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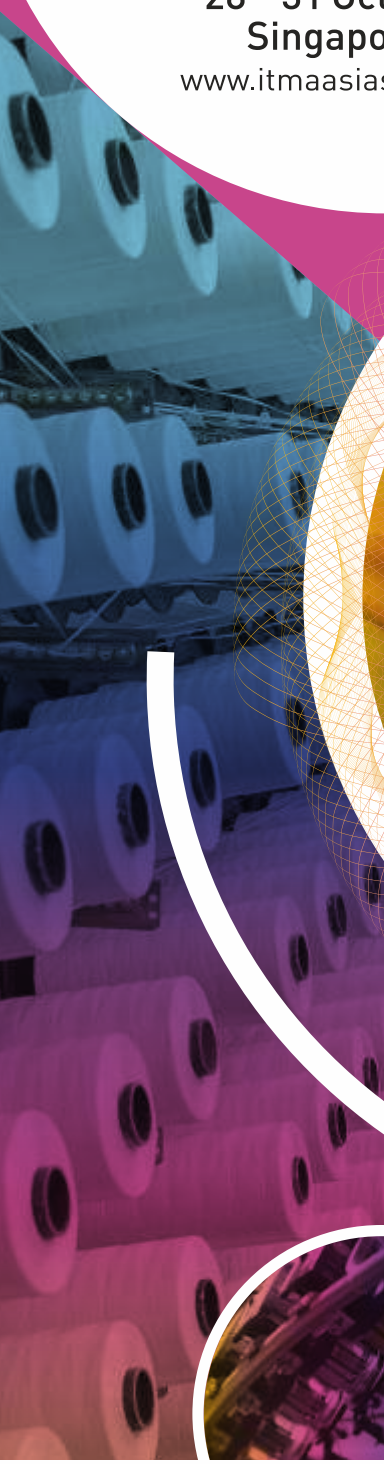

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# Celebrating Milestones in Textile Excellence

As we commemorate 85 years of the Textile Association (India) and 84 years of the Journal of the Textile Association, we are reminded of the enduring legacy and unwavering commitment to excellence that have defined our journey.

Since its inception, the Textile Association (India) has been at the forefront of fostering innovation, promoting collaboration, and driving advancements in the textile industry. Through decades of dedication, our association has played a pivotal role in shaping the trajectory of the textile sector, both nationally and globally. Similarly, the Journal of the Textile Association stands as an example of knowledge, offering insights, research findings, and scholarly discourse that have enriched the understanding and practice of textile science and technology.

Over the past 84 years, the journal has been a trusted source of information, providing a platform for researchers, academicians, and industry experts to exchange ideas and push the boundaries of textile innovation.

As we celebrate these significant milestones, we express our gratitude to all the members, advertisers, contributors, supporters, and partners who have been instrumental in our journey. It is through your dedication, passion, and collective efforts that we have reached this remarkable juncture.

Looking ahead, we remain committed to our mission of advancing the textile industry through education, research, and collaboration. Together, let us continue to build upon the rich legacy of the Textile Association (India) and the Journal of the Textile Association, and pave the way for a future defined by excellence, innovation, and sustainability.

**Dr. Aadhar Mandot**
Hon. Editor

*T. L. PATEL, President*

# The Textile Industry's Changing Landscape: Trends and Innovations

**T. L. PATEL,** President

## Congratulations!!!

I have immense pleasure to mention that on 9/04/2024, TAI celebrated its 85th Birth Anniversary, having been born on this day in 1939. For the past 85 years, TAI has lived a full and eventful life, contributing to its community and leaving a lasting impact on those around. On behalf of TAI and on my behalf congratulate each and every one for their continuous support, faith and cooperation extended us to reach this milestone.

Concurrently, Journal of the Textile Association (JTA), which TAI have been a loyal subscriber and supporter of its 84th years of publication on the same date. The Peer Reviewed journal, known for its insightful articles and thought-provoking content, has been a constant companion for TAI throughout its journey.
As TAI and JTA both reached these significant milestones, it is a testament to their resilience, adaptability, and the value, they have brought to their respective audiences over the decades. Here are many more years of the vibrant life of TAI and the continued success of JTA.

## Introduction

The textile industry has long been a cornerstone of the global economy, providing jobs, driving innovation, and meeting the clothing and textile needs of consumers worldwide. However, the industry faces a rapidly changing landscape, with new technologies, evolving consumer preferences, and shifting global dynamics all shaping its future. In this article, we'll explore some of the key trends and innovations that are transforming the textile industry.

## Sustainable and Ethical Manufacturing

One of the most prominent trends in the textile industry is the growing emphasis on sustainable and ethical manufacturing practices. Technologies, and catering to the demand for personalization, textile companies can position themselves for success in the ever-evolving global marketplace.

Consumers, particularly younger generations, are increasingly demanding that the products they purchase be produced in a responsible and environmentally-friendly manner. This has led many textile companies to adopt more sustainable production methods, such as using recycled or organic materials, reducing water and energy consumption, and implementing fair labor practices.

## The Rise of Smart Textiles

The integration of technology into the textile industry has given rise to the concept of "smart textiles." These advanced fabrics incorporate sensors, microprocessors, and other electronic components, allowing them to interact with their environment and the wearer. Smart textiles have a wide range of applications, from healthcare monitoring to sportswear that can track athletic performance. As this technology continues to evolve, we can expect to see even more innovative and functional textile products.

## Customization and Personalization

Another trend that is gaining traction in the textile industry is the demand for customized and personalized products. Thanks to advancements in digital manufacturing and e-commerce, consumers can now easily create and order custom-made clothing, accessories, and home textiles. This shift towards personalization is driven by consumers' desire for unique and tailored products that reflect their individual style and preferences.

## Conclusion

The textile industry is undoubtedly in a state of transition, but these changes present exciting opportunities for innovation and growth. By embracing sustainable and ethical practices, incorporating smart.

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

Journal of the TEXTILE Association

FASHION

# A Review on Human Consciousness Toward Sustainable Fashion

***P. Shwetha & T. Palani Rajan****

*VIT Fashion Institute of Technology, Vellore Institute of Technology Chennai Campus, TN*

**Abstract:**

*Fast fashion and fast disposal are the trends that have been following the past few years. Adapting to this has pushed the human consciousness to a lower level that people don't think about the impact a task will cause but rather just see the satisfaction that they get after the act. This article is about the lifecycle of clothing, from the state of pre-consumer and post-consumer lifecycle of textiles. This has been an unnoticed context because people just buy, use and dispose but they are unaware of all impacts that they are causing to the environment, such impacts have their effects on various forms of life in the surrounding. Therefore, this paper emphasizes using the 4R approaches like "REDUCE, REUSE, RECYCLE and RECOVER" to help with the solution for the impact caused by fashion minded people or the task of producing such fast fashion garments*

**Keywords:** *Carbon emission, environmental impact, fast fashion, sustainable, waste managemen*

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## 1. Introduction

The textile and apparel industry is the world's third-largest manufacturing sector after the automobile and technology industry. Its working model is intensifying the issue by leaping forward the rate of design and production. With the growing market and consumer's behavior to buy more clothes worldwide, the cheap items and new styles are taking a toll on the environment. Today, apparel production is the world's second most polluting industry next to the oil industry. The total carbon emissions from textile production in the current situation remain at 1.2 billion tons every year [1]. The sector's emissions are to spike more than 60% by 2030 if we don't foresee a change toward a sustainable fashion industry anytime soon [2]. The textiles industry proceeds in almost a procedural manner with the humongous quantity of non-renewable resources used to manufacture textile products and clothes, which are often used for only a short time; such highly esteemed clothing is dumped in landfills every year due to underutilisation and lack of recycling or reusing [3]. The replacement of clothing is no more a seasonal (spring summer/autumn winter) buying behaviour. It has become more frequent that people buy clothing every few weeks/months. Buyer's requirements can be fulfilled by the many cost-effective retail stores that offer new designs each week. In 2000, 50 billion new garments were made, and almost 20 years later, the figure multiplied [4]. In this increasing scenario, less than 5 % of used clothing is reused or recycled into new clothing and others ultimately end up in the landfill. It shows the resources used to derive such clothing have been wasted [5]. These factors combined make it a challenging task for the manufacturers to develop clothing without causing an impact on the environment, and to become eco-friendly and sustainable while additionally advancing better conditions for labourers in the unit. The industry's progress toward a sustainable model is increasing pace. Designers are exploring new aspects, to explore the region's biodiversity in promoting sustainable brands [6]. The process by which we design, produce, and the usage of clothing has drawbacks that are becoming increasingly transparent. The sustainable approach is required and holds even more importance as this is the year of the pandemic. One thing that we can follow is to understand and act according to the limits to which humans can push nature before it can negatively affect us in return [7]. Sustainable manufacturing and usage of clothing are all about doing great and better with less environmental impact [8]. This can have an impact on the aspects of life in matters of environmental degradation, increasing resource restoration, and promoting sustainable lifestyles in the minds of people.

