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Presents

77th All India Textile Conference

Theme

Post Pandemic Global Vision of Textile Industry

16th & 17th March, 2024

at

Department of Textile & Fibre Engineering
Indian Institute of Technology (IIT)
Hauz Khas, New Delhi

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THE TEXTILE ASSOCIATION (INDIA)
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Continuous journey towards progress and prosperity

I am happy to extend my warmest greetings to all our esteemed readers for the 75th Republic Day of India. This significant milestone reminds us of our nation's rich history, the sacrifices made by our forefathers, and the continuous journey towards progress and prosperity. The Indian Textile Industry, a crucial component of our economy, has played a pivotal role in India's growth story, and we are committed to bringing you discerning and cutting-edge research that contributes to its advancement.

In recent months, another massive event that has captured the nation's attention is the "Pran Pratishtha" of the Ram Mandir in Ayodhya. This momentous occasion marks the zenith of a long-standing cultural and historical process. The textiles and clothing industry has deep-rooted connections with our heritage, and it is essential to appreciate the synergy between tradition and innovation in this sector.

Owing to India's textile legendry heritage which dates back centuries, two events are planned in February. First, Bharat Tex 2024, a global textile expo in New Delhi from 26th to 29th Febuary'2024 which will highlight the richness of Indian textiles, tradition, innovation, and sustainability. Second, ITMACH India 2024, from 21st to 24th February'2024 at the Exhibition Centre, Gandhinagar, Gujarat. A trade show consisting of hundreds of exhibitors, exhibiting their machinery and products encompassing all the areas of textile.

The Textile Association (India), Mumbai Unit organized International Conference on "Sustainability and Circularity - The New Challenges for the Textile Value Chain" on 31st January, 2024 at Mumbai. The Conference received overwhelming response with 275 delegates in attendance. The theme of Conference, topics, presentations, and speakers were highly appreciated by one and all.

Distinguished guests discussed circular economy concepts and eco-friendly textile processes emphasizing the importance of sustainability in textile value chain. Sharad Kumar Saraf and Rajkumar Agarwal received recognition for their contributions to the industry.

Finance Minister Nirmala Sitharaman presented the Interim Union Budget 2024-25 on February 1, 2024 in Parliament. The government has announced the proposals for the implementation of various inputs but it was disappointing for the textile sector. In this interim Budget textile industry was quite hopeful for the tax incentives and better textile infrastructure in manufacturing and strengthening export. Now, the industry hopes that the same would be taken care in the final budget after election.

Moving on to the exciting journey in 2024, the Journal of Textile Association remains dedicated to promoting dialogue, disseminating knowledge, and endorsing excellence in textile research and development. We invite researchers, scholars, and industry experts to contribute their valuable insights to our journal, shaping the discourse and driving innovation in the textile sector.

Dr. Aadhar Mandot
Hon. Editor

T. L. PATEL, President

Reinventing the Indian Textile Industry in the Era of Technological Advancements

T. L. PATEL, President

It is with great honor and enthusiasm that I address you as the National President of The Textile Association India. As we embark on this promising journey together, I am filled with a sense of pride and responsibility to lead our industry towards new horizons of growth and innovation.

The Indian textile industry has a rich heritage and has played a significant role in shaping our country's economic landscape. However, to truly harness its potential and remain globally competitive, we must embrace the rapid advancements in technology that are transforming the way we conceive, design, manufacture, and market textiles.

The advent of Industry 4.0 has opened up boundless opportunities for our sector. Automation, artificial intelligence, big data analytics, and the Internet of Things have paved the way for greater efficiency, sustainability, and enhanced consumer experience.

The integration of smart textiles, embedded with sensors and wearable technologies, has brought us to the forefront of the global textiles market.

To leverage these technological breakthroughs and drive future growth of our industry, we must focus on the following key areas:

- Research and Development
  Encouraging investment in R&D by both public and private sectors will foster innovation and enable the development of cutting-edge technologies. Collaboration between academia, industry, and government institutions is essential to facilitate knowledge exchange and bridge the gap between theoretical advancements and practical implementation.

- Skill Development
  As we embrace new technologies, we must also invest in imparting the necessary skills to our workforce. Training programs and workshops aimed at upgrading technical expertise, data analytics, and software proficiency will ensure our workforce remains competent and adaptable to the rapidly changing industry landscape.

- Sustainable Practices
  Sustainability is no longer an option but a necessity. By adopting eco-friendly manufacturing processes and reducing our carbon footprint, we can attract environmentally conscious consumers and comply with global standards. Recycling and up-cycling initiatives should be encouraged to minimize waste and maximize resource efficiency.

As we embark on this transformative journey, we must remember that success lies not only in individual efforts, but also in collaboration, cooperation, and collective progress. With your unwavering support and contribution, we can propel the Indian Textile Industry to new heights of excellence.

Together, let us build a future that combines our rich heritage with modern technology, positioning India as a global leader in textiles. Let us inspire creativity, innovation, and sustainable growth, while remaining rooted in our values and traditions.

I am honored to serve as your National President, and I assure you of my complete dedication and commitment to the betterment of our industry.

T. L. PATEL
President
The Textile Association (India)

Journal of the TEXTILE Association

TECHNICAL TEXTILE

Application of Geotextiles in Riverbank Erosion Protection – A Review

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Abstract:

Rivers, except when flowing through well-defined narrow sections confined by high and stiff banks, have caused problems of flooding, change of course, banks erosion etc. Bank erosion can lead to large amount of losses in terms of human life and other utilities. Hence bank protection measures which aim at maintaining the stability of the cross section of river against the action of water is necessary. Commonly used bank protection measures are groins, revetment, riprap etc. Even though they have proven to be effective, most of them are costly and causes environmental issues. Geotextiles have come to play an increasingly important role in civil engineering and are being used for river bank protection. Geotextiles consisting of woven mats, rolls or bags of natural fibres are placed on the bank surface or bank toe to prevent fluvial scour and the removal of fines from the bank face. Coir (coconut fiber) geotextiles are now being used as popular solution for erosion control, slope stabilization and bioengineering, due to the fabric's substantial mechanical strength and its applicability to conserve soil and moisture. Coir geotextiles are better preferred compared to other natural materials owing to their properties like durability, strength, hairy surface etc. Since Kerala state is an abundant source of coconut trees, coir geotextiles are available at low cost. Coco logs are long knotted coir nettings filled with coir fibre. They are 100 % natural material and biodegradable, has high tensile strength, high water absorbency, is easy to install and is eco- friendly. This review paper focusses on study of various techniques used in riverbank protection.

Keywords: *Geotextiles, Geobags, Soil erosion, river training work, various techniques*

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1. Introduction

Riverbank erosion is a significant environmental issue that not only affects the stability of riverbanks but also poses a threat to nearby infrastructure and ecosystems. Traditional methods of erosion protection, such as riprap and concrete structures, are often costly, time-consuming, and environmentally intrusive. However, the application of geotextiles has emerged as a viable and sustainable solution to mitigate riverbank erosion. Geotextiles are permeable fabrics made from synthetic materials or natural fibers, designed to stabilize soil and prevent erosion. They can be used in a variety of applications, including road construction, landfills, and coastal protection. In the context of riverbank erosion, geotextiles offer several advantages over traditional methods. Firstly, geotextiles act as a soil filter, allowing water to pass through while retaining the soil particles. This prevents the scouring effect of water currents on the riverbank, reducing erosion. The fabric's permeability also promotes the growth of vegetation, which further strengthens the soil and adds to its stability. Additionally, geotextiles provide a physical barrier between the water and the soil, protecting against wave action and hydraulic forces. By absorbing and dissipating the energy of flowing water, they reduce the impact on the riverbank, minimizing erosion. Furthermore, geotextiles are flexible and adaptable, making them suitable for various riverbank profiles and conditions. They can be easily installed and customized to fit the shape and slope of the riverbank, allowing for a seamless integration with the surrounding environment. This flexibility also allows for the preservation of natural habitats and ecosystems, unlike concrete or riprap structures. Another advantage of geotextiles is their longevity. Unlike traditional erosion protection methods that may deteriorate over time, geotextiles are highly durable and resistant to ultraviolet radiation, chemicals, and biological degradation.

1. Cost considerations in Geotextiles

In terms of cost-effectiveness, geotextiles offer significant advantages. Compared to riprap or concrete structures, the materials and installation of geotextiles are generally less expensive. The lightweight and compact nature of geotextiles also make transportation and handling easier and more economical. Moreover, geotextiles have a lower carbon footprint compared to traditional erosion protection methods. The manufacturing process of geotextiles requires less energy and produces fewer greenhouse gas emissions. Additionally, their use promotes sustainable land management practices, as they work in harmony with the natural environment and provide opportunities for vegetation growth. However, it is essential to note that the successful application of geotextiles in riverbank erosion protection requires proper design, installation, and maintenance. Site-specific considerations, such as soil type, water flow, and vegetation, should be taken into account during the planning phase. Regular inspection and maintenance of geotextiles are also necessary to ensure their continued effectiveness.

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2. Work carried out by various researchers

The feasibility study of Geobags shows that a heap of Geobags of different sizes placed along the bank just below low water would launch when undercut by erosion and cover the eroding area with a 0.9 m thick layer of protection. Divers' observations clearly showed that this did not happen. The coverage was either by single bags or sometimes lumpy with bare patches. The smallest bags disappeared. Clearly adaptations were needed. For predominantly construction purposes, single-size Geobags are favorable so only 126 kg. bags will be used for future work in Jamuna River. The smaller size of 78 kg is proposed for smaller rivers. If there is to be a mix, it will be with the 78- and 126-kg bags. The protective system was to remain Geobags revetment protection below low water level and concrete blocks or interconnected systems such as grout-filled mattresses above low water. A multi-step implementation system combining a fast response to erosion threat and an optimized use of bags has been developed and implemented that has provided satisfactory protection [1].

Figure 1: Different types of Geobags placed as temporary wave protection.

Jute Geotextiles fabrics treated with 0.5% isothiazolinone and 1.0% fluorocarbon derivatives show higher water repellency as well as rot resistant characteristics. These improved functional properties of treated jute Geotextiles are advantageous in terms of its end use in river bank protection. It is observed in river bank simulation test that the life of treated jute Geotextiles under combined soil-water ambience is 600-700 days. Major functional properties desired for jute Geotextiles such as strength, elongation, porometry, water permittivity and rod puncture resistance etc. do not alter much due to such chemical treatment. All these positive attributes of specially treated jute Geotextiles suggest its effective application in river bank protection [2].

River training work is a complex and intricate process. Proper river training and protective work help protect the land of thousands of people in a densely populated country. Success of such works depend on a number of factors which should be carefully addressed [3].

Figure 2: Counting and lengthwise placing of filled geo-bags

The use of a thickly woven coir geotextile for construction of mud wall has been demonstrated in the Kuttanad area, which represents a typical peat soil. Besides it has been proved to act as good separator and drainage filter also. The strength of soil has been found to increase in course of time as the organic skeleton has remained in place in compressed form that acts as a filter cake providing sustainable protection to the streambank. Local vegetation grown over the embankment has been providing extra protection against erosion of mud wall. This treatment opens up new avenues for the application of coir geotextiles that could be applied in low-lying areas all over the world. It is seen that even after eight years the mud wall is intact and it is performing well. The tremendous strength and biodegradability of coir makes it suitable to various new areas of application in the soil bioengineering [4].

Figure 3: Close up view of applied coir geotextile on the stream bank

An analysis of the results of a distorted-scale laboratory investigation of geobag revetment performance, with particular emphasis on complete failure processes. Such analysis helps to predict the behaviour of a geobag revetment while it is exposed to different flow conditions and/or construction specifications. However, the distorted-physical model used for laboratory experiments had the limitations as Scale effects that existed due to the physical model. The fixed-bed nature of the experimental work, which helped isolate the impact of hydrodynamic loadings, meant that the impact of toe scour could not be incorporated [5].

Figure 4: Pull-out of a geobag from a layer close to water surface

Physical model studies were conducted on an undistorted river model to study the efficacy of coir geotextiles as a river bank protection measure using woven coir geotextile mat and cocologs. The placement of geotextiles increased the depth of water and decreased the velocity of flow compared to the unprotected bank (UB). Cocolog acted as soft toe armour and protected the side slopes by retaining the sediments above it. Cocolog has the ability of reducing water velocity by absorbing water and acting as a semi pervious media. Geotextile mat acted as check dams and arrested the migration of soil particles by flowing water. The best erosion protection was produced when woven coir geotextile mat was placed over the side slopes with one cocolog at bank toe as the volume of erosion was least in this case [6].

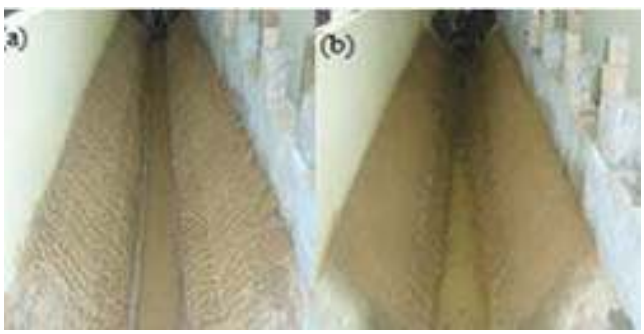

Figure 5 : River model with geotextile mat and cocolog (a) before experiment (b) after experiment

The study on the effect of installation of river bank protection measure along with bed protection using geotextile bags in river Jia Bharali has revealed the following important conclusions:

1. The protection work has successfully diverted the river from the protected bank and resulted in siltation creating a sand bar extending to a distance nearly 30 times that of the width of the launching apron.

2. Although flow of the river is diverted from the bank in the protected stretch the diverted steam has sharply come back towards the bank just beyond the downstream end of the protection work, thus, rendering the bank downstream of the protection work vulnerable to erosion.

3. The poor geotechnical properties of the bank subsoil has made it further susceptible to erosion.

4. The protection work in its downstream has adversely affected the very river bank causing erosion and gradual shifting of the major stream of the river into the bank within a period of 3 years [7].

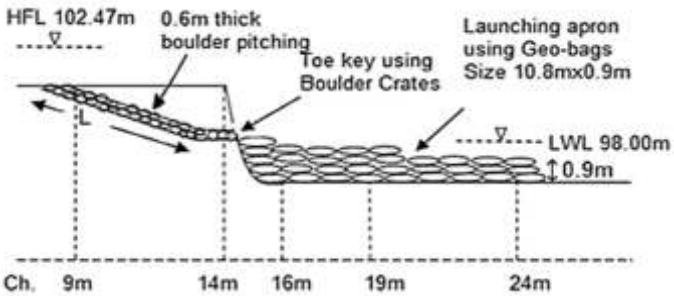

Figure 6: Technical details of the bank protection work installed

Government policies and frameworks can be a microcosm for similar such endeavours, particularly in the rural global south. Government policies and frameworks and local stakeholder involvements that facilitate such an undertaking, with particular emphasis on the organizational workflow and the ground-level perception of such endeavours, as these are crucial to the success and effectiveness of such schemes. The marked successes achieved through the use of the Vetiver grass in abating erosion and the hindrances encountered in implementing such mitigation projects are outlined, along with the importance of such community based approaches to river management and monitoring [8].

Figure 7: Aligning bamboo geogrids with bank geometry

High performance geotextile is always a crucial direction of geotextile development. At present, it is mainly to add additives and modify geotextile to make up for the performance defects of geotextile. Secondly, the geotextile with excellent properties can be made from high performance fiber, such as glass fiber or basalt fiber. In the future, it is possible to design geotextiles with unique and excellent properties by applying nanofibers to geotextiles. Application of intelligent geotextiles in geotechnical engineering is need of the time. [9].

Figure 8: Intelligent geotextiles for installation

An application of woven type geo-textile with sufficient pores to dissipate pore pressure can restore the foundation material. Above the geo-textile sheet riprap pitching of 15 cm thick gravel of 30 mm to 125 mm sizes and more than 20 cm thick water front stone boulders above 200 mm size may be suited to protect the embankment at the study section. The geo-textile reinforced revetment may act as a rescue against the alarming situation of cutting and erosion in the river. The protection has to be done up to scour depth also as per provision of relevant codes available and others. The normal scour depth calculated at section of km 37 and km 62 is 5.4 m and 6.4 m, respectively [10].

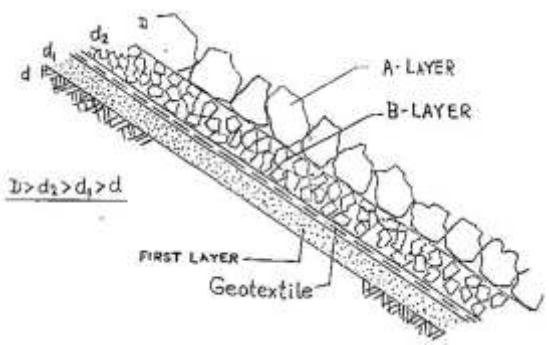

Figure 9: River bank embankment-Groyne layout-repelling type

4. Conclusion

Geotextiles are commonly used in riverbank erosion protection due to their effectiveness in stabilizing soil and preventing erosion. Some applications of geotextiles in riverbank erosion protection include:

Slope Stabilization: Geotextiles can be used to stabilize the slopes of riverbanks by preventing soil erosion caused by water flow. They are placed alongside the slope and act as a barrier that holds the soil in place, reducing the risk of slope failure.

i. Bank Protection: Geotextiles can be used to protect riverbanks from erosion caused by wave action or high water flows. They are placed along the waterline or submerged in the riverbed to prevent scour and stabilize the bank. Geotextile tubes or mattresses filled with soil can also be used as revetment systems to protect the bank from erosion.

ii. Filtration and Drainage: Geotextiles can be used to facilitate proper drainage of water from the soil, preventing saturation and reducing the risk of erosion. They can be used as a filter fabric to allow water to drain while preventing the loss of fine soil particles.

iii. Vegetation Support: Geotextiles can be used to support vegetation growth on riverbanks. They create a stable environment for plant roots to anchor and grow, reducing the risk of bank erosion. Geotextiles can also protect newly planted seedlings from being washed away by water flow.

iv. Sediment Control: Geotextiles can be used to control sediment runoff from construction sites or disturbed areas near riverbanks. They can be installed as silt fences or sediment barriers to prevent sediment-laden water from entering the river and causing bank erosion.

v. Geobags: Geotextiles can be fabricated into geobags, which are flexible containers filled with soil or other materials. Geobags can be used in riverbank erosion protection by creating a permeable barrier that stabilizes the bank and prevents soil loss while allowing water to pass through.

Overall, the application of geotextiles in riverbank erosion protection provides a cost-effective and environmentally friendly solution to prevent erosion and maintain the stability of riverbanks.

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Journal of the TEXTILE Association

APPAREL

Blockchain Technology- A Panacea to Circularity in the Indian Apparel Industry

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Department of Textile, DKTE'S Textile & Engineering Institute, Ichalkaranji

Abstract:

This study presents a review of the literature on circular economy supply chain management (CESCM) in the Indian apparel industry utilising blockchain technology (BT). With an increasing emphasis on sustainable business processes, CESCM research is gaining popularity. As a disruptive technology, BT has the ability to influence the CESCM. Using existing literature, the antecedents of CESCM employing BT have been determined, which will enable future research to develop a conceptual model of CESCM using BT for Indian apparel organisations.

Keywords : *Apparel, Blockchain technology adoption, Circularity, Circular Economy, Fashion, Textiles, supply chain management*

Citation: Citation: Ahmed Ashraf Zaidi & Rahul Chandra, "Blockchain Technology- A Panacea to Circularity in the Indian Apparel Industry", *Journal of the Textile Association*, **84/5** (292-300), (Jan-Feb'24), DOI No. https://doi.org/10.5281/zenodo.10634559

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1. Introduction

Increased affordability and consumerism have led to frequent replacement, which has slowed the adoption of the circular economy and increased waste; hence more reason to identify ways and means to emphasise technologies which can help achieve the objective.

Globally, practitioners and academics are struggling to design and develop a circular economy supply chain (CESC). Implementing CESCM in the Indian apparel industry is made more difficult due to the complex nature of the supply chain, which consists of physically separated, multi-echelon entities seeking to maximise their own profits. This complexity is exacerbated by factors such as globalisation, diverse regulatory policies, irrational human behaviour, and cultural influences, among others . Inefficient transactions, deception, theft, and underperforming supply chains result in a lack of trust and necessitate a system that is transparent and able to provide real-time information sharing and verification.

Currently, supply chains rely on systems such as enterprise resource planning (ERP) that store information in a centralised location most of the time. This ERP or similar systems have their own flaws. In addition, the lack of trust among supply chain members further complicates matters. This centralised system also has a single point of failure, making it vulnerable to attack, corruption, and hacking . In the realm of CESCM, validation and verification are of strategic importance, as processes, products, and events within the supply chain must meet specific sustainability criteria and certifications . The crucial question is therefore whether the current supply chain information systems can support the information required for the timely provenance of goods and services in a secure, transparent, and trustworthy manner. Improving supply chain transparency, safety, resilience, and process veracity is the solution to this complicated problem. The solution to this issue could be blockchain technology (BT).

BT is an emerging technology that is disrupting the market and broadening the horizons of business. BT employs a decentralised "trustless" database that enables high-volume transactions and process disintermediation, as well as decentralisation between contracting parties . Blockchain possesses all the characteristics that can enable diverse supply chain participants to coordinate their actions to achieve a common objective. A significant application of BT is the identification of social and ecological conditions that may pose safety, health, or environmental concerns """. Nonetheless, BT faces adoption challenges in Indian apparel industry supply chain networks, particularly on the technological, behavioural, policy-oriented, and organisational fronts, just like any other disruptive technology'. These issues require further investigation because they affect both practise and research. This study specifically attempts to answer the following question:

What are the enablers for the Indian apparel industry to adopt CE supply chain management using blockchain technology?

2. Problem statement

Blockchain for Circular Economy (CE) seems promising; however, as per the literature review, the adoption is slow in Indian apparel retail organisations closing the loop.

3. Objective of the study

To identify the enablers for adopting blockchain technology for circular economy in the Indian apparel retail industry.

4. Literature Review

4.1 From a Linear to a Circular Economy- Why?

Global demand-supply trends draw attention to the

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discrepancy between the availability of finite resources and demand. Environmental degradation, volatility in prices and depletion of resources have emerged from the rising competition. The burden on resources has increased tremendously because of various reasons:

1. Population growth
2. Rapid development and expansion of the fashion industry, fast-changing fashion trends, global-scale mass manufacturing model, extension of production to developing countries and the landfill of waste have significantly contributed to increased environmental issues
3. Pilot survey of brands and suppliers in the Indian textile sector was carried out (sample size of 570 consumers in Delhi & Bangalore) and key concerns highlighted are as follows (study done by Centre for responsive business on application of circular Economy in Indian Apparel & Textile sector):

   a. Huge fabric waste: As revealed by several suppliers, a lot of fabric waste, about one ton, is disposed of in landfills each month.

   b. The report identifies Blockchain technology adoption for waste mapping and traceability as a long-term intervention.

4.2 Circular Economy: An organisational perspective

From an organisational perspective, a comprehensive working definition of CE by Alhawari' is as below:

"CE is the set of organisational planning processes for creating and delivering products, components, and materials at their highest utility for customers and society through effective and efficient utilisation of ecosystem, economic, and product cycles by closing loops for all the related resource flows."

Alhawari goes on to state, "Organizational CE activities are actions that occur in developing infrastructure and relationships with different actors to achieve material efficiency through closing ecological loops. In essence, CE is a set of practices aimed to keep products in use as long as possible even after the end of their lives."'

4.3 Barriers to circular economy: An organisational perspective

Several studies have addressed barriers and obstacles to CE adoption specifically for the textile industry as per research done by A. Abdelmeguid et al. A. Abdelmeguid et al. carried out a systematic literature review to investigate the challenges of CE implementation in the fashion industry summarised in Table 1 .

Table 1- Systematisation of challenges for circular textile supply chains

Category	Challenge	Definition	Contextualization in the apparel and textile industry	Author
Economic and financial viability	1.Higher investments	Increased investments and decoupling between expenses and revenues may cause CE solutions providers to experience longer payback periods.	Fashion brands face risks in uncharted waters like circular redesign, renting models, and textile reuse, resulting in higher costs and reduced competitiveness.	S. Claxton and A. Kent [12]
	2. Financial risks	Financial risks could be incurred by CE solution providers (for example, because of servitization).		
	3. Operational risks	CE solution providers face financial and operational risks.		
Market and competition	1.Cannibalization	Circular product annihilation reduces profits and sales for businesses.	New circular textile products could cannibalize the clothing market, potentially compromising quality and damaging a company's reputation, both spatially and over time.	Y. F. Huang, S. G. Azevedo, T. J. Lin, C. S. Cheng, and C. T. Lin [13]
	2.Know-how access	Third-party CE operations may compromise device technology control.		
	3.Lower Brand Image	Third-party CE tasks can harm OEM brand reputation.		

Category	Challenge	Definition	Contextualization in the apparel and textile industry	Author
Product characteristics	1.Fashion change	Long-lasting products struggle to adapt to fashion trends.	Fast fashion uses chseaper materials, but textiles cannot be recycled due to color separation and plastic/metal content.	A. Abdelmeguid, M. Afy-Shararah, and K. Salonitis. Yarim [12]
	2.Product complexity	Complex product design challenges recovery processes due to poisonous ingredients.		
	3.Mass customisation	Mass customization increases recovery procedures complexity.		
Standards and regulation	1.Taxation and incentives unaligned	Current tax laws and incentives do not support CE.	Legislative frameworks lack incentives for circular clothing design and textile waste reduction, hindering a comprehensive policy framework and standardization.	I. Kazancoglu, Y. Kazancoglu, E. Yarimoglu, and A. Kahraman [14]
	2.Measures, metrics, indicators unaligned	Metrics and indicators do not align with CE.		
	3.Lack of standards	Current processes, activities, materials do not meet CE standards.		
Supply chain management	1.Return flows uncertainty	Uncertainty over end-of-use product returns quantity, quality, timing, location.	Ineffective communication, integration, and cooperation among supply chain members contribute to low clothing waste, increased transportation, challenges in finding partners, lack of textile product traceability, and internal resistance to change.	E. F. Dulia, S. M. Ali, M. Garshasbi, and G. Kabir [15]
	2.Increase in transportation	CE may increase transportation costs due to product return.		
	3.Availability of suitable skills and supply chain partners	Challenge finding CE partners with shared objectives and skills.		
	4.Lack of coordination and information sharing	Lack of communication and information sharing in global supply chains due to rivalry, sensitivity, and improper planning.		
	5.Lack of traceability	Product traceability lacking, hindering collection and recovery		

4.4 Circularity - Understanding the Indian textile waste landscape

A study done by Centre of Responsible Business and Fashion for Good ' states that India generates about 7793 kilotons, or 8.5%, of the world's textile waste each year. 59% of it is recycled and used again. The remaining 41% is either degraded (19%), burned (5%), or goes to a landfill (17%).

4.5 Blockchain Technology, origin, definition, and facilitation towards the circular economy

Nakamoto introduced blockchain technology in 2009, utilizing data mining and bitcoin techniques for data structure, ensuring high transparency and security in online storage .

At its core, BC is a distributed ledger that stores its users' transaction histories in blocks . After each successful transaction, a new block allowing access by any network node . It uses a consensus method to eliminate the need for a trusted third party, ensure data consistency, and prevent fraudulent storage in a distributed system " .

The critical characteristics of BT include - immutability ; decentralization ; disintermediation ; security ; privacy ; automation –; smart contracts ; trust ; transparency ; traceability ; information sharing – . These characteristics of the BC have been recognised as a facilitator of the CE.

5. Research methodology

Systematic review of literature(SLR) on circular economy(CE) and Blockchain technology for identification of gaps

SLR on CE

- Step 1- Search using relevant combination of key words using textile+ clothing + fashion+ circular economy on google scholar and Scopus from 2011-2022
- Step 2- Resulted in 935 articles
- Step 3- Removal of duplicates resulting in 482 articles
- Step 4- Reading of title and abstract to answer questions – what is meant by circular economy; strategies that support CE; barriers to adoption of CE
- Step 5 Removal of articles that do not answer the question resulted in 135 articles

SLR on blockchain technology(BT)

- Step 1- Search using relevant combination of key word using sustainability transition + circular economy +reverse logistics+ blockchain barriers and enablers + fashion ' textiles, clothing , apparel on google scholar + Scopus from 2011-2022
- Step 2- Resulted in 280 articles
- Step 3- Search included papers and review papers resulted in 200 articles
- Step 3- Reading of title and abstract to answer the questions what is BT; how can BT aid in CE and CSCM in ; what are the enables for adoption of BT for CE; resulted in 124 article

SLR on CE + BT

- Step 1- Reading of title and abstract to answer questions – what is meant by circular economy; strategies that support CE; barriers to adoption of CE & what is BT; how can BT aid in CE and CSCM in ; what are the enables for adoption of BT for CE
- Step 2 Removal of articles that do not answer the above questions resulted in 85 articles

6. Circular economy supply chain management (CESM) enablers for blockchain technology

The transition towards a circular economy faces challenges in various sectors, including the textile and apparel industry , which faces challenges in achieving circular transparency and reverse logistics for recycling initiatives. The globalized, complex supply chain requires extensive commitment, communication, and engagement among stakeholders .

Fashion designers face challenges in making sustainable decisions due to corporate profit targets, limited recycling materials, quality concerns, and lack of knowledge about sustainability and environmental impact. The transition to a circular economy is hindered by inadequate policies and workforce knowledge — .

Businesses often view waste as a cost, hindering efforts to close the resource loop. Recycling materials is expensive and challenging due to the diverse mix of materials, colors, and finishers '. The lack of technology is a critical barrier to developing a circular economy, as it does not return the same quality product .

Lack of consumer interest and awareness hinders the transition towards a circular economy . Returning used products requires commitment and new relationships with producers. Low collection rates in developed countries and lack of textile collection programs in developing nations make it challenging to convince customers to adopt circular business models .

End-of-life circularity faces challenges in collection and sorting schemes, necessitating innovative technologies to improve accuracy and speed. Retailers face challenges in reverse logistics management due to cost, staff, and procedures, requiring effective information systems for decision-making and resource management .

To mainstream the circular economy, several requirements must be met, including reversing cycles for material reuse, new business models, circular product design, and system conditions. Blockchain technology can provide information technology infrastructure, supporting resource efficiency, renewable input sourcing, and material recovery, particularly in recycling and refurbishing.

BT's data management can help the upstream and downstream flows of material and information reliably and transparently. This flow of material and information will have positive outcomes, such as higher customisation, reduced surveillance cost, and holistic management practices to serve the ultimate customer . Finally, using BT, the sustainability initiatives will be successfully implemented throughout the entire supply chain to achieve the triple bottom-line targets for economic, environmental, and social performance.

The economic benefits are easier to observe, and published literature establishes that BT helps increase the wealth of the partnering firms .

BT reduces malpractice, ensures human rights adherence, and promotes sustainable performance. Clear product history records boost customer confidence, and BT addresses environmental concerns and reduces recalls.

Real-time authentication of green products boosts buyer confidence and increases willingness to pay. "Black box" reverse logistics for recycling initiatives enhances consumer trust in sustainability-focused companies.

BT offers transparency and traceability in the supply chain, but adoption is slow and limited to high-end designer labels and expensive yarns, with no standardization in the platform.

Even though the benefits of BT in CESCM have been extensively enumerated, its adoption by the Indian apparel industry has been relatively slow. As BT is a disruptive technology, people are wary of its use in CESCM. Members of the supply chain must comprehend and prepare for these obstacles. The author determined the following enablers for BT in SSCM based on published literature. While compiling the final enablers, the opinions of experts were also considered. Table 2 contains a listing of these factors.

Table 2 - Enablers for CESCM implementation

S. No.	Enablers	Brief Description	Author
1.	Top Management support	The board of directors oversees organizational goals, vision, strategic decisions, and promoting a circular economy culture within the company.	J. Wolf [40]
2.	Infrastructure	Supply chain companies manage material and immaterial resources for sustainable activities, including reverse logistics infrastructure and used goods collection.	A. Diabat, D. Kannan, and K. Mathiyazhagan [57]
3	Financial Constraints	Raising funds for CESCM operations involves effective resource utilization and developing metrics to assess performance.	A. Chaabane, A. Ramudhin, and M. Paquet [43]
4.	Planning & Execution	Execute CESCM process planning, simplify execution, and educate key parties.	A. Diabat, D. Kannan, and K. Mathiyazhagan [57]
5.	Culture	Culture encompasses beliefs, values, symbols, and presumptions shaping a company's business practices.	M. Mettler [50]
6.	Information communication and Technology (ICT)	Utilizing advanced technology for efficient traceability and product recovery after use or end of useful life.	A. Diabat, D. Kannan, and K. Mathiyazhagan [46]
7.	Customer Acceptance	Promotes CE philosophy throughout hierarchy, providing assistance to downstream clients. Awareness campaigns can change consumer attitudes towards refurbished goods. Modernized marketing tactics and increased consumer awareness drive demand for circular products.	Y. Liu and Y. Bai [51]
8.	Supplier Acceptance	The organization assists upstream suppliers and ensures sustainability attitudes are passed down to suppliers, fostering awareness and actively demanding sustainable goods and services.	P. van Loon, C. Delagarde, L. N. Van Wassenhove, and A. Mihelič [52]
9.	Government Support	Regulatory bodies shape laws and regulations affecting CESCM initiatives.	S. Al Zaabi, N. Al Dhaheri, and A. Diabat [53]
10.	Competition	Group of businesses serving similar consumer groups, creating comparable goods or services, strategic component influencing CESCM.	S. Saberi, M. Kouhizadeh, J. Sarkis, and L. Shen [54]
11.	External Stakeholders	Industry and institutions that do not directly benefit economically from the CESCM processes are considered external stakeholders.	S. Saberi, M. Kouhizadeh, J. Sarkis, and L. Shen [54]
12.	People	Any and all staff members who significantly contribute to the CESCM processes.	H. Kagermann, W.-D. Lukas, and W. Wahlster [55]

This paper provides initial thoughts and insights regarding the adoption of blockchain technology (BT) for CESCM in the Indian apparel industry and how it may help SC players, policymakers, regulators, organisations, etc. use BT as a valid and efficient tool for CESCM. There are several advantages of BT in CESCM (e.g., access to confidential data, security protocols, improved communications among all key players, etc.), as well as opportunities and challenges in the near future (e.g., improving performance outcomes, creation of smart devices, etc). (e.g., readiness of SC players, lack of adequate regulations, loss of private data and identity, etc.). However, there are few obstacles to CESCM adoption of BT. First, BT by itself is not suitable for large data storage, despite the fact that there are various workarounds. Secondly, there are obstacles to cryptocurrency adoption, most notably regulation. It should be made clear that cryptocurrency is not required for the creation of blockchain-based value. Thirdly, costs associated with the BT must be considered. BT requires substantial infrastructure and software investments. Who will lead the effort and how? Does the expenditure outweigh the returns? Fourth, resistance to change may be another significant obstacle. Numerous supply chain (SC) players may be threatened by BT's transparency. How will the managers implement this change? How does the end consumer perceive the CESCM initiatives and how much value does him or her place on them? As BT is an emerging technology, these issues will gain clarity over time.

7. Conclusions

BT is rapidly establishing itself as a disruptive innovation in the field of technology, altering work environments and gaining widespread adoption across other sectors however it adoption is slow in the Indian apparel industry. As with any other study, this one has its limitations. First, it challenges the generalizability of the results by incorporating the opinions of a small group of experts. Second, because BT is still in its infancy and undergoing rapid transformation, this study may not have taken full advantage of emerging technology. Thirdly, because the current study focuses on India, it may not capture the challenges faced by other developing nations due to differences in factors such as culture, government support, etc. To uncover new dimensions, this study could be enhanced by adopting a mixed-method approach, such as interpretive structural modelling (ISM) with system dynamics or ISM with case study. Aspects such as carbon footprints, greenhouse gas emissions, etc., could be accurately captured with BT by tracing the complete process from the raw material supplier to the final consumer, thereby allowing for research on holistic circular economy supply chain management. With the implementation of BT in CESCM, the roles and responsibilities of various supply chain partners would shift, thus challenging the currently accepted theories. This presents an opportunity to expand the circular economy's supply chain domain's body of knowledge.

