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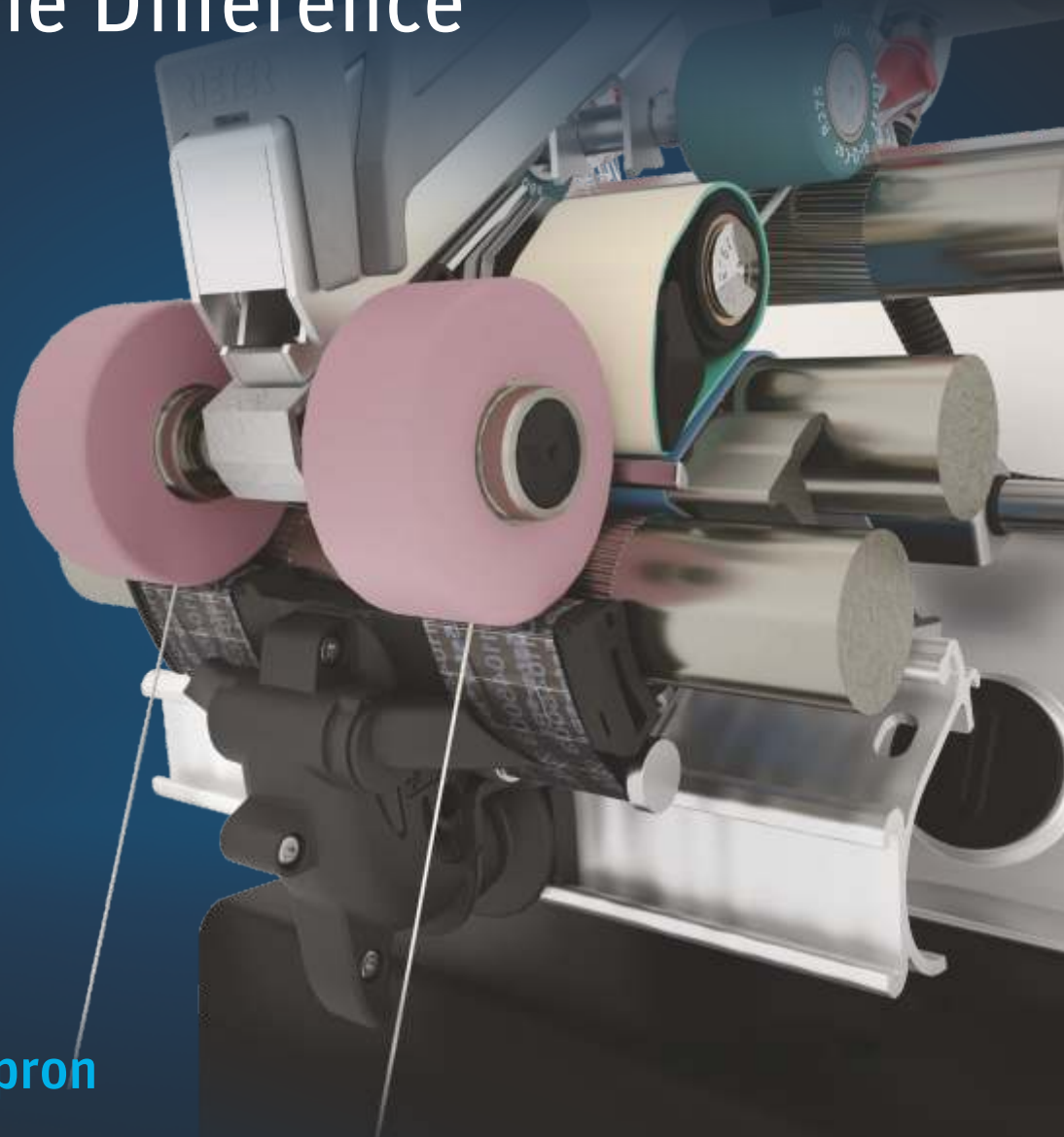


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ITMA 2023 - inspiration and a catalyst show for future growth in textiles

ITMA (International Textile Machinery Exhibition) showcase the world's top manufacturers of textile and garment technology on a global scale to transform the Textile & Garment Industry. The 19th edition of the world's largest textile and garment technology exhibition, ITMA 2023, was recently held in Milan, Italy from 8th to 14th June 2023, unveiling a definitive showcase of cutting-edge technologies presented by 1709 exhibitors from 47 countries. This year ITMA pivoted towards digital transformation & circularity and unveiling exciting innovations to a global audience across four key pillars such as Advanced Materials, Automation and Digital Future, Innovative Technologies and Sustainability and Circularity. This prestigious event brought together industry leaders, designers, manufacturers, and enthusiasts from around the world, creating a vibrant atmosphere of creativity and collaboration. It serves as a platform for textile machinery manufacturers to showcase their latest innovations, technologies, and solutions to industry professionals and stakeholders.

The ITMA 2023 exhibition claims its own 'triple' in sales, new software, and sustainability. The new developments in software, implementation of artificial intelligence (AI), driving the digitalization, automation, and global connectivity of the textile industry.

The ITMA exhibition was a melting pot of textile innovation, featuring an impressive display of cutting-edge technologies, materials, and design concepts. Exhibitors showcased state-of-the-art machinery to groundbreaking fabric developments, sustainable practices, revolutionary fabrics, and the exhibition presented a glimpse into the future of textiles. Exhibitors were introduced to groundbreaking advancements such as wearable technology, sustainable materials, and digital printing techniques that are revolutionizing the industry. From automated looms to, Digital printing, and 3D-printed textiles, the event highlighted the industry's commitment to pushing boundaries and embracing technological advancements.

One of the distinguishing features of the event was the emphasis on collaboration and networking. International exhibitors and participants had the opportunity to connect, exchange knowledge, and explore potential partnerships. The meeting facilitated meaningful conversations between industry professionals, leading to the sharing of best practices, emerging trends, and market insights. This fostering of global collaboration showcased the industry's commitment to collective growth and innovation.

Moreover, the exhibition emphasized sustainability and eco-consciousness. Exhibitors showcased environmentally footprint, friendly processes, recycled materials, circular economy initiative and innovative methods of reducing waste. This demonstrated the industry's dedication to responsible manufacturing and its role in shaping a more sustainable future. The event was not only a platform for showcasing products but also a hub for knowledge exchange. Renowned speakers delivered insightful presentations on topics such as the future of smart textiles, the impact of artificial intelligence in the industry, and the intersection of fashion and technology, shedding light on the latest trends and challenges faced by the industry.

It was a resounding success, highlighting the textile industry's boundless potential and its unwavering commitment to innovation, sustainability, and vibrant networking opportunities, the event has left an indelible mark on the textile landscape. The event served as a catalyst for industry professionals, designers, and enthusiasts to explore emerging trends, exchange ideas, and pave the way for a vibrant future in textiles. The exhibition not only celebrated the present achievements of the industry but also set the stage for future advancements and partnerships.

Announced in the ITMA 2023 press conference about the upcoming ITMA shows in Singapore in 2025 and Germany in 2027. As the textile sector continues to evolve, the ITMA will undoubtedly remain a beacon of inspiration and a catalyst for growth in the years to come with further gains, smarter and more sustainable for sure. Attendees had the opportunity to engage in dynamic discussions, fostering collaboration and inspiring new ideas.

The G-20 summit, consisting of 19 countries and the European Union, held its annual summit in India, aimed to address pressing global challenges and foster international cooperation. Leaders from the world's major economies gathered to discuss on the topics such as climate change, economic recovery, and global health. The host country, India, showcased its rich cultural heritage and emphasized the importance of inclusive growth, sustainable development and marked a significant milestone to tackle shared challenges and promote global prosperity.



Guest Editor
Dr. Chet Ram Meena
NIFT Jodhpur (Rajasthan)



Mr. R. K. Vij, President - TAI

PET Bottles to Bottles (Recycling)

R. K. VIJ

Indian Govt. is in process of allowing recycled PET bottles into the food and beverage products which is never allowed. World over it is mandatory to use some percentage of recycled pet bottles into food and beverage items.

The world is stamped with enormous amounts of plastic waste on a daily basis. More than 400 million tons of plastic that is produced every year, nearly half of it is designed to be used only once.

India has one of the highest pet bottle recovery rates in the world. However, safety and health considerations make it difficult to perform recycling for water and beverage use. Approximately 85-90% of collected pet bottles are already being recycled in India. Indian

Govt. also planning to make mandatory to use some percentage of recycled PET bottles into Food and Beverage products. In order to be approved for food contact recycled plastics must meet increasingly stringent quality criteria that lead to more demanding recycling processes.

This sector will grow more in time to come, pet resin consumption is about 1.7 million TPA, with an annual growth of average 9-10%. This industry of pet recycling is expected to grow double in next 4-5 years. Plastic bottle recycling market size is valued at USD 4.28 Billion in 2021-22 and projected to grow USD 4.8 Billion in 2023-24 and then 7.93 billion by 2032 at a CR GR of 5.8%, according to reportlinker.com report. The main growth drivers are;

- a. Increasing adaptation of recycled products is expected to boost the market growth.
- b. Rising awareness on utilization of recycled plastic will aid in the market growth.

The process of bottle to bottle recycling is fully continuous and integrates extrusion as a first process section and solid-state poly condensation as a second process section into one integrated system. A fully advanced automatic and intelligent control system is built in the line for easy and better operation. With impurities removed, it allows repeated cycle of PET bottle - to - bottle fabrication. In the end a PET bottle becomes the resource for creating another new PET bottle, which becomes a continuously circulating resource.

Out its technology in the area of PET bottle to PET bottle sorting, grinding, washing and recycling plants. Its upcycling concept encompassed the suitability of modifying the manufacture of a given packaging products like PET bottle by replacing virgin polymer with post-consumer material. It offers a system from 600 kg/Hr to 9000 kg/Hr. The demand for high-quality recycling is increasing because legal requirements and voluntary commitments of leading brand manufacturers demand a higher use of recycling in the end products.

“With the bottle to bottle technology catching up, the dream of recycling every PET bottle in the World may one day become reality. Also at time when Circular Economy is the hot topic amongst the packaging fraternity globally,”

A Review on Flame Retardant Jute-Based Protective Clothing

M. S. Parmar* & Palak Bansal

Northern India Textile Research Association, Ghaziabad, India

Abstract:

This article aims at updating the progression of the flame retardant (FR) chemicals specifically developed for cellulosic fabrics including jute. Jute is a flammable fibre with 20.5 % LOI value. The overall market of jute throughout the world is immense. To enhance its FR property in view of its advanced applications in various fields, this fibre must undergo chemical modifications. The data has been extracted and analysed from the reported literature to thoroughly discuss the advances and potentialities of distinct FR chemicals recently developed for fibres. Various FR chemicals and methods that have been developed for making cellulose-based fabric flame retardant, resistant to hot liquid splashes and steam hazards are discussed. The article also discussed the relevant performance parameters that must be taken into consideration to achieve the requirement of flame-retardant protective clothing with respect to industrial burn injuries. The collected data presented in this review article will help investigators working in this area to choose the suitable FR chemicals and the best technology among possibilities for making the jute and other fibres sufficiently FR as per the end uses.

Keywords: cellulosic fibre; flame retardant (FR); hot liquid splash; jute; protective clothing

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1. Introduction

Jute is a lignocellulosic fiber that mainly comprises α -cellulose (58–63 %), lignin (12–15 %), hemicellulose (20–24 %), and small amounts of constituents such as pectin, fats, aqueous extract [1]. The strength, structural stability, stiffness, and absorbency of this fibre are due to the presence of cellulose. The cellulose structure of the fibre comprises amorphous and crystalline regions, whereas hemicellulose and lignin are amorphous in nature. Both amorphous and crystalline regions contain hydroxyl groups. However, in crystalline, the hydroxyl groups are not accessible as these are strongly linked with the structure. On the other hand, the hydroxyl groups present in the amorphous region are loosely linked with the structure and relatively free to interact with chemicals [2].

The advantage of using jute fibre over manmade fibre is that it reduces the emission of CO₂. The Jute plant has the property to emit O₂ and absorb CO₂ from the environment. Thus, making it biodegradable and non-toxic with no adverse effects on the environment has compared to manmade fibres [3].

To enhance its applications in various fields, it is required to do some chemical modifications in this fibre. For these modifications, the most common are water-repellent, rot-proof, and fire-retardant jute materials. The overall market of jute throughout the world is immense. Jute is used in a variety of products like blankets, carpets, window curtains, wall coverings, upholstery fabrics, brattice cloth for decorative products, coal mines, and kitchen aprons that are prone to flame. Like other cellulosic fibres, Jute also burns easily. The untreated Jute fabric is having 20.5 % LOI value compared to cotton (15.5%) [4]. This LOI value of Jute indicates that jute

is flammable fibre. So making it flame retardant, it should be treated with flame retardant chemicals. In this article, various studies carried out on fire retardant (FR) chemicals and FR-treated jute fabrics are discussed.

2. Methodology

The secondary data has been collected from different national and international journals. Based on this secondary data, three variables have been selected for the systematic review of literature i.e. flame retardant chemicals, flame retardant protective clothing and flame retardant jute fabric.

3. Results and Discussion

3.1 Flame Retardant Chemicals

Fire hazards are one of the most life-threatening hazards. The textile material acts as fuel during a fire accident. It is well-known fact that the majority of fire accidents occur due to these textiles. To protect from fire hazard, clothing made out of inherent flame retardant (FR) fibres or FR chemical-treated fabric is used. FR finish can react chemically with the fiber's molecular structure, or it can cross-link at the surface of fiber or self-polymerize. An FR finish has a tendency to retard the development of fire/combustion during material pyrolysis or decomposition, heating, flame propagation, and ignition. FR chemical-treated fabrics are mostly not durable and their flame retardant property decreases with repeated washing. On the other hand, inherent FR fibres, like aramids, FR-viscose, modacrylic, etc, are durable in FR properties. Further, it was revealed that fabric produced using modacrylic, only FR viscose, Nylon 66 fibres, and their blends, showed that flame and thermal resistant properties are influenced by fibre blending ratio. To make a balance between FR, comfort, and durability properties, modacrylic fibre was blended with FR viscose and nylon 66. Due to well-known excellent abrasion resistance and durability properties, these blended fabric samples not only provided good FR properties but also gave excellent wear life to the fabric [5-7].

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Various studies [8-10] were carried out on the development of FR chemicals and inherent FR fibres. These studies discussed the development of organophosphorus-based chemicals, inherent FR fibres, char-forming FR additives, halogen-based FR products, nanotechnology-based FR agents, etc. Specifically, in relation to the field of textiles, FR chemical finishing may be classified in accordance with “laundry durability”. The non-durable FR chemicals get washed off immediately after soaking in water. While semi-durable FR chemicals resist water-soaking and durable FR chemicals remain in the fabric for around 50-100 washing cycles [11].

Now-a-day mostly, the vital FRs involve composition based on halogens like chlorine, bromine [12], aluminum trihydrate (ATH) [13], phosphorus [14], antimony oxides [15], phosphonium salt or alkyl-substituted, Tetrakis(hydroxymethyl)phosphonium chloride (THPC) and sulfate (THPS) [10]. However, in accordance with the stringent directives promoted by USA and EU communities, some halogen-based FRs have been banned, owing to their environmental persistence, toxicity to humans and animals, and hazard of released gases [8]. The structures of some of the most common FR chemicals are given in fig. 1.

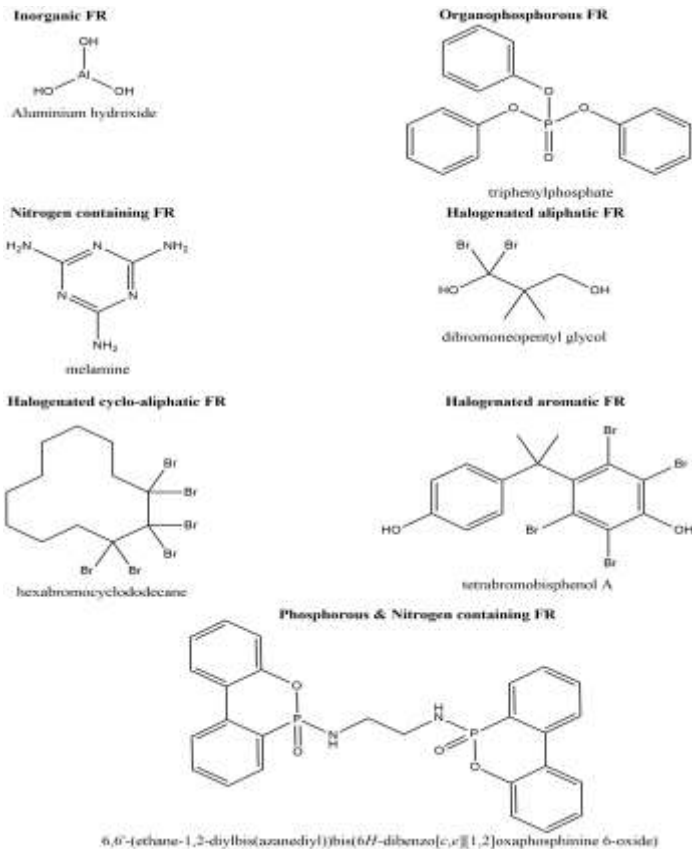


Figure 1: Chemical structures of different FR chemicals

Earlier studies have shown that phosphorous-based flame retardants along with nitrogenous and sulphur compound are the most-effective formulation for imparting flame retardant properties. The commercially available formulation of these FR compounds, which are widely used in the textile industry is Tetrakis phosphonium salt (Proban process) as shown in

Fig. 2 and N-alkyl phosphopropionamide (Pyrovatex process) derivatives [10] as demonstrated in Fig. 3. Although these formulations are widely used, there are some drawbacks are also associated with these formulations as these are applied on the cotton fabric in an acidic medium. Due to this reason, cotton-based material strength is reduced and becomes stiffer. Other drawbacks of these FR treatments are that the treatment with these chemicals is costlier as a very high quantity of chemicals at high-temperature curing is required. Besides, the process is not environmentally friendly due to the release of toxic formaldehyde if the process is not controlled properly. Although halogen and antimony-based FR chemicals provide good results, they possess environment-related issues so these are not recommended [8]. Research studies are also carried out on sustainable and eco-friendly flame retardants like sodium metasilicate nonahydrate, nano-oxide, and polycarboxylic acid for making a fire-retardant process environmentally friendly [13]. Despite, environmentally friendly treatments, the main problems with these chemicals are that they do not provide the required durability and also affect the strength of the cotton fabric. Some studies [11-15] were also carried out to use FR compounds, extracted from natural sources like spinach juice, waste banana pseudostem sap, etc. These studies reveal that despite maintaining strength and durability to some extent, the treated fabric after burning shows excessive smoke and afterglow, which is not acceptable.

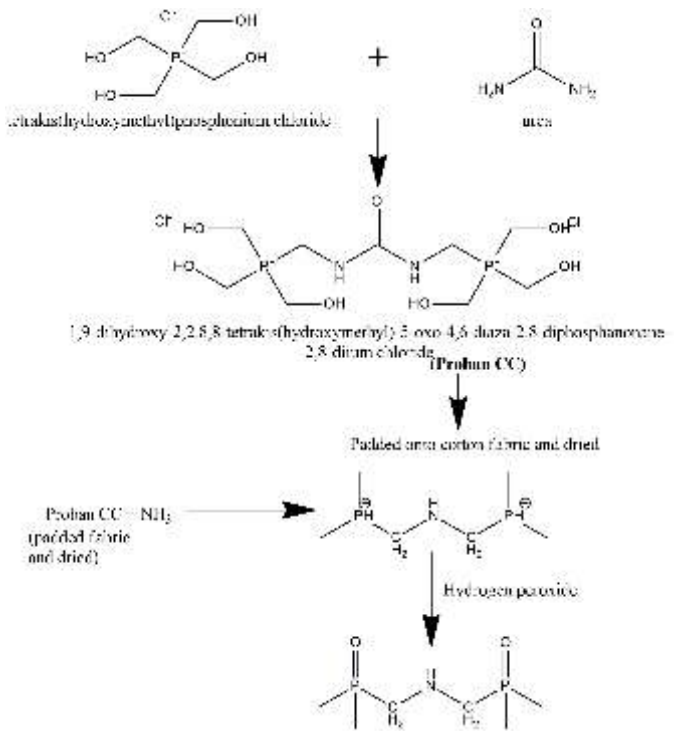


Figure 2: Proban process

As per today's requirements, it is necessary to develop highly efficient FRs with critical acceptability in terms of chemical toxicology, cost, and environmental sustainability [10]. In this view, Manich et al (2020) [16] evaluated the impact of FRs on the thermal behaviour of polyester/cotton, polyester, and cotton fabrics through differential scanning calorimetry and thermogravimetric analysis (TGA). They made efforts to

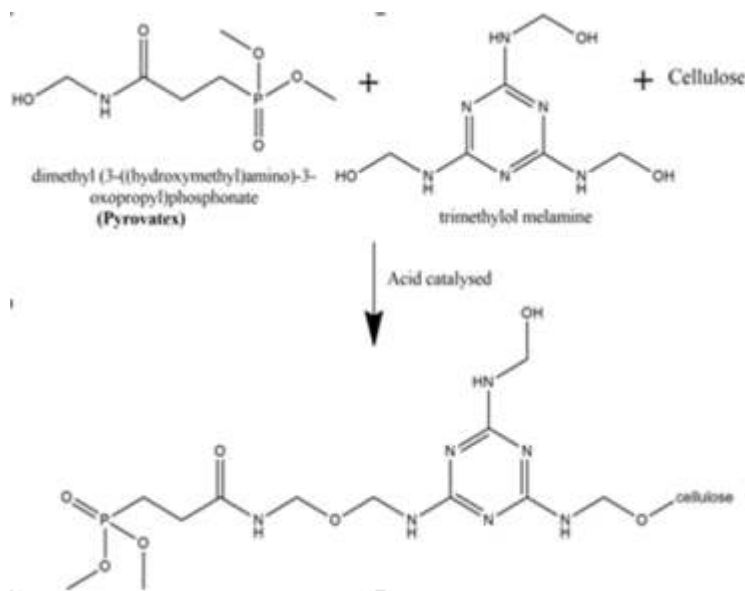


Figure 3: Pyrovatex process

look for some efficient, ecological, and healthy substitutes for FRs and concluded that expandable graphite and guanidine phosphate could serve as good substitutes for traditional FR's. An acceptable FR textile material must possess a limiting oxygen index (LOI) of around 35 and a char length of around 2-4 cm, after a glow time of 15 ± 5 sec possessing minimal loss of fabric tenacity as well as loss in tear strength [17]. In this context, numerous efforts have been made and are reported in the literature for FR-based fibres.

Halogen-free FR was synthesized for poly-Acrylonitrile (i.e. PAN) fabric depending upon the hybrid compound comprising phosphorus acid through the sol-gel process [18]. Khose et al. (2018) [19] investigated a methodology for preparing a water-dispersible FR, depending on graphene quantum dots (GQDs). The FR of the quantum dots of P-GQD was synthesized using graphene oxide and monosodium phosphate along with polyphosphoric acid following a hydrothermal treatment method and then it was applied on cotton fabric. It was concluded that the treated fabric demonstrated efficient flame retardancy. It emitted little smoke when in contact with flame and did not catch fire and maintained its shape with a little tilt.

Tian et al. (2019) [20] examined the flammability of FR finish (with ammonium salt of tetraethylene pentamine heptamethyl phosphonate i.e. ATEPAHP) of cotton fabric through P-O-C covalent bond. Where LOI of the treated cotton possessed 18-26% weight gain in ATEPAHP and attained an LOI of 37.0-40.5% while this LOI was reduced to 28-32% after 50 laundering cycles. Hence, it proved to be still an FR even after 50 wash cycles.

There is a growing interest in the development of toxicity-free and eco-friendly FRs or their nano-composites via sol-gel method recently. Nanomaterials like carbon nanotube (CNT) or nano clays have also been demonstrated to be effective co-additive in FR applications [21]. The main mechanism of FRs using CNTs during thermal degradation is

that they encourage the formation of a layer of char (behaving as an insulating barrier) covering the surface of the polymer. Such a barrier restricts the transmission of heat and oxygen diffusion into the material and thus, minimizing the escape of volatile, and combustible decomposition products into the flame. Thus, CNTs and their composites possess an ability to enhance the material's strength, fatigue resistance, and its electrical properties.

3.2 Flame Retardant Protective Clothing

As discussed so far, research related to FR in the field of textiles has paid major attention to protection from flame and heat, not against hot liquid splashes and steam hazards. Hot liquid splashes and pressurized steam usually cause a threat to the workers' health in oil and gas industries, foundries, nuclear industries, the navy, and to fire-fighters [22]. Generally, there are three kinds of molten metal exposures in industries which include welding droplets, poured molten metal, and molten metal splashes from an electric arc. Such industries create immense hot environments causing uncomfortable feelings that may lead to losing attention in case of short-term exposure or heat stress hazards in case of long-term exposure. Distinct kinds of fabrics are exploited in industrial workwear ranging from cotton to special fibres such as modacrylic, leather, and aramid. Hot water and steam can easily get penetrated into the clothing system resulting in serious damage to skin tissues. In this view, FR protective ensembles could be useful in protecting against steam, hot water, and flash fire burn injuries in the case of oil and gas industries. However, these conventional protective ensembles are ineffective in providing protection against hot steams and liquid. The majority of occupational burn patients include industrial workers. Contact/scald burns account for a greater fraction of injuries. The statistical data of the Chinese metallurgical industry from 2001 to 2018 reported 152 fatal accidents resulting in 731 deaths [23]. Therefore, from the reported studies, hot steam, and liquid splashes have been shown to be the most usual threat in terms of workplace safety of workers. Protective clothing remains the only barrier between the aforementioned thermal hazards and the skin. The thermal energy produced from such hazards can be transmitted via protective clothing and has the potential to cause skin burn injuries. A significant amount of thermal energy gets stored within the fabric upon hot liquid splashes which lowers the thermal performance of fabrics [24]. Hence, it becomes necessary to maintain the integrity of protective clothing for protection against hot molten splashes and pressurized steam. Better insulation properties of fabrics and the inclusion of a moisture barrier in the clothing like firefighter suit are considered to be effective means of protection against thermal injuries [25].

It was also reported that impermeable fabrics exhibited better performance against steam and hot liquid splashes than permeable ones [26]. They also reported that the thermal performance of FR-based fabrics can be enhanced by adding a spacer material behind impermeable fabrics. The placement/positioning of the moisture barrier also poses an impact on the thermal protection of fabrics against hot water splash [27]. Apart from this, fabric air permeability serves as a crucial factor in improvising the protective clothing's

performance against hot water splash [28].

During the splash of hot water over the fabric's surface, the liquid begins to spread radially from the point of stagnation till there is a sudden rise in the height of the fluid. This process is actually called a hydraulic jump. As a result, hot liquids must be kept at a distance from the skin to minimize heat transfer to the clothing [29]. Thus, any change in the impingement angle of hot liquid results in the liquid flow changes over the fabric surface and causes an impact on the liquid penetration. If the fabric's horizontal configuration is perpendicular to the hot liquid stream, it yields lower protective performance compared to a fabric inclined at an angle of 45°.

Barker and Yener (1981) worked on protective clothing material with respect to molten iron [30]. They concluded that iron resistance relies upon fabric thickness, air permeability, weight, and flammability properties. One of the other reported studies monitored the protection properties of Zirpro-treated FR wool along with other protective clothing materials against aluminium splashes and convective/radiant heat [31]. It was deduced that increased fabric density and weight, smooth fabric surface, and low thermal conductivity are vital for molten aluminium protection.

Coughlan (1992) carried out an investigation against molten aluminium and found that skin damage does not depend upon FR but over fabric's surface properties at higher temperatures and metal-fabric contact duration [32]. Magnússon et al. (2001) investigated several FR based clothing materials including cotton, viscose/wool/cotton blend, viscose FR/PVA/modacrylic, viscose /wool against molten aluminium. It was found that underwear usage is important to get D3 protection of ISO11612. Moreover, big folds in fabric may stop molten aluminium and cause damage to skin stimulant [33].

A reported study characterized 19 personal protective clothing (PPC) materials utilized in low-risk PPC [34]. It was concluded that material thickness, air permeability, density, and mass directly influence thermal/moisture management performance. Furthermore, in outdoor environments in the presence of wind, material air permeability plays a major role when wearing PPC.

Holmes and Horrock (2016) claimed that a blended fabric, PBI Gold (blend of polybenzimidazole fibre and an aramid), offers improvised FR property along with durability, strength and softness. A blend ratio of 40/60 PBI/aramid has been reported to be optimum for overall fabric performance [35].

Kutlu and Bitgen (2020) surveyed the protection properties of several work-wear fabric materials (FR-cotton, meta-aramid, cotton denim, aluminized aramid, modacrylic-viscose-FR cotton, leather, and FR viscose-wool-polyamide) against molten metal splash in industries [36]. Mandal and Song (2018) investigated the properties of different fabric materials in relation to contact with a hot surface. It was found that a thicker thermal liner in the case of multi-layered

fabric could result in higher performance while layered fabric comprising an outer layer of moisture barrier demonstrated minimal performance [37].

Shape memory materials (SMMs) can be incorporated into clothing materials for enhancing thermal protection by generating air gaps. These smart materials possess a shape memory effect means they can remember/ recover significant programmed deformation with particular environmental stimuli [38].

Naem et al. (2022) coated the outer shell of firefighter clothing with silver particles via physical vapor deposition (Magnetron sputtering) and these specimens proved to be highly durable in terms of thermal performance, vapour resistance, and thermal performance [39].

3.3 Flame Retardant Jute Fabric:

The burning behaviour of the jute depends upon the presence of lignin and cellulose. In the presence of a flame, cellulose starts burning and forms a highly flammable compound i.e. levoglucosan. On the other hand, the thermal degradation of lignin produces a high amount of char from its aromatic framework [40]. The ability to generate char during the thermal degradation is a basic aspect of flame retardant intumescent system. The formation of char acts as a physical barrier and slows down heat and mass transfer between the gas and the condensed phase. The studies showed that the presence of lignin reduce the flammability of polymers significantly. Thus, the thermal degradation of jute fibre relies upon containing a specific quantity of lignin [41].

The FR property of jute or jute-cotton fabric can be improved by utilising a commercially available FR chemical i.e. Pyrovatex CP New. It was earlier reported that the efficiency and durability of cellulosic fabric treated with FR could be increased by synergism with phosphorus through a combination of melamine resins and phosphorus acid [42]. However, Stęplewski et al. (2010) [43] concluded that the use of phosphorous acid and organophosphorus compounds in conjunction with melamine resins reduces the tensile strength of cellulosic fabrics and releases formaldehyde. Blanchard and Graves (2005) [44] successfully attained improved efficiency of FR on cotton/polyester fleece by the application of phosphorus-based poly-carboxylic acids. The other study reported the applicability of poly-carboxylic acids to bind in durable FR finishing by replacing melamine resins with citric acid and 1,2,3,4 butanetetra carboxylic acid and reducing the release of formaldehyde [45].

Dou et al. (2021) [46] prepared an efficient FR composite of jute and polypropylene via the surface powder spraying method using β -cyclodextrin (char agent), ammonium polyphosphate (acid source), and melamine (blowing agent). This composite demonstrated an enhanced LOI value of 27.8% and a self-extinguishing time of 37s. Oktem and Aydas (2022) [47] reported that the coating of polymerized dopamine hydrochloride over jute fabrics and its composites demonstrated better FR efficiency with higher LOI value.

The influence of chemical treatments (alkalized and silanized + alkylated) over the thermal characteristics of hybrid natural fibers (jute, sisal, ramie, curaua) reinforced composites (NFRCS) have been investigated [48]. The chemical treatments enhanced the composites' thermal stability of the composites, especially in the case of ramie and sisal. A similar study was conducted to check the impact of FRs on the thermal characteristics of jute fiber through DSC and TGA [49]. FR-treated jute fiber depicted lower thermal degradation temperature but more residue above 400°C in comparison to raw fibers.

In another reported study [50], FRs such as thiourea, borax, and diammonium phosphate were applied in varying concentrations in a raw/bleached jute fabric through the padding method. In this study, the effect of FR finish over tensile, vertical flammability, and wash resistance behaviour were investigated. It was concluded that the borax-treated specimen demonstrated the highest flame spread time and wash durability. In another publication by Repon et al. (2022) [40], the combinations of thiourea, borax, and diammonium phosphate were applied to the jute fabric following the pad-dry-cure methodology. Amongst different combinations, the combination of borax and diammonium phosphate at 6% concentration depicted 305% improvisation of flame spread time in the case of raw jute while 276% in the case of bleached jute fabric. Moreover, these FR-treated jute fabrics have been demonstrated to be effective in brattice clothes in mines and some other potential fields like FR kitchen aprons, and furnishings for theatres, hospitals, and public halls.

Phosphorous-based compounds have been proven to be effective FRs. It has been reported that FR efficiency can be improved by adding nitrogenous compounds, especially with reduced phosphorous quantities in P-N system. Davis et al. (2008) [51] found that Phosphoric acid in conjunction with ammonium salt of phosphoric acid effectively inhibits fire propagation in the case of cellulose. Samanta et al. (2011) [52] also reported successful semi-durable FR finishing of jute fabrics with P-N system and investigated their thermal degradation nature up to 500°C. Nada et al. (2009) [53] also reported that Phosphoric acid and its derivatives lead to the esterification of cellulose in the presence of nitrogenous buffer under elevated temperature with minimal acceptable degradation.

The major complications especially in relation to the FR

formulations of jute involve high cost, the addition of a high amount of chemicals, loss of strength, yellowing of fabric, and stiffness. Furthermore, majority of the FR methodologies developed in case of jute are non-durable [54].

The implementation of nano ZnO powders in FR finish has resulted in a significant reduction in the rate of flame propagation on cotton fibers, jute, and cotton/polyester. Samanta et al. (2017b) [54] prepared nano ZnO powder and applied it in combination with 4-6% poly-hydroxyaminosiliconate binders for fabricating FR finishing of jute fabrics. Zaman et al. (2021) [55] also reported a significant improvement in chemical and FR efficiency of jute and jute reinforcement (scouring, HFC 20 g/L, HFC 40 g/L, mercerizing) composites by coating ZnO nanoparticles on jute fibre involving different types of matrices.