## 2. Methods

Literature reviews were carried out to analyse the consumer and manufacturing initiatives, along with technological developments that have been involved in the last 15 years to understand and control textile waste. The search area for this review article is based on textile products, product life cycle, consumer behaviour, waste management, recycling, sustainable approaches and 4R concepts. From the analysis there is a comprehensive approach and awareness have been initiated worldwide to control landfill waste and utilise the textile product efficiently.

## 3. Discussions

### *3.1. Lifecycle of Textile*

Textile products inventiveness and novelties are presented based on the life cycle of textile products and figure 1 shows the same.

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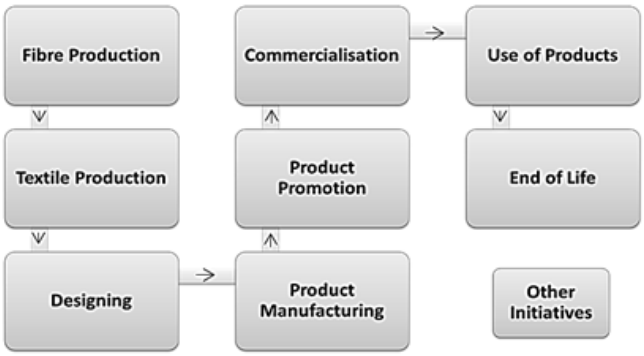


*Figure 1 - Textile Product Life Cycle*

*3.1.1. Pre-consumer life of textile*

The pre-consumer life of a textile includes different stages of production involved to come up with the desired garment, production of fibres on farms, making raw fibres into yarns and weaving yarns in the form of fabric, and eventually, the fabric into garment all processes come under pre-consumer life of textile. All these stages have individual process sequences to return up with the raw material for the subsequent process [9]. From the production of fibre or making the yarn or weaving/knitting them into fabrics and then cutting/sewing them into a garment, all these processes have an individual impact on the environment when the resource usage limit is not maintained. The variants in waste percentage can be varied depending on the multiple factors for instance, defective processes, faulty designs and extra materials bought to meet customer's minimums, but on average, the product process and samples account for the utmost whole waste generation [10]. Especially in the apparel manufacturing process, the cutting department sums up the maximum leftovers and the finishing department is the least. According to a study done by [11] in t-shirt manufacturing, the utmost wastage is from the cutting department, being in an average of 13.57%, in the control panel at 6.91%, in sewing at 4.31% and in finishing at 1.72%, with a total around of 26.51% wastages of the original fabric. Apart from the process waste, the wastage starts from the cultivation of raw materials like fibres, which requires the consumption of resources in the form of water, heat & electricity, labor, etc., are required to finish the cycle of production.

*3.1.1.1. Environmental Impacts*

The production has increased to almost 20% in 2019 due to the fast fashion market, which requires tons of resources than the usual limit to keep the fast fashion market going. Therefore, the consumption made by fast fashion regarding water, fossils for heat and electricity, and labour has made an impact [12]. The utilised resources like water used for printing/dyeing/washing which accounts for 17% to 20% of water pollution are not disposed of properly and are left untreated. It ends up in the water streams causing an impact on humans and aquatic life which needs the water stream. The possible approach to this impact is to reduce the production of fast fashion garments but instead to make good quality products with longevity and reusing the products will reduce the resource depletion.

This take-make-dispose kind of product reflects impacts on the environment, which in return makes it a hard time for any life that exists on earth. These harmful substances influence and degrade the quality of health for textile workers and consumers who use those clothes, and this substance escapes into the environment.

The carbon emission caused by every action that a human does causes an impact in protecting the environment from causing any harm to humans in from production of any natural fibre or making any synthetic fibre it releases Greenhouse gases (GHGs) in the surrounding and later each process like cleaning and washing fibres, running machines to produce yarns and fabrics also emit GHG [13]. Instead of producing small lifecycle garments, making garments with the fibres procured from existing/end-of-life textile waste from mills can reduce the amount of carbon emitted [14] and also reusing such products will reduce the process of the derived product from virgin materials. These are a few influences caused by the textile and apparel industry to environmental growth associated with pre-consumer lifecycle of textiles.

*3.1.1.2. Waste Management or Disposal*

Fibre stage cotton when sent to the production of yarns is initially opened and cleaned and then a series of the process happens before the fibre is converted into a fabric [15] and in course of these stages long and some short staples will be in the process but all those too short fibres will be in the air and this is known as cotton dust. This kind of too short fibre/cotton dust cannot be used in any textile application and this kind of waste is mostly burnt to dispose of which in return causes carbon emission [16]. Therefore, having suctioned or exhaust fans to collect this cotton dust and sustainably dispose of it by recovering energy in the means of biogas production, vermin-composting and fuel for the boiler.

In the fabric stage, wastage can occur concerning the defects that are caused in the fabric during the weaving or knitting process, and these defective fabrics will not be approved or accepted by the manufacturers or buyers for the order. In such cases, either the defective fabric can be reused by upcycling it in any other form or by recycling it to obtain another raw material that can be made into a new product [17].

In the production process initially, various samples will be sent here and there for the buyer's approval and these samples will end up in waste. Then, during the process of printing/dyeing process, several strikes off samples and defective pieces will be obtained which is ultimately a waste component. In bulk production, the fabric is laid into the ply and then the cutting happens, here the cutting waste is obtained [18]. Reusing these waste elements in the form of upcycling them into a new product that can be used in home textiles or any other textile application rather than ending up in landfills or burnt [19].

The majority of pre-consumer textile waste of these kinds is collected as municipal solid waste (MSW) and is burnt with the energy recovery concept [20]. But rather these components of waste have not been used by consumers therefore, it is nearly a virgin material that can be reused in various applications such as upcycling goods, stuffing material in soft toys/ home textiles [21], or can be recycled into fibre state again to come up with the garment rather than directly putting up as a recovering energy source. Starting the new production cycle and then the whole process continues which results in improper disposal of waste and unwanted usage of the resources for a new production which also causes carbon emissions [22, 23].

Recycling and efficiently reusing pre-consumer textile waste can cut down or reduce the production of new textiles and apparel from virgin materials and hence reduce the use of resources like water, energy and chemicals during the production chain [24]. In addition to that various risks associated with the chemicals used in the textile industry may be avoided by reducing the huge consumption of textiles in the first place [25], especially those which are made with unnecessarily huge chemicals just for the sake of trend-led fashion.

*3.1.2. Post-consumer life of textile*

The post-consumer life of textiles includes a different series of stages that follow after a customer purchases a garment in the retail store [26]. The usage, washing, drying, and wear and tear aspects of a garment play an important role when it comes to the durability of a garment and also due to the fast fashion trend the longevity of the garment collection has become too short than a few years back [27]. The fast fashion cycle in recent years is focused on a trend that leads to profit and cheap clothing, customers buy a garment and instead of a seasonal purchase now it has become a sub-seasonal purchase [28]. Because the retail stores make it a deadline to drop a new collection every week and customers are forced to make a purchase of the design in the fright of missing it out for the next time when they visit the store.

Purchasing a garment is not a big deal, it is a matter of money but when it comes to maintaining a garment and extending its permanence. It requires patience and resources to do the task [29]. This simply conveys the fact that resources like human effort, water, heat and electricity are needed to have a good ironed garment in our wardrobe. Again usage of all these resources more than a certain limit will be an impactful situation for the environment.

*3.1.2.1. Environmental impacts*

Fast fashion is a trend term used to sell bulk made goods at the lowest price and is focused only on economic growth in terms of profit but is not concerned about the influences these show on environmental growth [30]. Therefore, consumers need to know the sustainable approach toward environmental health and consciously avoid such fashion choices [31]. Instead of going with a big production number with less quality material for cheap prices, if the garments are made with good quality material that can last longer in a moderate price range will encourage people to buy and also when they want to dispose of these garments can be recycled or reused rather than burning or throwing them in landfills and then making new products again from scratch [32]. This approach can reduce the resources used in the process and save them for the future.

Reduction efforts for greenhouse gas emissions are known as accelerated abatement [33], with clothing brands and retail manufacturers as the main primary elements. A few such important aspects such as reducing the carbon emissions from the upstream process and the brand's self-oriented operations, and encouraging consumers to follow sustainable behaviours [34] were a few such attempts of this reduction process.

In the course of usage of a garment, washing several times and each time washed and dry, micro-fibres release into the water stream which is a big issue. When the usage of purchased clothes, several million tonnes of CO2 are emitted every year [35] from the process of washing and drying clothes. It leads to carbon emissions and this was not a big deal a few years back but now it has become a huge number that will have a harmful impact on the environment [36]. Therefore, reducing production and reusing/recycling the existing products can be a good solution to this issue.

*3.1.2.2. Waste management or disposal*

The naturally occurring fibres will demand higher energy for the decomposition process when compared with synthetic fibres, also synthetic fibres release microfibres into the water which can eventually end up in oceans. Such microfibres realised from natural materials break down quicker than synthetic materials which take a very long time and can be eaten by sea animals. Therefore, just washing causes many issues and when such kind of garment is disposed of in the ocean or landfills it is a nightmare to imagine the impacts that these could cause in our day-to-day life. In this case, both the ocean and land are polluted with excessive production of garments [37].