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Forest to Fashion: Harnessing Bamboo's Sustainability in Eco-printing and Textile Design

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Abstract

In the ever-evolving apparel and home textile market, a plethora of new fibers has emerged, offering enhanced qualities and functionalities to the existing fabric range. Among these innovative materials, bamboo stands out as a noteworthy addition. Its cultivation requires significantly less water compared to cotton, making it particularly advantageous in water-scarce regions. What makes bamboo truly remarkable is its sustainable harvesting process, which allows for selective harvesting without causing deforestation. Unlike hardwood trees, bamboo can be harvested without the need to cut down the entire plant. As the industry strives to adopt more environmentally friendly practices, careful consideration is being given to the dyeing and finishing processes of various materials. In this context, eco-friendly alternatives are gaining prominence. One such solution is eco-printing, which involves the use of organic materials derived from nature to infuse prints onto surfaces. This eco-friendly approach to printing aligns with the industry's conscious choices and sustainable objectives. With a focus on exploring the background of bamboo textiles, a comprehensive study was undertaken. The objective was to design an ensemble that not only incorporates the value addition of eco-printing but also embraces the emerging trend of minimalism. By combining the benefits of bamboo textiles and eco-printing, the aim was to create a sustainable and aesthetically pleasing ensemble that resonates with the evolving preferences of conscious consumers.

Keywords: *Bamboo, eco-printing, marigold, apparel, sustainability, summer wear*

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1. Introduction

Bamboo, a renewable plant with a short growth cycle of 3 to 5 years, offers a sustainable solution for textile applications due to its minimal resource consumption. It has gained popularity in the mainstream textiles and apparel industry, thanks to its remarkable qualities such as softness, comfort, moisture-wicking, antimicrobial properties, thermoregulation, and UV protection. In line with the industry's growing focus on sustainability, the textile wet processing stage, known for its pollution caused by synthetic dyes and hazardous chemicals, is shifting towards eco-friendly dyeing and printing methods.

Against this backdrop, a study was undertaken to explore the potential of bamboo fabric and create a summer ensemble using eco-printing as an additional value proposition. The research paper provides a comprehensive analysis of the bamboo plant, covering its historical background, production methods, inherent properties, and diverse application areas. Furthermore, it highlights popular brands that have embraced bamboo textiles, along with an in-depth exploration of eco-printing techniques and its aesthetic aspects in the realm of slow fashion.

The study aims to contribute valuable insights into the sustainable utilization of bamboo textiles, showcasing its versatility and eco-friendly characteristics. By incorporating eco-printing, the research strives to demonstrate how innovative and environmentally conscious techniques can enhance the creation of fashionable ensembles suitable for the summer season.

2. Understanding the selected fabric: 100% Bamboo

2.1 The plant

Bamboo is one of the fastest-growing plants on Earth with some species capable of growing up to 91 cm (36 inches) in a single day. It can reach full maturity soon while trees used for traditional timber can take decades to grow (Fig.1). This fast growth makes bamboo a highly renewable resource based on which products can be planned and they grow back quickly [1]. Bamboo cultivation generally requires minimal water, pesticides, and fertilizers compared to other crops. It can also grow in diverse climates and soil conditions without the need for synthetic inputs [2].

Bamboo has an extensive root system that helps prevent soil erosion and promotes water retention. The plant's dense growth and leaf litter contribute to the enrichment of soil

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organic matter [3]. It is cultivated on marginal or degraded lands, revitalizing the soil and preventing further degradation. On cultivation, bamboo also has the ability to absorb large amounts of carbon dioxide (CO2) from the atmosphere and release oxygen. It is estimated that bamboo can sequester up to four times more CO2 compared to hardwood trees. This makes bamboo plantations valuable in mitigating climate change and reducing greenhouse gas emissions [4, 5]. The cultivation is thus very helpful for the ecosystem and utilising the grown-up plants for textiles can be beneficial considering its biodegradable nature [6, 7].

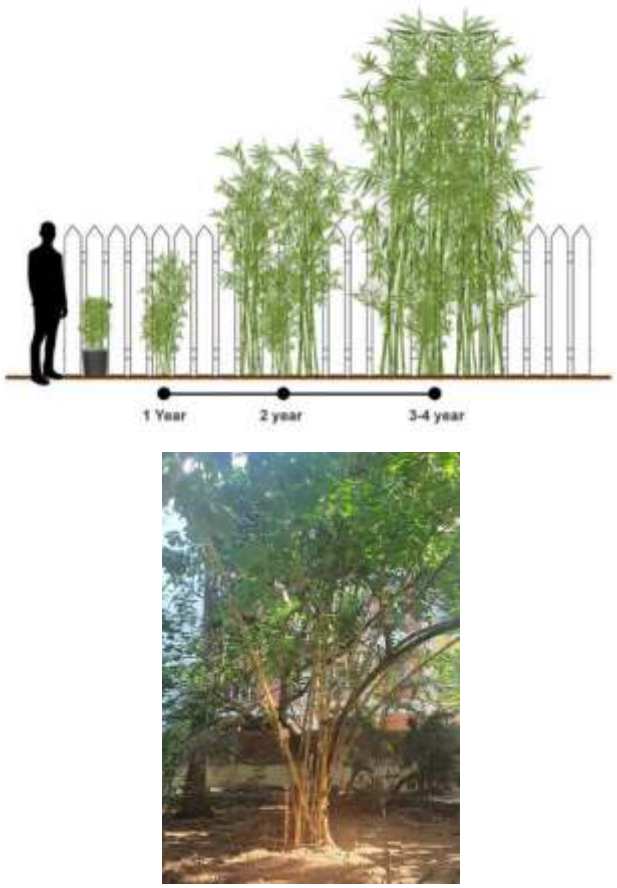

Figure 1 – Growth of Bamboo Plant
Image Source: https://
www.wilsonbrosgardens.com/propagation-of-bamboo-plants.html

2.2. History of Bamboo Textiles

The first known application of bamboo as a textile can be traced back to ancient civilizations in Asia, particularly in China. Bamboo has been used as a source of fibers for weaving into textiles for thousands of years. In China, historical records suggest that bamboo textiles were in use as early as the Ming Dynasty (13th – 16th century) and Qing Dynasty (16th -19th century). During this time, bamboo fibers were manually extracted from bamboo stalks and processed into yarn for weaving. Bamboo fibers are naturally soft, lightweight, and breathable, making them suitable for clothing and other textile applications. The traditional process of making bamboo textiles involved several steps. First, the bamboo stalks were harvested and soaked in water to soften them. Then, the outer layer of the stalks was removed, and the remaining material was mechanically crushed to extract the fibers. These fibers were then spun into yarn and woven into textiles using traditional weaving techniques. These were used for clothing, bedding, and household items such as mats and baskets. The use of bamboo textiles gradually spread beyond China to other parts of Asia, including Japan and Southeast Asian countries. One notable development in bamboo textile production occurred in the early 2000s when a Chinese company named Beijing Sen Li Da Xie Chemical Fiber Technology Co., Ltd. patented a bamboo fiber extraction method. This method involved using a combination of chemical and mechanical processes to produce bamboo viscose fibers suitable for textile production [8].

2.3. Production of Bamboo textiles

Bamboo fabric is derived from the bamboo plant, specifically the pulp of the bamboo stalks. Inorder to robust its textile quality, it is important to harvest bamboo at the right time and ensure optimal fiber quality. The quality and durability of bamboo fabric can vary depending on the manufacturing process and the specific brand. High-quality bamboo fabric can be durable and long-lasting, with the ability to withstand regular washing and wear.

Bamboo plant shoots are collected, chopped and the harvested bamboo culms (stems) are split or crushed to extract the bamboo fibers (Fig.2). This is s done in two ways;

i). Mechanical Processing: In this method, the bamboo culms are crushed and mechanically scraped to separate the fibers from the woody parts. The fibers are then mechanically combed to remove impurities and prepare them for further processing.

ii). Chemical Processing: In this method, the bamboo culms are treated with chemicals, such as sodium hydroxide, to break down the lignin and hemicellulose components. This process is known as "retting" and helps to release the fibers. The fibers are then mechanically extracted and cleaned [2, 9]. Bleaching and dyeing is an optional step after extraction, where the bamboo fibers may undergo a bleaching process to achieve a desired whiteness or color. Dyeing may also be performed to add color to the fibers before they are spun into yarn or used in fabric production. After extraction, the fibers obtained will be short in length which will be twisted and made into a yarn of continuous length. The spinning process can vary depending on the desired yarn thickness and type (e.g., single, plied, or blended yarns). The bamboo yarn is then used to create fabrics through weaving or knitting processes.

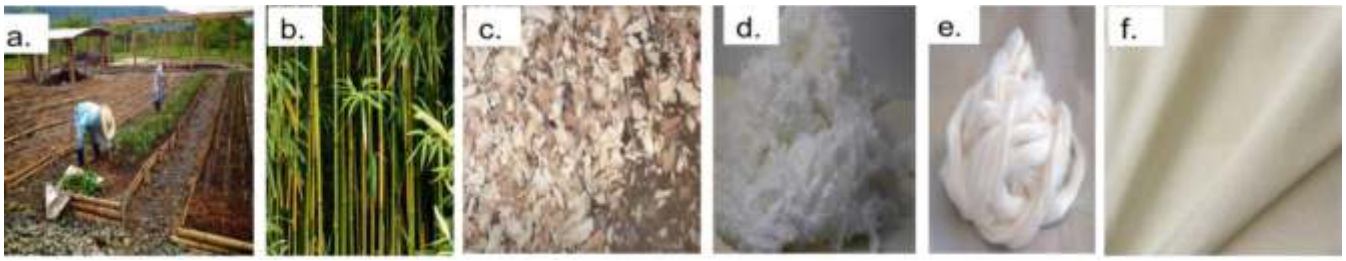

Figure 2 – Production of Bamboo Fabric

a.Cultivation of Bamboo, b. Soaking of Bamboo for fibre extraction, c. Bamboo Spun Fibre, d. D. Bamboo Yarn, e. Bamboo Fabric

Image source – https://www.guaduabamboo.com/blog/how-to-plant-bamboo
https://www.youtube.com/watch?v=cElGZ4WF5Fs

In case of bamboo fabric, after its production it undergoes various finishing to enhance its properties. Eg. Bamboo is known for its antimicrobial property which is mostly lost during the conversion of plant to fabric. Hence, after production, a coating of antimicrobial agent is usually done. In some cases, the fabric is also treated with softening agents to improve its drape and hand feel, making it softer and more comfortable against the skin. In addition to existing quality additional coating/ finishing is given to enhance the moisture management capabilities also. These treatments help to keep the fabric dry and comfortable by absorbing and wicking away moisture from the body.

To reduce the formation of pills (small fabric balls) on the surface of bamboo fabric, an anti-pilling treatment is given to maintain the fabric's smooth appearance and texture. When bamboo fabric is used for home textiles (bedding/upholstery) flame retardant finishes given help to improve its resistance to ignition and reduce flame spread [10]. Additionally, wrinkle-resistant finishes are given to reduce the formation of wrinkles and creases, making it easier to maintain a smooth and neat appearance.

On a similar note, antibacterial finishes are applied to the fabric to inhibit the growth of bacteria, thereby reducing odors and maintaining freshness [11]. Color fixation is also given to prevent color bleeding or fading. Other treatments include softening, dye fixation, and fabric stabilization based on the desired characteristics of the fabric [12, 13].

2.4 Properties of Bamboo textiles

It is identified that bamboo has 73% cellulose, 10% lignin, 12% hemicellulose, and for the textile use lignin and hemicellulose content should be reduced. Fabrics made from bamboo have properties similar to other regenerated cellulosic materials, such as viscose rayon, which are derived from wood (bast fibers). Bamboo fabric is known for its softness and luxurious feel, very similar to silk or cashmere wool in terms of its texture as well. Bamboo fabric is highly breathable and moisture-wicking due to the presence of microgaps that enhance ventilation and moisture absorption [14]. Studies show that bamboo fabric has excellent thermal-regulating properties, which help in keeping the body cool in hot weather and warm in cooler temperatures, making it suitable for various climates [15,16] Research has identified that bamboo fiber has a higher moisture regain capability than cotton or other natural fibers, due to its loose structure and disordered noncellulose material [17].

Figure 3 – Properties of Bamboo Textile

In addition to feeling comfortable, the wearer is also protected by the natural antimicrobial agent called bamboo 'kun', which helps to prevent the growth of bacteria on the fabric, reducing odor and keeping it fresher for longer periods which also contribute to odor control making bamboo fabric a favorable choice for activewear or undergarments. The material is naturally hypoallergenic making it excellent choice for individuals with sensitive skin or allergies. It is also naturally resistant to dust mites and mold. It also provides natural UV protection, and has the ability to block a significant amount of harmful UV rays, offering an additional layer of sun protection [18]. Bamboo fabrics have been reported to have good soil release and twice the moisture absorbency compared to cotton. Due to the absence of free electrons, bamboo fabric is antistatic and has a good drape on the skin. Considering the amazing

properties of bamboo (Fig.3), it is used in many applications that are expanding in all dimensions to meet the growing needs of the textile market.

2.5. The Diverse Applications of Bamboo Fiber

Bamboo has long been used for construction of home, furniture, as a writing material and even the biomass is used for bioethanol and biochar production [19]. In recent times bamboo has been used to make shopping bag, tote bag, gift wraps, and also in agro textiles such as like plant protection, erosion control, and weed suppression. Its application in textile and apparel are as follows;

Apparel and Fashion: Bamboo fabric is used to make a variety of garments, including t-shirts, dresses, skirts, underwear, socks, and activewear [20]. Its softness, breathability, and moisture-wicking properties make it comfortable for everyday wear and athletic activities. Considering the UV protection properties, apparels for pregnant women are made using bamboo to protect the mother from harmful radiation of sun's rays [21]. Accessories like scarves, hats, gloves, and socks are also made.

Intimate apparels: Bamboo is predominantly used in intimate apparels, as it is observed that bamboo fabrics are 1-2 degrees less than any other fabric type like cotton and linen. Bamboo fabrics are used to make underwear, bra, camisoles, tank tops, sleepwear, socks and leggings

Home Textiles: It is used as Mattresses, sanitary towels, table napkins, bags, curtain, television cover, sofa slipcover, bathrobes, bath towels, hand towels, shower curatins, bath mat, wash cloth, sheets, pillowcases, duvet covers, and blankets. Its softness and temperature-regulating properties contribute to a comfortable sleep environment. Bamboo is highly absorbent and quick-drying, making it suitable for bathroom textile products. It can be used to create lightweight and eco-friendly curtains and drapes for window treatments. [22]

Baby and Children's Products: The softness and hypoallergenic properties make it suitable for baby clothing, including onesies, pajamas, and bibs. It is sometimes used in cloth diapers due to its absorbency and antimicrobial properties.

Nonwovens: Considering the length of fiber, bamboo is used in paper-making industry and China having a long history on the same as early as 1700 years ago. Today compared to paper from wood, bamboo is less harmful [23]. It is also used in making of diapers, sanitary napkins, wipes, surgical gown, wound dressing, disposable bed sheets, cleaning wipes, mop heads and dishcloth.

Activewear and Sports: Considering the moisture-wicking and breathability qualities of bamboo sportswear, including workout tops, leggings, and sports bras can be designed. It is also used in outdoor clothing such as hiking shirts, pants, and jackets, due to its lightweight, moisture-wicking, and UV protective properties.

Interior Design: Bamboo fabric can be used for upholstery, cushions, and furniture coverings, adding a natural and eco-friendly touch to interior spaces. It is also applied as wall covering for decorative and sustainable purpose [24].

Medical and Healthcare: Bamboo fabric is used in some medical applications, including surgical gowns, wound dressings, masks, surgical clothes, nurses' wear, gauze mask and also as sanitary pads, sanitary towels, absorbent pads, toilet paper, tampons, menstrual underwear, reusable cloth pads, incontinence pads, panty liners and facial wipes. Its antimicrobial properties and hypoallergenic nature make it suitable for sensitive skin [25]. Recently sanitary napkins [26] and baby diapers made from bamboo have been reported to be very much welcoming in both urban and rural areas. Pre-folds and flat diapers is more commonly used as an absorbent insert in pocket diapers, all-in-one diapers, and hybrid diapers. The material is proven to be skin-safe and ecofriendly [27].

Smart Bamboo Textiles: Bamboo textiles are upgraded by using embedding sensors, microprocessors, and conductive threads for thermoregulation, moisture management, health monitoring, gesture control, energy harvesting (piezoelectric or solar cells into bamboo textiles) and interactive designs (LED lights or micro-displays) These textiles could change color, display patterns, or provide visual feedback based on user preferences or external stimuli.

2.6 Collaborative Efforts: Research Institutes and the Evolution of Bamboo Textiles

On understanding the applications of bamboo in textiles and fashion industry, it is significant to know the organisation/ research institutes who are actively engaged in research and development related to bamboo textiles.

Globally, International organisations include International Network for Bamboo and Rattan (INBAR), Bamboo and Rattan Research and Development Center (BARADECO), Forest Products Research and Development Institute (FPRDI) works and are channelled towards bamboo fiber extraction, textile innovation, and sustainable production practices. In India, Central Silk Board (CSB) is a statutory body under the Ministry of Textiles, Government of India, involved in research and development of various natural fibers, including bamboo, for textile applications. CSB has undertaken projects related to bamboo fiber extraction, processing, and fabric development. Bamboo Research and Training Centre (BRTC) in Kerala is a research and training institute focusing on bamboo and its applications. They conduct studies on bamboo textiles, including fiber extraction methods, fabric production, and product development. National Institute of Design has a 'Design Innovation Centre for Bamboo', where researchers and designers explore innovative applications of bamboo,

including textiles. They focus on sustainable design practices and work towards promoting bamboo as a viable material in the textile industry. The Indian Plywood Industries Research and Training Institute (IPIRTI) work towards bamboo-based textile composites and Bamboo and Cane Development Institute (BCDI) in Agartala, Tripura works on development of bamboo and cane-based products and on improving the quality of bamboo textiles.

2.7. Bamboo: The Sustainable Choice for Brands

In addition to various initiatives by research organisations/ institutes, bamboo has been heavily marketed by various brands and designers for their product development. Bamboo has become recognized as an eco-friendly option compared to conventional textiles like cotton or synthetic fibers. Bamboo is often blended with other fibers, such as organic cotton or recycled polyester, to enhance its properties and create unique fabric blends. This allows for improved durability, increased stretch, or moisture-wicking capabilities.

Some of the prominent players include Beijing-based Tenbro Bamboo Textile, Bo Group (BoNa), China, Hebei Jigao Chemical Fiber Co., Ltd., China, Sichuan Holly North Industrial Co., Ltd., and Chengdu Grace Fiber Co., Ltd. well-known manufacturer of bamboo fiber and bamboo blended yarns. Today, despite China's continued dominance in the textile industry, the United States remains the primary source of bamboo textiles.

Some of the interesting product categories are done by Eco HY (China) the brand specializing in the production of biodegradable dinnerware manufactured from bamboo fibers. Beco (Mumbai, India) a startup has been creating kitchen towel and trash bag from Bamboo and corn starch polymer. Ettitude is a brand based in Los Angeles, US to launch sleep wear and bedding items from bamboo which has reported to raise USD 1.6 million sales as per May 2020 [27] suggesting the application of bamboo in today's market to be extremely profitable.

Some other clothing and textile brands (Fig.4) working with bamboo are;

Cariloha – an US based brand comes with the tagline 'comfy way to save planet' that converts bamboo field into bamboo viscose fabrics for bedding, bath, apparel to create green fabrics.

Thought clothing - UK based brand has various product category like bamboo underwear, Socks, bamboo loungewear, leggings, tops, apparel that matches that sustainability goals.

TASC Performance, New Orleans-based company was started with the objective of 'reinventing performance apparel' using a new kind of patented concept in fabric finishing process called BamCo®, that result in anti-odor, comfort properties, durability, easy care and maintenance.

Bamboo tribe is an Indian brand that promotes their well-tailored wardrobe staples highlighting that conventional polyester based activewear can release 2808 bags of microplastics to the ocean every year.

Nature fab is yet another Indian brand that manufactures underwear, tees, pjs, leggings, towels, face mask and various other performance apparel using natural dyes with bamboo marketing their material as the softest fabric on earth.

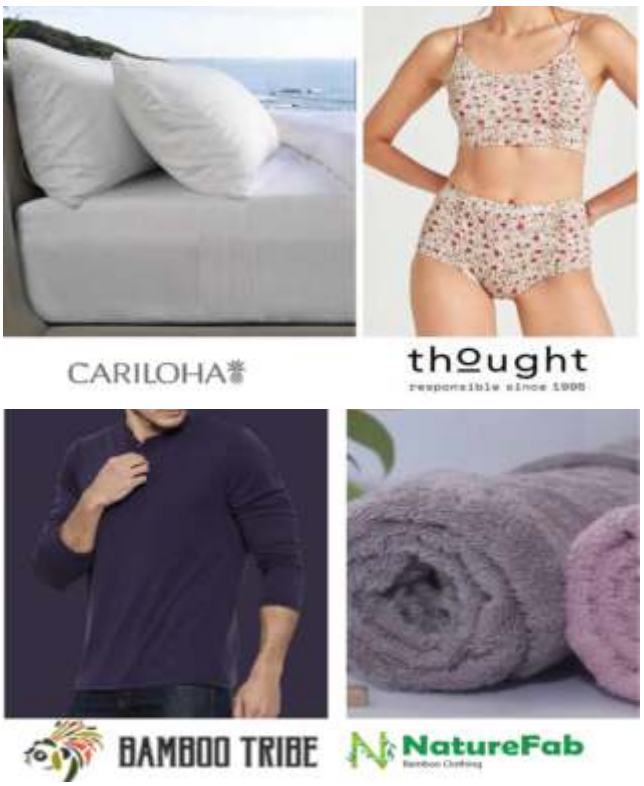

Figure 4 – Popular Brands using Bamboo Fibre

Apart from these brands Bam Bamboo clothing, Komodo, Thought, LNBF, Zen bamboo, Spun bamboo and Onno offer sustainable clothing solutions using bamboo.

2.8. The Green Truth: Sustainability Facts about Bamboo

Understanding how many brands are commercially successful, there are also remarks questioning how much bamboo is sustainable and environment friendly. The production of bamboo involves use of chemicals that can harm the environment as in the manufacturing of rayon from wood pulp. The conversion of bamboo into textile fibers often involves chemical processes. Depending on the specific manufacturing methods used, these processes may introduce potentially harmful chemicals and impact the sustainability of the final product. Consumers increasingly seek transparency and look for certified bamboo products. The flip side is bamboo doesn't contribute to deforestation considering the way it is removed (base stalk retained). Bamboo is also better than cotton because it is not a water and pesticide dependant crop and definitely a better alternative.

When a designer/ manufacturer is looking for sustainable options, it is better to look for materials with low carbon footprint in the overall processing rather than a 100% eco-friendly considering the real time challenges in creating something completely sustainable. To ensure a lower carbon footprint in bamboo, it is advisable to look for bamboo textile products that are sourced sustainably, manufactured using energy-efficient processes, and have transparent supply chains. In order to ensure the sustainability of bamboo textile products, certifications such as the Global Organic Textile Standard (GOTS) or the Oeko-Tex Standard, which provide assurance that the textiles meet specific environmental and social criteria throughout their production process can be verified. In future, mechanical processing methods that reduce chemical usage, use of closed-loop systems, more sustainable chemicals, and water-saving technologies can make bamboo 100% ecofriendly [28].

Understanding the significance and amazing properties of bamboo, the study was planned to use the source bamboo and create an ensemble for summer.

3. Exploring eco-friendly printing techniques

As a process of value addition dyeing or printing is done to the textile surface. In the rise of minimalisim and slow fashion, localised dyeing namely printing was adopted. In this context, safe and ecofriendly methods of printing were studied and documented as below.

3.1 Hand pounding

It is a technique that involves physically pounding or hammering the fresh flowers onto the fabric to release their natural dyes and create unique designs. A protective layer, such as a thin cloth or plastic wrap are kept over the flowers to prevent them from sticking to the pounding tool. Materials like wooden mallet, hammer, or similar tool is used for pounding the flowers, the pressure and force applied should be sufficient to release the pigments but too much that it can damage the fabric. In this method of eco printing the flowers/leaves are placed with white space in between them. In most cases only half the fabric is covered with plants and the other half is folded on top followed by a cover. Later the flowers are pounded with a hammer, hard enough as to absorb the dye from plants. After the bashing, the fabric will be opened to remove plants and to let it to air dry.

3.2. Bundle dyeing

Bundle dyeing involves bundling plant materials, along with the fabric, to create a package. This bundle is then steamed or simmered, allowing the colors to extract from the plants and transfer onto the fabric. In the process, the plant materials may or may not directly contact the fabric. Bundle dyeing often produces abstract or diffused patterns, as the colors spread and blend during the steaming or simmering, resulting in a soft and organic appearance. In bundle dyeing, the plant materials can be enclosed within the bundle, often sandwiched between layers of fabric or secured with string or fabric wraps.

Figure 5 – Hand pounding, Bundle dyeing and Eco-printing
Image source: The barefootdyer & Marta Mouka /Instagram

3.3. Ecoprinting

Eco-printing, on the other hand, entails placing plant materials such as leaves or flowers directly onto the fabric. Pressure is applied, usually through pounding or rolling, to transfer the colors and patterns from the plants onto the fabric. The patterns in eco-printing are more defined and closely resemble the shape and structure of the plant materials used. The direct contact and pressure allow for more precise and detailed patterns on the fabric. In eco-printing, the plant materials are placed directly on the fabric, leaving space between them to facilitate color and pattern transfer. When it comes to colorfastness, bundle dyeing generally yields more durable results. The dyes extracted from the plants are fixed onto the fabric through the heat and moisture of the steaming or simmering process. On the other hand, eco-printing may produce less colorfast outcomes, as the dyes from the plants are transferred through direct contact and pressure, which may not provide the same level of color fixation. Both bundle dyeing and eco-printing offer unique ways to incorporate natural colors and patterns into fabrics, providing opportunities for creative expression and sustainable dyeing practices [29].

3.3.1 Steps in eco-printing

It beings by collecting leaves, flowers, and stems to create a print from natural sources. These plant materials contain

pigments that can be transferred to fabric through a printing process. The fabric to be printed is typically pre-treated to improve dye absorption. This is done by the process of mordanting, which is the process of treating the fabric with natural substances to enhance its print quality. Mordants play a key role in fixing of plant pigment on the surface of the textile, intensity of the print color and permanency of the print.

3.3.2 Commonly used Mordants for eco-printing

Depending on the fabric selected for study, mordants are chosen. Generally, cotton, linen, requires intense mordanting as the fabric cannot readily take up natural dye. Myrobalan works well for cotton and alum for silk. Wool is the best fiber to be used for natural dyeing, and silk is the next option to get the best shades using natural sources. Synthetic textiles, do not have the ability to uptake nor hold back the natural dyes/pigments due to its chemical nature. There are different mordants used for ecoprinting namely;

- Alum/ Potassium Aluminum Sulfate is one of the safe and most commonly used mordants that helps in fixing and to intensify the colors, particularly on cellulose fibers like cotton and linen. It is ideal for silk and wool based fiber compositions.
- Iron/ Iron Sulfate/ Ferrous Sulfate is used to shift colors and create grey or black tones, darken and deepen any natural colors. These are usually used in small quantities as it can overpower other colors if used excessively. The effluent containing iron is also not disposed of to the plants immediately as it can be harmful.
- Copper/ Copper Sulfate can produce green hues and help in obtaining color variations, but should be used with caution as it is carcinogenic in nature.
- Soy milk is a natural binder and mordant that can help improve colorfastness in ecoprinting often used in combination with other mordants.
- Tannins are natural substances found in various plant materials and are often used as a mordant in ecoprinting. Examples include oak galls, tea leaves, pomegranate skins, banana skin, myrobalan, onion skin and tamarind. The use of these can enhance the colorfastness and create deeper and more durable prints.

3.3.3 Natural materials for eco-printing

- Marigold flowers are widely appreciated in ecoprinting due to their vibrant yellow and orange hues. They can create lovely, intricate patterns on fabric.
- Dahlia flowers offer a wide range of colors, including vibrant reds, pinks, and purples
- Roses come in various colors and can add elegance to ecoprinted fabrics. Different rose varieties yield different shades, ranging from deep reds to soft pinks.
- Geraniums are known for their vibrant and diverse colors, such as red, pink, and purple
- Coreopsis flowers is a very popular material for ecoprinting and can offer shades of yellow, gold, and orange
- Black-eyed Susan flowers have vibrant yellow petals with dark brown centers
- Eucalyptus leaves are widely cherished in ecoprinting due to their high tannin content, which can result in rich, deep prints. They can yield shades of reddish-brown, orange, and green.
- Maple leaves are known for their distinct shapes and can create intricate veining patterns when used in ecoprinting. They often produce shades of yellow, orange, and brown.
- Oak leaves are appreciated for their strong tannin content, resulting in deep, earthy tones, shades of brown, rust, and green.
- Rose leaves can contribute to delicate and elegant prints not in red but in soft green hues
- Ivy leaves offer unique shapes and textures with various shades of green and sometimes exhibit veining patterns as well
- Geranium leaves give green shade with distinct shapes and can create interesting patterns on fabric.

3.3.4 Process of eco-printing

In the process of ecoprinting, carefully selected raw materials are arranged on the fabric in a deliberate pattern or design. The aim is to achieve optimal contact between the plant materials and the fabric surface. To ensure this, the fabric is tightly bundled and secured. Subsequently, the bundled fabric undergoes either a steaming or boiling process, enabling the extraction of pigments from the plant materials and their transfer onto the fabric. The application of heat plays a crucial role in releasing the natural dyes and facilitating their absorption by the fabric fibers, resulting in vibrant colors. Once the printing process is complete, the fabric is left to dry. Excess plant materials are then removed, and the fabric often undergoes a thorough washing to eliminate any residual pigments or impurities, ensuring a clean and refined final product [30].

3.3.5 Surface manipulation and eco-printing

Ecoprinting offers a wide range of possibilities for enhancing the aesthetics of fabric through the integration of various techniques. By incorporating techniques such as accordion

folds, pleating, or spiral wrapping, diverse and captivating designs can be achieved, adding an element of visual interest to the ecoprinted fabric. Additionally, fabric manipulation techniques like pleating, shirring, or folding can be employed to introduce captivating textural effects. Another approach to further enhance the design exploration is through resist techniques, which create contrast and negative space. This can be achieved by applying natural wax or utilizing objects such as rubber bands or wooden blocks to create resist patterns prior to ecoprinting. To deepen or shift the colors in the prints, color modifiers like iron or copper mordants can be utilized, introducing unique and complex effects. Furthermore, after the ecoprinting process, the fabric can be enriched with hand embroidery or embellishments, including threads, beads, or sequins. These additional elements serve to enhance and complement the organic patterns created by ecoprinting, resulting in a truly captivating and unique final product [31].

3.3.6 Tests for ecoprinted fabric

Inorder to ensure the quality of the ecoprinted fabric various tests can be performed as discussed below;

pH Testing ensures that the fabric is within an acceptable pH range, as extreme pH levels can affect the fabric's durability and potentially cause skin irritation.

Colorfastness to Washing is washing the fabric according to specific standards, and any color bleeding or fading is observed and noted. Using the standard color scale the acceptance/ rejection is decided.

Colorfastness to Light is done by exposing the sample to simulated sunlight for a specified period, and to document any noticeable color changes.

Rubbing Fastness is done by rubbing the printed fabric against a white fabric or rubbing cloth, and to examine any color transfer or staining on the white/undyed/control sample.

Tear Strength is a test to measure the fabric's resistance to tearing. It helps determine the durability of the ecoprinted fabric and its ability to withstand normal wear and tear.

Seam Strength evaluates the strength of the seams in the ecoprinted fabric. It measures the force required to break or separate the seams, ensuring they are strong and secure.

Pilling Resistance assesses the fabric's resistance to pilling, indicating its ability to maintain a smooth and neat appearance. Here Pill refers to the formation of small balls of fibers on the fabric surface.

Dimensional Stability determines how well the fabric retains its shape and size after washing or other treatments. It measures any changes in the fabric's dimensions, such as shrinkage or stretching.

3.3.7 Care and maintenance of ecoprinted textiles

To ensure the longevity and preservation of ecoprinted textiles, it is recommended to follow specific care instructions. Generally, these textiles are best washed using mild detergent or pH neutral soap, or alternatively, traditional reetha nut can be used. Hand washing is preferable to maintain the delicate nature of the prints. When drying, it is advisable to opt for a shaded area to prevent any potential fading of the print caused by exposure to direct sunlight. When ironing ecoprinted textiles, it is important to use a mild temperature setting and place a layer of newspaper or butter paper between the fabric and the iron. This precaution helps to prevent the print from fading or getting damaged due to excessive heat during the ironing process. By adhering to these care guidelines, the beauty and integrity of the ecoprinted textiles can be preserved for an extended period.

3.3.8 Brands working on Eco-printing

The famous artists/ brand working with ecoprinting techqniues on textiles and leather are The Bare foot dyer (Austin, Texas), Marta Mouka (Canada), Flora obscura by Alison kelly, Earthues (Washington, USA), Fibershed (California), Ecopallete(India), The Colours of Nature (Tamil Nadu), Craftroots (India), Dastkar (NPO) (New Delhi), Kalhath Institute (Andhra Pradesh), Colorashram foundation, Econic India and Terrieakwong (Ecoprinting on leather).

These brands showcase many experiments, research design, working with artisans, collaborate with natural dyers, local communities to promote sustainable textile production methods.

4. Study on creating an ensemble for summer using bamboo and value addition through ecoprinting

As a design project bamboo fabric was purchased and ecoprinted for value addition. It was planned to construct an ensemble for summer, which has become a needy considering the global climatic issues/ ozone depletion and harsh summers. Objective of the study was to create a comfortable and breezy ensemble for a women clientele who is between the age group of 15 to 25years.

4.1. Sourcing of the fabric

Bamboo was selected for the considering its amazing benefits on skin and for hot climates to tackle heat and sweat. Woven bamboo fabric was purchased from the website 'Suvetah' (https://suvetah.com). The fabric had 140 GSM, 58' width and fabric count of 40S x 40S and priced at 4.27 USD per meter. (Fig.6).

4.2. Preparing the fabric for ecoprinting

Purchased 3 meters of bamboo fabric was treated with 64 gms of alum for 30mins to commence the process of mordanting. After the process, excess water was squeezed

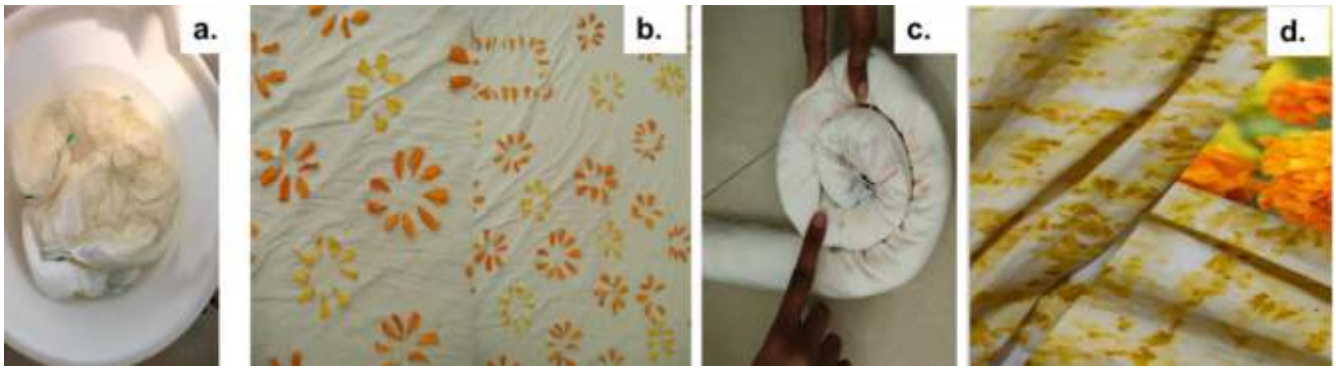

Figure 6 – Eco-printing 100% Bamboo Fabric using Marigold Petals
a. Mordanted Bamboo with alum, b. Patterning for eco-printing using marigold petal
c. Bundling for steaming, d. Eco-printed Fabric

SPECICIFICATION SHEET

Season	Spring Summer'24	Date	15 May, 2023
Group name	Marigold	Style #	BAMEC-001
Size range	S - XXL	Designer	Nil
Fabric name	Bamboo fabric	Product category	Frock/ Dresses
Fibre content	100% bamboo	Brand/ Label	Canecave
Style description	Puff sleeve dress with flared / gathered full length skirt		

Figure 7 – Prepared Flat sketch, Specifications sheet and Product shoot
Ensemble for summer made using marigold petal eco-printed on 100% Bamboo

and fabric was allowed to semi-dry which took 3 hrs. The semidried mordanted fabric is then laid on a flat surface and petals are placed by random lay.