4. Conclusions

This article revealed that the concurrent presence of nitrogen (or sulfur) and phosphorus elements is beneficial in developing synergistic effects when treated textiles are exposed to a flame. The commercially available FR compounds i.e. Tetrakis phosphonium salt and N-alkyl phosphopropionamide derivatives are widely used but these are costlier, not environment-friendly, and reduce the strength of fabric. Sol-gel method and hydrothermal method proved to be effective approaches in synthesizing environment-friendly FR chemicals. However, there is still a need to develop highly durable and compliant new protective clothing with respect to industrial burn injuries with optimized ergonomic and improvised thermal management properties.

Owing to the presence of high tensile strength, good thermal conductivity, ventilation function, and coolness, Jute can serve as the best candidate in the case of FR-treated fabric or fire-protective clothing. Further research is required to overcome the challenging issue of protective clothing against molten metal splash or burn injuries.

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Breathable Surgical Gloves having Antimicrobial and Thermo-control Functionality

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Abstract:

Surgical gloves are the first line of defence in resisting the spread of microbial infections and are irreplaceable due to ease of use and economic cost. Surgical gloves available as of date are single-use and are least efficient in providing safety against infection-causing microorganisms as they tend to rupture under working conditions exposing the skin of medical professionals. The single-use nature of surgical gloves makes them a bio-hazard when disposed of. Apart from the limited shelf-life, they lack specific anti-microbial characteristics. This research intends to create a novel method for preparing a reusable, superabsorbent and breathable material with a hydrophilic-hydrophobic bi-layer based on the two-face Janus concept. The experimental results and findings confirm the use of developed material to produce multi-layered, sweat-permeable, multi-use surgical gloves having anti-microbial and thermo-control properties.

Keywords : *Antimicrobial, Electro-spinning, Janus Material, Superabsorbent, Surgical gloves, Thermo-control*

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1. Introduction

1.1 Surgical Gloves

The importance of personal protective equipment (PPE) has been reinforced post covid-19. Irrespective of the pandemic need, surgical gloves form a crucial part of the daily lives of medical professionals and other hospitality service providers. The evolution of rubber gloves from 1890's to the present-day nitrile surgical gloves has been evident in providing a barrier, avoiding direct exposure from infections, pathogens, dust, stains, and sensitive chemicals, and ensuring overall safety measures. As of today, commercially available surgical gloves have been effective in providing safety along with other advantages of comfort wear and ease of use like puncture resistance, strength, non-sticky behaviour, elasticity, high touch sensitivity to palm, lightweight etc [1-4].

The popular categories of surgical gloves available in the market are Latex, Nitrile, Vinyl, Neoprene and polyisoprene. Each of them has its own set of advantages and disadvantages. Latex gloves derived from a natural source are durable and highly elastic but are not skin-friendly. Similarly, Vinyl gloves of natural origin are inexpensive but offer lesser protection and durability. Synthetic surgical gloves made from neoprene and polyisoprene offer excellent strength and latex-like properties but are expensive. Nitrile gloves are widely used and have dominated the market owing to their excellent strength, puncture and chemical resistance but are uncomfortable to wear and cause disposal hazards. The low-elasticity and non-permeability of this kind of gloves cause discomfort on wearing [5-8].

Disposal of such single-use surgical gloves is another

concern as a bio-hazard. To overcome these inadequacies in existing surgical gloves, developing multi-use, comfortable and eco-friendly personal protective equipment (PPE) is a new hope for emerging technologies. The objective of this research is to develop such multiuse base fabric made from cross-linking of two layers, hydrophilic from the inside which will ensure sweat and water permeability and hydrophobic on the outside, which can serve the primary purpose of acting as a barrier against exposure from external agents and direct skin contact [9-13].

1.2. Janus Material

Janus is a Greek word derived from the mythological God having two faces. It resembles the Indian mythological figure of Ardhanari-Nateshwar. Several researches have been conducted to produce Janus textiles, wherein a single fabric could offer two different characteristics on each side. The latest research on Janus textile found in literature unveiled the design for a fabric that could keep a person warm when worn one way while cooling them down if worn inside out. However, the research put forth in this study is confined to the preparation of polymeric bi-layered material suitable for making surgical gloves [14-18]. In this study, two fabrics with distinct characteristics were synthesized separately by a series of preparation steps and cross-linked by a fusion process to obtain a bi-layered Janus fabric with potential application in surgical gloves. The first layer is hydrophilic, constituted Polyvinyl alcohol (PVA) nano-film extruded by electrospinning and stabilized by the cross-linking process. The secondary layer was a blend of nano-film of Polyurethane (PU) + Polyvinyl Chloride (PVC) and Betulin. Both layers were synthesized independently using an electro-spinning process. The primary PVA nano-film layer formed the hydrophilic and superabsorbent side, much needed in the surgical gloves for a uni-directional sweat flow and breathable skin contact. The (PU+PVC)-Betulin formed a hydrophobic layer that primarily avoided direct skin contact with external agents like microbes. Figure 1 indicates the schematic diagram of a process flow for preparing a bi-layered Janus Material which has the potential for making multi-use surgical gloves [19- 23].

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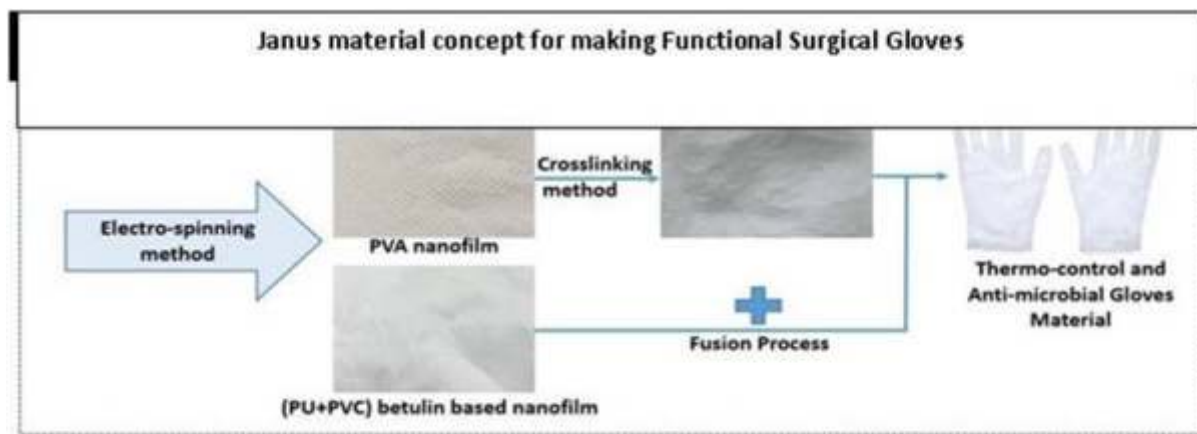


Figure 1: Process flow for preparation of bi-layered Janus material

The multi-step synthesis of surgical gloves base fabric constituted the following methodologies. The process flow can be understood clearly from the above figure.

2. Materials and Methods

2.1 Materials

Polyvinyl alcohol (PVA) $(C_2H_4O)_n$, having Molecular weight 85,000 - 1,24,000 and Acetone (C_3H_6O) were procured from S.D Fine-Chem Limited (SDFCL). Glutaraldehyde (GA, 25%), Hydrochloric acid (HCl), and Distilled water (DW), were consumed for the synthesis of the innermost layer/hydrophilic layer of the Janus material for making surgical gloves. Polyurethane (PU, Mw: 88g/mol), Polyvinylchloride (PVC, Mw: 62), Dimethyl formamide (DMF, Mw: 73) and Tetrahydrofuran (THF, Mw: 72) sourced from SDFCL were required for making the outermost hydrophobic layer. Betulin powder (85% purity) was procured from Natucare Herbessence Private Limited.

2.2 Methods

Electrospinning of Bilayer nano-films for Janus fabric

Step-1: Preparation of PVA nano-film (hydrophilic layer)

PVA was weighed and dissolved in distilled water by constant stirring with the help of a magnetic stirrer at 50°C for 60 minutes to prepare 8% concentrated solution. This solution was used to extrude PVA nano-fibre by maintaining a flow rate of 1ml/hr. The nanofiber sheet was kept at room temperature for 24 hours. The temperature and viscosity play a major role in the deposition as well as the diameter of the nano-fibre. The lower the humidity, the higher the solvent evaporation rate with a resultant thicker nanofiber and vice-versa. Thus, preparing the polymer solution as per desired viscosity is necessary. If the viscosity of the solution increases, then polymer beads get formed with larger sizes and longer average internal distance between them. This tends to increase the diameter of the obtained fibres. The viscosity of the polymeric solution having more than 20 poise during the electro-spinning is avoided because of unstable polymer flow and high cohesion of the polymer material.

Step-2: Cross-linking of PVA nano-film (for Stabilization)

The nanofilm after electro-spinning was hydrophilic and unstable in the presence of water/humidity and had inadequate mechanical and physical strength. Therefore, a suitable stabilization method was scouted to incorporate stability in the nanofilm. Various combinations were studied based on the literature survey and understanding of the material of construction. Experiments with encouraging results were further optimized to increase the order of stability to the film and crosslinking was considered a preferable method. Acetone, Glutaraldehyde (25%) and Hydrochloric acid were mixed with different dosing concentrations for the process optimization and chemical concentration determination. Hydrochloric acid acted as a catalyst, increasing the reaction rate for further stable linkage. In the medium of Acetone, the PVA in various concentrations was allowed to react with glutaraldehyde. Acidification of the hydroxyl group is the chain initiator reaction in this case. Generated nanofilm was found to be stable and easily separated from the substrate. Figures 2a and 2b depict the effect of crosslinking on the stability of the nano-film.

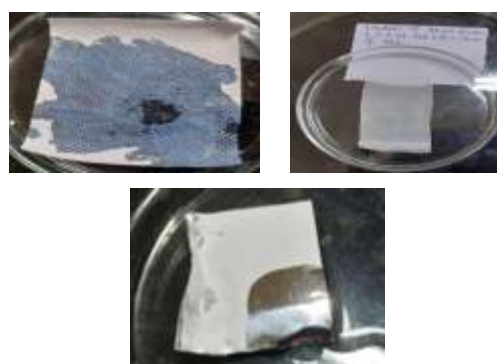


Figure 2a: Unstable nano-film before cross-linking



2b: Stable nano-film

Step-3: Electro-spinning of Betulin (PU+PVC) nano-film (hydrophobic layer)

The viscosity of the desired solution was optimized for PU: PVC at 4:1 ratio after dosage optimisations. The DMF: THF in the proportion 1:1 was found to be an excellent combination to dissolve the polymer combination at 4:1. 20 wt% solution of PU-PVC was prepared by adding 4gm PU, 1gm PVC and 0.095gm Betulin powder in 12.5ml each of DMF and THF solvent. The applied voltage was kept constant at 20KV, and the flow rate was maintained at 0.7 ml/hr. Betulin powder minimum inhibitor concentration (MIC) was determined as 85µg/ml, and the quantity was added accordingly in the solution. Beads were formed on the tip of the needle. So, it was concluded to make the solution less viscous. Further, a 15wt% solution was prepared in a similar process using 2.4gm of PU+ 0.6gm of PVC+ 0.095gm of Betulin powder in 12.5ml each of DMF and THF solvent was finalized for extrusion.

Step-4: Combination of bilayer nano-films by fusion process

The obtained nano-fibre of PVA and PU-PVC was cut into 36 cm² individual pieces. These two nano-films are not adhesive to each other due to the lack of chemical interaction. An adhesive agent was required to bind and hold both layers for a final product. Polyvinyl acetate (PVAc) was selected to merge the two layers of fabric into a single component after thermal curing. 5%, 10%, 15% and 20% PVAc concentrations in distilled water were prepared and experimented with for their adhesive properties. Each solution was stirred for 30 minutes, maintaining the temperature at 50°C. It was found that PVAc at 5% formed a non-sticky, at 10%, non-sticky with low viscosity and 15% a viscous gum having desired adhesive properties. Four sides of each film were applied with thinner adhesive (avoid applying all over the faces), and combined each side with light hand-tip pressure. Then the bi-layered film was inserted into an aluminium folded sheet. This sheet was pad dried with 30% expression, which resulted in the formation of hypothesized bi-layered Janus fabric.

3. Results and Discussion

3.1. Contact Angle Analysis

The bi-layered nanomaterial with hydrophilicity (water-loving) and hydrophobicity (water-repelling) behaviour was prepared like two sides of the coin. Both faces of the nanomaterial were different regarding physical properties with respect to water. The activity of water on the surface of fibre depends on the nature of the material, and the surface contact of water varies with hydrophilic/hydrophobic properties. The contact angle measurement verified the surface type produced on each side of the textile material. The stabilised PVA film on one side showed the capacity to absorb water, while the composite nano-fibre film of PU + PVC on the other side of the material exhibited



Figure 3a: Hydrophilic PVA nanofilm surface contact angle=11.67°



Figure 3b: Hydrophobic PU+PVC Surface contact angle=108.52°

hydrophobicity. The measurement of surface wettability through contact angle signifies the capillary action of the droplet. Contact angle θ ($\leq 90^\circ$) signifies the hydrophilicity and θ ($\geq 90^\circ$) defines the hydrophobic behaviour of liquid drop. KYOWA made (model no: DMO- 601) was the contact angle measurement instrument used for this analysis. Figure 3a and 3 b show the images taken during contact angle measurements. Figure 3a and 3 b represent the effect of hydrophilic and hydrophobic nanofilm surface on the contact angle of the water drop.

3.2. Tensile strength of PVA Nanofilm

Tinius-Olsen H5 K5U.K model-based Universal Testing machine was used to measure breaking strength and the Elongation to break analysis. Machine setting parameters were kept as load range (kgf) =5.10, speed (mm/min) = 1.00, gauge length (mm) =50.00 & extension range (mm) = 0.1. Figure 4 shows the effect of PVA crosslinked nano-film on the breaking strength and elongation.

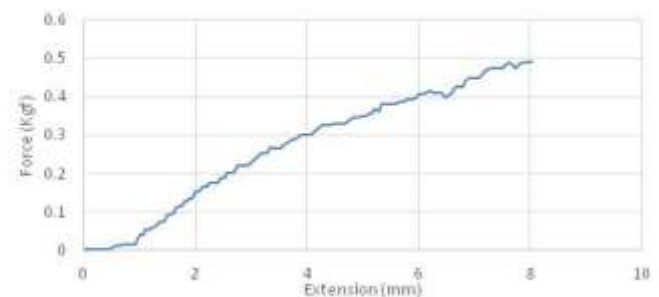


Figure 4: Breaking strength and elongation of PVA crosslinked Nano-film

The breaking strength of the PVA crosslinked nanofilm was lower than PVA nanofilm as fibre diameter directly determines the mechanical strength of the electro-spun film. The elongation extension was 18.45% and the breaking strength was 0.576 kgf.

3.3. Tensile strength of (PU+PVC) nanofilm

When an external force was applied to the nanofilm, the rupture was made on the weakest part during rapid expansion. For this, the highest film extension was 58%, while the breaking strength was 0.576 kgf. The effect of combined PU+PVC crosslinked nano-film is shown in Figure 5.

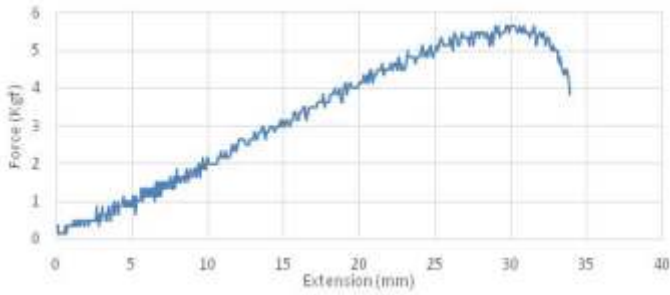


Figure 5: Breaking strength and elongation of PU+PVC crosslinked Nano-film

3.4. Bi-layered film -Tensile strength

The % extension and the breaking strength results for the Janus fabric having a bi-layered composite material were 11.13 % and 1.718 kgf respectively. The combined effect of the bi-layered Janus fabric is shown in Figure 6.

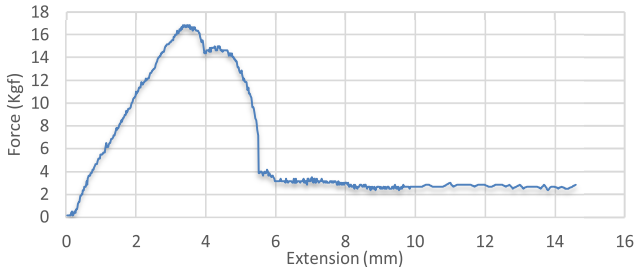


Figure 6: Breaking strength and elongation of Bi-layered Janus fabric

The results clearly show the synergistic benefit of the bi-layered material in terms of enhanced tensile strength as well as increased elongation before the break which would make this material highly suitable for making stretchable surgical gloves.

3.5. Antimicrobial property

The following study verified the presence of Betulin as an anti-microbial agent in the outermost hydrophobic PU+PVC layer. Antimicrobial properties of the finished fibre were analysed as per AATCC 100 method in the presence of bacteria i.e. S.Aureus Strain No. AATCC 6538 (Gram Positive Bacteria) and K.Pneumoniae Strain No. AATCC 4352 (Gram Negative Bacteria). The activity of Betulin was found to be retained after washing and there was no change in this property. The parameters for the quantitative evaluation of the antimicrobial performance of the prepared Janus material are given in Table 1.

Table 1: Evaluation of Antimicrobial Activity by AATCC 100-2019

Substrate under testing	1g sample of PU (Polyurethane file with Betulin Powder)
Sample size	48mm discs cut from larger submitted samples
Organisms used:	1. <i>Staphylococcus aureus</i> Strain No. ATCC 6538 (Gram Positive Bacteria) 2. <i>Klebsiella pneumoniae</i> Strain No. ATCC 4352 (Gram Negative Bacteria)
Method of sterilization:	Free steaming using Autoclave
Contact Time	24hrs

The performance evaluation results of the tested sample are given in Table 2

Table 2: Results of the AATCC 100 test method

Sample Identification	Test Culture	No. of colonies recovered at '0' hr [C]	No. of colonies recovered at '24' hrs [A]	Reduction of Microorganisms [R]
1. Sample-1 PU (Polyurethane With Betulin Powder	<i>S.aureus</i>	1.76 X 10 ⁵	1.2 X 10 ³	99.31 %
	<i>K. pneumoniae</i>	1.91 X 10 ⁵	1.9 X 10 ³	99.00%

The quantitative analysis of the antimicrobial activity of the prepared Janus fabric clearly shows that the bi-layered material achieved over 99 % reduction of both the Gram +ve and Gram -ve bacteria under study. This indicates that the Janus material developed for making surgical gloves can ensure desired antimicrobial properties.

3.6 Scanning Electron Microscope (SEM) Analysis

PVA fibre is susceptible to hydration and is easily soluble in water, therefore, in order to achieve stability of PVA fibre, Glutaraldehyde was inserted into the PVA matrix. SEM analysis of PVA-Glutaraldehyde-based fibre indicates smooth fibre strands with physical deformities below the detection level in the nanoscale range. PVA and Glutaraldehyde are compatible, forming a homogenous mixture and subsequent C-O-C linkage interaction as observed in FTIR analysis. Figure 7 shows that no microfractures were observed in any strand at the nanoscale of the whole sample fibre. The surface of each and every strand was smooth and clean. Voids were clear and free of debris arising from the electrospun process. The lack of micro fractures and debris reveals the complete mixing of chemicals and stabilization of PVA. Moreover, introducing Glutaraldehyde in the PVA matrix helped decrease the rigidity of PVA fibre marginally.

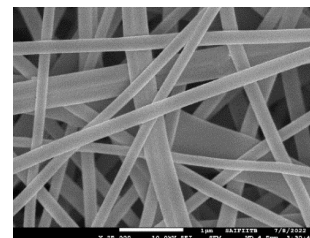
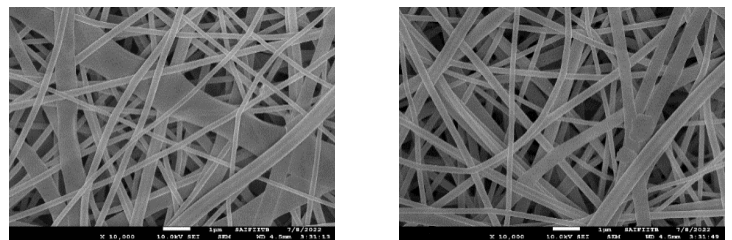


Figure 7: SEM Images of PVA nano-film after Glutaraldehyde cross-linking

3.7. Fourier Transform Infrared (FTIR) Analysis

The FTIR spectra (Figure 8a and 8b) were studied to determine the composite fibre formation and changes in its chemical moieties. Peak analysis of synthesized fibre with reference to the pure compound indicates the effect of cross-linking. Similar peaks near the wavenumber of 3400 cm⁻¹ & 2930 cm⁻¹ represent stretching vibrations undisturbed for –OH and –CH sp³, respectively. The –OH group in PVA gives a broader peak near 3400cm⁻¹ intra- and inter-molecular hydrogen bonding. Peaks at 1715-1735cm⁻¹ correspond to stretching vibration of –C=O. Moreover, the peaks at a wavenumber of 1450 cm⁻¹ and 1379 cm⁻¹ correspond to bending vibrations of –CH₂ and –CH₃ groups, respectively. In the case of PVA-GA composite, the peak near 3400cm⁻¹ became narrower. It depicts restrictions on intra-and inter-molecular hydrogen bonding. Interaction of PVA with GA resulted in a change in –OH stretching. Carbonyl group of GA form acetyl linkage with the hydroxy group of PVA. Stretching vibrations of –C–O–C near 2920 cm⁻¹ and –CH of the aldehyde group near 2845cm⁻¹ narrates the confirmed interaction and reduced availability of the free –OH group.

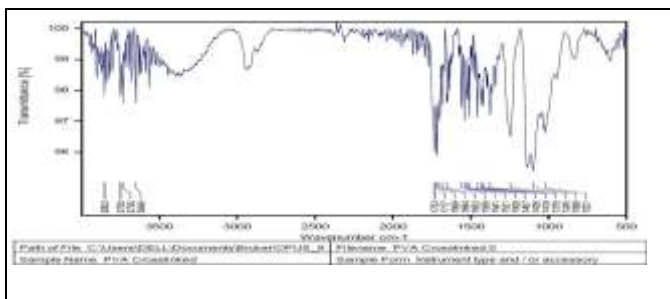


Figure 8a: FTIR result of crosslinked PVA nano-film

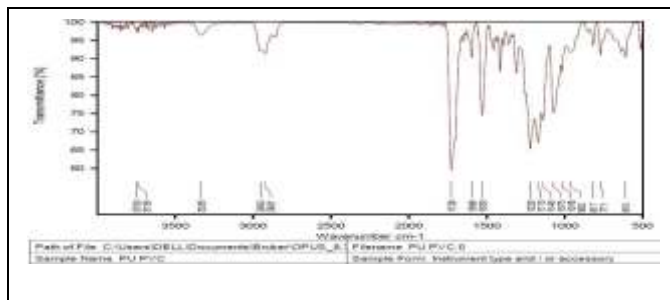


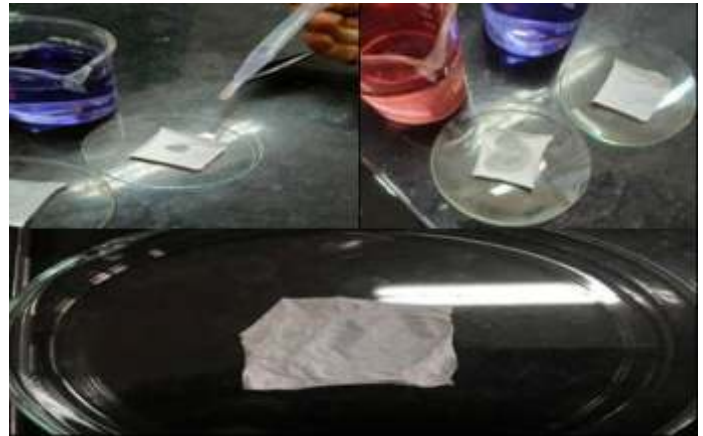
Figure 8b: FTIR result of PU+PVC nano-film

PU has characteristic peaks near 3335cm⁻¹, 2800cm⁻¹, 1728 cm⁻¹, 1596 cm⁻¹& 1170 for stretching vibrations of –NH, CH₂, C=O, –CN, & C–O–C respectively. The FTIR spectrum of PVC displays peaks at 2953 cm⁻¹ and 2921 cm⁻¹, consisting of the CH₂ asymmetric stretching vibration mode. The peaks near 1400 cm⁻¹ correspond to the C – H aliphatic bending. The peak at 1220 cm⁻¹ is accredited to the bending bond of C – H near Cl. The C – C stretching bond of the PVC backbone chain occurs in the range 1010 – 1140 cm⁻¹. C – Cl gauche formation gives peaks in the range of 600 – 620 cm⁻¹. FTIR analysis of PU-PVC composite shows almost no

deviation from the observed peaks for both chemicals. It indicates negligible changes in the chemicals, and the original properties of respective chemicals are retained.

3.8. Quick-dry and Wicking Test

The significance of this method is how quickly a wetted fabric can be dried through three parameters i.e. absorbency, wicking and evaporation. A single drop test was employed to measure the evaporation rate, as shown in Figure 9.



**Quick drying of bi-layered nano-film
Figure 9: Water absorbency, wicking and quick-dry effect**

The analysis and observation indicated that the absorbance of water drop was instantaneous, the spread of the wet area was uniform and wider and the 1 ml water put on the nano-film dried in approximately 80-85 seconds, which indicated satisfactory results.

3.9 Cost analysis of a pair of gloves

Table 3 represents the indicative cost analysis of the Janus material-based fabric prepared for making the surgical gloves.

Table 3: Cost of chemicals used

Name of Chemicals	Price of chemicals (?)	Per capita used X Price (?)
PVA	620/0.5kg	1g X 8 X 1.24= 9.92
PVC	170/kg	1gm X 0.12gm X 0.17= 0.0204
PU	400/kg	1gm X 4.8gm X 0.4= 1.92
Betulin	1000/gm	1gm X 1000 X 0.19gm= 190
DMF	310/0.5l	1ml X 25ml X 0.62= 15.5
THF	650/0.5l	1ml X 25ml X 1.3= 32.5
HCl	205/0.5l	1ml X 5ml X 0.41= 2.05
GA	490/0.5l	1ml X 0.5ml X 0.49= 0.245
Acetone	290/0.5l	1ml X 20ml X 0.58= 11.6
Total chemical cost (Approx.)		=?263.75

The cost calculation given in the above table indicates that even though the chemicals used are of laboratory reagent grade and procured in small quantities at a commercial price,

the overall cost of making the Janus material based surgical gloves would be comparable to the commercially available gloves in the market. However, the cost of machinery involved in making the moulded gloves is not taken into consideration.

- Total chemical consumption cost/pair of gloves \approx ₹263.75
- Price estimate excludes equipment cost, wages, and other utilities
- Large-scale manufacturing will further reduce the overall production costs

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4. Conclusion

Two separate nano-fibre materials of different properties were successfully synthesized using a multistep process. These fibres were independent, had no interacting properties, and fused using a suitable adhesive agent. Analytical evaluation of each fibre indicated that the synthesized material is chemically and physically up to the requirement for further tests. The performance of the Janus material was analysed and found to be effective, as hypothesized. The antimicrobial property of this material can reduce the rate of secondary infections. This material's reusability would help reduce wastage and resultant environmental pollution.

Fabrication of Tissue Engineering-Related Bio-composite Sheets from Silk Cocoons

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Abstract

Bio-materials based on silk have been investigated as a natural-based approach for tissue regeneration. By carefully controlling the deposition of hydroxyapatite (HA) using the precipitation technique with calcium chloride dihydrate and disodium hydrogen phosphate anhydrous solutions on porous silk cocoon structures, bio-composite sheets were created. The appearance of distinctive apatite peaks in the XRD patterns served as confirmation that hydroxyapatite coating had formed on the silk sheets. A change in the amide peaks of bio-composites, as seen from the IR spectra, served as proof of the interactions between HA and silk proteins. The thermogravimetric research showed that the mineralization of silk sheets did not affect their thermal stability. On the surface of the fibrous silk networks, hydroxyapatite had grown, as shown by scanning electron microscopy of the silk sheets. Compared to natural silk sheets, having a tensile strength of 32 MPa, the bio-composite sheets have tensile strength ranges from 21 to 30 MPa. The characteristics of the bio-composite sheets made of silk cocoon and hydroxyapatite show that they have the potential to be used as a viable substrate for bone tissue engineering.

Keywords: *Bio-composite, bone tissue engineering, mineralization, hydroxyapatite silk cocoon; silk proteins*

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1. Introduction

The aim of tissue engineering is producing an alternative biological structure in vitro that can enable tissue repair and regeneration in vivo at the defect location [1]. For usage as scaffolds, thin films, and bio-composite sheets in tissue regeneration, a wide variety of biodegradable polymer and ceramic materials of both natural and synthetic origin are available [2]. Due to their structural resemblance to host macromolecules, biodegradability, and biocompatibility, natural polymers have an advantage over synthetic polymers [3]. One naturally occurring biomaterial is the silk cocoon, which is composed of the two proteins hydrophobic fibroin and hydrophilic sericin [4]. The core protein known as fibroin and the glue-like compound known as sericin work together to create the successive layers of a cocoon. The composite structure of the silk cocoon is made up of this unusual porous network [5]. Among the silkworm species, *Bombyx mori* silk cocoons are a well-domesticated species. Excellent bioactivity, biocompatibility, biodegradability, water vapour permeability, and mild inflammatory response are all characteristics of silk proteins [6].

Because of its notable qualities, including mechanical integrity, minimal inflammatory response, bio-degradability, and biocompatibility, silk fibre has been utilised for millennia as suture material and gauze for medical purposes [7]. Silk fibres can be employed as scaffolds, hydrogels, films, and fibres as well as in their natural and regenerated forms [8–11].

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Recent research on silk-based biomaterials has focused on isolating silk proteins and combining them with other polymers and ceramics to improve their mechanical and physicochemical characteristics [4]. Typically, silk proteins are used in bio-composites as a matrix material or as reinforcing fibres. Silk is being employed to create composites for tissue engineering applications since it is a renewable, sustainable, and biodegradable material [12]. Sericin gives the cocoon structure in silk, the bonding agent, a great mechanical integrity. Sericin degumming might weaken the cocoon's mechanical qualities. Because of this, the native silk cocoons were employed in the current investigation without the sericin protein being degummed, and the characteristics of the silk sheets were examined for use in tissue engineering. In general, adding bio-ceramics to the polymer matrix gives bio-composites vital features including osteoconductive, biocompatibility, and bioactivity. Since more than 30 years ago, hydroxyapatite (HA), a well-known calcium phosphate bone mineral, has been employed widely for bone repair and regeneration.

By precipitating hydroxyapatite on the three-dimensional fibre networks of natural silk sheets, the current study aims to create a bio-composite sheet. It is anticipated that the silk proteins would help the apatite nanocrystals nucleate and form composites, simulating the way hydroxyapatite crystals naturally develop in bone. Hence, by using silk sheets in their natural state and mineralizing them could enhance their suitability for bone tissue engineering applications.

2. Materials and Methods

Bombyx mori cocoons were bought at the Vellore, India, Government silk cocoon sale (Figure 1).



Figure 1: Bombyx mori silk cocoon collection

The cocoons were cleaned after the larvae were removed, and then they were sliced into rectangular sheets with dimensions of 20 mm in height and 4 mm in breadth. Both disodium hydrogen phosphate anhydrous (Na_2HPO_4) and calcium chloride dehydrate ($\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$) were purchased (Figure 2).

2.1 Fabrication of bio-composite sheets

A calcium-phosphate (Ca-P) alternative soaking technique was used to mineralize silk sheets (SC) [11]. The cocoon sheets were immersed for 30 minutes in each of a series of calcium chloride and phosphate solutions to facilitate the mineralization process, which resulted in the precipitation of HA. The sheets, which were treated with calcium and phosphate for 2–5 cycles, are designated as SCM2, SCM3, SCM4, and SCM5, respectively. The bio-composite sheets were dried at 40°C overnight after the mineralization procedure to allow for a solid deposition of minerals on them.

2.2 XRD Analysis

The apatite formation in the bio-composite sheets was characterised by X-ray diffraction with monochromatic $\text{Cu-K}\alpha$ radiation ($\lambda = 1.54 \text{ \AA}$) as shown in Fig. 3. The instrument was operated at 40 kV and 30 mA.

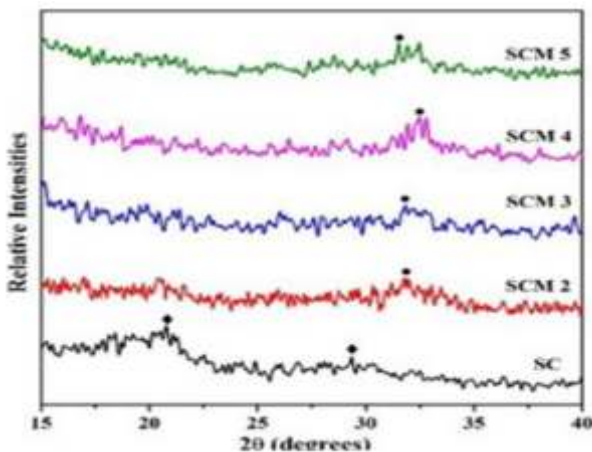


Figure 3 - XRD patterns of native silk sheet (SC) and bio-composite sheets

2.3 FTIR

The interaction between silk proteins and hydroxyapatite in the fabricated bio-composite sheets was determined by

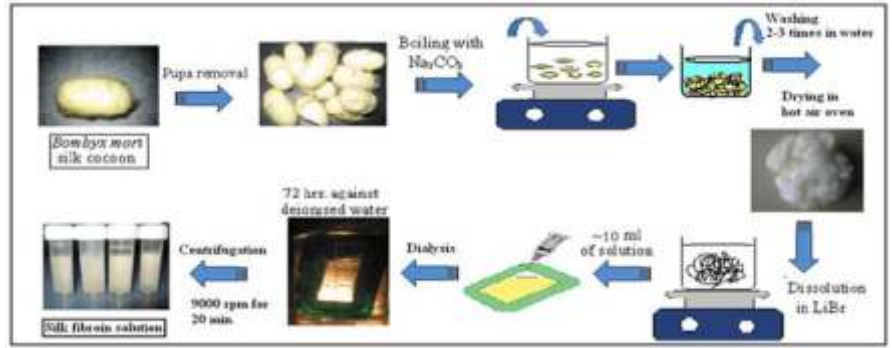


Figure 2: Extraction of fibroin protein from Bombyx mori silk cocoon

Fourier transform infrared spectroscopy. The spectrum was recorded in the range of 400–4000 cm^{-1} at a resolution of 4cm^{-1} . ATR-FTIR spectra of native silk sheet (SC) and bio-composite sheets are shown in Fig. 4.

