa (2.50 ± 0.25 lbf/in.2) and ignited pilot flame. The pilot flame is adjusted to a height of approximately 3 mm (0.12”) from its lowest point. Tip should not alter shape of the test flame during the 12s exposure time.
- Adjust the burner flame in the base of the burner to achieve a flame height of 38 mm (1.50 in.) using the needle valve. This height is achieved by fully closing the air opening on the burner tube base and full opening the solenoid valve [5].
- Place the burner so that the midpart of the bottom edge of the specimen holder is centered 19 mm (0.75 in.) raised the burner. (It may be needed to close corresponding lights to make sure of the exactness of intersect of the midpoint of the flame with the mounting clamp.)
- To customize the timer to supply a 12±0.2-s flame to the specimen. (By using stopwatch or timer, check the flame time.)
- To carry out this by measuring the interval through the opening and closing of the solenoid with correct laboratory timer or stopwatch [5].

2.3 Procedure
i. Display and expose each specimen to the flame within 4 min of separate from the conditioning area or storage.
ii. Catch the test specimen between the two halves of the flame.
holder, with the base of the specimen even with the base of the holder. With the holder controlled vertically, protect the specimen in the holder with a minimum of four clamps. Situate two clamps near the top of the holder, one on each side to stabilize the specimen. Similarly, situate two clamps at the base of the holder, one on each side.

iii. Turn off the exhaust hood. Introduce specimen which is hold on specimen holder into the test cabinet and place the burner with the middle of the bottom edge of the test specimen centered 19 mm (0.75 in.) above the burner and leveled with the bottom metal prong.

iv. Expose the specimen for the 12±0.2 s, after starting the flame impingement timer. Observe neatly for melting or dripping of specimen during the flame exposure. Record any observations. Start a stopwatch for measurement of the after flame and afterglow time, instantly after the flame is removed.

v. Observe the specimen how long it continues to flame after the 12 s exposure time. Record the after flame time to within 0.2 s.

vi. Observe the specimen how long it continues to glow after the after flame ceases or after removal of the flame if there is no after flame. Record this afterglow time to the nearest 0.2 s. Because of potential effect on char length, do not extinguish the glow.

vii. Put off the specimen holder from the test cabinet. Turn on the exhaust hood to clear the test cabinet of fumes and smoke. Keep the specimen for cooling purpose [5].

v. Measure the char length.

a. Make a crease by folding the specimen across a line through the peak of the highest charred area and parallel to the sides of the specimen.

b. From the lower edge and from the side edge of the specimen, pinhole the specimen with the hook approximately 6 mm (0.25 in.) To give a combined mass of the weight with the hook attach a weight of sufficient mass that will result in the applicable tearing force.

c. Apply the tearing force as follows. Control the corner of the specimen on the opposite bottom fabric edge from where the hook and weight are attached. Until the total tearing force is supported by the specimen, boost the specimen upward in a smooth continues motion. Record any fabric tear in the charred area of the specimen. Mark the end of the tear with a line across the width of the specimen and perpendicular to the fold line.

d. Measure the char length across the unaltered edge of the specimen to the closest 3 mm (0.12 in.) [5].

2.4 Calculation

- Afterflame Time— for each laboratory sample, calculate the average afterflame time to the nearest 0.5 s for the lengthwise and widthwise directions.
- Afterglow Time— for each laboratory sample, calculate the average afterglow time to the nearest 0.5 s for the lengthwise and widthwise directions.
- Char Length— for each laboratory sample, calculate the average char length to the nearest 3 mm (0.12 in.) for the lengthwise and widthwise directions [5].

2.5 Report

- State that the samples were tested as directed in Test Method D6413. Express the materials or product tested.
- Report the following fabric lengthwise and widthwise information for each specimens, for the laboratory sampling unit and for the lot as applicable to a material specification or contract order.
  - Afterflame time.
  - Afterglow time.
  - Char length.
  - Occurrence of melting or dripping, if any [5].

3. Horizontal Burning (HB) Test (ASTM D635, D4804, IEC707, ISO1210)

There are three samples are tested. (12.5 x 100 mm) (½” x 5”) of each specimen is to be marked with two lines which are perpendicular to the longitudinal axis of the bar, 25±1 mm (1”) and 100 ±1 mm (4”) from the end that is to be ignited. Figure 2.7 shows the experimental setup. Clamp the specimen at its end from the 25 mm (1”) mark, with its longitudinal axis horizontal and inclined at 45 ±2 degrees its transverse axis. Clamp the wire gauge horizontally at the base of the specimen. The distance between lowest edge of specimen and the gauge with the free end specimen is to be 10 ±1 mm even with the edge of the gauze (ANSI, 1996). The burner is supplied with the methane gas which produces a gas flow rate of 105 ml/min with a back pressure less than 10 mm water. Adjust the burner to produce blue flame 20 ±1 mm high. The air supply is increased until the yellow tip disappears. Measure the height of the flame and adjust again if it is necessary.

During the initial set up if the specimen sags at its free end, the support fixture is fixed under the specimen at least 20mm
from the free end of the specimen. Support fixture is capable to move freely side wards if enough clearance is provided at the clamped end of specimen. Support fixture is to be withdrawn at the same approximate rate as the combustion front progress along the specimen. Apply the flame to the free end at the lower edge of the specimen. Place the burner tube with its central axis is in the vertical plane as longitudinal bottom edge of specimen incline at 45 degrees to horizontal towards the end of specimen the end of specimen [2].

![Figure 2 - UL94 Horizontal flammability test](image)

The burner is placed so that the flame impinges to a depth of 6±1 mm for 30±1s on the free end of the specimen. The burner is removed as soon as the combustion front of the specimen reaches the 25 mm mark (after 30s). Note the after-flame burning time (in seconds) for the combustion front to travel from the 25 mm mark to the 100 mm mark. If the combustion front passes the 25 mm mark, but does not pass the 100 mm mark. The elapsed time is recorded (in seconds) and the damaged length L (in millimeters) between the 25 mm mark and where the combustion front stopped. Fig. b shows the experimental setup for horizontal burning test.

\[ V = \frac{6L}{t} \]

Where,
\[ V = \text{Linear burning rate} \]
\[ t = \text{The damage length in mm} \]

A material shall be classified HB when tested by this method. A material classed HB shall observed the following conditions

Not have a burning rate exceeding 40 mm per minute over a 75 mm span for specimens having a thickness of 3.0–13 mm, or (2)

- Not have a burning rate exceeding 75 mm per minute over a 75 mm for specimens having a thickness less than 3.0 mm, or
- Cease to burn before the 100 mm reference mark,
- A material classified HB in the 3.0+0.2 mm thickness shall automatically be classed HB down to a 1.5 mm minimum thickness without additional testing.

- A material having a thickness between 3 - 13mm will be classified as a HB material if it doesn't have a burning rate greater than 40mm per minute. For material with thickness < 3mm the burning rate should not exceed 75mm per minute. The material will also be rated as HB if it ceases to burn before the 100mm mark independent of thickness. Table 1 gives results of test criteria with their burning rates [2].

### Table 1 - Test criteria for burning rate

<table>
<thead>
<tr>
<th>Test criteria</th>
<th>Burning rate</th>
<th>Flammability rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specimen thickness 3–13 mm</td>
<td>=40 mm/min</td>
<td>HB</td>
</tr>
<tr>
<td>Specimen thickness &lt; 3 mm</td>
<td>=75 mm/min</td>
<td>HB</td>
</tr>
<tr>
<td>Flame is extinguished before first mark</td>
<td>= 0 mm/min</td>
<td>HB</td>
</tr>
</tbody>
</table>

(Source: UL LLC) [6].

4. Inclined flammability test (ASTM D1230-17 (ASTM, 2019, Vol. 07.01))

Standard Test Method for Flammability of Apparel Textiles, and 16 CFR 1610, covers textile fabrics intended to be used as apparel (other than children sleepwear or protective clothing). Most textile materials can be evaluated using this test with the following exceptions: children's sleepwear, protective clothing, hats/gloves, footwear, and interlining fabric. Two factors are measured, namely

i. Ease of ignition (how fast the sample catches fire).

ii. Flame spread time (The time required for a flame to spread a certain distance).

All fabrics made of natural and regenerated cellulose, as well as many others made from natural or man-made fibers, are combustible. The potential danger to the wearer depends on such factors as ease of ignition, flame spread time and amount of heat released, and design of the garment. The test measures two such factors, namely, ease of ignition and flame spread time [2].

4.1 Working principle

The test should be conducted under standard atmosphere, maintaining standard temperature and moisture. Samples are mounted in a frame and held in a special apparatus at an angle of 45 degrees. A standardized flame is applied to the surface near the lower end for specified amount of time (e.g., 1 s). The flame travels up the length of the fabric (usually 5 in.) to a trigger string, which drops a weight to stop the timer when burned through. The time required for the flame travel the length of the fabric and break the trigger string is recorded, as well as the fabric's physical reaction(s) at the ignition point. Fig. c shows the schematic diagram of inclined flammability tester.
4.2 Sample Preparation
1) The samples (both warp and weft directions) of 6.5/x 2/are cut.
2) All fabrics are oven dried for 30 min. at 105°C
3) All fabrics should then be placed in desiccator for at least 15 min. before testing
4) The individual specimen is clamped in the specimen holder, which consists of two frames – the lower one is small and the top one is longer. The specimen is inserted in the frame so that the bottom edge of the specimen coincides exactly with the lower edge of the longest (top) frame. The two halves of the frame are held together by bulldog clip. In some instruments, U Type 2 plates are used; one of them has five projected pins, while the other has five holes in the respective positions. The specimen is placed on the plate having pins under tension and then the second plate is placed on it so that the pins of the first plate pass through the respective holes of the second plate keeping the sandwiched specimen firmly held disallowing its movement.
5) The piled or napped fabric should be brushed with brushing device to raise the surface fibers.

4.3 Test procedure
1) The main power switch is turned ON.
2) The suitable auto impingement time (1, 5, 10 s, or manual) is selected. The control valve of the fuel supply is opened for 5 min. for the air to be driven out. The gas is ignited and the flame height is adjusted to 16 mm (5/8 in.) from tip to the opening in the gas nozzle.
3) On pressing start button, the impingement is automatic and the flame is applied for the selected period.
4) The time required for the flame to proceed up to the fabric at a distance of 127 mm (5 in.) is recorded. It is also noted whether the base of a raised-surface fabric ignites, chars or melts.
5) The timer starts automatically – starting upon application of the flame and ending when the weight is released by the burning of the stop cord.
6) The results are recorded.
7) When testing is done, the power switch is turned OFF. The gas supply is also turned off [2].

4.4 Results
- The arithmetic mean flame-spread time of all the specimens, usually 6 or 12 in number, is calculated. Faster the burning (less burning time), more chance for labeling as flammable and thereby subject to rejection.
- If the mean time is less than 3.5 seconds, or any of the specimens do not burn, an additional set of specimens is tested. The following three classes are used by the Consumer Product Safety Commission (CPSC), USA to interpret results for a similar test [2].

Class I- The test of ≥ 7 s and ≥ 3.5 s, respectively are considered by the trade to be generally acceptable for apparel.
- The fabrics those do not burn or burn with a surface flash (in less than 7 seconds) in which the base fabric is not affected by the flame are also accepted.

Class II- These textiles are considered by the trade to have flammability characteristics for apparel intermediate between Class I and Class III fabrics are limited to the following:
- The textiles having a raised fiber surface that have an average time of flame spread in the test of 4 to 7 seconds and in which the base fabric is ignited, charred or melted.

Class III- These textiles are considered by the trade to be unsuitable for apparel and are limited to the following:
- The textiles that do not have a raised fiber surface that have an average time of flame spread in the test of less than 3.5 seconds.
- The textiles having a raised fiber surface that have an average time of flame spread in the test of less than 4 seconds in which the base is ignited, charred, or melted [2].

5. LOI and Flammability
As discussed earlier the limiting oxygen index is the minimum concentration (%) of oxygen in the atmosphere surrounding a polymeric object that will support combustion
of the polymer. The relation between LOI and flammability of different textile fibers is as given in table 3.

**Table 2 - Effect of different LOI values**

<table>
<thead>
<tr>
<th>LOI</th>
<th>Effect</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 19</td>
<td>Easy ignition &amp; rapid burning</td>
<td>Cotton, acrylic, viscose, polypropylene.</td>
</tr>
<tr>
<td>19 – 22</td>
<td>Normal ignition and burning behavior</td>
<td>polyester, polyamide 6, polyamide 6,6</td>
</tr>
<tr>
<td>Around 25</td>
<td>Almost resist to the ignition</td>
<td>wool</td>
</tr>
<tr>
<td>25 – 30</td>
<td>Flame retardant</td>
<td>modacrylic, meta-aramid, para-aramid</td>
</tr>
<tr>
<td>Greater than 30</td>
<td>Flame resistance under sever conditions</td>
<td>Phenol/melamine formaldehyde, PBI, PTEE</td>
</tr>
<tr>
<td>Around 100</td>
<td>No burning, only melting occurs</td>
<td>Glass and ceramic</td>
</tr>
</tbody>
</table>

6. BS5438 series of tests

**Table 3 - LOI values of some different polymers**

<table>
<thead>
<tr>
<th>Polymer</th>
<th>Limiting Oxygen index (LOI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard polyurethane</td>
<td>16.5</td>
</tr>
<tr>
<td>PMMA(Perspex)</td>
<td>17.3</td>
</tr>
<tr>
<td>Poly(propylene)</td>
<td>17.4</td>
</tr>
<tr>
<td>Poly(styrene)</td>
<td>17.8</td>
</tr>
<tr>
<td>Plywood</td>
<td>23.0</td>
</tr>
<tr>
<td>Nylon 6,6</td>
<td>24 – 29</td>
</tr>
<tr>
<td>Polycarbonate</td>
<td>25 – 44</td>
</tr>
<tr>
<td>Nomex</td>
<td>28.5</td>
</tr>
<tr>
<td>Phenolic</td>
<td>26 – 64</td>
</tr>
<tr>
<td>PVC(Unplasticized)</td>
<td>45 – 49</td>
</tr>
<tr>
<td>PTFE</td>
<td>95</td>
</tr>
</tbody>
</table>

The LOI technique provides quantitative measurement for flame retardancy. Some conventional flame retardant finish gave linear LOI relationship with phosphorous content as shown in table 2. LOI of about 0.26 is associated with 5” char length in vertical test [7]. When "conventional" polyester fiber in polyester/cotton blend fabrics is replaced by this copolymer fiber (6% bromine), or by an equivalent modified polyester fiber, lower amounts of flame retardant finish are required to meet a given flammability test and undesirable effects on fabric properties are reduced. (v7) In the unmodified state, i.e. no flame retardant polymers vary greatly in their ability to support combustion at normal atmospheric conditions [2].

**Table 4 - Comparison of BS5438:1976, BS5438:1989, ISO 6940 and ISO6941, source (ref.1)**

<table>
<thead>
<tr>
<th>Test methods</th>
<th>BS5438:1976</th>
<th>BS5438:1989</th>
<th>BSENISO6940</th>
<th>BSENISO6941</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type of test</strong></td>
<td>Face</td>
<td>Face and edge</td>
<td>Face and edge</td>
<td>Face and edge</td>
</tr>
<tr>
<td><strong>Gas used:</strong></td>
<td>Butane</td>
<td>Butane</td>
<td>Butane or propane</td>
<td>Butane or propane</td>
</tr>
<tr>
<td><strong>Pre-conditioning:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Temperature</strong></td>
<td>15-25°C</td>
<td>20±5°C</td>
<td>20±2°C</td>
<td>20±2°C</td>
</tr>
<tr>
<td><strong>Relative humidity</strong></td>
<td>55-65%</td>
<td>65±2%</td>
<td>65±2%</td>
<td>65±2%</td>
</tr>
<tr>
<td><strong>Testing conditions:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Relative humidity</strong></td>
<td>20-65%</td>
<td>55±20%</td>
<td>15-80%</td>
<td>15-80%</td>
</tr>
<tr>
<td><strong>Flame:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Vertical height</strong></td>
<td>45±2mm</td>
<td>40±2mm</td>
<td>40±2mm</td>
<td>40±2mm</td>
</tr>
<tr>
<td><strong>Horizontal reach</strong></td>
<td>23±2mm</td>
<td>21mm minimum</td>
<td>21mm minimum</td>
<td>21mm minimum</td>
</tr>
<tr>
<td><strong>Type of burner</strong></td>
<td>Single hole</td>
<td>Multi-hole</td>
<td>Multi-hole</td>
<td>Multi-hole</td>
</tr>
<tr>
<td><strong>Face ignition:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>burner to fabric separation</strong></td>
<td>17mm</td>
<td>17mm</td>
<td>17mm</td>
<td>17mm</td>
</tr>
<tr>
<td><strong>Edge ignition:</strong></td>
<td>n/a</td>
<td>30° to horizontal</td>
<td>30° to horizontal</td>
<td>30° to horizontal</td>
</tr>
<tr>
<td><strong>Burner/fabric separation distance</strong></td>
<td>20mm</td>
<td>20mm</td>
<td>20mm</td>
<td>20mm</td>
</tr>
<tr>
<td><strong>Pre-heat before test?</strong></td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Minimum ignition time:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Specimen size (mm)</strong></td>
<td>220 x 170</td>
<td>200 x 80</td>
<td>Variable</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Flame application times (s)</strong></td>
<td>2,3,4,6,8,10,15,20</td>
<td>Variable from 1 to 20</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td><strong>Limited flame spread:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Specimen size (mm)</strong></td>
<td>220 x 170</td>
<td>200 x 160</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Flame application time</strong></td>
<td>10s and 2s</td>
<td>10s</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Bs2963 and then BS3119 are the tests in which vertical strips of fabric were ignited at their bottom edge and either the extent of damage or the rate of flame spread were determined. This tests based upon face ignition in order to give flammability performance of the materials under test. These tests have become the BS5438 series of tests as given in table 4.

7. Conclusion

This article gives you a short knowledge about testing methods of flame retardancy of fabric as well as we can study flammability of fabric. Some basic methods are described with their results and conclusion in this article. Also we attached some standard charts and comparison tables which is helpful for understanding this concepts in easiest way.

<table>
<thead>
<tr>
<th>Test Methods</th>
<th>Variants</th>
</tr>
</thead>
<tbody>
<tr>
<td>BS5438:1976</td>
<td>Flammability of vertically oriented textile fabrics when subjected to a small igniting flame.</td>
</tr>
<tr>
<td>BS5438:1989</td>
<td>Flammability of textile fabrics when subjected to a small igniting flame applied to the face or bottom edge of vertically oriented specimens</td>
</tr>
<tr>
<td>BSENISO6940</td>
<td>Textile fabrics: Burning behaviour: determination of ease of ignition of vertically oriented specimens</td>
</tr>
<tr>
<td>BSENISO6941</td>
<td>Textile fabrics: Burning behaviour: Measurement of flame spread properties of vertically oriented specimens</td>
</tr>
</tbody>
</table>

References

We at Wellknown firmly believe in optimizing our products and services by incorporating, **digitalization** of process for accuracy, **automation** of machinery to save time and **innovation** in enhancing our systems. So our customers can be assured to get the highest quality of filament Yarns such as DTY, FDY, ATY, PSF, Dope Dyed Yarn, Superstercth Yarns and IDY.