4.3 Preparing the printing material for ecoprinting

Marigold flowers offered to deity after worship is thrown away. This was collected from the temples to be used for the study and weighed approximately 0.5 kg. Here the petals can be placed randomly, as sandwich, or in patterns. For the study, pattern placements were used.

4.4 Process of printing

After placements, a plastic wrap or cloth is used to hold the elements in place, and then rolled up tightly, which is later secured with a string to hold the shape. The fabric bundle was kept in a steamer basket and steamed for 1-2 hours to extract the dye from the marigold petal to fabric. In some cases, boiling is tried, where the fabric bundle is kept in a pot filled with enough water to submerge it, boiled and simmered for 1-2 hours.

4.5 Cooling and Unwrapping:

It is done after steaming, where the bundle is allowed to cool. The unwrap of fabric is done, and marigold petals are carefully removed (Fig.6).

4.6 Finishing:

Rinsing is done using cold water to remove any excess dye or plant residue. The fabric is gently squeezed to remove excess water, dried in shade. The marigold flower eco-printing process can result in vibrant yellow and orange prints, capturing the essence of the marigold plant.

4.7 Designing ensemble for summer: The eco-printed bamboo fabric was used to make a summer frock for clientele in the age group of 15-20 years. The process began by taking measurements, creating the spec sheet, considering the age group, season, personality and economical status. The fit, wash and wear parameters were reported to be good and acceptable for the client.

5. Conclusion

Bamboo is often touted as a sustainable and eco-friendly fabric due to its rapid growth and minimal need for pesticides or fertilizers. Understanding the progress of the selected textiles in the market, bamboo was selected for the study and eco-printing was done to celebrate the natural world on a wearer. The fabric designed was extremely comfortable with no color bleeding, after the post mordanted treatment with alum and fixing of the print with hot steaming after a week. The ensemble is expected to have less carbon footprint than conventional textiles and perform better than them.

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Legacy and Luxury of Indian Cotton Textile Industry: From the lens of Indian Knowledge System

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Abstract

India, historically known as 'Bharat,' had a rich legacy in cotton textile production, influencing global markets since ancient times (Indus-Sarasvati Civilization). The traditional Indian chintz, calico, and muslin were especially famous, which helped Bharat establish a strong presence in the global textile market. The fine quality of Indian cotton and the mastery of craftsmen in creating intricate designs were unparalleled. The objective of this study is to explore the unique knowledge system that underpins the Indian cotton textile industry, encompassing traditional techniques, indigenous practices, and the intergenerational transfer of knowledge. The research methodology employed in this secondary study is literature survey. The findings of this research highlight the multifaceted nature of the Indian knowledge system (IKS) in the cotton textile industry. It explores the intricate techniques of spinning, weaving, dyeing, and printing that have been passed down through generations. These techniques encompass the utilization of traditional tools, such as the spinning wheel and handloom, and the employment of natural dyes derived from plants and minerals.

Keywords: *British colonialism, Chintzes and Calicos, Cotton textile industry, Indian knowledge system, Textile heritage*

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1. Ancient India and legacy of cotton textile

Ancient India demonstrated an exemplary prowess in the production and export of cotton textiles, dating back to the Indus Valley Civilization (2600-1900 BCE), when cotton was first spun and woven into cloth. Archaeological excavations at Indus-Sarasvati Civilization, one of the significant city sites of this civilization, revealed fragments of cotton cloth and traces of cotton cultivation, signalling the advanced level of textile manufacturing during this era. Furthermore, in the ancient Maurya period (322-185 BCE), the sector was so organized that cotton textiles were used as a medium of exchange in barter. In the ancient text of Arthasastra, as translated [1] [2], it is noted that those artisans who crafted silk, wool, and cotton textiles were often bestowed with gratifying presents such as aromatic fragrances and floral garlands as tokens of encouragement. Different regions developed distinct weaving techniques and designs, such as the intricate ikat or tie-dye method from Gujarat and the highly skilled Jamdani weave from Bengal. During the classical age of the Gupta Empire (320-550 CE), Indian cotton textiles gained international acclaim. Hence, this rich legacy in cotton textile production placed ancient India at the forefront of technological, economic, and cultural exchanges.

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This study aims to investigate the distinctive knowledge system supporting the Indian textile sector, which includes conventional methods, cultural practices, and the transmission of knowledge from one generation to the next. Furthermore, it seeks to understand the rich allure and distinctiveness of cotton that has been prevalent since antiquity in different parts of the world. The specific techniques and strategies intrinsic to the Indian Knowledge System that have facilitated the survival, evolution, growth and resilience of the cotton textile industry has also been analyzed. It is also inclined to assess the impact and continued relevance of the IKS in the contemporary cotton textile industry, with a focus on production, quality control, and global competitiveness. Historic texts have documented the widespread use of Indian muslin, a luxurious fabric once used to wrap Egyptian mummies [3]. The Overseas Historical Archives in Lisbon noted in their official records of 1794 that from the 1780s, Zuartes became the most sought-after fabric. This preference was so pronounced that Vashambadzi would not accept any other type of clothing. During the time of the Rozvi Empire, royal monarchs were presented with top-quality Gujarati clothing and fabrics during their coronation ceremonies [4]. These high-quality textiles were also gifted to the Mhondoro, the spirit medium of Mutapa. The state head consistently recognized Zimbabwe with these exquisite textiles. The fabric types such as Canequims, Sofala, Samateres, Cutonias (a blend of silk and cotton with a striped pattern), Capotins, and Ardians were integral to mercantile trade. The Doutins and Capotins were considered luxury goods, favoured by the elite class [5].

Towards the end of the 18th century, in Delagoa Bay, the demand for Gujarati textiles saw a significant increase, coinciding with economic growth.

2. Luxury status of cotton consumers in ancient times

In ancient times, cotton fabric wasn't just a common material but a symbol of luxury and wealth. Originating from the skilled artisans of the Indus Valley, cotton was admired for its lightness and quality. It wasn't just a piece of cloth but indicated a person's social and economic status. Rulers and nobles showcased their wealth and power by wearing extravagant cotton garments during public and religious events. Cotton's popularity wasn't confined to India; it was a prized item in international markets and even used as a form of currency. For instance, in the 1600s, Indian cotton textiles were bartered for spices from Indonesia as a unit of exchange. From being a symbol of affluence in ancient societies to becoming a global trading commodity, cotton's journey reflects its significant cultural, social, and economic influence throughout history.

3. Methodology

This study uses secondary data, including ancient texts and modern scholarly works, to explore the history of the Indian cotton textile industry. A literature review involved examining journal articles, books, manuscripts, and historical records to gain insights into the industry's ancient state. Archival research provided access to a hub of historical documents, including government reports and economic analyses, with records from the East India Company and British colonial administration being notably informative. These resources have been analyzed to understand the industry's context and evolution, considering the political, social, and economic conditions of each era. The study also includes a comparative analysis, contrasting the state of the textile industry during British rule and ancient times with its current state, offering a detailed view of its transformation over the centuries. The combination of these methods has enabled a thorough exploration and documentation of the Indian cotton textile industry's involved history to its soul.5

4. Ancient texts mentioned about Cotton

Indian textiles, particularly cotton, have been renowned for their superior quality and craftsmanship since ancient times. This recognition is well documented in various ancient texts and historical records, painting a vivid picture of the high esteem held for Indian cotton globally. Starting with local texts, the Arthasastra, a significant treatise on statecraft authored by the ancient scholar Kautilya, sheds light on the importance of textile production, in Mauryan society. These texts also detailed different classes of weavers and the variety of textiles they produced, highlighting the diversity and complexity of India's textile industry. In the classical age of the Gupta Empire, the demand for Indian textiles, including cotton, reached far beyond its borders. The Roman historian Pliny the Elder, in his work 'Natural History', dedicated passages to the textiles from India. He called Indian cotton 'woven winds' due to their lightness and fine quality, an epitome to the excellence of Indian weavers.

Furthermore, the ancient maritime trading manual 'Periplus of the Erythraean Sea' from the 1st century CE, documents the trade of fine muslin and cotton from the ports of the Ganges delta in modern-day Bangladesh to markets across the Red Sea, Egypt, and the eastern Mediterranean. This text underscores the significant demand for Indian cotton textiles in the international markets, a clear indication of their high quality. In Arab literature too, Indian textiles received high praise. The 10th-century Arab merchant Sulaiman described Indian cotton as 'a remarkable product that resembles the fluff of the reed, more delicate than the petals of a rose'. Arab traders played a critical role in disseminating Indian textiles throughout the Middle East and North Africa.

The travelogues of Marco Polo, the 13th-century Venetian explorer, bear further testimony to the grandeur of Indian textiles. He described the Indian city of Quilon, now Kollam, as 'one of the best cities in the world for trading', where merchants traded precious spices, ivory, and 'cloths of cotton, finely woven and of different colours'. Even Chinese Buddhist records from the Tang Dynasty mention the prestigious cotton textiles of India, which were often presented as tribute to the Chinese court. These textiles were highly cherished, and it is said that Empress Wu Ze Tian had a particular fondness for them. These accounts, spanning multiple cultures and centuries, illustrate a consistent admiration for Indian cotton and textiles. The fact that these descriptions endure in various texts, despite the passage of time and changing historical contexts, is a tribute to the skills of Indian artisans and the enduring appeal of their creations. It serves as an affirmation of the integral role Indian textiles have played in shaping global trade, cultural interactions, and historical narratives.

5. Unique Cotton Production Technology in Ancient Times: An In-Depth Exploration

The production of cotton textiles in ancient times was a multi-faceted process that combined advanced technology, skilled craftsmanship, and deep cultural traditions. It was an intricate art form, nurtured and perfected over centuries. The unique technology and techniques were used in cotton production in ancient times. The roots of cotton cultivation and production go back to the Indus Valley Civilization, where archaeological findings have suggested the cultivation of cotton as early as 2600 BCE. The ancient people of the Indus Valley not only cultivated cotton but developed tools and techniques for ginning (separating cotton fibres from their seeds), spinning (turning the fibres into thread), and weaving (turning the thread into fabric).

Ginning was likely carried out using simple handheld rollers, a technique still used in some rural parts of India. For spinning, they developed the spindle whorl, a device that increases the efficiency of the spinning process by maintaining the motion of the spindle. Clay models of such

devices have been found in Harappan sites. Weaving technology varied across different regions and eras. The backstrap loom, pit loom, and frame loom were among the commonly used looms in ancient India. The complexity of the loom depended on the intricacy of the patterns and the skills of the weavers. Some regions developed specific techniques and patterns, such as tie-dyeing in Gujarat or Jamdani in Bengal, which further enhanced the appeal of the cotton textiles. Furthermore, the ancient Indians mastered the art of dyeing. Natural dyes were extracted from various plants, flowers, bark, roots, and even insects. Indigo, a blue dye, was among the most prevalent, with India being one of the largest producers in ancient times.

The knowledge and skills for cotton production were often passed down through generations. This generational knowledge transfer ensured the survival and adaptation of these techniques, helping maintain the high quality and variety of cotton textiles produced in ancient India. Ancient Indian cotton production was a confluence of art and science. It was a culmination of keen observation of nature, technical ingenuity, and aesthetic sensibility. The mastery of the cotton production process led to a proliferation of trade, wealth, and cultural exchange. Moreover, the durable and eco-friendly nature of these practices have valuable lessons for our contemporary world, reminding us of the importance of sustainable and mindful production.

6. Community Cotton Connect

Local communities have always played a pivotal role in producing handloom cotton fabric sustainably and organically. They have deep-rooted knowledge of eco-friendly practices and traditional techniques, which prioritize environmental stewardship. These communities cultivate organic cotton without harmful chemicals, preserving soil health and biodiversity. Handloom weaving, a low-energy process, further contributes to sustainability. Additionally, local artisans often employ water-efficient methods, reducing wastage and promoting responsible water usage.

Ethical labour practices are prevalent, ensuring fair wages and safe working conditions. Through their collective efforts, these communities foster a sustainable and organic approach to handloom cotton production, preserving cultural heritage while supporting a greener and more socially responsible textile industry. For instances, the Bagru fabric undergoes a treatment process involving Fuller's earth (multani mitti) and turmeric (haldi). It is then hand-stamped with intricately carved wooden blocks and dyed using natural earth-toned dyes.

The colour dyeing plays a crucial role in textile production in the Indian subcontinent. Traditional methods involve extracting natural dyes from organic and mineral sources such as plants and the earth, which are then applied to yarn or fabric. Dyeing techniques vary across different regions.

Table 1: Community crafting the unique Textiles/Fabrics/Designs

Textile / Fabric / Design	Name of Community	State
Khadi	Khatri	Gujarat
Jamdani	Weavers' from Nadia district and Bardhaman district	Bengal (Present day West Bengal and Bangladesh)
Bandhani & Ajrakh	Khatri	Gujarat, Rajasthan
Chanderi	Weaver's community	Madhya Pradesh
Sambalpuri Ikat	Bhulia community	Odisha
Pochampally Ikat	Padmasali community	Telangana
Kanchipuram Silk	Kaikolar community	Tamil Nadu
Phulkari	Jat Sikh community	Punjab
Dabu	Chhipa community	Rajasthan
Kalamkari	Chitragars community	Andhra Pradesh, Telangana
Patola	Salvi community	Gujarat

Table 2: Colours with the respective Natural Dyes/Source Ingredient of the Colour and the Tree, Plant/Insect for extraction

Name of the Colour	Natural Dyes / Source Ingredient of the Colour	Extracted from Which Tree, Plant, or Insect
Indigo	Indigotin (True Indigo)	Indigofera tinctoria (Indigo) plant
Madder Red	Alizarin (Madder Root)	Rubia tinctorum (Madder) plant
Reds and pinks	Camellia sinensis	Chay-root
Yellow	Curcumin (Turmeric)	Curcuma longa (Turmeric) plant
Black	Iron salts and tannins (Catechu/Black Cutch)	Acacia catechu (Catechu or Cutch) tree
Orange	Lawsone (Henna)	Lawsonia inermis (Henna) plant
Red	Carminic acid (Cochineal)	Extracted from cochineal insect
Green	Chlorophyll (Leaf Green)	Extracted from various green leaves
Brown	Catechol (Cutch)	Acacia catechu (Catechu or Cutch) tree
Violet	Anthocyanin (Plant Violet)	Berries, flowers, and leaves of various plants
Beige	Tannin (Oak Tannin)	Extracted from various trees and shrubs, particularly oak

7. Virtuosity of Bharatiya Fabric as depicted in Kautilya's Arthashastra, Jainism, and Buddhist Literature

The history of Bharatiya fabric, particularly cotton, is steeped in antiquity and its brilliance, technique, and virtuosity find special mention in several ancient texts, including Kautilya's Arthashastra, Jain, and Buddhist scriptures. Kautilya's Arthashastra, written by the ancient scholar and advisor Kautilya (also known as Chanakya) in the 4th Century BCE, offers profound insights into the societal, economic, and political life during the Mauryan Empire. Among its diverse subjects, it encompasses details about the textile industry, highlighting its relevance in the economy and society of the time. The Arthashastra describes various types of textiles, the methods of their production, and the structure of the textile industry, revealing a highly organized and developed sector. Further, the treatise also underscores the professional status of textile workers and artisans, mentioning the rewards and incentives provided to them, thus highlighting the significant value placed on their skills and contributions.

Meanwhile, Jainism, as preached by Lord Mahavira, is another profound source of information about the contemporary textile industry. Jain texts, such as the Kalpasutras, (different types of fabrics like 'kappasi kadusam' and 'kappasikasuttam,') indicating the central role of cotton ('kappasi') in the textile industry. Jains, known for their strict adherence to non-violence, also promoted the use of plant-based fabrics like cotton, further popularizing it. Buddhist literature too is replete with references to the textile industry of the time. Terms like 'khoman', 'kosseyam', 'kappasikam', 'tantuvaya', 'tantaka', and 'tantavitatatthanam', 'tantabhanda', referring to various types of fabrics and aspects of the textile industry, recur in Buddhist Jataka tales and Vinaya Pitaka. 'Tantu' (thread), is often used in the context of weavers and weaving. The use of the term 'kappasikam' once again points to the importance of cotton. The mention of 'tantuvaya' (weaver) and 'tantabhanda' (a load of threads) alludes to the socio-economic importance of the weaving profession and the widespread trade in textiles. What these texts collectively reveal is the virtuosity of Bharatiya fabric. The technical sophistication required to produce such a wide variety of textiles, the cultural importance ascribed to them, the economic value they held, and the role they played in societal, religious, and spiritual discourse - all point towards a rich, thriving, and respected tradition. Moreover, these texts suggest a society where art and craft were integral to life, and where the craftspeople were accorded a place of honor.

These ancient scriptures - Kautilya's Arthashastra, Jain, and Buddhist texts, while being spiritual, philosophical, and political guides, also serve as a historical record, providing valuable insights into the craft traditions of the time. The admiration for Bharatiya fabric they express is an authentication to the high degree of skill, creativity, and knowledge possessed by the artisans of ancient India. Their works, crafted with immense precision and care, reflect a deep understanding of materials, techniques, and aesthetics, passed down through generations, creating an enduring legacy that continues to inspire and influence even today. Through these ancient texts, we understand that Bharatiya fabric, particularly cotton, was not just a material product but an integral part of the cultural, spiritual, and economic fabric of the society.

8. Indian Cotton clothed the world in Ancient Times

The historical narrative of Indian cotton and its profound influence on global trade provides a glimpse into a network of trade routes, and the exemplary craftsmanship of Indian artisans. Indian cotton, since its advent, has been a highly iconic item, forming the backbone of India's exports and fostering economic ties with numerous countries. Dating back to the Harappan civilization (2600 BCE), India began its journey as a pioneer in cotton cultivation and production. The knowledge and mastery of spinning and weaving cotton into fine fabrics gave birth to a robust textile industry, creating commodities that were greatly sought after both locally and internationally.

The sophisticated maritime trade networks of the ancient world facilitated the spread of Indian cotton far and wide. Archaeological and literary sources suggest that cotton textiles were among the significant commodities traded between ancient India and the civilizations of the Middle East, Egypt, and Rome. The Greco-Roman world developed a fascination for Indian cotton, with texts like the 'Periplus of the Erythraean Sea' specifically mentioning Indian cotton textiles among the imports into Roman territories. The high demand for Indian cotton in Rome was such that Pliny lamented the drain of Roman gold to India in exchange for its luxury textiles. This shows the significant role Indian cotton played in boosting India's exports and establishing its reputation as a hub of high-quality textile production. Indian cotton also made its way into Southeast Asia, significantly influencing the textile traditions of the region. Archaeological findings of Indian cotton textiles in countries like Indonesia, Philippines, and Thailand bear testimony to this exchange. Ancient Chinese records and Buddhist texts too make several mentions of Indian cotton, with the cloth often being presented as tribute to the Chinese imperial court.

The Islamic conquests of the 7th and 8th centuries further extended the reach of Indian cotton. The Arabs, who controlled the lucrative spice trade, also became conduits for Indian textiles, including cotton, to the Middle East and North Africa. Arab merchants and travellers, like Al-Masudi and Sulaiman, mentioned the quality and popularity of Indian textiles in their accounts, thus promoting the global appeal of Indian cotton. The presence of Indian cotton in Africa can be traced back to the Swahili coast's trading cities, which acted as a commercial bridge between India and Africa. Archaeological excavations have revealed fragments

of Indian textiles, suggesting a vibrant Indian Ocean trade. Indian cotton textiles were not just trade items but also markers of social status among the Swahili elites.

Indian cotton's widespread appeal lay in its quality, diversity of designs, and the high level of craftsmanship involved in its production. Different regions of India developed unique weaving and dyeing techniques, contributing to the diversity of the textiles. Indian cotton, yearned for its quality and aesthetic appeal, fostered economic relationships with numerous countries, boosting India's exports, and placing it firmly in the ancient global trade network. Its impact continues to resonate, as India remains a significant player in the global cotton industry today.

9. Decline of the Indian Textile Industry: A Historical Perspective

Traditional Indian textile methods include hand spinning, where cotton fibers are pulled and twisted using spindles like the "Charkha" and "Takli," to create yarn. This yarn is then woven on different types of handlooms, like pit, frame, and "khadi" looms, to make fabrics with intricate designs. Natural dyes from plants, minerals, and insects color these fabrics. Techniques like block printing and screen printing add beautiful patterns. India's textile styles are diverse, thanks to the country's rich cultural roots. Even as machines have modernized the industry, many artisans still practice ancient crafting methods. Efforts from the government and organizations are in place to preserve these traditional skills, providing training and support to artisans.

However, the golden age of Indian textiles faced a decline due to political unrest and colonial rule. The British East India Company initially fueled the boom of Indian textiles but later contributed to its downfall with the introduction of the Calico Acts. These acts restricted the import of Indian textiles to England to protect the local industry. The British Industrial Revolution further hampered Indian textiles as cheaper, machine-made fabrics flooded the market.

Colonial rule exploited India's textile industry. Raw cotton was shipped to England, and Indian markets were forced to sell low-priced British goods. This, along with high taxes and unfair pricing, led to widespread poverty among Indian artisans and a decline in traditional crafting skills.

Despite these historical setbacks, the legacy of Indian textiles, marked by its magnificent designs and craftsmanship, has prevailed. Today, the sector is a blend of tradition and modernity, with ongoing efforts to revive and sustain the rich textile heritage that has defined India for centuries. Each piece of fabric woven and dyed by skilled hands tells a story of resilience, cultural richness, and the undiminished spirit of Indian artistry. The Indian Cotton Textile industry has faced several challenges throughout history and continues to face some today, as it seeks to grow and sustain itself. Here are some of the key challenges:

1. Colonial Exploitation: The industry suffered under British colonial rule when imported goods were favoured over local produce, leading to the decline of the indigenous cotton industry.

2. Technology Gap: The lack of modern technology and machinery has made it challenging for the industry to compete with global counterparts. This is especially the case with handloom sectors that have not been able to keep pace with advances in textile technology.

3. Infrastructural constraints: The lack of proper infrastructure, including transport facilities, adequate power supply, and other necessary amenities, has consistently posed difficulties.

4. Intellectual Property Issues: Many artisans are unaware of Intellectual Property Rights (IPR), leading to the loss of exclusive rights over traditional and unique designs. This ignorance has left open opportunities for exploitation and counterfeits of designs.

5. Slump Productivity: Low labour productivity and low yield of cotton farms compared to other countries make it difficult for the industry to compete on a global scale.

6. Cost of Raw Materials: The cost of raw materials, especially cotton, has been rising steadily, putting pressure on the profitability of the sector.

7. Competition: Indian cotton textiles face fierce competition both domestically and internationally, from synthetic materials and machine-made textiles respectively.

8. Lack of Marketing and Branding: There is a lack of proper marketing and branding strategies to promote Indian cotton textiles at the global level.

9. Lack of Skilled Labour: While the industry provides employment opportunities to a large number of people, there's a shortage of trained and skilled labour.

10. Environmental Concerns: The cotton industry is also facing increasing pressure to become more sustainable, given the environmental impact of cotton farming and dyeing processes.

Addressing these challenges requires concerted efforts from the government, industry, and the weaver communities to ensure the sustainable growth and preservation of the Indian Cotton Textile industry.

10. Indian Textiles, Patents, and Geographical Indications (GI) Tags: A Confluence of Tradition, Innovation, and Protection

Indian textiles, synonymous with cultural richness, historical legacy, and diverse craftsmanship, have long commanded

global admiration. However, in an era defined by increasing globalization and mass production, preserving these traditional textile practices, and protecting the rights of artisans has become crucial. Herein lie the roles of patents and Geographical Indications (GI) tags, two significant legal tools that aid in safeguarding IPR and maintaining the exclusivity of Indian textiles. Patents, by definition, are exclusive rights granted to an inventor for a novel product or process, providing a temporary monopoly to the patent holder. While patents are generally associated with technological advancements, they play an essential role in the textile industry, particularly regarding innovative machinery, processes, or textile compositions. For instance, inventions enhancing the efficiency of weaving looms, improving dyeing methods, or developing new fibre blends could be patentable. Patents encourage innovation by providing inventors exclusive rights to profit from their inventions, ensuring a return on investment and further research and development.

The textile industry, following agriculture, stands as India's second-largest source of employment. Approximately 45 million people are employed directly within this sector, with an additional 60 million individuals benefiting indirectly through related activities. Do we really have a proportionally similar number of IPRs in Indian Textile sector? This needs to be considered crucially. However, most traditional Indian textile practices are the result of collective community knowledge passed down through generations, making them unsuitable for patent protection, which usually protects individual or corporate inventions. This is where GI tags come into play. A Geographical Indication (GI) is a sign used on products that have a specific geographical origin and possess qualities or a reputation attributable to that origin. GI tags help protect traditional products closely tied to their place of origin. For Indian textiles, GI tags have been instrumental in safeguarding the interests of artisan communities, maintaining the unique identity of different textile styles, and boosting their economic value. By linking a product to its place of origin, GI tags help authenticate and preserve the quality, technique, and heritage associated with it. A classic example is the GI tag granted to Pashmina products from Kashmir. Known for its fine quality and exquisite craftsmanship, authentic Pashmina is made of cashmere wool obtained from a particular breed of goat native to the high altitudes of the Himalayas. The GI tag helps protect this craft from imitations and assures consumers of the product's authenticity. Similarly, the hand-woven Banarasi Sarees, known for their intricate designs and rich use of gold and silver zari, received a GI tag in 2009. The tag not only protects the unique weaving technique and reputation of Banarasi sarees but also supports the livelihood of thousands of weavers in the region. Another example is the Madhubani/Mithila paintings of Bihar, a traditional art form often replicated on textiles, which was granted a GI tag in 2018, protecting the authentic art and its practitioners.

The patents and GI tags are two significant mechanisms that uphold the heritage and stimulate innovation in the Indian textile industry. While patents protect novel inventions and encourage technological advancements, GI tags play a crucial role in preserving traditional textile crafts linked to specific regions. Together, they help maintain the uniqueness of Indian textiles, support the livelihoods of artisans, and contribute towards a more sustainable and equitable textile industry. The challenge remains to effectively implement these protective measures and ensure that the benefits reach the artisans, the true bearers of India's rich textile heritage.

11. Continuity of Ancient Indian Textiles and Production Methods: Tradition in the Modern World

India boasts a rich textile heritage, rooted in traditional practices like hand spinning and handloom weaving. Despite the dominance of machine-made textiles, India's artisanal craftsmanship endures, celebrating age-old techniques. From the delicate muslins of Bengal to the vibrant silks of Kanchipuram and Banaras, each piece encapsulates the meticulous labor and skill of the artisans. Block printing, a technique with origins in the ancient Indus Valley Civilization, and natural dyeing methods are still employed. It is resonating with the global shift towards sustainable fashion. Yet, the competition from mass-produced, cost-effective machine-made textiles threatens these traditional crafts, prompting initiatives to safeguard and revive these timeless arts. Traditional practices such as block printing and natural dyeing contribute to the country's vast textile variety. Techniques like Dabu and Bagru printing, using hand-carved blocks and natural dyes, appreciating India's artistic flavor. Despite the challenges posed by machine production and low compensation for artisans, efforts to uphold these arts are significant. Various initiatives offer platforms for artisans, financial and technical assistance, and aim to educate the public on these crafts' cultural and economic worth.

India's textile legacy is not just a celebration of the past but a mean of sustainable and ethical fashion's future. Governmental and non-governmental bodies have inculcated measures to support and protect these crafts. Initiatives like the Handloom Mark scheme ensure quality and promote Indian handloom globally. The Cluster Development Program and the Geographical Indication Act empower artisans, preserving the unique heritage of traditional textiles and offering defense against unauthorized use. Despite these crafts' labor-intensive nature and the lure of machine-made alternatives, a global and domestic demand surge for handcrafted, sustainable products pushes life into traditional practices. The government, NGOs, and social enterprises are at the forefront, weaving together modern designs with traditional methods, ensuring their relevance on contemporary fashion arena. Each weave and stitch, imbibed with the essence of generations of craftsmanship, epitomizes not just aesthetic grandeur but a profound narrative of cultural richness and sustainable ethos.

In today's context, cotton's omnipresence as a staple fabric aligns with its comfort and durability. However, distinct elements and craftsmanship can elevate it to luxury status. The indigenous processes and skills involved in traditional textile creation are a testament to the artistry and heritage that imbues each piece with unique value. Efforts to uphold these traditions amidst a world dominated by fast fashion underscore the dynamic interplay between preserving historical craftsmanship and navigating modern consumer demands. Each piece of traditionally crafted textile thus embodies a narrative of resilience and cultural richness, offering more than just material value – a piece of history, art, and the enduring spirit of Indian craftsmanship. The following factors contribute to cotton's luxurious appeal for consumers:

1. Superior Quality and Artistry: Luxury cotton often signifies excellent quality and craftsmanship. Renowned brands and designers may prefer high-quality cotton varieties like Egyptian or Supima cotton, known for their plush, strong, and lavish feel. These elite types of cotton, painstakingly grown and boasting longer, finer fibers, result in superior and long-lasting fabrics. Moreover, the artisan skills involved in weaving, finishing, and detailing cotton garments can boost their luxurious appeal.

2. Unique Design and Branding: Luxury cotton garments usually showcase unique, intricate designs, one-of-a-kind patterns, and keen attention to detail. Prestigious fashion brands and designers use their skills and creativity to produce distinctive cotton wear that exudes exclusivity. Brand reputation and image significantly contribute to enhancing the prestige of cotton consumers. Brand-conscious consumers often correlate luxury with certain labels and pursue their cotton products for their perceived quality, reputation, and style.

3. Exclusive Editions and Personalization: The luxury quotient of cotton apparel can be amplified by offering limited edition or exclusive collections. These limited production batches, or partnerships with famous designers or artists, render these items rare and coveted. Customization adds an element of luxury, with tailor-made or bespoke cotton clothing, allowing consumers to select specific fabrics, accents, and details for a unique and exclusive experience.

4. Sustainable and Ethical Measures: Nowadays, the focus on sustainability and ethical practices has significantly influenced the luxury status of cotton consumers. Consumers increasingly opt for brands that endorse eco-friendly cotton cultivation, fair trade, and supply chain transparency. Cotton products derived from organic or sustainably-sourced cotton, manufactured with minimal environmental impact, are seen as luxurious due to their ethical and responsible production processes.

5. Pricing and Scarcity: The cost of cotton garments can also add to their luxury status. Although cotton is generally cheaper than other luxury fabrics like silk or cashmere, specific high-end cotton products can carry a higher price tag. Factors like limited supply, exclusivity, and brand positioning can affect the perceived value and desirability of cotton items, marking them as a luxury buy for consumers.

It's worth mentioning that luxury perceptions can vary between individuals, and different cultural contexts may shape what is deemed luxurious. Various factors such as quality, craftsmanship, design, branding, exclusivity or customization, sustainability, and pricing can influence the luxury status of cotton consumers in contemporary times. In essence, the journey of ancient Indian textiles and their production methods is one of remarkable endurance and adaptability. As we navigate through the 21st century, it is crucial that we continue to honour and uphold this rich textile legacy, supporting the skilled artisans and sustainable practices at its heart. After all, these traditional crafts are more than just fabric and thread - they are the narratives of India's cultural heritage, artistic prowess, and timeless innovation.

12. Recent Government Initiatives to Safeguard the Ancient Textile Industry in India

India's textile tradition, an amalgamation of a rich cultural heritage and skilled craftsmanship, has been a vital part of the country's socio-economic fabric for centuries. Recognizing this, the Indian government has initiated a few recent measures to preserve, promote and provide support to this vibrant sector. These initiatives, often aimed at boosting the productivity and global appeal of Indian textiles, provide financial, technical, and marketing aid to artisans. One such initiative is the National Handloom Development Programme (NHDP). Launched by the Ministry of Textiles, it seeks to develop and promote the Indian handloom sector by providing financial assistance for new looms and accessories, capacity building, and the creation of new design inputs. The program also facilitates better access to raw materials and markets, empowering weavers and improving the competitiveness of the handloom sector. The Handloom Mark Scheme, another significant initiative, has been introduced to assure consumers about the genuineness of hand-woven products. By providing a distinct identity to handloom products, it promotes the branding of Indian handloom products both within the country and for export. The government, recognizing the importance of geographical indications (GI) in protecting and promoting unique Indian textiles, has been proactive in registering several traditional textile forms under the Geographical Indications of Goods (Registration and Protection) Act 1999. These include Pochampally Ikat, Banarasi Sarees, Chanderi Fabric, and Muga Silk of Assam, among others. This not only safeguards these textile traditions from unauthorized use but

also enhances their market appeal by authenticating their geographical origin.

Under the umbrella of Make in India initiative, the government has also taken steps to attract foreign investments in the textile sector, aimed at technological upgradation and skill enhancement. This initiative aims to make India a global hub for textile manufacturing and design, thereby creating more opportunities for traditional textile artisans. The Ministry of Textiles also launched the Samarth Scheme for capacity building in the textile sector. This scheme focuses on skill development, providing training to many individuals in various segments of the textile sector, including traditional textiles and handicrafts. The Cluster Development Program is another key initiative, aiming to uplift artisan communities by providing them with essential infrastructure, new technologies, and training in improved techniques. By grouping artisans into clusters, the program facilitates easier distribution of resources and a better exchange of skills and knowledge. Moreover, the government has been increasingly leveraging digital platforms to bring Indian textiles closer to global consumers. The India Handloom Brand is an initiative to endorse the quality of handloom products in terms of raw material, processing, and product compliance to specifications. Through an online portal, it provides a platform for weavers to showcase their products to a broader audience. These initiatives reflect the Indian government's dedicated efforts to uphold the country's rich textile legacy. By integrating tradition with technology and local skill with global market access, these programs aim to ensure a vibrant and sustainable future for the Indian textile industry.

13. Findings

Thomas Ellison and Robert Robson, in "The Cotton Trade of Great Britain" and "The Cotton Industry in Britain," outlined the colonial oppression that transfigured India's prestigious textile industry. The East India Company's strategic moves downgraded a nation, once a significant exporter of cotton textiles, into a subjugated importer, pushing local farmers into a cycle of poverty and debt, and disrupting an economy once vibrant with indigenous craftsmanship. The British enforced rigid pricing and adopted manipulative technologies, establishing an era of unfair competition, biased taxation, and prejudiced duties. The Indian textile sector, a mosaic of diverse traditional fabrics and artistic expressions, faces the challenge of ignorance towards Intellectual Property Rights (IPRs) among local artisans. The potential for economic and cultural elevation lies latent, awaiting the recognition and patenting of unique designs crafted by tribal and regional artisans. However, the grandeur of handmade textiles is overshadowed by the industrial prowess of global machine-made fabric producers. This scenario underscores the dire need for a revival, where IKS is not just preserved but revered. The artistry of spinning, weaving, and dyeing, enriched by generations of cultural transmission, is evident to India's heritage. By illuminating these practices, we advocate for a paradigm where tradition is not just a reflection of historical grandeur but a living entity - evolving yet rooted in the timeless legacies of craftsmanship.

14. Relevance to Contemporary Times

The conventional mode of designing and weaving Indian cotton fabric holds significant relevance in contemporary times for a variety of reasons. Firstly, with the implementation of the National Education Policy (NEP), integrating the IKS in the cotton textile industry's curriculum from an early age can instil a sense of cultural pride and appreciation for traditional practices among students. This knowledge transfer will help preserve and promote India's rich heritage. Secondly, empowering the youth with skillsets in this traditional craft enhances their self-employability and fosters the spirit of "Aatmanirbhar Bharat". By nurturing a generation of skilled artisans, the country can reduce unemployment and boost its socio-economic growth. Thirdly, the global image of India can be significantly enhanced by conserving and promoting its cultural heritage through handloom cotton fabric. As sustainable and eco-friendly products gain recognition worldwide, India's reputation as a responsible and traditional textile producer will flourish. Moreover, the conventional mode of designing and dyeing fabrics offers sustainable solutions, contributing to the zero-waste industry. By utilizing natural dyes and eco-friendly techniques, this approach aligns with contemporary demands for environmentally conscious practices, attracting environmentally conscious consumers. Lastly, the current trend of de-dollarization presents an opportunity for India's exclusive textile exports. By focusing on creating premium products that demand payment in Indian Rupees, the nation can reduce its dependence on foreign currency and strengthen its economic independence. In conclusion, embracing the conventional mode of designing and weaving Indian cotton fabric aligns with contemporary needs and aspirations. It not only nurtures cultural identity but also contributes to skill development, sustainability, and economic autonomy. By preserving and promoting this traditional art form, India can carve a unique niche in the global textile market while staying true to its rich heritage.