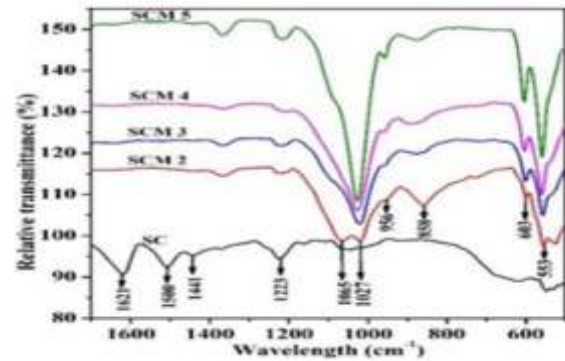


Figure 4 - ATR-FTIR spectra of native silk sheet (SC) and bio-composite sheets

2.4 Thermal Analysis

Thermogravimetric analysis (TGA) was used to determine the thermal deterioration of the silk and bio-composite sheets and is depicted in Fig. 5. Samples weighing around 4–5 mg were heated to 800°C at a ramp rate of 20°C/min and a nitrogen flow of 100 ml/min.

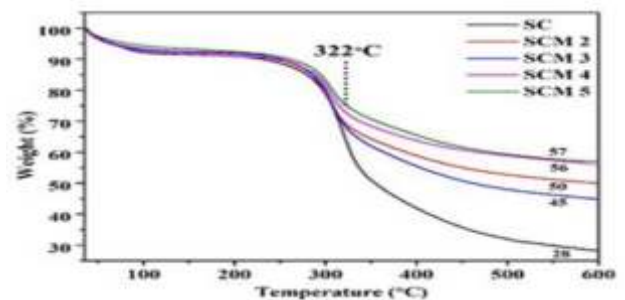


Figure 5 – TGA curves of native silk sheet and bio-composite sheets

2.5. Morphological Analysis

Scanning Electron Microscopy at 20 kV and a working distance of 10 mm was used to analyse the surface morphology of the samples in order to clarify the apatite production and microstructural arrangements in the native silk and bio-composite sheets. The samples were imaged

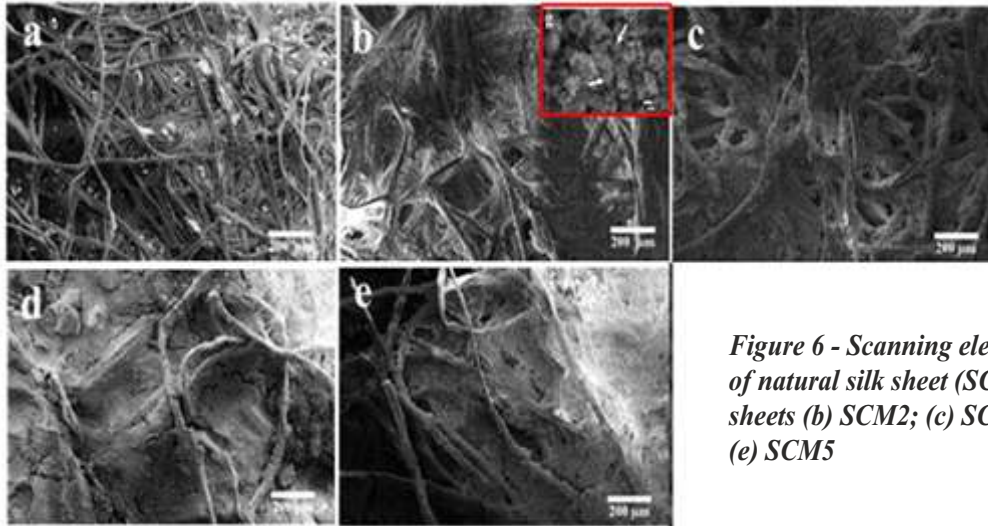


Figure 6 - Scanning electron micrographs of natural silk sheet (SC) and bio-composite sheets (b) SCM2; (c) SCM3; (d) SCM4; (e) SCM5

after being coated with a gold-palladium sputter layer and is depicted in Fig. 6. Scanning electron microscopy of natural silk sheets (Figure 6(a)) shows a random orientation of fibres which forms a three-dimensional, interconnected porous network suitable for the cells to migrate and proliferate. Surface morphology of bio-composite sheets revealed the coating of hydroxyapatite on the silk fibres and their deposition on the fibrous network of silk sheets with an increase in the mineralisation cycles (Figure 6(b)–(e)).

3. Results and Discussion

Biopolymers and ceramics reinforced with natural fibres derived from plant or animal origin make up the majority of bio-composites. The degummed bio-composite sheet at its free surface really showed far less variability in fibre orientation than the free surface of the original *B. mori* cocoon did [12]. Apatite crystals added to the fibre network would create a more favourable environment for osteoconductive, allowing these bio-composite sheets to function more effectively [13]. One of the animal-based natural fibres derived from silkworms is silk, which has promise for use as a biomaterial in a number of biological applications [14]. For their prospective uses, natural fibre bio-composites need to have the right fibre orientation, fibre dispersion, interfacial strength, and porosity [15]. We can employ a silk cocoon in its original state without losing its qualities for tissue engineering applications since the native silk cocoon shell has high fibre strength, dispersion, and porosity. Minerals were deposited on the surface of silk sheets as a result of the precipitation procedure used to mineralize silk cocoons. As the number of cycles treated to Ca-P treatments rises, so does the quantity of mineralization. The other treatments resulted in fibroins with noticeably distinct chemical shifts, but the regenerated fibroins from CaCl₂-ethanol were almost identical to degummed silk fibroin [16].

3.1 Thermal Analysis

The mass variations of native silk and bio-composite sheets were assessed using thermogravimetric analysis, which alters the mass of the samples as a function of temperature (Figure 5). The native silk sheets degraded in three stages, with the initial weight loss (6–8% wt%) occurring below 200°C as a result of surface water evaporation. The disintegration of side-chain groups of amino acid residues and the breaking of peptide bonds in the silk proteins is responsible for the second weight loss (21–28 wt%) between 200°C and 350°C [17]. Silk fibres degrade at temperatures between 350°C and 800°C. The only difference between the degradation curves of all the bio-composite sheets and those of native silk sheets is the overall amount of weight lost. The mass changes of the materials were assessed using a thermogravimetric analysis on native silk and bio-composite sheets. With further mineralization cycles, the residual weight % in the bio-composite sheets grew and was higher than that of the native silk sheets.

3.2 Structural morphology

From the scanning electron microscopy (Figure 6) of natural silk sheets demonstrates the fibres' random orientation, which creates a three-dimensional, interconnected porosity network ideal for cell migration and proliferation. The hydroxyapatite coating on the silk fibres and their deposition on the fibrous network of silk sheets with an increase in the mineralisation cycles were shown by the surface morphology of bio-composite sheets. Both the surface and the inside of the fibrous network showed signs of mineralization, and the quantity of mineralization grows as the number of Ca-P treatments increases. Compared to their initial state, regenerated fibroin materials exhibit inferior mechanical qualities and are more brittle [18]. With more mineralization cycles, apatite crystals spread out throughout the surface of the fibrous network and grow along the length of the fibres.

3.3 Mechanical Analysis

Compared to the bio-composite sheets, the natural silk sheets have relatively better tensile strength. The random orientation of the fibres provides reduced lateral resistance to crack propagation, which causes the initiation of fracture for the native sheets to rise quickly. The addition of hydroxyapatite plugs the holes and provides the bio-composite sheets a more robust structure. Although the tensile strength of the bio-composite sheets is lower than that of native silk sheets, the elastic modulus is higher for SCM3 and SCM4. The original silk sheets have a maximum elastic modulus of 432 MPa whereas SCM3 has a maximum elastic modulus of 464 MPa. Initial load resistance is provided by the inclusion of hydroxyapatite into the silk sheets, whereas mineral shedding provides that resistance.

The integration of hydroxyapatite into the silk sheets provides initial load resistance, however the loss of minerals caused by the sheets' mechanical integrity, as seen by the bio-composite sheet's greater elastic modulus and lower tensile strength.

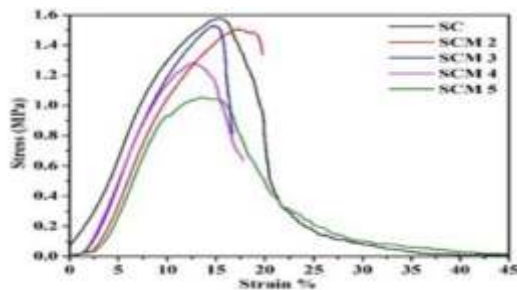


Figure 7 - Stress-strain curves of native silk sheet (SC) and bio-composite sheets

All of these SEM, XRD analyses, and FTIR studies effectively demonstrated that this composite would be a contender for use in bone tissue engineering [19]. Tissue engineering (TE) has attracted increasing attention as an alternative method for producing patient-specific tissues for repair and replacement applications [20]. The typical TE applications of SF-based scaffolds including bone, cartilage, ligament, tendon, skin, wound healing, and tympanic membrane, was highlighted and discussed, followed by future prospects and challenges needing [21].

4. Conclusion

Native silk sheets have been investigated as viable biomaterials for tissue engineering because of their intrinsic proteins' biocompatibility and strong mechanical strength. In this work, an effort was made to employ native silk sheets and mineralized silk sheets for applications since degumming of silk proteins may impair their mechanical strength. On the silk sheets, the development of hydroxyapatite was verified by XRD and FTIR analyses. The heat breakdown of silk proteins in the bio-composite sheets was unaffected by the mineralization process. Scanning electron microscopy was used to confirm that apatite crystals were growing on the silk sheets, and as the number of Ca-P treatments increased, more mineralization occurred. When compared to native silk sheets, mineralization reduced the tensile strength for all the bio-composite sheets while increasing the elastic modulus in SCM3 and SCM4. Structural and morphological studies revealed the effectiveness of this composite for use in bone tissue engineering.

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Review - Textile Fibres for Sports Applications

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Abstract

The sports and allied industries rely heavily on textiles. Active sports apparel is commonly made from a variety of natural and synthetic fibres, including cotton, wool, polyester, and nylon. The term "textile" is always supported in a variety of sports to enhance the performance of the athlete and sportsman. Researchers have begun developing a various apparels including swimsuit that quickly repels water without depleting the swimmer's vitality, suit constructed of modified polyesters for racers and cycle riders that improves performance without diminishing energy.

Keywords: Athlete, Cotton, Polyester, Sports

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1. Introduction

Sports textile is a growing industry in India and contributes 7% to the market for technical textiles as a whole. It includes several aspects of the sport, such as apparel, sports equipment, and sports accessories. Knowing the advantages of natural and synthetic textile materials is crucial because of the advantages of textiles in sport. It has been noted that modified synthetic fibres are utilised in numerous sporting goods applications to create shirts, pants, hats, and shoes to improve athletes' performance in a variety of sports competitions, including running, swimming, and many other competitions. The demand for textiles in the area of active sportswear and outdoor leisure activities like flying, climbing, and cycling has increased drastically. In a wide range of sports, such as cycling, skiing, bobsleighbing, sprinting, and speed skating, aerodynamics plays a vital part in high performance fabrics. The textile surface morphology, faster location, and air permeability are taken into account when analysing this aerodynamic performance [1]. Textile sensor development is discretely included into a sports clothing where some textile-based sensors that have been incorporated into apparel for various sporting purposes [2].

2. Review of literature

Sportswear's wearability is a key criterion for quality. It affects the wearer's performance and efficiency in addition to their general health. The "physiological function" of sportswear can be appropriately characterised as wear comfort. Another crucial part of sales is wearability. Many individuals think that one's level of comfort is unique to them and cannot be measured or quantified. But in reality, our bodies' physiological functions directly correspond to how comfortable our clothing is. Energy saving is the foundation of thermos physiological comfort [3]. The demand for active

sportswear is rising from kids, old age group, and women who participate in aerobics and competitive sports. A well-designed sports fabric should satisfy the comfort requirements tactile comfort, mobility, and psychological comfort. This could be done by controlling air permeability, moisture vapour, and moisture content while maintaining the necessary thermal insulation. The expertise of textile science and polymer science has been applied to the development of an engineered athletic textile. [4]. Sportswear is made to offer the athlete with physical support and not limit his movement while he is working out.

Sportswear can be categorised into four classes based on the degree of professionalism and intended use: clothing that is basic, casual, fashionable, and practical. In order to achieve the essential intemperance of heat and moisture, the fabrics used for active sportswear are particularly built in terms of the geometry, packing density, and structure of the component fibres in yarn as well as their construction. [5]. The sporting goods industry faced technological obstacles and opportunities as it sought to adopt the sustainable design model. The ecological use of composite materials in sports equipment was able to address the various hurdles and opportunities.[6] Sportswear made of textiles should pertain Some Essential characteristics like anti static, antimicrobial, water and air permeable, light weight, strong and stretchable. It should immediately absorb moisture to assist keep the skin dry and fast absorb sweat from the skin [7]. When evaluating the performance of specific clothes, comfort is one of the key factors for any sport textile material and can be regarded essential for fabric selection. Comfort is a feeling of fabric that everyone can identify when wearing clothing; it is a personal response brought on by a number of circumstances. Active sportswear must have four sorts of comfort features to function properly. These are:

2.1 Thermal comfort

When engaging in any athletic activity, the sportsperson's thermal balance is crucial. In this situation, it is clear that the rate of heat loss from the wearer's body is always equal to the rate of heat creation by the various physiological processes. Determining the breathability and moisture management

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capabilities of sports textile made fabric is always aided by this activity [7].

2.2 Tactile comfort

A primary sort of comfort is tactile comfort, which essentially has more to do with how a person feels when wearing a garment next to their skin than it does with temperature regulation. As these garments are worn close to the skin and function as a second skin, they impart the sensory feeling of the manufactured fabric, which is directly related to the cloth structure, kind of fibres, moisture absorbance, and moisture transport [8].

2.3 Mobility

Sportswear that is functional must be extremely light, have good wickability, and be sufficiently stretchable. It has been found that somebody components move when engaging in a variety of athletic activities. Stretch-to-fit clothing must be produced, and active sportswear must have elasticity (mobility) qualities to allow body components to move freely [9].

2.4 Psychological comfort

It is a necessary aesthetic quality for a sportsperson to feel at ease when engaging in a variety of sports activities, and we may ascertain this based on the wearer's psychological comfort [9].

3. Fibres used for sportswear Production

3.1 Cotton

A naturally occurring cellulosic fibre with remarkable comfort qualities, cotton is derived from the biological species *Gossypium*. It is a member of the Malvaceae family. The increased absorption and retention of moisture inside the cotton fibre has led to a noticeable decrease in the usage of cotton fibres for the manufacture of sportswear. The athlete's comfort has been impacted by this; while it offers outstanding comfort while dry, it gets heavier and stickier after sweat absorption and increases wearer discomfort [10].

3.2 Wool

Cycling and running clothing frequently uses wool and other fine wool fibres. The hydrophilic, great wicking, quick drying, and maintenance of the body's natural cooling system are all characteristics of merino wool fibre. The body's natural thermoregulatory system is maintained by fine wool fibres with outstanding absorption qualities, such as Wool fibres, in a variety of environmental circumstances [11].

3.3 Polyester

The majority of sportswear is made from polyester knitted fabrics. It is a synthetic fibre produced via polycondensation reactions between monoethylene glycol and PTA (Pure Terephthalic Acid). For PET polymer, two processes—esterification and transesterification—have been

favoured. Manufacturing polyester fibre and filament typically uses continuous polymerization and melt spinning. PET fibres have a density of 1.38 g/cm³, great mechanical qualities, and a wide range of textile applications that they can be used for. Different cross-sections of polyester fibre, including round, hollow round, trilobal, hollow trilobal cross-section, and bicomponent, can be produced. Polyester also has outstanding thermal stability or heat resistance. Cross-sectional fibres and filaments play a unique role in the phenomena of moisture transportation, which benefits athlete comfort [12].

3.4 Hollow fibres

A hollow fibre is a filament or staple fibre that has one or more axially implanted hollow (air) cores. They were developed with the goal of creating fibres with a lumen similar to cotton fibre. Although practically all synthetic fibres can be made as hollow fibres thanks to technological advancements, polyester and polyamide hollow fibres are most frequently utilised for athletic apparel. They might have a trilobal, square, hexalobal, or circular cross section. In addition to having superior bending and torsion (twisting) capabilities compared to normal fibres, hollow fibres have higher heat insulation. They are frequently utilised to create clothing with thermal protection qualities as well as clothing for a variety of winter sports. These fibres are extremely light because of the voids in the structure [12].

3.5 Polypropylene

One of the thermoplastic polymers produced by solution polymerization, polypropylene are finds extensive use in textiles. It is a member of the polyolefin family and contains non-polar and partly crystalline groups. Winter clothing and sports apparel can benefit from better moisture management because to the hydrophobic nature of polypropylene and its excellent thermal qualities [12].

3.6 Lycra

Due to its ease and comfort of wear, Lycra, a long-chain synthetic polymer fibre that contains 85% segmented polyurethane, has a wide range of uses in floor gymnastics, active sportswear, and swimwear. Lycra's stretch recovery feature gives value to sports fabrics used in gymnastics and swimming, where body skin flexing and stretching are inevitable [13].

3.7 Microfiber

Manufactured fibres with high linear densities, typically less than 0.4 dtex and available in polyester and nylon, are known as microfibers. These microfibers provide a soft feel, high strength, and durability. They are also water repellent and have good air permeability, which all contribute to the development of comfort features. The high fineness of microfibers results in enhanced porosity, which enhances the textile material's ability to move water vapour out of it and its capacity to regulate temperature [13].

4. Conclusion

Sportswear is made primarily of synthetic and natural fibres; tracksuits, swimmers, and t-shirts are typically made of cotton, wool, polyester, and microfibers. Due of its elasticity and player-friendly advantages, lycra is mostly utilised in

sporting and swimming. Microfibers are used because of their supple texture, capacity to wick away moisture, and capacity to control temperature. The purpose of new textile fibres is to benefit players as much as possible by enhancing their performance in games of ground, water, and air sports.

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Studies on Thermal Behavior of Cotton × Eri/Polyester Blended Fabrics Using Box and Behnken Design of Experiment

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Abstract

Among the four varieties of silk fibre available in India, eri is reported to possess excellent thermal insulation character and the fabrics made of eri silk yarn is popularly used as warmth giving apparels mostly among the people of in north-eastern states in India. On the other side, polyester fibre which is comparatively cheaper and most usable synthetic fibres has already registered its presence for making apparels. An attempt has been made in this paper to manufacture plain woven fabrics with eri / polyester blended yarn as weft over cotton warp yarn and to conduct an in-depth study on the effect of blend composition and yarn parameters like yarn count (Ne) & amount of twist on its thermal behavior. The Box and Behnken model of Design of Experiment for three variables and three levels, a popular statistical tool has been used to study the effect of chosen factors. The fitted regression equation has been found to be linear in nature indicating the presence of independent effect of yarn fineness, amount of twist and eri content in the blended yarn over thermal insulation value with strong degree of association. The effects of yarn count, amount of twist and proportion of eri in blends have been well justified using response surface methodology.

Keywords: Design of Experiment, Eri silk, Polyester, Surface and Contour plot, Thermal Insulation Value.

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1. Introduction

The functional behavior of a textile fabric is largely influenced by the characteristics of textile fibres and yarns of which it is made. Fabric structure and processing parameters to a large extent also determine the fabric character produced. The selection & arrangement of fibres within the yarn and the arrangement of interlaced yarns within the fabrics are always the chief concern of scientists and researchers for manipulating the behaviour of apparels.

Among many other tasks of clothing, the most important is to protect the wearer from heat and cold. Clothing should ensure appropriate heat transference between the human body and its surroundings in order to maintain the physiological balance of the wearer to provide thermal comfort since a large portion of total comfort is thermal comfort [1]. So, the heat transfer characteristics of textile fabrics which are very important in textile comfort evaluation are regarded as the subject of interest to work with. Quite a few research publications [2-10] are available describing the effect of fibre selection, yarn character, fabric construction, etc. on the thermal behaviour of fabrics. Several literature studies [11, 12, 13] reported that eri silk, the only domesticated non-mulberry variety [14] has very good thermal insulation properties. On the other side polyester, due to its favourable characteristics has already established its place in the domain of apparels. Polyester has also tremendous blending possibilities with other staple

fibre. But not much documented information is available regarding the studies on influence of yarn parameters made of eri and its blend particularly with polyester on thermal behaviour of fabrics made out of it scientifically in detail. Thermal behaviour of fabric is normally assessed by 'Clo' value of the fabric. 'Clo' value of 1 corresponds to the insulating value of clothing which is required to maintain comfort for a person sitting at rest in a room at 21°C with an air movement of 0.1 m/s and humidity less than 50%.

In the present work an attempt has been made to investigate the influence of proportion of eri in blend with polyester fibre and other blended yarn parameters like amount of twist & yarn count on thermal behaviour of the plain-woven fabrics manufactured using 100% cotton yarn as warp and eri/polyester blended yarn as weft in detail. The study has been conducted following Box and Behnken Design of Experiment [15] for three variables and three levels on thermal properties of the fabrics produced. The Box and Behnken Design of Experiment has been popularly used by some researchers in textile [16, 17] to study the effects of variables on responses during yarn manufacturing process. The factors exclusively selected in the present study are count of the blended yarn spun (Ne), amount of twist in yarn (T.M) & proportion of eri (%) in blends as they are supposed to influence the thermal behavior of the fabrics produced.

2. Material and Methods

2.1 Material used

The 100% cotton yarns and blended yarns made of eri with polyester in different proportion as detailed below were used to conduct the present study. Yarn parameters are detailed in Table 1 and 2.

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Table 1: Material used (Warp)

Type of yarns	Count (Ne)	T.M
cotton	2/20 ^S	4.0

Table 2: Material used (Weft)

Type of yarns	Blend ratio	33:67			50:50			67:33		
Eri/Polyester blend	Count spun (Ne)	20 ^S	40 ^S	60 ^S	20 ^S	40 ^S	60 ^S	20 ^S	40 ^S	60 ^S
	Twist multiplier	4.0	3.5, 4.5	4.0	3.5, 4.5	4.0	3.5, 4.5	4.0	3.5, 4.5	4.0

2.2 Sample Preparation

Fabric samples were prepared in a handloom (type: frame loom) using 100% cotton yarn of 2/20S Ne as warp and the eri/polyester blended yarns of varying parameters in terms of count, twist and blend composition as weft, following the Box and Behnken model on design of experiment for three variables and three levels.

Warping was done with required length of 2/20S Ne cotton yarn using vertical drum warping machine usually followed in handloom industries. Pirns were prepared from eri/polyester blended yarns with the help of a charkha usually adopted in handloom sector. Drawing of warp yarns were made through wire healds (one end per eye) followed by denting as two ends per dent in a reed of 40S Stockport. Two heald shafts were used to weave plain fabrics in handloom. After necessary looming work, weaving was carried out to make plain woven fabric samples of sufficient quantity following the sequence of Box and Behnken Design of Experiment. 15 number of fabric samples from each type of blended weft yarn were produced as per the Box and Behnken model of Design of Experiment.

2.3 Test Methodology

2.3.1 Measurement of thermal insulation of fabrics ('Clo' value)

SASMIRA thermal conductivity apparatus (electronic) based on guarded hot plate method was used to measure the thermal insulation properties of all the fabric samples following the standard instruction prescribed in the instrument manual [18]. Thermostat was set at 500C and then guard box was switched on. Temperature was allowed to stabilize at 500C. After the stabilization of temperature, the hot plate was switched on. Once the temperature reached 510C, thermostat became operational and temperature dropped to 450C. Samples were cut using prescribed round plate template and then placed on the hot plate. Once the temperature of the hot plate fall to 450C, sample was made covered with round plate. Temperature was then allowed to rise to 510C. When temperature started falling down again, time taken for the hot plate to cool down from 500C to 490C was measured using a standard stopwatch. Minimum 20 observations were made for each sample to find out average cooling time and the average 'Clo' value (a measure of thermal insulation) was read from the graph of 'clo' vs. time.

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

3. Results and Discussion

3.1 Influence of yarn parameters on thermal behaviour of fabrics

3.1.2 Evaluation of thermal insulation of fabrics made of eri/polyester blended yarn as weft.

In order to evaluate the relationship between the controlled experimental factors and response, the response surface methodology, an empirical modeling technique has been used in the present study. The controlled experimental factors are blended yarn count (Ne), T.M & eri% in the blends of eri/polyester blended yarn which has been used as weft on same cotton warp yarns under identical weaving conditions. The observed response is the thermal insulation values ('clo') of the fabrics.

In a system involving three significant independent variables X1, X2, X3, the mathematical relationship of the response on these variables can be approximated by the quadratic (second degree) polynomial equation;

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

Where, Y = predicted yield, C0= constant, C1, C2 & C3 = linear coefficients, C12, C13 & C23 = cross product coefficients, C11, C22 & C33 = quadratic coefficients

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

$$Y = C_0 + C_1X_1 + C_2X_2 + C_3X_3 \dots\dots\dots (2)$$

[Considering the linear terms only],

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

[Considering the linear + square terms only],

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

[Considering the linear + interaction terms only],

Multiple regression analysis in addition to ANOVA using MINITAB 13 software is done to obtain the coefficients based on best R2 (adj) value obtained among above four equations. The regression equations are evaluated through backward elimination method in which the factors are excluded based on their p-values at the level of 95%.

Using the experimental results of all the fabric samples as presented in Table 3 the regression equations for the response (T.I.V) is developed and shown in Table 4. The given R2 (adj) value of the equation depicts the strength of relationship between the factors and response. The generated Contour & surface plot of cotton × eri/polyester fabric samples in Fig. 3 to 5 show the effects of the blended yarn parameters on thermal insulation of the fabrics.

Table 3: Thermal insulation values (Clo) of fabrics made of eri/polyester blended yarn

Run No.	Combination of variables			Weft (eri/polyester) Thermal insulation values (Clo)
	Count (Ne) X ₁	T.M X ₂	% of Eri X ₃	
1	20	3.5	50	0.67 (4.58)
2	60	3.5	50	0.66 (5.04)
3	20	4.5	50	0.67 (4.98)
4	60	4.5	50	0.64 (5.09)
5	20	4.0	33	0.65 (5.78)
6	60	4.0	33	0.62 (4.27)
7	20	4.0	67	0.69 (4.86)
8	60	4.0	67	0.67 (5.21)
9	40	3.5	33	0.63 (4.92)
10	40	4.5	33	0.62 (5.01)
11	40	3.5	67	0.69 (5.32)
12	40	4.5	67	0.68 (5.42)
13	40	4.0	50	0.66 (5.66)
14	40	4.0	50	0.65 (5.33)
15	40	4.0	50	0.66 (4.85)

Note: Values within bracket show respective C.V%

Table 4: Response surface equation

Type of fabric	Response	Regression equation	Coefficient of Determination (R ²)
cotton×eri / polyester	T.I.V (Clo)	0.643 - 0.000563X ₁ - 0.0100X ₂ + 0.00154X ₃	93.0

It is observed from the above response surface equation that, the relationship between the response i.e., thermal insulation value of the fabric and the variable factors i.e., yarn count, amount of twist & eri% in blend of the blended yarn follows a linear one as judged from the best p-values of the variables. The co-efficient of determination value of 93% is also very good and acceptable. It is also observed from the equation in

Table 4 and Fig. 3 to 4 that the thermal insulation value of fabric increases with the increase in coarseness of the blended yarn, proportion of eri content in the blend composition and decrease in amount of twist in the yarn. Coarseness of the yarn increases the thickness and decreases the proportion of fabric cover facilitating more entrapped air in the fabric resulting in better thermal insulation. Eri silk having lower thermal conductivity of 0.118W/m-K in transverse direction as measured by Kawabata [19] along with its fluffy nature owing to specific volume of 0.765 g/c.c [20] increases the volume of capillary air in the yarn resulting better insulation properties of the fabrics. With the reduction in twist, the compactness of the yarn structure reduces and the increase in bulkiness of yarn increases the availability of air spaces in yarn structure, leading to increase in thermal insulation

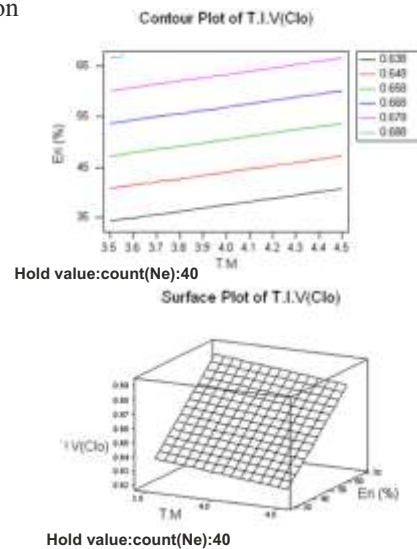


Figure 3: Effect of T.M and eri% in eri/polyester blended yarn at constant yarn count of 40S Ne on thermal insulation (Clo) of cotton × eri/polyester fabric

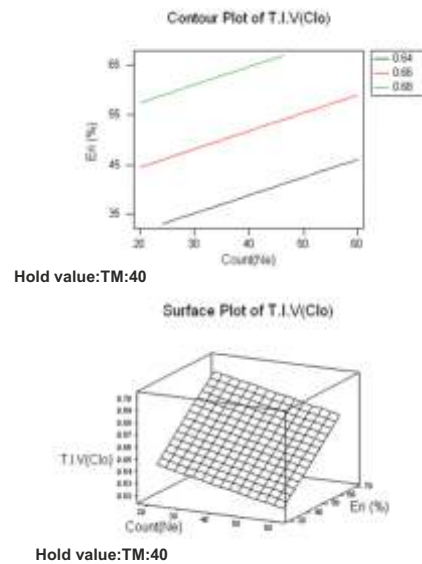


Figure 4: Effect of count and eri% in eri/polyester blended yarn at constant T.M of 4.0 on thermal insulation (Clo) of cotton × eri/polyester fabric

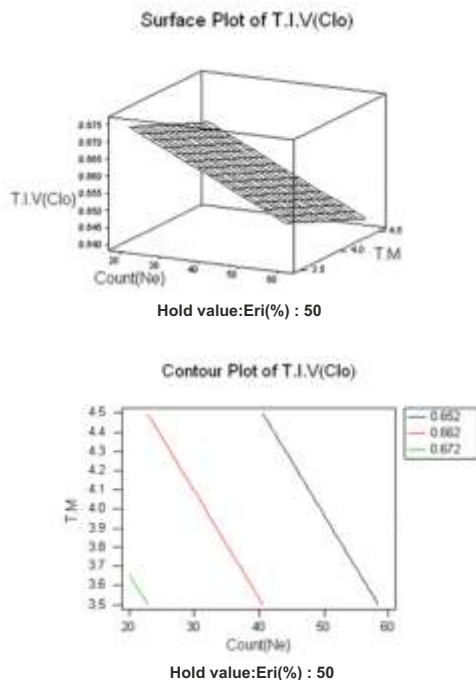


Figure 5: Effect of count and T.M in eri/polyester blended yarn at constant eri% of 50 on thermal insulation (Clo) of cotton × eri/polyester fabric

4. Conclusion

Thorough investigation in the thermal properties of the fabrics made of eri/polyester blended yarn over cotton warp have shown that thermal insulation values are largely dependent on the constituent yarn character of count (Ne), amount of twist and the blend proportion. It has also been found that the eri/polyester blended yarn has shown very good thermal insulation value (0.638 to 0.688 'clo') under the specified range of chosen factors. Investigation into the yarn parameters like fineness, twist and blend proportion on thermal behaviour of the fabrics produced has shown that the fitted regression equations is linear in nature indicating the presence of independent effect of yarn fineness, twist and eri content in blend over thermal insulation value with strong degree of association ($R^2 \% = 93.0$). The influence of yarn parameters on response has been explained judiciously.

Considering all the aspects of the present work it is expected that the findings may be useful in exploring eri in blends with polyester to design fabrics suitable for manufacturing warmth giving clothing meant for apparels.

Proper implementation of the findings of the present work will definitely improve the economic scenario of eri producing areas in our country.

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To Study the PET/Bamboo & PET/Cotton Blend Yarn to Made for the Knitted Fabric on Comfort Properties Behavior: Part-II

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Abstract:

Moisture management comfort property is an important aspect of any fabric meant for knitted & active wear, which decides the comfort level of that fabric specially used as T shirt. A fabric's moisture management performance is also influenced by its air and water vapour permeability. In this research work the effect of yarn count, types of fibre and blend composition on fabrics properties made from Polyester/bamboo and Polyester/cotton blended yarn has been studied. Three types of blend of polyester/bamboo and polyester/cotton (80/20, 65/35, 50/50) are used for 20s and 30s Ne yarn preparation. Air permeability and total absorbency parameters are higher in polyester/bamboo fabric as compared to polyester/cotton blended fabrics. However, vertical wicking is lower in polyester/bamboo blended fabrics.

Keywords: Knit Fabric; Air permeability; Total Absorbency; Vertical Wicking.