These days people have a big wardrobe where a teen girl/boy has an average of 20-30 t-shirts and 6-8 denim/ skirts with a variety of footwear to match the outfit [38], all this is not an essential thing but just to be aesthetically satisfied. From this, we can analyse that fast fashion has resulted in huge production numbers and all of these will be accumulated in landfills or will be burned to dispose of them, either way, it will cause an impact on the environment [39].

Fast fashion has forced our fashion population to buy more than needed and this ultimately is less durable clothing which is degraded in a few washes and then people throw away these and build their wardrobe with new collections and this cycle continues [40]. This has made landfills more crowded than ever before and being 3rd biggest country the waste treatment for such problem is still not having. A clear solution is adapting an approach like buying recycled clothing rather

than new virgin clothing can save money and also resources required to make the recycled products are only half the new product [41]. Also when landfills are crowded and during the rainy season the synthetic fibres release microfibre into the water streams causing harm to both aquatic life and human life which depend on the water source and this donates the effect of ocean plastic pollution [42].

The most preferred option to get rid of this excess clothing or waste clothing is by burning them to recover energy which again contributes to carbon emissions and is a very big cause of the climatic disasters that have occurred in recent years and then manufacturers make a completely new product from the virgin materials which is a source to resource waste and time waste [43]. Instead of all these aspects, a sustainable alternate option would be to recycle or reuse garments rather than buying new garments, in this recent analysis it is found that only 5-8% of clothing is being recycled and all others are dumped in landfills which are ultimately burned [44]. Therefore, following a good alternative measure to burning these garments would be the best option and the customers or manufacturers can understand the importance of recycling and the rate is expected to rise with such awareness.

*3.2. 4 R Concepts:*

The makers or buyers in the form of customers, buyers, manufacturers, retailers and disposers are required to overcome these issues caused by adapting the fast fashion model which was not an aesthetic behaviour but rather a functional behavior. The consumers who are fashion minded with no concern about the impacts that would cause to the environment in the upcoming future. Rather than scaling up production and increasing profits fashion brands, and manufacturers can adopt sustainable approaches to produce a garment in the required quantity to make the best out of existing products by adapting the concept of 4R has been encouraged and enhanced.

The 4R concept denotes the sustainable approach for the betterment of the environment and also the human quality of life in such surroundings will be enriched. The benefit of each R in the 4R is explained in the context: of "REDUCE" this aspect suggests the consumers and also the manufacturers focus on both quality and quantity on an equal basis and not just on quantity [45]. If the quality is to be the main focus then the commitment required to make a garment would be more than that of quantity focused garments, and in quantity focused garments all that matters is a huge production and this would just exhaust the resources given rise to water scarcity and other resources like heat and electricity produced by fossil a scarcity and this results in carbon emission which is again a regrettable reality [46]. To bring the reduction of resources into the picture then "REUSE" products that are in the urge of being thrown away for disposal [47]. Reusing is nothing but to up-cycle an existing product into a better product so that people would prefer to buy them for their added aesthetic or functional quality and make the best out of them rather than dumping those products in landfills or burning them for energy recovery [48]. Another alternate option to the reuse method is to donate products to non-charitable organisations or give them away to second-hand stores where they up-cycle these and develop them aesthetically for the second purchase and the life of such products is increased rather than buying a virgin product [49]. Even then if the fact of those products being already used exists in the minds of people, such products can be made into a new product with the concept of "RECYCLE", this helps a product to be utilised in a completely unique way because it is all the way made from the starting process except that the raw material comes from pre-existed product. These processes have a big impact on the development of the environment and help eradicate the landfills but only 5% of total clothing [50] is recycled and others end up in landfills/ oceans or sent for burning. Recently, several brands like H&M and ZARA have been approaching this recycling option to become sustainable brands and be eco-friendly [51]. Whereas few other brands have stated "if customers give them a garment for recycling they would get an offer of 10%" which is making new marketing strategies to make the consumer aware of the importance of recycling [52] rather than buying new virgin products made from complete virgin materials. Another main reason to take recycling of products forward is that making a product from recycled materials uses only 30-50% of a total resource than making a virgin product and carbon emission is reduced to up to 60% when a product is made from recycled materials. Because the most carbon emission is found to happen due to the fibre production stage in the farms [53]. The last no other choice option is to "RECOVER" when the material cannot be reused or recycled from an existing product due to several reasons, and this process can help in recovering the energy spent to make the product and can be refurbished in any other process so the no new energy is exhausted [54]. All these are the segmentation of 4R in the lifecycle of a product and making the best use of a product at every stage can save resources needed to make new products from scratch and eradicate the fast fashion concept where only profit is the main focus and not the environment.

## 4. Conclusion

The fashion industry is responsible for a major part of textile production. People nowadays buy 60% more clothing due to fast fashion trends than what they used to buy 20 years ago. This has caused environmental impacts that are now reflected as climatic disorders and environmental backfires. Also, the fashion industry is accountable for 15% of annual global carbon emissions. It exceeds any other industry by leaping the range of greenhouse gases emitted in various other fields. From all these matters we can undeniably state that the effects caused by the fashion industry will spike the levels of carbon footprint in the near future. Therefore, People should start adapting to buying clothes which is a necessity and avoid unwanted purchases each time they visit malls or each time they see a new collection. Instead of people or customers thinking for a moment and then reacting they can understand if that purchase is really needed for them. Maintaining a limit

on resource consumption can result in well balanced state, or else nature would backfire on the surroundings which will be hard for the human race to face reality. Therefore, adapting the 4R approaches like "REDUCE, REUSE, RECYCLE and RECOVER" can help people understand the importance of a sustainable and eco-friendly environment. Understanding the ways to manage/dispose of waste and understanding the impacts caused by underused/ overused clothing can help us move to a better lifestyle with better environmental surroundings. Hence, human consciousness in the form of customers, buyers, manufacturers, retailers and disposers is required to overcome these issues which have arisen knowingly or unknowingly by the fast fashion industry and the consumers who are fashion minded with no concern about the impacts that would cause to the environment in upcoming future.

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# A Study on the Socio-Economic Conditions of Khadi Artisans in Punjab

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**Abstract:**

***Background***

*The heritage fabric Khadi is integral to the apparel sector in India. It holds a distinct identity due to its historical significance in bringing rural empowerment. However, this handspun fabric suffered a decline when the British promoted cotton farming, which was processed in mills and later flooded back into the Indian market, thus creating the downfall of Khadi. Mahatma Gandhi's Swadeshi Movement played a pivotal role in reviving Khadi, positioning it as a symbol of self-sufficiency, sustainability, and employment. The Indian government, particularly through the Khadi and Village Commission (KVIC), endeavors to promote Khadi. Punjab has contributed significantly to the Khadi movement and houses various Khadi manufacturing units. The present paper aims to study the Socio-Economic conditions of Khadi artisans in Punjab and evaluate the extent to which the KVIC has been able to accomplish its overall objectives in Punjab.*

***Methods***

*Various Khadi manufacturing units were visited, viz., Punjab Khadi Mandal at Hariana, a unit of Sutlej Khadi Mandal at Nakodar, and a unit of Kshetriya Punjab Khadi Mandal at Kharar. The spinners and weavers working in these units were interviewed using a purposive sampling technique. The study explored demographic and socio-economic profiles, including gender, age, qualification, annual income, work experience with KVIC, etc.*

***Results and Conclusion***

*The data gathered through analysis revealed that Khadi artisans are disappointed due to very low wages, irregularity in employment, drudgery involved, and little social security. Consequently, the younger generation in the artisan's families is hesitant to continue in their profession and has resorted to alternative sources of income.*

**Keywords :** *Employment, Heritage, Khadi, Khadi Artisans, Socio-Economic, Sustainable*

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## 1. Introduction

The wearing of apparel is solely a human feature and is an essential element of society. People started wearing garments after the last Ice Age [1]. The Indian textile industry contributes around 2.3% to the GDP, 7% to manufacturing production, and 13% to the export earnings of the country. It is also the second-largest employer, employing around 45 million people as of 2019–20 [2]. A hand-spun Indian heritage fabric, Khadi, is also an integral part of the apparel segment [3, 4].

Originating from the word "khaddar," Khadi is a handcrafted textile created with the help of a charkha, a common instrument used in Indian villages for ages. This hand-spun Indian heritage fabric, Khadi, was stolen by the British. The East India Company promoted cotton farming, which was processed in mills as a textile and was later flooded back into the Indian market, thus creating the downfall of Khadi. Mahatma Gandhi initiated Khadi spinning for rural self-employment and self-sufficiency, thereby making Khadi an intrinsic part and emblem of the Swadeshi movement. He held out a fragile cotton thread as a sign of power and independence, as well as providing employment for millions. As a result, Khadi became India's national fabric and a symbol of India's freedom struggle. The motive behind this movement lies in the fact that Gandhiji saw Khadi as a means to elevate the masses [5, 6].

The tradition of wearing cloth made by human hands has persisted to this day [7-9]. Khadi continues to be the main source of employment for the spinners and weavers throughout the country because they cannot find an alternate source of employment at their doorsteps. Khadi is helping to support destitute, helpless rural women so they can work independently and earn their living [10 -12].