15. Conclusion and Policy recommendations

Embracing traditional Indian cotton fabric design and weaving promotes cultural preservation, sustainable practices, and economic growth. Integrating vocational training and sustainability measures, like organic dyes and energy efficiency, equips the youth with skills and minimizes environmental impact, while protecting intellectual property rights. Enhancing global market access through e-commerce and ensuring fair trade and compensation for artisans fosters equity and economic empowerment. To put it simply:

1. Government and educational institutions should collaborate to introduce certification programs and vocational training focused on handloom weaving and dyeing techniques.

2. Encouraging research and investments in sustainable practices, such as organic dyes and energy-efficient production methods, will help in achieving a greener and eco-friendly textile industry.

3. Stringent measures must be put in place to protect the IPRs of traditional designs and techniques, safeguarding the artisans' heritage.

4. Government agencies and non-profit organizations should create awareness campaigns to inform artisans about available financial support and grants to support their craft.

5. Promote market development by collaborating with industry experts to create e-commerce platforms that connect artisans directly with global consumers.

6. Establish fair trade policies to ensure artisans receive fair compensation and social security benefits, guaranteeing their well-being and improving their livelihoods.

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Mechanical Properties of Natural Fibre-based Woven Fabric-reinforced Thermoplastic and Thermoset Composites

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Abstract

TThis study evaluates the mechanical properties of jute and flax woven fabric-reinforced composites in both thermoplastic and thermoset matrices. This investigation examines the impact of natural fibres (jute and flax) as well as the influence of matrix materials (thermoplastic and thermoset), on the mechanical behaviour of advanced composites. A comprehensive suite of mechanical tests, including tensile, flexural, and impact assessments, were conducted to evaluate critical properties such as strength, stiffness, toughness, and durability. The results revealed that under quasi-static loads such as tensile and flexural tests, thermoset woven composites exhibited outstanding load bearing performance, while thermoplastic composites showed exceptional resistance to dynamic impact forces

Keywords: *Co-wrapped yarn, mechanical properties, natural fibers, thermoplastic, thermoset*

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1. Introduction

Recent research has been focused on developing eco-friendly and sustainable natural fiber-reinforced polymer composites (NFPCs) as alternatives to synthetic ones. Natural fibers, derived from renewable resources such as flax, jute, hemp, and kenaf, have gained prominence as reinforcing elements due to their inherent advantages such as low density, biodegradability, and renewability [1-3]. When interwoven into matrices, they contribute to the formation of composites that exhibit remarkable strength-to-weight ratios and enhanced sustainability profiles. The matrix choice, whether thermoplastic or thermoset, introduces a crucial dimension to the performance and processing characteristics of these composites [4-5].

The characteristics of composites are primarily influenced by three key elements: the type of reinforcement, the polymer form, and the interface between them. Polymers are divided into two groups: thermoplastics and thermosets. Thermoplastics are preferred when ductility and toughness are required, as they can be reversibly reshaped with changes in temperature and pressure. However, thermoplastics generally exhibit lower creep resistance at elevated temperatures compared to thermosets. Common thermoplastic matrix materials used in polymer composites include polypropylene, nylon, polycarbonate, and polyethylene. On the other hand, thermosets require a curing process during composite fabrication and cannot be re-melted or reformed after curing. They are characterized by brittleness, dimensional stability, and rigidity. Epoxy, polyester, and polyimides are examples of thermoset materials [6-10].

However, compared to thermoset matrix composites, thermoplastic matrix composites face challenges during the impregnation process due to their higher melt viscosity. This difficulty in impregnating the textile reinforcement structure with the thermoplastic matrix can lead to insufficient composite properties [11–13]. To address this issue and improve the impregnation process prior to consolidation, hybrid yarns can be employed in the production of the preforms. The use of hybrid yarns allows for better control and distribution of the thermoplastic matrix within the reinforcement structure, resulting in improved composite properties[14-16].

Despite significant progress in the development of woven-based thermoplastic and thermoset composites using diverse fiber types, there is a need for a thorough characterization of these composites, focusing specifically on the utilization of various natural fibers. Furthermore, the literature on fabric preforms made from cowrap spinning yarns is currently limited. Therefore, there is a crucial need in understanding the implications of hybrid yarns on the performance of thermoplastic composites reinforced with natural fibers that requires further exploration.

In this study, the mechanical behaviour of thermoset and thermoplastic resins is investigated with a specific focus on evaluating the influence of various natural fibers, such as jute and flax. To facilitate this investigation, cowrap spinning yarns were manufactured using a hollow spindle spinning machine, wherein polypropylene (PP) filament enveloped jute and flax rovings. The PP filaments functioned as carriers

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for the natural fibers throughout the processing stages and eventually transformed into the polymer matrix in the final composites. This approach not only alleviated challenges related to impregnation but also safeguarded the reinforcing natural fibers from potential damage during the processing steps.

2.Materials and Methods

2.1 Materials

The natural fiber yarns utilized in this research were Jute, sourced from Gloster Ltd., Kolkata, and Flax, obtained from Jaya Shree Textiles, Rishra. Both Jute and Flax yarns had a linear density of 600 tex. A comprehensive breakdown of the properties of various reinforcement fibers is presented in Table 1. For crafting hybrid reinforcements and developing hybrid dry-woven fabrics, the thermoplastic matrix fiber employed was 840-denier Polypropylene (PP) multifilament, procured from Fitpack Textile Mills Ltd. The thermoset resin selected for the study was Lapox ARL-125 epoxy, paired with AH-367 curing agent as the hardener.

Table 1. Mechanical properties of reinforcement fibers

Fibre	Linear Density [Tex]	Density [g/cm3]	Diameter [µm]	Tensile Strength (MPa)	Tensile Modulus (GPa)	Elongation at break (%)
Flax	600	1.4-1.5	40-600	250-700	40-70	2.7-3.3
Jute	600	1.3-1.5	25-200	200-600	10-30	2-3

2.2 Methods

2.2.1 Preparation of the Reinforcement/PP Hybrid Yarns

Hybrid yarns combining Reinforcement and PP were generated through the co-wrapping technique employing a hollow spindle spinning machine. The Reinforcement roving, having a pre-determined linear density, underwent processing through a roving condenser and inactive drafting rollers. Simultaneously, the PP filament, drawn from a package mounted on the hollow spindle, traversed through the spindle, enveloping the reinforcement roving at its core. The high rotational speed of the spindle induced pseudo-twist in both the reinforcement roving and PP filament. As illustrated in Figure 1, after passing through the twisting hook, the pseudo-twist in the reinforcement roving was eliminated, while the twist in the PP filament wraps was retained. A meticulous execution of this process ensured a consistent fiber volume fraction of 50% ± 5%. The resulting hybrid yarns, termed co-wrapped yarns (CWYs), were created by wrapping polypropylene (PP) filament around flax and jute rovings. These CWYs, characterized by shortened impregnation periods and reduced resin flow distances during processing, exhibit potential for the cost-effective production of intricately shaped composite parts.

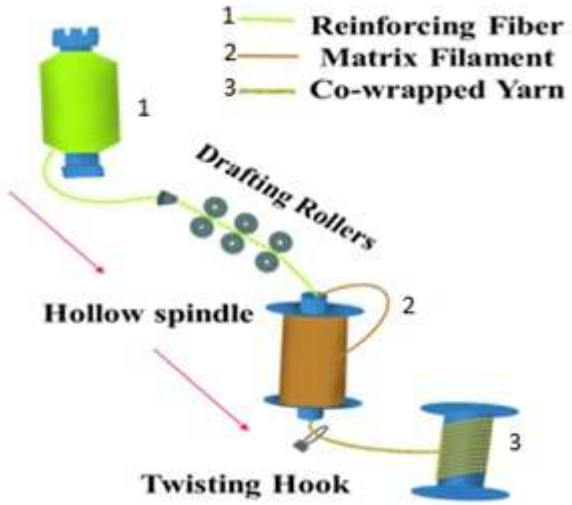

Figure 1. Manufacturing Process of Hybrid Reinforcement by Wrap Spinning

2.2.2 Preparation of two-dimensional (2D) woven fabrics

2D woven fabrics with plain weave design were developed on the customized rapier weaving loom at Focus Incubation Centre at Indian Institute of Technology Delhi. Ends per inch and picks per inch were calculated in a way so that constant areal density can be achieved. Subsequently, four layers of 2D woven fabrics were sequentially arranged, following a 0-900 sequence.

2.2.3 Manufacturing of thermoplastic composites

The thermoplastic composites were fabricated through the compression moulding technique. Utilizing their corresponding 2D woven performs of flax and jutedesignated as TPF2DFRC and TPJ2DFRC respectively. The 2D woven preform was positioned within the mould, enveloped with Teflon sheets at both the top and bottom, and underwent processing in a compression moulding machine. The processing conditions involved subjecting the composites to a temperature of 185°C and 10 MPa pressure for duration of 10 minutes full press heating and 10 minutes cooling, as shown in figure 2. The maintained thickness for all thermoplastic composites ranged between 2.5 to 3 mm.

Figure 2. Manufacturing Process of 2D woven fabric-based thermoplastic composites

The creation of 2D woven fabric-reinforced composites (2DFRCs) utilizing 2D weaving preforms of flax and jute, named as TSF2DFRC and TSJ2DFRC respectively, was achieved through vacuum-assisted resin transfer molding (VARTM). The optimal resin-to-hardener ratio, established at 100:32, was determined through the optimization of mechanical attributes using the same resin material. To eliminate any air bubbles, the resin-hardener mixture underwent de-airing in a desiccator through two two-minute cycles before impregnation. The VARTM process for producing 2DFRCs is illustrated in Figure 3. Subsequently, the samples underwent vacuum curing for 24 hours at 25°C post resin infusion to attain a high level of handling strength.

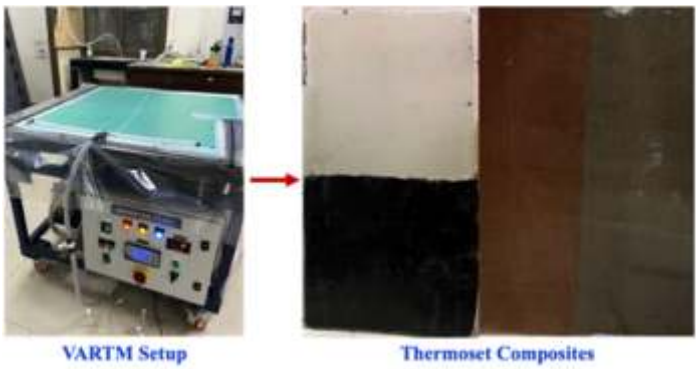

Figure 3: Manufacturing Process of 2D woven fabric-based thermoset composites

2.2.5 Characterization of mechanical properties of 2D woven structural composites

2.2.5.1 Tensile test

The tensile testing was carried out using ZwickRoell Z250 UTMin accordance with ASTM D3039 standards. The test speed was maintained at 2 mm/min, with a force shutdown threshold set at 80% of Fmax. The load-cell employed had a capacity of 250 kN, and the sample dimensions were 200 mm x 25 mm. The upper force limit was capped at 100 kN, and gauge length was 100 mm. Gripping attachment was pneumatic in nature.

2.2.5.2 Flexural (3-point bending) test

The flexural testing was carried out using ZwickRoell Z250 UTMin accordance with the ASTM D7264 standards. The test speed was maintained at 2 mm/min, with a force shutdown threshold set at 80% of Fmax. A 25kN load-cell was employed, and the span-to-thickness ratio was 32:1. The upper force limit was restricted to 100 kN, while the specimen width measured 13 mm. Gripping attachment was pneumatic in nature.

2.2.5.3 Edgewise impact test

The edgewise impact test was performed using an Izod Impact (Pendulum type) instrument, following the ASTM D256 standard. The impact velocity was set at 3.5 m/sec, with the pendulum energy and mass measuring 11 Joules and 1.84 kg, respectively. The angle of release was precisely set at 147.96°. Sample dimensions for this test were 64 mm x 12.7 mm, with a notch depth length of 2 mm and a notch angle of 45°.

3. Results and Discussion

3.1 Tensile behavior of thermoplastic and thermoset woven composites

Initially, TPJ2DFRC exhibited a higher tensile modulus in the elastic regime compared to TPF2DFRC, maintaining this superiority until a slight deviation occurred at approximately 2.5% strain. Beyond this point, both curves transitioned into the hardening phase. Beyond this point, both curves transitioned into the hardening phase, with strain continuing to increase at a reduced pace compared to the elastic range, ultimately reaching a maximum of 4.4%. Subsequently, a distinct region emerged, marked by a gradual reduction in hardness as the composite experienced strain failure at 5.4%. Due to its inherently low tensile strength, TPJ2DFRC witnessed fiber fracture shortly after reaching peak stress. In contrast, TPF2DFRC exhibited enhanced performance beyond the elastic regime. The resilience of Flax fiber against longitudinal force sustained a strain of 12.7% at tensile strength, breaking immediately after reaching peak force at 13.22% strain at break.

The thermoset composites demonstrated a lower strain percentage, attributed to their brittle failure nature, in contrast to the thermoplastic composites. Flax fibers exhibited a relatively better load-bearing ability than Jute fibers in this context. This emphasizes the overall superior mechanical performance of thermoset composites in terms of tensile properties. This superior performance can be due to thermoset matrices' specific properties, such as enhanced interphase bonding and stiffness, contributing to improved stress distribution along the longitudinal axis. While thermoset composites' inherent brittleness affects their strain %, paradoxically, it results in a more controllable and efficient load-bearing mechanism.

In comparison, despite their advantages in ease of processing and impact resistance, thermoplastic composites tend to exhibit limitations in terms of longitudinal load-bearing capacity. The polymer chains in thermoplastics allow for greater flexibility, but this can compromise their ability to efficiently transmit and distribute loads in the longitudinal direction, leading to reduced load-bearing performance. Understanding these details is essential for material selection in applications where longitudinal load-bearing capacity is important. For applications requiring longitudinal strength and stability, thermoset composites surpass thermoplastic composites due to their superior mechanical qualities.

When comparing the two natural fibers, it becomes apparent that flax fiber is more suitable for structural applications, primarily because of its superior tensile properties.

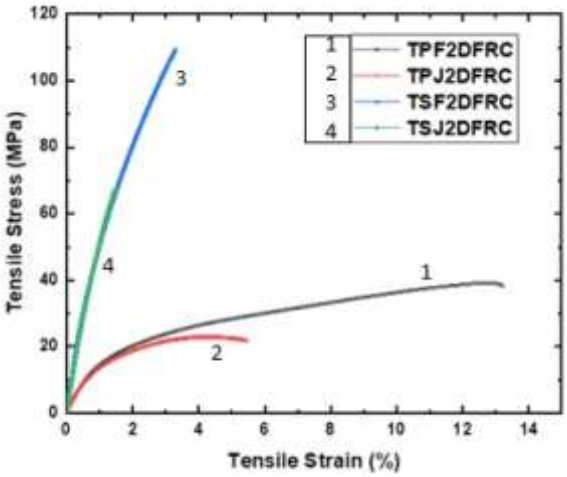

Figure 4: Tensile behavior of thermoplastic and thermoset woven composites

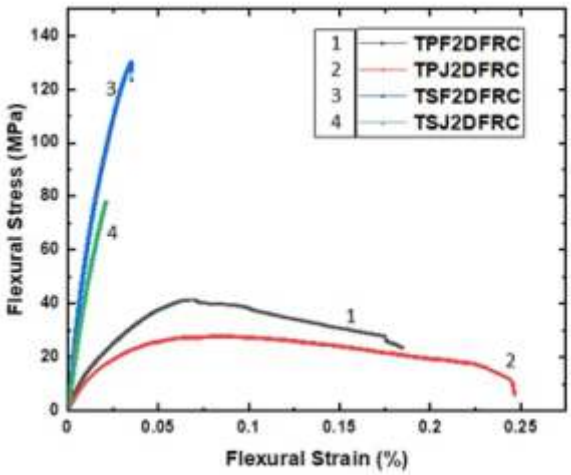

Figure 5: Flexural behavior of thermoplastic and thermoset woven composites

3.2 Flexural behavior of thermoplastic and thermoset woven composites

The Jute-based woven composite demonstrated a superior strain percentage at flexural strength compared to the Flax counterpart. It is worth noting that although the Jute-reinforced thermoplastic composite had lower overall flexural strength, it exhibited a greater strain capacity at maximum bending stress.The findings here emphasize the intricate relationship between fiber type and flexural performance, providing valuable insights into how the material behaves when subjected to bending loads. This knowledge can assist in selecting the most suitable material for specific applications. Flax-based thermoplastic composite (TPF2DFRC) demonstrates the higher Flexural Modulus and Flexural Strength, indicating superior stiffness and strength. On the other hand, Jute-based thermoplastic composite (TPJ2DFRC) exhibits relatively lower values, suggesting a more flexible nature. The Flexure-strain at Break with jute-based composite (TPJ2DFRC) reflects the material's deformation capacity before failure.

Comparing the flexural properties of Flax-based thermoset composite (TSF2DFRC) to Jute (TSJ2DFRC) reinforcements, the thermoset composites showcased superior flexural performance. Thermoset composites, particularly in tension mode, exhibited exceptional flexural properties compared to their thermoplastic counterparts, highlighting their increased ability to withstand heavy loads. The higher stiffness of thermoset composites necessitates greater stress for fracture under flexural loads, contributing to enhanced overall strength and durability. Despite the inherent fragility of the matrix, thermoset composites demonstrated improved flexural properties when compared to thermoplastic alternatives, attributed to the robust interphase between fibers and matrix, as well as the overall stiffness of the material.

3.3 Izod impact behavior of thermoplastic and thermoset woven composites

The observed superior pendulum impact resistance in thermoplastic woven composites can be ascribed to their distinct mechanical behavior, showcasing their ability to deform and absorb energy through plastic deformation. This behavior is inherent to thermoplastics and contrasts with the typically brittle nature of thermoset counterparts. The unique molecular structure of thermoplastics allows them to undergo plastic deformation, enabling precise energy absorption during impact events. Thermoplastics can rearrange their molecules without any permanent chemical changes, facilitating effective energy dissipation.

In contrast, thermoset woven composites are generally more brittle due to their cross-linked and rigid molecular structures. When subjected to impact forces, the possibility of limited plastic deformation increases, potentially leading to catastrophic failure characterized by crack propagation and fragmentations. Flax composites showed better impact resistance than jute counterparts due to its superior tensile properties, which outperform jute yarns.

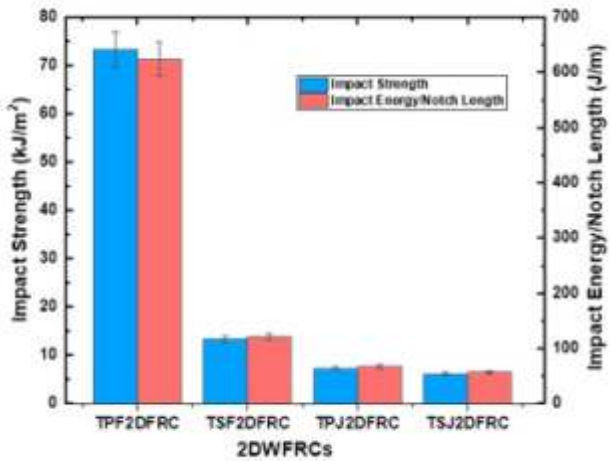

Figure 6: Izod impact behavior of thermoplastic and thermoset woven composites

4. Conclusions

This study sought to examine the relationship between matrix properties and the mechanical performance of natural fiber-reinforced composites. Thermoset composites demonstrated exceptional performance over thermoplastics in low-strain rate (quasi-static) mechanical tests. On the other hand, thermoplastic composites have shown remarkable resilience when it comes to edgewise dynamic impact properties. Flax-based structures demonstrated exceptional mechanical properties compared to jute fibers. These findings contribute valuable insights into the intricate relationship between matrix properties and the overall mechanical performance of natural fiber-reinforced composites.

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TECHNICAL TEXTILE

Some Factors Affecting Geotextiles Seam Strength Using Surface Response Methodology (Case Study)

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Abstract:

In Egypt, the long coastline of north and east Egypt is deeply connected with the culture, life and traditions of the country. Beach conservation, management and development works are effected to aid tourism to a large extent. Nowadays these coasts possess a potential erosion challenge due to increasing and dwindling of sea levels because global warming and land encroachment to the beachside. This study focuses on the study of investigate how various sewing parameters affected seam strength of nonwoven geotextiles which are used in coastal protection and offshore engineering structures in Egypt. In this study, the effects of nonwoven geotextiles sewing parameters namely, sewing yarn count, number of sewing lines and stitch type are studied and have been optimized using three variables Factorial design of Response Surface Methodology except stitch type with only two levels. The seam strength of the prepared samples was determined according to EN ISO 10321 standard technique. It is determined that polyester sewing yarn count of 15x3 and 18x3 tex with 2 or 3 number of sewing lines with 401 stitch type for nonwoven geotextiles seam strength results are the best optimal responses.

Keywords: *Geotextiles, Sewing yarn count. Number of sewing line, Stitch type, Response surface methodology (RSM), Seam strength*

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1. Introduction

Geotextiles are separated into two groups: woven and nonwoven. Any synthetic or natural materials may be used to create geotextiles. Synthetic polymers including polypropylene (PP), polyester (PET), and high density polyethylene (HDPE) make up the majority of synthetic products. It is noted that these polymers have very high resistance to biological and chemical degradation. Generally, glass fibers, polyamides, and polyvinyl chloride (PVC) are used less. Natural materials include cotton, jute, sisal, flax, and other fibers; they should only be used in the short term applications because they degrade quickly [1]. The geotextiles components are continuous filaments or staple fibers joined together to form a planar textile construction. The polymeric staple fibers used to make nonwoven geotextiles are constantly extruded and cut (2 to 6 inches) long. The mass of fibers is next needle punched, heat bonded, or both procedures are used. The mechanical entanglement of the fibers with the use of a series of specialized needles is known as needle punching. Heat bonding is the technique of joining fibers with low melt together using heat and pressure at contact sites to form a nonwoven fabric [2, 3].

Nonwoven geotextile can be used in marine constructions including breakwaters, revetments, and beach protection, among others. In general, geotextile should retain soil while allowing water to flow. The high tensile strength of the geotextile is essential for other coastal applications such soil bank reinforcement [4].

Sewing is used to reduce the cost and time of overlays, while in others it needs to be done as part of the application design. A few inches of geotextile from each piece or sheet are often needed for a stitched seam, as compared to two or three meters for an overlap [5]. Geotextile woven or non-woven is able to be stitched. Seaming adjacent geotextile fabrics also enables for rapid application of geotextile across a broad area, which is especially helpful when soil conditions are poor and/or access is limited, such as when underwater set up is necessary (6). The use of sewn seams in the strong axis direction (crosswise machine direction CMD) is accepted; however, the sewn seam strength zone is lowered to the strength of the geotextile nonwoven fabrics.

YLI Corporation provides factual information regarding sewing yarns and sewing needles appropriate for different types of materials (7). Two crucial elements influence the appropriate sewing needle selection: first, the yarn to be used and second, the fabric to be stitched. In the industry, yarn breakage brought on by a variety of factors, such as the following, can be minimized by using yarn / machine needle charts as guidance.

- Choosing an inappropriate yarn for the job.
- A damaged or the incorrect needle.
- Defects in the yarn.
– Excessive elongation.
- Having excessive tension when sewing.
- Worn machine parts.
- Unbalanced machinery.
- The operator's handling. (8)

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The most popular sewing yarn materials are Kevlar, polyester, polyester, and polypropylene. When sewing stronger geotextiles with cross-machine direction strengths of 52.5 kN/m (300 Ib/in) or more, polyester yarn is typically used. Geotextiles with lower tensile strengths may be seamed using polypropylene yarn. Kevlar yarn is incredibly pricey while being extremely strong. Kevlar yarn hasn't provided much help since the foundation geotextile's cross-machine direction tensile strength, which is much less in comparison to the Kevlar yarn, ultimately determines how strong the seam will be (9).

The act of interlacing sewing yarns in or around a material to create a stitch is called stitch formation. A seam is created when a stitch with a certain shape is used to arrange material layers. There are several international and national standards that categorize different stitch and seam kinds (10 - 11). To guarantee that 100% coverage will be maintained throughout the backfilling process when there are poor subgrade conditions present, geotextile panels are often sewn in the field.

Modern field industrial sewing machines come in a variety of designs and are quite technologically sophisticated mechanically and electronically. Depending on the sort of stitch the machine makes, there are field machines that function with either one yarn or two yarns. Because of their strength and extensibility, chain stitch 101 fig. 1 and chain stitch 401 fig. 2 are frequently used. In these stitches, a single yarn for the needle interloops with itself on the back of the cloth. In chain stitch 401 fig. 2, a needle yarn interloops with a looper yarn.

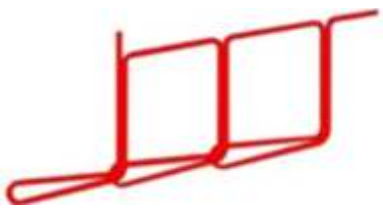


Figure 1 - chain stitch 101

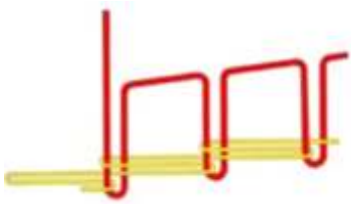


Figure 2 - chain stitch 401

2. Materials & Methods

The major factor in reaching the requisite seam strength is the geotextile's ultimate wide width tensile strength in the cross-machine direction, which is calculated using EN ISO 10319, "Standard Test Method for Geosynthetics — Wide-width tensile test". The use of sewn seams may be permitted in the strong axis direction; however, the strength of the geotextile will be reduced to the strength of the sewn seam. The EN ISO 10321 "Standard Test Method for Geotextiles – Tensile test for joints/Seams by wide width method" is followed for testing the seam strength on a broad specimen. Even though several potential methods for producing extremely high seam strength are now being studied, seam strengths frequently reach 90% or more of the maximum geotextiles wide width tensile strength in the cross-machine direction. The qualities of the geotextile affect the seam strength.

2.1. Geotextiles

A needle punched nonwoven geotextiles is one created from webs of fibers with certain fibers pushed upward or downward by barbed needles. This needling process interlocks fibers and uses the effects of friction to hold the structure together. A binding point is a collection of fibers having varying orientations that are held together by friction forces. The usage of hot melt adhesive fibers (low melt fibers) is one of the most convenient techniques for integrating nonwoven structures. Adhesive fibers are fibers that may form adhesive connections with other fibers due to their melting properties and special effects of hot calendar in finishing process. Nonwoven geotextiles, utilized for coastal erosion control and offshore engineering constructions along the Mediterranean and Red Sea coasts, especially Suez Canal coasts in Egypt were used in this study. Seam strength and its efficiency are an important parameter for geotextiles seam performance. Seam efficiency is the ratio of seam strength to fabric strength. Seam efficiency ≥90 % is more important for coastal erosion control application (according to the instructions of the Egyptian Coastal Protection Authority). Table 1 shows the physical and mechanical properties of this type of geotextiles fabric.

Table 1 - Physical and mechanical properties of nonwoven geotextiles

Test	Test Method	Result	Unit
1- Mass per unit area	*EN ISO 9864*	512	g/m^2
2- Thickness @ *2 kpa*	*EN ISO 9863-1*	3.38	mm
3- Wide width tensile strength	*EN ISO 10319*		kN/m
MD		40.5	
MCD		47.8	
4- Elongation @ max. load	*EN ISO 10319*		%
MD		70	
MCD		65	
5- CBR puncture resistance	*EN ISO 12236*	6.12	kN
6- Equivalent Opining Size	*EN ISO 12956*	< 74	mμ (micron)
7- Raw material	*100% polypropylene (include15% low melt fibers)*		

2.2. Sewing yarns

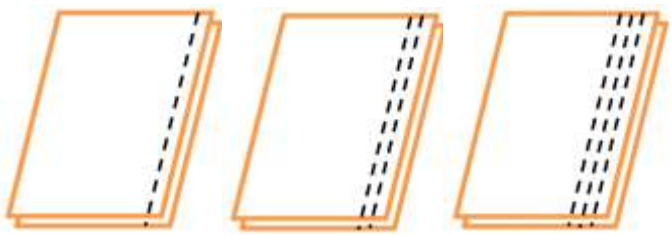
In this study, 12x3, 15x3 and 18x3 Tex filament polyester yarns were used. The fineness of the filament polyester fibers used was 1.2 Denier. Table 2 shows the physical and mechanical properties of the sewing yarns were used.

2.3. Stitch and seam type

In this study, 101 and 401 stitch with prayer type was used. The following diagrams (figure 1) indicate the prayer seam type with 1, 2 and 3 sewing lines. The other types of seams ("J" and "butterfly" seams) are more difficult to produce there for to increase the thickness when bending during the sewing process.

Table 2 - Physical and mechanical properties of the sewing yarns were used

Test	Test Method	Result			Unit
		-1	0	+1	
1- Yarn count		12x3	15x3	18x3	Tex
2- Twist in Yarns	*ASTM D 1423*	750	730	720	T/m
3- Tensile strength		37	34.7	34.5	g/denier
4- Elongation @ max. load	*ASTM D 2256*	28	25	23	%



Sewing machine

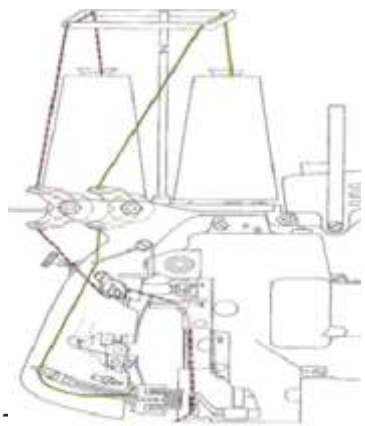


Figure 4 - machine

The equipment selected must be capable of producing a specific stitch geometry with the correct yarn type, denier, and should be selected based on the type of installation, geotextile construction and absolute seam strength requirements. There are two types of sewing equipment most commonly used: a) single-needle hand-held sewing machines and b) double-needle sewing machines, usually table mounted. Both methods are available in the field and in the factory. (1)

2.5. The Experimental parameters

The three factors sewing yarn count, number of sewing lines and type of stitch have been chosen for this factorial design experiment each with three levels except stitch type with only two levels. Coded levels with their respective values for the process parameters are shown in table 3.

Table 3 - The Experimental parameters and their levels

Parameters	Notation	Levels		
		-1	0	+1
Sewing yarn count (tex)	X_1	12x3	15x3	18x3
Number of sewing lines	X_2	1	2	3
Stitch type	X_3	101	-	401

The ASANO tensile machine was used to measure the tensile strength of geotextiles and seams. The readings were recorded for each of the identified tests.

2.6. Response Surface Methodology (RSM) method

In this study, Response Surface Methodology (RSM) with Factorial design was used. Response Surface is affected by a number of variables and the aim is to optimize this response. Response Surface is a set of mathematical and statistical approaches that are useful for modeling and problem analysis. The process of sewing nonwoven geotextiles is influenced by several input factors that consistently results in a set of output responses. The best method to explore the relationship between the input and output is the response surface methodology since it can determine the exact value within any given range of parameters value. The best technique to investigate the relationship between input and output is to use the response surface approach, which can identify the precise value within any given range of parameter values. The factorial design, which presented in 1960, is considered to be the most practical RSM design in this case. This design is more effective with small number of runs. The factorial design (32x2) has been used to calculate optimal result and also to find significance of each factor through STATISTICA version 10 software computes variance. Through software computes variance, the factorial design has been utilized to identify significance of each factor and also to evaluation optimal results. Furthermore, the interaction between variables was analyzed using analysis of variance (ANOVA).

3. Result and Discussion

3.1. Effect of sewing yarn count, number of sewing lines and type of stitch on geotextile sewing strength

Table 4 shows the design experiment and seam strength values (ST). Table 5 shows the result of analysis of variance (ANOVA) and parameters F value, p value, R2, and adequate precision were used to check the model adequacies. As shown in Table 5, a p value less than 0.05 indicates that the

corresponding model terms are significant, including X1, X2, X3, X1X3, X2X3 and X1X2X3. Furthermore, it is shown that R2 value of the model is 0.9150 which is good to 1. This means that only 91.50% of the whole variance data can be described by the model, and only 8.50% of the total variation cannot be explained, which indicates better accuracy. The quadratic model derived from the regression analysis of the experimental data is given below:

ST= 29.36+ 11.81 X1+ 5.66 X2 +3.74X3 +0.544X1X2 -2.7 X1 X3 +1.88 X2 X3 - 1.733 X1 X2 X3

Where: X1, X2 and X3 are sewing yarn count, number of sewing lines and stitch type respectively.

Table 4 - The Design Experiment and seam strength values

Run	Sewing yarn Count (tex) X_1	No. of sewing line X_2	Stitch Type X_3	Sewing strength ST kN/m	Seam strength efficiency %
1	-1	-1	-1	14.8	30.96
2	0	-1	-1	18.11	37.89
3	1	-1	-1	36.38	76.11
4	-1	0	-1	10.12	21.17
5	0	0	-1	14.16	29.62
6	1	0	-1	45.1	94.35
7	-1	1	-1	13.95	29.18
8	0	1	-1	33.35	69.77
9	1	1	-1	44.65	93.41
10	-1	-1	1	16.24	33.97
11	0	-1	1	17.89	37.43
12	1	-1	1	35.23	73.70
13	-1	0	1	24.13	50.48
14	0	0	1	36.14	76.61
15	1	0	1	45.39	94.96
16	-1	1	1	32.13	67.22
17	0	1	1	44.43	92.95
18	1	1	1	46.36	96.99

Equation 1 shows that the ST value is directly proportional to the increase in the concentration of sewing yarn count (X1) number of sewing lines (X2), stitch type (X2), sewing yarn count and number of sewing lines interaction (X1 X2), and number of sewing lines and stitch type (X2 X3), corresponding to a positive constant value. Meanwhile, interaction between the sewing yarn count and stitch type (X1 X3) and sewing yarn count, number of sewing lines and stitch type, interaction (X1 X2 X3) gave a negative effect on the ST value. Figure 1 shows the predicted against actual values for ST. The data distribution is relatively close to the straight line indicating that the regression model can predict the ST value. Furthermore, it is shown that R2 value of the model is 0.9465 which is close to 1. This means that only 94.65% of the whole variance data can be described by the model, and only 5.35% of the total variation cannot be explained, which indicates greater accuracy. Figures 3a-d shows the variable interaction of the 3D surface and contour plots on seam strength response.

Table 5 - The results of analysis of variance (ANOVA)

	sum of squares	DF	mean square	F-test	P-value
model	7407.2	7	1058.2	33.78486	4.45E-16
Sewing yarn Count X1	5132	1	5132	928.3	1.34524E-16
No. of sewing line X2	1192	1	1192	215.7	2.2745E-05*
Stitch Type X3	756	1	756	273.5	1.1782E-07*
X1*X2	238	1	238	21.6	0.063592
X1*X3	350	1	350	63.3	0.005285*
X2*X3	495	1	495	89.6	0.004925*
X1*X2*X3	586	1	586	53	0.045455**
R Square	0.9150				

*Significance level: P ≤ 0.01 at 99%.
** Significance level: P ≤ 0.05 at 95%

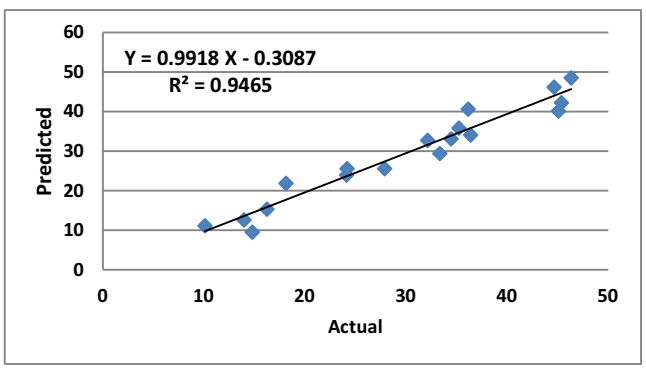


Figure 2 - The plot of predicted against to actual value for seaming strength

The dark red-red compositions are desirable, while the green-yellow compositions are less desirable. Figures 3a and b displays the effect of sewing yarn count and number of sewing lines on seaming strength for stitch type 101. It is clear from the contour plot that with the increase in sewing yarn count seaming strength also increases but seaming strength decreases with different levels of number of sewing lines with decrease sewing yarn count. This can be explained due to that chain 101 unravels easily. And therefore, the optimum results with chain 101 were obtained by 18x3 tex and sewing yarn count 3 lines. But it is not guaranteed because each stitch is dependent on the next.