Our commitment continues with latest high end machinery in IDY (industrial development yarn) for strengthening the nation.
Graded Wound Filter Performance Analysis – Mechanical Filter Produced on Step-Precision Winding Mode

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Abstract:
The graded wound filters can be manufactured using the winding technology. It is possible to produce those using different systems/modes of winding like Random, Precision or Step-precision. The study aimed to produce wound filters with three different coil angles on step-precision winding mode to find their performance characteristics. It was found that the pressure drop of filter wound with the lowest coil angle (20°) showed the highest pressure drop (4.72 psi) due to greater yarn content. The micron rating of the same filter was found to be 72 µm. The subsequent coil angle (25°) showed reduction in both the pressure drop (3.966 psi) and micron rating (85 µm). But the highest coil angle showed pressure drop of 0.445 psi and micron rating of 85 µm. The wound filters produced in precision winding mode showed higher values of pressure drop though their build-up parameters were same. This indicates that the filter manufacturers can produce cartridges in step-precision winding mode for better economy especially when produced at lower tension and higher coil angle and requiring rating of 85 µm and above.

Keywords: micron rating, porosity/surface area, pressure drop, step-precision winding mode, wound filters

Citation: Citation: P. Pratihar, P. S. Kanade & J. K. Chauhan, “Graded Wound Filter Performance Analysis – Mechanical Filter Produced on Step-Precision Winding Mode”, Journal of the Textile Association, 83/3 (181-185), (Sept-Oct’ 2022), https://doi.org/10.17605/

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1. Introduction
The world today is engulfed in several water related issues and days are not far when the struggle between nations/states/people over clean water would become intense. Different types of water filters are available like mechanical, absorption, sequestration, ion-exchange and reverse osmosis; selection of which depends upon the target particle group to be removed. Many a times combination of different filter types is preferred to remove wide range of particles in a heterogeneous mixture. This is especially true in case of domestic water purification plants, where the wound filters act as pre-filters aimed to carry out microfiltration, while the membrane targets the sub-micron particles including the viruses. The UV lamp kills the microbes and the activated carbon removes particles by adsorption, thus the entire system completes the process of water purification. Winding is a science used to produce the wound filters using the winding technology however not many manufacturers apply this knowledge while producing them for the desired filtration performance. The study aims to analyze the influence of winding mode i.e. step-precision winding mode on filtration performance and other related nuances to bridge the gap between wound filter manufacturers and consumers.

2. Material and methods

2.1 Material
Yarns used for filtration application have bulky appearance indicating porous nature [1]. They are usually produced by friction spinning technique where the spinning process parameters influence the yarn properties [2]. Polypropylene DREF spun yarn material was acquired from KBS filters, Makarpura, Vadodara, India. DREF spun yarns used for the study had fineness of 711 Tex (0.831’s Ne) which was established after taking an average of 20 readings applying cutting and weighing method. The yarn diameter was found using microscope and an average of 20 readings was found out to be 0.2 cm. Experimental work was carried out in the Textile Engineering Department, The Maharaja Sayajirao University of Baroda, in 2019.

2.2 Introduction to winding systems
Cross wound packages (including wound filters) can be produced using Random, Precision and Step-precision winding mode and their working principles along with characteristics is explained in detail [3]. Random winding mode is not preferable for filtration application due to the problem of pattern formation. The precision winding mode produces packages that are more compact in comparison to the both the step-precision and random winding mode. There is progressive reduction in coil angle that may influence the packing density and their appearances (package edges). The edges of package are not parallel either in case of precision (convex edges) or random winding (concave edges) while almost parallel configuration is obtained on step-precision winding mode [3]. Selection of winding mode significantly influences the package build characteristics. Since wound filters are also an example of cross wound package, the mode of winding can influence its performance characteristics like pressure drop and/or micron rating. Previous works related to hydraulic performance of wound filters are reported on the basis of experiments conducted in the laboratory [4-16]. The influence of winding parameters like coil angle, tension and gain on performance of wound filters built in the precision winding mode is reported [4]. The influence of winding parameters like spindle speed, circumferential diamons, package diameter and fineness of yarn on wound filter's performance built in the precision winding mode is also reported [5]. The effect of coil spacing on the performance of graded filters in precision winding mode is studied [6].
another such work the influence of coil number on the performance of graded wound filter for water application built using precision winding mode was investigated [7]. Wound filters have to be analyzed for their performance for which different test methods are available, along with the standard test dusts (air cleaner test dust) used in such test procedures is also reported [8]. There are different varieties of air cleaner test dusts and how their different particle size distributions contribute to the filter test result is also reported [9]. Another such work reported experimental confirmation of performance of wound filters constructed either from cotton or polypropylene, with specific ratings, procured from market [10]. Apart from the established test methods, a modified filter test [11] is reported where the conditions of test were altered to achieve change in the contaminant concentration level. The domestic market makes use of disposable filters but use of hybrid filter is advocated to achieve better results and comparison of performance of different filters like wound filters, thermal molded filters, fixed density filters and absolute rated depth filters using oil as the medium is presented [12]. Efficiency of novel cartridge developed from fiber was compared with wound filter [13]. X-ray technique was used to observe the extent of penetration of dust particles inside wound filters is reported [14]. One such recent work [15] hydraulic performance of wound filters used in domestic plants for drinking water is reported, where emphasis was on the head losses due their placement in the system, while another work investigated clogging pressure for filters with different rating [16]. However, none of them [8-16] used in-house manufactured wound filters on step-precision winding mode nor performance of such filters is reported. This paper focuses on engineering wound filters produced in the step precision winding mode and understand their performance characteristics.

2.2.1 Introduction to step-precision winding

Step precision winding mode is essentially an extended version of the precision winding mode and most importantly recommended to be used for flow applications like that of dyeing or filtration due to supposedly uniform density [3]. A diagrammatic representation of mechanically operated step-precision winding system is shown in figure 1. The motor drives the cross-wound package on which there are several gears labeled as A, B, C, D and E. The traversing cam is mounted on gear shaft carrying gears A’, B’, C’, D’, and E’. A & A’ is a gear pair and so are B & B’, C & C’, D & D’ and E & E’; at the time only one gear pair is engaged. The gear ratio in each of the gear pair is such that pattern formation will not take place.

![Figure 1: Schematic diagram of step-precision winding system](image)

Suppose when the package is empty at that time gear pair A & A’ are engaged. The number of teeth on A & A’ would not allow pattern formation to occur. But as the winding starts several layers are laid on the package and there is build up in its diameter leading to reduction in coil angle, just as Precision winding system. But the system ensures almost constant coil angle by shifting from the gear pair A & A’ to B & B’ which also produces pattern free package and at the same time reduces the number of coils laid on the package (traverse ratio). This happens due to inverse relation between coil angle and traverse ratio; traverse ratio being changed after definite increment in the package diameter to maintain almost constant coil angle. In all a step-precision winding mode combines the positive aspects of Random and Precision winding systems making more apt for certain applications related to fluid flow as explained in the following section.

2.2.2 Producing wound filters on step-precision mode

The most important requirement for a winding system to work on step-precision mode is that there should be provision to reduce the number of coils (wind ratio) at regular intervals so that the coil angle can be maintained throughout the build-up. This requirement is fulfilled in steps and hence the name; the number of coils laid are reduced after a certain amount of package diameter is built-up. In the mechanical system (figure 1) the gears are changed periodically while the same is achieved by the electronic gearing on electronically controlled systems. The experimental work was carried on electronically controlled filter winder [17] and the program allowed the packages to be built to full diameter in 4 steps [18]. This implied that four traverse ratios could be used such that, pattern formation is avoided and the subsequent traverse ratio would be smaller than the earlier one. To actually achieve this when the machine is set in step-precision winding mode the diameter increment and package diameter at each step has to be decided. During the experimental study it was observed that when initial layers of yarn were laid on a perforated core (bare bobbin), the diameter build-up was less and when yarn was wound on yarn its build-up was more, which is explained with help of following example. Suppose the initial package (bare diameter) of the perforated core tube is 34 mm, increment in diameter was taken as 6 mm for the first layer, while for all the subsequent layers it was taken to be 8 mm each; doing this ensured that almost a constant coil angle is maintained.

If a package with X° coil angle is to be produced then the numbers of coils that should be reduced with reference to increasing diameter can be found using equation 1 and equation 2. For calculating the traverse ratio for a particular step, increment mentioned earlier was added to the package diameter of that step.

\[
\text{traverse ratio} = \frac{2 \times \text{traverse length}}{\pi \times d \times \tan \theta}
\]

Where d is the package diameter at a given instant and \( \theta \) is the coil angle

\[
\text{gain} = \frac{\text{yarn diameter}}{\pi \times d \times \sin \theta}
\]

Where d is the package diameter at a given instant and \( \theta \) is the coil angle.
Using equations 1 and 2, it was found that the actual wind ratios (close) for the four steps during package build-up came out to be 5.973, 4.977, 3.982 and 3.516 considering coil angle of @ 21° and the coil angle could be controlled within 0.535° here. Same method of calculation can be followed for the other coil angles too.

2.3 Winding methodology

Wound filter for the experimental studies were produced on electronically controlled filter winder [17] selecting the step-precision winding mode; is stated in section 2.2.2. All packages were wound with an average tension of 55 g, spindle speed of 225 rpm, yarn count and yarn diameter of 0.8’s Ne and 2 mm respectively. The packages were produced with three different coil angles of 20°, 25° and 30°. All packages were produced with close wind and one circumferential diamond. The wound filter samples were coded as SPA1, SPA2 and SPA3, where SP stands for step-precision, A stands for angle while 1, 2 and 3 represent the coil angles selected for the trials namely 20°, 25° and 30° respectively.

2.4 Filter testing method

The wound filters were tested in-house on apparatus [19] that uses single pass and is a destructive test method [20]. The test slurry was prepared using ISO A3 test dust as contaminant, with particle size distribution in the range 1-100 μm. The concentration of slurry was 0.1 g/L, pumped to achieve constant flow rate conditions (400 L/h) for duration of 2 hours. The pressure drop was found from the inlet and outlet pressure ports during the test trial whereas the particle size distribution was found from the water samples collected from the respective ports. This was ultimately used in finding the retention efficiency (%) and micron ratings of the wound filters produced in this study.

3. Results and discussion

The wound filters were tested for their pressure drop characteristics and their retention efficiencies (%).

3.1 Pressure drop characteristics

Figure 3 shows comparative performance of the step-precision wound filter samples in terms of pressure drop experienced by each of them during the test trial.

It can be seen that the pressure drop experienced by package wound with the least coil angle (A1) showed highest resistance to flow while that with highest coil angle (A3) showed least resistance. These results are in accordance with the results obtained for precision wound filters [21], though the winding parameters may differ. The (%) rise in the pressure drop values of SPA1 and SPA2 is 15.983% while that between SPA2 and SPA3 is 90.244%. The pressure drop of the filter wound with coil angle 20° and 25° are following each other closely but a further increase in angle by a very small amount (only 5°), the pressure drop was reduced substantially indicating that the filter was not able to resist the flow and trap the suspended particle effectively; indirectly affecting its performance. It also implies that if the coil angle is increased beyond 25°, wound filters can show mechanical failure and is true for the said conditions of the wound filter considered in these trials. Trials taken for wound filters produced under similar winding conditions but in precision winding mode showed that the wound filters exhibited higher pressure drop compared to wound filters produced in step-precision winding mode [22], which is essentially due to the compact winding achieved with precision winding and hence the higher pressure drop.

3.2 Retention efficiency characteristics

The inlet and outlet filter samples collected during the test trials of individual wound filters were analyzed on microscope and the dust retention efficiencies were obtained. The micron rating of SPA1 was 72 μm, SPA2 was 85μm while that for SPA3 was 85μm. It can be observed that the micron rating of A1 is better than A2 which was mainly due to higher yarn content which is also the reason for higher pressure drop. Thus, in spite of having similar porosities and surface areas, A1 and A2 filters showed different micron rating and pressure drop values.

The other most obvious result was that the micron rating of SPA2 and SPA3 filters was same but the pressure drop difference between them was the maximum. The coil content in case of A2 filters was more than A3 but no significant improvement in its rating was found or in other words the SPA3 filter showed nominal rating of 85 μm and lower pressure drop in spite of having lesser yarn content. Thus from economy point of view this information should be of prime importance for the manufacturers. Here it is pointed out that when wound filters were produced in the precision winding mode, the micron rating of wound filter with lower coil angle was better (59 μm) and got poorer with angle increment. The filter produced on precision winding mode wound with highest coil angle coped badly than the filter produced on step-precision winding mode [22].
3.3 Influence of available trapping area

The particle trapping capacity of a filter may be attributed to the surface available for the particles to get deposited [23]. The calculated values of available surface area on the basis of physical dimensions for all filters are shown in Table 1.

<table>
<thead>
<tr>
<th>Filters</th>
<th>Length (cm)</th>
<th>Surface area (cm²)</th>
<th>% decrease with reference to SPA1T</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPA1T</td>
<td>23</td>
<td>226.8</td>
<td>-</td>
</tr>
<tr>
<td>SPA2T</td>
<td>22.7</td>
<td>223.9</td>
<td>1.279</td>
</tr>
<tr>
<td>SPA3T</td>
<td>22.5</td>
<td>221.1</td>
<td>2.513</td>
</tr>
</tbody>
</table>

This shows that all wound filters had similar surface areas. Since the build-up involved changing coil number progressively from center to surface, it would lead to change in the coil content present in each layer resulting in different densities across the build-up. Table 2 shows density changes during build up of SPA2T package. The bare bobbin weight was 55.93 g and package was built to give full diameter of 64 mm.

<table>
<thead>
<tr>
<th>Diameter build-up</th>
<th>Weight at every step (g)</th>
<th>Density (g/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step – 1 (bare – 40 mm)</td>
<td>59.1</td>
<td>1302.46</td>
</tr>
<tr>
<td>Step – 2 (40 mm – 48 mm)</td>
<td>60</td>
<td>826.074</td>
</tr>
<tr>
<td>Step – 3 (48 mm – 56 mm)</td>
<td>64</td>
<td>660.705</td>
</tr>
<tr>
<td>Step – 4 (56 mm – 64 mm)</td>
<td>65</td>
<td>567.054</td>
</tr>
</tbody>
</table>

It was found that the weight increased to 115 g from bare bobbin weight of 55.93 g, which was an increase of 59.1 g. Similarly for the second step the increase in weight was 60 g, and for the third and fourth step increase in weight was found to be 64 g and 65 g respectively. Thus the increase in weight was quite close in every step however the density (mass per unit volume) changed. When the bobbin was bare, the coil number (figure 2) was more making it denser, whereas the unit volume) changed. When the bobbin was bare, it was found that the weight increased to 115 g from bare bobbin weight of 55.93 g, which was an increase of 59.1 g. Similarly for the second step the increase in weight was 60 g, and for the third and fourth step increase in weight was found to be 64 g and 65 g respectively. Thus the increase in weight was quite close in every step however the density (mass per unit volume) changed. When the bobbin was bare, the coil number (figure 2) was more making it denser, whereas the coil number reduced progressively as the build proceeded to the surface of the package; leading to less dense packing. The characteristic feature of step-precision winding is that the length over which winding is done remains almost same resulting in similar surface areas and better edges of the wound packages.

4. Conclusions

• The wound filters could successfully be produced on step-precision mode.
• They were produced with three different coil angles for which the traverse ratio was changed in four steps in all cases.
• These filters also showed density gradient that is evident from its density values. The pressure drop of filters wound in this mode showed lower pressure drop than those wound on precision winding mode.
• The porosity of all wound filters came out quite close to one another mainly due to their similarity in surface areas.
• The pressure drop decreased with the increase in the coil angle; trend being similar to that of wound filters produced on precision winding mode but overall the pressure drop shows dependency on the winding mode.
• Wound filters produced with lower coil angle showed higher pressure drop with better micron rating.
• Further increment in the coil angle although resulted in reduced pressure drop but even the micron rating became poorer.
• It is suggested to use highest coil angle selected in the study when wound filter with micron rating of 80 μm or above have to be produced, as the pressure drop experienced will be less and the micron rating is also comparable with the filter wound with slightly higher coil angle; thus being more economical due to lower consumption of yarn.

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References

An Assessment of the Perception and Practices with Respect to the Use of Women Hygiene Products

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Department of Fabric and Apparel Science, Lakshmibai College, University of Delhi, Delhi

Abstract:
The aim of this study is to assess multiple factors being considered by females about the usage of women hygiene products and the various methods employed regarding their disposal. Also, there is a need to educate and create awareness about the environmental pollution and health hazards associated with the disposal and usage of these products. For the study, a sample size of 200 women, in the age-group of 18-40 years was considered. Questionnaire was circulated through an online google-form, having both close-ended as well as open-ended questions.

Based on the data obtained, it was found that 100% of the women preferred the use of sanitary napkins during menstruation over other alternatives available. Majority of the women (56.6%) experienced discomfort, rashes or allergies during menstruation. The study also confirmed that most of the women (51.2%) had little knowledge about the chemicals used in sanitary napkins. It was found that they were not aware of the non-biodegradable materials being used in the sanitary napkins but they understood that the plastic layer being used in these napkins can lead to environment pollution - soil pollution and if the napkins are incinerated, it causes air pollution as harmful chemicals get released in the air.

Keywords: Biodegradable, Eco-friendly, Hygiene, Sanitary Napkins

Citation: P. Vatsala, S. Sareen, N. Sonee & M. Goyal, “An Assessment of the Perception and Practices with Respect to the Use of Women Hygiene Products”, Journal of the Textile Association, 83/3 (186-188), (Sept-Oct’2022), https://doi.org/10.17605/Article Received: 16-03-2022, Revised: 11-07-2022, Accepted:29-08-2022

1. Introduction:
Disposal of women hygiene product is a problem in India, they contain plastic chemicals [1] and high concentration of volatile organic compounds (VOCs) [2] which are non-biodegradable [3] and lead to health and environmental hazards. In urban areas a fraction of menstrual waste reaches the incineration sites, while some burn them in open, which release harmful dioxins [4] rest overburden the landfill or pollute water bodies. Objectives of the study are to find factors considered by women for selection of women hygiene products and assess need to create awareness about the environmental pollution and health hazards associated with these products.

2. Materials and Methods
To conduct this study Convenience Sampling was adopted to know the perception and usage of women hygiene products. Sample size of 200 females within the age group of 18-40 years was targeted. A questionnaire having 13 questions was structured to assess the degree of knowledge of the respondents about proper use and disposal of women hygiene products. The questions also included problems faced with disposal and usage, side effects faced due to said issues and the impact of women hygiene waste on environment. The questionnaire was created and assessed using online-google form and Likert scale.

3. Results
In total, 200 females participated in this study. This study showed that only 13.3 % females had heard of tampons, 46.4 % female knew about disposable sanitary pads, 20.4 % knew about menstrual cups, very few 8.2 % were aware about reusable sanitary napkins which can be washed and reused and there were 53.1 % of females who had heard of all the women's hygiene products (Figure 1).

![Figure 1: Participants' awareness about Women’s hygiene products](image1)

![Figure 2: Response when females were asked what they normally use during their periods](image2)

The study revealed that almost all 96.9% of women used sanitary pads over cloth/towel, tampons, menstrual cups, and others (Figure 2). It was found that 56.6% participants were occasionally experiencing discomfort due to use of sanitary...
napkins, 14.3% were experiencing discomfort regularly, very few were experiencing discomfort frequently and 26.5% of participants are not experiencing any discomfort during their menstruation (Figure 3). Practices related to menstruation hygiene are of major concern as it has a health impact; if neglected, it leads to toxic shock syndrome, reproductive tract infections (RTI), and other vaginal diseases [5]. Less than half (45.9%) of the women changed their pads within recommended changing time period i.e. 3-4 hours, whereas 44.9% changed it at an interval of 8 hours even during their heavy bleeding days (Figure 4).

While assessing the means of disposal of women's hygiene products, it is discovered that 87.8% of the participants preferred throwing their pad in a bin which is collected by local garbage collectors, as part of the domestic waste disposal system (Figure 5).

In the study it was discovered that the comfort, quality and size factors influence most of participant's choice of usage of women's hygiene products while few of the respondents also showed a preference for fragrance, brand and design in sanitary napkins [Figure 7].