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1. Introduction

In last ten years the technology is changed a lot of, the demand of fabric is also changed and the changes in the cloth comforts in which sensorial, psychological and thermo physiological comfort. It is now not only about style and durability. The factors on which comfort is based are types of fibre, fabric structure, yarn properties, finishing treatments and clothing conditions [1]. Fabric's thermal comfort is controlled by the heat movement, flow of moisture and air through the fabric. To increase the properties of resultant yarn type and to reduce the cost of the raw material blending of different fibres is done which is a common practice in the spinning industries. The percentage of fibres in the blend have effect on various properties and besides it, the properties of blended yarns are affected by the properties of the constituent fibres and their compatibility. Further, it is observed that the stronger fibres have to be blended at least by a certain percentage in order to increase the tensile properties [2, 3]. Bamboo has a number of particular properties like anti-static property, inherent antibacterial property (a single antiseptic and bacteriostatic bio-agent known as "Bamboo Kun" is strongly combined with bamboo cellulose molecules and remains during the process of being produced into bamboo fibre) and good UV defense [4, 5]. Bamboo cellulose fibers that have been regenerated provide excellent comfort in a variety of applications. Innerwear, hygienic goods, home furnishings, sanitary fabrics, and nonwovens all use regenerated bamboo fibre these days [6, 7]. Eco friendly processes have been developed for the

bleaching of fabric with a view to reduce the water consumption and processing time. There is no significant difference in the whiteness values. Further, by employing eco-friendly processes, there is significant decrease in volume of effluent generated [8, 9, 10]. Although considerable research work carried out on study of cotton and bamboo fibres for apparel applications but limited work available on blended fabrics with finishing treatment like enzymatic finishing. Hence, in this research work, yarns and fabrics made from different blends of polyester/ bamboo and polyester/ cotton have been studied and analysed in grey and Bio-Finished stage. Due to the increasing demand for knitted garment these days, knitted fabrics have been produced and studied.

2 Materials and Methods

2.1 Raw Material

In the present study the various elements of textile material have been taken into account. For the blended fabric sample preparation three fibers used are Bamboo, Polyester and Cotton. Polyester fibers in various proportions are blended with two different fibres.

2.1.2. Fibres Parameters

Table 1 Specification of fibres

Fibre	Length (in mm)	Fineness	Tenacity (gpd)	Short fibre %	Elongation %
Bamboo	38	1.54 D	2.5	-	20.8
Cotton	30	3.5mic/1.23D	3.5	7.5	5.3
Polyester	38	1.38 D	5.8	-	24

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Table 2 Specification for the Polyester/Cotton and Polyester/Bamboo fabrics

S. No.	Blend ratio & samples	Count (Ne)	GSM (g/m ²)	Stitch length (mm)	WPI	CPI	Stitch density	Thickness (mm)
1.	80/20, PET/Cotton	20s	275	3.5	42	35	1470	0.672
2.	65/35PET/Cotton	20s	270	3.5	42	37	1554	0.652
3.	50/50PET/Cotton	20s	270	3.5	42	37	1554	0.652
4.	80/20, PET/Bamboo	20s	265	3.5	41	36	1476	0.641
5.	65/35PET/Bamboo	20s	268	3.5	41	37	1517	0.651
6.	50/50PET/Bamboo	20s	272	3.5	42	35	1470	0.662
7.	80/20, PET/Cotton	30s	228	3.5	47	42	1974	0.621
8.	65/35PET/Cotton	30s	220	3.5	47	43	2021	0.601
9.	50/50PET/Cotton	30s	218	3.5	46	44	2024	0.602
10.	80/20, PET/Bamboo	30s	221	3.5	47	73	2021	0.599
11.	65/35PET/Bamboo	30s	224	3.5	47	42	1974	0.611
12.	50/50PET/Bamboo	30s	226	3.5	47	41	1927	0.612

2.1.3. Preparation of yarn samples

20s Ne and 30s Ne yarns were prepared in the ratio of (50:50, 65:35, 80:20) using blend of Bamboo and cotton fibre with Polyester. A uniform blend of polyester/bamboo and polyester/ cotton is produced by manual opening and mixing. The ratio taken blending of Bamboo and Cotton fibres with polyester is (50:50, 65:35, 80:20) for Polyester : Bamboo and (50:50, 65:35, 80:20) for Polyester : Cotton. By blending, the functional properties, process performance properties get improved and also it helped in the reduction of cost of mixing. In a Lakshmi Rieters blow room line a predetermined quantity of fibres were mixed and processed.

2.1.4. Fabric samples preparation

The above P/B and P/C yarns were used to make fabric, the no. of different samples were twelve, by using 20s Ne & 30s Ne using circular knitting machine of single jersey. These samples were prepared from polyester/Bamboo and Polyester/Cotton in two set.

2.1.5. Bio-finishing treatment

In bio-finishing, 1% concentrated cellulose enzyme was used and 2g/l acetic acid was added in the bath to make a 5.5 pH buffer solution. The fabrics were treated at a liquor ratio of 1:20 for 60 min at 55°C. Then Na₂CO₃ (sodium Carbonate) was being added to the solution for deactivation by raising the temp up to 70°C for 15 min. After finishing, hot wash was done for 15 min followed by cold wash with addition of acetic acid for neutralization and then washed thoroughly with cold water and samples were air dried and conditioned.

2.2 Methods

Before testing, the conditioning was done for 48 hours of all samples in standard atmospheric condition where temperature was 27 ± 2°C and relative humidity 65 ± 5% as per standards.

2.1.1 Air permeability

The measurement of air permeability is the rate of flow of air which is passing from the fabric from a known area with a

given air pressure. This test method [ASTM D737-96] is used to test the mostly woven fabric, pile fabrics, air bag fabrics, napped fabrics, blankets, knitted fabrics etc. Sample is cut into circular shape and it is clamped in the tester and vacuumed is used and air is charged at one side of fabric. If the air pressure is higher than air will passed from side so lower air pressure is used. The air permeability of fabric is measured by the air flow rate. The tester used for the measurement of air permeability was done on TESTEX TF 164A.

2.2.2 Total absorbency

This test measures the capacity of fabric that how much water it can holds and the measurement is done by using 0.2% of the soap solution. The size of sample was 20 cm x 20 cm. The sample was dipped for 5 minutes in the solution and for removing the extra water drops from sample it was hanged vertically for 5 minutes. The calculation of total absorbency was done by weighing the sample and weight gain in %age was taken of sample.

2.2.3 Vertical wicking

The test of vertical wicking for the fabric was carried out as per the TAPCC standard. The fabric sample from warp and weft direction of sample size 20cm X 2.5 cm was cut after keeping in standard atmospheric conditions. The fabric sample was set up and hanged in vertical direction with the help of ring holder. A beaker was taken in which a coloured solution of naphthalene blue dye with 2gpl was taken. On every sample a line in length wise direction was marked with 3cm distance from edge of fabric. The sample was immersed in the aqueous solution up to the mark line and the height was evaluated after the time period of 1, 5, 10 and 15 minutes respectively.

3 Results and discussion

3.1 Air permeability

The effect of blend, count, fibre type & finish on the air permeability of the fabric is observed from Table 3 and Figure 1. The air permeability of the fabric increases with the

increase in bamboo and cotton %age in the blend. Further, air permeability values are higher in Polyester/ bamboo blend as compared to Polyester/ cotton blend. It may be due to the enhanced rate of air flow as a consequence of the reduced bulk of bamboo fibre and yarns have less hairiness, which offers less resistance to flow of air.

Further it is observed that there is a significant reduction in air permeability of fabrics after bio-finishing. The air permeability of the polyester/cotton blended fabrics is slightly less as compared to polyester/bamboo blended fabrics. The air permeability decreases by increasing the %age of cotton fibre in the blend. It may be due to shrinkage of cotton fabric after washing during bio-finishing. Hence, air permeability decreases due to bio-finishing.

Table 3 : Effect of count, blend, fibre type & finishing on air permeability of polyester/cotton and polyester/bamboo blended fabrics

Yarn Count (Ne)	Blend	Air Permeability before Bio-Finishing (cm ³ /cm ² /sec.)		Air Permeability after Bio-Finishing (cm ³ /cm ² /sec.)	
		Polyester/Cotton	Polyester/Bamboo	Polyester/Cotton	Polyester/Bamboo
20 ^s	80/20	645.72	717.67	596.42	635.79
	65/35	650.22	688.77	615.45	588.43
	50/50	679.58	722.25	697.24	659.45
30 ^s	80/20	678.51	709.58	662.78	677.21
	65/35	696.68	685.54	678.87	650.45
	50/50	698.35	721.15	668.35	672.89

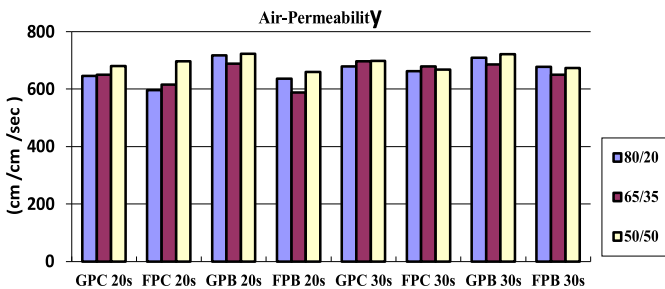


Figure 1 : Effect of count, blend, fibre type & finish on air permeability of fabrics

3.2 Total absorbency

It has been observed from Table 4 and Figure 2 that change in blend percentage of fibre, yarn count and finishing on the fabric effects total absorbency of the fabric. As the % age of cotton and bamboo fibre is increased in the blend the absorbency of the fabric increases. Polyester/Cotton blended fabrics have lower water absorbency as compared to bamboo blended fabrics. It may be due to the presence of micro channel in the bamboo fibre which ultimately results quick transportation water. Further a slight improvement is found in absorbency of fabrics after bio- finishing. This is due to the

removal of oil and wax contents from the fabric surface and presence of cellulose enzyme which improves partial surface hydrophilic nature of the fabrics.

Table 4: Effect of count, blend, fibre type & finishing on total absorbency of polyester/cotton and polyester/bamboo blended fabrics

Yarn Count (Ne)	Blend	Total Absorbency (%) before Bio-Finishing		Total Absorbency (%) after Bio-Finishing	
		Polyester/Cotton	Polyester/Bamboo	Polyester/Cotton	Polyester/Bamboo
20 ^s	80/20	197	215.70	212.67	215
	65/35	217.47	221.15	252.45	235.90
	50/50	253.78	275.90	261.28	304.95
30 ^s	80/20	213.38	290.50	231.40	315.66
	65/35	285.72	320.29	292.20	325.56
	50/50	295.20	350.55	323.96	365.33

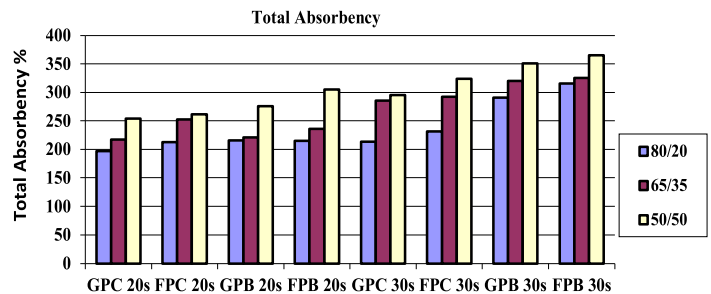


Figure 2 : Effect of count, blend, fibre type & finish on fabric total absorbency

3.3 Vertical wicking

The vertical wicking property of fabric is observed from Table 5 (A) and Figure 3 shows the effect of blend, count, fibre type & finish on the fabrics. Wickability increases with increase in bamboo percentage in the P/B blend. It is due to the high water absorption of bamboo fibre. The cross-section of fibre is filled with micro pockets and channels that give the fibre/fabric high wicking property. Hence the wickability of fabric increases with increase in bamboo fibre content in the blend.

It is further added that enzyme treated fabric shows higher wicking property for both polyester/cotton and polyester/bamboo blends as compared to grey fabric irrespective of count. It is due to the sufficient removal of oils, gums and other intercellular substances for cellulose mass after bio-finishing.

It can be also observed from Table 5 (B) and Figure 4 that wickability of fabric is more in wale wise direction as compared to coarse wise direction. It is due to the fact that the transfer of water is easier in wale wise direction due to better capillary action in wale wise direction.

Table 5 (A) : Effect count, blend, fibre type & finishing on vertical wicking of polyester cotton and polyester-bamboo blended fabrics wale wise

Yarn Count (Ne)	Blend	Vertical Wicking before Bio-Finishing (wale wise) cm/15 min		Vertical Wicking after Bio-Finishing (wale wise) cm/15 min	
		Polyester/Cotton	Polyester/Bamboo	Polyester/Cotton	Polyester/Bamboo
20 ^s	80/20	5.7	6.5	11.7	14.0
	65/35	5.3	6.6	11.8	14.0
	50/50	5.5	6.9	10.2	14.3
30 ^s	80/20	5.5	5.5	11.5	14.1
	65/35	5.0	5.9	12.4	14.1
	50/50	5.1	6.6	10.3	14.6

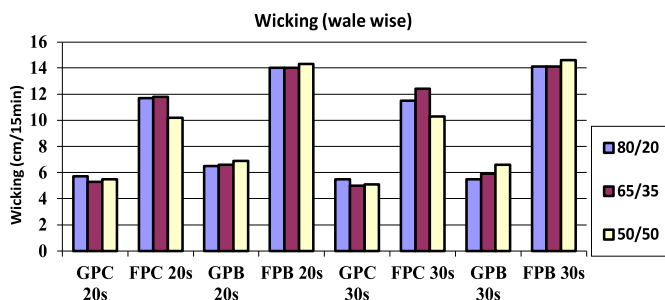


Figure 3 : Effect of blend, count, fibre type & finish on fabrics wicking (15 min) for wale wise direction

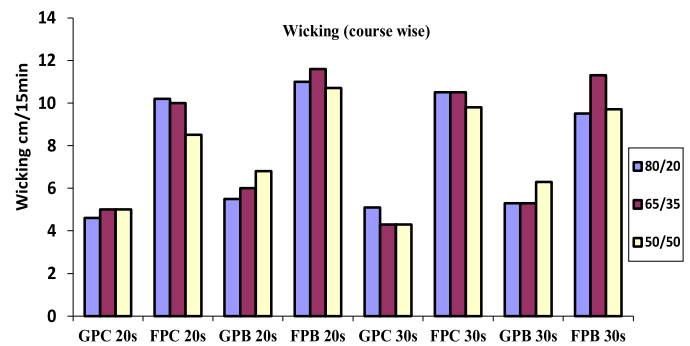
Table 5(B) : Effect of count, blend, fibre type & finishing on vertical wicking of polyester cotton and polyester-bamboo blended fabrics course wise

Yarn Count (Ne)	Blend	Vertical Wicking before Bio-Finishing (course wise) cm/15 min		Vertical Wicking after Bio-Finishing (course wise) cm/15 min	
		Polyester/Cotton	Polyester/Bamboo	Polyester/Cotton	Polyester/Bamboo
20 ^s	80/20	4.6	5.5	10.2	11
	65/35	5.0	6.0	10.0	11.6
	50/50	5.0	6.8	8.5	10.7
30 ^s	80/20	5.1	5.3	10.5	9.5
	65/35	4.3	5.3	10.5	11.3
	50/50	4.3	6.3	9.8	9.7

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Figure 4 : Effect of blend, count, fibre type and finish on fabric wicking (15 min) course wise direction



4 Conclusions

Effects of Fibre: The polyester/bamboo blended yarns are not similar to polyester/cotton blended yarn in terms of their mechanical and physical properties. Bamboo blended fabrics have higher values of total absorbency, air permeability, wicking and whiteness index rather than cotton blended fabrics.

Effect of Blend: The air permeability and total absorbency increase as bamboo and cotton % age increases.

Effect of Count: Air permeability, total absorbency and wicking performance increased.

Effect of Bio-finishing: Grey Polyester/bamboo blended fabrics have higher values of air permeability and total absorbency rather than polyester/cotton blended fabrics. On the other hand, lower value of vertical wicking is noticed in polyester/bamboo fabrics.

Bio- finished polyester/bamboo fabrics have higher values of total absorbency and wicking rather than polyester/cotton blended fabrics, but reduction in air permeability is observed. For the apparel purpose 20s Polyester/bamboo is better compare to other fabric, this is due to its better moisture related properties.

Study on Tactile Comfort Characteristics of School Uniforms

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Abstract:

The present work has its aim in examining tactile comfort properties of summer school uniform fabrics related to frictional characteristics. Surface characteristics play a significant role in comfort, as the fabric of clothing comes in contact with skin. Students while wearing uniforms have to perform many activities which demand different body movements and postures; therefore, their uniform clothing should not create clothing distress. Surface properties of different summer uniform fabrics are tested on Kawabata Evaluation System, KES FB-4. The coefficient of friction (MIU), deviation from the coefficient of friction (MMD), and Geometric roughness (SMD) have been tested and analyzed statistically. Shirting fabrics of summer school uniforms are divided into two groups based on fabric sett; one group has a relatively higher sett than another. The statistical analysis of test results found significant for fabric sett; it is observed that higher fabric sett has better surface properties. This may be assigned to a more continuous surface offering lower asperities on higher sett fabrics. Trouser fabrics of summer school uniforms are divided into two categories based on their weaves, viz. plain weave and twill weave. The effect of weaves was found significant for trousers fabrics. School uniform manufacturers may use small twill weave in shirting fabrics of summer school uniforms, to enhance the tactile comfort of clothing.

Keywords: *Asperity, Comfort, Correlation, Friction, Functional Clothing, Kawabata Evaluation System, Low Mechanical Properties, Tactile Comfort, School Uniform*

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1. Introduction :

This is the age of competition and students are expected to involve in a variety of activities. It has been a matter of discussion, in many countries whether school uniform should or should not be mandatory. If a uniform clothing policy is not applied then schools face many problems including poor academic achievements and attendance [1]. On the other hand, some cognitive consequences of formal clothing are also studied [2]. Clothing comfort is one factor that may influence the performance of the wearer. School uniforms may be considered as functional clothing because these are required to perform many functions other than the basic function of clothing. Tactile comfort is largely determined by surface and frictional properties. Tactile comfort is the combination of low mechanical properties and surface properties. Sensorial comfort has been studied since early 1990s, initially, most of the studies were based on subjective tests and now the focus is on objective tests of sensorial comfort [3].

Subjective study for comfort assessment is done by delineation of clothing attributes and descriptors derived from several attributes. Descriptors are used on different rating scales and responses received are analyzed by data analysis techniques [4]. A multidisciplinary approach to comfort prediction has also been suggested but not widely

applied because of the diverse nature of the data acquisition requirements [5]. Some literary work introducing bench-type instruments to measure friction properties of the fabric is also available. A study suggested that from very dry to normal skin conditions, the increase of friction happens to be higher in women than men and they also found that when friction was measured against wet fabric it was more than two times higher than in natural skin condition [6]. The frictional interaction between fabric and skin during contact are the key factors determining some of the important tactile sensations which are the perception of roughness, smoothness and scratchiness. The mechanoreceptors located in the human skin Fig.1 are primarily responsible for touch sensations experienced by a person [7]. A study concluded that humans can ignore significant levels of discomfort in the short term, i.e., up to 2 hours, to maintain necessary task performance [8], however, students have to wear school uniform for long hours. Uncomfortable uniform will adversely affect students' cognitive performance. Uncomfortable clothing may cause prickly, sticky and clammy feelings to the wearer; such feelings further adversely affect the performance of the wearer. The comfort properties are a function of many variables like sett of the fabric, the weave of the fabric and other constructional parameters. A twill-woven fabric has been found preferable as compared to a plain-woven fabric in all aspects of comfort. The sensory perceptions are also influenced by the psychological and physiological state of the individual wearer and the external environment [9] [10]. Skin is the largest organ of the human body and tactile comfort is mainly associated with the response of mechanoreceptors. The tactile comfort is associated with skin tribology. Skin

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tribology is the field that deals with the collection of phenomena related to contact of skin against itself or foreign surfaces and accompanying frictional loading, tissue damage and sensory outcomes produced by such contact [11]. In a study, skin surface friction has been measured and correlation with other physiological parameters is studied to evaluate the potential of physical measurement of tactile sensation [12]. Another study focused on friction behaviour of skin concluded that there is a positive correlation between the coefficient of friction and vibrotactile sensation on nano-scale and macro scale [13]. This information highlights that prickle sensitivity increases with the moisture content of the skin, as water can soften the stratum corneum and allow the protruding fibres to penetrate more readily [14]. Fabric parameters do influence somebody response such as the state of hydration [15]. There are references of test methods and instruments which claim to measure fabric roughness, some of those are contact type [16] while some others are non-contact type which makes use of optical theories to measure roughness. The tactile comfort is dependent on the surface and frictional properties of the fabric [17]. The school uniforms can be considered as a functional garment since students are required to perform many activities while wearing them. Thus, it can be derived that uniform clothing has the potential to affect the performance of the wearer, and tactile clothing comfort becomes vital for unimpeded performance. Roughness and smoothness affect the tactile comfort of the clothing hence its evaluation is important. This paper aims to study surface characteristics of summer school uniforms concerning tactile comfort.

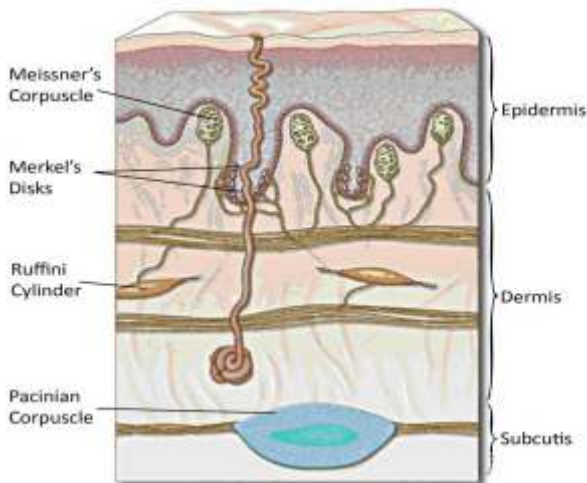


Figure 1: Mechanoreceptors in skin [7]

2. Material and method

2.1 Material

Summer uniform fabric samples were collected from uniform suppliers after taking source details from schools. Here, eight shirting and six trousers fabric of summer uniform are selected, these samples are coded S1 to S8 and T1 to T6 respectively.

2.2 Methods

2.2.1 Physical Parameters

This study is focused on frictional characteristics of summer school uniform and their association with physical parameters of uniform clothing. The samples were conditioned as per ASTM D1776 (standard practice for Conditioning and Testing Textiles). The constructional and dimensional parameters of conditioned samples are recorded. The fabric sett is measured by pick glass, following ASTM D3775 test method. The yarn number is measured by following ASTM, D 1059: 2017. The GSM is measured by implementing ASTM D3776. These constructional parameters are presented in table 1. The objective test results of tactile comfort have also been analyzed with respect to these parameters.

Table 1: Physical Parameters

Sample code	EPC	PPC	Warp (Tex)	Weft (Tex)	GSM (gm/m ²)	Thickness (mm)	Weave
T1	22	22	43.74	43.74	185.60	0.532	Plain
T2	24	24	40.72	40.72	180.17	0.518	Plain
T3	22	22	42.18	42.18	185.60	0.503	Plain
T4	22	22	42.18	42.18	190.60	0.42	Twill
T5	32	28	43.74	43.74	231.99	0.64	Twill
T6	36	24	31.92	31.92	191.50	0.557	Twill
S1	46	28	11.81	11.81	90.00	0.332	Plain
S2	42	38	13.89	13.89	111.50	0.332	Plain
S3	38	49	10.84	10.84	94.57	0.387	Plain
S4	34	30	17.37	17.37	111.30	0.20	Plain
S5	28	26	26.84	26.84	145.41	0.21	Plain
S6	34	29	16.87	16.87	106.287	0.22	Plain
S7	24	28	25.67	25.67	133.99	0.237	Plain
S8	33	28	24.60	25.13	151.54	0.38	Plain

2.2.2 Categorization of samples

The trousers samples are categorized on the basis of weave, which are plain and twill weaves. The plain-woven samples are coded as T1, T2, T3 and twill woven samples are coded as T4, T5, and T6. Shirting samples are divided into two groups on the basis of their sett, all eight shirting samples were arranged in descending order of sett, and first half is categorized as group A and second half as group B. The samples of higher fabric sett group A are coded as S1, S2, S3, and S4. The samples of lower fabric sett group B are coded as S5, S6, S7, and S8.

2.2.3 Objective test parameters for tactile comfort

Roughness and smoothness of school uniform clothing is largely decided by the surface and frictional characteristics of fabric the uniform is made of. The surface properties related to tactile comfort are tested on Kawabata Evaluation System KES FB-4. The roughness and surface properties are objectively tested by three parameters, viz. MIU, MMD, and SMD. MIU is mean frictional coefficient and it is a unitless term. Higher value of MIU means fewer tendencies to slip. Considering tactile clothing comfort, a high value of MIU is not desired.

MMD is Deviation from coefficient of friction; it is also a unitless term. This is a measure of fluctuation of mean frictional coefficient. Higher value of MMD means less smoothness and more roughness and it is not preferred for tactile comfort. SMD is measure of geometric roughness; it is measured in micro meter. Higher values of SMD mean more surface unevenness, and surface unevenness is directly related to its roughness.

2.2.4 Test method for surface properties

The parameters for tactile comfort of summer uniform fabrics are tested on Kawabata Evaluation System KES FB-4. An image of instrument is shown in Fig. 2 and working principle of this instrument is presented in Fig. 3. This instrument has a sensor unit which facilitates a load and surface treatment that mimics a human fingertip. The sensor unit has two probes, one measures dynamic friction and it is called friction contact probe and another measures roughness and it is called roughness contact probe. These probes are set on suitable position automatically, when machine is switched on. A sample size of 20 cm x 20 cm is standard for this testing instrument. Measurement of friction and roughness recorded simultaneously on this instrument.

The friction and roughness signals are converted to voltage, and indicated as numerical value. This instrument displays values of MIU, MMD, and SMD numerically; hence it quantifies a very complex qualitative feature of tactile clothing comfort.

3. Result and discussion:

Tactile comfort pertaining to touch can be anticipated to an extent by observation of these objective test results. The mechanoreceptors in the human body skin [7] are mainly responsible for tactile sensation. Skin sensory responses are simulated by testing instrument, and this can be understood that tribological interaction sensed by the brain leads to form a perception of clothing comfort.



Figure 2: KES FB-4 [18]

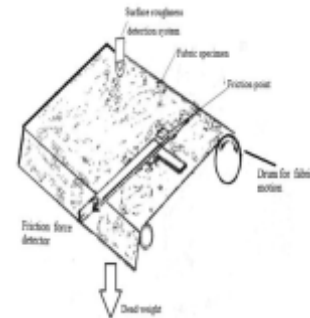


Figure 3: Principle of KES FB-4 [7]

3.1 Effect of fabric grain direction on the surface and frictional properties

The test results of all samples are presented in Table 2. Fig. 5(i) is presenting the MIU of trousers fabric along warp-ways and weft-ways, and Fig 6(i) is showing the MIU of shirting fabric along warp-ways and weft-ways. It has been observed that MIU is generally higher in weft-ways than warp-ways for both, trousers and shirting fabrics.

Fig. 5(ii) is presenting the MMD of trousers fabric along warp-ways and weft-ways, and Fig. 6(ii) is presenting the MMD of shirting fabric along warp-ways and weft-ways. This is observed that MMD is lower in warp direction than it is in the weft direction. The difference between warp-ways and weft-ways MMD has also been analysed for both, shirting and trousers. It is found that the difference between warp-ways and weft-ways MMD is very high in trousers fabrics than shirting fabrics.

The SMD for trousers fabric along warp-ways and weft-ways presented in Fig. 5(iii) and for shirting fabric it is presented in Fig. 6(iii). The SMD values in trouser samples are higher in weft-ways than warp-ways, in all the samples while it is not the case with shirting fabric samples.

The tactile comfort related parameters are tested and analysed in their relation with the grain line of the trousers and shirting samples. Surface characteristics are found better in warp direction than in weft direction in the majority of samples and it can be due to higher crimp in the weft -ways. This may be understood in light of the higher resistance offered to the probes due to the higher crimp of the weft.

Table 2: Surface properties measured on KES FB-4

	Sample Code	MIU		MMD		SMD (µm)		
		Warp	Weft	Warp	Weft	Warp	Weft	
TROUSERS	PLAIN WEAVE	T1	1.87	1.94	0.137	0.141	10.81	11.5
		T2	1.52	1.63	0.134	0.14	9.87	10.28
		T3	1.8	1.86	0.138	0.141	10.95	11.76
	Twill WEAVE	T4	1.63	1.72	0.134	0.139	9.85	10.2
		T5	1.45	1.39	0.131	0.133	8.04	8.18
		T6	1.47	1.52	0.133	0.137	8.43	9.1
SHIRTING	GROUP A	S1	0.86	1.05	0.11	0.115	4.66	4.72
		S2	0.79	1.03	0.109	0.114	4.77	4.19
		S3	0.7	0.68	0.112	0.099	3.92	3.11
		S4	1.01	1.16	0.112	0.117	4.8	4.99
	GROUP B	S5	1.32	1.34	0.123	0.125	6.69	7.01
		S6	1.21	1.25	0.118	0.122	5.27	5.9
		S7	1.39	1.36	0.127	0.121	6.98	7.19
		S8	1.28	1.31	0.121	0.124	5.44	6.01

3.2 Effect of weave on surface and frictional properties

The twill -woven and plain-woven uniform trousers fabrics are studied for their tactile comfort properties. T1, T2, and T3 are plain-woven while T4, T5, and T6 are twill woven samples. Fig. 5(i) shows the MIU of trousers samples, this is observed that plain-woven fabrics have higher MIU than twill woven fabric samples. Fig. 5 (ii) shows the MMD of trousers samples, this is observed that plain-woven fabrics have higher MMD than twill woven fabric samples. This is found that MMD is lower in both, warp and weft direction for twill than it is in plain-woven samples. The comparison in SMD for these two weaves can be observed from Fig. 5(iii) for warp ways and weft ways respectively. The SMD values are higher for plain weave samples than twill weave samples. The higher values of MIU, MMD and SMD for plain structures can be assigned to higher asperities due to a greater number of interlacements. The fabric geometry of these weaves justifies this explanation.

3.3 Effect of fabric set on the surface and frictional properties:

Shirting fabrics' group A is having a higher sett than group B. The test results of shirting fabrics for all three tactile comfort parameters are presented in table 2. The test results for MIU of shirting samples are shown in Fig. 6(i), it is found that higher sett group A has better MIU properties than lower sett group B.

The test results for MMD of shirting samples are shown in Fig. 6(ii), it is observed that the MMD is higher in Group B samples in both, warp-ways and weft-ways.

The SMD for shirting group A and B has been studied and results are presented in Fig. 6(iii) for warp ways and weft ways. This is observed that Group B having samples of lower sett has higher SMD values in the weft direction.

This may be attributed to the gaps between yarns of fabric structure leading to enhancement of asperity and resulting in higher values of the SMD. Fabrics with higher sett have better surface properties this may be assigned to fewer surface variations in depth.

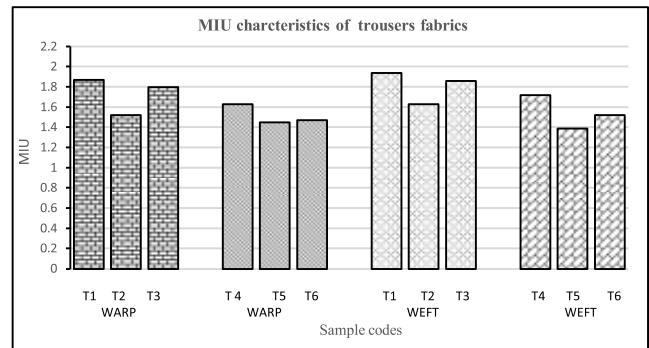


Figure 5(i): MIU of trousers fabric along warp and weft ways

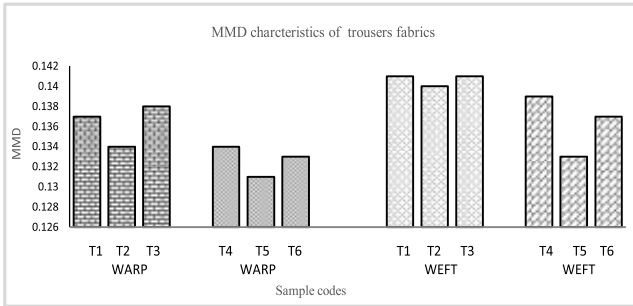


Figure 5 (ii): MMD of trousers fabric along warp and weft ways

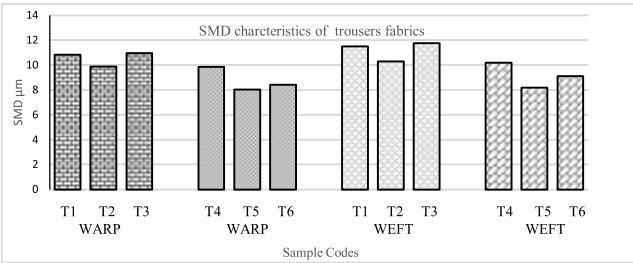


Figure 5(iii): SMD of trousers fabric along warp and weft ways

For Fig.5 (i),(ii) and(iii)

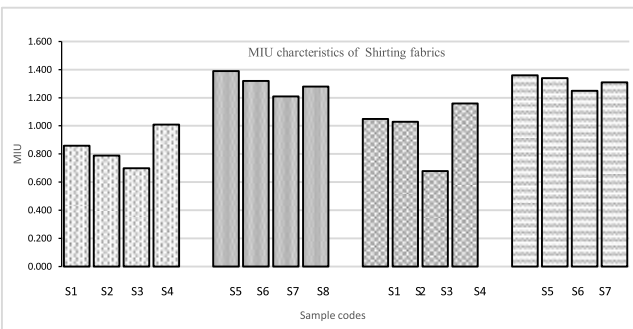


Figure 6(i) MIU of shirting fabric along with warp and weft

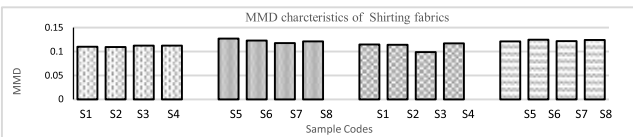
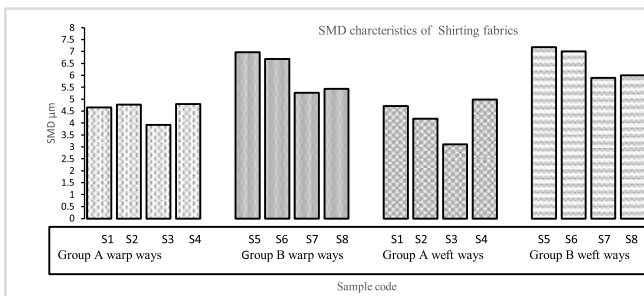


Figure 6(ii): MMD of shirting fabric along warp and weft ways



For Fig.6 (i),(ii) and(iii)

3.4 Effect of Constructional parameters and surface related comfort characteristics

Fabric comfort characteristics have been analyzed with respect to constructional parameters viz. GSM, EPC, PPC and thickness. A significant correlation found between these constructional parameters and all tested comfort characteristics; MIU, MMD and SMD, this is presented in table 3. GSM and thickness have positive while EPC, PPC have negative correlation with all tested characteristics. It is pragmatic for tested samples that beyond 150 GSM, comfort properties decrease and a thickness little less than 0.40 mm may be considered adequate after 0.40 mm values of MIU, SMD and MMD rise which is not desirable for comfort of clothing.