### *1.1 Techniques of Khadi Making*

Since its inception, Khadi production has gone through a lot of technological advancements. Improvements have been made at various stages, such as spinning, weaving, finishing, etc., to improve the quality, productivity, overall efficiency, and wages of all classes of Khadi workers [13, 14]. The performance and design of the spinning instrument have undergone extensive improvements. In the early days, the raw cotton was spun using a straightforward device called a "takli." The Takli was 10 to 14 inches long and thick, like a

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big needle made of iron with a brass circle at the bottom (Fig. 1) [15-20].

***Figure 1: Takli used for spinning cotton Khadi***
*Image Source: https://spinoffmagazine.com/troubleshoot-your-takli-spindle/*

Charkha was later introduced as a more efficient tool for spinning yarns and was mostly made from wood. Bardoli Charkha and Yerwada Charkha were the two major varieties of charkha used for spinning during the freedom struggle. Bardoli charkha is a regular form with a spinning wheel (Fig. 2). This is the oldest known type of spinning wheel that works by turning the drive wheel by hand while the yarn spins off the spindle tip. Artisans use a variety of Bardoli charkhas to spin the yarn [21, 22].

***Figure 2: Bardoli Charkha***
*Image Source: https://en.wikipedia.org/wiki/Spinning_wheel*

Mahatma Gandhi had a need for a device that could be easily transported while he was in Yerwada jail, and so he created the Yerwada Charkha, or Peti Charkha (Fig. 3), which was a box-shaped device that was efficient, portable, and foldable. This was due to the fact that the traditional Charkha was cumbersome and difficult to transport. This portable spinning wheel was compact and could be folded into a small wooden box and carried with a handle. [15].

***Figure 3: Yerwada Charkha or the Peti Charkha***
*Image Source: https://charkhatales.com/blogs/chronicles-of-a-charkha/chronicles-of-a-charkha*

The introduction of KVIC's ring spinning technology, featuring multiple spindles ranging between two and twelve, has led to the development of new Charkhas. These modern Charkhas enable faster speeds and higher wages for spinners. While the majority of wheel spinning now occurs in the New Model Charkha (NMC) (Fig. 4), traditional hand-spinning wheels are still being used in rural villages. The spun yarns are wound into reels, each measuring 1000 meters [15].

***Figure 4: New Model Charkhas***
*Image Source: https://www.kvic.gov.in/kvicres/snt.php*

Currently, Khadi is viewed as a transformational fabric that is a fusion of traditional and modern heritage. It is worldwide preferred for its versatile features, resembling cotton in texture yet as supple as silk. Khadi is renowned for its eco-friendliness, adaptability to easy printing and embroidery, cooling properties in summer and warmth in winter, bucolic and unpretentious appearance, and skin-friendly characteristics owing to its breathable nature [16].

### *1.2 Khes and Phulkari: The Heritage of Punjab*

Despite facing adversity, Indian artisans have withstood the test of time and have kept their great crafts alive. Over the centuries, handlooms have come to be associated with excellence in India's artistry in fabrics. The fabrics and designs of the region are influenced by its geographic, religious, and social customs. Different parts of India have produced distinct styles: the muslin of Chanderi, Varanasi brocades, Rajasthan, and Orissa have given tie and die products; Patola sarees from Patan; himroos of Hyderabad; phulkari and khes from Punjab; Daccai and Jamdani from Bengal; traditional designs from Assam and Manipur like the Phenek and Tongam. Indian handloom designs and weaves have been famous the world over, and it is important to ensure the sustenance of our cultural heritage [23].

The term "Phulkari" refers to Punjabi traditional needlework. Although it refers to flowers, the designs also feature geometrical patterns, which consist of flowers (phul) and shapes (akari). This style of clothing art is created on kurtis, dupattas, stoles, sarees, salwar suits, and juttis. The origin of the craft is debated. Some scholars suggest that it was introduced to India from Central Asia by the Jat community in the late medieval period, while others state that the craft was influenced by Persian gulkari embroidery designs. Phulkari embroidery and the traditions surrounding it have

been mentioned in the Sikh holy book Guru Granth Sahib and the eighteenth-century Punjabi epic Heer Ranjha [23].

Phulkari embroidery is done using a running stitch with brightly colored untwisted silk thread, historically imported from Kashmir and Bengal. It uses a base of coarse hand-woven cloth called khaddar (or khadi), typically comprising strips about half a meter wide, or less, stitched together. In most cases, the khaddar is traditionally dyed red using plant-based dyes obtained from palash (Butea monosperma) flowers, madder root (genus Rubia), or the bark of acacia (genus Acacia) trees. Embroidery threads are often yellow, orange, or pink; darker colors like black, brown, and green are less frequently used, and blue is rarely used [23–25].

Another important heritage of Punjabi textiles is khes, which has its roots in Khadi. Khes is a floor spread and bed covering that is traditionally made of cotton. The thinner ones are used as bed coverings in winter, and the thicker ones are used in place of shawls during winter. For generations, women residing in the villages of Punjab, have woven khes with bold, harmonic, and imaginative color patterns as a part of the trousseau they take to their future homes [22].

### *1.3 Emergence of KVIC*

Khadi was brought to the people of undivided India in the year 1918 with the aim of achieving self-reliance and breaking away from British textiles. However, in May 1915, the Khadi movement, a socio-cultural story, was initiated by Mahatma Gandhi from the ashram of Satyagraha, Sabarmati, in the district of Ahmedabad, Gujarat [18]. Khadi became an important part of the national movement in 1921, and in 1923, the All-India Khadi Board, overseen by the Indian National Congress, was established to manage the growth of the Khadi program. Another organization, the All-India Spinners Association, also known as Akhil Bharat Chakra Sangh, was founded in 1925. Despite its close ties to the Indian National Congress, the All India Spinners Association (AISA) was an autonomous organization that focused on the manufacturing, marketing, and promotion of Khadi products until 1935 [25–28].

Later, with the efforts of Mahatma Gandhi, a system for providing a fair wage to Khadi spinners was devised in 1938. In addition to standardizing wages, Gandhi also emphasized the importance of Khadi, emphasizing its self-sufficiency and decentralization of supply and demand.

He personally got in touch with Khadi workers and contributed greatly to their economic development. After gaining independence in 1947, the AISA formulated a robust plan to generate employment in rural regions, simultaneously addressing the nation's demand for Khadi through hand spinning and hand weaving [29, 30]. The All India Khadi and Village Industry Board was established in January 1953. The All India Khadi and Village Industry Board replaced the Akhil Bhartiya Sarva Sangh, which had merged with the AISA [18]. Later in 1957, the Khadi and Village Industries Commission was created to address some procedural issues that were preventing the growth of the KVI program in India, as well as to publicize and uplift the growth and trade of Khadi products [12].

The Khadi and Village Industries Program played a significant role in providing rural artisans with more targeted service opportunities for the weaker strata of the culture [21]. KVIC is charged with organizing, developing, coordinating, and using projects for the improvement of Khadi and other town ventures in rural areas in collaboration with other offices involved in rural progress wherever necessary. Additionally, it develops a stockpile of raw materials and finished goods for distribution to manufacturers, establishes standard support offices for handling raw materials as semi-finished goods, and sets up offices for the marketing of KVI products apart from the preparation of craftsmen engaged in these enterprises and the facilitation of cooperative efforts among them.

### *1.4 Role and Functions of KVIC*

The Khadi and Village Industries Commission (KVIC) falls under the Ministry of Small and Medium Enterprises, which oversees the sector's manufacturing, sales, distribution, and marketing processes [13]. The KVIC was established with the following fundamental goals in mind: (a) Social Goal: To develop non-farm job prospects in rural regions at wages that are, at the very least, equivalent to the current levels of salaries in the agricultural sector outside the peak season. (b) Economic Goal: to create salable items for the provision of services for which there is an actual demand. (c) Wider Objective: To encourage rural development in all of its forms and to raise living standards. Through its twin programs of Khadi and Village Industries Commission, KVIC has contributed to the creation of job possibilities in the unorganized rural non-farm sector.

Khadi refers to the production of handloom textiles, and Village industries include additional handicrafts and small, home-based businesses including lime production, beekeeping, oilseed processing, home-made soap, handmade paper, and fruit processing and canning. Planning, promoting, organizing, and assisting in the execution of plans for the development of Khadi and Village Industries are typically the responsibilities of the KVIC. In order to do this, it undertakes the following activities: (a) funding of eligible agencies; (b) training of individuals working in or seeking employment in the Khadi and Village Industries, supervisors, and other officials; and (c) developing the material reserves. Among other things, this includes (d) research and development in the field of Khadi and Village Industries; (e) promoting the selling and marketing of Khadi and Village Industries products; and (f) promoting and encouraging cooperative efforts among the people involved in Khadi and Village Industries, among other activities [21, 22, 23].

Over the past couple of years, the primary objective of KVIC has been to generate sustainable employment for the artisans

and young people who are out of work. In 2022–23, the KVIC achieved a milestone of creating 9.5 lakh jobs in rural areas. Over 80% of the Khadi units are established in rural areas. More than 50% of the units are led by SC, ST, and women entrepreneurs [16].