Graphical representation in Figure 8 displays that 55.1% of participants have little knowledge about non-biodegradable materials used in the preparation of sanitary napkins and other women's hygiene products, 27% of participants were not at all having any idea about it and 17.9% of participants were aware about the materials.

Participants were also asked about their knowledge on reusable sanitary fabric napkins. Graphical representation [Figure 9] displays that 53.1% have knowledge about it while 46.9% were not aware of such fabric napkins.

Many participants expressed their willingness to try fabric sanitary napkins if they are available in market at affordable price. Since they are made up of environmental friendly soft and hygienic materials, it will be comfortable as well as it will not harm to the environment. According to a study, a reusable solution is most logical for eliminating waste and for enabling affordability given the tangential problem of sustainability in development. Many modern technologies...
turn to the propagation of menstrual cups in order to fill these requirements. In many regions however, the use of invasive absorbents is culturally inadmissible. In addition, an economically feasible solution would ideally be one that is produced locally [6].

Moreover, it is assessed through an open ended question in this study that more than 30% participants were aware that their methods for disposal of women's hygiene products are harming environment. While around 45% of participants believe that their method for disposal of women's hygiene products is environmentally friendly because they roll their pad into paper and keep that in polybag then throw in garbage and when the garbage goes off then the things are separated and incinerated, this further proves lack of awareness about the effect of sanitary napkins on the environment in several ways as the plastic sheet used in sanitary napkins may not decompose and result in the soil pollution and if incinerate the napkins it cause air pollution/ poor quality of air as harmful chemicals mix in the air we breathe. In India, menstrual products are considered as medical products and as per law the companies are not required to disclose all the ingredients [7].

This further advocates need to create awareness among women in different sections of society about effects of women sanitary hygiene products on health and environment.

4. Conclusion
From the findings, it was concluded that maximum respondents were not aware regarding the non-biodegradable materials and chemicals used in the women hygiene products. It was found that most of participants considered various factors like comfort, quality and size to make choice of women hygiene products. A significant number of participants were unaware that their disposal method of waste creates a negative impact on the environment in several ways as the plastic sheet used in sanitary napkins may not decompose and result in the soil pollution. Also, if incinerated these napkins cause air pollution as harmful chemicals and toxins are released in the air.

5. Acknowledgement
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References
Application and Innovation of Sustainable Geotextiles
In Road Safety Engineering

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Abstract:
Technical textiles have been successfully utilized from last few decades and majority of the sectors includes Medical, Civil, Transportation, Agriculture and Mechanical. The various functions such as filtration, stabilization, separation, reinforcement can be achieved by using geotextile. The paper proposes utilization of geotextile in the field of road safety engineering more particularly a real time roadside or road crossing stray animal detection and early warning system for the vehicles. Every year due to the collision between animal and vehicles hundreds of people as well as animal are get injured and died. On the report of veterinary department, the number of accidents increased by almost 23% in last six years. Here we are proposing a sustainable geotextile deployed wireless communication and machine learning based warning station that could detect the animal and warn the vehicles on the roadway. A robust stray animal detection model using YOLO version5 has implemented using on-road cattle image dataset. The trained model can predict 80% to 85% true positive results with 90.5% accuracy on real world camera feed.

Keywords: Geotextile, Glass fiber, Object Detection, Pavement, Road Safety, YOLO

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1. Introduction:
One of the biggest problems in front of developing country is the deaths and injuries due to road accidents. As per as India is concerned out of the total population 65% people lives in rural area and 35% live in urban area. Therefore, domestic animals like cow, buffalo etc. kind of cattle are usually observed at the road side or on the roadways. Due to the lack of animal protection fencing at road sides they can enter at any instance on road. This kind of situation usually observed on the roads near to the agriculture field or in jungle areas. The unpredictable behavior of animals can cause dangerous accidents between vehicle and animals where both get injured [1]. Apart from these issues like abrupt lane change due to path holes, bad road conditions are responsible for human injuries and deaths on roadways. Due to rapid growth and heavy traffic, the traditional design and construction of roadways cannot fulfill the construction standards [2]. To tackle this issue the paper provides an innovative design of pavement using geotextile material that could help improve reinforcement of roadway. The applications like separation, drainage, reinforcement, sealing and protection, filtration are also possible using geotextile [3]. This paper presents utilization of sustainable geotextile material in transportation and road safety engineering using a robust machine learning and wireless communication methodology.

2. Materials and Methods

2.1 Materials
The high strength, density, stiffness, porosity, permeability, elongation, biodegradation, low cost and ease of use are the major and important characteristics of woven (Figure 2.1), non-woven (Figure 2.2) or knitted (Figure 2.3) geotextile materials [4].

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Therefore, such materials are widely used in geotechnical engineering. The proposed work consists a pole mounted wireless and machine learning based system. Here light weight, low maintenance, high mechanical strength, corrosion resistive and handy Glass Fiber-Reinforced Plastic (GFRP) poles are sustainable solution as compared to traditional steel or concrete poles [5]. The non-metallic enclosure made up of thermostet polyester material reinforced with glass fibers proposed for electrical and electronics circuit board in the system. It is preferred due to their high impact strength and rigidity, high impact resistance, superior working temperature range (-31°F to 300˚F), excellent electrical properties, excellent moisture and overall chemical resistance and cost effectiveness.

2.2 Methods
The present paper provides a sustainable geotextile material reinforced robust system for transportation and road safety engineering. The mode of operation of a geotextile in our work is given below.

2.3 Separation
Separation is nothing but introduction of a flexible porous textile placed between dissimilar materials so that the integrity and the functioning of both the materials can remain intact or be improved [4]. Geotextile plays an important role in transportation engineering in preventing the intermixing of two adjacent soils. It is achieved by separating fine subgrade soil from the aggregates of the base course; the geotextile provides strength to the aggregate material and preserves the drainage. The effect of separation is illustrated in figure 2.4.

2.4 Reinforcement
Reinforcement could be accomplished by placing geotextiles in the interior of the soil as reinforcing materials. This reinforced material get combines with the soil to form a reinforced composite soil [7]. It improves the strength and deformation performance of the reinforced composite soils as compared with the unreinforced soil. Figure 2.5 shows the reinforcement function of geotextiles.

Three major mechanical properties of geotextiles used for reinforcement: Tensile modulus, tensile strength and surface friction. In geotechnical engineering most commonly geotextiles preferred for reinforcement function.

2.5 System Design and Implementation
The functional block diagram of stray animal detection and early warning for the vehicles on the roadways is shown figure 3.1. The warning station in the present work comprises a computerized control unit interfaced with vision sensor, driver unit, antenna and transmitter section, and charge controller unit. The power management scheme consists of solar cells, power bank and battery charger unit. The computer unit receives the power supply from interfaced charge controller. The deployed power bank in the system can be charged through solar charger by taking electrical supply from solar cells. The solar charger and UPS battery backup can also be connected to local electricity line therefore the system can work on electricity line as well as on solar and battery backup scheme. The wide field of view fish eye night vision infrared sensor interfaced to the computer and can provide sufficient features to the algorithm.

![Figure 2.4 - Separation Function of Geotextiles](image)

![Figure 2.5 - Reinforcement Function of Geotextiles](image)
4. Software and Hardware Implementation

The flow diagram of the animal road crossing surveillance and early warning system are shown in figure 4.1.

At step 1, the deployed vision sensor in the invention continuously monitors the surveillance zone by using its wide field of view.

At step 2, the system undergoes through movement detection in the scene and video capturing process if any movement get detected in the scene.

At step 3, the standalone computer vision and machine learning algorithm processes data frames for the feature extraction, the algorithm utilizes the obtained features to recognize the cattle in the scene.

At step 4, based on the detection and recognition results decision is made the cattle are present in the scene or no.

In the absence of cattle in scene, system continues with step 1 for monitoring and if cattle get detected then algorithm turn ON the flashing of LED active road stud and active road sign until the count become zero. Simultaneously system sends the alert signal wirelessly to the vehicle on the roadway. This flashing indication by using active road stud and road sign and wireless alert signal transmission maintained turn ON during the presence of cattle in the surveillance zone.

The output of the control panel has connected to fiber glass external junction box which has installed at the bottom of pole. The connector terminals inside the junction box have been used to connect light emitting diode-LED active road sign and LED active road stud by using connecting wire. The LED active road sign consists of LEDs mounted on Fiberglass Reinforced Plastic-FRP sheet. Both are connected to the control panel via junction box by using connecting wires. The LED active road sign has deployed on the pole and road studs are installed on the roadway by burring the shank of stud. The buried connecting wires passed through an underground conduit which is used to house and protect the wire. The geotextile material in this arrangement plays important role by preventing the intermixing of two adjacent soils. The geotextile functions as a separator between fine subgrade soil and the aggregates of the base course. It preserves the drainage and the strength characteristics of the aggregate material.

5. Performance Evaluation of System

The performance evaluation of the animal detection and warning system has carried out by considering the validation matrices. Figure 5.1 shows the box loss and objectness loss which represents how well the model can locate the center of the predicted animal and how well it can be covered by the predicted bounding box. Objectness deals with measure of
the probability that the animal exists in a region of interest. High objectivity represents the image window is likely to contain an object. The model has trained and improvements are observed in terms of precision, recall and mean average precision before flattening after about 100 epochs as shown in figure 5.2. All the losses in the validation data show a rapid decline until around 100 epochs.

![Figure 5.1 - Plots of Box Loss, Objectness loss over the training epochs](image1)

![Figure 5.2 - Plots of Precision Recall and Mean average precision (mAP) over the training epochs](image2)

The response for F1 score verses confidence shown in Figure 5.3. It’s value ranges from 0 to 1 and value 1 indicates highest accuracy. The result shows obtained optimization accuracy of 0.81 at confidence value 0.39. The confidence value indicates the probability that an anchor box contains an object and as per graph its value is 0.8. The precision verses confidence plot shown in Figure 5.4. Here precision is 1 at 0.8 confidence score. The precision versus recall plot serves as an evaluation of the performance of model. Figure 5.5 shows the good response of precision and recall of our model. The plot obtained for recall and confidence is shown in figure 5.6. We have selected accuracy, sensitivity and F-measure performance metrics to evaluate the performance of system.

![Figure 5.3 - F1 vs Confidence Graph](image3)

![Figure 5.4 - Precision vs Confidence Graph](image4)

![Figure 5.5 - Precision vs Recall Graph](image5)

![Figure 5.6 - Recall vs Confidence Graph](image6)
The performance of the algorithm is measured with the help of four matrices these are True Positive (TP): means model predicted positive when the ground truth is indeed positive, False Negative (FP): specifies the wrong positive predictions, False Negative (FN): specifies an actual instance that is not predicted by the model, and True Negative (TN): means a negative prediction given that the actual instance is also negative. The performance metric accuracy Eq. 1 is the ratio of total number of true positives and true negatives to the all four metrics. Sensitivity Eq. 2 is the number of true positive to the sum of true positives and false negatives. The metric F measure Eq. 3 is the ratio of twice the number of true positive to the summation of twice the number of true positive, false negative and false positive.

$$\text{Accuracy} = \frac{(TP + TN)}{(TP + TN + FP + FN)}$$

$$\text{Sensitivity} = \frac{TP}{(TP + FN)}$$

$$\text{F - Measure} = \frac{2 * TP}{(2 * TP + FN + FP)}$$

The performance of the algorithm is measured with the help of four matrices these are True Positive (TP): means model predicted positive when the ground truth is indeed positive,

<table>
<thead>
<tr>
<th>Batch Value</th>
<th>Epoch Value</th>
<th>Precision</th>
<th>Recall</th>
<th>mAP 0.5</th>
<th>TP</th>
<th>TN</th>
<th>FP</th>
<th>FN</th>
<th>Accuracy</th>
<th>Sensitivity</th>
<th>F Measure</th>
</tr>
</thead>
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<td>0.64</td>
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<td>0.91</td>
</tr>
<tr>
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<td>0.70</td>
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</table>

The animal detection model in the work trained using thousands of ground truth image samples acquired by using vision sensor. The training dataset consists of stray animals like cow buffalos observed on Indian roads. The mean precision, recall and mAP acquired during the training of model. Table 1 also shows the results of three performance metrics F-measure, Sensitivity and Accuracy to measure the performance of the model.

6. Results and Discussion

The stray animal detection and early warning system for the vehicles in the field of road safety engineering is presented. The developed model in the system is efficient one in terms of mean accuracy of 90.5%, mean sensitivity of 81.5% and mean F-measure of 89.5%. We have tested the model on Intel, Core2 Duo CPU with 2.93 GHz and 2 Gb of RAM by considering various poses of cattle and in real world critical road conditions. The figure 6.1 and figure 6.2 illustrates the detection results in diverse scene as well as animals either in sitting or standing position. The model can efficiently detect the cattle in occluded situation as in figure 6.3. At poor light situation detection result is shown in figure 6.4. In these results the red color bounding box indicates the detection of animal in the scene and the values at top right corner are nothing but the accuracy of the recognized object.

Figure 2: Cycle of formation and destruction of ozone

Figure 6.1- Recognized Seated Cattle

Figure 6.2 - Herd Detected Result

Figure 6.3 - Recognized Cattle in Occluded Situation

Figure 6.4 - Detection at Low Light Condition
7. Conclusion

The aim of this research work to design and develop an innovation for road safety engineering using sustainable geotextile material. The number of accidents and injuries on the roadways could be minimized by the inclusion of geotextile as well as smart electronics system. An efficient stray animal detection and warning system presented in the paper using single stage object detector YOLO model. The pole mounted wireless station in the work could continuously monitor and warn the vehicles on roadway. The model has achieved 90.5% detection accuracy for the domestic animals usually found on Indian roads. The uneven road surface, cracked pavement, path hole tends to abrupt lane change or lose control of the vehicle. The use of geotextile in transportation engineering will helps to improve bearing capacity and strength of soil. The sustainable system in the present work also uses fiber glass reinforced plastic which is more economical.

References

Robotic Applications in Garment Manufacturing: Revival of Garment Industry

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Abstract:
Robotic process automation is a software technology that makes it easy to build, deploy and manage software robots that emulate human’s actions interacting with digital systems and software. Physical robots may be used in automation, but many robots are not created for automation. Robots are used to automate some physical tasks, such as in garment manufacturing. However, many types of automation have nothing to do with physical robots. Artificially intelligent robots are the bridge between robotics and Artificial Intelligence (AI). These are robots that are controlled by AI programs. Most robots are not artificially intelligent. Up until quite recently, all industrial robots could only be programmed to carry out a repetitive series of movements which do not require artificial intelligence. However, non-intelligent robots are quite limited in their functionality. The applications of robots in fashionable garment manufacturing have seen tremendous infusion of technology in the manufacturing plants. The robots are effectively used in Fabric Inspection, fabric spreading, fabric segregation, cut piece assembly, garment pressing and garment packaging. This present paper deals with an indepth and extensive applications of Robots in apparel manufacturing.

Keywords: Artificial Intelligence, Fabric segregation, Physical robots, Robotic process automation, Software robots

1. Introduction:
Automation and robotics are the two terms that are often used interchangeably. Automation is the term pertaining to all the process based on using mechanical processes, computerized software and additional engineered machinery to accomplish those tasks that are usually performed by human workforce. Automation has many levels, ranging from the entirely mechanical to the wholly virtual and also, from very simple designs to the mind-bogglingly complex configurations.

The Robotics is the term related to the process of designing, developing and applying robots to execute plentiful tasks. In addition, Industrial automation relates to the processes of automating various physical processes using shop-floor robots and their dedicated controllers. On the other hand, Software automation is the extensive use of software to perform the tasks performed by computers. There are abundant categories of software automation as test automation, robotic process automation, intelligent automation, and many others. Robotics engineering refers to the design and development of robots by incorporating software, hardware, sensors and other devices, for quality inspection, assembly, packaging, handling etc [1].

1.1 Robotics as an integral part of automation
The processes that utilize the application and combination of mechanics, electronics and computer based systems to operate and control the apparel manufacturing systems and their support systems is termed as AUTOMATION. It's the use of mechanical systems, control systems and web based technologies to implement suitable control on the apparel production. A robot is the technological advancement concerned with the accomplishment of a dedicated process with the use of structured commands may be combined with automatic feedback control systems to ensure the proper execution of the process. The broad areas of application of automation encompass manufacturing departments and manufacturing support systems. The typical areas to be covered in the automation of manufacturing departments of a garment industry are 3D Body scanning, Automation in fabric & trim inspection, fabric spreading, fabric cutting, garment sewing, fusing, moulding, welding, garment pressing & packaging, workflow systems, Robots, Programmable Logic Controllers, Automated Geared Vehicles, Art work processes and Computer Integrated Manufacturing (CIM) [2].

On the other hand, the computerization of manufacturing systems is about the reduction of human participation to only supervisory control and elimination of the clerical/maunal work carried out by the human assistance especially in the product designing, planning, assisting and product control and process control. The various segments affected by automation in this are MRP (Material Requirement Planning), Lean manufacturing, Agile manufacturing, MRPII (Management Resource Planning), JIT (Just In time), Inventory Management & Handling, MIS (Management Information System), CAPP (Computer Aided Process Planning) and ERP (Enterprise Resource Planning) [3].

Robots are able to fit into the genre of flexible automation due to its unmatchable capabilities of reprogramming, ease of changeovers, efficient and error-free task accomplishment.

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1.2 History of Robotic Technology Evolution & Developments

The robot history is the amalgamation of fiction and real time technological advancements. The first modern automation was invented in the year of 1810 by a German artist Friedrich Kauffman. The initial prototype of this robot looked like a soldier equipped with automatic bellows to blow a trumpet. “Robot” term came from the Czech literature that meant “forced labor.” They looked like humans but instead of metal, chemical batter was used to produce them. In the 1950s, George Devol designed a revolutionary “Unimate”, a robotic arm device that transported die castings in a General Motors plant in New Jersey in 1961. In addition to it, by mid-1950s, the German firm “Kuka” developed an automated welding line for appliances as well as a multi-spot-welding line for Volkswagen. After this, by 1970s, Stanford University designed the “Standard Arm” to be used for small part assembly for the incorporation of touch and pressure feedbacks. In 1973, Kuka had introduced the six-axis robotic arm, which became an industry standard after its commercialization [4].

At the same time fully electrical systems based robots began to emerge in the Industrial arena. By 1970s, many new endeavors were tried for Robots as a microprocessor-controlled robot, increased ability to handle higher payloads (ability to lift high weights), a sensor-based welding robot, development of the SCARA arm and PUMA robot for small parts assembly, hand on trials of basic robot programming languages & Speeds and capacities were also worked upon tremendously. In 1990s, first packaging robot was innovated with pure robot controls and synchronizations. The onset of 21st century had completely revolutionized the robot technology with the invention of a handheld teach pendant, robot multi axial synchronization, Automated geared technology with the invention of a handheld teach pendant, Collaborative Robots (COBOTS) and Autonomous Mobile Robots (AMR) by 2010. The progression of the Robotic developments is depicted in Figure 1.

Figure 1 - Evolution and development of Robots from the infant stage to the modern forms

1.3 Robotic applications in the garment manufacturing processes

The requirements of the Robots for the Garment Industry are entirely different from those required by the other hard core manufacturing plants due to the complexities involved in the assembly and handling of textile materials in raising the garments. The major challenges implicated in the infusion of the Robots in the garment manufacturing include the use of extremely limpy, unstable and delicate raw materials as fabrics, threads and notions; high speed processes; minuscule labor intensive processes; huge diversity and variability in the raw materials in each lot and requirement of human intelligence and intervention in all the processes to some extent. These challenges posed by the garment Industry had deferred the use Robots in this specific segment of production Industry. But with the advent of Science, Engineering and Technology, even the Garment Industry hasn't remained unsathed for the Robotics [5].