Table 3: Correlation between constructional variables and comfort factors

Correlation between constructional variable and comfort factors	GSM (gm/m ²)	EPC	PPC	Thickness (mm)	Correlation between Warp and Weft
MIU	0.801	-0.857	-0.877	0.512	0.9727
MMD	0.888	-0.827	-0.887	0.643	0.9156
SMD	0.828	-0.809	-0.810	0.630	0.9917

This is also observed that a twill structure with slightly lower sett can offer better tactile properties than a plain structure having higher sett, this may be practically applied to reduce material cost, i.e. twill weave with lower sett may be preferred to some extent over plain weave with higher fabric set.

Frictional and surface properties are found better warp ways than weft ways. The role of asperity of surface is important and extent of its fluctuation decides surface profile which governs roughness and friction behaviour. This is found that twill woven fabrics have better tactile properties than plain woven fabrics for trousers. Further, it may also be concluded that higher sett group of shirting has better surface properties than that of lower sett group.

3.5 Statistical analysis

The tactile comfort-related, surface and friction properties are tested, and test results are analyzed statistically for their significance. ANOVA results for all three tactile comfort characteristics are presented in table 4. A very low value of P is observed in all the ANOVA tests. The critical value of F is lower than F in all the analysis of variance tests, therefore the significance of the factors can be accepted for tactile comfort of the fabrics. The effect of weave is found significant for the trousers and the effect of the sett is found significant for shirting fabric samples.

Table 4: ANOVA results

ANOVA single factor	Comfort feature	F	P-value	F critical
Trousers' sample weave twill and plain	MIU	9.4627	0.0371	7.7086
Trousers' sample weave twill and plain	SMD	22.9100	0.0087	7.7086
Shirting group A and B	MIU warp	37.1228	0.0009	5.9874
Shirting group A and B	SMD warp	10.5234	0.0176	5.9873
Shirting group A and B	MIU Weft	9.8515	0.0201	5.9873
Shirting group A and B	SMD Weft	18.24036	0.0052	5.9874

4. Conclusion

Summer school uniform fabric samples were tested and analysed for their surface characteristics. Surface properties are mainly related to the friction properties of fabrics, in this study, these are tested on Kawabata Evaluation System FB-4. Fabric is subjected to real fingertip-like contact conditions simulated through sensors.

It is observed that twill woven fabrics have better surface and frictional properties than plain-woven fabric. This may be assigned to a more continuous surface of the twill woven fabric than plain-woven fabric. It is found that there is a negative correlation between fabric sett and tactile comfort parameters, higher sett fabrics have better surface and frictional properties than lower sett fabrics. This is also observed that there is a very high positive correlation found between all warp and weft surface properties.

The roughness and frictional surface properties of summer school uniform fabrics are found negatively correlated with fabric sett; higher fabric sett has better surface properties related to tactile comfort, this fact may be applied while planning fabric structure. It is known that fabric manufacturing cost is largely governed by the cost of pick insertion.

Based on the results of this study, the EPC may be made higher and pick density may be lowered to an extent, without compromising on comfort characteristics and body of the fabric. Use of small twill in shirting fabrics may be recommended to school uniform manufacturers for enhancing tactile comfort of shirting clothing.

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Study on Application of Various Blends of Soya and Cotton in Medical Gauze Bandages

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Abstract:

This Study is focused on applying the Soya material in medical textiles and to improve the absorbency, better wound healing, with moderate cost than that of cotton material. To use the soya as substitute for cotton in medical field as gauze it has to be bleached in order to enhance its absorbency. We have studied about the usage of Soya /cotton union woven product in the medical field. We started by weaving the fabric with a Soya as weft, cotton as warp and it was also bleached. It should be emphasized here that Soya on its raw form could be used for medical purpose because of the presence of amino acid. The raw Soya and processed Soya material were made as gauze and applied to the patients with the varying wound types such as lacerations, abrasions, incisions.

Keywords: Absorption, Bandage, Gauze, Lacerations, Soya Protein Fiber

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1. Introduction :

Soya protein fiber is gaining importance due to its excellent moisture absorption, soft, smooth and good drapability. It is a regenerated protein fiber with excellent absorption and healing properties. It has been taken by many people for strength and essential amino acids and is now emerging in textile field and diverse application. This study aims to use this Soya protein fiber in medical textile arena. [1]. This study compared the absorbency, biodegradability and smoothness of cotton gauze fabric with Soya and Soya/cotton blend fabric to improve its absorbency and better wound healing. It found that Soya protein fiber is having similar properties as that of cotton.

2. Medical Textiles

Textile materials used in medical field include fibers, yarns, fabrics and composites. Polymers, ceramic fibers, alginate fibers, cotton, silk, viscose, nylon, polyurethane are all used. The medical and related health care and hygiene sector is growing due to developments in both textile technology and medical procedures.

The application of textile in medical field is huge and diverse ranging from a single thread suture to the complex composite structures for bone replacement.

2.1 Classification of Fibres in Medical Textiles

Fibers used in Medicine and surgery may be classified depending on the materials from which they are made from:

- Natural Fibers - Cotton, Silk.
- Regenerated cellulosic fibers - Viscose rayon

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- Synthetic Fibers - Polyester, Polyamide, Polypropylene, Carbon, glass.

2.2 Specialty Fibres

i. Natural Polymers

Natural polymers Collagen, Alginate, Chitin and Chitosan have been found to be useful for modern wound dressings. Collagen obtained from bovine skin is a protein available either in fiber or hydro gel. It is biodegradable, strong as silk and used for sutures. Its hydro gel form can be processed into soft contact lenses [12] (Table-1).

Fibers melt-spun from Lactic acid have similar strength and heat properties as Nylon and are also biodegradable.

ii. Hollow Fibres

Hollow fibers are presently used in kidney dialysis and blood oxygenation equipment. They are also being evaluated for use in immobilized enzyme and controlled drug delivery systems.

iii. Optical Fibres

Optical fibers are hair-thin strands made of glass or plastic with the ability to guide light along their axis. The materials being currently employed are silica, glass, other glass materials, polycrystalline materials and polymeric plastic materials. The use of fiber optics allows a substantial reduction in the size of certain diagnostic equipment.

2.2 Properties of Fibres used in Medical Application

Textile material for medical applications typically has specific requirements Strength related to strength, stiffness, abrasion resistance and mechanical patency [6] (Table-2).

Table – 1 Fibers used in Hospital Textiles

Product Application		Fiber Type	Fabric construction method
Gowns		Cotton, polyester, Polypropylene	Nonwoven, Woven
Caps		Viscose	Nonwoven
Masks		Viscose, Polyester, Glass	Nonwoven
Surgical Cover	Drapes	Polyester	Nonwoven, Woven
	Clothing	Polyethylene, Polyester	Nonwoven, Woven
Blankets		Cotton, Polyester.	Woven, Knitted
Sheets		Cotton	Woven
Pillow Case		Cotton	Woven
Clothing	Uniforms	Polyester	Woven
	Protective Clothing	Polypropylene	Nonwoven
Incontinence diaper/sheet	Cover stock	Polypropylene	Nonwoven
	Absorbent layer	Wood fluff, (super absorbents)	Nonwoven
	Outer layer	Polyethylene	Nonwoven
Surgical hosiery		Polyamide, polyester, Cotton elastomeric yarn	Knitted
Cloths/Wipes		Viscose	Nonwoven

a. Strength

The strength requirement of medical textile materials varies depending upon its end uses. For some of the applications like bandages cloth, extensibility of material is more important than strength and for artificial ligaments, a high strength product is required.

b. Stiffness

Bending stiffness, which governs the handling comfort and comfort ability of a fabrics, is a critical parameter of medical textiles. For examples, suture with low bending stiffness requires fewer throws to tie a secure knot and has higher knot strength. The most important factors affecting bending stiffness are the shape of fiber, modules, linear density and specific gravity of material.

c. Abrasion resistance

Where fibers, yarns or fabric rub against themselves or other structures, abrasion resistance assumes an important role. A high value is usually desirable, especially in applications such as artificial ligaments or tendons. The factors considered for these properties are denier of fiber, orientation of molecules in the fibers, amount of twist in the yarn and surface co-efficient of friction.

d. Mechanical potency

Implanted products must bear load over a long term and maintain their dimensional integrity require a high degree of mechanical potency. Theses mainly include the ability to resist permanent change in physical properties, the chemical, and biological and stress environment into which the implant

is placed, the non-reactivity of polymer with the environment and the most important viscoelastic properties of material. For example, tissue engineering, vascular grafting tubes, covering of heart valve ring, etc.

2.3 Wound Care Textiles

Wound dressings are composite materials consisting of an absorbent layer held between a wound contact layer and a flexible base material. They provide protection against infection, absorption of blood and exudates, and promote healing. The absorbent pad absorbs blood or liquids and provides a cushioning effect to protect the wound. The base materials are coated with an acrylic adhesive to provide the means by which the dressing is applied to the wound.

Textile materials used for wound dressing applications include:

- i. Gauze
- ii. Lint
- iii. Wadding
- iv. Bandage

Gauze

Gauze is an open weave, absorbent fabric that when coated with paraffin wax is used for the treatment of burns and scalds. In surgical applications gauze serves as an absorbent material when used in pad form (swabs), yarns containing barium sulphate are incorporate so that the swab is X-ray detectable.

Lint

Lint is a plain weave cotton fabric that is used as a protective dressing for first-aid and mild burn applications.

Wadding

Wadding is a highly absorbent material that is covered with a Non-woven fabric to prevent wound adhesion or fiber loss.

Bandages

Bandages can be woven, knitted or non-woven and are either elastic or non-elastic. The most common purpose of bandages is to hold dressing in place over wounds, such as light weight knitted or simple open weave fabrics made from cotton or viscose. Elasticized yarns are incorporated into the fabric structure to impart support and conforming characteristics. Woven light support bandages are used in the management of sprains or strains and the elasticized properties are obtained by weaving. (Table-2).

Table 2 - Types of medical bandages

S. NO.	Type of bandages	Commercial name	Remarks
1	Retention bandage	Slinky, stayform, easifix, tensofix.	Exert very little pressure on a limb.
2	Compression bandage	Light compression	J-plus, K-crepe
		Moderate compression	Veinopres, Granuflex compression Adhesive compression
		High compression	Surpress
		Extra-high compression	Blue live, Webbing

The required property for wound dressing medical fibers:

Fabric properties such as tensile strength, Air permeability, Flexural rigidity and liquid interaction properties can be predicted accurately by equation based on aerial density and bulk density for needle punched fabrics and by modules of aerial density and fabric thickness for hydro entangled fabrics. (Table-3)

3. Extra Corporeal Devices

Extracorporeal devices are mechanical organs used for purification of blood, such as the artificial kidney, the artificial liver, and the mechanical lung. They circulate the blood through a membrane, which may be either a flat sheet or a bundle of hollow regenerated cellulose fibers. Biodegradable sutures are used for internal wound closures, while non-biodegradable ones are used to close exposed wounds.

Table 3 - Application of fibers in Extracorporeal

S. No.	Product Application	Fiber Type	Function
1	Artificial kidney	Hollow viscose, Hollow polyester	Remove waste products from patients' blood
2	Artificial liver	Hollow viscose	Separate and dispose patients plasma and supply fresh plasma
3	Mechanical lung	Hollow polypropylene, Hollow silicone, Silicone membrane	Remove carbon dioxide from patients' blood and supply fresh blood

a. Soft-tissue implants

Textile materials are particularly suitable for soft-tissue implants, such as tendons, ligaments and cartilage. Artificial tendons are woven or braided porous meshes or tapes surrounded by a silicon sheath. During implantation, the natural tendon is looped through the artificial tendon and then sutured to itself to connect the muscle to the bone. Textile materials used to replace damaged knee ligaments must possess biocompatibility properties and have the physical characteristics needed for a demanding application.

b. Orthopedic implants

Orthopedic implants are materials used to replace bones and joints, and fixation plates are used to stabilize fractured bones. Fiber reinforced composite materials are now replacing metal implants, and a non-woven mat is used to promote tissue growth around the implant. To promote tissue in growth around the implant a non-woven mat made from graphite and PTFE.

c. Cardiovascular implants

Commercially available vascular grafts are produced from polyester (e.g. Dacron or PTFE (e.g. Teflon) with either woven or knitted structures. Straight or branched grafts are possible by using either weft or warp knitting technology. Polyester vascular grafts can be heat set into a crimped configuration that improves the handling characteristics.

4. Fabrics used in Medical Textiles

The basic fabric structures used for medical implants or sutures are:

I. Woven

The fabrics that are woven are usually dimensionally very stable but less extensible and porous than the other structures. One disadvantages of woven is their tendency to unravel at the edges when cut squarely or obliquely for implantation. However leno weave can substantially alleviate this fraying or unraveling.

ii. Knitted

Weft-knitted structures are highly extensible, but are also dimensionally unstable unless additional yarns are used to interlock the loops and reduce the extension. Knitted materials are externally versatile and can be engineered with a variety of mechanical properties matching those of woven fabrics. Their major advantage is their flexibility and ability to resist unraveling when cut, but their high porosity limits their use in applications requiring low porosity.

iii. Braided

Typically employed in cord and sutures, braided structure can be designed using several different patterns, with or without a core. To reduce their capillarity, braided materials are also treated with biodegradable (Teflon) creation. Such a coating also serves to reduce chatter or noise during body movement, improve hand or feel, and help position suture knots that must be transported by pressure from outside the body to the wound itself.

iv. Nonwoven

Non-woven are now being used in a range of tailor-made products, improving properties such as tensile strength, abrasion resistance and handle. Pore size and fiber diameter depend on the processing technology and process parameter, and different cell types require different structures. Special non-woven technologies have been developed to allow the economic production of high porous structures.

5. Materials and Methods

5.1 The Soya Bean Plant

Nomenclature

The bellow table (Table-4) shows detailed nomenclature of soya plant.

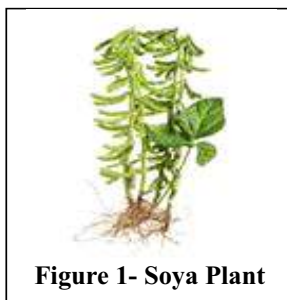


Figure 1- Soya Plant

Table – 4 Nomenclature of Soya Plant

Kingdom	Plantae
Clade	Tracheophytes
	Angiosperms
	Eudicots
	Rosids
Order	Fabales
Family	Fabaceae
Subfamily	Faboideae
Genus	Glycine
Species	Glycine max

The Soya bean plant is a bush-like annual, growing about 1.8 m tall and bearing pods which each contain several smooth seeds. It was first cultivated in the USA in the nineteenth century and by the late 1990s, 70 million hectares worldwide were being used for Soya bean cultivation. It became a significant crop in the early twentieth century in a linked producer/processor development known as the 'American Soya complex'. Thousands of new varieties were introduced and USA Soya beans have an export value of \$ 7.2 billion, with major markets being Europe, China, Mexico and Japan. Du Pont researchers have been experimenting with modifying soya beans to give them higher oil or protein content.

In the following table (Table-5) we have compared the amino acid content in soya bean, wool and silk.

S. No	Amino Acids	Soya	Wool	Silk
1.	Alanine	4.12	4.10	26.40
2.	Arginine	5.80	3.60	1.05
3.	Astartic acid	3.86	7.27	2.00
4.	Cystine	1.00	11.30	-
5.	Glutamic acid	19.46	16.00	2.03
6.	Glycine	0.23	6.50	43.80
7.	Histidine	2.30	0.70	0.47
8.	Isoleucine	4.00	-	1.37
9.	Leucine	8.40	9.70	0.80
10.	Lysine	5.40	2.50	0.88
11.	Methionine	2.00	0.35	-
12.	Phenylalanine	5.30	1.60	1.50
13.	Proline	3.04	7.20	1.50
14.	Serine	6.00	9.50	12.60
15.	Threonine	4.00	6.60	1.50
16.	Tryptophan	1.50	0.70	-
17.	Tyrosine	4.30	6.10	10.60
18.	Valine	4.50	5.50	3.20
19.	Ammonia	-	1.18	-
20.	Hydroxylysine	-	0.10	-

5.2 Sanitary Property and Content of Amino Acid

The soybean protein contains (Table-7) lots of polar amino-acids necessary for human body, such as hydroxyl, aminocyanogen and carboxyl. The content of parts amino-acids is listed below

Table 7 - Parts amino-acids in degrease and separate soybean

Type of Amino Acid	Histidine	Isoleucine	Leucine	Lysine	Threonine	Tryptophan
Degrease Soybean	26	48	78	64	39	14
Separate soybean	28	49	82	64	38	14

It is obvious that the soybean fiber has good biocompatibility and is beneficial to the human health. Furthermore, the anti-bacterial agents, which were added to the soybean fiber in spinning process, can restrain the growth of colon bacillus, impetigo bacterial and sporothrix. Therefore, soybean fiber is a kind of sanitarian fiber.

6. Soya Protein Fibre

Soya protein fibers are naturally colored light yellow and have a soft lustrous similar to silk(fig-2). Chinese manufacturers compare it to cashmere and it has good warmth retention and better moisture transmission than cotton. The Dry strength of the Soya protein fiber is higher than that of wool, cotton and silk at 3.0 c Nd Tex⁻¹, while the Wet strength is similar to cotton. It has a higher breaking strength and is stable to normal domestic washing. It has been blended with wool, silk, alginate and cotton and its properties were studied.[6]



Figure 2 - Soya Fiber and Yarn

6.1 Identifying procedure of Soya protein fiber

1. Fine marks and striations may be visible on the surface of all such fibers.
2. Fletches reports that Soya bean fibers responded like wool to chemical and burning tests.
3. It can also be identified by burning tests. Soya bean protein fibers melt away from the flame before touching the flame and melt and burn in the flame with smell of burning feathers although they do not combust easily, tending to melt before burning.
4. The black ash is said to be brittle, puffy and easily crushable.

6.2 Properties of Soya Fiber

- i. It has a good alkali and acid resistance and also it wear well. Two months outdoor exposure of the Soya protein fiber resulted in little fading, 11% strength loss and fungal formation.
- ii. Exposure to UV for 120 hours resulted in a 9.8% strength loss.[9]
- iii. Exposure to dry heat caused the fiber to become yellow and sticky.
- iv. The fiber itself is said to be biodegradable in land fill and it seems likely that biodegradation processes would be initiated through exposure to water.
- v. Fletcher reports that Soya bean fibers mildewed less easily than natural and casein fibers but more easily that

synthetic fibers. The residues of the Soya beans may be used as animal fodder once the protein has been extracted. The wider environmental impact large-scale Soya bean farming needs to be factored into an overall evaluation of the environmental impact of Soya protein fiber (SPF).

6.3 Comparison of the properties of Cotton Fiber with Soya Protein Fiber

Table 8 - Properties of Cotton and Soya fiber

S. No	Property	Soya Protein Fiber		Cotton
		Dry	Wet	
1.	Breaking Strength (CN/dtex)	3.8-4.0	2.5-3.0	1.9-3.1
				2.2-3.1
2.	Dry breaking extension (%)	18-21		7-10
3.	Initial modulus (Kg/mm ²)	700-1300		850-1200
4.	Loop Strength (%)	75-85		70
5.	Knot Strength (%)	85		92-100
6.	Moisture regain (%)	8.6		9.0
7.	Density (g/cm ³)	1.29		1.50-1.54
8.	Heat endurance	Yellow and tackifing at about 120° (BAD)		Becoming brown after long time processing at 150°C (Excellent)
9.	Alkaline resistance	At general level		Excellent
10.	Acid resistance	Excellent		Bad
11.	Ultraviolet resistance	Good		At the general level

7. Conversion of Soya Protein Fiber to Fabric

7.1 Weaving of the Soya yarn

Warp Yarn

100% Soya is procured from the market with the following specification. Count – 14S is used in warp.

Weft Yarn

100% Soya is procured from the market with the following specification. Count – 14S is used in weft

Weaving Process

The prepared warp is loomed in a sample power loom and weaved. The loom performance is good and in order to avoid the slippage between particulars are shown below (Table - 9,10). Warp and weft yarn rice starch was applied for the warp yarn.

Fabric particulars for pure Soya gauze

Table 9 - Specification of Soya gauze

Warp Count	14 ^S
Weft Count	14 ^S
Ends per inch	19
Picks per inch	19
GSM	40

Fabric particular for soya/cotton blend gauze

Table 10 - Specification of Soya/Cotton gauze

Warp Count	14 ^S
Weft Count	14 ^S
Ends per inch	19
Picks per inch	19
GSM	40

7.2 Desizing

Both the pure Soya and Soya cotton sized fabrics were desized with concentrated Hydrochloric acid (33-35 g/l) for one hour at room temperature with a material to liquor ratio of 1:30. The desized fabrics were washed thoroughly in cold water and dried. Then desized fabrics are subjected to recipe.

7.3 Bleaching

Bleaching of pure Soya and Soya cotton was done in a vessel for one hour at 95° c in gas stove keeping the material to liquor ratio at 1:30 with hydrogen peroxide (40g/l), sodium carbonate (5g/l), sodium silicate (8g/l) at the PH of 11. The bleached sample was washed thoroughly in cold water and the bleached fabric was dried.

Chlorine bleaching should not be used for medical textile due to their harmfulness to skin.

8. Testing the produced Gauze Fabrics

8.1 Test for Absorbency

The main object of this is to compare the absorbing capacity of the Raw Soya with bleached Soya, Cotton and Soya Cotton.

Procedure

Take 2.2 Gms of Raw Soya, Bleached Soya, Cotton and Soya Cotton union fabric separately and immerse the samples in two separate beakers, which are filled with water. Keep the samples as such for 5 minutes.

After 5 minutes the four samples are weighted separately. The reading is tabulated. The test is repeated for 5 different samples.

8.2 Absorbency by Sinking Method

Objective

The main objective of this sinking method is to compare the absorbency capacity of bleached Soya, Cotton, Soya Cotton and unbleached Soya of using stop watch.

Materials

1. Glass beaker
2. Distilled water
3. Stopwatch

Procedure

Cut out five 1" x 1" squares of fabric from the material to be tested. Drop one of the pieces gently on the surface of distilled water in a beaker and start the stop watch as soon as the corner of the piece leaves the water surface and the piece begins to sink to the bottom of the beaker. Repeat the above procedures with the remaining pieces of fabric.

8.3 Bending Length

Objective

The main objective this test is to find the stiffness of the fabric with its curve.

Principle

The stiffness of the fabric is being found with the help of the bending curve scale. The readings are to be taken in cm.

Procedure

1. The fabric or the sample is being placed on the smooth surface in the market line.
2. Note that the fabric does not touch the sides of the surface.
3. Now place the scale over the fabric which is marked too.
4. Now glide downs slowly along with the fabric. Fill the fabric until touches the line.
5. The bending curve can be noted on the mirror and reading are taken.

8.4 Air permeability

Objective

The main objective of this test is to measure the permeability of fabrics to Air.

Principle

This method is based on the measurement of rate of flow of Air through a given area of fabric by a given pressure drop across the fabric.

Procedure

1. Take the conditional specimen and mount a portion between the clamp and circular orifice with sufficient tension to eliminate wrinkles, if any, taking care to see that the fabric is not distorted in its own plane.
2. Start the suction fan or other means to force Air through the fabric and adjust the rate of flow of Air pressure drop of 1 cm water head across the fabric is indicated.
3. Note the rate of flow of Air in cm³ and repeat the same.

9. Results and Discussion

9.1 Test for Absorbency

Results of the for absorbency of Raw soya, Bleached Cotton, Cotton and Soya/Cotton blend is tabulated bellow

Table 12 - Results for absorbency test

Sample NO.	Raw Samples	Bleached Samples		
	Soya	Soya	Cotton	Soya/Cotton
1.	4.3	6.53	7.2	7.65
2.	4.5	6.42	7.3	8.15
3.	5.35	7.75	7.2	6.5
4.	4.5	6.42	7.4	7.35
5.	4.4	6.53	7.3	8.05
Average	4.61	6.73	7.28	7.54

**All the units are in cm*

9.2 Test for Absorbency by Sinking Method:

Results for the absorbency by Sinking Method of Raw soya, Bleached Cotton, Cotton and Soya/Cotton blend is tabulated bellow:

Table 13 - Results for absorbency by Sinking Method test

Sample No	Raw Samples	Bleached Samples		
	Soya	Soya	Cotton	Soya/Cotton
1.	22	2	0.5	2.0
2.	20	1	0.3	1.8
3.	25	1.3	0.2	1.7
4.	30.5	1.5	0.3	1.5
5.	23	1.2	0.5	1.6
Average	24.1	1.4	0.36	1.72

**All the units are in cm*

9.3 Test for bending Length

Results for the bending Length test for raw soya, Bleached Cotton, Cotton and Soya/Cotton blend is tabulated bellow:

Table 14 - Results for bending Length test

Sample No	Raw Samples	Bleached Samples		
	Soya	Soya	Cotton	Soya/Cotton
1.	1.4	2.0	2.1	2.0
2.	1.5	2.4	2.0	2.0
3.	1.6	2.0	1.9	2.4
4.	1.5	2.2	2.0	2.0
5.	1.4	2.0	2.2	2.3
Average	1.48	2.12	2.04	2.3

9.4 Test for air permeability

Results for the air permeability test for raw soya, Bleached Cotton, Cotton and Soya/Cotton blend is tabulated bellow:

Table 15 - Results for air permeability test

Sample No.	Raw Samples	Bleached Samples		
	Soya	Soya	Cotton	Soya/Cotton
1	27.5	59.02	60.8	25.9
2	30.5	61.8	69.7	27.6
3	29.16	62.5	58.5	27.3
4	28.47	61.8	87.5	25.7
5	28.47	59.75	78.6	29.3
Average	28.86	60.96	71.02	27.16

**All the units are in cm³/s*

10. Conclusion

In conclusion, Soya gauze material has better absorption, air permeability, and less soakage than cotton. It is also more economically viable, as it requires fewer dressing changes and has a shorter healing granulation period. Therefore, Soya gauze is a more suitable choice for wound dressings than cotton.

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Use of Textile Maternity Wear for Rural Women Communities

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Abstract:

Textile Maternity wear such as Diapers and the sanitary pads etc., serves as a specialized garment exclusively designed to cater to the needs of pregnant women. Its primary objective is to provide sufficient space to accommodate the various bodily changes that occur throughout the entire pregnancy period, ensuring optimal comfort and support for both the mother and the baby [1]. This essential attire should seamlessly transition from the first trimester to the last, adapting to the evolving needs of expectant mothers. Moreover, it should not only fulfil functional requirements but also enhance the mother's beauty and self-expression. Achieving these goals necessitates the application of technical skills in the realms of design, pattern-making, cutting, and garment construction.

In our research endeavour, we aim to develop an adaptive and caring maternity garment that addresses these critical aspects. To gain comprehensive insights and understand the existing challenges and expectations of pregnant women, we have incorporated a research methodology that involves home visits and visits to maternity hospitals. By directly engaging with expectant mothers, we seek to gather invaluable input that will guide us in creating a comfortable and well-suited maternity wear solution. Recognizing the inherent aesthetic consciousness of women, we understand that maternity wear can serve as a means for them to further embrace and celebrate their own beauty. During pregnancy, the female body undergoes significant physical changes, particularly in the bust and hip regions. Additionally, there is gradual growth in the biceps and thighs [2]. In response to these transformations, women often resort to purchasing oversized garments, as standard options fail to provide the necessary horizontal and vertical fittings [3]. Unfortunately, these ill-fitting choices do not fully meet the required needs [3]. Thus, our research endeavours to address these specific issues and provide an effective solution. Moreover, we place special emphasis on catering to the unique requirements of women residing in rural and semi-urban areas. By developing a thoughtful and well-crafted maternity wear solution, we aim to empower women throughout their pregnancy journey. Our focus on design, functionality, and comfort will not only enhance their physical well-being but also enable them to embrace their maternal roles with confidence and pride.

Keywords: *Comfort, Loose garments, Maternity garments, Maternity phase, Satisfaction*

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1. Introduction :

The rural and suburban areas have witnessed significant changes, with increased access to education and employment opportunities for women. This has led to a shift in their clothing needs during pregnancy. Maternity wear plays a crucial role in accommodating the physical changes and ensuring the comfort and satisfaction of expectant mothers. In the past, makeshift solutions or traditional garments were commonly used in these areas. However, the demand for specialized maternity wear has increased. This research aims to revolutionize maternity clothing for women in rural and suburban regions by offering innovative, stylish, and comfortable options. By prioritizing their unique requirements and desires, we seek to empower expectant mothers and celebrate the remarkable journey of pregnancy. Survey conducted in Latur, Maharashtra. Latur is a city in South Eastern of Maharashtra, with a population of approximately 469,000. It experiences a tropical climate with limited rainfall, particularly in the summer season. The city is known for its government and private medical colleges and hospitals, serving both the local population and patients from neighbouring regions, which exhibits a diverse cultural

and social lifestyle due to its mixed population composition.

Objectives

- i. Exploring Maternity Transformations: Our research delves into the profound changes experienced by expectant mothers, unravelling the physical and emotional transitions of the maternity period.
- ii. Comfort and Style Combined: Focusing on rural and suburban areas, we craft maternity wear that seamlessly blends comfort, style, and functionality, empowering women with confidence and fashion-forward choices.

2. Methodology

2.1 Market survey of maternity garment retail stores

In the market survey of maternity garment retail stores are of limited brands were found to offer maternity wear, with a restricted product range and availability of sizes. Greater awareness and access to maternity wear options are needed in the local market to cater to the diverse needs of pregnant women. Improvement in brand choices, product variety, and size availability can enhance the shopping experience for expectant mothers.

2.2 The assessment of awareness

The assessment phase of the study involved conducting

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surveys and interviews with expectant women to gather insights into their awareness and preferences regarding maternity wear. Data collection methods included questionnaires, face-to-face interviews, and sessions with gynaecologists. The research focused on bodily changes during pregnancy, the importance and availability of maternity wear, suitability to sociocultural backgrounds, brand guidelines, and affordability. Additionally, body measurements were collected from expectant mothers to develop size charts for guidance in selecting appropriate garments. The data gathered provides valuable information for improving the accessibility and quality of maternity wear options.

2.3 Sample selection and sample size & Inclusion and Exclusion criteria for sample selection

For the current study, pregnant women between the ages of 18 to 40, in their II and III trimesters, with a single healthy fetus, and without mental or physical disorders or disabilities were included. Pregnant women below 18 or above 40 years, those with medical illnesses, disorders or disabilities, malnourished or overweight individuals, and those carrying multiple foetuses were excluded. A probability sampling method, specifically simple random sampling, was used to select a sample of 200 pregnant women from survey area. This method ensures that every individual in the population has an equal chance of being selected. A market survey was conducted at 41 garment stores to gather information on pregnant women's preferences for garments during their pregnancy period. The survey results were analysed and used to design suitable garments that align with the preferences identified.

3. Physical Change in the Maternity Period Trimester wise

During the first trimester, pregnant women experience fatigue, morning sickness, frequent urination, and hormonal changes in the skin. However, the physical changes are minimal, so the study did not include women in this trimester. In the second trimester, pregnant women start feeling better and experience breast growth, darkening of the nipples, abdominal expansion, skin changes, leg cramps, and weight gain. These changes were considered significant for the study, and measurements were collected. The third trimester brings further growth of the fetus, increased discomfort, swelling of hands and ankles, numbness, backaches, contractions, weight gain, breast enlargement, skin pigmentation, and fatigue. These changes were also considered important for the study and measurements were collected. Overall, the study recognized the need for appropriate maternity wear to accommodate the physical changes and provide comfort and support to pregnant women throughout their pregnancy journey. The study suggests the use of trimester-wise size charts to assist pregnant women in selecting suitable maternity garments [2].

3.1 Data on the awareness and need of maternity wear among expectant women

To collect data on the awareness and need of maternity wear among expectant women, a field study was conducted. A survey questionnaire was designed and administered to a representative sample of expectant women in various healthcare facilities. The questionnaire covered points such as awareness of maternity wear, perceived need, factors influencing choices, and sources of information. The collected data was analysed to gain insights into the awareness and requirements of maternity wear [4].

3.2 Assessment of branded readymade garments

To assess the branded readymade garments, a sample of maternity wear was obtained from retail outlets. The garments were distributed to expectant women for a week, and their feedback was collected using a questionnaire. The feedback focused on comfort, belt and expanding features, design, and fitting style. A rating scale ranging from 0 to 3 was used to evaluate the garments based on the feedback received from the expectant women.

3.3 Assessment of Branded Readymade Garments by Expectant Women.

During the testing phase, a sample of readymade maternity garments was obtained from retail outlets. Five expectant women from each trimester (T1, T2, T3) were randomly selected and assigned codes A, B, C, D, and E. Each participant wore all the designs of the maternity wear for a period of seven days. A questionnaire was developed to capture the feedback of the participants, focusing on the comfort level, belt and expanding features, design, and fitting style of the garments. The participants used a rating scale ranging from 0 to 3 to evaluate each aspect of the maternity wear based on their experience. This scale allowed for a numerical assessment of the garments using the feedback provided by the expectant women. The objective of this process was to gather reviews and feedback regarding the maternity wear and assess its suitability in terms of comfort, functionality, design, and fitting for pregnant women in different trimesters.