### *1.5 Khadi movement in Punjab*

Punjab has contributed significantly to the Khadi movement. Following the Non-Cooperation Movement's suspension, Gandhiji carried out a number of initiatives to further the Swadeshi policy. Adampur, in Punjab, was famed for its weavers with a tradition of hand woven fabrics. There is a story that local craftsmen in Adampur welcomed Mahatma Gandhi with cotton garlands weaved by hand rather than flowers when he arrived in 1925. Gandhiji, a strong supporter of Khadi, considered it a vital instrument for the Swadeshi movement. Moved by the fervor of the Adampur artisans, he founded the All India Spinners Association and established its first office there. The weavers of Adampur helped the independence struggle by making Khadi more popular than English-imported textiles and opening up jobs for artisans in the villages. Hundreds of weavers and spinners were employed in making durris, khes, shirts, towels, and other items. Later, the center encompassed regions up to Jammu, Kashmir, and Delhi. During the Freedom Struggle, the Punjab Charkha Sangh was instrumental in popularizing and promoting Khadi [28].

However, in post-independence popular culture, the perception of Khadi altered, and its popularity dropped in Punjab as a result of a lack of diversity, design, innovation, and cheaper substitutes in the market. Due to changes in lifestyle and the rise of the latest technology, the demand for Khadi products decreased tremendously. The production of blankets and hosiery garments dented the Khadi market, and demand for Khadi products decreased. As demand continued to decline, weavers and spinners scattered across the country [15, 25, 28]. Most of the Khadi institutions are facing problems like a lack of working capital and financial assistance to improve retail outlets. Khadi stores in Punjab are flooded with unsold stocks of durris, khes, and towels [24]. The decline in demand for Khadi goods has hugely impacted the lives of Khadi artisans (spinners and weavers) in Punjab.

## 2. Objectives

This paper primarily aims at studying the socio-economic conditions of Khadi artisans in Punjab.

## 3. Material and Methods

The present paper aims to study the socio-economic conditions of Khadi artisans in Punjab and evaluate the extent to which the KVIC has been able to accomplish its overall objectives in Punjab. Following is the research methodology that opted to study the same.

### *3.1 Locale of the study*

To carry out the survey, the researchers visited various Khadi manufacturing units, viz., Punjab Khadi Mandal at Hariana (a town in Hoshiarpur district), Sutlej Khadi Mandal at Nakodar, and Kshetriya Punjab Khadi Mandal at Kharar. Permission was sought from these Mandals to interview spinners and weavers working in these Mandals.

### *3.2 Population of the Study*

All the respondents, both male and female artisans, were interviewed.

### *3.3 Sample Size*

A total of 31 artisans (depending on availability), comprising 23 spinners and 8 weavers, were taken as a sample for the above study.

### *3.4 Data Collection*

This study primarily used primary data, and to collect data, researchers used a semi-structured interview schedule containing open-ended and closed-ended questions. Secondary data was acquired from various government websites and publications related to KVIC.

### *3.5 Sampling Method*

A purposive sampling technique was used for the selection of the sample.

### *3.6 Time Span*

This research was conducted from August 2022 to April 2023.

## 4. Results & Discussions

This part of the research paper presents the results regarding the socio-economic conditions of Khadi artisans in Punjab. Table 1–13 shows the demographic profile of the Khadi artisans in Punjab.

### *4.1 Gender*

The respondents were asked a categorical question to determine their gender. For the response, they were asked to choose a male, female, or transgender option. The responses are mentioned in Table 1.

***Table 1: Gender of Khadi Artisans***
*(N=Total number of respondents; N=31)*

| | Male | | Female | | Others | |
|---|---|---|---|---|---|---|
| | N | % | N | % | N | % |
| Weavers | 8 | 100 | 0 | - | 0 | - |
| Spinners | 0 | - | 23 | 100 | 0 | - |

The data pertaining to gender revealed that in all the manufacturing units, all the spinners were female and all the weavers were male. However, female members of the weavers' family assist them in various tasks related to weaving.

### *4.2 Age*

Age plays an important role. A higher number of years of age

accounts for greater experience. Hence, age was also taken into consideration. Table 2 revealed that there were mostly experienced artisans who played a predominant role in Khadi.

***Table 2: Age of Khadi Artisans***
*(N=Total number of respondents; N=31)*

| | Under 18 years | | 18-25 years | | 25-35 years | | 35-45 years | | 45-55 years | | 55-60 years | | 60 years and above | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | N | % | N | % | N | % | N | % |
| Weavers | 0 | - | 0 | - | 0 | - | 2 | 25 | 3 | 37.5 | 1 | 12.5 | 2 | 25 |
| Spinners | 0 | - | 0 | - | 3 | 13 | 4 | 17.4 | 6 | 26.1 | 4 | 17.4 | 6 | 26.1 |

It can be elucidated that all most of the weavers, and spinners are above the age of 45.

### *4.3 Qualification*

It can be elucidated that most artisans have received little or no formal education (Table 3).

***Table 3: Qualification of Khadi Artisans***
*(N=Total number of respondents; N=31)*

| | No Schooling | | Till Middle or Below | | Matricul-ation | | Senior Secondary | | Bach-elor's Degree | | Master's Degree | | Ph. D. or Higher | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | N | % | N | % | N | % | N | % |
| Weavers | 5 | 62.5 | 2 | 25 | 1 | 12.5 | 0 | - | 0 | - | 0 | - | 0 | - |
| Spinners | 11 | 47.8 | 8 | 34.8 | 3 | 13 | 1 | 4.4 | 0 | - | 0 | - | 0 | - |

This implies that most of the artisans have only practical knowledge that they have learned from their elders.

### *4.4 Work Experience*

Data on work experience shows that 50% of weavers have been with KVIC for 30 years or older, while the majority of spinners (56.7%) have been with KVIC for 20 years or more (Table 4).

***Table 4: Khadi Artisans' Work Experience with KVIC***
*(N=Total number of respondents; N=31)*

| | 0-5 years | | 5-10 years | | 10-15 years | | 15-20 years | | 20-25 years | | 25-30 years | | Above 30 years | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | N | % | N | % | N | % | N | % |
| Weavers | 0 | - | 0 | - | 0 | - | 1 | 12.5 | 2 | 25 | 1 | 12.5 | 4 | 50 |
| Spinners | 3 | 13 | 1 | 4.6 | 3 | 13 | 3 | 13 | 7 | 30.4 | 2 | 8.7 | 4 | 17.6 |

It can be elucidated that most of the older workers possessed significant work experience, while the younger generation lacked expertise in the art of weaving Khadi.

4.5 Annual Income from Khadi

The data pertaining to income revealed that the annual income of 50% of weavers is between Rs 60,000 - Rs 80,000 (Table 5). Furthermore, they live with their families in free quarters given by Khadi Mandals, where they have free access to water and electricity. However, the majority of spinners earn between Rs 10,000 and Rs 20,000 a year. The majority of the artisans stated that irregular employment was the primary cause of their poor annual income.

***Table 5: Approx. annual income of Khadi Artisans***
*(N=Total number of respondents; N=31)*

| | Less than 10,000/ | | Rs 10,000/- 20,000/- | | Rs 20,000/- 40,000/- | | Rs 40,000/- 60,000/- | | Rs 60,000/- 80,000/- | | Rs 80,000'/- 1,00,000/ | | Rs 1,00,000/- 2,00,000/- | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | N | % | N | % | N | % | N | % |
| Weavers | 0 | | 0 | | 0 | - | 0 | - | 4 | 50 | 1 | 12.5 | 2 | 37.5 |
| Spinners | 3 | 13 | 14 | 60.9 | 3 | 13 | 3 | 13 | 0 | - | 0 | - | 0 | - |

### *4.6 Level of Satisfaction*

It was revealed that most of the artisans are dissatisfied with their income from KVIC (Table 6), as the cost of living has risen and it is difficult to feed or support the family with such low income wages.

***Table 6: Level of Satisfaction with Income from KVIC***
*(N=Total number of respondents; N=31)*

| | Highly Satisfied | | Satisfied | | Fine | | Dissatisfied | | Highly Dissatisfied | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | N | % | N | % |
| Weavers | 0 | - | 0 | - | 3 | 25 | 3 | 37.5 | 3 | 37.5 |
| Spinners | 3 | 13 | 2 | 8.7 | 4 | 17.4 | 11 | 47.8 | 3 | 13 |

### *4.7 Income from other sources*

Respondents were also asked about their secondary source of income, and data showed that 50% of weavers work outside of KVIC to supplement their income (Table 7). However, because women must additionally care for household responsibilities, only a minority (13%) of spinners have a supplementary secondary source of income.

***Table 7: Secondary source of income***
*(N=Total number of respondents; N=31)*

| | Yes | | No | |
|---|---|---|---|---|
| | N | % | N | % |
| Weavers | 4 | 50 | 4 | 50 |
| Spinners | 3 | 13 | 20 | 87 |

### *4.8 Family Structure*

According to family structure data, the majority of artisans (weavers and spinners) lived in joint families (Table 8).