The design of Robots for the garment manufacturing has always required different class of manipulators and its subparts, control systems and driving mechanisms to suit the requirements of the variable garment making steps just as movable platform based manipulators are always preferred for the material transfer within a department; use of combined pneumatic and hydraulic drives for assembly of garments; variety of sensors as touch, tactile and vision systems are the most common preference for fabric spreading, cut fabric segregation and seaming of cut parts; special designs and materials for grippers & end effectors based on the clamp, pinch, pins, vacuum, air jet blow principles are devised to suit the raw material variables as Materials type, Weight per unit area, Thickness, Wettability, Stiffness, Hairiness, Permeability, Friction, Elasticity and the ability to keep an electric charge [6].

2. Robots in Fabric Spreading

In this area, Robots are used for the identification of the fabric defects, shade matching of different plies, adjustment of ply tension during the spreading process. This is made possible by employing different types of touch, tactile and vision sensors to the manipulators. The major challenges posed by this process line to the use of Robot is that these programmed machines are not able to distinguish various fabric weaves and patterns or other types of fabric details during ply matching as shown in Figure 2.

Figure 2 - Spreading process with the interface of Robots

3. Robots in Fabric Cutting

Robots are used with two main perspectives in the garment cutting room. In the first scenario, the robotic arm is equipped with the cutting aids as drills at the position of its manipulator grippers. This will eliminate the need of manual drills for the cutting room. In the second perspective, the Robotic arms are interfaced with the cutting tables to sort the cut pieces from each other as front, back, sleeves, pockets, collars etc. either bundling cum ticketing or for UPS production lines to be transferred to the next production processes as can be seen in Figure 3. In this, the exact position of each cut part and its suitable picking points should be programmed along with other details as decisions have to be taken on what is to be
picked and where is it required to be delivered. Highly sophisticated tactile sensors are required to accomplish this task. The clamp and pinch type of mechanical grippers can be chosen with the two sided attraction and of handling and mechanical gripping principles. Clamp grippers are successful in fabric ply picking and also ply separation [7, 8].

4. Robots in Garment Assembly

The most complicated automation and robotics are used in sewing section of the garment industry. This is due to the reason that sewing process employs very small and yet complex tasks for garment assembly. Also, the variety of tasks, machine settings according to the raw materials and raw material composition further makes the integration of Robots more challenging. There are numerous approaches in which robots are used in the garment assembly.

In the first approach, Robots are used in material handling between the sewing processes. In the second approach, Sewing robots as “SEWBOTS”– Robotic sewing- It is the advanced technology that is based on the combination of machine vision systems and pneumatic robot drive systems to maneuver the fabric compositions upto and from the needle with greater speed and accuracy than humans can achieve. It is commercially applicable in the automated production of different types of floor coverings as bath mats, carpets, rugs, automotive textiles, medical textiles, bath towels and several categories of 3D composites. The fabric compositions are fed by soaking them in highly diluted liquid polymers solutions to turn them into thermoplastic hard composites that robots can easily handle. The sewing machine assembles the stiffened compositions of fabrics to produce a neatly seamed product. After sewing the fabrics, the polymers are washed off with running water without the need of detergents (Figure 4). Sewbots suffers from a few limitations as fabrics like wool or leather can’t be easily used with this technology as they can loose some of their properties while getting wet [7, 9].

In another approach, stitching robots are equipped with the sewing zones to assemble the preformed composites for automotive, as earlier flat sewing techniques are not suitable for these preformed 3D auxiliary automotive parts due to their large dimensions. In this interface, the workpiece is fastened on to the fixation devices and the stitching heads are carried along the seamline of the resting workpiece. One side stitching is only performed in this mainly with single thread chain stitches. Other approaches of robots include the integration of robots with already existing sewing units.

5. Robots in Garment Packaging

In addition to manufacturing, machining and assembly; robots can be used for garment packaging, cartoon sorting and order picking. Variable types of grippers and gripping principles are employed for the robots to order pick and package the ready garments as per the packaging materials. Clamp type of grippers is the best choice for the garment packaging robots interlaced with the packaging workstations for garment sorting, picking them at the correct positions by using two attachment points with the options of changing the distance between them to handle wide range of textile materials as shown in Figure 5. In addition to it, specially designed Pinch grippers are also used to pinch the textile materials using soft tipped fingers while packaging. The design of this gripper has followed the engineering design principles with low cost, non-destructive, minimum DOF and cycle time [10].
The leading manufacturers of robotic assemblies providing solutions to the garment industries include Siemens Technology in association with Sewbo Inc., Bluewater Defense and University of California at Berkeley; Interface Technologies, Hickey Freeman; Yaskawa Electric Corporation (Japan); Universal Robots (Japan); Universal Robots (Japan) and Midea Group (Kuka of Germany).

6. Conclusion
The applications and success of robots in the garment industry was long awaited till 21st century. In the current scenario, most of the segments of the garment industry have been able to employ the robot technology to the pinnacle of success. But the newer face of the Industry have brought many provocations as it has led to unrest among people due to the reduced requirement of the labour, thus leading to increased unemployment, need of only literate and technology compliant workforce, massive initial capital and maintenance investment, lacking creativity and many more. Yet the changing implications of automation and robots in the current fashionable garment industry will surely give innovative horizons to the manufacturers, designers and consumers as well.

References
Manufacturing Properties and Applications of Nonwoven Fabrics – A Review

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Abstract:
This paper reviews various techniques for producing nonwoven fabrics made from natural and synthetic fibers. The overview of different types of nonwoven fabrics is also considered as per the requirements. It has been shown that needle piercing is widely used in the manufacture of nonwoven fabrics for industrial use. The various physical, mechanical, and functional properties of the different kinds of woven fabrics are discussed here. The different properties nonwoven such as oil absorption, thermal insulation, air permeability, noise reduction, compressibility, water absorbency, acoustic insulation, etc. are discussed here.

Keywords: functional properties, industrial applications, nonwoven, textile, needle punching, physical properties


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1. Introduction:
Nonwoven Fabric
Nonwoven fabrics are one of the oldest and simplest textile fabrics. Applications of the nonwoven fabrics are multifold, such as geotextiles, dry filtration, Acoustic and thermal insulation, personal hygiene, healthcare, clothing, home, automotive, construction, home furnishing, etc. are discussed here. One of the frequent applications of nonwoven fabrics is for home applications, such as cleaning cloth. Nonwoven fabrics are highly porous material, and therefore found suitable for cleaning cloth. For cleaning cloth, among the others the important end-usage properties are softness and strength.

Nonwoven fabrics are formed by joining together or by wrapping textile fiber by machine, heat or chemicals. They are flat or perforated sheets made directly from different fibers, molten plastic or plastic film. They are not made by weaving or knitting and do not need to be twisted into threads. The important properties of nonwoven fabrics include absorbance, dehydration, durability, elasticity, softness, strength, fire resistance, etc. These structures are often combined to make fabrics suitable for specific tasks, while obtaining a good balance between product life and cost. They can mimic the look, texture and strength of woven fabric and can be as large as very large pads. In conjunction with other materials they supply a wide range of products with different properties, and are used alone or as parts of clothing, household goods, and health care, engineering products, industrial goods and consumers.

Mechanically blending fibrous wool is known as a needle piercing [1]. The threads are machine-bound to produce fabric by repeating sharp needles (attractive needles) with a moving batter of threads on the needle thread. The needle piercing process is well suited to produce intermediate and heavy nonwoven weight from 300 gsm to 3000 gsm. So using needle piercing is the best way to produce nonwovens.

2 Overview of Types of Nonwoven Fabrics
As shown in Fig. 1, the nonwovens can be categorized in three types- viz. natural fiber, regenerated fiber, and synthetic fiber.

![Figure 1 - Types of Nonwoven Fabrics](image)

The nonwoven fabrics can be divided into 8 types according to different manufacturing processes [16].

2.1 Spunlace Nonwovens
The spunlace nonwoven is a category of nonwovens manufacturing that employs jets of water to entangle fibers and thereby provide fabric integrity.

2.2 Heat-Bonded Nonwoven Fabrics
Heat or Thermal bonding is the most popular method of bonding used in nonwovens manufacture. It offers high production rates. This type of nonwoven fabric is produced mainly by adding adhesive materials to the fiber network, and then strengthening the network into fabric by heating and cooling.

2.3 Pulp Air-Laid Nonwovens
Nonwovens that are air-laid are also known as dust paper or

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dry paper nonwovens. It employs air-conditioned technology to change wood pulp fiberboard into a single state fibre, then an air flow method to turn fibre agglomeration into a net curtain, and finally fibre web into fabric.

2.4 Wet-Laid Nonwoven
Wet-laid nonwovens are prepared by dispersing the short fibers of 30 mm length in water and deposited on the wire mesh, allowing the water to drain from the web. The fibers within the web were entangled by means of either fiber-to-fiber friction or binding agent.

2.5 Spunbond Nonwovens
Spunbond is a nonwoven fabric made from 100% pure polypropylene. The polypropylene pellets are melted and extruded, then spun into fine fibers which in turn are laid and bonded by heated rollers to form spun bond fabrics.

2.6 Meltblown Nonwovens
Melt-blown nonwoven fabric is made by extruding melted polymer fibre through a linear die with hundreds of microscopic holes to generate long thin fibres that are stretched and cooled as they fall from the linear die. This type of nonwoven fabric is usually combined with spunbond to create SM or SMS webs. Meltblown cloth mainly uses polypropylene as the main raw material, and the fiber diameter can reach 1 to 5 microns.

2.7 Acupuncture Nonwovens
Acupuncture nonwoven is a form of nonwoven fabric that is used for acupuncture. Needle penetration reinforces the fluffy fibre into the textile.

2.8 Stitch-bond Nonwovens
Another type of dry nonwoven fabric is stitch-bond nonwoven. A stitch-bond nonwoven fabric is made on a weaving machine that bonds the web, or holds the web in place, with longitudinal yarns. The market size of nonwoven used for various applications is given in Fig. 1.2.

3. Methods of Manufacturing
There are three major bonding methods for nonwoven fabrics- chemical bonding, thermal bonding, and mechanical bonding. Hydro entanglement and needle punching/ needle felting are the two main methods used in mechanical bonding.

3.1 Hydro Entanglement
Hydro-entanglement is the process of producing nonwoven fabric that involves bonding together textile and high performance fibres and their blends by using very fine, high pressure water jets.

3.2 Thermal Bonding
Thermal bonding is one of the most common method of bonding used in manufacturing nonwoven fabrics. It offers high production rates because bonding is accomplished at high speed with heated calendar rolls or ovens. At the point where two or more fiber strands meet, thermoplastic powders are burnt which melts to join the fiber strands.

3.3 Chemical Bonding
The process of chemical bonding involves the application of a “chemical binder” to join polyester and rayon fibers to impart unique and beneficial characteristics to nonwovens. In chemical bonding, chemical bonds (adhesive materials) are used to hold the fibers together in a non-woven fabric. Chemical bonds are polymers formed by emulsion polymerization. The most widely used binder today is water-based latexes. They are used in many different ways in nonwovens and because their viscosity is close to that of water. They can easily penetrate into nonwoven structures with emulsion. After applying the binder it is dried and water evaporates. The binding then makes the adhesive film between or between the fiber crossings and the fusion of the fiber occurs.

3.4 Needle punching/Needle Felting
Out of the four knitting methods, the needle piercing is found to be the most effective.

4. Mechanical Properties of Needle Punched

4.1 Thermal Insulation
The thermal insulating properties of textile fabrics depend on their thermal conductivity, density, thickness and thermal emission characteristics. Thermal insulation material is one of the most important materials for technological fabric use. The most commonly used methods of measuring thermal insulation value (TIV) are disk method, the constant temperature method, and cooling method. Temperature resistance and stiffness increase but air permeability and air permeability are significantly reduced by increasing the weight of the fabric at all levels of jute content [6].

4.2 Fabric Density, Percentage, Compression, and Thickness
Fabric thickness is one of the most important factors determining thermal comfort. It was found that fabric thickness had a direct effect on thermal transmittance, where the thicker the material, the lower the thermal transmittance [1].
4.3 Air Permeability
Air permeability is a measure of air passage through the fabric. This parameter highly affects the comfort obtained from a particular fabric. Different products require different amount of air permeability. For example, the amount of air permeability is distinctly different for various products like clothing, parachute, bag, packaging textile, agro-textiles, etc. Also the air flow resistance increased with decreased fiber width and porosity [1]. The air permeability of the fabric increases with the increase in the amount of polyester compound in the composite. It is observed that air permeability decreases sharply with increasing fabric weight in case of polyester and jute fibers. The inflow of air also follows the same process with the weight of the fabric [11]. As expected, with a growing number of layers air permeability is reduced and, as a result, air flow resistance increases [14].

4.4 Water Absorbency
The water absorbency of the textile material is very important, and especially it is of paramount importance in case of diapers. Jute fabrics are used for a variety of applications like floor covering, wiping, suction, agro-textile, where water absorption is an important parameter. The nonwoven structure manufactured with porous needles is expected to improve the water holding capacity of the fabric. The density of the fabric plays a significant role in the absorption [8].

4.5 Acoustic Characteristics and Sound Absorption Coefficient
Sound absorbents are highly used at various workplaces like auditorium, theatre, class room, etc. Various natural and artificial products are used to enhance sound abortion. The capacity of the sound absorption of a material per unit surface area is given by absorption coefficient. Higher the value of absorption coefficient, higher is the amount of absorption. A study on the effect of various fabric parameters such as fiber filtration, surface effect, punch congestion, area congestion, and chemical bonding on the amount of sound absorption was performed. The results show that fiber fineness has a strong effect on the absorption of sound by nonwoven fabrics [4].

4.6 Bulk and Physical Properties
The bulk and physical properties of the fabric determine the performance of the fabric during the use. The physical characteristics of the fabric are directly or indirectly influenced by the fiber material, manufacturing process, and quality of raw material. The physical properties of needle fabric determine its suitability of the fabric in its various uses. Typically, a thin nonwoven fabric exhibits low air penetration, and high strength. Large incorporation of nonwoven fabric is usually achieved by high needle and needle penetration. Compressibility is reduced but pressure recovery is improved by increasing the penetration depth of the needle [3].

4.7 Oil Sorbents
Oil spills on water are removed using various techniques such as skimmer, chemicals, bacteria, etc. But these techniques are time-consuming. Similarly, the chemical method is dangerous for the environment. So, to overcome these drawbacks fibrous assemblies called sorbents are being studied for improved removal of oil spills. They possess oleophilic and hydrophobic properties. Sorbents are natural or synthetic materials with high capacity to absorb oil and repel water. They are spread over the oil slick to absorb the oil. Milkweed and kapok fiber-based nonwovens showed the highest oil sorption rate. Thirumurugan et al. (2011) reports that cotton fiber based nonwoven was found to absorb 26 g of oil per g of fiber. It exhibited a small water sorption capacity of about 1.67 g/g. The oil and water soaked sorbent didn't show any chemical degradation or microbial attack even up to 10th day in the sea water. The two natural fibers- Milkweed and cotton had shown good selective sorption of oil over water. Milkweed and cotton could replace around 90 % and 85 % resp. of the previously imbibed water by oil [17]. This indicates that natural nonwovens should be developed as potential oil sorbents to eliminate oil spills [13].

5. Conclusion
Nonwovens is an important branch of textiles and it accounts for the global market size of $38.3 billion in 2020 and it is expected to reach $68.1 billion by 2030. This sector is growing at average CAGR of more than 6%. Although an extensive research and development has taken place in the field of nonwoven, still there is a room for improvement. The nonwovens finds its presence in a variety of applications such as technical textiles including geotextiles, medical textiles, agricultural textiles, vehicle textiles, etc. By taking an overview of different manufacturing methods of nonwoven fabrics, it is found that needle punching is the most advanced and well-suited technology.

References
Development of Polypyrrole Coated Organic Textile Thermoelectric Materials

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Abstract:
In this research, various spunlace non-woven fabrics (100% polyester, 100% viscose and 50/50 polyester-viscose blend) are coated with an electro-conductive polymer polypyrrole by in situ chemical polymerization with FeCl3 as oxidant and thermo-electric effects of the coated fabrics are evaluated. In this approach, a flexible, wearable, and organic thermo-electric textile material is developed for conversion of heat energy to electrical energy. Electrical properties of the developed coated nonwoven textiles are evaluated and reported. The average electrical resistivity of a 60 GSM of 100% viscose fabric is obtained about 45.83 kΩ/cm² with 11.11% of polypyrrole add-on. Thermo-electric performance of these polypyrrole coated fabrics is investigated for a wide range of temperatures. The Seebeck coefficient turns out to be comparable with that of metals and inorganic semiconductor-based thermocouples.

Keywords: Electrical resistivity, In Situ polymerization, Non-woven fabric, Polypyrrole, Thermo-electric effect


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1. Introduction:
Clothing is worn by human being as its basic necessity. It has acted as an item of utility and adornment. Textiles have been worn next to the skin, making it a perfect medium for using body heat in order to generate power. It has unique features like comfort, flexibility, air permeability, etc. Now, these features are missing in semiconductor-based materials. Thus, textiles can be a perfect material as a thermoelectric generator to generate electricity utilizing body heat [1, 2]. In traditional method, conductive textiles are made by incorporating metallic fibers or metallic yarns in yarn or fabric structure. Though textile structures became conductive in nature by incorporation of metal fibers or yarns, their application areas became limited because of low flexibility, stiffness, low compatibility with other materials, increased weight, high cost involved in production [3]. Compared to the metal conductors, polymeric conductive textile has more advantages and thus make conductive textile unique in nature [4]. So conductive textile is one of the most promising and steadily growing fields in smart textile. If textiles are made as conductive without losing any of its natural characteristics like lightness, breathability, extensibility and flexibility, it can find more application areas [5, 7].

For this conducting polymer is taken in to account which can make conductive textile without compromising its natural properties. Conducting polymer field has come a long way since the Nobel Prize award discovery of the first member of this class- polyacetylene by A. J. Heeger, A. MacDiarmid and H. Shirakawa. Since then, more than 20 conductive polymers have been synthesized which have multiple applications [8, 9].

Polypyrrole is one of the most studied conducting polymers because of its fairly high conductivity, better environmental stability and ease of preparation [10]. Polypyrrole is one of the intrinsic conducting polymers very promising for wide thermoelectric applications because of its several attractive properties, such as easy preparation with low costs. Conductive textiles, with a modified polypyrrole coating have been commercially developed that are more conductive and thermally stable. While imparting electrical conductivity and a dark color to the substrates, the coating process barely affects the strength, drape, flexibility, and porosity of the starting substrates [11].

Synthesis of polypyrrole through in situ polymerization on textile substrates in the form of uniform coating was first reported by Kuhn et al 1995. Application of pyrrole on textile structure can be done in three different ways and they are chemical polymerization, electro-chemical polymerization and vapor polymerization [12,13]. Method adopted to polymerize pyrrole monomer in this study is two-step chemical polymerization. Formerly textile structure is impregnated in pyrrole enriched solution, latter put into oxidant solution for polymerization of pyrrole in second step.

Polypyrrole coated textile shows extremely low thermal diffusivity regardless of the electrical conductivity and their low thermal conductivity gives significant advantage to the thermoelectric figure of merit ZT, comparable with that of some traditional thermoelectric materials according to the study of Sparavigna et al, 2010[14]. So application of polypyrrole coated textiles as a heating and cooling garment is possible and there has been growing interest for applications of polypyrrole incorporated textiles in smart clothing, strain sensors, electrotherapy, resistive heating pads, stealth technology, electromagnetic interference (EMI) shielding, antistatic and electrostatic discharge (ESD) protection.