3.4 Data Collection of requisite body measurements of expectant women

In Latur, a total of 300 expectant women participated in the study, with 100 women in each trimester (I, II, and III). The objective of the study was to collect data on the body measurements of these women and understand their body shapes and sizes in relation to maternity wear. Measurements were taken, including five length measurements and five girth measurements. The length measurements included height, torso length, arm length, leg length, and inseam, providing insights into overall body proportions. The girth measurements included bust/chest circumference, waist circumference, hip circumference, thigh circumference, and calf circumference, which help determine specific girth dimensions relevant to maternity wear. By analysing these measurements, patterns and trends in body proportions

among expectant women can be identified. This information is crucial for designing accurate size charts and creating well-fitting maternity wear that offers comfort and support throughout pregnancy. The collected data will be carefully analysed to derive meaningful insights, which will inform the development of appropriate size charts and aid in designing maternity wear that caters to the specific body shapes and sizes of the expectant women in the study.

3.5 Designing and analysis of developed garments based on bodily changes according to the trimesters

In response to the bodily changes experienced during different trimesters of pregnancy, new designs of maternity wear were developed. Posture straightening belts and spinal support belts were incorporated to address the issues of imbalanced posture caused by weight gain and the baby bump. These designs received positive feedback from expectant women. The study involved creating mood board inspiration boards and designs based on feedback from participants. Five unique designs were crafted for each trimester, considering the specific body changes and requirements during each stage of pregnancy. Size charts were developed using collected data to ensure accurate sizing [5]. The designs, mood boards, and size charts showcased the practical application of the study's findings, providing visual representations of the design concepts tailored to each trimester [6].

During the testing phase, expectant women evaluated the comfort and satisfaction levels of the developed maternity wear using a rating scale system. The garments designed for the first, second and third trimesters were labelled as T1, T2 and T3, respectively. A rating scale from 0 to 3 was used, with 0 representing low ratings and 3 indicating high ratings. Symbols A1, B1, C1, D1, E1, were used for the first trimester, A2, B2, C2, D2, and E2 were used for the second trimester garments, and symbols A3, B3, C3, D3, and E3 were used for the third trimester garments to differentiate and analyse the reviews. The inbuilt belt and expanding features were particularly appreciated by expectant women in the second trimester, while design, fitting, and style were important considerations for all trimesters. The feedback collected

from the expectant women helped assess the comfort level and satisfaction of the maternity wear, leading to insights for potential improvements and adjustments in the design and construction of maternity wear for women in rural and peri-urban areas.

4. Result and Conclusion

Maternity wear plays a crucial role in the comfort and satisfaction of expectant women, yet there is limited research on its design and fit based on trimesters. Studies have shown that pregnancy can lead to aches and pains, with pelvic girdle pain and lower back pain being common. Maternity support garments have been recommended as a remedy to alleviate discomfort and improve quality of life. However, current ready-made maternity clothes often fall short in terms of design, fit, and fashion ability. To address these issues, researchers conducted a study involving pregnant women. The study aimed to assess the satisfaction levels of different maternity clothing designs and gathered feedback on belt and expanding features. It was observed that younger respondents initially gave lower ratings in the first trimester but showed improved ratings in the second trimester. Pregnant women in the third trimester appreciated the characteristics of the maternity designs even more. Comparisons were made between ready-made garments and custom-designed ones, with the latter receiving higher ratings for fit, comfort, and fashion ability. Qualitative research and focus groups have also highlighted the importance of maternity wear in promoting positive body image and expressing maternal identity. Studies suggest that specific colour choices and details can influence how pregnant women perceive their bodies. Comfort, functionality, and fashion ability are key considerations in designing maternity clothes that accommodate changing body shapes and sizes. The market for maternity apparel needs to align with current fashion trends while fulfilling the demand for comfortable and well-fitting clothing that enhances a pregnant woman's body form. By combining style and functionality, maternity wear can empower expectant women and contribute to their overall well-being and confidence during pregnancy.

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Application of Lean Manufacturing in Packaging of Handblock Printed Products – A Case Study

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Abstract:

India is enriched with various artforms and rich heritage of unique crafts that thrives in heart of Indian rural areas. Survival and sustenance of these artforms largely depends on its productivity and commercialization, one such artform is hand block printing which has larger scope of commercialization and demand. Productivity in medium-sized hand block printing units is not able to upscale the productivity due to various leading factors resulting in limited customer value and less commercial opportunities for this hand block printing units. The need of research on studying various processes involved in hand block printing in different medium-sized units in Rajasthan cluster and to identify numerous wastes in the process involved in hand block printing. The study was planned in two phases with an objective to assess the impact of different waste on hand block printing productivity and apply production systems to increase productivity.

Keywords: Continuous Improvement, Fashion Production, Handblock Printing, Intervention, Lean Manufacturing, Productivity, Efficiency

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1. Introduction :

The handicraft industry has challenges due to its unstructured and vast nature. The term "handicrafts" refers to the use of a huge variety of diverse materials, skills, tools, and techniques, and can refer to a wide range of items, from unique works of art to practical and ornamental goods made in a semi-industrial setting (Mikkelsen and Hagen-Wood (1998).

Because the majority of craftsmen in the handicraft sector come from economically challenged social strata, financing business endeavors and meeting the brotherhood's development demands remain among the most important challenges. Crafts people's inability to access materials coming from modern industries is exacerbated by low literacy and education levels. (2011 Craft Economics and Impact Study)

This study is aimed to identify the leading factors affecting the productivity in medium-sized hand block printing units and apply production systems to achieve higher productivity resulting in creating customer value and exploring more commercial opportunities for the hand block printing units.

2. Materials and Methods

2.1 Materials

The study's major data were gathered through interviews that were semi-structured, direct observations, participant feedback, dialogues, and time measurements. Following

that, secondary data was acquired through literature reviews, archival material, and company paperwork.

2.2 Method

Study was conducted at R K Derawala Which involved extensive field work or gimba with semi structured interviews, of liberations, dialogues and time measurements what are used for collecting the primary data and PDCA cycle was implemented to conduct this study. To initiate the intervention it is important to identify the major area of concern at R K Derawala since the organizations core area is to offer a mix of product therefore sales report from the month of April 2020 to Jan 2021 was extracted. The sales report was required to be sanitized since the organization did not follow a standard process to define their products in the Tally Software therefore the data had to be sanitized before analysis.

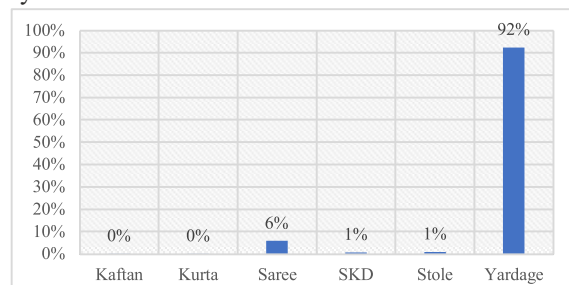


Figure 1: Product Quality Analysis

The data set provided in figure 1 derives product quantity end product routing analysis wedding the yardage products contributed 92% to their business, therefore it was evident that the study should be focused on improvising the handle of printing processes in preparing the yardages thereafter as per the principles of lean manufacturing other product categories needs to be focused for continuous improvement.

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3. Results and Discussion

Table 1: Pre-Intervention Process Cycle Efficiency

Hand Block Printing Activity	Value Added Time	Non-Value Added Time			
	Cycle Time	Inventory (In mtrs.)	Inventory (In yardage)	Process Talk Time	Total Talk Time
Packing	324	6804	1238	122	151036

3.1 Problem Statement: Errors in packaging resulting to rejection/return of hand block printed products.

Reducing the cycle time for packaging of hand block printed products.

3.2 Goal: To establish zero error packaging mechanism for hand block printed yardages products.

Developing a prototype enabling the artisans to process the packaging efficiently.

3.3 Analysis of Problem: Errors while packaging the hand block printed products. Packaging of hand block printed product is a very cumbersome process which includes organizing different packaging tags such as brand tag, MRP tag and craft mark tag which has to be sequenced as per the buyer requirement. post analysis of the data receipt from the buyers mentioning the detail of rejection reasons was analyzed with the help of pareto diagram. The pareto chart it's a very powerful tool which contains bars and line where in the individual values are represented in a descending order by the graphs and the cumulative total of the number of rejections are represented in a curved line. It follows that 80/20 rule that illustrates 80% of packaging defects arise from 20% of the causes therefore if we find a solution towards the 20% of the causes are 80% of the packaging defects were reduced finally achieving lower returns or rejections from the customer's end major majorly sighting the packaging as an issue.

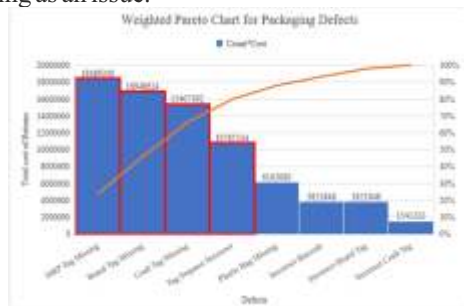


Figure 4: Future Value Stream Mapping



Video 1: Packaging of pre- intervention

3.4 Develop a plan:

Developing a prototype for packaging focusing on the 4 key defects in packaging

1. MRP Tags Missing
2. Brand Tag Missing
3. Craft Tag Missing
4. Tag Sequence Incorrect

A fixture was developed based on the lean manufacturing tool poka yoke (mistake proofing) and 5 S.

3.5 Do phase:

The fixture was designed based on the concept of prevention-based Poka-Yoke mechanisms which enabled the artisan for prevented an abnormality such as when the artisan was fetching and picking the tags it followed a left to right motion of picking and the tags were sequenced in the same motion therefore whenever the tags were not available the motion of the hand halted the artisan from completing the tagging process.

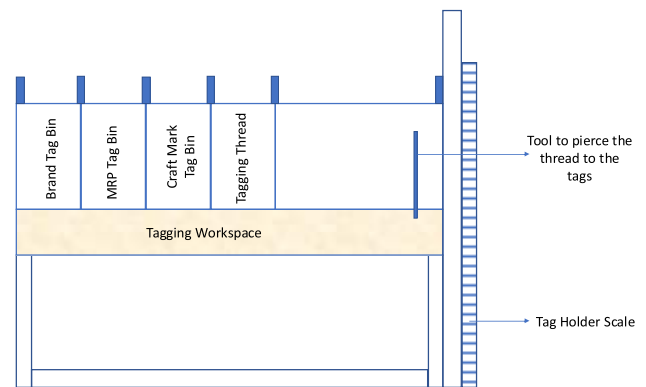


Figure 5: Packaging Table Sketch



Image 1: Pilot Run Packaging Layout

It was observed that there were multiple human errors in tagging therefore to a control method was applied to identify and eliminate the human work error by mode of displaying standard operating procedure for tagging in a more simplified and visually accessible standard work sheet which is an effective lean manufacturing tool. The standard worksheet was color coded as per the color codes on the fixture bins it prevented the mixture of the tags and helped improving the visual controls of the artisan.

Implementation of acceptable quality level quality (AQL) quality control tool which ensured that randomly 10% of the



Image 2: Packaging Table Prototype

packed goods were tested and if the number of defective items are below the predetermined acceptable quality level, then the entire lot is unpacked and tagging is reviewed this ensured that the area of cause is detected and defective packed goods are not shipped for the unit.



Video 2: Pre-Intervention Pilot Run



Video 3: Post Intervention Pilot Run

The packing of products was processed in lots of 58 pieces considering the carton size, in the old tagging process the artisan counted the tags and the garment pieces which resulted in errors in no. of pieces to be packed in a carton such as some cartons had excess pieces and some had less pieces. To ensure the accuracy and reducing the cycle time of this sub activity the fixture was attached with additional tag holders which has a flexibility to reduce and increase the no. of holding spaces. In this case the holdings were set to 58 numbers which eliminated the entire process of recounting the tags and pieces. Once the holder is full the artisan processed the tags for attaching activity to the products.

Table 2:

Hand Block Printing Activity	Value Added Time	Non-Value Added Time			
	Cycle Time	Inventory (In mtrs.)	Inventory (In yardage)	Process Talk Time	Total Talk Time
Packing	188.61	273			

4. Conclusion

Errors while packaging the hand block printed products resulted in increase in cycle time. Adopting zero error packaging mechanism for hand block printed yardages products and developing a prototype enabling the artisans to process the packaging efficiently. Cycle time for packaging pre intervention was 151036 seconds which was reduced to 6100 seconds post intervention and defect rate was reduced from 9.90 % to 1.45%.

Overall, all the interventions resulted in

- Reducing the cycle time from 733708 second to 22448 seconds
- Increasing Product life cycle time from 0.18% to 4.08%

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Mr. Avinash Mayekar

Mr. Avinash Mayekar, Textile Engineer from VJTI, Mumbai, MD of SUVIN has more than 3 decades of experience working in consulting firms and various textile companies of India. He has completed many assignments such as Business strategies, Advisory services, Project management, Modernization Studies, etc. He is one of the rare consultants cognizant on most of the reputed technologies for technical textiles and was instrumental in promoting technical textiles in India for past 20 years as a subject matter expert.

His expertise lies not only in technical skills but in overall textile project conceptualisation to implementation. His main specialization lies in Strategy building, Business Process Re-engineering and Technical textiles. This in depth & vast knowledge comes from his choice of choosing varied job profiles at Gherzi, A.T.E. group, Technopak and Mafatatlal group. This has enabled him to implement innovative skills and do something different at each and every stage of life.

Working with a reputed global consulting firms, he has gained huge overseas experience for textile technologies, plant and machinery related projects. He has been attending INDA exhibition (IDEA) in USA & EDENA exhibitions in Switzerland on Technical Textiles in USA since 2007. Also, participated in the exhibition IDEA 2016 in Boston, USA.

He is a renowned speaker and has presented many innovative technological concepts in International & National conferences. He is on advisory board & regular writer in various reputed publications. He has extensively worked for textile, food and exhibition industry.

ITMA 2023 – Impressions on a few Innovations & Launch

Compiled by **Avinash Mayekar, MD, Suvin**

Ø SPINNING:

LAKSHMI MACHINE WORKS (LMW), INDIA

Card LC636 SX

- Smart card LC636 SX with optional features CDS (Card with Drafting System) and Fix-Fil- Can changer arrangement
- Ensures high efficiency and productivity up to 250 kg/hr with consistent quality
- 1.5 meter working width and 36 working flats ensures quality derivable. Highly impressive active carding and cylinder area.
- It's unique design of various technological elements and energy efficient drives, the smart card delivers higher realization up to 1% with power saving up to 15%
- New patented 120 mm height flats to have constant cylinder & flat setting across the card width.
- Optical sensors installed on four flats to sense the setting between cylinder and flats. LRJ 90/SX compact ring frame for smart spinning
- LR 90 series is the longest ring frame in the market with maximum spindles up to 2400 with higher mechanical spindle speed up to 30,000 rpm
- Machine gives quality package with 30% improvement in yarn imperfections and classimat H1 faults.



Card LC636 SX

LRJ 90/SX compact ring frame for smart spinning

- LR 90 series is the longest ring frame in the market with maximum spindles up to 2400 with higher mechanical spindle speed up to 30,000 rpm
- Machine gives quality package with 30% improvement in yarn imperfections and classimat H1 faults.
- Saves power up to 8% with energy efficient low decibel HLED spindles. With improvised pneumafil suction and compact suction overall power saving is 10% including spindles
- Frame occupies lowest footprint and saves up to 8% space as spindle gauge is of 65 mm
- Automation with Ring rail drive, new auto –doffer drive mechanism and suction with AWES



LRJ 90/SX

Ring Frame Auto Piecing (RAP)

- Fully automated yarn piecing system for ring spinning machines, receives information on yarn break through YBS (Yarn Break Sensor) and travels to the particular spindle and automatically pieces the yarn instantly. Piecing cycle is 35 seconds
- RAP ensures auto piecing hence reduces dependency on skilled manpower. Package quality remains un contaminated due to non- handling by the human while piecing
- **Other Launches by :** LMW LR90 SX/SXL Without Compact, LRJ90 SX/SXL With Inbuilt Suction Compact Arrangement

RIETER, SWITZERLAND

J 70 air-jet Spinning Machine

- Delivery speed up to 600 meters/minute
- Each spinning unit is individually automated and thus independent, enabling maximum efficiency & flexibility
- VARIOlot enables to produce up to 4 lots at the same
- Lower conversion cost due to low energy consumption
- Quality monitoring with latest generation of Rieter yarn clearers Q 30A with larger measuring slot



J 70 AIRJET

Com4Recycling System

- Production of Ring & Compact yarn from blends of recycled and raw cotton
- Production of Ring and Compact yarns with almost 40% of recycled fibers with high yarn quality
- Presently recycled and raw cotton are still mostly processed on Rotor Spinning machines. The few ring yarns are available in coarse counts and with a recycled cotton content not more than 20%. To produce fine yarns with higher proportion of mechanically recycled fibers is major challenge being faced by the industry.
- Optimised their machines from blowroom to winding for processing of recycled cotton blends

TRUETZSCHLER, GERMANY

TC 30i Card

- Achieves higher level of performance & quality with 35% more active flats and 14% extended carding length
- Sophisticated waste suction makes to reuse more than 50% of card waste. Or high- quality waste can be sold to third parties with attractive value
- T-GO automatic gap optimiser for optimal carding gap settings which ensures increased productivity and quality TC 30i Card



TC 30i Card

The TCO 21 XL Comber

- TCO 21 XL with 12 heads maximise the productivity by 50% and saves space by 25% without compromising the sliver quality.
- Operating 12 instead of 8 heads reduces energy consumption by 10% per head, which minimizes conversion cost per kilogram
- Online Noil Monitoring solves major challenges for combing and shows noil changes online



TCO 21 XL Comber

TRUETZSCHLER CARD CLOTHING (TCC), GERMANY

Flat Tops PRECISETOP/MAGNOTOP

- Higher constant yarn qualities are possible. Quick & precise replacement of flat tops
- No need for a flats workshop
- One additional grinding interval = +10% production
- New flat top 45R combines highest quality with the necessary stability for recycling applications



Flat Tops 45R

SUPERTIP ultra- long service life

- Clothing with enormous durability, great variety and highest precision
- Excellent yarn quality
- Significant added value due to longer operation time STATIONARY FLATS
- NOVOFIX stationary flats are made of exclusively of special steel
- Ensures an even gap between cylinder and stationary flats, allowing optimum opening of the raw material lumps, the reverse side is also precisely machined MY Wires – Digital Clothing Management
- A digital App to keep track of maintenance schedules for their clothing. Users can choose Truetzschler's recommendations or their own to either grind the clothing or change it



TCC Demonstration at ITMA

STATIONARY Flats

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MY Wires – Digital Clothing Management

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MARZOLI, ITALY

Roving Frame FTM320

- The innovative roving frame with a central headstock and independent double side modules works simultaneously, to allow spinners to increase efficiency by up to 5%



MARZOLI

The CMX state-of-the-art 10 combing head comber

- Production capacity up to 115 Kg/hr
- Productivity level 25% higher than previous model
- Energy saving of about 20% KW/Kg

The MDS2 ring frame with Active Flute energy consumption reduction system

- Capable to spin cotton, man-made fiber and blends up to 60 mm. Spindles up to 182

SWINSOL, SWITZERLAND

- Sustainable mechanical compacting system by Swinsol as these units don't need electricity and therefore CO2 neutral in operation

MURATA, JAPAN

FLcone Link Coner

Commercial launching will be in next 24 months

High productive winding Machine's concept is “non–stop” winding. Winder does not stop winding even during yarn breakage & splicing.

PROCESS CONER Alcone

- High productivity, energy saving and good package quality are the major features



Process Coner

SAVIO, ITALY

PROXIMA Smartconer

- Savio's Proxima Smartconer stands for high-tech winding machine capable of perfectly adopting to demands of connectivity, Industry 4.0 and industrial internet of Things.
- It gives an advantage for high productivity, low energy consumption, premium yarn quality, automation and data connectivity.
- It enables to work faster and reduces manual and repetitive tasks, can increase both efficiencies and overall productivity. It is faster, safer with better quality but with less waste, less maintenance and less resource usage.



PROXIMA Smartconer

GROZ-BECKERT

Card Clothing – Spinning Carding

- Maintenance free reel clothing with increased service life and low maintenance cost.
- Developed fixed flats with new resistant aluminium profile and revolving tops are also available

Ø WEAVING:

TSUDAKOMA, JAPAN

Zaxneo001 air-jet weaving machine

- Special frame structure, direct gear drive for smooth start-up and advanced beating system.
- Significant increase in working rpm & 30% reduction in vibration than previous model with advance weaving performance.
- Enhancing weft insertion performance with optimized nozzles, valves and control technology.
- The combination with TAP creates significant reduction in air consumption and low pressure in high speed operations.
- High speed weaving by positioning the first heald frame closer to the beating point and further energy saving.
- In-house developed heald frame is highly robust and light and designed for ultra-high-speed operation.



Zaxneo001

PICANOL, BELGIUM

OminiPlus-I Connect Airjet Loom

- The machine was running at highest speed of 1500 rpm on bottom weight even with 100% recycled yarn.

O Leno

- It is a big relief from changing E leno bobbins at every 4 days. No more moving of E leno assembly, regular consumable items.
- O leno is with bigger bobbin with 10 time's longer running time. No more leno bobbin winder required nor you need extra person required for operating Leno Winder.

Ultimax rapier weaving machine

- Ultimax 12-J-340 – for Flat Carpet
- Ultimax 4-R-220 – for Denim
- Ultimax 8-R-360 – for Voile
- Ultimax Terry- 8-J-260 – for Terry towel



PICANOL

LAXMI LOOMS, INDIA

- LHR 450 high speed rapier loom
- LHR 450 high speed rapier loom is a state-of-the-art cam beat-up loom under “Make in India” campaign
- Touch panel for easy access to operational parameters and with a vision integrating IOT 4.0 in the near future
- LHR 450 is available in width from 180 cm to 340 cm with weft insertion rate of 1000 meters/minute with suitable servo take-up & let-off (up to beam flange dia. 1000 mm)
- With stepper motor driven 8- colour presenter, with pickfinding device, independent leno motion
- With energy efficient motor which make it sustainable for weaving light to heavy fabrics



LHR 450

ITEMA, ITALY

EVO Weaving Machines

- Advanced solution for weft transfer to enhance versatility and machine performance
- iSAVER range available in up to 6 colours and for many more fabrics apart from Denim
- Innovative digital software like iKNOW which contains know-how collected on the field by ITEMA experts and MyWeave advanced mill monitoring system

Rapier Weaving Machines

- R95002, R95002 Denim, R95002 Terry, R90002, HERCULES for Technical Textiles

Air Jet Weaving Machines

- A95002, A95002 Bed sheeting

SMIT, ITALY

High speed weaving machine

- SMIT brought weft tension control device 2SAVE that saves selvage at both left & right side. Thus brings sustainability by reducing the waste. 2SAVE saves 50 mm & 80 mm of yarn at each pick

STAUBLI, SWITZERLAND

SAFIR S60 – automatic drawing-in system

- With Active Warp Control 2.0 (AWC 2.0) for setting standards in yarn recognition and management



SAFIR S60

Staubli Jacquards LX PRO, LXL PRO, LXXL PRO

- Energy efficient PRO series in the production of flat, terry or OPW (one – Piece woven) fabric.
- Available in formats ranging from 4,608 hooks (LX PRO) to 25,600 hooks (LXXL PRO)

Carpet Weaving System ALPHA for rug production

GROZ-BECKERT

KnotMaster - Knotting Machine

WarpMasterPlus – Automatic Drawing-in Machine

- Reeds for the customers who produce fabrics in the range of high fineness (both wire and synthetic fabrics). Weaving reeds are used for production of fabrics used in technical filtration, membrane technology, solar cells or touch screens.



WarpMasterPlus

TOYOTA, JAPAN

JAT 910 Air Jet Loom

- 20% reduction in air consumption than previous model with 10% reduced air pressure
- New main motor & inverter achieves 10% reduction in power consumption.
- Use if i-SENSOR world's first sensor that detects weft yarn insertion timing as the yarn is passing inside the warp yarn, enables the optimum air pressure and weft insertion requirements to be automatically calculated based on Toyota Industries' proprietary algorithm, thereby supporting improved efficiency



JAT 910 Air Jet Loom

MAYER & CIE, GERMANY

OVJA 2.4 EM Knitting machine

- Machine knits double jacquard with electronic individual needle selection in the cylinder and double fabric with weft thread.
- Most productive machine in its class.
- Spacer fabric also can be knitted on this machine



OVJA 2.4 EM

Reliant 3.2 HS

- Machine is with improved yarn guides
- Needles with optimized hook and tongue shape and pre-determined breaking point to improve safety at higher output.
- The new sinker is another feature of Reliant 3.2 HS which makes the machine run smoother and reduces wear and tear

SF4-3.2 III

- This machine is for three- thread fleece, especially for leisurewear, both in pure cotton and blends, which is in great demand.

Braiding Machine

- MR-15/18 C / Single Deck braider for textile braiding.
- The new capstan wheel pull-off that is especially suitable for smaller- diameter hoses with textile braiding.
- The Speed Booster upgrade kit delivers more speed and up to 10% more output

SMART FUNCTIONS for fewer faults and less waste

- Knithaw recognizes and identifies knitting faults fast during the knitting process, switching the machine off automatically. That makes production significantly more efficient and sustainable
- Knithaw is the platform that links the manufacturer, representatives and customers. IIoT based and central location for all the machine data that every customer can use to record and evaluate the performance of his machines.
- Knitlink provides every customer with remote access to the circular knitting machine. Digitally linked new - generation control 5.0 web shop

CIXING STEIGER, SWITZERLAND

STG860 Multi-functional Flat Knitting machine

- Machine makes sweater with multiple patters and various product range to release higher profit range
- The machine can be used for various applications including Technical Textiles



LC Max

GROZ- BECKERT, GERMANY

LC Max Circular knitting needles

- New wave- shaped shank geometry, reduces energy cost through minimal power consumption and reduced machine temperatures compared to standard needles. Up to 20% energy consumption can be saved with LC Max needles.
- Use of LC Max enables utilisation of maximum machine speed and easy handling



SNK-SF Sinker

SNK-SF Sinker needles

- Features significantly higher wear resistance
- Ensures smoother running of circular knitting machine and improved loop structure.

SANTM DUO and SAN-DUO Needles

- Features low shank with predetermined breaking groove in turn enables controlled needle breakage in the event of wear at the desired point. This reduces errors in knitting process as well as downtimes.



SAN TT

Compound Needle

- With this needle variant, the closer is guided safely and precisely in the groove in the needle shank. At the same time, however the base of needle shank is worked in close manner, ensuring maximum stability.
- The compound needle reliably prevents latching and makes decisive contribution to process reliability.
- It's use ensures a uniform and speed-independent loop structure, even at maximum speeds.

SAN TT Flat knitting needles

SAN TT needles are suitable for multi-thread knitting of narrow loops in the field of technical or medical textiles.

SAN FY- Flat knitting needles

The SAN FY is designed for robust, uneven fancy yarns.

TUFTING - Needle & Looper Modules for Tufting

- For the production of tufted floor coverings such as carpets, bath mats, or artificial turf.

INDITEX & JEANOLOGIA, SPAIN

Air Fiber Washer

- First industrial air system designed to reduce microfibers (small particulates having length less than 15 mm) shedding in textiles to extract microfibers during garment fabrication and reduce subsequent shedding in domestic laundering.
- With this technology microfiber shedding reduces up to 60% through the use of air without employing water or thermal energy without compromising quality of fabric.
- Each washer collects up to 325 Kgs of microfibers per annum.
- Thus fibers going in to effluent are arrested and ensures zero waste as these fibers can be recycled.

FABRIC PROCESSING

FONG'S, CHINA

THEN Smartflow TSF

- TSF softflow's advanced features gives high quality results with minimal water, energy and chemicals
- Machine's smart fabric transport system ensures extremely even dyeing of the fabric through accurate control of the nozzle pressure and pump power
- PLC controlled plating system and variable chamber adjustment depending on fabric characteristics is another feature
- Heat exchanger enable to heat the liquor quickly and efficiently to reduce energy consumption
- Bath preparation unit and chemical dosing system ensure accurate and precise dosing of chemicals, dyestuff and salt, reducing chemical waste and optimizing results while reducing process times
- TSF operates with low liquor ratio of 1:2.5 with full loading of synthetic fabric. Resulting not only reduction in consumption of steam and water but also less amount of waste water generation.



Air Fiber Washer



THEN Smartflow TSF

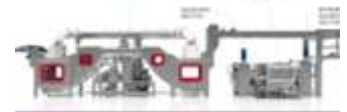
BIANCALANI, ITALY

AQUARIA Washer

- An open-width tumble washing and wet treatments system
- Designed to reduce water and energy consumption in a very special way
- Washing after-print in AQUARIA offers very important savings in terms of water and energy

DUETTO Dryer

- Continuous open drying machinery
- Is in line with Biancalani's philosophy to dry and soften fabrics reducing energy consumption while significantly increasing productivity and efficiency



AQUARIA Washer

COLORJET, INDIA

MetroNext Digital printer

- Made in India digital textile printing machine
- High quality and high speed digital textile printer.
- It has 8 color options with speed reaching up to 9000 sqm/day

Earth Series - Advance Sustainable Pigment Solution

- 98% less water consumption per meter printed
- Super-Efficient water filtration & reclamation System
- High printability sharpness & fastness properties
- Immediate visibility of printing results
- Binder technology, Deep colour intensity

EFI REGGIANI, USA

EFI Reggiani ecoTERRA

- Pigment print line is all-in-one solution for water based pigment printing that requires no ancillary equipment for pre and post treatment.
- It's a truly sustainable direct fabric printing solution by significantly reduction in water, energy and chemical consumption in overall process



MetroNext



EFI Reggiani ecoTERRA

Reggiani HYPER

- It is the fastest scan digital printer available in the market. Available in 1.8, 2.4 & 3.4 meter wide options with 72 printheads and ink recirculation up to the nozzle plate.
- It can print two pass, production quality at speeds up to 13 linier meters per minute on 1.5 meter wide roll. 20 meters per minute speed can be achieved by using dual-roll capacity on 3.4 meter model.
- EFI Reggiani BOLT XS printer with speed up to 100 linier meter per minute. This machine is claimed true digital replacement for rotary printing.

MIMAKI, JAPAN

Dye sublimation transfer printer – Tiger600 – 1800TS

- Production rate 550 sq. meter per hour
- Space required to install the machine is just 3.5 meters
- Ink is Oeko-Tex certified and Bluesign certification is awaited
- The Neo – Chromo process promotes circular economy by releasing a sublimation ink from polyester textiles, it enables reprinting or reusing of textiles almost without use of the water
- Print of the signage's can be removed and reuse and reprint the signage's



Tiger600 – 1800TS

Texcol an innovative pigment transfer paper

- Waterless process, offering the versatility to print on wide range of textiles, with sharp details and high colour brilliance
- Main attraction of this innovation is that the textile does not require pre or post treatment

ALEPH, ITALY

LAFORTE 400 Fabric H printer

- Pre-treatment of fabric can be performed in line with extra print heads installed on the printer
- Production rate up to 480 sq. meters/hour and easy to handle three – step processing
- Printed utilises apeph GOTS certified pigment inks for improved sustainability
LAFORTE 600 paper is another fastest industrial printer in sublimation market with speed up to 1000 sq. meter per hour



LAFORTE 400

EPSON, JAPAN

Monna Lisa series

- Capable of printing on any fibre surface up to a fabric width of 340 cm
- 8 base colors with extension option up to 740m²/h and 600 x 600 dpi.
- Advanced automatic cleaning and adjustment mechanism
- High ink/fabric capacity all you need for top quality and high-speed printing, with no errors and almost zero down time
- The highest standards and unmatched flexibility, able to adapt in real time to the needs of our increasingly dynamic market



Monna Lisa

GURJAR, INDIA

Rotary Screens for Printer

- Launched 4th generation screen technology, 225- Mesh screen allowing for even finer designs and improved aesthetic appeal.
- This screen also brings greater efficiency in production process with reduced chemical & dye usage, lesser requirement of manpower and increased automation

WEFFAN

- 3D Woven Garment System (Garments from yarn through 3D Weaving)
- From existing jacquard looms and software, instead of weaving a single layer of fabric, actually engineers the garment shape and garment components on the loom.
- In a textile value chain garment manufacturing step is being removed with this system. Currently weavers take a pattern to be cut and sewn, processes that may happen at different facilities or factories before being shipped to the consumer. Weffan is putting those steps in to one machine

GARMENTING



3D Woven

GROZBECKERT, GERMANY

Sewing Needles SANTM Special application needles

- SAN 5.2TM suitable for sewing a technical textiles such as airbags. Needles is having increased stability and secured loop pick-up.
- SAN 6TM for sewing of woven fabric such as Denim
- Both needles are equipped with GEBEDURTM coating which protects needle from wear & damage, especially in the point area.
- SANTM 10 slim & dimensionally stable needle used for sewing of fine knitted & woven fabrics. Whereas SANTM 10 XS is for extremely fine material or materials that requires critical sewing

TRUETZSCHLER NONWOVENS, GERMANY

Needle Punch Line

- T-SUPREMA, package of excellent machinery, tailor made production lines, integrated digital support and global service
- Web weights from 60 – 1000 gsm, wide range of fibers in various fineness
- Output up to 7,500 tons/ year and end products mainly for technical applications such as geo and automotive textiles, filtration media (gas & liquid filtration), home textiles, furnishings and others
- Italian company Texnology is partner for the needling machines, web drafters and crosslappers.



ANDRITZ, AUSTRIA

- Andritz introduced new Spunlace pilot line for natural & recycled fibers at its center of competence in Montbonnot, France.
- It allows customers and partners to conduct trials for producing nonwovens from recycled and/or natural fibers such as hemp, flex and cotton.