***Table 8: Family Structure of Khadi Artisans***
*(N=Total number of respondents; N=31)*

| | Individual and there is no Family | | Nuclear Family | | Joint Family | |
|---|---|---|---|---|---|---|
| | N | % | N | % | No | % |
| Weavers | 0 | - | 1 | 12.5 | 7 | 87.5 |
| Spinners | 0 | - | 8 | 36.4 | 15 | 63.6 |

### *4.9 Reasons to Join KVIC*

*The majority of weavers (75%) joined KVIC since weaving is their family's profession. However, ease of work, utilization of free time, no investment, and financial support for the family were identified as important factors for spinners joining KVIC (Table 9).*

***Table 9: Reasons to Join KVIC***
*(N=Total number of respondents; N=31)*

| | Family Profession | | No Investment | | Ease of work | | Utilization of free Time | | Financial Support to the family | | No other option | | Others | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | N | % | N | % | N | % | N | % |
| Weavers | 6 | 75 | 0 | - | 0 | - | 0 | - | 0 | - | 2 | 25 | 0 | - |
| Spinners | 1 | 4.3 | 8 | 34.8 | 18 | 78.3 | 16 | 69.6 | 8 | 34.8 | 2 | 8.7 | 1 | 4.3 |

### *4.10 Technology prevailing in the Khadi Industry*

During the survey, an investigation was also done on the type of technology used in the spinning and weaving of Khadi. Tables 10.1 and 10.2 represent the data pertaining to the types of charkha and loom used.

***Table 10.1: Types of Charkhas Used by Spinners***
*(N=Total number of respondents; N=31)*

| | N | % |
|---|---|---|
| Bardoli (Traditional) Charkha | 10 | 43.48 |
| Yerwada (Peti) Charkha | 4 | 17.39 |
| New Model Charkhas | 6 | 26.09 |
| Both Bardoli and New Model Charkhas | 3 | 13.04 |

It was found that most of the spinners are still using old models of Charkhas, i.e., Bardoli (traditional) Charka (43.48%) and Yerwada (Peti) Charkha (17.39%). Only 26.09% of spinners are using New Model Charkhas (NMC). However, 13.04% of spinners are using both Bardoli and New Model Charkhas depending on the type of yarn required.

***Table10.2: Types of looms used by weavers***
*(N=Total number of respondents; N=31)*

| | N | % |
|---|---|---|
| Simple Horizontal Loom (beaten in place by Panja, Metal Beater) for weaving of Panja Durris | 4 | 50 |
| Pit Loom | 4 | 50 |

It was reported that nearly half of weavers were using simple horizontal looms for making Panja Durris, whereas the other half were using Pit looms.

4.11 Review of artisans on changes observed in the technology of Khadi Manufacturing

As far as new technology is concerned, weavers at Punjab Khadi Mandal and Sutlej Khadi Mandal unanimously stated that they had not seen any improvements in weaving technology over the years. They continue to weave the same Panja Durris on the same looms.

Weavers for the Kshetriya Punjab Khadi Mandal mentioned a shift from hand looms to pit looms. However, they expressed greater comfort with handlooms.

Spinners of Punjab Khadi Mandal stated that they had been using the same Peti Charhkas for years. The remaining spinners, on the other hand, were familiar with New Model Charkhas (higher spindles) and acknowledged their advantages. A significant number of them have adopted these New Model Charkhas.

4.12 Challenges at the Workplace

Data pertaining to workplace challenges (Table 11) revealed that artisans faced significant challenges such as lesser wages and income when compared to hard work, irregularities in employment, and job-related health issues. Artisans said that they are experiencing pain in their knees, arms, and back, as well as respiratory issues and irritation in the eyes and skin due to exposure to cotton fibers.

***Table 11: Challenges being faced by the artisans at the workplace***
*(N=Total number of respondents; N=31)*

| | Less Wages | | Improper Infrastructure | | Income is less when compared to hard work | | Irregularity in employment | | Less Awareness about government schemes | | Less awareness about Technology | | Facing Health Issues | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | N | % | N | % | N | % | N | % |
| Weavers | 8 | 100 | 3 | 37.5 | 8 | 100 | 4 | 50 | 2 | 25 | 3 | 37.5 | 4 | 50 |
| Spinners | 20 | 86.9 | 0 | - | 16 | 69.5 | 16 | 69.5 | 0 | - | 0 | - | 7 | 30.4 |

Spinners mentioned that earlier Khadi Mandals used to provide them consistent work throughout the year, but after the COVID-19 pandemic, work is very irregular, and sometimes they don't get employment for 2-3 months.

The spinners working for Punjab Khadi Mandal, Adampur of Nazian village (at town Hariana), mentioned that they were facing a huge issue in cotton collection and transporting spun yarn. The absence of a collection center in their village forces them to struggle with the inconvenience of traveling with bulky bundles of cotton and spun yarn, which is particularly challenging when relying on public transportation.

### *4.13 Training Programs attended*

A significant percentage of both spinners (91.3%) and weavers (87.5%) said that they have not attended any training programs organized by Khadi Mandals.

### *4.14 Suggestions for the Government and KVIC by Khadi Artisans*

Increment in wages, regular employment, implementation of a pension plan for artisans, support with advanced Charkhas and looms, and the introduction of innovative designs and technologies in Khadi making were among the primary suggestions opined by Khadi artists. These suggestions reflect the artisans' aspirations for better working conditions and enhanced support from the government and KVIC.

## 5. Conclusion

The data obtained from the survey revealed that technology in Khadi making has not advanced much. Artisans face challenges due to the absence of advanced charkhas, looms, workplace amenities, and toolkits, resulting in low production and inconsistent product quality. Despite working diligently, Khadi artisans are susceptible to low wages and irregular employment, making it challenging to sustain a basic standard of living. Resultantly, the number of Khadi artisans in Punjab has drastically reduced, with artisans seeking opportunities in labor-intensive fields for better pay and improved social and economic security.

The study reveals that innovation, including the adoption of higher spindle Charkhas and more advanced looms, holds the key to overcoming these challenges. This shift would involve less drudgery and fetch more wages. Recognizing the significance of a diverse range of products, new designs, and quality offerings influencing customer behavior, the study underscores the potential of innovation and improvement in Khadi fabric and garment design to boost sales, thereby creating more opportunities for Khadi artisans and fostering prosperity.

## 6. Suggestions for upgrading Khadi

Khadi, being a symbol of livelihood and self-sufficiency and an integral part of India's independence movement, serves as a crucial support for cottage industries. In Punjab, with its extensive history and significant potential, there is a unique opportunity to further promote and advance the cause of Khadi. Additionally, Khadi is intricately linked with the rich heritage of Punjab, including traditional textiles like Phulkari and Khes. To preserve these cultural treasures and bolster the promotion of Khadi and its products, it is imperative for the state government to implement measures that increase the demand for Khadi.

- The KVIC should organize training programs for artisans where the artisans should be made aware of the latest technologies and current trends.
- The government should facilitate the artisans with better work sheds, advanced toolkits and charkhas, and modern looms, which would involve less drudgery, better production, and fetching more wages.
- The government's national minimum wage system should be applicable in the Khadi sector, and artisans should benefit from it, as this is the only source of income for most of the artisans.The improvisation in the design of Khadi products needs to be undertaken to encourage the production of high-value-added products, which may lead to the increased sale of Khadi products.
- The marketing and branding of Khadi products should be stronger to compete with other global brands.
- There is a necessity to raise awareness about Khadi among buyers who seek high-quality and sustainable fabrics.
- The young buyer needs to be initiated into the sustainable properties of Khadi, as they are carbon-neutral and environment-friendly, plus they are handcrafted. Moreover, Khadi is a service to the nation as it provides employment to rural people.

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GARMENT

# Analysis of Labor Compliance Execution in the RMG Sector of Bangladesh: Attempting to Meet SDG-8

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**Abstract**

*The RMG or ready-made garments are among the few sectors that are currently flourishing in Bangladesh. Considering the significant contribution of this sector the economic growth of Bangladesh, this sector has a high probability of playing a vital role in achieving the SDGs or the Sustainable Development Goals, especially SDG-8. This goal has the objective of achieving sustainable employment and economic growth along with full and productive employment. This highlights some notable conflict while also providing attention to the significance of universal labor rights. The proportion of forced labor in the official and informal industries has significantly increased in the current situation. RMG factories should also appropriately concentrate on the Decent Work indicators for achieving SDG-8. This study aimed to examine the compliance status of the RMG industry with ILO norms and decent work indicators. These factors might play a vital role in establishing SDG-8 through Decent Work in the RMG sector of Bangladesh. Hence, we prepared a questionnaire related to compliance issues regarding ILO conventions to conduct our research work. We collect feedback from 245 different RMG industry personnel in Bangladesh. We applied the chi-square test to conduct an appropriate analysis of our collected dataset to justify the execution status of labor compliance in the RMG sector.*

**Keywords:** *: Compliance, Decent work, Forced labor, ILO, Labor law, Trade Union*

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## 1. Introduction

International labor laws are the result of a growing global awareness of the need for action on certain problems, including guaranteeing safe working conditions for agricultural workers or offering maternity protection to working women [18]. The improvement of global work principles at the ILO is a special regulative interaction that includes delegates of states, laborers and businesses from all through the earth [30]. A unique worldwide supervisory framework supports international labor standards and guarantees that the agreements adopted by each country are put into effect [12]. In the event that nations encounter difficulties implementing standards, the ILO attempts to support them by means of social consultation and technical guidance [25].