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2. Experimental

2.1 Materials and chemicals

Undyed spunlace non-woven fabrics made of 100% polyester, 100% viscose and 50/50 polyester-viscose blend each of 60 GSM are procured from Ginni Nonwovens, India. These spunlace nonwoven fabrics are used as substrate of coating of polypyrrole. The chemicals used are pyrrole (Leonid Chemicals, India) as monomer, FeCl₃ (Qualigens Fine Chemicals, India) and deionized water are solvent media. All the chemicals used are of laboratory grade and they are used as received.

2.2 Preparation of conductive fabric by coating through in situ polymerization method

100% Polyester, 100% viscose and 50/50 polyester-viscose blended fabric samples are taken and their weight are measured separately on a microbalance. Monomer and oxidant baths are prepared separately in separate beakers by dissolving required amount of pyrrole and ferric chloride in deionized water. The pyrrole and FeCl₃ concentrations in the bath are 0.1M and 0.2M respectively. Material to liquor (M:L) ratio is kept equal to 1:20 for both the bath. The fabric samples are first dipped into the monomer solution for 10 minutes at room temperature (22°C) with mild stirring so that pyrrole molecules get adsorbed onto fiber surface. After that, pyrrole enriched fabric samples are taken out from the monomer bath and dipped into oxidant bath for 60 min keeping inside a cryostat at 5°C. As a result, oxidative in-situ chemical polymerization takes place and adsorbed pyrrole molecules are converted into greenish back polypyrrole molecules. Then the polypyrrole coated fabrics were taken out of the oxidation bath and thoroughly rinsed and allowed to dry at room temperature (27°C and RH of 65%) for 3 days. All the fabric samples are converted in greenish black color which is the color of polypyrrole.

2.3 Preparation of Textile-Thermocouple

Thermocouple is a combination of two joined dissimilar metals kept at different temperature. Depending on the temperature difference between two junctions, voltage generation in the thermocouple circuit will be observed. In place of metal, the Polypyrrole coated electro-conductive fabric is coupled with copper wire as shown in Figure 2. Here the dimensions of the fabric samples taken are 2 cm × 6 cm, and the copper plate dimensions are (2 × 4) cm. Then, fabric samples are triple layered for a considerable thickness and resistivity. Fabric samples are gripped between the copper plate (bended in the middle to cover both side of fabric) at both ends. Copper wires are connected at both ends for easy connection to the further instruments.

2.4 Measurements Polypyrrole Add-on percentage on fabric

Samples are weighed before and after the in situ chemical polymerization. In order to measure the add-on % of the coated fabrics accurately, fabric samples are dried properly at room temperature before coating to reduce the influence of moisture on add-on%. And then the weight of the fabrics is measured, also the same procedure was carried out to measure the weight of fabrics after the polymerization process. The percentage weight increases or weight add-on% (W %) is calculated by using Equation (1).

\[
W\% = \frac{W_f - W_i}{W_i} \quad (1)
\]

Where, \(W_i\) - Initial weight and \(W_f\) - Final weight

2.5 Surface resistivity of Polypyrrole coated Spunlace fabric

The surface resistivity was measured as per AATCC 76-2005 standard and using a concentric ring electrodes setup where, \(R_1\) is the outer radius of the center electrode, \(R_2\) is the inner radius of the outer ring electrode, as it is shown in Figure 3. It is important to remember that when testing the surface resistivity (or resistance) of any material, it is assumed that all the currents flow between electrodes along the surface and do not penetrate into the bulk of the material. In order to ensure that the surface currents are measured properly, some more advanced techniques for surface resistivity measurements have been developed.

The value of surface resistance is given by \(R_S = \frac{\rho_s}{2\pi R_1} \ln \frac{R_2}{R_1}\)

Where, \(R_S\) is the surface resistance, \(\rho_s\) is the surface resistivity (obtained from literature part) or \(\rho_s = \frac{R_S}{K}\), Where K is constant value. So, the unit of surface.
2.6 V–I characteristics

The prepared sample shows the electrical conductivity, so the fabric prepared is connected to a D.C. voltage supplier. The voltage is supplied up to 30 V across the coated fabrics and corresponding current flows across the fabrics are measured.

2.7 Thermoelectric effect measurement

For measuring the thermoelectric effect of conductive fabric samples, one end of the textile thermoelectric was kept at room temperature and other end was kept at variable temperature with the help of heating element. Thermal image camera is used to measure the temperature difference between the junctions. A microvoltmeter is being used for measuring the generated e.m.f.

Here the setup for the measurement of thermoelectric effect is given in Figure 4. And the left side junction is at low temperature (cold junction) and right side junction is heated (hot junction).

3. Result and discussion

3.1 Add-on percentage of Polypyrrole on fabric

100% polyester, 100% viscose and 50/50 polyester-viscose are coated with polypyrrole and the weights before and after the polymerization are recorded, add-on values are calculated and the results are shown in Figure 5. 100% viscose fabric shows the highest add-on percentage of 11.11%. This is due to the high absorbency viscose fiber, with high amorphous area and irregular cross-section of the fibers.

3.2 Surface resistivity of PPy coated Spun lace fabric

The surface resistivity of all fabric sample is measured using concentric ring electrodes and the results are shown in Figure 5. The value of surface electrical resistivity for 100% viscose fabric is found to be 45.83 kΩ/cm², which is lowest among all these three fabrics. Least resistivity of viscose nonwoven is due to highest polypyrrole add-on.

3.3 V–I Characteristic

The prepared sample shows the electrical conductivity, so the fabric prepared is connected to a D.C. voltage supplier and current flows across it is measured. The voltage is supplied up to 30 V and the variation in current flows across the 100% viscose sample is plotted in the graph (Figure 6). Here the voltage–current (V-I) characteristics of 100% viscose fabric is only shown as its performance is best among 100% polyester and polyester/viscose blended (50/50) fabrics. From figure 6, it is clear that the V-I characteristic is nonlinear unlike Ohmic conductor. So, the fabric has non-ohmic electrical properties like inorganic thermo-electric materials.

3.4 Thermoelectric effect measurement

The emf obtained from PPy coated 100% viscose fabric shows the maximum emf of 0.27 mV/°C. And if the cold and the hot sides are reversed, thermoelectricity will be negative. It is much better result from the previously obtained values from different fabric types which is given in the range of 0.15 mV/°C (E Hu, A kaynak, Y Li, at-el 2005) [13].
4. Conclusions
The three different spunlace nonwoven fabrics viz. 100% polyester, 100% viscose and polyester–viscose blend (50/50) are coated with polypyrrole by in-situ chemical polymerization for the evaluation of their thermoelectric performance. Among these three spunlace fabrics, the performance of 100% viscose fabric is found to be best in terms of highest PPy add-on (11.11%), lowest electrical resistivity (45.83 kΩ/cm²) and highest thermoelectric effect (0.27 mV°C). The voltage-current (V-I) behavior clearly shows non-Ohmic characteristic of the PPy coated conductor. Unlike inorganic semiconductors such kind of PPy coated textile thermoelectric materials is organic, non-toxic, environment friendly, as well as flexible, wearable, strong and durable. Therefore, such types of textile thermoelectric materials are excellent alternative materials to conventional inorganic materials and can play a big role for conversion of waste heat energy to electrical energy in near future.

References

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Development of Nonwoven Composites for Acoustic Applications

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Abstract:
The fashion industry has seen a significant growth in the number of fashion shows taking place per year. The Lakme Fashion Week, Wills Lifestyle India Fashion Week, India Bridal Fashion Week and many more such fashion weeks are organized each year in halls and auditoriums. Most of the times parallel fashion shows are conducted in adjacent halls. Acoustic designing of these halls is of great importance for disturbance free results and viewer satisfaction. Disturbances within the hall can be caused by reflections from the walls and ceiling and also due to the echoes produced by objects and articles present in the hall. Disturbances between the halls can be caused due to the leakage of sound from doors or other openings. All the existing solutions available for minimizing these acoustic disturbances are either very thick or heavy or needs to be used in combination with other materials which reduces the cost effectiveness, the most commonly used materials being fiber glass, foam, partitions, etc. To overcome this disadvantage, in the present study, an attempt has been made to develop a ready to use nonwoven composite material manufactured by stitch bonding different nonwoven fabrics into a single structure. The nonwoven composite developed in this study are tested for sound absorption and transmission loss as per the ISO 10534-2 and ASTM 2611 respectively. The results showed that the developed nonwoven composite is at par with the existing materials available for acoustics. The material provides combination of both sound absorptive as well as sound reflective properties along with the added advantage of reduced thickness. The nonwoven composite also proves to be a one-stop solution for most of the acoustic applications.

Keywords: Acoustics, Nonwoven composites, sound absorption, stitch bonding, transmission loss


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1. Introduction:
Acoustic designing of halls, especially during adjacent fashion shows, is of great importance for disturbance free results and viewer satisfaction. Disturbances within the hall can be caused by reflections from the walls and ceiling and also due to the echoes produced by objects and articles present in the hall. Disturbances between the halls can be caused due to the leakage of sound from doors or other openings. The present study was undertaken to provide an efficient, cost effective and one-stop solution to these acoustic disturbances.

1.1 Research problem
The existing acoustic solution offered by various companies, require the use of combination of different layers of various materials to be fixed one by one with the help of adhesives. These different materials include a ply wood, a thick nonwoven backing, a glass wool fabric and the outer layer for aesthetic purpose. Fixing these layers is a tedious job and requires lot of time and efforts. Also, for excellent sound absorption properties, the material needs to be porous. The existing acoustic solutions use adhesives to fix the materials together. The adhesive materials reduce the porosity of these combinations of materials, which leads to the reflection of sound back to the hall. In order to overcome these problems, the researcher had undertaken a study to develop a one-stop solution and replacement for existing acoustic solutions.

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1.2 Literature review
Acoustics deals with the scientific study of sound which includes the effect of reflection, refraction, absorption, diffraction and interference. Absorption coefficient is defined as the fraction of randomly incident sound energy which is absorbed by the surface. The basic parameters of acoustic materials are the impedance and the surface shape. The law of conservation of energy states that energy can neither be created nor destroyed, but it can change from one form to another. Absorption converts sound energy into heat energy. It is useful for reducing sound levels within rooms but not between rooms. Each material with which a sound wave interacts absorbs some sound. The most common measurement of that is the absorption coefficient, typically denoted by the Greek letter $\alpha$. The absorption coefficient is a ratio of absorbed to incident sound energy. The reflection coefficient is a ratio of reflect to incident sound energy. A material with absorption coefficient 0 reflects all sound incident upon it. If a material absorbs all sound incident upon it, its absorption coefficient is 1. In practice, all materials absorb some sound, so this is a theoretical limit [1].

The phenomenon of persistence of sound due to multiple reflections from the ceiling, floor, walls and other material objects in an enclosure is called reverberation. Reverberation time (RT) may be defined as the time required from the moment of cessation of sound for the intensity to drop by 60 dB. Research has shown that it is the initial portion of the sound decay curve process which is responsible for our subjective impression of reverberation as the later portion is usually marked by new sounds. For this Early Decay Time (EDT) is used. This is measured in the same way as the
normal RT but over only the first 10-15 dB of decay, depending on the work. The optimum reverberation time of an auditorium is dependent on the use for which it is designed. The reverberation time of auditorium should be long enough at around 1.5 s to 2.5 s and this time should be longer for low frequency sound and shorter for high frequency sound [2].

Although, almost all materials possess some amount of sound absorption property, acoustic materials are those that can absorb the majority of the sound energy impinged on them. Acoustic materials can be used to control and reduce the noise levels from various sources. These materials absorb and dissipate the energy converting some into heat when sound travels through them. Acoustic materials can be of two types such as (a) noise absorption type and (b) noise reduction type. The former class of materials works by suppressing the sound, whereas the latter class works by reducing the sound energy when it passes through them. Acoustic materials reduce the energy of sound waves before it is reached with the receptor. Several methods can be used to reduce the sound such as: (a) use of acoustic barriers that can absorb sound energy, (b) increasing the distance between the source and receptor, (c) use of sound baffles and (d) use of anti-noise sound generators [3].

Acoustical materials play a number of roles that are important in Acoustic engineering such as control of room Acoustics, industrial noise control, sound studio acoustics and automotive acoustics. [3, 8] describe the sound absorptive materials generally used to counteract the undesirable effects of the sound reflection by hard, rigid and interior surfaces and thus help to reduce the reverberant noise levels. They were used as interior linings materials for auditoriums, halls, apartments, automotive, aircrafts, and ducts and encloses for noise equipments and insulations for machineries.

- Acoustic treatments are used for a variety of buildings in various forms. For example:
  - Educational buildings, learning centers, common areas, auditoriums or lecture theatres.
  - Community areas such as churches, chapels, airports and travel hubs.
  - Entertainment rooms such as theatres, clubs and art galleries.
  - Commercial applications such as call centre cubical, meeting or conference rooms.
  - Residential settings such as home theatre rooms or houses that are near heavy noise sources like a freeway to control the internal or external noise level.
  - Residential buildings closer to airports or highways with excess noise.

An auditorium is an indispensable one for performing arts, music concerts and various social functions. Acoustic and thermal comforts are the figures of merit of such a building. One purpose of the acoustic retrofitting or acoustic treatments in auditoriums is to absorb unwanted noise echoing and to confine the sound inside the room, avoiding any disturbance to neighbours. Another purpose is to restrict the entrance of unwanted noise into the room and to avoid disturbances.

Acoustic baffle systems are widely used in conference rooms, shopping mall lobbies, lecture theatres, warehouses or even car parks to reduce the internal noise level. Acoustic baffle systems are usually made of panels of sound absorbent material such as wood panel, cellular foam material, and they are used in large rooms and lobbies with ceilings of an adequate height and a large volume. Baffle systems are designed with continuously changing the size and the shape of the baffles and the stance between them to allow for maximum sound attenuation. The foam type lighter materials are chosen and the panel thickness, panel edge shape is considered to provide an efficient sound attenuation while the color is chosen to add to an enhanced visual image [4].

Absorbent materials are usually elastic, not very dense and permeable. They are formed mostly by air. These are soft or fibrous materials containing fine channels interconnected with each other. They can absorb acoustic energy through two mechanisms: when they are soft materials, they absorb due to the deformation that occurs when the sound wave hits them. When they are porous materials, they absorb by the vibration of the air contained in its pores, which loses energy by friction against their edges. A detailed list of materials used in auditorium is given in table 1[5].

### Table 1: Sound absorbing materials used in auditoriums

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Sound absorbing material</th>
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<tbody>
<tr>
<td>1.</td>
<td>Wood</td>
</tr>
<tr>
<td>2.</td>
<td>Glass wool</td>
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<tr>
<td>3.</td>
<td>Foam</td>
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<td>4.</td>
<td>Acoustic fiberglass</td>
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<td>5.</td>
<td>Acoustic cotton</td>
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<td>6.</td>
<td>Acoustic foam</td>
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<td>7.</td>
<td>Acoustic partitions</td>
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<td>8.</td>
<td>Hanging baffles</td>
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<td>9.</td>
<td>Water resistant panels</td>
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<td>10.</td>
<td>Echo absorbers</td>
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<td>11.</td>
<td>Wooden panels</td>
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<td>12.</td>
<td>Acoustic plasters</td>
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<td>13.</td>
<td>Acoustic tiles</td>
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<td>Strawboard</td>
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<td>Pulp boards</td>
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<td>16.</td>
<td>Compressed fiber boards</td>
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<td>17.</td>
<td>Compressed wood particle board</td>
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<td>18.</td>
<td>Perforated plywood</td>
</tr>
<tr>
<td>19.</td>
<td>Wood wool board</td>
</tr>
<tr>
<td>20.</td>
<td>Quilts</td>
</tr>
<tr>
<td>21.</td>
<td>Mats</td>
</tr>
</tbody>
</table>
2. Methodology
To conduct the study, following methodology was adopted:
1) Theoretical review of existing acoustic materials used in auditoriums
2) Sourcing of nonwoven fabrics for acoustic application
3) Stitch bonding of two and three layers of nonwoven fabrics to form nonwoven composites
4) Testing of samples for properties like thickness, areal density and volumetric density
5) Testing of nonwoven composites on acoustic impedance tube to measure absorption coefficient and transmission loss
6) Comparative analysis of the results obtained

Sample Preparation

![P1](image1) ![P2](image2) ![P3](image3)

**Figure 1: Polyester Nonwoven Samples**

As shown in figure 1, for the present study, five different polyester needle punched nonwoven fabrics were selected. The fabrics were cut in circle of diameter 100 mm by a laser cutting machine. Two and three layers of the fabrics samples were than manually stitched bonded using a polyester sewing thread.

### Preliminary Properties

The nonwoven fabric samples were tested for the measurement of thickness and GSM on thickness gauge and weighing balance respectively as per ASTM standards. Volumetric density and porosity was calculated theoretically using the following equation 1 and 2 respectively:

\[ \text{Volumetric density} = \frac{\text{Areal density (g/m}^2\text{)}}{\text{Thickness (mm)}} \times 100 \]  
(Equation 1)

\[ \text{Porosity} = \frac{1 - \text{volumetric density}}{\text{fiber density}} \]  
(Equation 2)

Fiber density of polyester is taken as 1.38 g/cm^3

### Acoustic impedance tube testing procedure

The sample was mounted on the sample holder of the tube and the holder was kept at a distance of 150 mm from the microphone. The sound source was at a distance of 350 mm from the test sample. The tests were carried out using a MATLAB programme designed specifically for the impedance tube setup. The effective testing frequency range of the setup was 0.1 kHz to 3.5 kHz. The sound absorption coefficient was calculated using the following equation 3:

\[ \alpha = 1 - 10^{-\left(\frac{d}{50}\right)} \]  
(Equation 3)

Where, \( \alpha \) = sound absorption coefficient, \( d \) = difference between empty reading and sample reading.

Noise reduction coefficient (NRC) and noise attenuation are the parameters that describe the ability of these materials to reduce the noise. NRC represents the amount of sound energy absorbed by a material when sound wave strikes a particular surface, which ranges from 0 to 1. A NRC value of 0 indicates perfect reflection; whereas a NRC of 1 indicates perfect absorption. NRC is measured by acoustic instruments using frequencies of 250, 500, 1000 and 2000 Hz.