DILO, GERMANY

“MicroPunch” complete production line for intensive needling

- MicroPunch technology is for needling fine and lightweight fleeces to be used in hygiene, medicine, apparel and other applications.
- Good abrasion resistance of the intensely needled materials suggests further application filed such as apparel, artificial leather, battery separators and filter media.
- More focus on environmental sustainability and recyclability on processing of biologically degradable fibres is a major goal.
- Compare to hydroentangling the “MicroPunch” needling allows reduction of energy consumption of about 75% based on the complete installation.
- MicroPunch line consist of
 - ✦ Fibre preparation – DiloTemafa components
 - ✦ Universal or Randa Card – DiloSpinnbau
 - ✦ Pre & finish needlelooms & Winding Unit – MicroPunch Speciality needling

GROZBECKERT, GERMANY

Felting Needles

- Felting needles for classic needling or hydroentanglement. HyTec™ P Jet strip features significantly improved wear resistance and handling properties.

Card Clothing - Nonwoven

- World's finest interlinked card clothing for reduced crash risk
- SiroLock plus types inline card clothing series is for higher line availability and more even carding result.

SAFR – FR SUSTAINABLE FIBRE BY BIRLA CELLULOSE, INDIA

- Birla SaFR is a Phosphate based inherently fire retardant sustainable cellulosic fibres ideal for making flame retardant fabrics with eco- friendly characteristics Made in India indicative to provide an alternative to imported Fire Retardant fibres SaFR can be blended with other high performance fibres like aramid, FR mod acrylic, FR polyester etc.
- SaFR ia applicable in the industries requiring highest standards against fire protection such as thermal protection, electric arc protection, molten metal splash protection catering to the unique needs of sectors such as defence, emergency response (ER), oil & gas, electrical utility companies etc.
- SaFR has the Oxygen Limiting Factor (OLF) >28 and it sustains the FR efficacy post multiple washes (>50 washes)



SAFR – FR

Uster Fabriq Assistant

- Artificial intelligence in fabric inspection. Uster Fabriq Assistant is a central platform for automated processing, analysing and visualizing quality data from Uster fabric inspection systems.
- The application is web based tool and shows summary of quality performance from all the fabric rolls inspected in the mill
- Fabriq Assistant removes unwanted workload of manual data preparation and analysis. It also provide basis for maximum decision- making accuracy, using advanced technologies such as Artificial Intelligence (AI)

ERCA

Textile Specialties has developed a technology to transform common waste material, such as exhausted vegetable cooking oil into an up cycled certified high performance, safe textile chemical. REVECOL is sustainable chemical agent

SUMMARY

Sr. No.	Exhibiting Countries	% Space Occupation	No. of Exhibitors	Sr. No.	Participating Sectors	% Space Occupation	No. of Exhibitors
1.	Italy	30%	422	1.	Finishing	27%	329
2.	Germany	15%	198	2.	Spinning	13%	257
3.	Turkey	12%	191	3.	Weaving	10%	161
4.	China	7%	231	4.	Printing	12%	146
5.	India	6%	181	5.	Knitting	10%	128

For additional information, please contact:



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- Bank Name: **Bank of Maharashtra**
- Account Number: **60059709862**
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Growing Indian Economy and Opportunities in Stock Markets

Mr. Murarilal L. Jhunjunwala,

Former President of RSWM Ltd, a Cost Accountant by profession, and an expert in forex management and foreign trade affairs

Indian economy has been growing at about 6% to 6.5% since last few years. The growth of India is much better than other economies. Following are the details of growth in India and other countries.

	2021-22	2022-23	2023-24 (Expected Growth in %)
India	6.8	5.9	6.3
China	3.0	5.2	4.5
Emerging Asian Countries	4.4	5.3	5.1
USA	2.1	1.6	1.1
Europe	3.5	0.8	1.4
Advanced economies	2.7	1.3	1.4
World output	3.4	2.8	3.0

From above it can be seen that Indian economy is growing at a rate which is higher than giants like China, other emerging and developing Asian countries and advanced economies like USA, Europe etc.

India has done exceedingly well in handling the crisis faced by the whole world due to Covid pandemic. INDIA not only ran the world largest vaccination programme but also exported vaccines to lot of countries who needed it.

Following are the other key highlights.

1. India is world's 5th largest economy. Its economy size is now \$3.75 trillion.
2. India is largest recipient of FDI Investment despite covid. Forex reserves are at a record high of \$ 598 billion.
3. Share of India in global trade has increased from 2% to 2.2%
4. Share of India in global GDP increased from 2.6 % to 3.2%
5. India is second largest producer of steel.
6. India is 4th largest producer of Automobile. Will shortly overtake Japan.
7. India was a small producer of mobile phone. In 2022 India exported mobile phones worth \$5 billion. Currently India is exporting mobile phones worth \$1 billion every month. World's largest mobile factory is in Agra. With PLI scheme in place, mobile component suppliers and ancillary suppliers are putting up factories for manufacture of mobile phones in India. It's nice to see that Made in India smartphones are being sold on the

shelf of American retail stores.

8. Semiconductor chips is being produced by only 5 countries in the world. India is trying to bring a manufacturer to set up in India. If that happens it will greatly boost Indian economy.
9. Inflation is high but the whole world is struggling with inflation. Europe and UK have inflation rates around 10%. USA has inflation of around 7-8 %. Inflation in India has come down around 4%.
10. Foreign Institutional investors has lost \$280 billion in Russia. They are losing
11. GST collection which was Rs.1.00 lac crores is now at Rs.1 .50 lac crore.
12. International players want to shift their business from communist countries to democracies.
13. There is no growth in USA/EU/Latin America, rather there is degrowth, but Indian economy is growing at steady pace.
14. Airports and infrastructure have increased in India.
15. India is investing heavily in green and alternative energy.
16. Private sector is now ready to invest to take part in growing economy.
17. IMF data says that India is the fastest growing economy.
18. Every top global brand is willing to set up a shop in India. Apple has opened its first store in Mumbai and is setting up stores in other cities. GLOBAL brands like IKEA, Decathlon, M&S, Zara, you name any brand it is here.
19. Indian merchandise exports are likely to touch \$750 billion in next few years.
20. In FY 2024, overall capex of Rs.10 lacs crore is being planned.
21. DEMOGRAPHIC balance is in favour of India. India is a country of young people. At least till 2050 we will not be aging. Whereas other countries like China, Japan are aging.
22. Indian aviation market is growing. In May there were 13m air traveller.
23. EVERY hotel brand is increasing its room capacity and are setting up hotels in 2 tier and 3 tier cities.
24. REAL estate markets which was stagnant since 2015 is

now looking up. Piled up inventories of flats and offices are getting sold. MNCs are taking large office premises on lease.

25. Developers are buying large parcels of lands. Stamp duty and registration fees collection are at record high.
26. Per capita income of India is going to increase from \$2278 to \$ 5242 by 2030.
27. Exports which are currently at 2.2% of global exports are likely to rise to 4.5% by 2030.
28. There are 11 crore DEMAT account holders in India and this no is steadily increasing.

Now look at the golden decade ahead.

Current Size of Indian Economy : \$ 3.75 TRILLION

First Target : \$5.00 TRILLION

Second Target : \$10 TRILLION

- From all above indicators we can say that Indian economy is at a flash point. These data have a tremendous impact on Indian stock markets. BSE Sensex has given CAGR of 15.2%.
- Indian investors are investing about Rs.14,000 crores per month in SIP which amount goes into stock markets to buy equities. Total Assets under Management with Mutual funds for equity investment is Rs.7.50 lac crores. Earlier when FIIs used to sell Indian stock markets would fall but now the situation has changed. When FIIs sell Indian investors are ready to buy.
- FIIs sold equity shares of more than \$35 billion last year which was grabbed by Indian investors. Sensex is at all-time high of 63000+.

World economies including India has passed through one of the worst crises but now the worst is over.

From above it can be seen that whatever India has earned in last 30 years, we can make in next 5 years, when in next 5 years Indian economy will double the net worth of every Indian will be doubled.

Opportunities in Indian Stock Markets

FROM all above it is clear that Indian economy is in growth mode and Indian growth story is intact. Economic development has a direct impact on stock markets.

As a sound investment strategy, one should not put all its eggs in one basket. One should ideally have a basket of investment as under.

Equities	: 50%
Fixed income	: 15-20 %
Real estate	: 10-15 %
Bullions	: 10-15 %
Cash and bank	: 5-10%

Out of above asset classes equities are most wealth creators. Other assets are wealth preservers. While investing in stock markets/equities, one has to be very careful, as investment in

equities is subject to market risks.

As a sound investment strategy, one should look at the following criteria before investing in equities:

1. Business sector: One should look at the business sector to which the company belong to. If the business sector is performing well the companies in that sector are bound to do well. In the year 2023-24 following sectors are doing well and are worth watching:

- a. AUTOMOBILES: Sales of cars, three wheelers, and two wheelers is increasing month by month. Production of E vehicles, E scooters is increasing. Sales of luxury and premium cars is increasing. In fact, there is long waiting list for premium cars. Most of the car makers are increasing capacities. In view of this investment in companies which are in this sector can give good returns.
- b. BANKING: With growing economy banking sector is like to have a good run. Demand for credit will increase as new capex is being done. With rising income levels of Indians more and more business is coming to business. Banks has good opportunities in housing loans, auto loans and education loans. With higher spending on infrastructure, the business with banks will rise multi fold. If we look at the annual results of banks for FY 2023 profits of all banks has increased by 20 to 50 %. Asset quality of banks is also increasing as NPAs are at lower levels. With speedy resolutions on stressed assets through NCLT banks are recovering loans against which provisions has been made. Thus investment in share of banks could give good returns.
- c. CAPITAL GOODS: During Covid most of the capital goods manufacturers cut down their costs and are now slim and trim. They are now ready to seize the opportunity which is arising due to increasing capital expenditure plan. Thus, one can look at investing in companies in this sector.
- d. DEFENCE PRODUCTION SECTORS: Govt. of India is increasing its defence spending. With higher thrust on Indigenisation of defence equipment the Indian Defence product manufacturer are flush with order. Companies in this sector should do well.
- e. Hospitality and Aviation: During covid hotel and airlines were the worst hit. After covid there is a tremendous increase in travel by Indians. Record numbers are flying. In May a record no of 13 million passengers travelled through air. All hotels are full due to travel by Indians and also due to wedding season, more and more weddings are taking place as destination wedding. Room tariffs are at record high. All hotel brands are increasing their capacity and setting up new hotels in Tier-2 and Tier-3 cities.
- f. FMCG & RETAIL SECTOR: Economy has almost recovered from shocks of pandemic. Indian consumer has started spending and discretionary spending has also increased. Inflation is also under control, footfalls in

shopping malls has increased. Thus, companies in this sector are expected to do well.

2. TRACK RECORD OF PROMOTERS & CORPORATE GOVERNANCE:

Second criteria to check before investing is to check track record of promoters of the company and the corporate governance in the companies. One should avoid companies where track record of PROMOTERS with dismal record. One should see that whether the promoters are fulfilling their commitments to shareholders. One should also see that proper corporate governance systems are in place.

3. DIVIDEND TRACK RECORD:

One should also see the dividend track record of the company. When company regularly pays good dividend, it is an indication that company is having good cash flow. There are companies who declare good profits but either do not pay dividend or pay very low dividend. One should avoid such companies.

After looking into above sectors, one should select good companies for investing.

One should invest only that amount which is saving and will not affect the routine life of the family, if the amount invested is lost. While investing one should also adopt proper stop loss levels to minimise the losses in adverse situations.

The above are few guiding principles which one should be following while investing in stock markets. If one invests in equities after taking due precautions, it is expected that one can get good returns. There may be situation that out of 10 investments there could be losses in 2-3 cases but that is the case in all businesses. So, the growing Indian economy is offering tremendous opportunities, grab it. Those who do not take part in this will miss a great investment opportunity.

Disclaimer: Views expressed in the above article are personal views of the author. Anyone who intends to invest in stock markets should do it after proper study and research. Author is in no way responsible for any losses which the investor may suffer on his investment in stock markets.

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TAI - MUMBAI UNIT

**Post Event Report of Half Day Seminar
“INNOVATIONS @ ITMA MILAN 2023”**

The Textile Association (India), Mumbai Unit Jointly with Veermata Jijabai Technological Institute (VJTI) organized Half Day Seminar on “INNOVATIONS @ ITMA MILAN 2023” on 7th July 2023, Krantijyoti Savitribai Phule Sabhagruh, V.J.T.I., Mumbai. The seminar was inaugurated by the Chief Guest Mr. Ketan B. Sanghvi, Hon. Treasurer, India ITME Society. Mr. Rajiv Ranjan, President, TAI, Mumbai Unit in his welcome address welcomed the Chief Guest and the Speakers. He also welcomed the Press, Media and Delegates. He gave the brief about ITMA and different activities undertaken by The Textile Association (India), Mumbai Unit for the benefit of textile community.

He mentioned that ITMA 2023, the Olympics of latest developments in textile machinery and accessories, was a resounding success. The focus on advanced materials, AI, digitalization and automation, coupled with the focus on sustainability augured well for the industry. A revelation was the fifth largest presence of 181 exhibitors from India, out of a total of 1,709 exhibitors, and occupying 6% of total space, most of them MSMEs, led by a fearless breed of new generation entrepreneurs who believe in themselves and the India story.

Mr. Haresh B. Parekh, Convenor of the seminar while addressing said that ITMA is the biggest market place and one-stop sourcing platform for emerging trends and innovation solutions. The TAI, Mumbai Unit & VJTI thought it prudent to highlight on the innovative product displayed at the show for those who missed ITMA show and could not attend it. Dignitaries who attended ITMA 2023 held in Milan, Italy, had been invited to give the firsthand information about the latest developments in international market.

TAI Mumbai Unit had made all attempts to give the glimpse of ITMA Exhibition to the delegates. Mr. Parekh also showed the ITMA Impressions video of Mr. G. V. Aras, Trustee of TAI, Mumbai Unit and Strategic Advisor who visited the ITMA2023 show.

Dr. Arvind L. Bhongade, Head, Dept. of Textile Engineering, V.J.T.I. briefed about various activities of V.J.T.I. In his address he said that the name of the department is changed from Textile Manufactures Department to Department of Textile Engineering with effect from 1st June 2023. He also informed that the department is likely to change the title of PG Program from M. Tech. (Textile Technology) to M. Tech. (Technical Textiles) to participate in the National Technical Textile Mission Program, Ministry of Textiles, Government of India. Institute is in process of revision of its undergraduate courses in compliance of NEP 2020 and its implementation from the coming academic semester. He appealed to all the Alumni, industry personals to share their ideas and views to design the academic curriculum for the Undergraduate students from the department in line with NEP2020.

Mr. Ketan B. Sanghvi, Hon. Treasurer, India ITME Society while giving his inaugural address as a chief guest congratulated the TAI-Mumbai Unit and V.J.T.I., Department of Textile Engineering for organizing such unique event after ITMA-2023. He said that theme of ITMA2023 was “Transforming the world of textiles”. He also displayed the statistics of country – wise and segment wise participation. He said that the industry was going through a difficult phase with drop in order positions and a pessimistic short term outlook which was having a dampening effect on the machinery manufacturing industry. Digitalisation, automation, sustainability, circularity, artificial intelligence were the terms increasingly being heard from the global leaders and from the user industry. The Spinning industry was increasing its focus on processing recycled & regenerated fibres, increasing use of AI and smart processing. Mr. Sanghvi also gave information about India ITME Society’s promotional activities.



Mr. Rajiv Ranjan, President, TAI, Mumbai Unit during his welcome address



Mr. H. B. Parekh, Convenor, TAI -Mumbai addressing the gathering



Dr. Arvind L. Bhongade, Head, Dept. of Textile Engineering, V.J.T.I. briefed about various activities of V.J.T.I



Mr. Ketan B. Sanghvi, Hon. Treasurer, India ITME Society during his inaugural address

Mr. N. D. Mhatre, Director General (Tech.), Indian Textile Accessories & Machinery Manufacturers Association (ITAMMA) in his presentation briefed about the key trends observed during ITMA 23 along with the statistical data. He talked about Sustainability, Digitalization, Circularity, Smart factory, Industry 4.0 / 5.0, He stated that Transformation starts with Innovation' – “Start-up Valley”, Transforming the World of Textiles through Sustainable Innovations & Digital Advancements”, Human-Machine collaboration developed to establish a symbiotic relationship and Social & environmental Sustainability was in focus at ITMA to reduce waste, energy consumption & environment impact while ensuring fair & ethical treatment of workers. He also gave the details about the various machines displayed at the show with their strength and capacity.

Mr. Navin P. Agrawal, Vice President, Textile Engg. - Fabric Forming, A.T.E. Enterprises Pvt. Ltd. discussed about the advanced materials, automation and digital future, innovative technologies, and Sustainability and circularity. He also discussed about the Impact of Digitalisation and Automation on Sustainability, Textile Chemicals and a Circular World, Textile Recycling for a Circular Economy and transition towards a Circular Textile Industry. He covered the developments in weaving & knit segment with details information about the various machines of SMIT, Picanol, ITEMA, Tsudakoma, Toyota, Staubli, Groz-Beckert, Karl Mayer, Mayer & CIE, Santoni, Pailung, etc.

Dr. Ashok Athalye, Professor - Textile Chemistry, ICT, Mumbai in his presentation highlighted the key points of Take Away from ITMA 2023. He talked on Farm to Fashion – Value Chain. He showed the complexity in textile processing and said that the developments on display at ITMA would help in reduction in Cycle time and reduction in consumption of water, energy, dyes, chemicals and thus effluent load. These factors would result increase in profits and decrease in environmental impact. Mr. R. R. Patil, Vice Chairman, TAI, Mumbai Unit proposed the Vote of Thanks. The seminar was very successful and was attended by around 125 participants including students.



Mr. N. D. Mhatre, Director General (Tech.), ITAMMA during his presentation



Mr. Navin P. Agrawal, Vice President, Textile Engg.-Fabric Forming, A.T.E. Enterprises Pvt. Ltd. during his presentation



Dr. Ashok Athalye, Professor -Textile Chemistry, ICT, Mumbai during his presentation



Mr. R. R. Patil, Vice Chairman, TAI, Mumbai Unit presenting Vote of Thanks

TAI - SOUTH INDIA UNIT

Foundation Day Program

The Textile Association (India) – South India Unit has conducted its Foundation Day Program on 27-05-2023 at Auditorium, Coimbatore with the presentation on the topic “Managing Emotions for Better Interpersonal” by Dr. R. Deepa, Associate Professor & Head Faculty of Human Resources, PSG Institute of Management in Session – I and “Sustainable Energy Savings – Low Hanging Fruit” by Mr. R. Nagasubramaniam of R. N. Energy Systems, Coimbatore in Session – II.

Shri K. Gandhiraj, Hon. Secretary, TAI – South India Unit delivered the welcome address and Shri R. Seenivasan, Vice President, TAI – South India Unit delivered his special address.

About 200 members attended the program. There was a good interaction between the Speakers and the participants. Finally the program ended with the vote of thanks by Shri A. Sivaramakrishnan, Hon. Joint Secretary, TAI – South India Unit.

Call for Articles

Journal of the Textile Association

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

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Beyond innovation
Bring your brand to India's
booming technical textile industry

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RIETER AirJet Spinning at a New Level with Rieter's J 70

The new Rieter air-jet spinning machine J 70 with individually automated, independent spinning units and optimized technology components enables the production of high-quality yarns with maximum efficiency. Together with the excellent raw-material yield and low energy requirements, spinning mill owners can benefit from low yarn conversion costs. With the J 70, spinning mills are ideally positioned to exploit the growth potential in standard and blended airjet yarns.

Air-jet yarn can be made from a wide range of fibers such as cotton, polyester, and viscose, making it suitable for a variety of applications. In combination with the high productivity, the unique yarn characteristics such as low hairiness and low pilling tendency will contribute to strong growth of this segment in the coming years. The air-jet spinning machine J 70 is the ideal solution for spinning mills – it is characterized by low conversion costs, low energy consumption and high raw material utilization.

Autonomous spinning units and high delivery speed

Each spinning unit is now individually automated and thus independent, enabling maximum efficiency and flexibility (Fig. 2). Each unit fixes yarn breaks independently – both natural and quality cuts. This makes waiting times for the robot obsolete. Up to 20 spinning units can repair and re-piece ends down simultaneously. This allows high production speeds.

A delivery speed of up to 600 m/min is achieved through new technology components. Four robots handle package changes, yarn insertion, and unit cleaning. One robot per side is usually enough, but up to two can operate for specific applications like shorter yarn lengths and dye packages, enabling seamless changes.

Maximum flexibility and efficiency

The J 70 air-jet spinning machine offers remarkable flexibility, revolutionizing modern spinning mills. With the VARIOlot option, it can simultaneously handle up to four different lots, allowing for smaller lot sizes, diverse yarns, and shorter delivery times. Customizable settings for each lot are easily managed through tube color assignments and separate shift reports.

The J 70 also boasts significant cost savings, with up to 50% less fiber loss compared to competitors, energy-efficient drives, optimized suction, and reduced air inlet pressure. Moreover, the machine enables streamlined dye package production, eliminating the need for rewinding after dyeing or bleaching.

Quality assurance

The J 70 utilizes the advanced Q 30A yarn clearer from Rieter for quality monitoring. Adjusting the sensor has been simplified, allowing for flexible cleaning limit adjustments based on quality requirements. A scatter plot visually illustrates the impact of settings on quality cuts, aiding

operators in making informed decisions. The Q 30A features a larger measuring slot, reducing contamination and enabling longer production runs without interruptions for cleaning. Optional features like foreign fiber detection and weak yarn detection can be added through a software update, eliminating the need for hardware replacement.

Innovative solution for a wide range of customer needs

The air-jet spinning machine J 70 offers top raw-material yield, low energy consumption, and simplified operation. It efficiently produces high-quality yarns, meeting the growing demand for polyester-cotton and polyester-viscose blends. With advanced automation, the J 70 is an innovative and cost-effective solution for diverse customer needs.

For further information, please contact:

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State-of-the-art individual automation for maximum flexibility and productivity



The air-jet spinning machine J 70 enables the production of high-quality yarns with maximum efficiency



Birla SaFR - Launch of Sustainable Flame-retardant

Birla Cellulose, a unit of Grasm Industries Limited and part of the Aditya Birla Group, proudly unveils its latest innovation, Birla SaFR, at ITMA 2023, Milan, Italy. This groundbreaking product marks a significant milestone in Birla Cellulose's strategic vision to offer products for the technical textile industry. Birla SaFR, is a phosphate based inherently flame-retardant sustainable cellulosic fibres, ideal for making flame retardant fabrics with its exceptional

immense pride in knowing that our product will be used in various categories of protective wear, ultimately safeguarding lives."

Birla SaFR-Launch of Sustainable Flame-retardant Fibres_02

Birla SaFR, can be blended with other high-performance fibres (e.g aramid, FR mod acrylic, FR polyester) to create a diverse range of protective clothing solutions. This cutting-edge fibre offers enhanced protection against a multitude of heat-related hazards while ensuring optimum comfort for the wearer without compromising on the fire protection standard of the garment thus enhancing the user experience.

Birla SaFR will be an ideal choice for industries requiring highest standard against fire protection, such as thermal protection, electric arc protection, and molten metal splash protection catering to the unique needs of sectors such as defense, emergency response (ER), oil & gas, electrical utility companies and for various manufacturing industries. Birla SaFR has the Oxygen Limiting Factor (OLF) > 28 and it sustains the flame retardant efficacy post multiple washes (>



L to R: Mr. ManMohan Singh, Mrs. Rachna Shah, Mrs. Darshana Vikram Jardosh, Mr. H.K Agarwal

performance and eco-friendly characteristics.

L to R: Mr. ManMohan Singh, Mrs. Rachna Shah, Mrs. Darshana Vikram Jardosh, Mr. H.K Agarwal
Birla SaFR was launched on the 10th of June at ITMA Milan by Honorable Minister of State for Textiles (India), Mrs. Darshana Vikram Jardosh in the presence of Secretary (Textiles), Mrs. Rachna Shah, Mr. H.K Agarwal, Managing Director, Grasm Industries Ltd and Mr. ManMohan Singh, Chief Marketing Officer, Birla Cellulose. With this revolutionary breakthrough, Birla Cellulose sets a new standard for flame-retardant fibres and solidifies its position as a leading solution innovator in sustainable textiles.

Crafted with utmost precision, Birla SaFR results from meticulous research and development efforts combined with a deep understanding of industry demands. This remarkable achievement showcases Birla Cellulose's commitment to fostering innovation and delivering products that revolutionize the textile landscape.

Mr. H.K Agarwal, Managing Director, Grasm Industries Ltd & business director, Pulp & Fibre Business, expressed his pride in the groundbreaking achievement, stating, "Birla SaFR is the first flame retardant fibre developed in India specifically for the technical textile segment. We take



Birla SaFR-Launch of Sustainable Flame-retardant Fibres_02

50 washes) as tested and verified by 3rd party agencies.

Commenting on the occasion of the launch of Birla SaFR at ITAM 2023, Mr. ManMohan Singh, Chief Marketing Officer, said "It is a significant milestone and a proud moment for Birla Cellulose and the Aditya Birla Group as Birla SaFR fibre is developed indigenously providing an alternative to imported flame retardant fibre aligning to "Made in India" initiative and poised to make lasting impact on the global textile industry".



LMW's latest innovations for benchmark productivity and superior quality

The longest smart Ring Frame LR 90 Series, the first of its kind to the market with a host of features that deliver superlative benefits to the end user. The machine comes in two variants, LR90 SX/SXL (without compact) and LRJ 90 SX/SXL (with inbuilt suction compact arrangement).

Smart Card LC636 SX with CDS & Fix-Fil, the most innovative card that drives productivity and quality to the highest levels. With optional features of CDS (Card with Drafting System) and Fix-Fil can changer arrangement, this card ensures high efficiency and productivity up to 250 kg/hr with consistent quality.

The 1.5-meter working width and 36 working flats ensure quality deliverable, thanks to the highly impressive active carding and cylinder area. Due to its unique design of various technological elements and energy efficient drives, the smart card delivers higher realization of up to 1% with power savings of up to 15%.

This smart card is equipped with a new patented 120 mm height flats to have stable and constant cylinder to flat setting across the width. The flats to cylinder setting sensing are through optical sensors mounted on four flats



Card LC636 SX

such that any time the distance is sensed and known (Optional feature). To improve the user friendliness and maintenance friendliness, FASS – Flats Automatic Setting System is provided as an optional feature wherein it retains the 5 individual place adjustments through motor.

This card is loaded with a host of features that benefit customers and meet the demanding requirements of the market. Overall, experience high productivity, enhanced quality, better realization, lower power consumption, optimized space utilization, and reduced manpower requirements. It's time to take your spinning game to the next level with this innovation.

Choosing the LC636 SX Card is a significant step towards achieving optimal utilization of resources and increasing productivity.

Presenting the Twin Delivery Auto Leveller Draw Frame LDF3 2S in succession with the most successful Auto Leveller Draw Frame model LDF3 S. This innovative state-of-the-art machine has the most compact footprint and is designed to deliver consistent quality, with a high degree of auto levelling efficiency, and works up to delivery speed of 1100 m/min.

Some of the key features of LDF3 2S include:

- Independent drive arrangement
- Duo Digital Auto Levelling
- Servo drive for precise operation
- Speed and draft changes through display
- Mechanically well synchronized drive system with timing belt
- SMART Quality set- Online Quality Monitoring
- Efficient TR Strip and SP SMART Auto piecing system
- Centralized roller setting
- Kinetic back up technology



Auto Leveller Draw Frame LDF3 2S

With its superior deliverables the Twin Delivery Auto Leveller Draw frame LDF3 2S is the perfect choice for modern textile mills.

Ring Frame LRJ 90/SX

The Ring Frame LR 90 Series is the longest Ring Frame offering in the market with a maximum spindleage of up to 2400. With a higher spindle speed of up to 30,000 rpm (mechanical), the machine delivers higher productivity with consistent quality.



Ring Frame LRJ 90/SX

The technological enhancements and the quality package ensure up to 30% improvement in yarn imperfection and classimat H1 fault and reduction in EBH up to 2-3%.

Power Savings

The energy efficient, low decibel HLED spindles coupled with HK RYC consumes lower power and saves up to 8%. The pneumafil suction and compact suction are so designed that the overall power savings including the spindles is up to 10%.

Space Savings

This Smart Ring Frame is designed with a gauge length of 65 mm and occupies the lowest footprint and saves space of up to 8%.

Automation

The state-of-the-art automation includes the Ring rail drive, new Auto-doffer drive mechanisms and Suction unit with AWES.

Ring Frame Auto Piecing (RAP), the fully automated yarn

piecing system for ring spinning machine, receives information on yarn break through YBS (Yarn Break Sensor) and travels to the particular spindle and automatically pieces the yarn instantly as a human does.



RAP – Ring Frame Auto Piecing
“As human piecing”

Manpower Savings

The biggest challenge faced by the spinning industry is shortage of skilled manpower, especially in Ring spinning. The piecer needs to be trained and skilled to do the piecing with lesser end mending time to avoid production losses. The RAP ensures auto piecing thus reducing the dependency on manpower.

Increased Productivity

RAP consistently works 24 x 7 throughout the year. The RAP



ITMA 2023 - An exhibition that impressed

CEO Arno Gärtner shares his thoughts on the highlights of the KARL MAYER GROUP stand at ITMA 2023

The KARL MAYER GROUP was among the companies involved in the recent ITMA trade show in Milan, with a large, inviting stand full of innovations that quickly became the place to be. Visitor feedback confirmed that the global market leader really hit the nail on the head with its selection of machines, new textile developments and digital solutions. Without exception and throughout the entire duration of the trade show, the guests' response to the products showcased by each of the Group's business units exceeded all expectations. KARL MAYER GROUP CEO Arno Gärtner was interviewed by Ulrike Schlenker from the global player's Corporate Communications team, revealing which products impressed and interested the visitors the most, and what the customers from the flat knitting sector thought about the Group's exhibition.

Q.: The KARL MAYER GROUP stand focused on the topics of sustainability and digitalization. What was the visitor response to the exhibition?

Ans.: The textile industry has finally become highly aware of the topic of sustainability. Our customers already offer a wide range of products with a low environmental impact; however, we were nevertheless able to show them solutions that unlock completely new possibilities for them. What is important for us is that our products are sustainable as well as profitable. Our new jacquard raschel machine for processing staple fibres – for example, 100% cotton – and the new energy monitoring system in our HKS range for matching the energy consumption to the production targets generated a

unit receives signal from the YBS (Yarn breakage sensor) and travels directly to the respective spinning position and automatically mends the yarn as a human does. RAP captures the broken end from the package in a unique way without lifting the package, then inserts the yarn into the traveler and gets over pieced. The immediate attention to the broken end and the shorter auto piecing cycle time around 35 seconds ensures higher productivity.

Precise Quality

RAP ensures the consistent piecing length in the mended yarn. Auto Piecer also eliminates the contamination on the cop outer surface (through manual handling) which enhances and retains the quality of the yarn.

Flexibility

The unique design of Ring Frame Auto Piecing (RAP) is suitable for both types of spinning technology, Normal Ring Spinning and Compact Spinning. It works ease on all applications.

huge amount of interest. We intend to continue our development work in these areas. The sustainability highlights from the other business units, including an extremely fine flat knitted all-rounder T-shirt made from bio-based materials with a back and front worked from one piece to avoid unnecessary waste, our latest weft-insertion machine WEFTTRONIC® II G, which also produces less waste, and CASCADE, an innovative steam and condensation system that uses up to 7% less steam during the drying process of sizing and indigo dyeing machines, also attracted a lot of attention.

Our denim customers were impressed by the results of the first practical application of our water- and chemicals-saving BLUEDYE. The consumption of hydrosulphite and caustic soda alone – the main environmental pollutants involved in the process – can be more than halved, and it waste less yarn.

Digitalization is also no longer a new topic for our customers. Nevertheless, most visitors did not know – and were very impressed by the fact – that our group of companies is a major player with a strategic approach in this area. With our software company KM.ON, we not only offer individual solutions, but also provide our customers with bespoke overall concepts designed to support their value creation processes individually. The interaction of real machine products and software solutions was impressively demonstrated. Our digital portfolio includes software products for highly efficient design processes of knitted and flat knitted fabrics, smart machine functions that enable, for example, highly flexible and simple patterning with data from the cloud on warp knitting machines, and digital tools

for production management. The production data analysis tools that form the basis for more production flexibility and efficiency are now available for warp and flat knitting machines, as well as for warp preparation systems.

We are also increasingly focusing on digitalization in the after-sales service area. Through the combination of our conventional offers with new digital services such as an e-learning platform, our customers benefit from unparalleled next level support. An equally new and intuitive customer portal ensures that the individual solutions can be accessed quickly and easily, and an incredible number of visitors signed up as future portal users on the spot during the trade show.

Q.: Beyond the principal focus topics, were there exhibits that attracted a particularly level of high visitor attention?

Ans.: Yes, definitely! We are all experiencing times full of uncertainties and upheavals right now. This is why we wanted to take the opportunity at ITMA to show our customers a mixed bag of coordinated solutions and new developments to help them get to grips with these fundamental changes. Our wide range of exhibition offers was all about profitability despite rising costs, sustainability, being able to respond quickly and flexibly to the market dynamics, new business opportunities, and stable value creation processes despite a shortage of skilled workers. This trade show concept hit the bull's eye. Our stand soon became the place where everyone from the industry wanted to meet, and many exhibits attracted a huge amount of visitor attention. Of course, there were some particular highlights to look back on, including the HKS 3-M ON in the warp knitting area. The latest model of this digital tricot machine generation offers maximum benefits thanks to an outstanding machine performance and state-of-the-art technical features. But what's especially impressive is its incredible speed, even when working with sequential yarn feeding from the warp beam and numerous pattern changes. This machine actually clocked up an unparalleled 2,900 revolutions per minute during the trade show.

The customers from the flat knitting area were impressed by the ADF 530-32 ki FLEX. With its tag line of 'One machine for everything', this STOLL model really does revolutionise the concept of variability. The all-rounder clearly demonstrated this by whipping up a pair of trousers, a dress, a top, a jumper and even some upholstery fabric during the trade show itself. With its unparalleled spectrum of different high-quality knitted products, it not only offers incredible speed, but also the flexibility to handle changes that might be made to the order.