Figures 3c and d displays the effect of sewing yarn

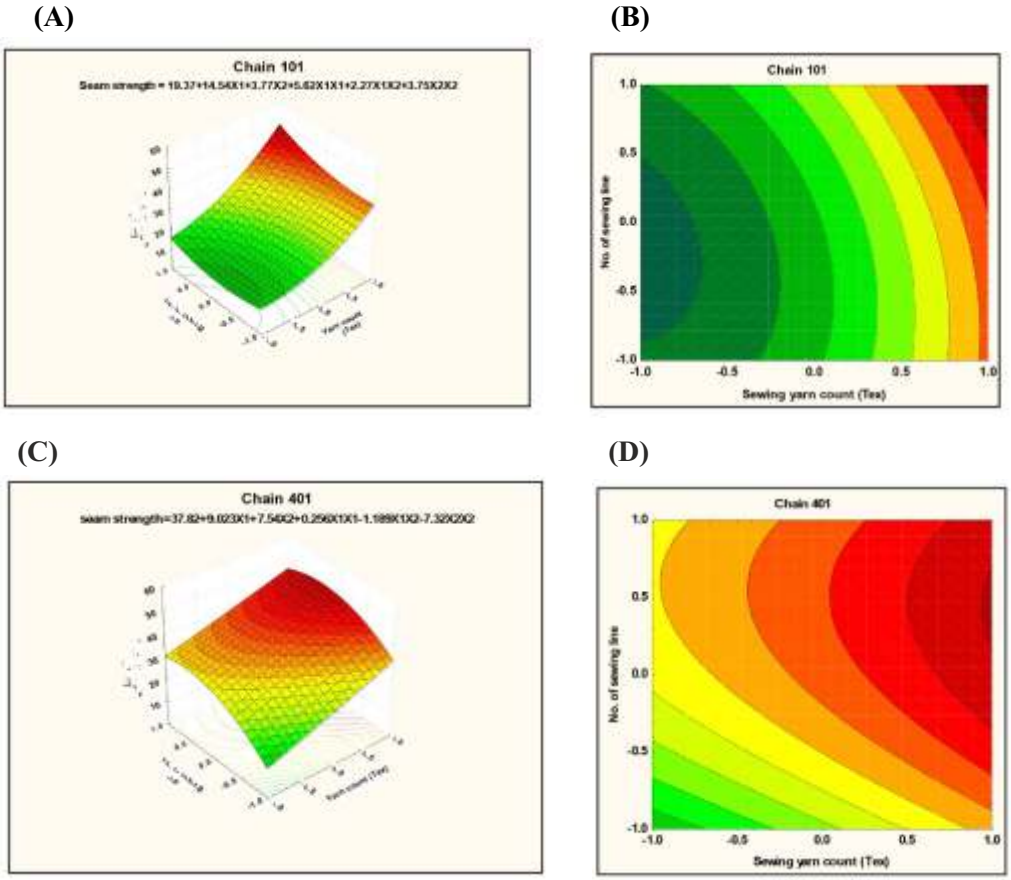


Figure 3 - a-d Surface and contour plots on seam strength response

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From Table 6 it is shown that R2 value of the model is 0.9044 which is good to 1. The meaning behind this is that 90.44% variation can be explained by this model and only 9.56% of total variation cannot be described, which is an indication of well correctness.

Table 6 - Response surface equations, correlation coefficients and significant values for parameter affected on each stitch type 101 and 401 samples

Stitch type	Response surface equations	R^2	P-value				
			X_1	X_2	X_1X_1	X_1X_2	X_2X_2
101	$Y_{101} = 19.37 + 14.54X_1 + 3.77X_2 + 5.62X_1X_1 + 2.27 X_1X_2 + 3.75 X_2X_2$	0.9044	1.39E-11*	0.002*	0.008*	0.1083	0.0646
401	$Y_{401} = 37.82 + 9.023X_1 + 7.54X_2 + 0.256X_1X_1 - 1.189X_1X_2 - 7.32X_2X_2$	0.9394	1.05E-08*	2.1E-07*	0.807	0.343	0.0003*

X_1: Sewing yarn Count, X_2: number of sewing lines

*Significance level: $P \leq 0.01$ at 99%.

**Significance level: $P \leq 0.05$ at 95%

count and number of sewing lines on seaming strength for stitch type 401. It is clear from the contour plot that with the increase in sewing yarn count and number of sewing lines seaming strength also increases. This can be explained due to the fact that as the sewing yarn count and number of sewing lines increase the binding force between the fibers of geotextiles increases by increasing the fiber to fiber-frictional coefficient that held the fiber more compactly at seaming zone and therefore causes seaming strength increases. And therefore, the optimum results with chain 401 were obtained by 18x3 or 15x3 tex sewing yarn count and number of sewing lines is 2 and 3 and give the seam strength that suits to the final application of geotextiles. Therefore, interaction between the 18x3 or 15x3 tex sewing yarn counts and 2 or 3 lines of sewing gave the best results for the seam strength with chain 401. In additional, that is suitable for the final application of geotextiles. From Table 6 it is shown that R^2 value of the model is 0.9394 which is close to 1. This means that 93.94% of the whole variance data can be described by the model, and only 6.06% of the total variation cannot be explained, which indicates good accuracy. Stitch 401 is formed by passing the loop of one sewing yarn through the loop of another sewing yarn. This type of stitch is more durable than back stitching and reduces the likelihood of puckering in the seam. But stitch type 101 is formed by passing the loop of one yarn through the loop of the same yarn. This type of stitch is very unsafe because each stitch is dependent on the next, and a single broken yarn could tear the entire stitch apart. Therefore, 401 stitches are significantly stronger and more durable than 101 stitches.

4. Conclusion

Seam strength and its efficiency are an important factor for seam performance of nonwoven geotextiles. The objective of this work was to study some factors affecting geotextiles seam strength which utilized for coastal erosion control and offshore engineering constructions by using surface response methodology. Factorial design of response surface methodology can be successfully used to analyze and optimize the parameters which influence seam strength of geotextiles properties. The seam strength and its efficiency properties of nonwoven geotextiles made from polypropylene fibers have been studied and analyzed. It is observed that the three factors sewing yarn count, number of sewing lines and two types of stitch parameters are significantly affected geotextiles seam strength and its efficiency. The experimental studies results carried out are summarized as follows:

- Analysis of variance (ANOVA) and parameters F-test, P-value, R^2, and adequate accuracy were used to check the model suitability. they showed that the seam strength properties were significantly affected by sewing yarn count, number of sewing lines and two types of stitch parameters and its interactions (except interaction between sewing yarn count and number of sewing lines) at P-value ($P < 0.05$) for all samples.
- For stitch type 101, it is clear that with the increase in sewing yarn count seaming strength also increases but seam strength decreases with different levels of sewing lines number with decrease sewing yarn count. The optimum results with chain 101 were obtained by 18x3 tex and sewing yarn count 3 lines.
- For stitch type 401, it is clear that with the increase in sewing yarn count and number of sewing lines seaming strength also increases. The optimum results with chain 401 were obtained by interaction between the 18x3 tex sewing yarn counts and 2 lines of sewing lines or 15x3 tex with 3 lines of sewing lines gave the best results for the seam strength with chain 401. In additional, that is suitable for the final application of nonwoven geotextiles.

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SUSTAINABLE

Synergizing Medicinal Herbs for Sustainable Eco-friendly Herbal Healthcare Textile Products

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Abstract:

Musculoskeletal disorders represent a prevalent global health concern, necessitating effective and sustainable solutions for symptom alleviation and improved quality of life. The paper explores the extraction and analysis of medicinal herbs, with a specific emphasis on their utilization in creating herbal finished textile products. These products are designed to cater to musculoskeletal disorders while aligning with eco-friendly materials, ensuring minimal environmental impact and promoting overall well-being. By combining the inherent therapeutic properties of medicinal herbs with sustainable practices, this study aims to contribute to a more environmentally conscious and holistic approach to managing musculoskeletal disorders.

Keywords: *Ecofriendly materials, herbs, herbal dyeing, musculoskeletal disorders, Sustainable products.*

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1. Introduction :

Sustainability, a complicated, multifaceted notion, considers the effects on the economy, society, the environment, and human health. From the beginning of time, the traditional and ancient Indian medical systems of Ayurveda, Siddha, Yoga, and Unani have been providing people with healthcare solutions. Ayurveda has been a part of India's rich culture and history since the dawn of time. Even though Ayurveda use has been declining in recent years, its therapeutic applications have lately experienced a resurgence, and the western world has accepted it considering the answers it provides to a variety of healthcare concerns [1]. The utilisation of natural items with plant, animal, or mineral origins forms the basis of all this holistic medical approach and offers many sustainable solutions [2]. Plant-based ingredients make about 90% of Ayurvedic preparations, which helps regulate the doshas and reverse pathophysiological conditions [3].

According to World Health Organisation, 80% of people globally rely on traditional medical systems for some part of their basic healthcare need and around 21,000 plant species have the potential to be utilised as medicinal plants. 65 percent of the population in India depends on traditional medicines for healthcare solutions. Treatment with herbal remedies is seen to be quite safe as there are either no or relatively few adverse reactions [4]. Ayurveda is a holistic approach to health and personalised medicine. The rising adverse effects of synthetic pharmaceuticals, the absence of effective treatments for many chronic conditions, the high cost of new medications, microbial resistance, developing disorders, etc. have all boosted public interest in complementary and alternative medicine [5].

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One of the major occupational healthcare problems is Musculoskeletal Disorders or MSDs. Musculoskeletal disorders (MSD) are a broad category of disorders that can affect any part of the musculoskeletal system, such as the muscles, bones, joints, spinal discs, supporting blood vessels, and connective tissues including tendons, ligaments, and cartilages [6]. These are normally degenerative disorders and worsens over time if not treated on time properly.

2. Material and Methods

2.1 Fabric selection

Hundred per cent bamboo (100% B) and hundred per cent wool (100%W) yarns were taken for the study. The selection of these yarns is based on their inherent characteristics of comfort, breathability, and eco-friendliness [7]. The hundred per cent yarns selected were blended with cotton in the ration 50:50 to get blended yarns namely 50:50 cotton bamboo (50:50CB), 50:50 cotton wool (50:50CW) The four selected yarns were subjected to yarn strength and yarn elongation tests. The developed hundred per cent and 50:50 blend yarns were then converted into fabric by handloom, powerloom and knit method of fabric construction. The nomenclature of the developed materials is given in Table 1.

Table 1 - Nomenclature of the Developed Fabrics

Handloom Fabrics		Powerloom Fabrics		Knit Fabrics	
100% pure	**50:50 Blend**	**100% pure**	**50:50 Blend**	**100% pure**	**50:50 Blend**
Bamboo (HB)	Cotton Bamboo (HCB)	Bamboo (PB)	Cotton Bamboo (PCB)	Bamboo (KB)	Cotton Bamboo (KCB)
Wool (HW)	Cotton Wool (HCW)	Wool (PW)	Cotton Wool (PCW)	Wool (KW)	Cotton Wool (KCW)

2.2 Selection of Disease conditions

Musculoskeletal disorders refer to a range of conditions that affect the muscles, bones, joints, tendons, ligaments, and other supporting structures of the body [8]. Disease conditions like knee pain, elbow pain, heel pain and wrist pain were taken for the study.

2.3 Selection, extraction and optimization of medicinal herbs

Medicinal herbs namely Ricinus Communis, Holoptelea Integrofolia, and Terminalia Chebula were taken to study the properties of each herb and to understand its effectiveness in treating musculoskeletal disease conditions. The selected three medicinal herbs were taken separately, dried, grinded under hygienic conditions and the powder obtained was subjected to ethanolic extraction. Phytochemical screening test of the extracted medicinal herbs were done to identify the secondary metabolites present in each one of them. The extracts of the herbal solutions were taken in four different proportions namely 1:1:1, 1:2:1, 1:2:3 and 2:3:2 and subjected to antibacterial activity to select the best proportion for herbal dyeing. FTIR Spectroscopy was performed on the selected optimized ratio to find out the functional groups present in the medicinal herbal combination.

2.4 Application of the optimized herbal extracts to the developed fabrics

The selected optimized herbal extracts were applied to the developed hundred per cent and blended bamboo and wool fabrics of handloom, powerloom and knit by dip pad dry method and microencapsulation methods. The original and dyed fabrics were subjected to visual inspection to evaluate the colour, texture, lustre, odour and general appearance. The developed microencapsulated fabrics were subjected to SEM analysis to study the fixation of the dye.

2.5 Developing herbal finished products for musculoskeletal disorders

The hundred per cent and 50:50 blend handloom, powerloom and knit herbal finished dip pad dry and microencapsulated bamboo and wool fabrics were used for developing healthcare products like knee band for knee pain, elbow brace for elbow pain, wrist band for wrist pain and heel wrap for heel pain. The developed herbal finished products were evaluated for its performance by wear study among the selected patients.

3. Results and Discussion

3.1 Analysis of Yarn strength and Elongation

The results of the yarn strength and yarn elongation of 100% B, 100%W, 50:50 CB and 50:50 CW is given in Table 2.

Table 2 - Yarn strength and Yarn Elongation of Selected yarns

Name of the Spun Yarns	Single Yarn Strength		Single Yarn Elongation	
	Avg. Strength (g/tex)	CV% of Strength	Avg.% Elongation	CV % of Elongation
100% B	353.5	6.59	14.91	5.75
100% W	954.7	13.42	13.58	15.52
50:50 CB	285.7	6.12	13.45	10.11
50:50 CW	765.8	12.14	9.56	10.45

The results from Table 2 indicates that all the spun yarns had good strength and elongation which makes it suitable for weaving and knitting operations. Hundred percent wool and wool cotton blend yarns exhibited good strength and elongation when compared to hundred per cent bamboo and bamboo and bamboo cotton blends.

3.2 Phytochemical screening analysis of selected medicinal herbs

The Phytochemical analysis of the selected medicinal herbs Ricinus Communis, Holoptelea Integrofolia and Terminalia Chebula given in Table 3.

Table 3 - Phytochemical Analysis of Selected Medicinal Herbs

Selected Medicinal Herbs	Phytochemical Screening Tests								
	Alkaloids			Flavonoids	Glycosides	Saponins	Tanninsand Phenols		Sterolsand Terpenoids
	Mayer's Test	Wagner's Test	Dragondroff's Test	Shinoda Test	Salkowski's Test	Froth Test	Lead Acetate Test	Ferric Chloride Test	Libermann Burchard Test
Ricinus Communis	-	+	-	+	-	+	+	-	+
Holoptelea Integrofolia	-	-	+	+	-	+	-	-	-
Terminalia Chebula	-	-	+	+	+	-	+	+	+
Note:+ present - Absent									

The results from the phytochemical screening of the selected medicinal herbs indicates that all the medicinal herbs are good in advantageous phyto-constituents like alkaloids, flavonoids, glycosides, saponins, tannins, phenols, sterols and terpenoids. Flavonoids present in Ricinus Communis, Holoptelea Integrofolia, Terminalia Chebula, indicated the herbs potential as anti-viral, anti- inflammatory, cardio-protective, anti-ageing, anti-cancer, and anti-diabetic activities [9]. Glycosides are detected in Terminalia Chebula. Tannins, phenols and saponins are known to be anti-microbial, anti-fungal anti-inflammatory, neuro protective and destressing agents. Terminalia Chebula can also be used as natural mordant besides its medicinal properties.

Table 4 – Analysis of Antibacterial Activity of Selected Medicinal Herbs

RiC, HI, TC in ratios	ZONE OF INHIBITION (in mm) FOR HCB- RiC, HI TC								
	Escherichia Coli (Gram -ve bacteria)				Bacillus Subtilis (Gram +ve bacteria)				
	100% HB	100% HW	50:50 HBC	50:50 HWC	100% HB	100% HW	50:50 HBC	50:50 HWC	50:50 HMC
1:1:1	25	35	33	30	32	40	33	38	36
1:2:3	25	28	25	40	30	36	35	33	38
3:2:1*	35	45	35	43	35	42	37	43	44
2:3:2	27	38	32	26	34	37	36	38	38

3.3 Analysis of Antibacterial Activity of the selected Medicinal Herbs

The anti-bacterial test was performed on pure handloom 100% HB, 100% HW,50:50 HCB and 50:50 HCW blend fabrics as handloom fabrics consists of same type of yarn in both warp and weft directions. Agar Diffusion Test was conducted using Bacillus Subtilis (Gram Positive) organism and Escherichia coli (Gram Negative) micro-organisms for the selected herbal combination in four ratios 1:1:1, 1:2:3, 3:2:1 and 2:3:2 respectively for Escherichia Coli (gram negative bacteria) and Bacillus Subtilis (gram positive bacteria). The results of antibacterial activity for the selected medicinal herbal combination consisting of Ricinus Communis, Holoptelea Integrofolia and Terminalia Chebula (RiC, HI, TC) to optimize the herbal ratios 1:1:1, 1:2:3, 3:2:1 and 2:3:2 is recorded in Table 4 and Fig.1.

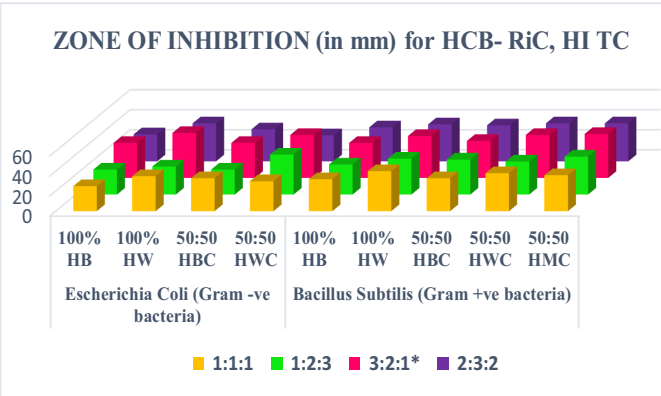

Figure 1 - Analysis of Antibacterial Activity of Selected Medicinal Herbs

The results from Table 4 reveals that among the four ratios 1:1:1, 1:2:3, 3:2:1 and 2:3:2 of herbal combination, comprising of Ricinus Communis, Holoptelea Integrofolia and Terminalia Chebula, the highest zone of inhibition is displayed in the ratio 3:2:1 for all the treated 100% HB, 100% HW and 50:50 HBC, 50:50 HWC pure and blend handloom fabrics for Escherichia Coli (gram negative) and for Bacillus Subtilis (gram positive) respectively(Fig 2, Fig 3). Hence for Knee pain, Tennis Elbow pain, Heel pain and Wrist pain, the selected medicinal herbs Ricinus Communis, Holoptelea Integrofolia and Terminalia Chebula in the optimized ratio 3:2:1 was selected for herbal dyeing.

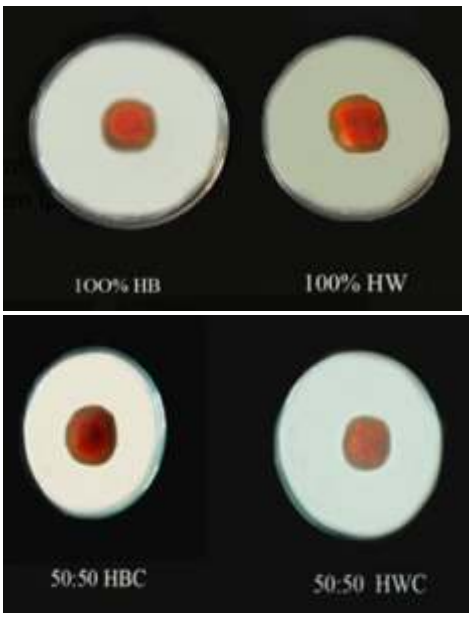

Figure 2 - Antibacterial Activity of Gram-Positive Bacteria in the Ratio 3:2:1

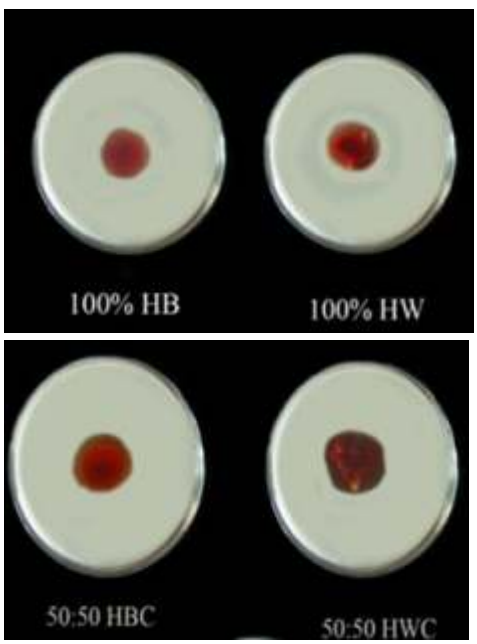

Figure 3 - Antibacterial Activity of Gram-Negative Bacteria in the Ratio 3:2:1

3.4 FTIR Spectroscopy of selected Medicinal Herbs

The results of FTIR spectrum of the selected herbal combination for the optimized ratio 3:2:1 is given in Fig.4 and the functional groups identified are given in Table 4

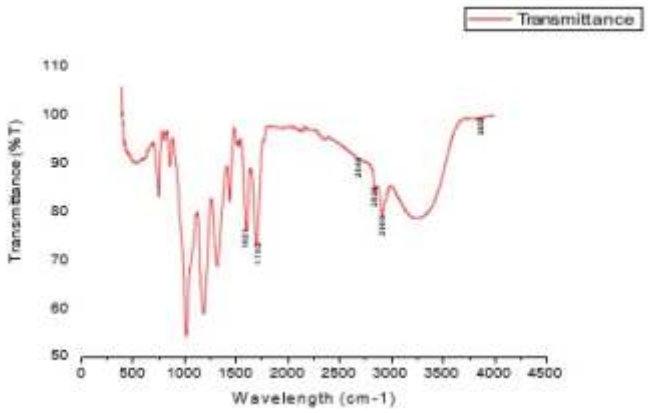

Figure 4 - FTIR Spectroscopy of Optimized ratio 3:2:1

Table 5 - FTIR Spectral Peak Values and Functional Groups

RiC, HI, TC in 3:2:1 Ratio		
Peak values	**Groups**	**Compound class**
2936	C-H stretching	Alkane group
2844	N-H stretching	Amine Salt
3243	C-H stretching	Alkyne group
1710	C=O stretching	Conjugated aldehyde
1600	C=C stretching	Conjugated alkene
1450	C-H bending	Alkane

From Fig.4 and Table 5, it is observed that the extracts of herbal combinations consisting of Ricinus communis, Holoptelea Integrofolia and Terminalia Chebula in the ratio 3:2:1 exhibited characteristic bands at 2936cm-1, 2844 cm-1 indicating the presence of alkane group and amine salt. The characteristic band 3242cm-1 shows presence of alkyne group, the wavelengths 1710cm-1, 1600cm -1 and 1450cm-1 indicates the presence of aldehyde, alkene and methyl group.

3.5 Analysis of Visual Evaluation of original and Treated Handloom, Powerloom and Knit Fabrics

The results of visual inspection was conducted for original (O), dip - pad dry (D) and microencapsulated (M) treated samples with herbal combination Ricinus Communis, Holoptelea Integrifolia, and Terminalia Chebula is given in Table 6.

The feedback received for visual evaluation of H, P, K dip pad dry (D) and micro encapsulated (M) fabrics from Table 5 reveals that, the handloom, powerloom and knit dip pad dry and microencapsulated fabrics were good in color, soft in texture, high in lusture and had pleasant odour. The general look of the dip pad dry and micro encapsulated treated fabrics altogether had evenness in appearance.

Table 6 - Visual Inspection of Handloom, Powerloom Knit Original and Treated fabrics

VISUAL EVALUATION OF H, P, K DIP PAD DRY FABRICS														VISUAL EVALUATION OF H, P, K MICROENCAPSULATED FABRICS												
H, P, K Dip pad dry fabrics	Colour			Texture			Lusture			Odour		Appearance		H, P, K Microencapsualted Fabrics	Colour			Texture			Lusture			Odour		Appearance	
	Good	Fair	Poor	Soft	Medium	Rough	High	Medium	Dull	Pleasant	Unpleasant	Even	Uneven		Good	Fair	Poor	Soft	Medium	Rough	High	Medium	Dull	Pleasant	Unpleasant	Even	Uneven
100% HB^D	100	-	-	100	-	-	100	-	-	100	-	100	-	100% HB^M	100		-	100	-	-	-	100	-	100	-	100	-
100% HW^D	100	-	-	100	-	-	100	-	-	100	-	100	-	100% HW^M	100		-	100	-		-	100	-	100	-	100	-
50:50 HBC^D	100	-	-	100	-	-	100	-	-	100	-	100	-	50:50 HBC^M	100		-	100	-	-	-	100	-	100	-	100	-
50:50 HWC^D	100	-	-	100	-	-	100	-	-	100	-	100	-	50:50 HWC^M	100		-	100	-	-	-	100	-	100	-	100	-
100% PB^D	100	-	-	100	-	-	100	-	-	100	-	100	-	100% PB^M	100	-	-	100	-	-	-	100	-	100	-	100	-
100% PW^D	100	-	-	100	-	-	80	-	-	100	-	100	-	100% PW^M	100	-	-	100	-	-	-	100	-	100	-	100	-
50:50 PBC^D	100	-	-	100	-	-	100	-	-	100	-	100	-	50:50 PBC^M	100	-	-	100	-	-	-	100	-	100	-	100	-
50:50 PWC^D	100	-	-	100	-	-	80	-	-	100	-	100	-	50:50 PWC^M	100	-	-	100	-	-	-	100	-	100	-	100	-
100% KB^D	100	-	-	100	-	-	100	-	-	100	-	100	-	100% KB^M	100	-	-	100	-	-	-	100	-	100	-	100	-
100% KW^D	100		-	100	-	-	100	-	-	100	-	100	-	100% KW^M	100	-	-	100	-	-	-	100	-	100	-	100	-
50:50 KBC^D	100		-	100	-	-	100	-	-	100	-	100	-	50:50 KBC^M	100	-	-	100	-	-	-	100	-	100	-	100	-
50:50 KWC^D	100		-	100	-	-	100	-	-	100	-	100	-	50:50 KWC^M	100	-	-	100	-	-	-	100	-	100	-	100	-

3.6 SEM Analysis of Microencapsulated Fabrics

Handloom (H) and knit (K) materials consisted of the same type of yarn in both warp and weft, wales and course directions. Hence to understand the binding of herbal microcapsules to the fabric surfaces, handloom fabrics in the optimized ratio 3:2:1 were subjected to SEM analysis to confirm the binding of microcapsules. The results (Fig.5) revealed that 100% HB, 100% HW images revealed the herbal deposition on the surface of the fabrics with some protruding fibres and gap in the capsules whereas the handloom blend fabrics, 50:50 HBC, 50:50 HWC showed a uniform deposition of the herbal capsules with a reduced pore size on the surface of the fabrics.

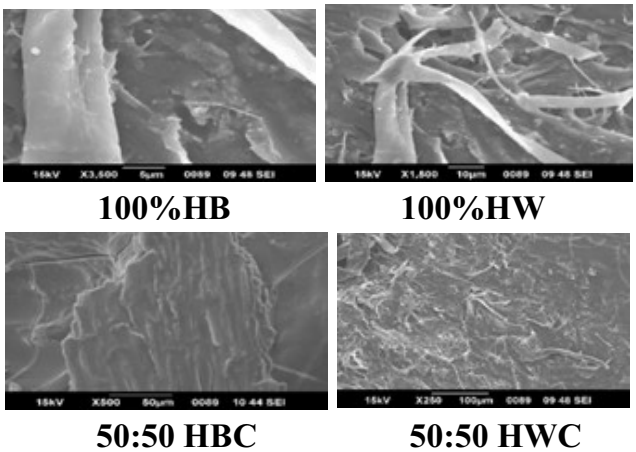

Figure 5 - SEM Analysis of Microencapsulated Fabrics

3.7 Aesthetic and Performance Analysis of Developed Healthcare Herbal Dyed Products

3.7.1 Aesthetic Evaluation

The developed herbal healthcare products aesthetic properties like design, comfort of wearing the product, texture and suitability of the product to the ailments were evaluated by the selected patients. The results are given in Table 7.

Table 7 - Aesthetic Evaluation of the Developed Herbal Health Care Products

Evaluation of Aesthetic Properties of the Developed Herbal Healthcare Products												
Health care Products	Handloom (H)				Powerloom(P)				Knit(K)			
	Design	Comfort	Texture	Suitability of the Product	Design	Comfort	Texture	Suitability of the Product	Design	Comfort	Texture	Suitability of the Product
Knee Pad	5	4	4	5	5	4	4	5	5	5	4	5
Elbow Wrap	5	4	4	5	5	4	4	5	5	5	4	5
Heel Wrap	5	4	4	5	5	4	4	5	5	5	4	5
Wrist Band	5	4	4	5	5	4	4	5	5	5	4	5

Key: Excellent-5, Very Good-4, Good-3, Fair-2, Poor-1

From Table 6, it is noted that the design and suitability of the handloom, powerloom and knit healthcare products were ranked as excellent whereas the texture and comfort of wearing the healthcare products were rated as very good by all the subjects for all the treated products.

The developed herbal dyed handloom (H), powerloom (P) and knit (K) herbal healthcare products were given for wear study to ten selected patients, each having the respective ailments, in consultation with a doctor. The wear study on selected patients with the respective disease conditions was carried on after getting approval from the Ethical Committee. The products were given to selected patients and were asked to wear the product for a specific time duration and the results were recorded.

The evaluation of wear study of dip pad dry and microencapsulated knee pads for knee pain (Sample Fig.6) made from handloom, powerloom and knit fabrics reveal that, hundred per cent subjects revealed that after using the treated knee pads for a period of one month for eight hours from 8 am to 5 pm there was a considerable reduction in the knee pain and stiffness felt in the knee was reduced. All the subjects remarked that while using the product and afterwards, there was an improvement in walking without stiffness and pain. The results of the wear study for Elbow brace for Tennis Elbow (Sample Fig.7) shows that all the subject had a considerable reduction of pain in the elbow and stiffness while moving the elbow joint was reduced. Hundred per cent subjects were of opinion that after using the treated handloom, powerloom and knit elbow braces for one month for eight hours, the elbow joints were movable without much pain and there was improvement in the flexibility of the hand.

The wear study of heel wrap for heel pain made from dip pad dry and microencapsulated handloom, powerloom and knit fabrics for heel pain (Sample Fig.8) reveal that there was a reduction of pain in the heel, early morning stiffness and pain was considerably reduced for all the subjects. Hundred percent subjects were of opinion that there was an average improvement in the reduction of pain while standing for long period of time after using the product for eight hours for one month. The results of the wear study of the wrist band for wrist pain (Sample Fig.9) shows that all the subjects observed that there was a considerable reduction of pain in the wrist area and stiffness of the wrist was reduced after using the herbal finished handloom, powerloom and knit products for a period of eight hours for one month. All the patients revealed that there was improvement in the flexibility of finger from where the pain was feeling.

All the developed herbal healthcare products for the selected disease conditions such as Knee pad for knee pain, Elbow brace for Tennis elbow, Heel cover Heel pain, Wrist band for Wrist pain with suitable herbal combinations performed well on the subjects chosen with the respective ailments. All the subjects preferred to use herbal microencapsulated products more than dip pad dry products as they showed considerable reduction of symptoms related to specific ailment.

Figure 6 - Knee Pad

Figure 7 - Elbow Brace

Figure 8 – Heel Wrap

Figure 9 – Wrist Band

4. Conclusion

One of the main issues on which the world is currently focusing is sustainability. Environmental sustainability may be accomplished by manufacturing products without disrupting or harming the earth's biological equilibrium [10]. Using herbal textile products can make a significant contribution to the textile industry's environmental sustainability. Ancient scholars were of opinion that medicinal herbs are the only way to cure diseases and regain health. The herbal healthcare products were made from hundred per cent and blend eco-friendly fabrics which were finished with extracts of medicinal herbs. The herbal products were safer to use, didn't cause any harm to the individuals and performed well, revealing the properties of the medicinal herbs and textile materials it were made of. The wellness of the herbal healthcare products developed smoothened the soul, contributed to sustainability, developed eco-consciousness, and gave relief to the body.

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Journal of the TEXTILE Association

HANDLOOM

The Study on Challenges Faced by the Women Weaver's in Udupi Taluk

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Abstract:

The handloom business is producing jobs at all stages of farming, raising, and weaving. It has made a tremendous impact to the socioeconomic lives of people, particularly women. However, it has recently been observed that, as a result of globalization and changing market needs, this industry is in turmoil, facing detrimental effects from government policies and discriminatory competitors, as well as piracy in product quality. Women's empowerment is a critical instrument for bringing about changes in their socioeconomic status. Weaving is an important source of revenue for the residents of Udupi. The goal of this study is to examine how this field affects women's empowerment and the economic situation of female weavers. A qualitative research technique adapted with primary data gathering processes such as questionnaire surveys and personal interviews was utilised to investigate information from 100 samples of women weavers in Udupi. Data were analysed using Microsoft Excel in a detailed manner utilising graphs, charts, and diagrams. Henry garret ranking Technique has been used to rank the challenges faced by women weavers in Udupi District. The findings shows that the women weavers of Udupi are rising at a rapid pace and empowering themselves via their job, and that women are strengthening themselves economically through the weaving sector. At the same time, they confront obstacles like as raw material availability, lack of demand, work-life balance, health issues, traditional stereotypes, marketing problems, and a lack of income during the off-season. Among the aforementioned concerns, health issues are regarded as the most serious issue confronting women weavers in this region. It may be inferred that women weavers are very important in the research area and that treatments should be implemented by government or non-government organizations.

Keywords: *Challenges, Health issue, Problems, Women, Weavers*

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1. Introduction :

With a rich history, the handloom sector is the second largest employer after the agricultural sector. It is one of the oldest. This industry plays a significant role in rural and semi-rural livelihoods because it provides distinct benefits like low power consumption, low capital intensity, eco-friendly production techniques, adaptability in small-scale production, and the ability to innovate and customise products to meet market demands. Handloom weaving, with its decentralised structure, is primarily done by weavers from the lower and middle classes of society. These knowledgeable people meet their domestic demands and make a substantial contribution to the textile industry alongside it. Notably, women actively engage in handloom weaving and are essential in supporting their families monetarily. But the difficulties encountered by female weavers present a complexity picture. They struggle with problems like low pay, health troubles, and a shortage of raw supplies yet playing a crucial role. Due to their lack of resources, many women weavers are unable to access digital banking services. In order to shed light on the nuances of the lives of women weavers in Udupi, this study aims to explore the various issues and difficulties they face. Impact on society and economy, contributes to the wider socio-economic effects of women's handloom weaving participation. Considering how their contributions affect the general well-being of their communities as well as the local economy. Secondly, obstacles to education, the relationship between the educational attainment of female weavers and their financial situation. Finding out how educational obstacles might be a factor in their difficulties. Well-being and Health, investigation of the unique health problems that women weavers encounter, taking into account the physical strain of their work and the possibility that they may not have access to healthcare. Evaluating the effect on their general well- being and access to healthcare. Evaluate the effect on their general well-being and output. Availability of Raw Materials, analysing the difficulties in obtaining raw materials for handloom weaving. Considering the effects of limited access to high-quality resources on the calibre and volume of their production. Difficulties with Technology, considering the unique technology obstacles that women weavers must overcome, particularly with regard to the use of digital banking services. Examining the obstacles preventing them from utilising technology for financial transactions and consider possible remedies. The Function of Government Policies, investigating how well the current policies of the government assist women weavers. Determining whether the policies in place effectively handle the issues at hand and suggest any improvements that should be made.

This study intends to give a detailed understanding of the difficulties experienced by women weavers in Udupi by carefully investigating these factors. By doing so, it hopes to provide insights that can guide targeted interventions and policy proposals to improve the socioeconomic well-being

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of these women weavers. In this study an attempt has been made to investigate the level of problems and challenges faced by women weaver in Udupi.

2. Objective

- To understand about the technical support involved in the design input and weaving/dyeing/printing/etc.
- To identify problems faced by women weavers in Udupi District.

3. Literature Review and Theoretical Background

Women are having a significant impact across all economic sectors. India has been under lock down because of COVID-19. It affected women handloom weavers who suffered a severe crisis and lost their means of support.