### Analysis & Findings

The preliminary results obtained by testing the samples are given in table 2.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Materials</th>
<th>Thickness (mm)</th>
<th>Density (kg/m^3)</th>
<th>Absorption coefficient (α)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Glass wool</td>
<td>50</td>
<td>50</td>
<td>0.45, 0.65, 0.75, 0.80</td>
</tr>
<tr>
<td>2</td>
<td>Rock wool</td>
<td>50</td>
<td>80</td>
<td>0.29, 0.52, 0.83, 0.91</td>
</tr>
<tr>
<td>3</td>
<td>Polystyrene</td>
<td>50</td>
<td>28</td>
<td>0.22, 0.42, 0.78, 0.65</td>
</tr>
<tr>
<td>4</td>
<td>Polyurethane</td>
<td>50</td>
<td>30</td>
<td>0.30, 0.68, 0.89, 0.79</td>
</tr>
<tr>
<td>5</td>
<td>Polyethylene</td>
<td>50</td>
<td>32</td>
<td>0.25, 1.00, 0.40, 0.70</td>
</tr>
<tr>
<td>6</td>
<td>Polyester</td>
<td>45</td>
<td>20</td>
<td>0.56, 0.85, 0.98, 0.95</td>
</tr>
<tr>
<td>7</td>
<td>Hemp fibers</td>
<td>40</td>
<td>40</td>
<td>0.59, 0.60, 0.56, 0.52</td>
</tr>
<tr>
<td>8</td>
<td>Kenaf fibers</td>
<td>50</td>
<td>50</td>
<td>0.48, 0.74, 0.91, 0.86</td>
</tr>
<tr>
<td>9</td>
<td>Mineralized wool fibers</td>
<td>50</td>
<td>470</td>
<td>0.25, 0.65, 0.60, 0.55</td>
</tr>
<tr>
<td>10</td>
<td>Flax</td>
<td>35</td>
<td>43</td>
<td>0.66, 0.84, 0.79, 0.53</td>
</tr>
<tr>
<td>11</td>
<td>Coconut fibers</td>
<td>35</td>
<td>70</td>
<td>0.28, 0.40, 0.64, 0.74</td>
</tr>
<tr>
<td>12</td>
<td>Reed grating</td>
<td>50</td>
<td>130</td>
<td>0.46, 0.86, 0.71</td>
</tr>
<tr>
<td>13</td>
<td>Sheep wool</td>
<td>60</td>
<td>25</td>
<td>0.24, 0.38, 0.62, 0.84</td>
</tr>
<tr>
<td>14</td>
<td>Cellulose</td>
<td>50</td>
<td>28</td>
<td>0.60, 0.90, 0.75, 0.53</td>
</tr>
<tr>
<td>15</td>
<td>Rubber grains</td>
<td>5</td>
<td>1400</td>
<td>0.20, 0.82, 0.50, 0.56</td>
</tr>
</tbody>
</table>
### Table 2: Preliminary test results

<table>
<thead>
<tr>
<th>Fabric No.</th>
<th>Thickness (mm)</th>
<th>Areal Density (gsm)</th>
<th>Volumetric Density (g/cc)</th>
<th>Theoretical Porosity</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>3.50</td>
<td>290</td>
<td>0.083</td>
<td>0.66</td>
</tr>
<tr>
<td>P2</td>
<td>4.00</td>
<td>300</td>
<td>0.075</td>
<td>0.67</td>
</tr>
<tr>
<td>P3</td>
<td>5.00</td>
<td>415</td>
<td>0.083</td>
<td>0.66</td>
</tr>
<tr>
<td>P4</td>
<td>5.00</td>
<td>900</td>
<td>0.180</td>
<td>0.59</td>
</tr>
<tr>
<td>P5</td>
<td>6.00</td>
<td>700</td>
<td>0.117</td>
<td>0.64</td>
</tr>
</tbody>
</table>

The test results obtained for the single layer of fabrics tested for their acoustic behavior are given in table 3:

### Table 3: Acoustic behavior of single layer nonwovens

<table>
<thead>
<tr>
<th>Frequency (kHz)</th>
<th>0.1</th>
<th>0.25</th>
<th>0.5</th>
<th>1.0</th>
<th>1.5</th>
<th>2.0</th>
<th>2.5</th>
<th>3.0</th>
<th>3.5</th>
<th>NRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>ER (dB)</td>
<td>69.8</td>
<td>88.0</td>
<td>89.1</td>
<td>77.1</td>
<td>83.0</td>
<td>82.4</td>
<td>65.7</td>
<td>83.8</td>
<td>78.6</td>
<td>0.06</td>
</tr>
<tr>
<td>SR (dB)</td>
<td>69.4</td>
<td>86.7</td>
<td>89.1</td>
<td>76.7</td>
<td>82.7</td>
<td>81.9</td>
<td>65.5</td>
<td>83.5</td>
<td>77.7</td>
<td>0.17</td>
</tr>
<tr>
<td>SAC</td>
<td>0.05</td>
<td>0.14</td>
<td>0.00</td>
<td>0.05</td>
<td>0.03</td>
<td>0.06</td>
<td>0.02</td>
<td>0.03</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>TL (dB)</td>
<td>0.4</td>
<td>1.3</td>
<td>0.0</td>
<td>0.4</td>
<td>0.3</td>
<td>0.5</td>
<td>0.2</td>
<td>0.3</td>
<td>0.9</td>
<td></td>
</tr>
<tr>
<td>P21</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.25</td>
</tr>
<tr>
<td>SR (dB)</td>
<td>64.9</td>
<td>85.9</td>
<td>89.1</td>
<td>75.6</td>
<td>81.7</td>
<td>79.1</td>
<td>65.2</td>
<td>79.1</td>
<td>76.9</td>
<td>0.34</td>
</tr>
<tr>
<td>SAC</td>
<td>0.43</td>
<td>0.21</td>
<td>0.00</td>
<td>0.16</td>
<td>0.14</td>
<td>0.32</td>
<td>0.06</td>
<td>0.42</td>
<td>0.18</td>
<td></td>
</tr>
<tr>
<td>TL (dB)</td>
<td>4.9</td>
<td>2.1</td>
<td>0.0</td>
<td>1.5</td>
<td>1.3</td>
<td>3.3</td>
<td>0.5</td>
<td>4.7</td>
<td>1.7</td>
<td></td>
</tr>
<tr>
<td>P31</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.20</td>
</tr>
<tr>
<td>SR (dB)</td>
<td>65</td>
<td>85.9</td>
<td>88.9</td>
<td>74.1</td>
<td>79.3</td>
<td>76.5</td>
<td>64.8</td>
<td>77.5</td>
<td>75.9</td>
<td>0.56</td>
</tr>
<tr>
<td>SAC</td>
<td>0.42</td>
<td>0.21</td>
<td>0.02</td>
<td>0.29</td>
<td>0.35</td>
<td>0.49</td>
<td>0.10</td>
<td>0.52</td>
<td>0.27</td>
<td></td>
</tr>
<tr>
<td>TL (dB)</td>
<td>4.8</td>
<td>2.1</td>
<td>0.2</td>
<td>3.0</td>
<td>3.7</td>
<td>5.9</td>
<td>0.9</td>
<td>6.3</td>
<td>2.7</td>
<td></td>
</tr>
<tr>
<td>P41</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.32</td>
</tr>
<tr>
<td>SAC</td>
<td>0.55</td>
<td>0.47</td>
<td>0.03</td>
<td>0.32</td>
<td>0.39</td>
<td>0.56</td>
<td>0.25</td>
<td>0.50</td>
<td>0.32</td>
<td></td>
</tr>
<tr>
<td>TL (dB)</td>
<td>7.0</td>
<td>5.5</td>
<td>0.3</td>
<td>3.4</td>
<td>4.3</td>
<td>7.1</td>
<td>2.5</td>
<td>6.1</td>
<td>3.3</td>
<td></td>
</tr>
<tr>
<td>P51</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.32</td>
</tr>
<tr>
<td>SR (dB)</td>
<td>64.4</td>
<td>84.7</td>
<td>89.1</td>
<td>75.7</td>
<td>81.5</td>
<td>78.8</td>
<td>63.0</td>
<td>78.6</td>
<td>76.3</td>
<td>0.56</td>
</tr>
<tr>
<td>SAC</td>
<td>0.46</td>
<td>0.32</td>
<td>0.00</td>
<td>0.15</td>
<td>0.16</td>
<td>0.34</td>
<td>0.27</td>
<td>0.45</td>
<td>0.23</td>
<td></td>
</tr>
<tr>
<td>TL (dB)</td>
<td>5.4</td>
<td>3.3</td>
<td>0.0</td>
<td>1.4</td>
<td>1.5</td>
<td>3.6</td>
<td>2.7</td>
<td>5.2</td>
<td>2.3</td>
<td></td>
</tr>
</tbody>
</table>

*ER = Empty reading, SR = Sample reading, SAC = Sound absorption coefficient, TL = Transmission loss, NRC = Noise reduction coefficient

Table 3 and figure 3 suggests that low transmission loss and hence low sound absorption coefficient was observed for the single layer nonwoven samples. More noise was able to pass through the sample which is disadvantageous since more noise will escape from the hall, causing disturbance to the adjacent halls. Though samples P3 and P4 are shows better acoustic behavior in the frequency range of 1000 Hz to 3000 Hz, than other samples. This is because of the higher areal density of the fabrics leading to loss of permeability compared to other fabrics.
Table 4: Acoustic behavior of double layer nonwoven composites

<table>
<thead>
<tr>
<th>Frequency (kHz)</th>
<th>0.1</th>
<th>0.25</th>
<th>0.5</th>
<th>1.0</th>
<th>1.5</th>
<th>2.0</th>
<th>2.5</th>
<th>3.0</th>
<th>3.5</th>
<th>NRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>ER (dB)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P12 SR (dB)</td>
<td>68.6</td>
<td>85.3</td>
<td>88.9</td>
<td>75.4</td>
<td>79.7</td>
<td>78.4</td>
<td>61.4</td>
<td>82.4</td>
<td>78.0</td>
<td>0.21</td>
</tr>
<tr>
<td>SAC</td>
<td>0.13</td>
<td>0.27</td>
<td>0.02</td>
<td>0.18</td>
<td>0.32</td>
<td>0.37</td>
<td>0.39</td>
<td>0.15</td>
<td>0.07</td>
<td></td>
</tr>
<tr>
<td>TL (dB)</td>
<td>1.2</td>
<td>2.7</td>
<td>0.2</td>
<td>1.7</td>
<td>3.3</td>
<td>4.0</td>
<td>4.3</td>
<td>1.4</td>
<td>0.6</td>
<td></td>
</tr>
<tr>
<td>P22 SR (dB)</td>
<td>64.2</td>
<td>83.6</td>
<td>89.1</td>
<td>74.7</td>
<td>78.1</td>
<td>74.4</td>
<td>61.1</td>
<td>74.1</td>
<td>72.9</td>
<td>0.31</td>
</tr>
<tr>
<td>SAC</td>
<td>0.48</td>
<td>0.40</td>
<td>0.00</td>
<td>0.24</td>
<td>0.43</td>
<td>0.60</td>
<td>0.41</td>
<td>0.67</td>
<td>0.48</td>
<td></td>
</tr>
<tr>
<td>TL (dB)</td>
<td>5.6</td>
<td>4.4</td>
<td>0.0</td>
<td>2.4</td>
<td>4.9</td>
<td>8.0</td>
<td>4.6</td>
<td>9.7</td>
<td>5.7</td>
<td></td>
</tr>
<tr>
<td>P32 SR (dB)</td>
<td>63.7</td>
<td>84.5</td>
<td>88.9</td>
<td>73.7</td>
<td>79.0</td>
<td>75.7</td>
<td>63.2</td>
<td>76.9</td>
<td>75.7</td>
<td>0.30</td>
</tr>
<tr>
<td>SAC</td>
<td>0.50</td>
<td>0.33</td>
<td>0.02</td>
<td>0.32</td>
<td>0.37</td>
<td>0.54</td>
<td>0.25</td>
<td>0.55</td>
<td>0.28</td>
<td></td>
</tr>
<tr>
<td>TL (dB)</td>
<td>6.1</td>
<td>3.5</td>
<td>0.2</td>
<td>3.4</td>
<td>4.0</td>
<td>6.7</td>
<td>2.5</td>
<td>6.9</td>
<td>2.9</td>
<td></td>
</tr>
<tr>
<td>P42 SR (dB)</td>
<td>62.1</td>
<td>79.9</td>
<td>88.8</td>
<td>70.3</td>
<td>74.6</td>
<td>70.3</td>
<td>58.3</td>
<td>72.3</td>
<td>70.6</td>
<td>0.48</td>
</tr>
<tr>
<td>SAC</td>
<td>0.59</td>
<td>0.61</td>
<td>0.03</td>
<td>0.54</td>
<td>0.62</td>
<td>0.75</td>
<td>0.57</td>
<td>0.73</td>
<td>0.60</td>
<td></td>
</tr>
<tr>
<td>TL (dB)</td>
<td>7.7</td>
<td>8.1</td>
<td>0.3</td>
<td>6.8</td>
<td>8.4</td>
<td>12.1</td>
<td>7.4</td>
<td>11.5</td>
<td>8.0</td>
<td></td>
</tr>
<tr>
<td>P52 SR (dB)</td>
<td>63.4</td>
<td>81.0</td>
<td>89.0</td>
<td>74.5</td>
<td>80.3</td>
<td>76.5</td>
<td>61.5</td>
<td>76.3</td>
<td>76.1</td>
<td>0.33</td>
</tr>
<tr>
<td>SAC</td>
<td>0.52</td>
<td>0.55</td>
<td>0.01</td>
<td>0.26</td>
<td>0.27</td>
<td>0.49</td>
<td>0.38</td>
<td>0.58</td>
<td>0.25</td>
<td></td>
</tr>
<tr>
<td>TL (dB)</td>
<td>6.4</td>
<td>7.0</td>
<td>0.1</td>
<td>2.6</td>
<td>2.7</td>
<td>5.9</td>
<td>4.2</td>
<td>7.5</td>
<td>2.5</td>
<td></td>
</tr>
</tbody>
</table>

*ER = Empty reading, SR = Sample reading, SAC = Sound absorption coefficient, TL = Transmission loss, NRC = Noise reduction coefficient

Table 4 and figure 4 advocates that fair transmission loss and sound absorption coefficient was observed for the double layer nonwoven composite samples. Compared to single layer fabrics, less noise is able to leak through the samples, which is one of the requirements for a sound proof auditorium. This will lead to less disturbances in the adjacent and nearby halls and rooms. Samples P42 behaves excellently at all frequencies, showing absorption coefficient above 0.5. Combination of two layers has increased the areal and volumetric density of the fabric leading to less air permeable fabrics. This also suggests that there is a significant improvement in the acoustic behavior of double layer composite nonwovens compared to single layer nonwovens.

Figure 4: Acoustic behavior of double layer nonwoven composites
Table 5: Acoustic behavior of triple layer nonwoven composites

<table>
<thead>
<tr>
<th>Frequency (kHz)</th>
<th>0.1</th>
<th>0.25</th>
<th>0.5</th>
<th>1.0</th>
<th>1.5</th>
<th>2.0</th>
<th>2.5</th>
<th>3.0</th>
<th>3.5</th>
<th>NRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>ER (dB)</td>
<td>69.8</td>
<td>88.0</td>
<td>89.1</td>
<td>77.1</td>
<td>83.0</td>
<td>82.4</td>
<td>65.7</td>
<td>83.8</td>
<td>78.6</td>
<td></td>
</tr>
<tr>
<td>P12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>0.24</td>
</tr>
<tr>
<td>SR (dB)</td>
<td>64.9</td>
<td>84.7</td>
<td>89.1</td>
<td>75.3</td>
<td>81.1</td>
<td>77.5</td>
<td>61.3</td>
<td>77.6</td>
<td>77.1</td>
<td></td>
</tr>
<tr>
<td>SAC</td>
<td>0.43</td>
<td>0.32</td>
<td>0.00</td>
<td>0.19</td>
<td>0.20</td>
<td>0.43</td>
<td>0.40</td>
<td>0.51</td>
<td>0.16</td>
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</tr>
<tr>
<td>TL (dB)</td>
<td>4.9</td>
<td>3.3</td>
<td>0.0</td>
<td>1.8</td>
<td>1.9</td>
<td>4.9</td>
<td>4.4</td>
<td>6.2</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>P22</td>
<td></td>
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*ER = Empty reading, SR = Sample reading, SAC = Sound absorption coefficient, TL = Transmission loss, NRC = Noise reduction coefficient

Table 5 and figure 5 indicates that an average value of transmission loss and sound absorption coefficient was observed for the triple layer nonwoven composite samples. But compared to double layer nonwoven composites, it can be seen that there is no significant improvement in the acoustic behavior of triple layer nonwoven composites. This is because, the maximum attenuation of the sound energy takes place till the second layer, and hence the addition of the third layer does not significantly reduce the sound energy. Hence addition of the third layer to the nonwoven composite is not a cost effective option. Again, samples P32, P42 and P52 behave better than other samples almost at all frequencies.

The below given figure 6 shows comparative data of the P4 sample, which shows good acoustic behavior at all frequencies for single, double and triple layer nonwoven composites. It can be clearly seen that the sample P42 behaves very well compared to the samples P41 and P43.
4. Conclusions

Nonwoven fabrics of polyester were used for making the nonwoven composite by stitch bonding of two and three layers. The nonwoven composite developed in this study were tested for sound absorption and transmission loss as per the ISO 10534-2 and ASTM 2611 respectively. The results showed that the developed nonwoven composite is at par with the existing materials available for acoustics specifically in the range of 1000 Hz to 3500 Hz. The double layer nonwoven composites is the most efficient option for effective sound attenuation and damping. The developed nonwoven composite provide combination of both sound absorptive as well as sound reflective properties along with the added advantage of reduced thickness. The nonwoven composite also proves to be a one-stop solution for most of the acoustic applications.

References

[7] ASTM E 1050: Standard test method for impedance and absorption of acoustical materials using a tube, two microphones and a digital frequency analysis system
In view of increasing cost due to various factors it is very necessary to reduce cost without compromising Product Quality. Similarly, it is also expected by customers to have new features in every new product.

Hence, we need to have brainstorming to convert our Leaner Economy system to Circular Economy.

Please find some basic information for your perusal.

“A circular economy is an Industrial system that is restorative or regenerative by intention and design. It replaces the end-of-life concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse and return to the biosphere, it aims for the elimination of waste through the superior design of materials, products, systems, and business models.

A circular economy is a systemic approach to economic development designed to benefit businesses, society, and the environment. In contrast to the ‘take-make-waste’ linear model, a circular economy is regenerative by design and aims to gradually decouple growth from the consumption of finite resources.

The Principles of Circular Economy

In a circular economy, manufacturers design products to be reusable. For example, electrical devices are designed in such a way that they are easier to repair. Products and raw materials are also reused as much as possible. For example: by recycling plastic into pellets for making new plastic products.

The circular economy keeps resources — such as products, materials, and energy - in the economic system for as long as possible and at the “highest value” possible. Products gain value as they’re manufactured, through the input of materials, labour and energy.

A circular economy is fundamentally different from a linear economy. To put it simply, in a linear economy we mine raw materials that we process into a product that is thrown away after use. In a circular economy, we close the cycles of all these raw materials.

It is estimated that a circular economy path adopted by India could bring in annual benefits of 40 lakh crores or approximately US$ 624 billion in 2050. The greenhouse emission would reduce by 44%. The recent agreement of Adani Group has with French Total Energy group to convert 25% into green energy.

Read more at:

A sustainable circular economy involves designing and promoting products that last and can be reused, repaired and remanufactured. This retains the functional value of products, rather than just recovering the energy or materials they contain and continuously making products.
Principles of a circular economy

“It sounds complicated, but the Circular Economy is really based on three simple principles: Designing out Waste and Pollution, Keeping Products and Materials in Use, and Regenerating natural systems.” While zero waste focuses on keeping waste out of the environment, a circular economy goes one step further by striving to regenerate the environment.

The 5 Common Obstacles in Implementing Circular Economy:
1. The horror of disrupting consumer's convenience
2. Local regulations versus the circular economy concept
3. Lack of infrastructure for waste treatment
4. Lack of recycling technology
5. Poor business model plans

Business Model Concept

What We Can Do to Overcome the Circular Economy

Let's not get the priorities mixed together. In order for the circular economy implementation to succeed you need to make sure that:

1. The people are ready to accept the change. We need not compromise on quality in this process.
2. The government regulations are ready to monitor the change.
3. The waste treatment facility is ready to support the change.
4. The waste recycling facility is ready to execute the change. There will be opportunity to have new business for recycling waste.
5. The business model is ready to maintain the change sustainably.

Now imagine that each of us tries to build an environmentally-friendly business from scratch, what would happen?

Here's what possibly will happen: we will need more time to reduce the number of unhandled wastes. The waste will continue to pile up in the landfill and our sea, all waiting for us to be fully able to reduce the number of wastes we generate.

Collaboration

The key to accelerating change is by collaborating with other stakeholders. Better materials, a source of renewable energy, better connection to spread awareness, or are you looking for a great Extended Producer Responsibility, waste management program? Great collaborations could help you to be a step closer to the circular economy.

Economic Benefits of the Circular Economy

When compared with the raw material extraction that's common on the linear approach, the circular economy model has the potential to lead to a bigger amount of material savings. Considering that the total demand for materials will increase due to the growth of the world population.