The main attraction in the technical textiles areas was the



ITMA 2023

ITMA connect opens to virtual visitors

Recovering from the impact of the pandemic, the global textile industry has demonstrated remarkable resilience, capturing the world's attention with its strong presence at ITMA 2023 in Milan. This highly anticipated exhibition

WEFTTRONIC® II G, which now ensures even greater competitiveness thanks to new features and upgrades. The new VARIO WEFT laying system in particular proved a real hit with our customers. The weft insertion component is aimed at maximum flexibility. With this machine, the patterning of the weft thread can be changed electronically – quickly and easily, without mechanical intervention in the process of threading in or limitations with regard to the repeat lengths. It also produces less waste. With this in mind, the WEFTTRONIC® II G scores well when it comes to sustainability and costs.

A highlight in the warp preparation area that we exhibited at ITMA was the MULTI-MATIC® 32 Compact. The new warp sampling machine has the same footprint as its predecessor while being twice as productive. It also makes it possible to react flexibly to market requirements thanks to quick and easy pattern changes and short changeover times. What's more, the fully automatic model with optimised ergonomics can still be safely operated in the event of a shortage of skilled workers.

Q.: This year's event was the first European ITMA where you exhibited with STOLL as a KARL MAYER GROUP business unit and brand. What feedback did you receive from your visitors on the group exhibition with the extended product portfolio?

Ans.: As far as the STOLL customers were concerned, we successfully won and also regained their confidence in the brand's future and independence. Of course, some of the flat knitting companies were still unsure about STOLL being integrated into our group, but our exhibits really hit the mark and showed that STOLL continues to stand for innovative flat knitting machines with maximum customer focus.

In fact, customers are already starting to see some initial benefits of the integration. We launched a machine at ITMA that combines knitting, warp knitting and weaving technologies to offer completely new product design possibilities. These include the ability to create textile textures with sectoral multidirectional reinforcements, decorative stitching effects, and innovative designs and functional features by combining special yarns with standard materials.

The fantastic feedback on this new development encourages us to go further in this direction. In fact, the prototype was constantly surrounded by crowds of people for the duration of the trade show. A number of other synergies also became apparent at the event, with many visitors looking for innovations in the knitting area that go beyond technological boundaries. As luck would have it, they didn't have to look any further than our stand.

ITMA 2023 Ends on a High Note with Strong Industry Participation

served as a comprehensive showcase of cutting-edge technologies, brought to life by an impressive gathering of 1,709 exhibitors.

ITMA 2023 attracted decision-making industry leaders and influential entrepreneurs who recognised the exhibition's

significance in shaping the textile industry's future. With an overwhelming response, the exhibition was attended by a diverse and enthusiastic visitorship of over 111,000 from 143 countries. The top six visitor arrival countries are Italy (29%), followed by Turkey, India and Germany (6% each), France (4%) and Brazil (3%).

Mr. Ernesto Maurer, President of CEMATEX said: "This edition has been a great success with the visitorship higher than the previous exhibition in 2019. At this ITMA, the transformation journey toward digitalisation and sustainability has taken a huge leap forward. It has been a mega gathering with the presence of stakeholders of the entire textile and garment making ecosystem. CEMATEX associations and their member companies, as well as all other exhibitors, are delighted with the results as the exhibition has surpassed all our expectations."

Mr. Federico Pellegata, director of ACIMIT, noted: "The results of Milan edition confirmed ITMA as the most important showcase for world textile machinery industry. It was a great success, judging from the quality of visitors in attendance, and many Italian exhibitors have secured contracts and sold their machines."

The 19th edition of the world's largest textile and garment technology exhibition also drew the participation of several delegations and supporting organisation groups. Among many officials and government representatives, ITMA 2023 hosted high-level country delegations from two of the major textile producing countries, India and Uzbekistan.

The delegation from the 6th largest cotton producer in the world was led by President Shavkat Mirziyoyev of Uzbekistan, who declared his strong intentions to boost the textile industry in his country.

India was represented by Smt. Darshana Vikram Jardosh, Minister of State (Textiles and Railways) of India who led the Confederation of Indian Textile Industry (CITI) business delegation. The delegation comprised 39 top Indian textile and apparel CEOs keen to seize new opportunities by riding on the digitalisation and sustainability wave.

Smt. Jardosh said: "ITMA 2023 was an excellent showcase of textile machinery. I am confident that interactions during the fair will further spur investments in the sector and help India achieve Prime Minister Narendra Modi's 5F vision of Farm to Fibre to Factory to Fashion to Foreign vision."

ITMA 2023 also welcomed Ms Valentina Superti, Director, European Commission, DG GROW-Internal Market, Industry, Entrepreneurship and SMEs. She gave a presentation at the Impact Financing for Sustainable Transformation forum.

Thumbs Up

Exhibitors, ranging from start-ups to seasoned industry bellwethers at ITMA, gave the 2023 edition the thumbs up.

Mr. Arno Gärtner, CEO Karl Mayer Group said: "ITMA 2023

is once again the place to be for decision-makers and experts from all over the world. Our participation with the strategic topics of sustainability and digital process solutions provided answers to current customer challenges. We had an unbelievable number of intensive discussions with our international customers. We are glad that the enforcement of IPR regulation is taken seriously at ITMA. We had successfully taken action against a case of infringement of our patent rights during the exhibition."

A first-time exhibitor at ITMA, Ms. Ida Alnemo, Head of Application & Sustainability, TreeToTextile, said: "ITMA 2023 in Milan was our first participation in a large trade show, where we were offered the opportunity to participate in the Start-up Valley, a truly innovative environment which drew high attention amongst the visitors. We had an overwhelming positive response from all over the world, and from all parts of the value chain. ITMA has been a great platform for future collaboration needed to scale breakthrough innovations like ours, to make a positive change of the textile industry in offering better fibres to all."

Summing up the positive response from participants, Dr Janpeter Horn, Chairman, VDMA Textile Machinery, said: "ITMA 2023 is one of the few international shows that did not suffer a drop in the number and quality of visitors after the pandemic. This speaks volumes about the brilliance of ITMA! The Milan exhibition has set the benchmark for ITMA 2027 in Hanover. We are eager and confident to continue ITMA's success story 36 years after it has been hosted there."

The next ITMA will be held at the Hannover Exhibition Center from 16 to 22 September 2027.

ITMAconnect Platform

ITMAconnect, the world's largest digital listing of textile and garment technology manufacturers, was launched to complement this year's ITMA exhibition. Non ITMA 2023 visitors are now able to access the platform to source and network with international technology owners and manufacturers who took part in the Milan exhibition. To register, please click on this link:

<https://www.itma.com/dashboard/visitor/login>.

ITMA 2023 featured textile solutions on advanced materials, automation and digital future, innovative technologies, and sustainability and circularity the exhibition in Milan ended on 14 June.

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Post Event Report of International Conference on Technical Textile

The Textile Committee of PHDCCI organized the “International Conference on Technical Textile”, themed: Market Growth, Opportunities, and Challenges in Technical Textiles at PHD House, New Delhi on 15th May 2023. Over 130 delegates that include experts, industry players, and researchers, attended the conference to deliberate on the potential and challenges pertaining to technical textiles.



Mr. Rajeev Saxena, Joint Secretary, Ministry of Textiles, Government of India & Mission Coordinator, National Technical Textile Mission, was the Guest of Honour during his address mentioned that the Technical Textiles, India's sunrise sector, is witnessing rapid growth. He stated that the PM's vision of making India a developed nation by 2047 will be accelerated by the significant growth in the technical textiles sector. He mentioned that the mission is dedicated to encouraging domestic production of technical textiles in order to explore the global potential and meet domestic and international market demands. Mr. Saxena also released the Knowledge Paper on Technical Textiles prepared by the Fibre2Fashion.

Mr. Madhu Sudhan Bhageria, Chair, PHDCCI Textiles Committee & CMD, Filatex India Ltd, during his welcome address and overview of the conference, said India has a small presence in the global textile market but has the potential to become a key player in the industry. The Indian Textile market is expected to grow rapidly in the upcoming years due to a variety of factors including favourable government initiatives, increasing demand for technical textiles in various end-use applications and the country's robust manufacturing capabilities.

Prof. Abhijit Majumdar, Department of Textile and Fibre Engineering, IIT Delhi, called the Indian Technical Textile sector a knowledge and research-driven sector and emphasized on the need to bring in a UG-level curriculum that is principle based while eliminating the perimeter-centric learning.

Mr. Nandan Kumar, Director, High Performance Textiles, Pvt. Ltd., emphasized on the collaborative working of all the stakeholders to promote the adoption of the new standards in the Industry, while pressing on the importance of recycling of high-performance protective textiles.

Dr. Arindam Basu, Director General Northern India Textile



Research Association, said, as India is expected to invest-\$1.4trn by 2025 on infrastructure across roads, rail, ports and housing, all these industries pose a huge market for the Indian Technical Textile Industry. He said that we have to go for high-value products that are not very easy to copy. Given the surge in demand and usage for these products around the world, the emphasis should be on domesticating technology and implementing quality standards in specialized items, added Dr Basu.

Mr. R. K. Vij, Co-Chair of PHDCCI Textile Committee presented the vote of thanks in the opening session. The session 1 was addressed by Prof. B. S. Butola, Department of Textiles and Fibre Engineering, IIT Delhi, Mr. Umashankar Sinha Mahapatra, MD Pulcra Chemicals India Pvt. Ltd., Mr. Shishir Tyagi, DD, Wool Research Association COE Sportech, Mr. Yatee Gupta, CEO, Fabiosys Innovation Pvt. Ltd., Dr. Anasuya Roy, Founder Nanosafe Solutions Pvt. Ltd. Dr. Ajay Kumar, Chemical Department, Sharda University.

The IIT Delhi was the Academic Partner and Fibre2Fashion was the Knowledge Partner and Textile Value Chain was the Media Partner. The Conference was sponsored by M/s Imagine Fibre Pvt. Ltd. The Conference was moderated by Mr. Mayank Chatwal, Secretary, PHDCCI.

The recording of the conference is available at

<https://www.youtube.com/watch?v=oQnIXxYbAbs>

Choose the Right Space to Showcase Your Brand



Post Event Report of ITTA National Conclave on Sportech

NATIONAL CONCLAVE ON SPORTECH - “The Future of Sport Textiles and Accessories Industry in India”

Indian Technical Textile Association (ITTA) jointly with the National Technical Textiles Mission (NTTM), MoT, GoI and in partnership with the Wool Research Association, COE, Sportech have organised the NATIONAL CONCLAVE ON SPORTECH - “The Future of Sport Textiles and Accessories Industry in India” on Friday, 2nd June 2023 at the Shangri-La Eros Hotel, New Delhi.

The leading Sportswear brands and senior officials from leading associations, namely Sports Authority of India (SAI), All India Football Federation (AIFF), Sports Goods Manufacturers & Exporters Association (SGMEA), and Sports Goods Export Promotion Council (SGEPC) gave the presentations on their requirements & expectations on Sportech products. More than 300 delegates attended the



Lamp Lighting



Dignitaries on Inauguration Session

The Hon'ble Minister of State for Textiles & Railways, GoI, Smt. Darshana Jardosh was the chief guest of the conclave and addressed the delegates. In a special interactive session, she actively discussed and answered the questions raised by the industry representatives and other delegates along with

conclave and got the networking opportunity with potential buyers and senior Govt. officials.

In the inaugural session, welcome address was given by Shri. Amit Agarwal, Chairman, ITTA followed by key note



Smt. Darshana Jardosh, MoS delivering her speech



Smt. Rachna Shah, Secretary Textiles delivering her speech

the Secretary- Textiles, MoT, GoI, Smt. Rachna Shah. The context setting of this session was done by Shri. Rajeev Saxena, Joint Secretary, MoT, GoI.

address by Shri. Rajeev Saxena, Joint Secretary, Ministry of Textiles, GoI and address by Shri. Rajesh Kr. Pathak, Secretary, Technology development Board, GOI. A short film on Technical Textiles prepared by NTTM was shown to delegates covering the overall scenario and progress made by the NTTM.

The Objective of the Conclave, having Conference & Exhibition, was to create awareness on the latest product innovations & technology developments, acquire knowledge & ideas for new investments & export opportunities on Sports textile, enhance knowledge base on requirement of current Sportech industries & market, to understand product standards & certification process and creating the B2B & B2G platform for Sports textile industry.

There were four Technical Sessions in the conference. First Session deliberate ways to unlock the requirements & experience of Indian Sportech consumers like Sports Authority of India, Sports Associations, SGEPC, Mountaineering Institutes and Leisure Sport Agencies. FDI opportunities in Sportech & market size assessment was



Speakers in Session 1

presented by Invest India. Session was moderated by Ms. Bhavna Rathee, Assistant Vice President- Invest India and Eminent panelists were Shri. Vishnu Bhagat, CEO- Shiv Naresh Sports Pvt. Ltd., Shri. N. Mohan, Director & CEO- Kothari Industrial Corp. Ltd., Shri. Amit Jain, Managing Director- Shingora Textiles Ltd., Shri. R. Selvam, Executive Director- Council for Leather Exports, Smt. Shubhra Agarwal, Trade Advisor- Ministry of Textiles and Ms. Aprajita Saini, Manager- Startup India.

Next session was moderated by Dr. Anup Rakshit, Executive Director, ITTA, dealt with Sports Goods and Accessories covering Footwear components, Shoe uppers, and use of coated fabrics, Leather and Rubber products. Presentations and discussions by the following panelists were focused on details of the above areas- Smt. Susmita R. Jyotsi, Regional Director- Sports Authority of India (SAI), Shri. Arun Kumar Sinha, IAS, Managing Director- Footwear Design & Development Institute, Dr. K. Rajkumar, Director- Indian Rubber Manufacturers Research Association (IRMRA) and Shri. Sunil Gupta, Principal Director- Process cum Product Development Centre (PPDC).

Third session was devoted to Innovations & Research in Composites and Smart Textiles and moderated by Dr. Bipin Kumar, Assistant Professor, IIT - Delhi. Panelists were- Dr. Sanjay R. Dhakate, Chief Scientist and Professor AcSIR, Head- Advanced Materials and Devices Division, CSIR-NPL, Dr. Nandan Kumar, Managing Director- High Performance Textiles Pvt. Ltd. and Shri. K. K. Misra, Director & COO- Wool Research Association. This session focused on the Raw materials like conductive Threads and Fabrics used in Sportech, latest innovations & future opportunities in composites and Smart Technology in Sportswear.



Speakers in Session 3



Speakers in Session 2

The fourth session focused on Design, Branding & Quality in the Value Chain, which was moderated by Shri. Anjani Kumar Prasad, M.D & Head Business, Archroma India Pvt. Ltd. The eminent panelists were- Smt. Roop Rashi, Textile Commissioner- Ministry of Textiles, Shri A. Sunil Kumar, Director- Techno Sportswear Pvt. Ltd., Dr. Ketan Kumar Vadodaria, Associate Senior Faculty- National Institute of Design, Ahmedabad, Dr. V. Senthil Kumar, Associate Professor- National Institute of Fashion Technology, Delhi, Shri Mayur Katiyar, Scientist B- Textiles, Bureau of Indian Standards (BIS) and Dr. Mrinal Choudhari, Joint Director- Wool Research Association. Panel members addressed the problems for availing latest technology for manufacturing sportswear, Sustainable solutions to the specific issues & concerns, Challenges faced in supply chain management, Quality standards & Certification required for QCO of sportswear.

Finally, the conference was concluded by giving vote of thanks by Shri. Avinash Misar, Vice Chairman, ITTA.



Speakers in Session 4



Release of Conclave Booklet



Prof. (Dr.) Suresh Gasavi appointed as Vice Chancellor of Savitribai Phule Pune University

Prof. (Dr.) Suresh Gosavi, the Head of Department of Environmental Sciences has been appointed as Vice Chancellor of Savitribai Phule Pune University, Pune (formerly University of Pune). He is originally from Dhamangaon, Dist.: Jalgaon. He is M.Sc. PhD in Physics. With his appointment, the University got its full-time Vice Chancellor after a gap of a year.

After his graduation from NM College, Jalgaon, he started his career as a lecturer in the Physics Department of the Pune-based SP College. Since 2006, Gosavi has been attached with the SPPU as a Lecturer in the Physics Department. Over the last 17 years, he has been associated with teaching subjects like electronics, nanotechnology, and physics of semiconductor devices, optoelectronics and other subjects.

Dr. Suresh Gosavi, a distinguished Senior Professor at the



Prof. (Dr.) Suresh Gosavi, VC is being congratulate.
L to R: Yogesh Dalvi, Vijay Rajguru, J. B. Soma, Prof. (Dr.) Suresh Gosavi, V.C., Dilip Choudhary, Mahesh Sonavane & Shivaji Mali

Department of Physics at Savitribai Phule Pune University, is well-regarded for his research and academic achievements. Dr. Gosavi, has vast experience in teaching and research. He has authored over 209 journals, both national and international, and also participated in numerous conferences both in India and abroad. Dr. Gosavi has worked on nanoparticles and Nano-composites among other fields of electronics and physics.

On behalf of the Textile Association (India), along with the alumni of VJTI, in Pune welcomed and congratulated him for his appointment as Vice Chancellor.

His appointment is expected to further enhance the reputation and academic standing of the University. The Textile Association (India) wishes him for a successful tenure as Vice Chancellor.



L to R.: Shivaji Mali, Dilip Choudhary, Vijay Rajguru, Yogesh Dalvi, J. B. Soma & Mahesh Sonavane



The Yarn Bazaar, B2B Managed Marketplace Secures INR 150 Million Funding

The Yarn Bazaar, a purpose-led, online B2B managed marketplace, providing a one-stop solution for all yarn-related requirements, including discovery, trading, financing, logistics, advisory, and market intelligence services, thereby creating a favourable and efficient ecosystem for yarn buyers and sellers, has raised INR 150 million in their Pre-Series A Round. The investment was led by the Rajiv Dadlani Group and Equanimity Ventures and also saw participation from reputed Family Offices and HNI investors.

The funding will primarily be used to solidify its base, by building a strong senior leadership team, also expand its operations, by increasing its market reach, strengthening its technological infrastructure, and activating its existing

strong inbound pipeline, in order to meet the growing demand. Additionally, The Yarn Bazaar will be investing further to enhance its online presence and improve the overall user experience, allowing suppliers and buyers to connect more easily, as well as access helpful resources and data.

Founded in 2019, The Yarn Bazaar has already had a resounding start to its journey. The company is transforming the highly fragmented USD 200 billion textile industry, by solving for the broken supply chain and working capital constraints. The company burst into prominence, during the first season of Shark Tank India, when it successfully secured INR 1 crore in funding from prominent entrepreneurs and investors Peyush Bansal, Co-Founder & CEO, Lenskart;

Ashneer Grover, previously Founder, BharatPe; Anupam Mittal, Founder & CEO Shaadi.Com, and Aman Gupta, Co-Founder and CMO, boAt. This early support has helped The Yarn Bazaar establish a strong foothold in the textile market.

The latest round of funding has also witnessed participation from a number of successful and prominent Individuals, as well as Family Offices of, Arihant Patni, Ekta Kapoor of Balaji Films, Ritesh Malik of Innov8, Aakrit Vaish of Haptik, Sumeet Srivastava of Spocto. Cred's Miten Sampat, also participated in the round, along with textile industry stalwarts Anil Mansingka and Dr Amit Lath, Sharda Group of Companies, Nikunj Bagdia of Ken Enterprises and Vineet Garg of Shri Ram Sarup Garg Cotton Mills.

Since its inception in 2019, The Yarn Bazaar platform has already completed over INR 370 crores worth of transactions, with an average order value of INR 19 lakhs. It is important to note that all transactions involved 100% advance payments (pre-shipment) by the buyers, which is a stark departure from the way the industry has traditionally operated. In a sector that works largely on credit, facilitating advance payments is a significant step towards addressing the problems of smaller textile companies, and creating an equitable and nurturing ecosystem for all textile manufacturers.

Commenting on the funding announcement, Pratik Gadia, Founder & CEO, The Yarn Bazaar, said, "At the Yarn Bazaar, we have a very clear vision and focus for the future, and we are grateful to all our investors for the confidence they have demonstrated in us. The current round of funding we have received from the Rajiv Dadlani Group, Equanimity and all our other investors is a testament to their trust in our business

model and future potential. We are committed to endeavouring continuously to improve our platform and offerings, thereby creating a favourable ecosystem for yarn buyers and sellers. Exciting opportunities lie ahead, and we are laser-focused on our journey towards becoming the go-to platform for high-quality yarn."

Mr. Rajiv Dadlani, from the Family Office of the Rajiv Dadlani Group, said "We have tracked The Yarn Bazaar's impressive growth journey for a while. They have immense potential and are also well poised, with their unique business model and the potential of the large textile market, ripe for disruption, to be a leading brand, in the yarn and textile industry. Pratik and Team, have a strong pedigree, rich experience and have built a solid foundation in their niche space. We are very excited to partner as long-term investors, and support them in their journey."

Mr. Rajesh Sehgal, Managing Partner, Equanimity Ventures, said, "The Yarn Bazaar is building a full-stack solution for organizing the large, fragmented and unorganized textile value chain. Pratik and team are equipped with unique insights and experience of operating in the traditional textile sector and are rethinking the engagement between yarn buyers and sellers from first principles. We believe that Yarn Bazaar has the potential to streamline operations, improve efficiency, and create new growth opportunities for all stakeholders in the value chain and we are excited to partner with them on this journey."

Website: <https://theyarnbazaar.com/>
LinkedIn: <https://www.linkedin.com/company/the yarnbazaar/>

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Think quality

Uster Fabriq Assistant – the whole story for quality info

Automated data preparation saves time and ensures decision-making security

The new Uster Fabriq Assistant is a central platform for automated processing, analyzing, and visualizing quality data from Uster fabric inspection systems. Its three value modules – AI Classification, Quality Reporting and Central Management – give fabric producers the whole story for quality, saving time and driving operational excellence.

Uster's latest innovation in the field of fabric inspection is an online tool giving a user-friendly summary of quality performance data from every fabric roll inspected in the mill. A range of statistical analysis tools highlight key info through various charts, histograms or trend diagrams. With the new Uster Fabriq Assistant, there is no need to toil over manual data. It's all automated, so decision-making is simpler and much faster for fabric manufacturers.

Classification and reporting tasks

Fabriq Assistant introduces three value modules. AI Classification is at the heart of the system, delivering levels

of accuracy and performance that human operators could never match. The Artificial Intelligence attaches codes to each image generated by the Uster Fabriq Vision products.



Without this AI Classification, mill personnel would have to spend time and effort inserting codes to each defect at a PC, to carry out a data review. Artificial Intelligence means data classification is fully automated, so producers can save over 80% of the time taken by manual methods.

With Fabriq Assistant, old-fashioned manual data collection and analysis are consigned to history. Fabriq Assistant automatically gathers all the information from connected Uster fabric inspection systems – and applies smart analysis principles to calculate the most meaningful results. The Quality Reporting value module lets managers focus on the

most important decisions, based on the guaranteed accuracy of advanced technology.

Benefits from synergies

Fabriq Assistant unites all the data from AI Classification and Quality Reporting. Combining classified details of defects with smart analysis of inspection data gives producers a valuable advantage: Fabriq Assistant not only gives alerts of issues, it also goes a stage further by both describing and locating a problem. This is the knowledge required to enable continuous and systematic improvements to be made.

Combining data from AI classification and Quality Reporting unleashes the full power of the value modules. The real impact comes from meaningful data which is automatically analyzed. "Using the synergies from AI classification and Quality Reporting maximizes the business value for all stakeholders in the production and the quality department," says Michelle Salg, Product Manager Fabric Inspection at Uster Technologies.

Centralized efficiency

Fabriq Assistant cuts down the unnecessary workload on managers, allowing them to focus on steering profitable production. The third value module, Central Management, makes this benefit clear, as all the required data is presented on a unified platform at the manager's desk, in a real time-saving benefit. It means there is no need to check for machine alarms or identify finished rolls. Fabric inspection info for all connected Uster systems is readily available at this central platform.

"We have customers who produce thousands of meters of fabric daily. Imagine the difference the Central Management or Fabriq Assistant with its full capability makes for them," says Salg. "It's not only about managing a large number of machines but also controlling the quality of the whole production." The dashboard on the manager's screen shows the number of defects, ongoing articles and orders, start and end time of rolls, and downtime, at a glance.

Indispensable assistant

Data from fabric inspection builds a reliable picture, as a sound basis for decisions. Cutting-edge hardware can be seamlessly integrated into production – at line running speeds up to 1,000 meters per minute – for consistent and efficient defect detection. After that Uster Fabriq Assistant takes over.

Automation also allows users to customize their experience in a highly flexible way, to suit their own mill organization, thanks to the smart machine learning technology in Fabriq Assistant. For fabric producers it's an indispensable route to greater efficiency and productivity.

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KARL MAYER The colorful world of trendy flat knits

Introducing STOLL's latest trend collection COLOR IN KNITTING

Just in time for ITMA 2023 in Milan, the flat knitting machine manufacturer STOLL has launched its new trend collection COLOR IN KNITTING which is a rich source of inspiration and know-how. It holds a range of exciting knitting techniques that were ideated for novel super fine machine gauges such as the E20.

In addition, STOLL reveals its internal design workflow, showcasing how digital software tools can speed up the design process. The core of this is k.innovation CREATE DESIGN. Through the utilization of STOLL's jointly developed design software solution, k.innovation CREATE DESIGN, in collaboration with @KM.ON, the shape and structures of a garment, can be digitally created, allowing for its simulation before it is even knitted. The interfaces to various external 3D software tools, allow for a realistic representation of the garment facilitating faster design decisions. Once the virtual knits, made in the CREATE DESIGN software are ready for manufacturing, it will be sent to a knitting technician for further processing in k.innovation CREATE PLUS, This significantly speeds up product development while reducing communication issues between designers and technicians.

Sustainability and responsible handling of precious natural resources were key factors driving the development of the

latest trend collection, COLOR IN KNITTING. STOLL-knit and wear®, a technique that stands for seamless knitted garments, can play a significant role in reducing waste. In addition, fewer process steps are required in the production chain - with advantages for production efficiency.

For another highlight of COLOR IN KNITTING, the STOLL creatives have worked on imitating different yarn effects with knitting technology such as slub yarn optics or the simulation of fabrics like crepe de chine/crepe georgette. The results are impressive!

On the occasion of the 150th anniversary of STOLL, COLOR IN KNITTING features a selection of amazing vintage pattern replicates. These patterns can be found in STOLL's extensive sample archives in Reutlingen. It is extremely impressive to learn that all these former fabric constructions can still be replicated today and also reinvented with today's cutting-edge machine features. This approach stunningly showcases the steep progression of technical advancements over the past 150 years.

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Lenzing signs strategic partnership with NBond

Lenzing signs strategic partnership with NBond to accelerate the innovation of flushable nonwovens products globally.

NBond has been a long-term user of Lenzing's VEOCEL™ branded fibers in nonwoven products, and the first to incorporate VEOCEL™ branded lyocell shortcut fibers in flushable feminine care products globally. The new strategic partnership will enable both parties to explore new possibilities for the application of VEOCEL™ branded lyocell fibers in flushable nonwoven products to address changing consumer needs

Lenzing Group, a leading global producer of wood-based specialty fibers, has announced the signing of a strategic partnership between its flagship specialty nonwovens brand, VEOCEL™, and Hangzhou NBond Nonwovens Co., Ltd. (NBond) to accelerate the innovation and application of wood-based VEOCEL™ branded lyocell fibers in flushable nonwovens products, from moist toilet tissues to feminine hygiene products and other personal hygiene product offerings. NBond, one of the earliest manufacturers to launch flushable feminine care products globally, is also the first to use VEOCEL™ branded lyocell shortcut fibers in flushable feminine care products.

With collaboration key to ongoing product innovation, the strategic partnership will feature long-term technical and innovation support towards the development of new nonwoven fabrics using VEOCEL™ Lyocell fibers at NBond's production facilities.

“Lenzing has been working closely with NBond for more than a decade. The new strategic partnership with NBond represents a milestone for both companies as we continue pioneering sustainable development of the industry, and help addressing the growing demand for high quality sustainable and flushable nonwovens products in Asia and globally,” said Steven Tsai, Senior Regional Commercial Director for Nonwovens Asia, Lenzing. “With VEOCEL™'s expertise and NBond's technical knowledge and consumer brand network, we are well-positioned to advance new innovations and product applications which meet the evolving needs of consumer brands and enable them to stand out from the crowded marketplace of nonwovens products.”

“Sustainability is not just a topic of consensus between the suppliers and manufacturers. With the macro direction to actively reduce carbon emissions across industry value chains, sustainability has become the basic standard for any nonwoven product globally. At NBond, sustainability will remain a core focus of what we do,” said Jinrui Gong, Chief Executive Officer of NBond. “Together with value chain partners and customers, we will continue to develop sustainable and biodegradable nonwovens products that are made of natural botanic materials, like VEOCEL™ fibers. Ongoing investments will also be made on innovative technologies that could improve our future product offerings.”



Industry leaders join hands to empower growth in flushable nonwovens applications

A globally recognized nonwovens value chain partner, NBond's flushable products have been introduced in the US, Europe, Asia-Pacific, and more. In China and Asia-Pacific in particular, NBond has collaborated with mainstream household brands such as Kimberly-Clark, Vinda, and BabyCare on flushable products.

In addition to joint product innovation, the collaboration between VEOCEL™ and NBond will cover the three key pillars of product, service, and sustainability. On product, to differentiate from flushable products made of wood pulp, VEOCEL™ Lyocell fibers with Disperse technology will help strengthen NBond's nonwoven fabrics in wet conditions, ensuring flushability while improving user experience. Moist toilet tissues, sanitary napkins and other personal hygiene products produced by NBond which adhere to G4 guidelines and the National Standards of China for flushability of nonwoven materials can decompose easily after being immersed in water. To date, high-quality, flushable, and degradable nonwoven products made of VEOCEL™ fibers have been widely recognized as a solution that covers fiber dispersion and strength.

On service, the technical support and consultancy service provided by VEOCEL™ empowers NBond to continuously optimize wetness, strength, thickness, safety, and sustainability in nonwovens fabrics, developing a strong portfolio of flushable products that focuses on comfort and care. In terms of sustainability, VEOCEL™ branded fibers, which have been certified by the EU Ecolabel for meeting high environmental standards throughout the entire life cycle of the fibers, can help NBond address heightened global consumer demand for premium nonwovens products that are made of botanic materials which can be biodegradable and compostable at the end of use.

“With NBond, it hopes to expand the portfolio of flushable nonwovens products globally, not only around flushable wet wipes and sanitary products in the hygiene and surface cleaning segments, but also multipurpose dry flushable wipes in Asia,” added Steven.



ITMA ASIA + CITME Show Owners Extend Cooperation to Launch Combined exhibition in Singapore

The show owners of ITMA ASIA + CITME have extended their collaboration to organize the combined textile machinery exhibition in a second Asian location. The combined exhibition has been held biennially in Shanghai since 2008. Show owners - CEMATEX (the European Committee of Textile Machinery Manufacturers) and its Chinese partners comprising China Textile Machinery Association (CTMA) and the Sub-Council of Textile Industry, CCPIT (CCPIT-Text) - have selected Singapore to host the exhibition in 2025.

ITMA ASIA + CITME, Singapore 2025 will be held at the Singapore Expo from 28 to 31 October 2025. It will be organized by ITMA Services and co-organized by Beijing Textile Machinery International Exhibition Co.

Mr. Ernesto Maurer, President of CEMATEX, said: “We have successfully held seven editions of ITMA ASIA + CITME in Shanghai. As part of our strategy to support the aspirations of local manufacturers in South Asia, South East and the Middle East to modernize their operations, we are augmenting the series with a second location in Asia to better reach out to the textile hubs in these regions.”

Mr. Gu Ping, President of CTMA, said: “Asia is the world's biggest textile manufacturer and exporter. We are delighted to extend our cooperation with CEMATEX to bring ITMA ASIA and CITME to other parts of Asia to support our members' marketing efforts.” Billed as The Leading Textile Technology Exhibition Driving Regional Growth, ITMA ASIA + CITME, Singapore 2025 is expected to gross 60,000 square metres. It aims to attract over 700 exhibitors and a visitorship of 30,000.

Mr. Maurer added: “Singapore is no stranger to hosting a huge textile machinery exhibition. ITMA ASIA was held in Singapore in 2001 and 2005 before it combined with CITME. We moved the exhibition to Shanghai to enable our members to take advantage of the buoyant textile sector in China after the country joined the World Trade Organization in 2001.”

A Vibrant Destination

Due to its world-class facilities and business-friendly environment, Singapore is an attractive destination for

exhibitions and conferences.

Mr. Charles Beauduin, Chairman of ITMA Services, explained: “Singapore is an attractive MICE destination and well connected to the growing textile hubs in South Asia and Southeast Asia, as well as the Middle East. Its extensive airlinks and visa-friendly policies make it an accessible destination for these visitors. The exhibition also requires robust infrastructural and technical facilities to support live machinery demonstrations, which Singapore's exhibition venue can provide.” The decision to host the second combined exhibition in the island republic is welcomed by the Singapore Tourism Board (STB).

Mr. Yap Chin Siang, Deputy Chief Executive of STB, said: “We are pleased to host ITMA Asia + CITME for the first time in Singapore. ITMA Asia + CITME is an important Asian and global platform for growth, connectivity, and trade integration in the textile market. The choice of Singapore as host affirms our position as a global hub for MICE and business, where entrepreneurs and forward-thinking partners meet. We look forward to welcoming ITMA Asia + CITME participants to Singapore in 2025.”

The upcoming ITMA ASIA + CITME exhibition will be held in Shanghai at the National Exhibition and Convention Centre from 19 to 23 November 2023. It was postponed from last year due to the pandemic. Grossing 160,000 square metres, the combined exhibition has, to date, attracted over 1,400 exhibitors.

The ITMA ASIA + CITME series will continue to be held biennially on even years in Shanghai. The 2024 combined exhibition will be held from 14 to 18 October 2024.

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