- Main problems faced by women are lack of working capital, increasing price of raw material, stiff competition from the power loom sector and lack of policy support [1].
- Women weaver suffered from health problems, financial problems and also women weaver are quite dissatisfied with being members in co-operative societies [5].
- While considering the marketing problem- lack of attractive promotion, lack intensive distribution, and lack of customer Relationship management was the severe problem, International Journal of Trade and Commerce, 4(1), 28-33. The handloom industry plays a crucial role in the nation's economy, ranking as the second-largest employer after agriculture. This sector contributes approximately 14% to the country's total cloth production, as per the Annual Report of the Ministry of Textile for 2010-11. In Tamil Nadu, handloom weaving is a significant economic activity, engaging over 1.89 lakh weaver households and 3.19 lakh weavers. Notably, 50% of the state's handloom weavers operate within the cooperative sector, surpassing the national average of 25%. The Handlooms and Textiles Policy Note for 2012-2013 reveals that Tamil Nadu's Handloom Weavers' Cooperative Societies produced 892.22 lakh meters of handloom cloth valued at Rs. 695.08 crore during 2011-2012. These societies sold handloom fabrics amounting to Rs. 852.42 crore, with 824 cooperative societies operating profitably. However, recent trends indicate a decline in the performance of these societies, attributed to various factors impacting weavers, input materials, and marketing challenges [4].
- Majority of weavers are women, and these women experience health issues like leg and back discomfort as well as a shortage of raw materials. The paper brings out the majority of problems in the society as well as physiological problem for women workers during their menstruation, in which they are not permitted to work in the traditional and work place. Even weaving for more than 12 hours a day, they underwent gynecological problems too [2].
- In a research study various problems and challenges faced by the weavers were bought in to notice. It also focuses on the welfare programme conducted by state and central government to promote the handloom product [8]
- "A Socio-Economic Conditions of handloom weaving: A field study in kallidaikurichi of thiruneveli District" detailed on the socio-economic conditions and prolems faced by the handloom weavers [3].
- In a research study it is found that education levels of male weavers were more than the female weavers [7].
- The majority of female entrepreneurs are between the ages of 21 and 30. It has also been noted that the majority of them are experiencing financial difficulties. Knowing the issues that women handloom weavers face in this context is crucial [6]. In order to resolve this, we are conducting the research to get more insights on the challenges faced by the women weavers.

4. Research Methodology

In this study, primary data has been obtained using a scheduled interview process. It identified the concerns about the socioeconomic landscape and the difficulties women confront in the handloom industry. In this study Mixed method approach has been used to be obtain the data.

Personal interviews had been undertaken in this study to elicit the information.

In this study methodology adopted is Convenience sampling method, Women weavers who live in Udupi Taluk were chosen as a sample. The data has been analyzed using Simple Percentage in Microsoft Excel.

Data sources: The structured questionnaire is prepared to collect the data.

Data collection: Data is collected by face to face interview and through administering the structured questionnaire.

Sampling: A sample of 100 Women weavers are taken into study, from the Taluk of Udupi. Data Analysis: The data is evaluated and analysed using statistical tools- Microsoft excel.

5. Data Analysis and Interpretation

The team of researchers surveyed through personal interviews and structured questions with Women Weavers to know the Challenges faced by Women Weavers in Udupi District. A total of 100 respondents are being taken as the sample size in the district.

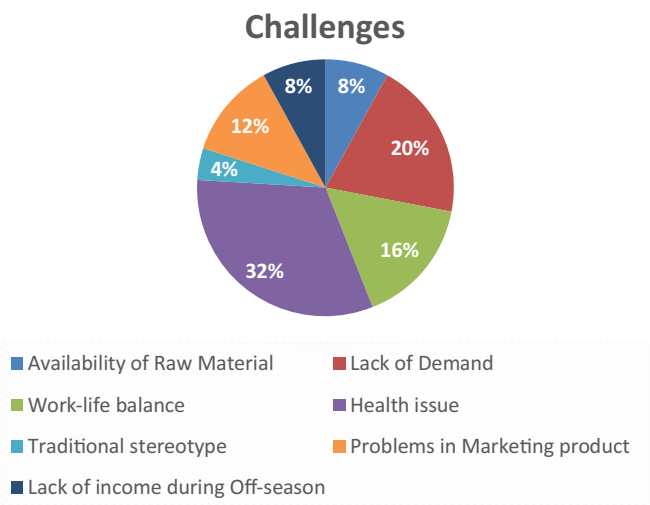
Data collected has been evaluated and analysed using statistical tool- Microsoft Excel.

i. Challenges and Problem faced by the Respondents

Table 1: Challenges faced by women weavers

Challenges	Respondents	Percentage
Availability of Raw Material	8	8%
Lack of Demand	20	20%
Work-life balance	16	16%
Health issue	32	32%
Traditional stereotype	4	4%
Problems in Marketing product	12	12%
Lack of income during Off-season	8	8%
Total	100	100%

Chart 1: Showing challenges faced by the women Weavers



ii. Interpretation

The above table and chart show's various challenges and problems faced by the women weavers in the Udupi Taluk.Weavers faced the health-related problems because of weaving are 32%. They have been encountered health issues like severe back pain, leg pain, and muscle catch for being continuously involving in weaving. Whereas 20% of the respondents were facing lack of demand for the product in the market. As technology, trends, and changing customer taste and preference were creating lack of demand for the handloomed clothes. Rise of e- commerce platforms were also made constraints to create demand for their products.The weavers found it was difficult to market their product in the current market scenario represented 12% of total sample size. Many of the customers are delighted to go with e-commerce platforms and readymade garments compare to handloomed once. The 16% of the respondents were facing difficulties in managing work life balance. This was caused mainly due to lack of time, where the weavers finding difficult to manage household duties with the weaving. Availability of raw material and lack of income during off season was also remained as a challenge for women weavers, 8% of total sample size faced this problem. Due to variation in the demand and economic downturn it was difficult for the weavers to get access for the raw material. Adding to the above problems 4% of weavers faced traditional stereotyping in their work. There was lack of support from the men in their family. These above-mentioned problems were acting as a constraint for the weavers to overcome in weaving.

iii. Techniques used in this Research to Rank the Challenges are Henry Garret Ranking

To find out the extent of influence of the challenging factor, Garret Ranking Technique was adopted.

Here, Respondents are asked to mention their challenges faced by them. Challenges then ranked from 1 to 7 by 100 respondents.

The Order of challenges are given by the respondents are changed in to percent position by using the following formula.

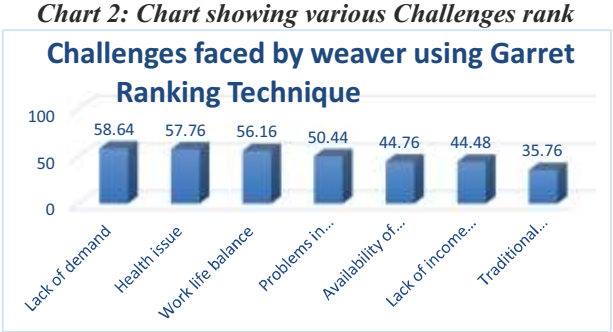
$$\text{Percent Position} = \frac{100(Ri-0.5)}{Nj}$$

Where, Ri is rank given for the ith challenges by jth respondent, Nj is number of challenges ranked by the jth respondent.

Table 2: Ranking of Challenges faced by women weavers

Challenges	Ranks	Formula	Percent position	Garret score	Mean Score
Lack of demand	1	100(1-0.5)7	7.14	78	**58.64**
Health issue	2	100(2-0.5)7	21.43	65	**57.76**
Work life balance	3	100(3-.05)7	35.71	57	**56.16**
Problems in marketing the product	4	100(4-.05)7	50	50	**50.44**
Availability of Raw Material	5	100(5-0.5)7	64.29	42	**44.76**
Lack of income during offseason	6	100(6-0.5)7	78.57	34	**44.48**
Traditional stereotype	7	100(7-0.5)7	92.86	22	**35.76**

Chart 2: Chart showing various Challenges rank



iv. Interpretation

Weavers were asked to rank from 1 to 7 for the challenges faced by them. The above table 2.0 and chart 2.0 shows the mean score which has been calculated from the garret ranking score. The highest mean score has been ranked 1 where mean score = 58.64 represents challenge of lack of demand, weavers were finding difficult to sell their product due to lack of demand in the market. With the changes in the customer trends and preference, in the apparel and fashion handloom products tends to lose their market shares. This factor has majorly impacted even the earnings of the weavers. Rank 2, with the mean score of 57.76 has been factored to health issues faced by the weavers such as back pain, leg pain, muscle catch etc. Rank 3, with the mean score of 56.16 represents the challenges related to work life balance, weavers found difficult to manage weaving with their house hold duties. Rank 4, has been given to problems in marketing the product with the mean score of 50.44, pushing the handloom product to the market was difficult due to lack of accessibility towards customer. Lack of promotional and advertising has kept their product away in the market. There was constraint in budget pertaining to promote their product in the market. Rank 5 has been based on the mean score 44.76 has given to challenges in availing of raw material, weavers were finding difficult to receive raw materials like threads, yarns and other raw material pertaining to weaving. Lack of income during off season was ranked 6 with the mean score of 44.48, weavers were earning less income during offseason due to lack of demand in the market to the handloomed products. Traditional stereotype has been ranked 7 with the 35.76 as a mean score, were traditional influence on the gender stereotyping was too least compare to other factors of challenges.

5. Summary of Findings

In the study conducted, it is evident that, weavers are facing numerous challenges and problems such as Availability of raw material, Lack of Demand, work life balance, health issues, traditional stereotype, problems in marketing product and lack of income during off-season. In the above-mentioned challenges, health issues considered to be the majorly faced problem by the women weavers. Health issues pertaining to back pain, leg pain, muscle catch etc. It was also difficult to the weavers to weave during pregnancy. Lack of demand was also another challenge, were weavers found difficult to sell and market their product in the market. The study also discloses the problem of weavers to manage their work life balance. Women weaver were finding difficult to manage housel hold duties with the weaving. The both the work was contradicting for them to manage.

With the change in the technology, changing customer taste and preference made the weavers challenging to push their product in to the market.

Study also discloses the changes in the wage payment during the off season to the weavers. Due to lack of income during off season 8% of the total respondent of the sample size found problems in this aspect.8% of the women weaver faced the problem of traditional stereotyping were there was lack of support to weavers in their family.

6. Suggestion to overcome the problems faced by the Women weavers:

- Marketing of the products can be improved through promotion in the social media in Whatsapp, facebook, Instagram, linkedin.
- Government should organize numerous training programmes to the weavers, so that they can improve their skills in weaving the latest cloth design. Which in return help them to earn more wages.
- In order to avoid competition from mechanized textile sector the government should insist the compulsory usage of handloom mark in the product.
- Government implement special health scheme and welfare schemes to those womens who are involved in weaving, so that women can overcome the burden of expenditure incurred on health related issues.

7. Conclusion

The study sheds light on the challenges faced by women weavers in Udupi Taluk in the handloom sector. These challenges range from health issues and traditional stereotypes to difficulties in marketing products and managing work-life balance. Despite these obstacles, women weavers play a crucial role in their households and contribute significantly to the handloom industry. Irrespective of their education qualification, age, weavers have been possessed with good weaving skill. The major challenge that they faced was health-related. But then the weaving has positively impacted the livelihood of women weavers in Udupi district. Research highlights the need for targeted interventions and policy proposals to improve the socio-economic well-being of women weavers. It emphasizes the importance of addressing health concerns, improving marketing strategies, and providing support for work-life balance. Additionally, the study underscores the impact of digital financial services on women weavers, suggesting the need for initiatives to enhance their access to such services. The findings point towards the resilience of women weavers who, despite facing various challenges, continue to positively impact their livelihoods through handloom weaving. The study concludes by offering practical suggestions, including promoting products through social media, enhancing skill development programs, and implementing health and welfare schemes to empower women weavers in Udupi. Overall it can be said handloom weaving is more than just making clothing; it's also a means of preserving a portion of history and bringing our ancestors' memories to life.

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Journal of the TEXTILE Association

DYEING

Extraction of Pigment from Prodigiosin and Carotenoid Bacteria for Dyeing of Textile Material

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Abstract:

Innovation in the manufacturing of textile dyes and auxiliary chemicals is nowadays essential tool to maintain the proper balance between the process and environment. Many attempts are taking place to develop sustainable and eco-friendly textile dyes and pigments to minimize the adverse effect on the environment. The present study is aimed to extract the pigment from prodigiosin and carotenoid bacteria which can be effectively used in the dyeing of cotton and polyester. Prodigiosin and carotenoid pigment was extracted from isolated soil samples by the bacterium Serratia marcescens and Micrococcus luteus respectively. The extracted pigments are biochemically characterized for confirmation of Serratia marcescens and Micrococcus luteus. Finally production of prodigiosin was optimized with respect to different parameters such as pH, temperature, incubation period.

Keywords: *Carotenoid, dyes, Micrococcus luteus, Prodigiosin, Serratia marcescens, Thin layer Chromatography*

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1. Introduction :

Production of pigments from natural resources is nowadays important part of textile industry for production of sustainable and eco-friendly products to meet the demands of the customer. It is essential to explore various natural sources of dyes for maintaining the sustainability in the process and product and human ecology [1]. Production of pigments from the natural resources has many advantages because of their easy availability of cultivation technology. Pigments extracted from biological shows promising avenues due to its biodegradability and higher compatibility with the environment. Carotenoids is one of the most important pigment group comprising of yellow to orange-red variants, which are ubiquitous in nature with proven anti-carcinogenic and immune-modulation properties which is extracted from Micrococcus luteus bacteria and is harmless to mankind. This yellow pigment has shown promising UV-protective, antioxidant and antibacterial activity [2]. It clearly indicates the potential for exploration of these pigments as natural colouring agents in the textile industries and also as a U.V protective agent. The structure of M. Luteus is as shown in the Fig. 1

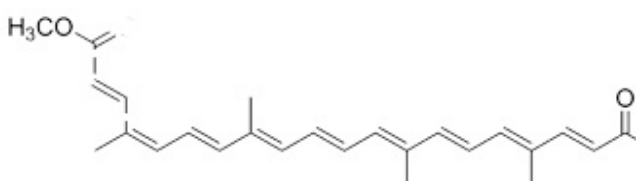

Figure 1 Structure of Carotenoid Pigment

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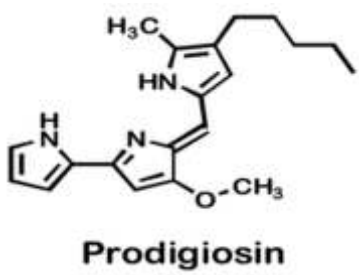
Prodigiosin have health benefits antifungal, antibacterial, antimalarial, immune suppressive, anti-neoplastic and UV-resistant properties due to its chemical structure [3]. Fabric can be endowed with added value when the pigments are used as dyestuff which gibes scarlet red colour variants and hence used in textile industries. This kind of pigments has been utilized to dye wool, polyester and acrylic fabrics with relatively good colour fastness, cotton can only be stained by the pigments without chemical mordants because of low affinity between prodigiosin molecular and cellulose. The structure of pigment is as shown in the Fig.2.



Fi***gure 2 Structure of prodigiosin pigment***

Pigments extracted from prodigiosin and carotenoids can be used successfully to dye textile substrates and is completely eco-friendly.

In several studies, it has been reported that natural dyes are restarted to be used in colouring fabrics like cotton, silk, wool, nylon etc. [9]. Moreover, the growing interest on natural colorants also keeps the researchers busy to innovate convenient techniques to apply it on the textile substrate. The natural products have some drawbacks such as low predictability and extractability; very minute amount of dye might be extracted from kilograms of raw materials. To cope

up with this hindrance, it is usually being suggested to apply appropriate selection techniques such as mutation or genetic engineering techniques for successful application of selected pigment at given process condition [9]. Microorganisms, for instance, bacteria as well as fungi are reported to be potent pigment producer. So, study with these creatures from environmental samples will unveil their hidden capability and application to mankind.

2. Material and Method

2.1 Collection of Soil Samples

Rhizosphere soil samples of banana tree were collected from the depth of 10 -15cm and kept in a sterilised glass container. The other laboratory chemicals such as methanol, concentrated HCl, concentrated ammonia solution, chloroform, acetone, ferrous sulphate, copper sulphate, lemon are used from the chemistry lab for the purpose of the extraction of pigments.

2.2 Isolation of Bacteria

The soil samples were serially diluted, 0.1ml of diluted samples from each dilution was spread over the Nutrient agar surface. Then the plates were incubated at 37˚C for the period of 24 hrs, to observe the growth of morphologically distinct colonies. So, after this trail the experiment was carried out by using Micrococcus luteus which is also Carotenoid pigment producing bacteria with antibacterial property and yellow tone and studied all its aspects which are discussed further.

2.3 Presumptive test for prodigiosin pigment

The isolated organism was inoculated in the nutrient broth and incubated at 37°C for 24 hours to observe the pigment production. The culture broth was centrifuged at 10,000 rpm for 10 minutes. The supernatant was discarded and the pellet was suspended in 95% methanol to extract the pigment from the cells. The suspended pellet was centrifuged at 10,000 rpm for 10 minutes. Debris was removed and the supernatant was taken in two tubes. The content of the first tube was acidified with a drop of concentrated hydrochloric acid and the second tube was alkalinized with a drop of concentrated ammonia solution. Then the colour change was observed.

2.4 Extraction of Pigment

Bacterial cultures from the liquid broth were centrifuged at 10,000 rpm for the period of 15 minutes. The supernatant and cell pellet were extracted with acetone and ethyl acetate. Then the cell pellet was repeatedly centrifuged to obtain white pellet. The pigment extracts of ethyl acetate fraction and acetone fraction were evaporated separately in evaporating dishes at room temperature till the powder appears.

2.5 Purification of Pigment

Thin layer chromatography is a technique used to separate non-volatile mixtures. The prodigiosin pigment was separated using TLC plate coated with silica gel. In the chromatographic tank the developing solvent such as chloroform, methanol and acetone (4:2:4v/v) was standardized and poured, then it was saturated with a filter paper soaking in the mobile phase. Then the Rf value of the chromatogram was found as 0.78 in the TLC plates.

3. Results and Discussion

3.1 Production of pigment in nutrient broth

In the present study nutrient broth was used for the production of the pigment, the yield of prodigiosin pigment on nutrient agar is 1326.07 mg/L. It was observed only after 96 hours of incubation. The bacterial growth in the agar plate is as shown in the Fig. 4 (a) and 9(b).

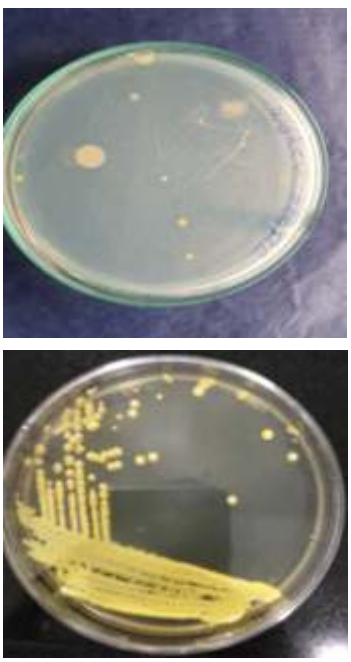


Figure 4 (a) - No bacterial growth for S. Marcescenes (b) Micrococcus luteus on nutrient agar

3.1 Presumptive test for prodigiosin pigment

The colour of the pigment is observed in solution of hydrochloric acid and alkaline ammonia solution. The colour of the solution found to be yellow after addition of hydrochloric acid and orange with the solution of ammonia.

3.2 Extraction of the Pigment

The supernatant obtained from the repeated centrifugation of bacterial cultures was extracted with ethyl acetate, petroleum ether and methanol. None of the extracts gave residual crude pigment. Then the pellet was extracted with acetone which yielded a residual crude pigment. The Carotenoid pigment is as shown in Fig. 4, and production is found to be 1326.07 mg/l on the nutrient agar.

Figure 4 - Carotenoid Pigment

4. Conclusion

In this study, a novel method of dyeing of textiles with pigments was carried out. It has been found that the pigments which are extracted from bacteria namely *Micrococcusluteus* and *Serratia marcescenes* shows highest yield at 30°C at 7 pH for 96 hours of incubation period. The pigment producing bacteria was isolated and characterized using nutrient broth. In large scale production, the pigment will make it an alternate to chemical dyes and further study can carried out in anticancer activity in human cervix carcinoma cells.

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DYEING

Exploring Quality Parameters in Lycra-Viscose Core Yarns: A Comparative Analysis of Ring- and Air-Jet Spinning Systems

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Abstract:

The structure and properties of lycra-viscose core-spun yarns manufactured on ring- and air-jet spinning machines have been investigated with respect to ribbon width, filament position, and spinning speed. Under all experimental conditions, the air-jet spun core yarns exhibit lower strength, reduced extensibility, increased hairiness, and inferior abrasion resistance compared to conventional core yarns, however, the positioning of the filament on the roving has a decisive effect on core yarn quality. Core yarns produces with a centered adjustment of the Lycra filament generally demonstrate significantly higher strength and breaking extension, less bulk, reduced hairiness, and inferior abrasion resistance and regularity and more imperfections regardless of the yarn structure. Furthermore, fine air-jet core yarns display a smaller helix diameter, more wrapper fibres, and a higher number of wraps per centimeter. They also possess a larger helix angle than coarse core yarns. An increase in spinning speed results in a higher incidence of wrapper fibres; however, both wraps per centimeter and helix angle initially increase and then decrease with increasing spinning speed.

Keywords: *Air-jet spinning, Core-spun yarn, Lycra filament, Ribbon width, Wrapper fibres*

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1. Introduction :

For numerous years, cotton- wrapped, filament-core spun yarns have been in production [1-5]. However, their widespread utilization is hindered by incomplete core coverage and inadequate strip resistance. To address these limitations [6], introduced various modifications to the conventional core-yarn ring spinning system. Recently, they proposed a novel tandem core-yarn spinning system utilizing air jets and friction drums [7]. Additionally [8], explored the impact of jet spinning parameters on sheath resistance and other related properties of polyester-viscose jet spun yarns [9] delved into the influence of elastane ratio on the mechanical properties of cotton-wrapped elastane-core spun yarns. Textile fabric producers frequently require yarns containing elastomers to produce elastic textile products and accessories. Elastic yarns find applications in diverse market segments such as hosiery, swimwear, sportswear, underwear, and lace, as well as in fashionable clothing. The most common methods of producing elastic yarns include the hollow spindle technique, entangling, twisting, and core spinning on a modified ring frame, as well as rotor, friction, and air-jet spinning. These processes exhibit distinct yarn properties, structures, and yarn count ranges. This study aims to analyze the impact of core positioning, ribbon width, and spinning speed on the structure and properties of lycra-viscose ring- and air-jet spun core yarns.

2. Materials and Methods

2.1 Preparations of Yarn Samples

Two sets of elastomeric core yarns, with Tex values of 19.6 and 29.5, were spun using viscose staple fibre with a length of 51 mm and a fineness of 1.66 dtex, in conjunction with Dupont Lycra filament of 63 dtex, on air-jet spinning machine. The specifications of viscose staple and Lycra filament used in the study are given in Table 1. The viscose fibre lap was prepared on Lakshmi Reiter's blow room line and subsequently carded on an MMC carding machine. The conversion to a drawn sliver was executed using Lakshmi Rieters' draw frame DO/2S. Three draw frame passages were given to the carded sliver to produce a finisher sliver of 3 ktex. The drawn silver was then spun into yarns using a Murata air jet spinner 802 MJS. The Lycra filament was positioned on a modified creel and directed to the nip of the front roller with a filament pretension of 45. 9 grains. It was accurately positioned at the center and then at the edge of the drafted ribbon of fibres before being spun into yarns. The process parameters employed to produce these yarns are outlined in Table 2.

Table 1: Specifications of Lycra filament and viscose staple fibe

Fibre / Filament	Length mm	Linear density dtex	Tenacity cN/tex	Breaking elongation %
Viscose	51	1.66	19.42	18.7
Lycra	51	63.18	13.24	716.0

Table 2: Spinning parameters for Lycra viscose MJS core yarns [NP1, 2.5kg/cm2; NP2, 3kg/cm2; Feed ratio, 0.98 and Distance between front nozzle and nip of front roller, 39.5mm

Yarn ref. no.	Yarn tex	Fibre composition (Lycra:Viscose)	Ribbon width mm	Filament position	Spinning speed m/min
S1	19.6	13:87	4	Core	150/170/190
S2	19.6	13:87	4	Side	150/170/190
S3	19.6	13:87	6	Core	150/170/190
S4	19.6	13:87	6	Side	150/170/190
S5	19.6	0:100	0	Nil	150
S6	29.5	9:91	4	Core	150/170/190
S7	29.5	9:91	4	Side	150/170/190
S8	29.5	9:91	6	Core	150/170/190
S9	29.5	9:91	6	Side	150/170/190
S10	29.5	0:100	0	Nil	150

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Table 3: Effect of spinning speed, ribbon width and filament position on structural parameters of Lycra-Viscose air-jet spun core yarns [NP1, 2.5kg/cm2; NP2, 3kg/cm2; Feed ratio, 0.98 and Distance between first nozzle and the nip of front roller, 39.5mm]

Yarn Ref. No.	Wrapper fibres/ m			Wraps/cm			Helix diameter, mm			Helix angle, deg		
	150[a]	170[0]	190[a]	150[a]	170[0]	190[a]	150[a]	170[0]	190[a]	150[a]	170[0]	190[a]
S1	9	10	13	12	14	13	0.138	0.130	0.145	39	43	40
S2	7	9	12	11	13	12	0.148	0.144	0.144	38	39	41
S3	11	14	16	14	16	15	0.123	0.121	0.141	42	44	41
S4	9	12	14	12	14	13	0.131	0.124	0.125	41	43	41
S5	11	11	11	13	13	13	0.138	0.138	0.138	44	44	44
S6	5	6	10	8	11	9	0.208	0.198	0.217	38	39	39
S7	4	5	8	7	10	8	0.212	0.203	0.209	38	39	38
S8	8	11	13	10	13	11	0.180	0.173	0.184	40	45	42
S9	6	10	12	9	11	10	0.184	0.183	0.185	40	42	40
S10	7	7	7	9	9	9	0.204	0.204	0.204	41	41	41

[a] Spinning sped, m/min

2.2 Test methods

Prior to processing, 0.8% of viscose fibres dyed with red colour were added to the grey fibres during mixing, and the lot was spun into yarns in a normal manner. Subsequently, the yarns were immersed in methyl salicylate with the same refractive index as the fibres, enabling easy observation of the dyed fibres through an image analyzer. Yarn structural parameters, including wrapper fibres, wraps/meter, helix angle, and helix diameter were then measured for sheath fibres using a Leica Q 500 M C image analyzer. For each yarn sample, eighty yarns with both ends shown on the screen were observed. Additionally, the yarns underwent testing for various properties following ASTM standards. These properties included tenacity and breaking extension (Instron), mass irregularity and imperfections (Uster evenness tester), abrasion resistance (Universal wear tester), and hairiness (Zweigles 565 hairiness meter).

3. Results and Discussion

3.1 Yarn Structural Parameters

3.1.1 Wrapper Fibres

The experimental results for the structural parameters are presented in Table 3. The findings suggest that wrapper fibres are sensitive to the yarn spinning technique, with fewer wrapper fibres observed for core-spun yarns compared to staple spinning. The positioning of the filament at the edge of the fibre ribbon plays a critical role in wrapper fibre formation. The data reveals that placing the filament at the edge of the fibre ribbon leads to a significant reduction in the formation of wrapper fibres. Additionally, the ribbon width is another crucial factor influencing the occurrence of wrapper fibres. As is evident from Table 3, core yarns spun with larger ribbon widths exhibit a higher incidence of wrapper fibres. The increase in wrapper fibres is attributed to the greater number of edge fibres, which later become wrappers after being separated from the main strand due to yarn ballooning action. Among air-jet spun yarns, 19.6 Tex yarns demonstrate a higher incidence of wrapper fibres compared to 29.5 Tex yarns, and this incidence further increases with an increase in spinning speed.

3.1.2 Wraps/m

Table 3 displays the wraps/m concerning different spinning parameters. It is observed that as the yarn linear density decreases from 29.5 to 19.6 Tex, there is a noticeable increase in wraps/m, as expected. In comparison with 100% viscose yarn, core yarns exhibit fewer wrapper fibres, possibly due to increased balloon tension resulting from the higher retraction power of the elastomeric component, This, in turn, disturbs the ballooning action and leads to the generation of wild fibres. While the positioning of the Lycra filament at the edge of the ribbon produces a yarn with fewer wraps/m, the use of a larger ribbon width can enhance wraps/m. On increasing the spinning speed, the wraps/m initially increases but reduces thereafter as the spinning speed is raised to 190m/min. The air flow at the nip of the front roller at higher spped causes the fibres to move away from the fibre bundle, resulting in longer and even wrappings. However, a further increase in spinning speed causes the filament to bounce back to the original position, which, in turn, results in uneven wrapping and consequently decreased wraps/m.

3.1.3 Helix Diameter and Helix Angle

Changes in both yarn linear density and filament position can affect helix diameter and helix angle, although 100%viscose staple yarn is generally bulkier than air-jet spun core yarns (Table 3). When the spinning speed is increased from 150 m/min to 170 m/min, the helix diameter of air –jet core yarns reduces considerably but starts to increase at 190 m/min spinning speed. The initial reduction in helix diameter arises due to more uniform, even, and tight wrappings of wrapper fibres, which later become more irregular at high spinning speeds. The helix diameter of all the yarns produced with a 6 mm ribbon width, however, is much larger than the yarns produced with a 4 mm ribbon width. For all experimental combinations, the helix angle maintains a relationship that coincides with wraps/m.

Table 4: Effect of spinning speed, ribbon width and filament position on tenacity, breaking extension , diameter and abrasion resistance of Lycra-Viscose ring- and air-jet spun core Yarns [NP1, 2.5kg/cm2; NP2, 3kg/cm2; Feed ratio,0.98 and Distance between first nozzle and the nip of front roller,39.5mm

Yarn Ref. No.	Tenacity, g/tex				Breaking extension, %				Diameter, mm				Abrasion resistance, cycles			
	Ring yarn	Air- jet yarn			Ring yarn	Air- jet yarn			Ring yarn	Air-jet yarn			Ring yarn	Air-jet yarn		
		150[a]	170[a]	190[a]		150[a]	170[a]	190[a]		150[a]	170[a]	190[a]		150[a]	170[a]	190[a]
S1	11.5	10.2	10.4	10.2	11.2	9.3	9.5	9.9	0.168	0.158	0.150	0.162	305	223	258	234
S2	11.2	9.5	9.8	9.2	11.0	9.1	9.2	9.6	0.170	0.167	0.163	0.169	340	236	269	253
S3	11.5	8.8	9.4	8.9	11.2	8.8	9.4	9.5	0.168	0.145	0.139	0.158	305	256	287	266
S4	11.2	8.6	9.3	7.9	11.0	8.2	9.1	9.3	0.170	0.147	0.146	0.150	340	290	293	276
S5	14.2	10.9	10.9	10.9	12.2	7.9	7.9	7.9	0.164	0.157	0.157	0.157	78	53	53	53
S6	12.9	9.8	10.1	9.7	12.9	8.4	8.9	9.0	0.228	0.226	0.217	0.218	376	241	301	278
S7	12.7	8.9	9.2	9.0	12.7	8.2	8.7	8.8	0.235	0.230	0.222	0.226	419	320	339	300
S8	12.9	9.1	9.3	8.8	12.9	8.0	8.5	8.8	0.228	0.203	0.189	0.202	376	295	363	350
S9	12.7	8.6	9.1	8.0	12.7	6.8	7.3	7.6	0.235	0.205	0.202	0.200	419	359	390	371
S10	15.0	10.1	10.1	10.1	12.8	6.8	6.8	6.8	0.226	0.219	0.219	0.219	88	67	67	67

[a] Spinning speed, m/min.

3.2 Tensile Properties

Table 4 illustrates that the air-jet spun core yarns, whether produced with Lycra filament positioned at the edge or at the center of the ribbon, are weaker than the conventional core yarn. However, the contribution of the wrap material to the overall yarn tenacity is minimal in both methods. The lower tenacity of air-jet core yarn can be attributed to its unique structure. For both types of yarn structures, the core- spun yarn with the Lycra filament core exhibits significantly lower tenacity than that of the 100% viscose staple yarn. This may be explained by assuming that core spinning lacks good fibre control compared to staple spinning. When comparing the two core-spun yarns, the one spun with centered adjustment on the roving shows markedly higher tenacity than that of the core yarn produced with core at the edge of the roving. Surprisingly, however, the tenacity of air-jet spun core yarns first increases significantly and then drops with increasing spinning speed. This is due to the increase in the incidence of wrapper fibres with increasing spinning speed from 150 m/min to 170 m/min, which produces a compact structural matrix due to increased radial pressure on core fibres. However, at 190 m/min spinning speed, the fibres are less compact due to increased yarn unevenness. Consequently, there is less radial pressure on core fibres, affecting the average value of packing density and yarn tenacity. On the other hand, a consistent decrease in core yarn tenacity with an increase in ribbon width could be related to the large reduction in load bearing core fibres [10]. Regarding yarn linear density, yarn tenacity shows opposite trends for ring- and air-jet spun core yarns. In the case of ring-spun yarns, the tenacity is lower, as usual, for finer yarns. However, for air-jet spun yarns, the tenacity is higher for 19.5 Tex yarns, and it decreases as the yarn linear density increases to 29.5 tex.

Invariably, ring- and air-jet spun core yarns exhibit higher breaking extension than that of 100% viscose staple yarn. However, air-jet spun core yarns are less extensible than their ring-spun counterparts. On the other hand, the breaking extension of air-jet core yarn spun with a centered filament position is much higher compared to the core yarn spun with the filament positioned at the edge of the roving. Both yarn linear density and ribbon width play a significant role in influencing breaking extension .As can be seen from Table 4, the breaking extension is appreciably low in coarse core yarns, and it decreases further with an increase in ribbon width. This may probably arise from a high wrapper -to- core fibre ratio that makes the yarn insufficient to sustain tensile loading, leading to a decrease in breaking extension. Changes in spinning speed also has a marked impact on yarn breaking extension, and the core yarns spun with a higher spinning speed have much higher breaking extension.

3.3 Bulk

Table 4 compares the diameters of lycra-viscose ring- and air-jet spun core yarns. Generally, air-jet spun core yarns possess less bulk than their ring-spun counterparts, and its variance depends on the experimental conditions used. The lesser bulk of air-jet spun core yarns results from a higher incidence of wrapper fibres and wraps/m, causing the structural matrix to become more compact. On the other hand, lycra-viscose core yarns, whether produced on ring- or air jet spinner, are bulkier than 100% viscose staple yarn owing to poor fibre control exercised during core yarn spinning. Among the air-jet spun core yarns, the yarn spun with the centrally positioned filament has less bulk than that of the core yarn produced with the filament at the edge of the ribbon. The impact of yarn linear density is along the expected lines, a higher linear density results in higher bulk. As the spinning speed increases, the bulk of air-jet spun core yarns first reduces significantly and then increases. This is because of higher fibre cohesion attained at higher spinning speeds due to the presence of more wrapper fibres and hence compact yarn. However, at a spinning speed of 190 m/min, uneven and irregular wrappings are formed, which, in turn, exerts less radial pressure on the core fibres, resulting in a larger yarn diameter. Furthermore, the average yarn bulk reduces significantly with an increase in ribbon width.

3.4 Abrasion Resistance

Table 4 depicts the number of rubs required to rupture lycra-viscose ring- and air-jet spun core yarns. Invariably, core-

spun yarns exhibit higher abrasion resistance than 100% viscose staple yarn, regardless of the spinning system used. This is quite understandable and is the result of high abrasion resistance of the Lycra filament present in the core yarn. Amongst air-jet spun core yarns, the one spun with the filament positioned at the edge of the ribbon displays much higher abrasion resistance than that spun with filament positioned at the center, the presence of a high abrasion-resistant filament at the surface reduces the intensity of abrading action. Increasing spinning speed from 150 m/min to 170 m/min enhances the abrasion resistance of air-jet spun core yarns due to an increased incidence of wrapper fibres. However, a further increase in spinning speed no longer favors an increase in abrasion resistance on account of decreased packing density. Moreover, abrasion resistance increases with an increase in both yarn linear density and ribbon width.