A circular economy leads to lower material needs, as it skips landfills and, focusing on making materials’ cycles last longer. On the environmental side, it also avoids bigger pollution that extracting new materials would represent.

Employment Growth – Economic Benefits Of The Circular Economy

According to the ‘world economic forum’, the development of a circular economy model, together with a new regulation (including taxation) and organization of the labour markets, can bring greater local employment in entry-level and semi-skilled jobs.

New Profit Opportunities – Benefits Of The Circular Economy On Businesses

Lower input costs and in some cases create entirely new profit streams that can be achieved by businesses that move to the circular economy model.

It is now time to take advantage of changing scenario of eco-friendly & qualitative products with affordable cost to costumers.

Circular Economy in Textile Industry

A circular economy for textiles, fashion, and apparel is important because it aims to eliminate waste in the textiles industry, championing resource reuse, bringing clear benefits for natural resources, economic wellbeing, and the health and safety of the people who produce and dispose of our textiles.

How many times a day do you slip into textiles? How many time use wardrobe and clothing, towels, blankets, even car seat. It is difficult to imagine a world without textiles - they are a fundamental element in everyday life and a very important sector of the global economy.

Applying CE Principles to the Textile and Fashion Industries

The current system for producing, distributing and using clothes moves in a linear way. Tons of non-renewable resources are selected to produce apparel that will most likely be used for a limited period of time. Think about that $5 t-shirt you bought for a last-minute event or emergency that you threw away after only a couple of months. This kind of system not only leaves economic opportunities unused, but it puts great pressure on the resources themselves, creating multiple negative impacts.

What is trending in textile industry?

The global textile industry is changing to meet the needs of the new market. With new trends in technology, non-woven materials, domestic sales, green textiles and environmental sustainability, textiles will no longer just be clothing anymore. These new trends have started to increase growth in the market as well.

In short in every industry, we need to change from linear to circular manufacturing systems for survival. We need to tap resources & suitable consultants to assist you.
Is your Textile Manufacturing Capacity Optimally Utilized?

By Sanjeev Pandey,
Capximize India

Are the textile manufacturers and fabric manufacturers in India utilizing their manufacturing capacities optimally? Are they able to cover the cost of capital expenditure in their textile manufacturing units for better profitability? Therefore, how can these textile and cloth manufacturing companies in India utilize their manufacturing capacities optimally? Is outsourcing textile manufacturing the answer?

Cost of capacity
Every manufacturing unit, irrespective of the sector, will incur a cost of capacity on setting up its manufacturing plant and machinery. As a result, this makes optimal utilization of manufacturing capacities indispensable and textile industry is no exception to this. Before we delve into more details, it is important to know what is meant by cost of capacity.

What is Cost of Capacity?
Cost of Capacity is the cost incurred by a manufacturing unit for its continuing business operations and also for future expansion in its operations. Generally, capacity costs are fixed in nature and do not change even with varying levels of output. Some examples of the cost of capacity are insurance, depreciation on equipment, maintenance and repair, rent payments, property taxes, etc.

This cost remains the same even when there is underutilization of available manufacturing capacities. Hence, if you are a textile or fabric manufacturer having underutilized manufacturing capacities, you can prevent these costs from affecting your business profitability by leveraging your surplus capacities into a profitable opportunity. Any Indian manufacturer can achieve this by outsourcing surplus capacities to other textile companies seeking to set up manufacturing facilities.

How can you utilize your textile manufacturing capacity optimally?
There are several ways by which you can utilize your textile manufacturing capacity optimally by outsourcing and white-label or private label manufacturing top the list.

Outsourcing manufacturing capacity
Outsourcing of manufacturing capacities simply means allocating them to external manufacturers. These external manufacturers may not have the necessary capital or infrastructure but are looking to either expand their operations or outsource parts of their production operations. There is a great demand for outsourcing in the textile industry specially, as textile goods have a short life cycle. In spite of that there is a need to deliver goods on time at an affordable price and still earn profits. This necessitates outsourcing as part of its operations.

White label manufacturing
White label manufacturing involves manufacturing products for different retailers who sell these products with their own branding and logo. The textile company utilizing this service will benefit it reduces production cost significantly by saving time and cost.

Technology
Indian manufacturers looking to outsource their manufacturing capacities or looking to provide white-label manufacturing services need access to up-to-date and first-hand information from a reliable centralized platform. Similarly, Indian and global textile companies are looking to utilize outsourced manufacturing capacities also needs this information to find right manufacturing partner.

Technology platforms like Capximize is helps in online manufacturing by providing in-depth and broad-spectrum information about textile manufacturing companies in India. With its proprietary algorithm-based recommender system it helps its members to connect with global textile manufacturers looking for manufacturing capacities across India.

What Makes India An Attractive Manufacturing Destination for The Global Textiles Manufacturers?

• Variety
India’s textiles industry has the manufacturing capacity to produce a wide variety of products suitable not only for domestic but also for international markets. As per 2001 data, India has the second-largest yarn-spinning capacity in the world only behind China, accounting for roughly 20 percent of the world’s spindle capacity.

• Competitive advantage
India enjoys a competitive advantage in terms of availability of well-developed infrastructure in this sector. In addition it provides affordable and skilled labour, focus on research and development activities and strong manufacturing capabilities.

• Policies
The investment-friendly policies introduced by the Indian Government in the year 2020-21 has led to an increase in foreign direct investment, therefore attracting more global companies to set up their operations in India.

• Infrastructure
Advanced infrastructure and manufacturing capabilities in the textile hubs of India. Textile hubs include Tirupur, Madurai, Mumbai, Delhi, Amritsar, Ludhiana, Ahmedabad, Surat and Kanpur. These hubs are great attractions for global textile manufacturers looking to outsource their production operations. Tirupur textile industry has manufacturing capabilities for all aspects of knitwear, starting from spinning, knitting, wet processing, printing, garment manufacturing and exports.

Maharashtra, especially Mumbai, has the best infrastructure and the state has an installed capacity of 1.66 million spindles. This is equivalent to 17 per cent of the country’s capacity for cotton yarn production. Surat is the hub for synthetic textiles production and has a weaving capacity of 7,20,000 weaving machines. Ahmedabad has excellent manufacturing capabilities for cotton textiles, while Ludhiana has facilities for woolen and acrylic knitwear.

Hope this threw sufficient light on the optimal utilization of manufacturing capacities.

For more details, please reach to; Sanjeev.pandey@capximize.com
www.capximize.com
Interview with Mr. Mayank Tiwari

Mr. Mayank Tiwari is the Founder and CEO of ReshaMandi, India's first and largest digital ecosystem for natural fibre supply chain, starting from farm to retail; aimed at creating definitive fashion trends. In his present capacity, Mayank is responsible for leading effective teams, streamlining operations and strategy across the organisation, with the objective of enhancing market share and driving sustainable growth.

Mr. Mayank has 13 years of cross-domain experience across user experience, retail, e-commerce, and lean manufacturing to drive continuous business improvement and help exceed the revenue and profitability objectives. Utilising his experience and expertise, Mr. Mayank aims to help rural India by providing sustainable livelihood, financial inclusion, and making them rural super consumers via ReshaMandi. This is aligned with his vision to build India as the natural fibre powerhouse that would streamline the apparel and textile industry and empower stakeholders in the ecosystem.

He is a gold medalist from the prestigious NIFT (Batch of 2007) with a specialisation in apparel technology. Beyond his corporate life, Mr. Mayank takes a keen interest in travelling, poetry, singing, and reading books in his leisure time.

Mayank has featured in the Fortune India 40 under 40 lists of 2022.

Speaking with Publisher & Correspondent of JTA – Mr. J. B. Soma, Mr. Mayank Tiwari tells us about his business development and innovation at ReshaMandi.

Q.: How's ReshaMandi changing the natural fibres space in India?
Ans.: The inspiration for ReshaMandi first occurred to me in early 2020 when I was wondering how I could help promote natural fibres. India is the world's second-largest producer of silk, second only to China and even though silk is in short supply in India, demand exceeds supply. The current gap between supply and demand is being filled by imports, indicating both challenges and vast potential for improvement in the sector.

Today, ReshaMandi is India's first and largest farm-to-fashion digital ecosystem for the natural fibres supply chain. The concept of ReshaMandi is unique and has never been tried before. Therefore, this is an industry-first initiative and a disruptor in the sector.

The natural fibre industry as an entity in itself provides livelihood to numerous farmers, artisans and weavers. Issues such as lack of standardization, poor database management and a diverse range of practices leading to fluctuations in production and quality are still plaguing the segment. For our stakeholders, we offer insights across the value chain. These include weather and soil quality updates and how they could impact cocoons, market linkages of input procurement (cocoons) and selling output (yarns), maintaining ledgers, information on best practices, purchasing machine tools, etc. Our application, ReshaMandi, is a 360-degree solution that engages all stakeholders in the natural fibres industry such as farmers, weavers, reelers and retailers, enabling them to buy raw material or sell their produce directly and with full transparency. We also have a huge network of Procurement Centres around the country where farmers can get in touch with our representatives, either through a phone call or by physically visiting the centre with a prior appointment.

At ReshaMandi, we are determined to standardize the industry starting from the grassroots level, i.e., the farmers, reeler, weavers, retailers and, finally, the consumers. Farmers have the option to pick up inputs directly or order through the app with the representative's help. We have the flexibility to book an appointment with them to collect the cocoons from the farmer's house to avoid a long journey to the mandis. For ease of usage, the application is available in various regional languages to give farmers access to an online marketplace where input products required for rearing silkworms and mulberry plantations are available. We also enable the logistics aspect of the supply chain and reduce the burden on the farmer, helping with trust-building in the process. Subsequently, it also allows weavers, reelers and retailers to place an order on the application for procuring cocoons or yarns.

We are focused on sustainability and reduction of wastage in the supply chain where by-products from the farmlands and reeling units can be reused in pharmaceutical, packaging and other industries. We aim to enable the ecosystem so that it will elevate, empower and build India into an Atmanirbhar powerhouse.

Q.: How do you promote sustainability at ReshaMandi/ across the textile value chain?
Ans.: Our Company has only been around for two years and we have been advocating sustainable fashion from the beginning of our journey. Earlier, waste generated during the various stages of silk production was being discarded by farmers (mulberry twigs) and reelers (dead pupae). This waste contained Sericin a silk protein that is used in various industries such as FMCG, pharmaceuticals, packaging, etc. Today, we work closely with farmers and reelers to reutilize silk waste and waste cocoons (waste generated at reeling units and farmlands respectively). In line with our Sustainability goals, we recently invested in Bangalore-based skincare brand Healios Wound Solutions, which is a natural fibre disruptor and manufactures or formulates skin care products utilizing silk protein Sericin as the base ingredient. Sericin has unique antioxidants, anti-ageing, moisture
retention and de-pigmentation properties that are ideal for effective skincare. Also, pupae (waste generated at reeling units) can be used in fish feeding and poultry feeding. We are working towards educating the farmers to utilize the farmland's waste in other industries as well.

On the industry front, the government is already taking steps to ensure that reebers utilize power-driven reeling equipment rather than crude methods that waste a lot of firewood, coal and hot water. They are making it easier for reebers by offering big discounts on these machines.

There are recycling systems in place to ensure that the water table is not depleted. The Internet of Things (IoT) technology aids farmers in controlling water usage for mulberry plantations by advising them about the soil conditions so that plants are not over or under-watered. There is a soil moisture sensor buried underground, which relays data to the cloud, where intelligent algorithms identify primary and secondary soil moisture as well as other relevant parameters. This information is then used to advise farmers on irrigation schedules.

Q.: What are the initiatives ReshaMandi is taking to ensure stability and transparency in the traditional weaving industry?
Ans.: The textile industry is highly unorganized with many problems, including price fluctuations, the absence of proper markets and logistics, no definitive advisory, minimal quality testing and no transparency in the processes. Therefore, ReshaMandi works as a grassroots-level technology enabler, digitizing the entire supply chain, working directly with farmers (60,000+), fabric weavers (10,000+), reebers (6,600) and retailers (4,400+), enabling them to procure the best quality products at a fair price, reducing the time to market and making sure they are supplied with the best raw materials. We aim to eliminate uncertainties by presenting a transparent process across the entire value chain. With our growing network, we are facilitating a smooth procurement of natural fibres for reebers, which in turn help weavers to acquire quality assured yarns, thereby providing market linkages at every stage of the process. We also offer weavers the option of buying back their produce (fabrics or finished products). The transparency guaranteed under this process allows for fair pricing and better output, due to which farmers, reebers and weavers have increased their earnings.

Q.: In which states ReshaMandi is working?
Ans.: We run 20 to 25 Mandis (big markets) across Karnataka, Tamil Nadu, Andhra Pradesh and Maharashtra. We are present in four weaving clusters in some of India's silk capitals – Varanasi, Dharmavaram, Salem and Kanchipuram, with offices in all four regions.

Q.: What is the role of the ReshaMandi Super app?
Ans.: The ReshaMandi Super app connects different stakeholders across the supply chain. The platform is a single-stop solution providing linkages across verticals as well as integrations with fintech partners and marketplaces. Through mobile app, IoT devices and tech-enabled grading systems, we are enabling farmers to increase production, lower wastage, improve quality and get access to better pricing. ReshaMandi's technology intervention and people-first approach have helped farmers to improve their productivity by 20% and boosted incomes by nearly 30% enabling them to afford better quality raw materials, higher quality labour, fertilizers and other essential inputs, which in turn are pushing yields even higher. With the help of AI and IoT technologies, the farmers who were struggling with six crops are now producing 18 crops a year by crop rotation. The engagement that the app has witnessed in the last two years is immense. Today we have almost 100% app adoption among the farmer community that works with us regularly.

Q.: What is your strategy for expansion?
Ans.: We have ventured into global markets, intending to become a one-stop sourcing solution for all natural and recycled fabrics. We are entering various countries, including the Middle East, Europe, North and South America and South East Asia to replicate our successful Indian model and to take India's natural fibres to the world.

Q.: Do you have any new products in the line that is to be launched in the near future?
Ans.: We have launched ReshaMandi's Fintech arm, ReshaMudra, which will offer personalized credit solutions to the stakeholders of the textiles industry. ReshaMudra will give business partners across the ecosystem access to working capital solutions as well as long-term loans, enabling them to secure crucial funding to help grow their businesses or tide over challenging times.

ReshaWeaves e-commerce platform, a consumer division of ReshaMandi, aims at offering responsibly sourced natural fibre products that are exclusive and sustainable. Each product is a curated effort of our farmers, whose cocoons are utilized to derive the yarn, which is then used to create the fabric and our weavers, whose designs create one-of-a-kind masterpieces. ReshaWeaves connects all stakeholders of the natural fibres supply chain whilst empowering them. We also plan to become a one-stop natural and recycled fibres sourcing platform globally.

Q.: What will be the export opportunities for MSME's textile & apparel sector?
Ans.: The Indian textile and apparel industry is highly diversified with a wide range of segments ranging from products of traditional handloom, handicrafts, wool and silk products. India is the sixth-largest exporter of textiles and apparel and the textile industry contributes around 4% of the country's GDP. The market for textiles is presently valued at US$138 billion and is expected to grow to US$195 billion by 2025. There is tremendous potential for MSMEs in the textile segment because of the rising demand for apparel and textiles.

Q.: What are your views on technology gaps and how to attract foreign technology into India through R&D & other activities?
Ans.: Textile is a look and feels sector, digital adoption is expected to be slower. It is horizontally spread, which means
the cost of using sophisticated AI-based systems is relatively much higher. Open source availability of learning datasets for use by various ML algorithms can solve one of the biggest issues for digital adoption. If we take our example, the initial days were difficult because we had to convince stakeholders about our platform and the value we bring to them. We are attempting to mitigate this problem by educating them on the most recent technological solutions, such as Artificial Intelligence and Machine Learning. Our technological interventions have revolutionised the natural fibre supply chain since its inception, helping to regulate this unorganised segment.

We have managed to reduce crop failure risk by 80% by using AI-enabled crop tracking and providing IoT-led advisories directly to app users, providing the stakeholders with increased production capacity and, ultimately, higher revenue. The quality of the cocoons has greatly improved, and as a result, the farmer's rates have increased by more than 35%. Since the launch of the app in 2020, the app has witnessed growing engagement from farmers, reellers, weavers, and retailers. The engagement seen on the app in terms of procurement and sourcing is immense. We have done around 570 mega tonnes of transactions of cocoons since the time we started. 4 mega tonnes of yarns and about 1 mega tonne of raw cotton have been purchased using the app.

Q.: What are your views on the increase in GST on textiles and apparel products?
Ans.: The Central Board of Indirect Taxes and Customs proposed a 7% increase in GST to address the issue of inverted duty structures, which affect only a small portion of the textile value chain. However, there are both advantages and disadvantages to this imposition. The proposed move will have an impact on the cotton value chain in the textile industry and put a strain on manufacturers' working capital needs, particularly micro, small, and medium enterprises. Fluctuating prices force the industry to reduce capacity in the hope of achieving long-term stability.

A wholesome benefit from the introduction of GST would be:

a) Break in input credit chain: A significant portion of the textile industry in India operates under the unorganised sector or composition scheme, thereby creating a gap in the flow of input tax credit (ITC). GST would enable a smoother input credit system, shifting the balance towards the organized sector.

b) Reduction in manufacturing costs: GST is also likely to subsume the various fringe taxes such as octroi, entry tax, luxury tax, etc. which will help reduce costs for manufacturers.

c) ITC allowed on capital goods: Currently, the import cost of procuring the latest technology for manufacturing textile goods is expensive as the excise duty paid is not allowed as ITC. Whereas under GST, ITC will be available for the tax paid on capital goods.

d) Export of textile products to get a boost: GST would streamline the process of claiming ITC, allowing the textile industry to be more competitive in the export market.

e) Opportunity for long-term growth: This will help the industry in the long run by getting more registered taxpayers under a well-regulated system. GST could also help the textile industry become more competitive in global and domestic markets, creating opportunities for sustainable, long-term growth.

Q.: How the increased prices of cotton and yarn will affect the textile value chain?
Ans.: Lately, with cotton prices breaching the Rs.100,000 per candy mark, the entire textile value chain, including the smaller and bigger players are facing a challenge. There is a limitation on the production and companies are finding it difficult to match retail rates in proportion to high cotton prices. Procurement of cotton from spinning mills has gone down by 50% in the last quarter. The industry is currently waiting for the new harvest anticipating it will cool down prices. If we work on the pointers given above, we should be able to create some relief for the textile industry.

Q.: How the increased prices on Cotton and Yarn will be affected on the Textile Value chain?
Ans.: Lately, with cotton prices breaching the Rs.100,000 per candy mark, the entire textile value chain, including the smaller and bigger players are facing a challenge. There is a limitation on the production and companies are finding it difficult to match retail rates in proportion to high cotton prices. Procurement of cotton from spinning mills has gone down by 50% in the last quarter. The industry is currently waiting for the new harvest anticipating it will cool down prices. If we work on the pointers given above, we should be able to create some relief for the textile industry.
TAI M.P. Unit

New Office Bearers elected of TAI M.P. Unit

The Textile Association (India) – M.P. Unit conducted their Annual General Body Meeting on 22/9/2022 at 5.30 pm in a hybrid mode (online and offline).

After completing the meeting Agenda points, elections for the New Office Bearers for the vacant posts was conducted. The process of election was smoothly conducted and the following Office Bearers were elected for the term 2021-2023.