Bangladesh, an ILO member nation, has supported the Decent Work (DW) objectives since the outset of the program. The "Decent Work" initiative of the International Labor Organization has focused on creating opportunities to obtain productive work conditions of freedom, equity, security, and human dignity for women and men [5]. Since the introduction of the SDGs, which included "Decent Work" as a key component, the agenda has acquired increased support. As a result, SDG lenses offer the current Decent Work Country Program (DWCP) direction for selecting goals and priorities. The Bali Declaration, which called on governments, labor unions, and owners' associations in the area to support inclusive growth, social justice, and decent work, was also strategically aligned with the DWCP. The announcement was made during the ILO Asia Pacific regional meeting in December 2016. To date, Bangladesh has carried out two DWCPs, which span the years 2006–09 and 2012–2015. [27]. The current DWCP, which will be executed from 2017 to 2020, will be focused on outcomes, targeted, and organized with national strategy forms and international expansion ingenuities. These initiatives have been developed through extensive stakeholder discussions with a wide variety of stakeholders and additional pertinent parties, which have formed the foundation for a participatory assessment of the country's current challenges [14].

Since the SDG is very important in the RMG sector and, most importantly, is a new concept, very little research has been conducted on this topic. In various qualitative studies, respondents provided their own answers, which were irrelevant for completing statistical analysis [3]. However, in

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this study, the survey was administered in an appropriate way through binary questions with close-ended yes/no answers. Investigating the challenges and barriers that hinder the effective execution of labor compliance measures on the RMG side is crucial [28]. This could include examining factors such as regulatory gaps, enforcement issues, or resistance from industry stakeholders. Moreover, the assessment of the long-term sustainability of labor compliance initiatives that leads to lasting improvements in labor standards and economic growth is another issue to be discussed. Anticipating and addressing emerging trends in the RMG sector that may affect labor compliance efforts and SDG-8 attainment, such as automation, sustainability, or changes in consumer preferences, can also be investigated [24]. Many studies have not focused on generating specific, evidence-based policy recommendations for enhancing labor compliance in the RMG sector, indicating the need for adjustments or interventions to better connect the industry with SDG-8 objectives.

Execution and achievement will depend on nations' own reasonable improvement strategies, plans and projects and will be driven by nations [4]. The SDGs will be a compass for adjusting nations' arrangements to their worldwide responsibilities [26]. Broadly claimed and country-drove practical advancement procedures will require financing strategies and resource mobilization. This study aimed to prioritize the barriers to implementing SDG-8 standards in Bangladeshi RMG factories by identifying the execution status of compliance issues and developing an interrelationship among the variables via the chi-square test.

Here, we list several research questions that are covered in this study (RQs):

RQ1: Is there any punishment in your company/industry as a penal offense for illegal exaction of forced or compulsory labor?

RQ2: Is your factory aware of the 'Modern Slavery Act 2015?

RQ3: Is there any kind of discrimination in terms of racial, social, national or religious aspects in your workplace?

Rq4: Does your collective bargaining agent involve practicing policies and procedures in writing to protect children from any kind of exploitation?

The goal is to accomplish the following research objectives (ROs) in a manner that addresses the research questions:

RO1: To determine the execution status of labor compliance according to the ILO Conventions.

RO2: To verify whether factories want to accomplish SDG-8 by implementing decent work factors for compliance.

Ro3: To determine an agreeable way to develop an adequate solution to ensure the proper level of labor for achieving SDG-8 in RMG factories in Bangladesh.

The remainder of this paper is arranged as follows. A review of the literature is presented in Section 2, and a thorough explanation of the methodological strategy and the complete logic of all pertinent operations is given in Section 3. The results and data analysis are presented in Section 4. A thorough analysis of the study's conclusions and consequences is provided in Section 5. In Section 6, the research is concluded with an outline of its limitations and a call for additional research directions.

## 2. Literature Review

The ILO's constituent governments, employers, and labor organizations draft legal documents referred to as international labor standards that define essential workplace norms and rights [10]. While recommendations function as nonrestrictive guidelines, agreements (or procedures) have the force of law agreements that restrict international settlements, which may be accepted by specific states. The basic conditions that sanctioning nations must fulfil are outlined in the Convention. Moreover, by adding more significant guidelines for its execution, a related recommendation strengthens the Convention [18].

### *2.1 Sustainable Development Goals*

Sustainable development goals are international initiatives to address poverty, save the environment, and enhance the opportunities and quality of life for all people worldwide [23]. The 17 goals were adopted by the UN General Assembly, which took place in 2015 as a component of the UN's 2030 Schedule for Sustainable Development, which also included a fifteen-year plan for achieving the goals. While there has been progress in many areas at the moment, in general, the rate and breadth of action in achieving these goals have not been fully met. A decade of intense action must begin in 2020 to accomplish these goals by 2030 [7].

### *2.2 SDG-8: Decent Work and Economic Growth*

SDG-8: Economic growth and decent work

The goals of SDG-8 are inclusive, sustained, and sustainable growth in the economy; full and productive employment; and decent work for all. It highlights the reciprocal benefits of social, economic, and environmental policies and full employment with decent work [29]. The twelve interrelated SDG-8 targets have largely made slow progress. There are large gaps, and regional growth has not always been steady. Some notable emerging economies have experienced extremely rapid economic development and expansion, while others have lagged further behind. Numerous areas do not meet the standards for equitable and feasible growth in their economies. Despite many improvements, many employees have employment opportunities that are lucrative [16].

To promote long-term, equitable economic growth, access to financial services must also increase. To accomplish SDG-8, an established strategy that emphasizes the objectives of economic development for society, the economy, and the earth calls for inclusivity and resource decoupling [15].

*2.2.1 Policies needed to achieve SDG-8 implementation*
According to the Global Civil Society Report (given on the 2030 Agenda and the SDGs), several policies were presented to accomplish SDG-8. These are described below:

- To put the 2030 Agenda into practice, apply international labor standards, such as those pertaining to social dialogue, collective bargaining, and freedom of association.
- Establish all-encompassing employment policy frameworks and provide labor market institutions with support.
- To create green jobs and a low-carbon economy, implement a "just transition."
- Controlling corporate power: guaranteeing corporate responsibility, openness, and "due diligence" in international supply chains

**Source:** Paola Simonetti, International Trade Union Confederation (ITUC) [11].

### *2.3 Decent Work*

"Women and men's decent employment opportunities that are profitable in environments that promote human dignity, freedom, and security" is how the International Labor Organization (ILO) defines decent work, a definition endorsed by the global community [22]. The ILO's 2008 Announcement on Social equity for a Fair the rise of globalization endorses four of the goals of the fair Work Agenda. The following topics are covered: (i) the creation of jobs, (ii) social protection, (iii) international labor standards, and (iv) social dialogue and tripartism.

This decent work initiative was founded in 2008 with the goal of assisting participants in assessing the state's implementation of decent work and generating comparable information for the analysis and formulation of policies [20]. The Government, the National Coordination Committee for Workers Education, the Bangladesh Employers' Federation, and the ILO worked closely together to develop the Bangladesh DWCP. In accordance with national strategy forms and worldwide progress creativities such as the Sustainable Development Goals, this DWCP is driven by targeted outcomes [2].

The survey will be carried out from 2017 to 20 years, with a focus on four major goals and outcomes that will aid in achieving the objectives and main goals of the 7th Five Year Plan (FYP) [21]. The DWCP is pertinent to the following targets in this context:

- Streamlining actual GDP progress over the Plan period
- Dropping the headcount proportion of scarcity
- Expanding the proportion of jobs in the manufacturing field can assist many insecure people and recent workers in finding legitimate positions in occupations
- Aggregate productivity and financing access for urban SMEs
- Enhancing the environment, disaster management and climate change
- Promoting female enrollment in technical and vocational education

### *2.4 ILO Convention*

The ILO initially acknowledged eight "fundamental" Conventions as essential workplace rights and principles, including the effective outlawing of child labor, the freedom and right of association, the acknowledgement of the right to bargain collectively, and the outlawing of prejudice according to employment and occupation [6]. These ideas were also covered in the ILO Statement on Fundamental Rights and Principles at Employment (1998) [13].

This adoption can assist in addressing these issues in achieving SDG-8 through decent labor since it strikes a balance between employment and economic goals while taking social impacts into consideration. At the yearly International Labor Conference, conventions and recommendations are drafted by businesses, delegates from governments, and employees [1]. Article 19(6) of the ILO Constitution mandates that after a standard is set, member states must submit it for review to their responsible authority, typically the Parliament, within a year. This refers to the conventions' potential for ratification. A Convention typically enters into force for a country one year after it is ratified, if it is. Ratifying nations commit to incorporating the Convention into their national regulations and procedures and to periodically reporting on how well it is being implemented. If necessary, the ILO offers technical support. In addition, countries might be subject to representation and complaint processes for transgressions of a convention they have ratified [17].