3.5 Hairiness

Table 5 shows the hairiness of different yarns. Under all experimental conditions, the hairiness of core-spun yarns is generally higher than that of 100% viscose staple yarn. This is an expected consequence of poor fibre control exercised in core spinning compared to staple spinning control. However, the core-spun yarn with the centered adjustment of the filament core has much less hairiness than that of the core-spun yarn produced with the core at the edge of the ribbon. On the other hand, the hairiness of air-jet spun core yarns tends to increase with an increase in spinning speed and ribbon width, owing to an increase in number of floating fibres [11]. When comparing ring- and air-jet spun core yarns, the hairiness of the former is lower. However, the variation in hairiness is greater for the air-jet spun yarns than for the ring-spun yarns. Hairiness increases with increasing yarn linear density for both ring- and air-jet spun yarns.

3.6 Unevenness and Imperfections

Table 5 shows that Uster values (U %) and imperfection figures for core-spun yarns are generally much less than those for 100% viscose staple yarn. Although thin places (50%) per 1000- meter length of the 100% viscose staple yarn are considerably higher than that of the core-spun yarns, the other IPI values (imperfections per 1000 meter) are very close to those for the three types of yarns produces on the air-jet spinner. This suggests that core-spun yarn spinning process does not adversely affect yarn evenness and imperfections.

4. Conclusions

Yarn characteristics in air-jet spun core yarns are influenced by factors like linear density, ribbon width, spinning speed, and filament position. Fine air-jet spun core yarns have smaller helix diameter, more wrapper fibres, and wraps/cm, along with a larger helix angle compared to coarse core yarns. Increasing spinning speed generally leads to more wrapper fibres, but wraps/cm and helix angle initially increase and then decrease. Placing the filament at the center increases wrapper fibres and wraps/cm but reduces helix diameter. Larger ribbon width in core yarns results in a larger helix diameter, smaller helix angle and more wrapper fibres and wraps/cm.

Air-jet spun core yarns, overall, are weaker, less extensible, hairier, and have poor abrasion resistance compared to conventional core yarns. However, filament positioning on the roving significantly affects core yarn quality. Core yarns with a centered lycra filament display higher strength and breaking extension, less bulk, less hairiness, poorer abrasion resistance, regularity, and more imperfections, irrespective of yarn structure.

High spinning speed is crucial for air-jet spinning to generate ample wrapper fibres. The optimal speed around 170 m/min, depends on factors like filament position, ribbon width, and yarn linear density. Inadequate wrapper fibres result from a too-small ribbon width, leading to a weak yarn. Conversely, an overly large ribbon increases wrapper fribres, negatively impacting yarn regularity and hairiness. While thin places in 100% viscose staple yarn exceed core-spun yarns, other imperfections per 1000-meter values are similar. This suggests that core-spun yarn spinning process does not detrimentally affect yarn evenness and imperfections.

Table 5: Effect of spinning speed, ribbon width and filament position on hairiness, unevenness and imperfections of lycra-viscose ring- and air-jet spun core yarns [NP1, 2.5kg/cm2; NP2,3kg/cm2; Feed ratio 0.98 and Distance between first nozzle and the nip of front roller,39.5mm]

Yarn ref. no.	Hairs/10m				Unevenness, U%				Imperfections/100m			
	Ring yarn	Air-jet yarn			Ring yarn	Air-jet yarn			Ring yarn	Air-jet yarn		
		150[a]	170[a]	190[a]		150[a]	170[a]	190[a]		150[a]	170[a]	190[a]
S1	62	51	82	94	10.7	13.1	12.4	11.6	4	22	12	13
S2	65	70	90	108	11.1	12.5	12.3	11.1	8	19	24	30
S3	62	104	156	200	10.7	12.8	12.4	12.0	5	14	20	15
S4	65	108	180	202	11.1	12.7	12.6	12.3	8	17	12	15
S5	47	59	59	59	11.7	13.1	13.1	13.1	9	20	20	20
S6	64	83	104	116	9.5	12.8	12.3	11.6	3	5	33	8
S7	68	126	132	176	10.1	12.3	10.8	10.6	8	4	7	22
S8	64	210	232	242	9.5	12.6	12.2	12.1	3	6	12	12
S9	68	282	313	234	10.1	11.4	11.0	11.0	8	5	6	5
S10	50	53	53	53	11.5	13.0	13.0	13.0	9	14	14	14

[a] Speed, m/min

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Potential Future Developments in the Global textile Industry in 2024

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Vilas Gharat

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

Mr. Gharat is having Specialization in various field of textile value chain like;

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

He has wide experience in:
Business Consultant for Oswal Hammerle, for their upcoming state of art technology plant for manufacture of sophisticated Yarn Dyed Shirting Project, primarily catering to the needs of international garment manufacturers. This is a Joint Venture project of Oswal group and F.M. Hammerle (Austria)

His previous assignment involves restructuring and transformation of a large Textile units

He worked with various executive capacities as Executive Director -Suvin Advisors Pvt Ltd.; Senior President in S Kumar's., Technical & Commercial Advisor in J. K. Cotton Mills, Senior President in Morarjee Brembana Ltd., Birla's in Indonesia, Oswal Hammerle, Bhojsons, Nigeria etc.

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

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

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Sustainability and Eco-Friendly Practices

- Increased emphasis on sustainability and eco-friendly practices throughout the entire textile supply chain, driven by consumer demand and regulatory pressures.
- Greater adoption of recycled materials, up-cycling, and sustainable production methods to minimize environmental impact.
- Expansion of certifications and standards for sustainable and ethical textile production, ensuring transparency and accountability in the industry.

Digitalization and Automation

- Continued integration of digital technologies, such as automation, AI, and big data analytics, to streamline operations, enhance productivity, and optimize resource utilization.
- Adoption of digital platforms for supply chain management, inventory tracking, and e-commerce to improve efficiency and responsiveness to market demand.
- Implementation of 3D printing and digital design technologies for rapid prototyping and customization, leading to faster product development and reduced waste.

Smart Textiles and Wearable Technology

- Advancements in smart textiles and wearable technology, with a focus on integrating electronics, sensors, and connectivity into clothing and textile products.
- Growth of smart apparel for health monitoring, sports performance, and lifestyle applications, creating new market opportunities and enhancing consumer experiences.
- Development of sustainable smart textile materials and manufacturing processes to address concerns about electronic waste and environmental impact.

Global Supply Chain Shifts

- Continued diversification and reshaping of global textile supply chains in response to geopolitical and economic dynamics, emerging market trends, and trade policies.
- Increased localization and regionalization of production to mitigate risks associated with long and complex supply chains, leading to more resilient and agile manufacturing ecosystems.
- Shifts in sourcing strategies and partnerships to leverage regional strengths, promote ethical practices, and ensure supply chain flexibility.

Innovation in Textile Materials

- Advancements in sustainable and high-performance textile materials, such as biodegradable fibres, bio-based polymers, and advanced composites, to meet evolving consumer and industry needs.

- Application of nanotechnology and biotechnology in textile material development, leading to functional fabrics with enhanced properties, such as durability, water repellence, and antimicrobial characteristics.

- Exploration of unconventional and renewable sources for textile materials, including agricultural by-products, waste streams, and natural fibres, to reduce reliance on traditional resources.

Consumer-Centric Customization

- Growing demand for personalized and customizable textile products, driving the adoption of on-demand manufacturing, mass customization, and co-creation approaches.

- Integration of digital tools and platforms for consumer engagement, allowing individuals to participate in the design and personalization of their clothing and home textile items.

- Collaboration between brands, retailers, and consumers to co-create sustainable, tailor-made products that reflect individual preferences and values.

Regulatory and Trade Dynamics

- Changing regulatory landscape impacting the textile industry, including evolving standards for environmental protection, labour rights, and chemical management.

- Continued trade tensions and trade policy shifts influencing global textile trade patterns and market access, prompting companies to adapt their sourcing and production strategies accordingly.

- Heightened focus on responsible and transparent supply chains, with stricter due diligence requirements for companies to ensure ethical practices and sustainability throughout their operations.

- Global Fashion industry

- Continued growth in sustainability and ethical fashion practices

- Increasing use of technology and AI in design, production, and retail

- Growing demand for diversity and inclusivity in fashion marketing and branding

- Shift towards more conscious and mindful consumption habits

- Emphasis on transparency in the fashion supply chain

- Expansion of online and digital platforms for fashion retail

- Renewed focus on local and artisanal production

- Adoption of circular economy principles in the fashion industry

- Integration of virtual and augmented reality experiences in fashion retail and marketing

- Greater collaboration between fashion brands and technology companies

Applications of Artificial Intelligence (AI) in the Textile Industries

Dr. N. N. Mahapatra
Business Head (Dyes), Shree Pushkar Chemicals & Fertilisers Ltd.. Goregaon (East), Mumbai, India

Artificial Intelligence is the future of textile manufacturing. Whether it's used to automate production or help factories improve quality, AI has the potential to revolutionize the entire industry from top to bottom. The textile industry impacts nearly every facet of our life. From clothing to home decor, textiles are everywhere. However, like many other industries, textile manufacturers face significant challenges like high competition, supply chain disruptions, rising costs, and low efficiency.

Artificial Intelligence (AI) has the potential to revolutionize the textile industry. It can provide solutions to these challenges and unlock new opportunities for growth and innovation. Let's explore how AI will impact the textile industry, and how textile businesses can leverage AI to stay competitive.

Artificial Intelligence (AI) is one of the most talked about technologies today (and that includes the fashion and textile industry). It's being actively used to digitally transform the finance, healthcare, automotive industries and more. While its application might be controversial for certain creative industries, many experts think that AI can help solve many of the long standing challenges that the textile industry faces today.

What is Artificial Intelligence (AI)?
Artificial intelligence refers to a simulation of human intelligence in smart machines which are programmed to think like humans, and mimic their actions. It is a wide-ranging branch of computer science which concerned with building machines capable of performing tasks that typically require human intelligence. The term AI can also be applied to any machine that exhibits traits associated with a human mind such as learning and problem-solving.

Why AI Used in Textile Industries?
The high demand for the quality increased leading to the application of automated artificial intelligence in textile industries recent years. The automation with applications of artificial intelligence in textile production is becoming much popular due to the technical developments and the use of modeling and simulation.

Artificial intelligence (AI) is gaining impetus over the last two decades, in the textile industry. The automation of various instruments by the application of artificial intelligence in spreading, cutting, sewing, and material handling can reduce the production cost and minimize faults in the overall textile production.

In many instances of textiles production, there are huge chances of error. The application of the AI can deal with the production process without error. As a result, over the last decade, the use of AI is rapidly growing in textile industries for various applications.

Textile industries are becoming more automated to cater the increasing demand of consumers. Adoptions of AI reduce the number of faults, and keep the production cost low. It is applied in all the stages (preproduction, production, and postproduction) of textile manufacturing.
AI is increasingly used to different stages of a sewn seam, design development, in PPC, fabric spreading, cutting, bundling, in various sewing operations, pressing, ironing, packaging, quality control, SCM, etc. Some of the important applications of artificial intelligence in textile industry are discussed in the below section. Out of several types of artificial intelligence, Artificial Neural Network (ANN) is widely used in textile industry in the following fields:

Following are the application of AI in the textile mills.

1. Optimize Textile Production
Textile mills can use AI-powered robots to automate tedious tasks like material handling and cutting to improve precision and accuracy, leading to higher productivity and fewer errors. They can use AI to analyze large amounts of data from textile production to optimize production schedules. Artificial intelligence and Machine Learning (ML) can help textile manufacturers optimize production processes, increase efficiency and reduce costs. Textile mills can use AI-powered robots to automate repetitive tasks like material handling and cutting to improve precision and accuracy, leading to higher productivity. They can use AI to analyze large amounts of data from textile production to optimize production schedules.

2. Auto-Schedule Predictive Maintenance
Textile businesses can use AI-powered sensors and monitoring systems to predict when equipment is likely to fail and schedule maintenance accordingly. This can help reduce downtime and increase productivity. Predictive maintenance allows textile companies to optimize their maintenance schedules, reducing the need for unnecessary maintenance, further increasing efficiency.

3. Production planning and control
Production planning and control (PPC) coordinates between various departments of production so that delivery dates can met and buyer orders are delivered on time. AI can be used to solve of the machine layout, operation assignment, sewing line balancing, etc. AI can help in achieving the main purpose of PPC.

4. Dyeing & Colour Matching
Colour is an important aspect of textile products. The appearance of a textile product is perceived to be related to its quality. The colour of a product is judged to be acceptable/unsatisfactory, or it can be judged in more details to be: 'too light 'or, 'too dark', 'too red' or, 'too green'. To solve this problem, AI can be developed that has 'Pass/Fail' feature to help improve the accuracy and efficiency.
AI can be used to improve the precision and accuracy of color

matching and dye formulations. With AI, textile companies can identify the ideal color match and dye formulation for a specific product. AI-powered systems can predict color fading, enabling businesses to make adjustments to the dye formulation, and reduce waste and costs. AI can also optimize the dyeing process, reducing water and energy consumption.

With AI, textile companies can improve the precision and accuracy of color matching and dye formulations. AI-powered systems can predict color fading, enabling businesses to make adjustments to the dye formulation, and reduce waste and costs. AI can also optimize the dyeing process, reducing water and energy consumption.

5. Fabric defect identification

AI-powered sensors, cameras, and ML algorithms in textile factories can improve the accuracy and efficiency of quality control processes. AI-powered cameras can be used to identify defects such as holes, stains, and uneven stitching, in real time, and with a high degree of accuracy. Textile companies can reduce the need for human inspection by using Artificial Intelligence, which can bring down costs and human errors.

Defects in fabric reduce the value of the textile products. Any defect in the fabric is passed into the final product, which can result in the rejection. That's why fabric it is very essential to check the quality of the fabric before the manufacturing. Fabric inspection is manually checked by skilled workers using lighted tables with equipment. This process is slow and many times can allow faults to pass to the product.

In this case, the application of AI can perform this task at a faster rate, with much higher accuracy and without fatigue. Artificial intelligence can be used to predict the fabric properties before manufacturing with the help of the neuro-fuzzy or other system by using the yarn, and fabric's constructional data.

AI-powered sensors, cameras, and ML algorithms in textile factories can improve the accuracy and efficiency of quality control processes. They can identify defects such as holes, stains, and uneven stitching, in real-time and with a higher degree of accuracy than human quality specialists.

6. Pattern inspection

Fabric pattern may have multiple aspects such like: weaving, knitting, braiding, finishing, and printing, etc. By replacing visual inspection with vision-based inspection could help manufacturers avoid human fatigue and errors in the detection of novelties and defects. AI techniques like ANN are applied for defect identification in fabric inspection of the textile industry. The fabric picture to be analysed is obtained from the image acquisition system and saved in relevant standard image format (.JPEG, .JPG, .PNG etc.). Different Multi-Layer back propagation algorithm is used to train and test this ANN system. The system learns the weaving pattern, yarn properties, colours and tolerable imperfections from these images.

7. Sewn seam

In sewn, seams and stitches are used to join two or more pieces of fabric together. The ease of seam formation and the performance of the seam are the important parameters are known as "sew-ability." Fabric low-stress mechanical properties such as tensile, shear, bending, etc. may affect the sew-ability. Artificial intelligence system can be used to find the sew-ability of different fabrics during the production.

8. Minimize Supply Chain Risks

Textile manufacturers can use AI-based analytics to predict demand, optimize production schedules, and manage inventory levels in real-time. AI-powered systems can identify and mitigate supply chain risks, where potential issues are addressed proactively. Supply Chain Management in fashion includes the flow of fibres, yarns, fabrics, garments, trims, and accessories in between different production points or to retail. SCM integrates various business processes, activities, information, and resources for creating value for the buyers. Standard Supply Chain Management can manage the cost and business competitiveness.

9. Inventory Management

Utilizing AI in textiles can predict demand, optimize production schedules, and manage inventory levels in real time. AI-powered systems can identify and mitigate supply chain risks, where potential issues are addressed proactively. AI not only improves efficiency and reduces costs, but it also leads to faster time-to-market, better customer service, and increased competitiveness.

Textile companies can use AI to analyze sales data and predict future demand to make more informed decisions about inventory levels, reducing the risk of stockouts and overstocking. Using AI in textile companies can help identify slow-moving items, allowing them to adjust their inventory and distribution strategies. : Textile companies can use AI to analyze sales data and predict future demand to make more informed decisions about inventory levels, reducing the risk of stockouts and overstocking. Using AI in textile companies can help identify slow-moving items, allowing them to make adjustments to their inventory and distribution strategies.

10. Design Textiles

Textile designers can use generative AI to create new patterns, textures, and designs faster and more efficiently. AI-powered systems can also be used to analyze consumer preferences, allowing designers to create designs that are more likely to appeal to customers. CAD systems: One of the important steps in textile production is pattern making. In this process, basic patterns are made by the designers and subsequently digitized to computer. Various CAD software are used in the textile industry for pattern-making, digitizing, grading, and marker planning.

The CAD software helps in achieving high productivity and improved quality of the product. AI can be used to help textile designers create new patterns, textures, and designs. They can employ ML and generative AI to create new designs faster and more efficiently. This can increase creativity and innovation in textiles. AI-powered systems can also be used to analyze consumer preferences, allowing designers to create designs that are more likely to appeal to customers.

11. Market Analysis & Demand Forecasting

AI can help analyze textile market trends and make forecasts.

By analyzing large amounts of data, such as sales data, consumer preferences, and industry trends, textile companies can gain valuable insights into the market and make more informed business decisions. Additionally, AI-powered systems can be used to predict future market trends, allowing textile companies to proactively adapt to changes in the market.

12. Energy Management

AI can improve energy management in textile factories by regularly monitoring energy consumption.AI in textile mills can identify areas where energy is being wasted and take steps to reduce consumption. By using AI for energy management, textile companies can reduce energy costs, increase efficiency and minimize their environmental impact. Furthermore, this can help textile companies to comply with energy regulations and reduce their carbon footprint. AI in textile mills can identify areas where energy is being wasted and take steps to reduce overconsumption. This can help textile companies reduce energy costs, minimize their environmental impact and thus comply with current and upcoming energy regulations.

13. Final inspection

The inspection of finished and semi-finished textile product during their production is essential to get fewer rejections. The final quality inspection of finished garments is mainly done by experienced people, which is very time-consuming and may be influenced by the physical and mental condition of the inspector. As a result, automated AI inspection is essential to achieve the efficiency and accurate results. Automated inspection can be performed by the use of AI and image processing for inspection of the quality of the product.

14. Virtual Showroom Simulation

AI-powered virtual and augmented reality technology can be used to create immersive virtual showrooms. Textile companies can use this technology to showcase their products to customers in more interactive and engaging ways. Virtual reality can be used to simulate the production process, allowing textile companies to test new ideas and designs. The existing AR/VR technologies will get a big boost in creative capabilities from generative AI. AI will allow textile firms to visualize realistic immersive virtual factory twins and virtual showrooms. They can simulate the entire production process to get better transparency, spot hiccups, and test new ideas.

15. Apparel Retails

In Apparel retail, specifically, e-commerce, is driven by the fashions trending globally. AI helps computers identify images and recommend those products online which the customer is more likely to buy. E-commerce platforms, through artificial intelligence capabilities, are able to leverage the information available about the customers, and their inclinations, similarities, and differences in the kinds of applications and products they seek for. In this way AI can actually create a personalised shopping experience.

16. Reinforcement Learning

Garments industry, specifically apparel manufacturing is a set of processes carried on repeatedly. AI is used for reinforcement learning can be used to teach computers to take different actions based on the situational parameters. It is the best possible for the optimal decisions in that situations. In this way, AI can be used in many processes like cut-order-planning, line balancing, inspection decisions, etc.

17. Communication

AI can help reduce the manual efforts required for communication via natural language processing and learning capabilities. It helps the businesses automate conversations with the buyers. AI can help the business transpire with low error scope and personalised experience for the buyers.

18. Data Analysis: Artificial intelligence intervention can help the industry to not just analyse large data volumes, but also predict consumer trends, making merchandising operation error free, and more aligned to that customer needs.

19. The Impact of AI in the Textile Industry

a) Trend-Spotting: With artificial intelligence, fashion brands can boost their business by tracking the latest fashion trends in just minute which would take days or even months.

b) Machine-assisted designs: AI tool can be analysed and learned the interred images and accordingly generate an altogether new fashion by itself.

c) Customers Experience: From providing customers with personalized advertisement notifications to alerting them on price drops to clearing their doubts or queries with chat bots to being a personal stylist. AI can provide customer instant outfit suggestions and fashion brands can meet their aim of elevating customer experience.AI system is one of the best choices in the textile industry to integrate the features like production, quality, cost, info, applied mathematics method management, just-in-time production and digital integrated production. Artificial intelligence in the textile industry brings cutting-edge revolution and disruption that's never been seen before. The application of artificial intelligence in textile industry has a bright future similar to other areas of applications.

It seems like nearly every industry is harnessing the power of AI, including garments and textiles. But there are many more technologies such as Internet of Things (IoT), deep learning and blockchain, among others that textile firms can use to optimize their operations.

- AI can help optimize supply chain logistics and ensure that raw materials are delivered on time, saving money and improving quality.
- With AI, machines will be able to make smarter decisions about when, where, and what to produce, which will help reduce costs and waste at textile mills.
- AI will allow for more efficient data collection which will make it easier for companies to manage their supply chains effectively.

Post Event Report - International Conference
"Sustainability and Circularity - The New Challenges for the Textile Value Chain"

The Textile Association (India), Mumbai Unit organized International Conference on "Sustainability and Circularity - The New Challenges for the Textile Value Chain" on Wednesday, 31st January 2024 at Hotel the Lalit, Mumbai. The Conference received overwhelming response with 275 delegates in attendance. The theme of Conference, topics, presentations, and speakers were highly appreciated by one and all.

Guest of Honour Ms. Seema Srivastava, Executive Director, India ITME Society lighting the lamp L to R: Dr. G. S. Nadiger, Dr. Naresh Tyagi, Mr. R. R. Patil, Mr. Rajkumar Agarwal, Mr. A. V. Mantri, Dr. Sharad Kumar Saraf, Ms. Seema Srivastava, Mr. V. C. Gupte, Mr. G. V. Aras, Mr. Rajiv Ranjan

Table 4: ANOVA model results of Sapindus extract degumming of Tussar silk

Mr. V. C. Gupte, Chairman, TAI, Mumbai Unit and Convener of the Conference welcomed Guest of Honour, Ms. Seema Srivastava, Executive Director, India ITME Society, Keynote Speaker, Dr. Naresh Tyagi, Chief Sustainability Officer, Aditya Birla Fashion and Retail Limited, Awardees, Speakers, Press, Media, and delegates. Mr. Gupte welcomed and congratulated two awardees Dr. Sharad Kumar Saraf for The Lifetime Achievement Award and Mr. Rajkumar Agarwal for The Industrial Excellence Award. Mr. Gupte explained what is circularity and circularity model, in which all materials are viewed as a resource, there is no waste. A circular textiles system will require solutions that would enable us to recycle textiles back into textiles without degrading quality. He explained when a product reaches the end of its life, its materials are kept within the economy wherever possible, The circular economy involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible. These can be productively used again and again, thereby creating further value. This is Circular Economy which is departure from the current model of which is based on a take-make-consume-throw away pattern. However, it is now realized to relook at this model for better sustainability of the planet Earth.

He mentioned that TAI, Mumbai Unit has always selected contemporary & innovative topics in all the conferences organized and presentations by high profile speakers. This conference is also no exception to the set tradition especially the theme being of international importance.

Presidential Address by Mr. Rajiv Ranjan, President, TAI, Mumbai Unit

Address by Conference Chairman, Mr. G. V. Aras

Mr. Rajiv Ranjan, President, TAI, Mumbai Unit in his Presidential Address started with the UN definition that a

sustainable development meets the needs of the present generation without compromising the ability of future generations to meet their needs. Since the textile industry was very polluting in nature and as per estimate more than five per cent of total Green House Gas (GHG) emission was due to this industry, the 3R principle of Reduce, Recycle and Reuse was never more valid. In its efforts towards sustainability, it was extremely important for the textile industry to look at steps to conserve resources, optimise efficiencies across the manufacturing process and minimize waste at every stage. If a proper mechanism was adopted by the industry to work on collection for recycle and reuse, then remarkable changes could be brought to nurture sustainable development. ESG (Environment, Corporate and Social Governance) and sustainability were essential principles that organizations must adopt to operate in a responsible and sustainable manner. These measures not only benefit the environment and the society, but they also contribute to the company's long term profitability and success.

Mr. G. V. Aras, The Conference Chairman and Trustee, TAI, Mumbai Unit briefed about the details of the Conference, including topics and speakers. He said every attempt has been made to address the theme from the perspectives of organized industry and MSMEs apart from international perspectives. Sustainable development with circularity is emphasized by the speakers from different angles so that a holographic picture can be conceived at the end of the conference. He reiterated that sustainability and circularity are the most important aspects of manufacturing for reducing environmental impact. While sustainability is the goal, circularity is a milestone that results to achieve sustainable objectives. In circularity model, all materials are viewed as resources and as such there is no waste. A circular textile system requires solutions that would enable us to recycle textiles back into textiles without degrading quality.

Key Note Speaker Dr. Naresh Tyagi, Chief Sustainability Officer, Aditya Birla Fashion and Retail Limited addressing the gathering

Dr. Naresh Tyagi, Chief Sustainability Officer, Aditya Birla Fashion and Retail Limited in his Keynote address described the sustainability and various steps involved in establishing the goals set towards circularity. He emphasized that the holistic approach to develop strategies to achieve the goals set and collate with national and global perspectives. He described the various facets of sustainability and in turn strategies developed through circularity in line with sustainable development goals set by UNO as India is a signatory for the seventeen sustainable goals. With his rich experience in sustainability solutions at Birla Cellulose, he unfolded in a lucid way the importance of the subject and relevance to textile and clothing industry.

His keynote address set the pace of the theme of the conference rolling to extend the deliberations on various other aspects of sustainability and circularity.

Honouring the best in class under the Textile and Trade Family Tree

TAI Mumbai Unit takes it as privilege to honor the distinguished achievers in the textile trade and industry every year. As a tradition, the following luminaries were honored during the international conference.

Dr. Sharad Kumar Saraf, Chairman and Managing Director, Technocraft Group receiving The Lifetime Achievement Award by the hands of Guest of Honour Ms. Seema Srivastava

Mr. Rajkumar Agarwal, Managing Director, SVG Fashions Ltd. receiving The Industrial Excellence Award by the hands of Guest of Honour Ms. Seema Srivastava

The Lifetime Achievement Award

The Textile Association (India), Mumbai Unit has set a precedent by felicitating the textile professionals/industrialists for their outstanding contribution to the textile industry. In this Conference, the TAI, Mumbai Unit felicitated Dr. Sharad Kumar Saraf, Chairman and Managing Director, Technocraft Group with

"The Lifetime Achievement Award" for his Contribution and Services to the Textile & clothing Industry. In his remarks, the awardee Dr. Saraf highlighted the key features of sustainability based on his rich experience in the industry and trade.

The Industrial Excellence Award

TAI, Mumbai Unit also felicitated Mr. Rajkumar Agarwal, Managing Director, SVG Fashions Ltd. with "The Industrial Excellence Award" for his contribution in the field of textile and clothing industry. Mr. Rajkumar in his remarks, emphasized the role of the textile and clothing sector in the light of international scenario.

Guest of Honour Ms. Seema Srivastava, Executive Director, India ITME Society addressing the gathering

Release of Book of Papers

Ms. Seema Srivastava, Executive Director, India ITME Society who was the Guest of Honor addressed the delegates. She described the importance of the theme of the conference regarding holistic approach for the development of the textile and clothing sector. She highlighted the synergy of machinery development and promotion in achieving the sustainability and circularity. She complimented the TAI, Mumbai Unit for choice of the topic and organizing the international conference as it is an important topic of current interest to the textile trade and industry.

Knowledge Sharing and Informative technical sessions

The international conference organized with two technical sessions and one panel discussion. A summary of the proceedings is described below under the head of the name of the eminent speakers:

- Mr. Ullhas Nimkar, Chairman, NimkarTek Technical Services Pvt. Ltd. presented a paper on "Understanding Sustainability and Circularity in the Textile Value Chain". With his vast exposure to national and international ecosystem in the context of the theme of the conference, he described in lucid terms the significance of circularity and sustainability in textile value chain. He took various cases in the recycling of waste and development of sustainable fibres which are beneficial to the ecology and environment management.

- Mr. Mayank Mody, Director, Mody Linen Fibre Pvt. Ltd; and Dr. G. S. Nadiger, General Secretary, Non-Conventional Fibres Association made the presentation on "Sustainability in Textile Fibres". Presentation highlighted the role of non- conventional fibres as supplementary raw material base to be harnessed to address some of the key aspects of circularity and sustainability. Keeping the potential of these fibres, the use of them as an additional source of raw material to supplement the needs of the textile industry is an important step in sustainable development. The nonconventional fibres originate from three sources: namely plant, animal, and manmade routes. However, the presentation focused on the fibres from plant origin. Authors emphasized the developmental activities taken up jointly by Nonconventional Fibre Association (NCFA) and Mody Linen Pvt Ltd. Continuing the presentation, advantages of fibres such as banana, sisal, flax, bamboo, hemp, and screw pine fibres. Among the animal fibres, it was listed that the wild silks such as Eri, Muga and Taser along with pashmina are very important from Indian context.

- Mr. Shiladitya K. Joshi, Deputy General Manager - Product & Marketing, Truetzschler India Private Limited, made the presentation on "Truetzschler's Approach towards Sustainability". As one of the leading machinery manufacturers globally, presentation focused on machineries required for recycling of the textile/fibres to address circularity. He informed the appropriate machines and technology available for the recycling of different types of reclaimed textiles towards sustainability.

- Mr. Prashant M. Pote, Customer Relations Management Manager, India, bluesign technologies AG made the presentation on "bluesign ® Solutions for Sustainability & Circularity". The speaker discussed the scope of the ecolabel "Bluesign" with four tiers of achieving the sustainability. The tiers included people (Consumer Safety and Occupational Safety); Environment (Water Emission, Air Emission, Wast & Soil); Resources (Energy, Water, Chemicals, Raw Materials including Benchmarking) and Blue Sign System (Risk minimization, Reduction of impacts, Protection of people and environment & Resource productivity). In achieving the approval of 'bluesign' labelling, role of testing in the entire lifecycle process as the important step was highlighted in establishing the ecofriendly features of the process/materials involved.

- Mr. Umasankar Sinha Mahapatra, Managing Director, Pulcra Chemicals India Pvt. Ltd. made the presentation on "Sustainable Wet Processing of Textiles". Speaker highlighted the scope and goal of establishing the circularity and sustainability in the textile value chain while illustrating the developmental work done by M/s Pulcra Chemicals India Pvt Limited. He informed Fashion & textile industry in one of the top manufacturing sectors in terms of its negative environmental footprints. There is an immediate need to adopt more sustainable practices to make it safer to the consumers and to the environment. Various material innovations are happening in sustainable fibers, but unless those are processed using sustainable processing chemicals, it's not complete. Textile processing chemicals can be categorized in two buckets: a. EcoLogical Textile Products and b. EcoNomical Textile Processes.

- In case of EcoLogical textile products, it is produced from renewable sources, mostly biodegradable, recycled and none/less toxic. In case of EcoNomical Textile Processes, it helps to reduce resource (water, energy & time) intensity of the manufacturing process. Processing chemicals play a vital role in both these categories. Product designing plays a big role in making products safe for use by consumers, during service life (low temp washing, quick drying) and at end of life (easy to recycle/safe disposal). Various biobased/biodegradable functional finishes are available to improve product features, such as thermal regulations, moisture management, safer DWR and stain release. Health & hygiene of wearers can be improved by using performance finishing such as plant-based antimicrobial, skin moisturizing finishes etc. There are use cases of adopting pro- biotics and CBD based products in textiles. Case studies of some of these products and processes are available from Pulcra Chemicals and Devan Chemicals (part of Pulcra Group). Breviol DNV is a sustainable dyeing technology for Indigo and/or Sulphur dyed Denim which reduces water and dyes consumption along with making the effluent much cleaner than traditional dyeing process. Sustineri coloring technology is revolutionary single bath pretreatment and dyeing technology which can reduce water, steam, and electricity consumption up to 60% for 100% cotton and Polyester/Cotton fabrics. Many innovations happening in processing equipment as well which can help making wet processing more sustainable. Some of these new technologies are disruptive in nature making use of spray, plasma, laser, ultrasonic etc.

- Dr. Ratnakar R. Mahajan, Regional Technical Manager, Maccaferri Environmental Solutions Pvt. Ltd. made the presentation on "Nurturing the World of tomorrow using Geosynthetics". The speaker discussed the importance of geosynthetics in various infrastructure projects and its impact on environmental aspects. While describing various projects, the highlights of the activities of the organization over a period were narrated by the speaker.
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- Mr. Ranga Nathan NS, Vice President – Head of Customer Engagement, TextileGenesis made the presentation on "Why Traceability has become top-priority for Fashion brands". The presentation highlighted the importance of traceability in the context of sustainability and circularity. The speaker informed the role and contribution of TextileGenesis in the context of Life Cycle Assessment/impact in the value chain right from raw material to finished goods.

- Dr. Ajay Ranka, Chairman and Managing Director, Zydex Group made the presentation on "Farm & Forest Sustainability for Organic Fibre Production – Profitable one crop transition". In his presentation, he informed that today, India is the largest organic cotton grower in the world, accounting 50% of global share but represent less than 1% of total cotton produce. The process of conversion of conventional farms to organic remains financially unfeasible for most farmers, despite various benefits. During transition, yields drop significantly leading to losses to farmers, thereby conversions become a challenge. As an acceptable solution to organic farming, the speaker highlighted the developments made in their organization. He informed that Zydex has developed Zytonic Soil amendment technology platform, inoculated with mycorrhiza and different microbial like NPK consortia, which help for faster conversion of soil to organic farms. It addresses all the aspects of physical, biological, and chemical properties of farm soils. This is a biodegradable and biology boosting technology. It makes soils soft and reduces crusting, thereby improving germination and helps in faster transition to organic farms. He also conveyed that there are case studies carried out by the company in adapting them for harnessing positive results. A positive note on the developments highlighted include Zydex with its innovative Zytonic technology is collaborating with stakeholder to revive cotton land, making farming processes sustainable and organic all in a single crop cycle.

There was good interaction by speakers with the delegates during question answer sessions resulting thereon effective delivery of the though sharing on the theme of conference "Sustainability and Circularity".

Panel Discussion on "Achieving the UN Sustainable Development Goals (UN-SDGs)"

The third technical session was Panel Discussion with the theme "Achieving the UN Sustainable Development Goals (UN-SDGs)". The panel discussion was moderated by Ms. Chandrima Chatterjee, Secretary General, CITI. The Panel consisted of Mr. Rahul Bhajekar, Managing Director, Global Organic Textile Standard (GOTS), Mr. Shyamlal Patnaik, Joint President - Head Specialty Products, Grasim Industries Ltd., Mr. Kapil Pathare, Director, VIP Clothing Ltd., Mr. M. Gunasekaran, Technical Marketing & Development Manager (South Asia), Lenzing Fibers, Mr. Avik Banerjee, Material and Components, H&M Group, Hennes & Mauritz India Pvt. Ltd., Mr. Srinivasan Krishnamurthy, Raw Material Specialist, IKEA Services (India) Pvt. Ltd.

Panel Discussion Session: (L to R): Mr. Srinivasan Krishnamurthy, Raw Material Specialist, IKEA Services (India) Pvt. Ltd., Mr. Kapil Pathare, Director, VIP Clothing Ltd., Mr. Rahul Bhajekar, Managing Director, Global Organic Textile Standard (GOTS), Ms. Chandrima Chatterjee, Secretary General, CITI, Mr. Shyamlal Patnaik, Joint President - Head Specialty Products, Grasim Industries Ltd., Mr. M. Gunasekaran, Technical Marketing & Development Manager (South Asia), Lenzing Fibers, Mr. Avik Banerjee, Material and Components, H&M Group, Hennes & Mauritz India Pvt. Ltd.

Ms. Chandrima Chatterjee made her initial remarks on the relevance of the theme and proposed appropriate queries to each panel member from the point of view of the sustainable development goals and their share of experience / contribution of the organization in contributing to the Indian/international perspectives. While responding to the moderator's specific query, each panel member responded to bring home the relevant goals of the SDG interfacing Sustainability and circularity in relation to textile and clothing industry. The strategies of program for attaining the results under SDGs from different perspectives and documentation with digitalization, Organic Certification, Generation of sustainability report on annual basis as corporate philosophy, Value Chain, Raw material flow in the ecology and environment while achieving the efficiency etc. were discussed.

The panel discussion brought home the salient features of SDGs collating to circularity in achieving sustainability through the thematic delivery by panel members and interaction by the delegates.