**New Office Bearers elected of TAI M.P. Unit**

- **Mr. R. P. Gautam**
  - President

- **Prof. Rajiv Gupta**
  - Chairman

- **Ms. Seema Mishra**
  - Hon. Secretary

- **Dr. Amrita S. Rajput**
  - Hon. Treasurer

**Other Office Bearers**

- Ms. Preity Sarva
  - Vice President

- Mr. Deepak Bhandari
  - Vice Chairman

- Ms. Sakshi Gupta
  - Hon. Jt. Secretary

- Mr. Vijay Muvel
  - Hon. Jt. Secretary

**Governing Council Members**

- Mr. N. S. Nirban
- Mr. Kailash Agarwal
- Mr. Ved Prakash Gupta
- Ms. Seema Mishra

**Trustees**

- Dr. Prabhu Narayan Mishra
- Mr. Virendra Kumar Porwal
- Mr. Ramesh Chandra Gupta

TAIMU Student Chapter

Office Bearer's felicitation of TAIMU Student Chapter and seminar on ERP - SAP

TAIMU student chapter and DKTE- TEI jointly organised program on August 19, 2022. Newly elected TAIMU student chapter office bearers elected for the academic year 2022-23 were felicitated at the hands of dignitaries and wished them for future endeavors.

TAIMU (The Textile Association (India) Ichalkaranji – Miraj Unit) has been sanctioned an amount of One Lakh rupees by the AICTE NEW Delhi (All India Council for Technical Education) under the SPICES scheme (Scheme for Promoting Interests, Creativity and Ethics among Students) for organising various activities to enhance students' skills. This fund was will be utilized for conducting different events throughout the year. Textile Dept. HoD, Prof. (Dr.) U. j. Patil and Coordinator Prof. R. H. Deshpande submitted the proposal and strived hard for the sanction.

Seminar was organised on Application of ERP-SAP into Textile industry. The eminent speaker Mr. Kamlesh Raje alumnus of the Institute passed out in 1994-95 from B. Tech. Man Made Textile Technology and currently working as a trainer in the...
It is pleasure to inform you that the 83Rd Annual General Body Meeting of The Textile Association (India) held on 16TH September, 2022 at 04.15 pm at The Textile Association (India) – Mumbai Unit Hall, 602, 6TH Floor, Santosh Apartment, Dr. M. B. Raut Road, Shivaji Park, Mumbai – 400 028.

Mr. R. K. Vij, President of The Textile Association (India) presided over the meeting. 26 members were attended the 83RD Annual General Body meetings from various TAI Units.

Mr. Mahendrabhai G. Patel, Hon. Gen. Secretary and Mr. D. I. Patel, Trustee of TAI came from Ahmedabad to attend the AGM. Also Dr. P. A. Khatwani, President of TAI-South Gujarat Unit attended the above AGM.

Mr. Mahendrabhai G. Patel, Hon. Gen. Secretary briefed the financial status of the Association and also gave brief report of the accounts & audited balance sheet for the year ending 31ST March, 2022. He further highlighted the details of various heads under Income & Expenditure Account and Audited Balance Sheet of the financial year 2021-2022.
International Conference on “Digitalization – A Step towards Textile 4.0”

Digitalization Conference gets an overwhelming response from industry

The Textile Association (India), Mumbai Unit organized Annual Conference on “Digitalization – A Step towards Textile 4.0” on Friday, 14th October 2022 at Hotel The Lalit, Mumbai. The Conference received overwhelming response as over 300 delegates attended the Conference. The theme of Conference, topics, presentations and speakers were highly appreciated. This was the first Conference on Digitalization in Textile industry in India.

Mr. Rajiv Ranjan, President, TAI, Mumbai Unit welcomed the Chief Guest, Ms. Roop Rashi, Textile Commissioner, Ministry of Textiles, Government of India, Guest of Honour Mr. Rajesh Kumar Pathak, Secretary, Technology & development, Government of India (present virtually), Mr. Prashant Agarwal, Wazir Advisors, Awardees, Speakers, Press, Media and delegates. Mr. Ranjan welcomed and congratulated two awardees Mr. Yogesh K. Kusumgar for The Lifetime Achievement Award and Mr. Anil Kumar Jain for The Industrial Excellence Award. Mr. Ranjan said that all the conferences organized by TAI, Mumbai Unit have always selected contemporary & innovative topics presented by high profile speakers. This conference is also no exception to this.

Mr. V. C. Gupte, Chairman, TAI, Mumbai Unit and Convener of the Conference briefed about two previous conferences on Textile 4.0 held in 2018 and 2019. The main objective of those Conferences was to familiarize the textile fraternity on what is Textile 4.0 and what impact it would have on the textile industry. Textile 4.0 is basically an extension of Industry 4.0 as applicable to textiles & apparel industries. He also described what Smart Factory is. The aim of extending the textile industry to Textile 4.0 is to increase productivity, flexibility and efficiency through use of automation, robotics, artificial intelligence, Internet of Things etc. Textile 4.0 is already used in spinning, weaving and in garment or apparel industries. There are new norms and Digitization, Digitalization and Digital Transformation became the new buzz words. These three words also became part of advancement in textile industry, particularly in the apparel & garment sectors. It became obvious that the change is certain, but in what form and shape will it take for textile industry. How should textile & garment industry engage with the new trend, what future might hold for business and investment decision makers, what impact it would have throughout the textile value chain? And how digitization would help and benefit the textile industry in supply chain, timely deliveries and competitiveness. In this pursuit, The Textile Association (India), Mumbai Unit decided to hold this Conference with a view that the Textile fraternity gets closer to these new buzz words - Digitization, Digitalization and Digital Transformation. As a Convener of the Conference, he thanked all the speakers, sponsors, advertisers and delegates for their kind support to make this conference a great success.
Mr. G. V. Aras, The Conference Chairman, briefed about the details of the Conference, including topics and speakers. He said Digitalization and Industry 4.0 are the keys to process excellence - and thus the opportunity to save costs and resources. Through the possibilities of digitalization, manufacturers can strengthen their production, improve their competitiveness and react more quickly to changes. He further emphasized that for this to be successful, the textile value chain manufacturers and retailers will have to invest in digitization. The garment and retail supply chain has to larger extent adapted Digitalization which is helping them in becoming more efficient, cost competitive and respond fast to market needs. It is high time that the Indian textile companies also adapt Digitalization on priority and participate in the making of the Digital India, a dream project of our prime minister. He further said that now the digitalization is not a choice anymore but a necessity.

Mr. Prashant Agarwal, Jt. Managing Director, WAZIR Advisors Pvt. Ltd. in his Theme Presentation said that Industry 4.0 refers to the Fourth Industrial Revolution and describes the growing trends towards automation and data exchange in technology and processes within the manufacturing industry. He further said that a smart factory is a highly digitized and connected production facility that relies on machinery and equipment that are able to improve processes through automation and self-optimization. He said that manufacturing processes need to be digitalised to create an ecosystem of data which further can be used to fully implement the Industry 4.0 technologies. He showed the actual working of the smart factory in his presentation.

Mr. Rajesh Kumar Pathak, Secretary, Science & Technology Development Board, Govt. of India who was the Guest of Honour made his presentation online from New Delhi and said that Digitalization has very significant role in today’s industrial revolution and the industry should accept the challenge and diversify their activities towards the smart factories. He discussed various initiatives taken by Govt. of India in this direction.

Honouring the best in class:

Mr. Yogesh K. Kusumgar, Chairman, Kusumgar Corporates Pvt. Ltd. receiving The Lifetime Achievement Award by the hands of Chief Guest Ms. Roop Rashi

Mr. Anil Kumar Jain, Executive Chairman, Indo Count Industries Ltd. awarded The Industrial Excellence Award. This was received by Mr. K. K. Lalpuria on behalf of Mr. Jain by the hands of Chief Guest Ms. Roop Rashi

a) The Lifetime Achievement Award
The Textile Association (India), Mumbai Unit has set a precedent by felicitating the textile professionals for their outstanding contribution to the textile industry. In this Conference, the TAI, Mumbai Unit felicitated Mr. Yogesh K. Kusumgar, Chairman, Kusumgar Corporates Pvt. Ltd. for his pioneering work in the field of technical textiles with “The Life Time Achievement Award”.

b) The Industrial Excellence Award
TAI, Mumbai Unit also felicitated Mr. Anil Kumar Jain, Executive Chairman, Indo Count Industries Ltd. with “The Industrial Excellence Award” for his contribution in the field of man-made fibres. As Mr. Jain was unable to attend the conference Mr. K. K. Lalpuria, Executive Director, Indo Count Industries received the award on behalf of Mr. Jain.

Ms. Roop Rashi, Textile Commissioner, Govt. of India who was the Chief Guest addressed the delegates with her thoughts on Textile 4.0. She wondered why the Textile 4.0 is not extended beyond spinning and garment industries. She emphasized the Government of India has initiated many projects & plans and pushing for digitization in all industries. She appealed to the textile heads to adopt digitalization very fast to keep up with the pace of the international industry.

Knowledge and Informative technical sessions
Mr. Ram Sareen, Chairman & Founder, Tukatech, USA presented paper on “Welcome to the Future. It Arrived Yesterday”. He said that in the world of digital design and development, everyone in the supply chain needs to collaborate with real data. Designers can use these true-to-life digital resources to see how a garment will look and fit in virtual design software, then purchase the physical material from the mill knowing it is exactly what they need.

Mr. Sudhir Mehani, Chief Digitalization Officer, Marzoli India presented paper on “Digital Transformation – Step towards Smart Factory Operations”. He said to maximize overall equipment effectiveness (OEE) and minimize the total cost of ownership (TCO), there is a need to take steps towards maintenance of the machines and taking optimized production.
Mr. Ashish Sharma, Sr. Vice President (Sales & Marketing), Truetzchler India Pvt. Ltd. presented paper on “My Intelligent Mill – by Truetzchler”. He discussed about the concept of My Mill. The cloud-based mill monitoring system can be accessed over web frontend. Data is sent from the machines to the My Mill cloud via secure gateway. My Mill frontend can only be accessed by authenticated & authorized mill personnel.

Mr. Ricardo Vega Ayora, Project Engineer, ITA Academy GmbH, Digital Capability Centre, Germany presented his paper virtually on “Process Mining for a Sustainable and Efficient Textile Industry”. He said in a world with always greater concerns regarding climate change and increasing energy prices, every industrial company needs to increase resource efficiency, in particular reducing their respective carbon (product) footprint and energy consumption. The textile industry is no exception. This comes as no surprise given the amount of resources required to finish textiles by washing, coating and thermo-fixing processes.

Mr. Ronnie Hagin, Group CEO, Datatex AG, Switzerland presented paper on “Systems on the path to profitable sustainable textile manufacturing – Achieve business & sustainability objectives by applying available opportunities of systems, AI and Blockchain”. He said that systems have been available for the industry since the early 1980’s, difference to day is the availability of affordable technology to support big data and fast processing, allowing for fully seamless integrated business solutions. The availability of new technology also has increased the opportunities using AI and ML and also the newly introduces blockchain technology. AI will be used to optimize business results while improving customer service.

Mr. Surinder Pal Singh, Head of Customer Support and Asset Management, Forbes Marshall presented paper on “Digital as a Tool for Utilities Sustenance – Beyond Connectivity”. He said that Digitising the most important and relevant parameters enables continuous monitoring, advanced analysis and predictions. This helps plants improve and on their own with their internal teams. He further said Digital connectivity of devices enables monitoring on a continuous basis by subject matter experts who can use statical tools, their experience and knowledge to come up with optimum performance points. Digital, plays multiple roles of providing visibility (and triggering basic corrections), information on uptime of equipment (and possibly prediction of failure) and possibilities of improvement and sustenance.

Mr. Atul Vaidya, Managing Director, Oerlikon Textile India Pvt. Ltd. presented paper on “Smart Factory – Digitizing the Polyester Value Chain”. He said that current industry pains points and needs for digitalizing production information and processes. He discussed the Key challenges in digitalization of factory viz. Huge upfront investment from both money and people resources, Redesign production processes to unleash the potential, Mindset change, digital talents, and trainings and lack of industry standardization.

All Papers received very high response as well as interactions from the participants.

The Panel Discussion was moderated by Mr. Prashant Agarwal, Jt. Managing Director, Wazir Advisors Pvt. Ltd. The theme of the discussion was “Digitization: The New Era in Textile and Apparel Industry”. The Panel Members were Mr. Kapil Pathare, Director, VIP Clothing Ltd., Mr. Yashasvi Sahajpal, Leadership Team – Digital Initiative, Forbes Marshall, Mr. Raja Harbinder Singh, Head Global Sourcing-Westside, Trent Ltd and Mr. Bhavin Seth, President and CTO, ATE Enterprises Ltd.
Report of Business Growth - A CMR-Airtel Forum

Business Growth Forum 2022 organized the Panel Discussion to Brief on “Ensuring Sustainable Business Growth in the Post-Pandemic World” on 26th August, 2022 at 06.30 pm onwards followed by the Networking over Dinner at TAJ Skyline, Ahmedabad.

The Textile Association (India) Central Office were invited for Panel Discussion on “Ensuring Sustainable Business Growth in the Post-Pandemic World” Dr. V. D. Gotmare, Chairman, JTA Editorial Board was one of the Panelist in the above discussions.

Journal of The Textile Association was the Media Partner of the above forum. Mr. Mahendrabhai G. Patel, Hon. Gen. Secretary, TAI-Central Office was invited on behalf of Journal of The Textile Association and he received a Memento in the hands of Mr. Abhishek Sinha, Head, Airtel Business as a token.

Mr. Ashok Juneja receiving the Award

Textile Machinery Manufacturer's Association (TMMA) conducted its 62nd Annual General Meeting at hotel Trident, Mumbai. After the AGM Session, the Association presented the Export and R&D Awards for the year 2021-22.

Chief Guest of the function, Hon’ble Smt. Roop Rashi, Textile Commissioner of India, gave away the awards to all the winners.

Mr. Ashok Juneja, Director, Saurer Textile Solution Pvt. Ltd. Was awarded for the export of textile machinery during the period.

SRTEPC organizing SOURCE INDIA – 2022-23

The Synthetic & Rayon Textiles Export Promotion Council (SRTEPC), under the aegis of the Ministry of Commerce & Industry and Ministry of Textiles, Govt. of India, is organizing 7th Edition of “Source India – 2022-23” in Mumbai from 28th November to 30th November, 2022 at Hall No.3, Bombay Exhibition Centre, NESCO Centre, Western Express Highway, Goregaon (E), Mumbai.

It will be a Mega Reverse Buyers-Sellers Meet (RBSM), and invited buyers from around 30 countries. The 3-day Flagship Export Promotion Program of the Council.

India 2022-23” in Mumbai is an Event, where Indian suppliers of Man-made fiber textiles and MMF blended Textiles can showcase and demonstrate their latest range of products and meet foreign buyers right here in India. The Program offers a “tailor-made opportunity” to members to negotiate business deals with international buyers under one roof without expenses and hassles of traveling to foreign countries.

There will be about 100 participants and about 100 foreign buyers. Buyers from Saudi Arabia, Morocco, Kenya, Ethiopia, Egypt, Sudan, Nigeria, Iran, Korea, South Africa, Myanmar, Indonesia, Malaysia, Thailand, Peru, Colombia, USA, Brazil, Guatemala, Turkey, Poland, Germany, Bangladesh, Vietnam, Afghanistan, Uzbekistan etc. are participating.

For more details, please follow below links:
Website: http://www.srtepc.org/gallery/view/170484
Online Reply Form (https://forms.office.com/r/CzZLevtqt7)
Mr. B. Purushothama has been awarded with National Gold Medalist Padma Award by Bharat Rattan Publishing House, New Delhi. They choose men and women from India, who have exceptionally excelled in their chosen areas of activity. Their opted spheres include politics, social welfare, industry, commerce, law, education, cinema, architecture, engineering, medicine, drama and crooning.

The people identified need not be famous personalities, but have made remarkable contributions to the society. In the year 2022, Bharat Rattan Publishing House has identified 62 people, out of which Mr. B. Purushothama is one, who is an active member (Patron) of The Textile Association (India).

Mr. B. Purushothama, born in 1949 is an eminent Textile Technologist, Quality Management expert and Chartered Engineer having over 43 years’ experience in Textile and Garment industry. He guided number of Textile and Garment industries in India and abroad for implementing Quality Management System and has trained thousands of shop-floor technicians for implementing TQM and QMS.

He has guided hundreds of technicians for getting ATA and GMTA, hundreds of students for their project works in B Tech, M Tech, MBA, and MPhil etc. He has helped enhancement of textile education in India. He was a committee member for setting up syllabus for various universities for their courses, like Shivaji University, NMIMS University, YCMO University, and JOC of Karnataka.

Mr. Purushothama authored 32 Technical and Management books having International reputation, presented over 60 papers in various national and international seminars, written 45 books in Kannada on various subjects.

He was in the Advisory Subcommittee of Bombay Textile Research Association (BTRA), TX-30 committee of Bureau of Indian Standards (BIS), senior examiner for Tata Business Excellency Model and an examiner for ATA and GMTA examinations of the Textile Association (India) and for number of colleges and universities. Actively participating in the activities of The Textile Association (India) and served as Hon. Secretary and Chairman of Ichalkaranji-Miraj Unit, Hon Secretary of Karnataka Unit, Co-chairman of Book Publishing Committee and Syllabus committee member for ATA and GMTA examinations.

Mr. Purushothama has been honoured with various awards like TAI Ratna by the Textile Association (India), Bharat Gaurav Award, Bharat Ratna APJ Abdul Kalam Excellence Award, Bharat Ratna Atal Bihari Vajpayee Excellence Award, Best Citizens of India Award and Pride of India Award, Glory of India Gold Medal etc.

Sarees and Fabrics predicted to rule the festive

“Sarees in rich and opulent hues & fabrics predicted to rule the festive and fall season”, predicts ReshaMandi in latest trend forecast report

Season is to be marked by lavish and upbeat tones that offer a sense of luxury and hope in the face of adversity.

The largest farm-to-fashion digital ecosystem for natural fibres in India, ReshaMandi, has identified the major trends that will influence consumer-buying behavior this festive season. The company recently introduced its trend forecast report, a first for the industry, that deep-dives into trends that will impact the industry for the next six months to a year. According to the most recent report for the upcoming festive and fall seasons, sales of sarees, a staple Indian ethnic wear and a crucial part of festival attire, are anticipated to increase. This is significant as particularly in the last two years consumers were keeping their celebrations very limited or casual due to the pandemic.

The season will be marked by rich, upbeat tones that offer comfort and luxury in the midst of challenges. Ten main colours are expected to dominate the colour scheme for the festive and winter seasons, namely classic blue, crystal teal, green jacket, love potion, rubocondo, orchid, jaffa orange, calendula, bright chartreuse, and star white.

In November, it’s anticipated that slightly more sentimental hues like orchid and love potion will take centre stage alongside the traditional blue and green jacket and the same is expected to continue in December. The opulence of winter gradually gives way to the approach of spring in February
and colours like jaffa orange, green jacket, and vivid chartreuse are predicted to grow increasingly in demand among consumers.

The prevalence of Indian traditional fabrics will continue, especially those used for sarees; soft silk, cotton, cotton silk, organza & tissue, chiffon, georgette, and banarasi silk are projected to be the most popular textiles. Given the popularity of reviving traditional clothing and promoting locally produced materials, traditional sarees such as those woven in the Kanjeevaram, Banarasi, Tant, Pochampally, and Kota styles are likely to be more in demand.

ReshaMandi’s Founder and CEO, Mayank Tiwari said, “With the popularity of Kanjeevaram, Banarasi, and Kota sarees, the anticipated trends for this festive season reflect the pan-Indian desire to embrace more natural materials and revitalize traditional weaving patterns.

This is encouraging for us as a company working to build a productive environment for natural fabrics.”

Small border/borderless, micro motifs, updated zari, scalloped/lace edges, and translucency are likely to be favored in terms of details. Dots, stripes, and checks, painterly florals, delicate vines, cluster florals, birds and animals, and mix-and-match are among the popular patterns.

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