Vote of Thanks by Mr. Haresh B. Parekh, Hon. Secretary, TAI, Mumbai Unit

Mr. Haresh B. Parekh, Hon. Secretary, TAI, Mumbai Unit proposed a vote of the thanks to everyone who have contributed for the success of the international conference which was attended by around 275 participants.

The Distinguished Audience

Suvin

Kenya & India - Strategic Partnership!!!

By **Mr. Avinash Mayekar**, Suvin Expo LLP

Change the mindset…Devise strategy & Plan roadmap

During my recent visit to Kenya for the ITME Africa & ME 2023 technology & engineering show, I gained a lot of insights about Kenya as the developing textile hub. Through key interaction with the government, local bodies and industry patrons of Kenya, I came to know the industrial scenario of Kenya and was able to manifest a synergy between Kenya's needs and India's offerings. Which I feel must be developed into a strategic relationship.

I would like to narrate that Kenya has a very good potential, resources, a ready domestic market eager for import substitutes, cotton cultivation & a proactive & learning manpower. To succeed they need to just explore the new products coming into their market for technical specifications and most of these products they can easily manufacture in-house with technology advancement from India and technologies yet not manufactured by India can be easily outsourced.

Resources of Kenya:

Kenya has naturally available cotton soil, making it a desirable location for cotton harvest. It has good resource availability for cotton fiber.

Strengths of Kenya:

- Population: Kenya has an 82% literacy rate - The highest in Africa and 70% of its population is under 35 years and is English-speaking. This provides them with a good manpower resource which can be easily trained for acquiring textile skills and utility management for running the units.
- Natural fiber Availability: It has rich cotton-growing soil and also ready availability of power and adequate water.
- Free Market Entry: Access to International market – AGOA
- Favorable for FDI: Kenya is the 3rd largest economy in sub-Saharan Africa with a GDP of US$ 113.4 Billion and a 5% average annual growth rate
- Well-networked connectivity: It is 2nd in Africa in the Logistics Performance Index having access to regional transport corridors. There are 4 international airports: JKIA is the busiest airport in East Africa. It has 2 seaports and 2 ICDs. Kenya is also labeled as a Green data center. Its capital city Nairobi, is a leading tech innovation hub in Sub-Saharan Africa. 3rd most established startup ecosystem in Africa. The MPesa has enabled Global Money transfer which has 50 Million customers in 7 countries.

Existing Textile Industry of Kenya:

As far as the existing textile industry of Kenya is concerned, there are 65 Textile and Apparel Manufacturers. 7 textile mills out of which 3 mills are running on cotton. 29 units are operating under the Export Processing Zones (EPZ). There are 4 ginneries in operation. Although the numbers are not that huge, Kenya has been the leading Apparel exporter, in sub-Saharan Africa, to the USA under AGOA provisions. This indicates that there is a huge scope for backward integration as the culture of textiles as well as the market reach is readily available in Kenya.

What India can supply

- Textile Machinery & Accessories: All that is needed is the technology advancement. Here I feel seeing Kenya, can build strategic relations with India for technology and skill set development. The existing Indian textile technology and engineering manufacturers can supply the needed machines to Kenya. India can supply the complete setup for ginning, spinning, weaving looms for textiles as well as technical textiles, Processing & printing machinery. It can also be the right partner for knitted garments and woven garment machines.

- Also, financial aid can be taken from the Exim Bank of India which assists in funding for capital good sourcing and has various schemes for overseas projects that export Indian goods. Their "Ubharte Sitaare Programme" not only provides finance but also extends extensive handholding support with technical assistance.
- Cotton: India can also be the right partner for ensuring the quality yield of cotton. A research association from India can assist in testing and harvesting by supplying the right quality of seed and training. Till the harvest is at full peak in Kenya, the balance of Cotton can be made available from India along with comber noil & fine variety
- Woven Technical Textiles: like Canvas Fabric / Tarpaulins and canopies for transportation and buildings
- Tents for camping
- Camouflage fabrics for their military and army
- Agrotextiles for quality cotton harvest and other farming requirement
- Nonwovens for Hospitals & Healthcare like Bleach cotton & disposable products
- Geotextiles, geo bags, acoustic panels, insulation felt etc.
- Rugs, Mattress, nonwoven blankets
- Weaving & Digital Printing - For beautiful African prints at economical cost and scale of operation
- Industrial textiles for a rising manufacturing base
- Supplying recycled fibres to globe from recycled textiles

Conclusion:

For success, it is necessary to have a strategy. And strategy should be very specific with proper research and actual analysis of the country. We, Suvin, as a management consultant can map the strategy that will be specific for Kenya. We can help formulate the short-term goals, long-term goals, mission and vision for Kenya's textile industry. With our experience, we can suggest profiles with investment ratios and profitability indexes for various textile opportunities in Kenya. The probable investor would have to select the right product mix from the profiles created. We can also assist in collaboration and joint ventures with the right partners in India and overseas.

Way forward

- Kenya can strategically partner with India to gain experience not only for developing strong dominance in the spinning segment but also encash on the appropriate machinery manufactured by the Indian players

- Kenya is predominately focusing on their rich culture and colorful apparels. As is seen from the data most of the Kenyan textile mills are closing due to old technology and higher operating costs. India can supply the latest textile engineering technology and take care of skill development in Kenya to revive the Kenyan textile Industry
- Kenya can take advantage of cotton research from India to increase their yield and quality of cotton
- Kenya can look at India as their partner for raw materials for manmade fiber for technical textiles to be produced as import substitute
- Suvin as a management consultant can hand hold Kenya to devise strategy

INTERIM BUDGET 2024- Industry Opinion

Finance Minister Nirmala Sitharaman presented the Interim Union Budget 2024-25 on February 1, 2024 in Parliament. The government has announced the proposals for the implementation of various inputs. The Textile Association (India) would like to incorporate the views end the opinions from the various industry leaders and the personalities in their Journal of the Textile Association.

Following opinions are of some industry personalities

Gurudas Aras, Strategic Advisor & Mentor, Independent director (Certified by IICA, Ministry of Corporate Affairs), Former Director at A.T.E. Group

Interim Budget 2024, although pragmatic is disappointing for the Textile sector. Finance Minister Nirmala Sitharaman on February 1 presented her sixth consecutive Budget with a speech lasting 56 minutes, her shortest-ever.

The textile and apparel industry was quite hopeful that the interim budget will announce tax incentives and better textile infrastructure so that manufacturing and exports can be strengthened. However there have been very few announcements concerning this important sector.

Overall increased allocation of around 27.60% for the Ministry of Textiles for the year 2024-25 when compared to the previous year is a welcome move.

This allocation will be towards various schemes being operated by them including PM MITRA Park, NITTM, A-TUFS, ISDS, RoTDEP, RoSCTL, etc., apart from making allocation for Cotton Corporation of India to exercise MSP operation for cotton.

The textile and apparel industry, has welcomed the extension of the Rebate of State and Central Taxes and Levies (RoSCTL) scheme for two years. Continuation of the RoSCTL was essential for the long-term trade planning. The scheme has seen an increased allocation from ₹8,404.66 crore last year to ₹9,246 crore in the budget this year.

Measures to encourage green power, including bio-manufacturing, roof top solar and offshore wind to reduce the carbon footprint and the initiatives to prepare the country for meeting the sustainability goals will go a long way in making the industry turn to green.

The continuous efforts made in strengthening the logistics infrastructure facilities, aimed at reducing the transaction cost and thereby increasing the global competitiveness of the manufacturing sectors in the country is going to benefit the textile industry. There was no major policy announcement in the interim budget for the textile industry apart from the above few. The industry needed immediate relief from the financial stress, especially in the spinning sector.

The budget does not offer any major supportive measure to the industry. It did not remove the import duty on cotton and neither changed the duty on fabric imports, which the industry was keenly looking forward to. The man-made fibre industry was looking forward to rationalization of the GST rates for the manmade fibre sector. But this was not touched upon.

I hope that the finance minister will prudently consider the above demands of the industry in the full-fledged budget which will be announced around July this year.

R. K. Vij,

This is interim Budget. Govt. has announced few major schemes to benefit the masses. Not touched upon Income taxes and custom duties.

We were expecting that anomaly of Custom duties in-between Woven and Knitted fabric to finish by keeping same custom duties on Knitted fabric equal to Woven fabric to stop illegal massive quantity import of knitted fabric from China underutilization of whole upward value chain. Hope in the final full budget after election will cover these important point along with GST rates rationalization on MMF.

Still few good announcements done as new Solar Power Scheme on roof top will be enabled to get 300 units per month, PM Awas Yojana Grameen. Ayushmaan Bharat to cover all worker under ASHA and Anganwadi scheme.

Corpus of 1 lakh crore to be established with 50 year interest free loans for sunrise domains. 40,000 Rail Bogies to be converted to Vande Bharat standards. More Medical Colleges by using existing hospital infrastructure development of Tourist Centers More metro trains Corporation tax Extension of one year period for new unit.

Indian industry bodies hope full budget to address existing issues.

Textile industry organizations in India have welcomed the Interim Budget 2024-25 presented by Finance Minister Nirmala Sitharaman today in Parliament. However, the industry is disappointed because there are no measures announced to tackle important challenges facing the industry. The industry hopes that raw material structural issues will be addressed in the full-fledged Union Budget after the general election.

Dr. S. K. Sundararaman, chairman, The Southern India Mills' Association (SIMA) welcomed the interim Union Budget

and hoped that the demands of the textile industry relating to the raw material issues and few other industry demands will be considered in the full-fledged budget which will be presented in July this year. However, he expressed satisfaction about the overall increased allocation of around 27.60 per cent for the Ministry of Textiles for fiscal 2024-25. Higher allocation will provide sufficient funds to various schemes being operated by the ministry including PM MITRA, NITTM, A-TUFS, ISDS, RoTDEP, RoSCTL, etc.

Industry organizations had sought for removal of 11 per cent import duty on ELS cotton, exempting the same for other cotton varieties exclusively during off season (April to October) to protect the interests of farmers; announcement of Technology Mission on Cotton - II to increase the cotton production, productivity and doubling the farmers' income; exempting the man-made fibre imported under the Advance Authorization Scheme from the respective Quality Control Orders and exempting man-made fibres that are not produced indigenously from the Quality Control orders.

Commenting on the Interim Budget, Sudhir Sekhri, Chairman Apparel Export Promotion Council (AEPC) said, "This budget underlines the progressive vision of the government for holistic growth. It is balanced, reform oriented and forward looking. It has taken care of both the growth of the economy and the geo-political situation of the time. The Interim Budget 2024 also successfully underlined the roadmap with time-frame for bringing the Indian economy as an attractive destination for investment and growth."

AEPC also expressed satisfaction over the extension of RoSCTL scheme as it will ensure competitiveness of RMG exports in overseas markets. Union Cabinet has today approved the continuation of the Scheme for export of Apparel/Garments and Made ups up to 31st March 2026.

R. K. Vij, President, Emeritus of Textile Association (India) said that they were expecting removal of anomaly of custom duties between woven and knitted fabric to stop illegal massive quantity import of knitted fabric from China. Now, the industry hopes that the same would be taken care in the final budget after election.

Sanjay K Jain,
Managing Director, T T Ltd.

The budget is honestly a nonevent as it is an interim budget and for Textiles nothing really has happened apart from some increase in allocation in cotton purchase, Technical Textiles and extension of ROSCTL till 2025.

Disappointed that no reduction in import duty on cotton imports and levy of fixed import duty on knitted fabrics to stop dumping from china.

Amar Nagaram, Founder and CEO of Virgio

"Finance Minister Nirmala Sitharaman, in the interim budget announcement, encapsulated the remarkable growth witnessed by the nation in the last six years. Noteworthy initiatives such as green India initiatives, technological advancements, and startup-friendly budgets, including PM Mudra Yojana, which approved 43 crore loans totalling ₹22.5 lakh crore for the entrepreneurial aspirations of the youth, have played a pivotal role in the country's economic progress. Additionally, schemes like Fund of Funds, Startup India, and Start-Up Credit Guarantee have significantly contributed to the advancement of our youth.

FM Sitharaman emphasized a golden era for tech-savvy youth, introducing a corpus of ₹1 lakh crore with a fifty-year interest-free loan.

This corpus aims to provide long-term financing or refinancing with extended tenors and low or negligible interest rates, fostering research and innovation in sunrise domains within the private sector. This move is particularly beneficial for D2C startups in India.

The circular aspect of Virgio aligns with the broader vision outlined in the budget, striving to create an ecosystem where sustainability and innovation coexist. We eagerly anticipate contributing to this transformative journey by utilizing technology and research to shape a fashion industry that not only upholds the highest standards of quality but also champion's environmental responsibility. The proposed measures will undoubtedly inspire and empower fashion brands to further integrate circular practices and innovative technologies into their business models.

Shiv Kanodia, Hon. Gen. Secretary, Bharat Marchents' Chamber

The interest rates which the MSME pays in India is very high. When we compare other developed nations, viz Japan, Europe US etc. with India, it will be shocking that the difference is mind boggling. The cost of funds for the Banks, Repo reverse Repo rates and the PLR and the PLR+ charged to MSME's has a very wide gap. This spread by the banks is dwarfing our Indian economic growth. It was expected that the Finance Minister would have reduced this wide gap, in this interim budget. Nevertheless, hope that the July budget addresses this age old problem.

Bharat tex 2024 Global Textile Expo New Delhi | Feb 26-29

Maiden Success of the Bharat Tex 2024 Exhibition

Bharat Tex 2024, a global textile event organized by a consortium of 11 Textile Export Promotion Councils and supported by the Indian Ministry of Textiles had taken place from February 26-29 in New Delhi. The event focused on sustainability and resilient supply chains and showcased the complete textile value chain, including fibers, fabrics, apparel, home textiles, and more. It will feature exhibitions, knowledge sessions, discussions, meetings, product launches, and networking opportunities, attracting top policymakers, CEOs, exhibitors, and buyers. The event highlighted sustainable practices and offered collaboration opportunities between traditional craftsmanship and modern technologies.

Prime Minister Narendra Modi inaugurated Bharat Tex 2024 at Bharat Mandapam on February 26, 2024. The Prime Minister also took a walkthrough of the exhibition showcased on the occasion.

Mr. Gurudas V. Aras, Strategic Advisor & Mentor, Independent Director (Certified by IICA, Ministry of Corporate Affairs), former Director at A.T.E. group visited the Bharat Tex 2024 exhibition held at Bharat Mandapam and Yashobhumi, New Delhi. He stayed for 3 days and shared his experience at Bharat Tex 2024 as below.

"I was overwhelmed by the sheer size of this exhibition, which so far has been the forte of China. 12 halls with 3500 exhibitors from across the textile value chain, big and small, producers of traditional textiles as well as technical textiles, all under one roof for the first time in India.

Hall no.14 was the main attraction being a theme hall which exhibited India's history of traditional textiles to modern day innovative textiles including technical textiles used in infrastructure, aerospace, defence as well as smart textiles.

The Prime Minister in his inaugural address said that the event encompasses many dimensions as the thread of Bharat Tex connects the glorious history of Indian tradition with today's talent; technology with traditions and is a thread to bring together style, sustainability, scale, skill. He also saw the event as a great example of Ek Bharat, Shreshtha Bharat, encompassing myriad textile traditions from all over India.

Talking about India's growing profile as a cotton, jute and silk producer, PM Modi said that the government is supporting cotton farmers and is buying cotton from them. He said Kasturi Cotton, launched by the government, will be a big step in creating India's brand value globally. The government is also supporting the jute and silk sectors, and developing India's technical textiles sector.

Right from the first day the exhibition had a very high number of footfalls of both domestic as well as foreign visitors. The Textile Ministry's pavilion along with the National Technical Textile Mission (NTTM) exhibited all the innovation projects sanctioned under the NTTM scheme. Interesting innovations like Hydrogen Storage tanks, medical textile devices, Smart textiles and projects under protech, Mobiltech were on display. The knowledge sessions and round tables on contemporary topics also received a grand response.

The success of Bharat Tex underlined the importance of such large scale exhibitions covering the entire value chain and displaying the prowess of Indian textiles to the world. The overwhelming response to this unique exhibition might create a need to have this exhibition every year.

Further, he added that the organizers did an excellent job within just a few months of planning. The scale of the exhibition, with 3500 exhibitors, was impressive. More importantly, the footfall exceeded our expectations right from Day 1. It was particularly convenient for us as all our key customers were present, mainly concentrated in halls 4 and 5.

I don't think even the organizers anticipated such a tremendous response. It's been a fantastic experience being a

part of it. This made networking effortless. By the third day, it was evident that Bharat Tex was a resounding success.

He mentioned that one of the standout areas for innovation was at the stalls sponsored by the Ministry of Textiles, where a variety of innovations were showcased. Additionally, individual exhibitors, particularly in the home textiles sector, showcased significant innovations, particularly in fabric finishing. I noticed a trend towards antimicrobial properties and fabrics that are skin-friendly. There was a plethora of new fabric types introduced by various exhibitors. Moreover, I was impressed by the emphasis on recycling as a part of sustainability efforts. Many exhibitors integrated recycling into their innovative solutions, showcasing a commitment to environmental sustainability across the board.

Kudos to the Textile Ministry and the organisers comprising 11 textile associations for executing the gigantic task of setting up a huge exhibition with hardly 4 to 5 months lead time.

Maiden Success of the Bharat Tex 2024 Exhibition signs grand Arrival of India on Global Textile Map. One thing is sure that India has arrived on the global textile map with a bang".

KARL MAYER Group focuses on sustainability and cost-effectiveness

More ecology and economy thanks to natural fibre composites and knit to shape products

KARL MAYER GROUP focuses on sustainability and cost-effectiveness at JEC World 2024, 05 - 07 March 2024, Hall 5 K 32

The KARL MAYER GROUP is an innovative player in the composites industry and has been an exhibitor at JEC World for many years.

At this year's leading industry trade fair from 5 to 7 March, the company will be exhibiting with KARL MAYER Technical Textiles and its STOLL Business Unit in Hall 5 at Stand K 32 in the Parc des Expositions in Paris Nord Villepinte.

One focus of the exhibition will be non-crimp fabrics and tapes made from bio-based yarn materials for the reinforcement of composites. Last year, KARL MAYER Technical Textiles had already shown exhibits in this area and hit a nerve: Under pressure from the looming climate crisis and rising energy prices, the composites industry is constantly looking for sustainable solutions. "While our business with multiaxial and spreading technology for processing conventional technical fibres such as carbon or glass continues to do well, we are seeing increasing interest in the processing of natural fibres into composites. That's why we have a new product in our trade fair luggage for the upcoming JEC World: an alpine ski in which, among other things, hemp fibre fabrics have been used," reveals Hagen Lotzmann, Vice President Sales KARL MAYER Technische Textilien.

The winter sports equipment is the result of a subsidised project. The hemp tapes for this were supplied by FUSE GmbH and processed into non-crimp fabrics on the COP MAX 5 multiaxial warp knitting machine in the KARL MAYER Technical Textiles technical centre.

With the capacities in the company's own application technology centre and the expertise of its composite specialists, the company is able to support its customers in the implementation of projects and processing trials. The aim of the trade fair is to strengthen the company's image as a contact point for innovators also with unusual ideas. "Everyone is currently looking for new applications. We want to present ourselves as a competent development partner and special machine manufacturer in the composites sector," says Hagen Lotzmann. The sales professional and his team will also be presenting an innovation from the multiaxial machine sector for the production of composites made of glass rovings.

The STOLL Business Unit will be focussing on

knit to shape sample

Hagen Lotzmann, Vice President

thermoplastic materials. Several knit to shape parts with a visually appealing textile outer surface and a hardened inner surface will be on display. The double-face products can be made from different types of yarn and do not need to be back-moulded for use as side door panels or housing shells, for example. In addition, the ready-to-use design saves on waste and yarn material.

The KARL MAYER Group is looking forward to its guests, numerous discussions and many new ideas.

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Donear Introduces Revolutionary Four Way Stretch Fabric at Bharat Tex 2024

Mr. Rajendra V. Agarwal, Managing Director, Donear Industries Ltd., informed during the launch of Neo Stretch Fabric at Bharat Tex 2024 that the "India is known for its vast and exquisite variety of textiles, techniques and customs. It is a melting pot of legendary textile heritage that can be traced back to a millennium. Now Donear Group has dedication on quality and innovation in the textile and apparel industries demonstrated at Bharat Tex 2024 on launching of Neo Stretch."

"On participation in Bharat Tex, an international platform, we feel to present a wide variety materials that cater to the diverse tastes in fashion through the premium in-house brands including Donear, Graviera, Grado and Mayur. Donear Group is skilled at taking the best aspects of international trends and transforming them to suit Indian traditional tastes. We also lay heavy focus on reinventing the fashion landscape to raise the bar for luxury and craftsmanship in the business," he added.

As we are known for its exquisite craftsmanship in the suiting category, Donear Group introduced and showcased Neo Stretch Fabric, a four way stretch suiting and shirting fabric that not only offers more comfort to its patrons but also has a better shape retention. The fabric not only upholds quality as per international standards but also has better breathability.

Neo Stretch is a revolutionary fabric that not only sets itself apart from the category but also provides for enhancing the overall suiting and shirting experience. Given the uniqueness of the fabric, the brand also introduced its campaign starring actors Tiger Shroff that is 'Freedom to Move' emphasizing on the comfort, flexibility and quality of the fabric that makes it a diverse choice for any kind of activity. Donear Group is the largest manufacturer of four way Stretch fabric in India and one of the biggest suppliers to renowned brands in Europe.

The brand is primarily engaged in the manufacturing and marketing of textiles in different formats and specializes in suiting fabrics and is known for its flagship brand. Donear suiting, which offers high quality and fashionable suiting materials for men.

Birla Cellulose Launchs Birla Viscose Intellicolor at Bharat Tex 2024

Birla Cellulose Launchs Birla Viscose Intellicolor at Bharat Tex: A Groundbreaking Solution Set to Transform the Textile Industry

In a revolutionary move, Birla Cellulose has unveiled its latest innovation, Birla Viscose - Intellicolor, at the prestigious Bharat Tex event. Birla Cellulose is poised to redefine the landscape of the textile industry with its patented product, addressing a long-standing challenge with conventional reactive dyeing.

Intellicolor represents a groundbreaking advancement in the dyeing process, using Cationic or Basic dyes. It boasts a remarkable dye exhaustion rate exceeding 95%, surpassing conventional methods. It eliminates the need for salt and soda ash in the dyeing process, streamlining operations and reducing environmental impact.

By achieving brighter shades with higher tinctorial value and color depth compared to reactive dyes, it offers superior color vibrancy while using lower dye concentrations.
This results in reduced chemical consumption, lower utility usage, shorter processing times, and decreased dye quantities required, thereby promoting sustainability in dyeing practices.

In conventional or traditional reactive dyeing processes, the use of reactive dyes often necessitates the addition of large quantities of salt to the dye bath. This is primarily due to lower dye bath exhaustion, which results in inadequate dye fixation onto the fabric. As a consequence, high salt concentrations are required to facilitate the dyeing process, leading to significant levels of both salt and unreacted dye being discharged as the effluent. The presence of excessive salt and unreacted dye in the effluent not only poses environmental concerns but also adds to the costs associated with effluent treatment. Intellicolor, aims to usher in a new era by introducing an innovative solution that not only overcomes this challenge but also enhances the overall quality of dyed fabrics.

Moreover, Intellicolor facilitates a more sustainable approach to dyeing by necessitating fewer washes post-dyeing and eliminating fixing steps. This not only conserves water but also reduces energy consumption and ETP operating cost thus leading to huge savings on the utility consumption. It marks a significant advancement by

Birla Cellulose Launches Birla Viscose Intellicolor at Bharat Tex

enabling dyeing with Basic dyes, promising enhanced dye uptake and superior wash fastness compared to traditional Reactive dyes.

Speaking on this ground-breaking achievement, the Chief Marketing Officer (CMO) of Grasim Industries, Pulp & Fibre Division, Mr. ManMohan Singh expressed pride in the company's commitment to innovation. "This is a proud moment for Birla Cellulose as Birla Viscose Intellicolor marks the first of its kind in our ongoing pursuit of excellence. Our commitment to pushing the boundaries of what is possible in textile manufacturing has led to this remarkable innovation," the CMO stated.

Further, the MD of Grasim Industries, Mr H.K Agarwal, stated, “Today, we mark not just a milestone in innovation, but a commitment to sustainability. Birla Viscose Intellicolor heralds a new era of vibrancy and responsibility in the textile industry, where innovation meets environmental consciousness. At Birla Cellulose, we weave sustainability into every thread of our operations, ensuring a brighter, more sustainable future for textiles."

The launch of Intellicolor at Bharat Tex signifies a monumental moment in the textile industry and promises reduction in water & energy. This fibre not only meets the immediate needs of the industry but also aligns with the sustainability goals of leading brands, marking a significant step towards a more environmentally conscious and vibrant future for the textile sector.

Major Win for Rieter in Patent Dispute in China

In a judgment in December 2023, the Supreme People's Court of the People's Republic of China ruled in favor of Rieter in a legal dispute. The case concerned the infringement of a Rieter patent by a competitor's draw frame. Rieter protects its innovations with patents and registered designs and consistently takes action against infringements of its intellectual property.

Rieter draw frames are known for their stable operation with high sliver quality and productivity. Superb scanning precision and highest auto-leveling dynamics ensure outstanding sliver evenness and thus the production of high-quality yarns.

Comprehensive customer service for mechanical and electronic repairs

Draw frames have also been the subject of a patent litigation by Rieter in China at various levels of jurisdiction. Rieter had sued a competitor for unauthorized use of its patented draw frame technology.

In the summer of 2022, the Shanghai Intellectual Property Court confirmed the patent infringement identified by Rieter and prohibited the accused competitor from continuing to use Rieter's patented technology. The infringing party was also ordered to pay damages to Rieter.

The culpable competitor then appealed the decision of the Shanghai court to the Supreme People's Court of the People's Republic of China.

In December 2023, the Supreme Court of China in Beijing upheld the Shanghai decision, confirming that the patent had been infringed. As a result, Rieter's competitor is prohibited from selling the infringing machine types and is required to pay the damages determined by the court.

This Supreme Court decision represents a major success for Rieter in defending its proprietary technologies in China. It is further proof that foreign companies can effectively defend their intellectual property in China.

As the technology leader in spinning machinery manufacturing, Rieter invests around 5% of its turnover annually in research and development. Rieter protects its innovative products with patents and registered designs and takes consistent action against infringements of industrial property rights.

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Lenzing
Innovative by nature

TENCEL and INTIMASIA 2024 - Catalyzing the innovation of Intimate Wear in India

TENCEL™, Lenzing's leading textile brand for lyocell and modal fibers, joined hands with Intimasia for its 6th edition, marking a significant advancement in India's intimate wear industry. This impactful collaboration heralded a new era of innovation, culminating in a visionary showcase at TENCEL™ x Intimasia, hosted in Mumbai from January 22nd to 24th, 2024. The event solidified its position as the premier B2B fashion expo for intimate wear in South Asia.

Covering an extensive area of 120,000 square feet, the show boasted over 250 renowned exhibitors, 300+ brands, and drew in more than 20,000 retailers and distributors, with a notable attendance of 500 delegates. Over the course of its three-day duration, TENCEL™ INTIMASIA showcased its latest innovations, conducted product demonstrations, and unveiled collections, serving as a central hub for producers, wholesalers, suppliers, retailers, and industry experts to converge.

The demand for TENCEL™ branded lyocell and modal fibers, as well as LENZING™ ECOVERO™ viscose fibers have been increasing rapidly in the Indian intimate wear market which reflected in various collections displayed by Indian brands as well as through interest shown by visiting manufacturers, retailers and distributors. Derived from controlled or certified wood sources, these fibers are made with at least 50% less carbon emissions and water consumption - are known globally for meeting high environmental standards .

Endorsed by leading brands and designers, TENCEL™ Intimate cellulosic fibers have been elevating underwear and lingerie with their delicate texture, superior moisture absorption, and enhanced breathability, ensuring enduring softness and heightened hygiene.

The first-ever Lingerie Fashion Week premiered at the TENCEL™ Intimasia event, showcasing a diverse array of products spanning lingerie, loungewear, and sportswear. At the grand fashion show during the fashion week TENCEL™ collaborated with well-known Direct-to-Consumer (D2C) and mainstream brands such as Bummer, XYXX, ForceNxt (Dollar), Red Rose, and Juliet, unveiling a spectrum of lifestyle innovations in intimate and loungewear segment. This vibrant presentation underscored TENCEL™'s adaptability and significant impact on shaping modern fashion trends in India.

Avinash Mane, Senior Commercial Director of Textile business at Lenzing AMEA & NEA expressed. "In formulating our fibers for intimate wear, we prioritize a delicate balance of softness and skin-friendly properties, ensuring a premium quality that caters to individuals seeking comfort in their clothing selections. Our focus has been towards enhancing the overall intimate wear experience of the Indian consumer. Our partnership with Intimasia represents a significant step in our endeavor to enrich the

Indian intimate apparel market. Hosting this trade show not only allows us to showcase our innovations but also offers us a comprehensive industry outlook. This helps us to continuously offer the most relevant solutions to the Indian market."

Conducted alongside Intimasia, Source NXT ran simultaneously as a comprehensive sourcing hub, offering a crucial platform for manufacturers, suppliers, and buyers from across the globe to showcase and procure a wide range of products and materials crucial for producing Hosiery & Knitwear. In this all-encompassing event, Lenzing spotlighted the distinctive and varied attributes of TENCEL™ and LENZING™ ECOVERO™ fibers. The gathering fostered a global dialogue, enabling participants to present the latest trends and innovations in the manufacturing of hosiery and knitwear items.

To learn more about the TENCEL, please visit https://www.tencel.com

ITAMMA completes it's 5th webinar of the on-line series

ITAMMA completes it's 5th webinar on 29th January, 2024 of the on-line series of webinars for the Development of Capital Goods Sector of Textile Industry with the funding support of Ministry of Heavy Industry inviting Experts' View in the Development of Capital Goods Sector. Ms Shangrila A. Sharma being moderator Introduced eminent speakers.

Key take-a ways of the webinar on 29th January'24

This webinar provided an extensive insight into the technological advancements shaping the landscape of textile machinery in India, offering a comprehensive overview of the dynamic evolution of textile product manufacturing. Within industries and organizations, industrialists, experts, marketing and development professionals, and managing directors play pivotal roles in charting their respective trajectories. Industrialists serve as visionary leaders, driving innovation, investment, and sectorial expansion by leveraging their experience to navigate market dynamics and seize emerging opportunities. Experts contribute specialized knowledge and skills across technical, operational, and strategic domains, providing invaluable guidance. Marketing and development professionals spearhead initiatives to promote products, discern market trends, and foster strategic partnerships, while managing directors provide overarching leadership, ensuring operational efficiency and fostering a culture of excellence and innovation. Together, these stakeholders collaborate to drive progress, innovation, and sustainable growth within their industries.

The webinar emphasized the significance of elements like strong after-sales support, well-equipped research and development infrastructure, and insightful market analysis. Additionally, it brought attention to the observation that the quality of both imported and exported machinery has now reached similar standards, underlining the necessity for acknowledgment and continual promotion, possibly through governmental actions. This webinar serves as another praiseworthy endeavor by ITAMMA, demonstrating its continuous dedication to promoting technological progress and overall growth in the textile machinery domain.

The event commenced as the moderator introduced the proceedings and extended an invitation to Mr. Nimesh Shah, President of ITAMMA, to deliver his welcome address. Since Mr. Shah was unable to do so; he asked Mr. N. D. Mhatre to welcome the Speakers and the attendees. Following this, a concise overview of the speakers and their diverse topics was provided, covering a wide spectrum of subjects. These ranged from Technological Developments at Moksha Thermoplastics Pvt. Ltd. to Technological Developments at Embee Corporation, with subsequent presentations focusing on the Smart Data Clinic and MHI schemes aimed at sustaining the development of the Capital Goods Sector within the Textile Industry.

Technological Developments at Moksha Thermoplastics Pvt. Ltd. in the Textile Capital Goods Sector- Mr. Anil Yadav- Technical, Marketing & Development, Ahmedabad, Gujarat. During his presentation, Mr. Yadav delved into the realm of capital goods within the textile industry, showcasing a typical image of a spinning bobbin. He provided insights into his family business, Moksha Thermoplastics, established in 1954, renowned for manufacturing a diverse range of products including rolling bobbins, yarn dyeing products, simplex bobbins, and roving bobbins, among others. He highlighted significant milestones such as the production of Shin Line Tubes in 2016 and the CANs project initiated in 2022, with plans for backward integration set to hit markets by 2024.

Furthermore, Mr. Yadav elaborated on the evolution of spinning frame/roving/flyer bobbins, distinguishing between ancient, conventional, and engineered variations. While ancient bobbins were traditionally crafted from wood, paper, or polypropylene, conventional ones were made from ABS, and engineered bobbins utilized impact- modified ABS with additional modifications. He provided a comprehensive overview of the transformative journey of various manufacturing accessories within the textile capital goods sector, illustrating the continuous improvements and enhancements achieved over the years.

Technological Developments at the Embee Corporation - Mr. Manan Shah, MD, Embee Corporation, Ahmedabad, Gujarat

Mr. Manan Shah extensively discussed the advancement of sustainable machines tailored for both customer satisfaction and environmental preservation. Specifically, he highlighted

the manufacturing of the stripping machine, with the latest addition being the utilization of laser technology, which not only preserves colors but also minimizes environmental hazards. In contrast to the previous method involving toxic chemicals, which posed risks to both workers and the environment, Embee Corporation innovatively introduced a laser source that efficiently burns out the photo emulsion, emitting no smoke or odor and leaving behind no ash residue. This breakthrough solution significantly extended the screen life while reducing costs, labor, and efforts. Embee Corporation strategically employed cutting-edge technology in countries such as India, Mexico, South America, and Turkey, ensuring widespread accessibility to these advanced machines and solutions through online platforms, thereby minimizing machine downtime. These technological advancements and solutions not only demonstrated a commitment to customer satisfaction but also upheld the vision, mission, and values of the Embee group.

Updation on ITAMMA-SAMBUQ Digital Enabler Platform & SMART DATA Clinic Mr. Mehul Goswami, Director/Digital Business Enabler, Sambuq.com India Pvt. Ltd.

Mr. Mehul elaborated on the significance of digitalization and the Digital India initiative spearheaded by Prime Minister Narendra Modi, which is revolutionizing the nation's technological landscape. He outlined the nine pillars of Digital India, including Digital Infrastructure, Digital Information Technology, and Digital Payments, among others. Specifically, he delved into the transformative impact of digital payments, highlighting their widespread adoption and scale, which have reshaped India's payment landscape. Mr. Mehul underscored the staggering statistics from 2019, such as 560 million internet subscriptions, 294 million social media users, and 200 million WhatsApp subscribers, illustrating the immense reach of digital technologies in India.

Furthermore, he discussed the Smart Data Clinic, a comprehensive information-sharing and market research platform that adds value to ITAMMA members and its ecosystem. This platform serves as a centralized hub with features like a knowledge portal and virtual learning hub, facilitating business networking opportunities, and providing a digital marketplace for affiliates and members. Moreover, Mr. Mehul highlighted the platform's collaboration with the government on schemes and grants, emphasizing its role in fostering a collaborative and supportive ecosystem for technological advancement and growth.

MHI Schemes for the Development of Capital Goods Sector of Textile Industry-- Mr. N. D. Mhatre, Director General (Tech), ITAMMA

Mr. Mhatre provided insights into the MHI schemes designed for the capital goods sector, highlighting that imports of spare parts and accessories currently stand at 83%, underscoring their cutting-edge technology. He emphasized the availability of these schemes for industrialists aiming to elevate their manufacturing processes to state- of-the-art standards. Specifically, he addressed key subsectors such as heavy electrical equipment, textile machinery, plastic machinery, printing machinery, machine tools industry, and metallurgical machinery, among others, for which schemes exist to enhance the capital goods sector. Notably, he elaborated on the backward and forward integration schemes within the machine tools sector. The schemes are categorized into five sectors including research and development, green engineering, and IT application and development centers. Mr. Mhatre stressed the importance of utilizing various funds allocated for sector development, such as the Technology Acquisition Fund (TAF) and Technology Updation Funds (TUF), all of which are accessible on the ITAMMA website. Furthermore, he underscored ITAMMA's commitment to promoting public-private partnerships, exemplified by initiatives like Vocal for Local and Atma Nirbhar Bharat. Additionally, he highlighted the presence of advanced centers of excellence and the availability of funds for joint ventures, providing crucial support to the textile industry and fostering innovation and collaboration within the sector.

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