*2.4.1 Convention 4: Abolition of Forced Labor*

The Abolishing of Forced Labor Convention, 1957, is one of the eight major conventions of the International Labor Organization. It is also known as the Convention Concerning the Abolition of Forced Labor, 1957; No. 105. Some forms of forced labor were still permitted under the Forced Labor Convention of 1930. Examples of these include retaliation for taking part in strikes and punishment for having certain political beliefs. The convention concerning the Abolition of Forced Labor outlaws these. The Special Action Program to Combat Forced Labor was established to carry out the 1930 Convention on Forced Labor and the 1957 Convention Abolishing Forced Labor [8].

Convention No. 105, Abolition of Forced Labor Convention, 1957, is the ILO write-down that has been ratified the most. There are four fundamental principles and rights at work that are covered by the International Labor Organization's 1998 Declaration on the Four Fundamental Principles and Rights at Work. One of these steps is the elimination of all forms of forced labor. All members of the organization make a commitment to "respect, promote, and think, with integrity and belief" this promise. A comprehensive and productive

response to forced labor encompassing prosecution, victim protection, and prevention within the larger framework to encourage decent work can be gained from the years-long observations of the ILO supervisory bodies as well as from experience acquired via technical interaction with the member nations [19].

## 3. Methodology

The methodology adopted for this study is a quantitative survey study. This study was conducted by administering a set of questionnaires containing dichotomous questions to various factory personnel (entry, mid and top level) based on compliance status with ILO conventions in the RMG industry of Bangladesh to help achieve SDG-8 through decent work. After receiving the responses, we obtained the primary data and the total responses, which were all approximately 245. Among the 245 respondents, 79 were from the entry level, 156 were from the mid-level level and the remaining 10 were from the top level of different textile factories. According to these data, we identified several reasons for forced labor and the violation of fundamental labor rights in various factories. The information and data collected were arranged so that further study and analysis could be performed. This study helps us to identify whether there is any forced labor or contravention of labor rights in Bangladesh and what should be done by different companies to eliminate these issues in a systematic manner.

To complete the study, ten dichotomous questions related to compliance with the four decent work indicators were asked of the respondents, and after that, from the given responses, a chi-square hypothesis test was performed to determine the correlation among the variables. The dichotomous questions and feedback percentages of the answers (yes/no) from 245 respondents from different RMG factories in Bangladesh are presented below:

Rq1: Is there any punishment in your company/industry as a penal offense for illegal exaction of forced or compulsory labor?

In response to this question, 68% of all respondents stated that in their company, punishment is available as a penal offense for illegal exaction of forced or compulsory labor, while 32% of respondents mentioned that there is no such punishment represented in Figure 2.

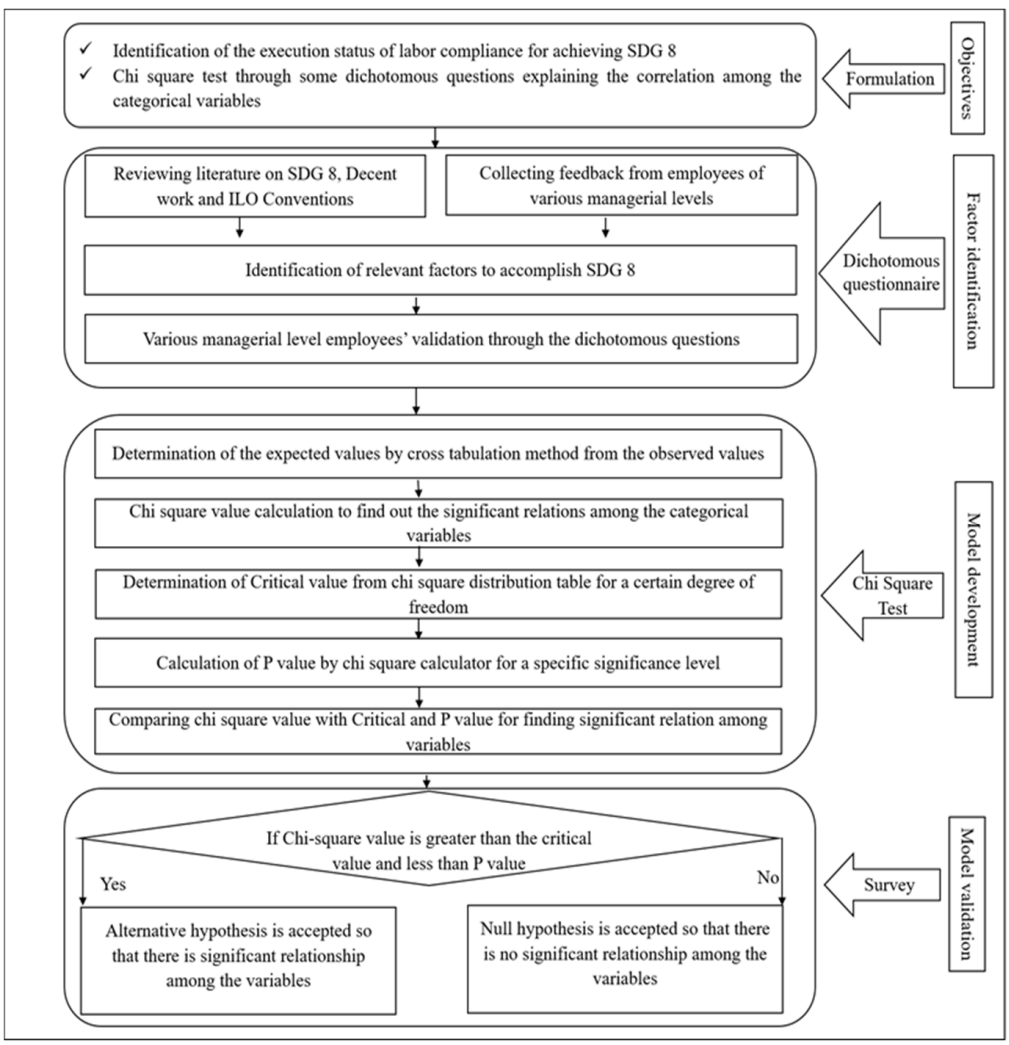


*Figure 1. Research methodology*

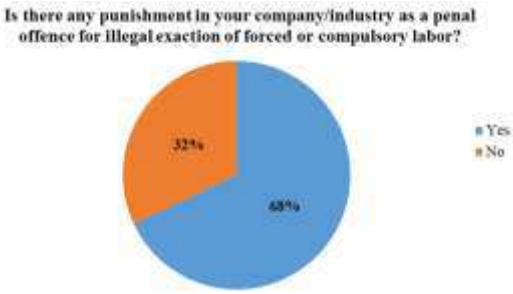


*Figure 2. Pie chart of the total yes/no percentage*

The percentage of employees at various companies that produce RMG who say yes or no to a given RQ is expressed in Table 1

***Table 1 - Yes/no percentage of a specific respondent level***

| Position at work | Yes | No |
|---|---|---|
| Entry-Level | 51.89% | 48.10% |
| Mid-Level | 62.82% | 37.17% |
| Top-Level | 90.00% | 10.00% |

The following shows the bar diagram of yes/no percentage of a particular RQ from a specific level of employees of various RMG factories in Bangladesh:

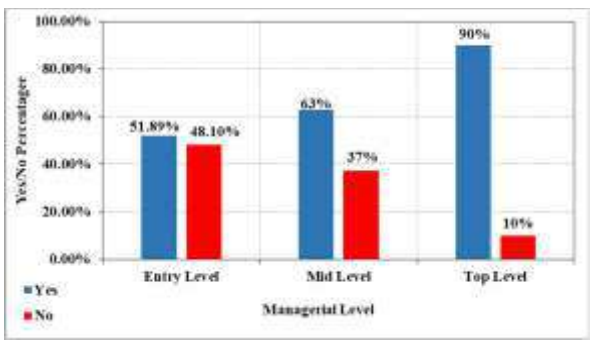


*Figure 3 - Bar diagram of the total yes/no percentage*

Table 2 lists the total yes/no percentage, yes/no percentage of entries, and mid- and top-level responses to all the survey questions.

The questions are first listed below:

1. RQ1: Is there any punishment in your company/industry as a penal offense for illegal exaction of forced or compulsory labor?
2. RQ2: Is there any discrimination against racial, social, national or religious aspects in your company?
3. RQ3: Do pregnant women receive their maternity leave on time with promised benefits at your workplace?
4. RQ4: Is your factory aware of 'Modern Slavery Act 2015'?
5. RQ5: Is the salary/wage structure of your company based on national laws or regulations?
6. RQ6: Do you have any policy to prevent discrimination in the workplace?
7. RQ7: Does your collective bargaining agent involve practicing policies and procedures in writing to protect children from any kind of exploitation?
8. RQ8: Is there any active labor union/trade union in your organization for the sake of worker welfare?
9. RQ9: Is there any protest from the trade union or a group of employees when workers remain unpaid?
10. RQ10: Is there any PC (participation committee) in your factory to ensure compliance?

***Table 2 - Yes/no percentage of respondents from various RMG factories***

| Sl. No. | Questions | Total Yes/No percentage | | Yes/No percentage of three levels of respondents | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Yes | No | Entry Level | | Mid-Level | | Top Level | |
| | | | | Yes | No | Yes | No | Yes | No |
| 1. | RQ1 | 68% | 32% | 51.89% | 48.10% | 62.82% | 37.17% | 90% | 10% |
| 2. | RQ2 | 19% | 81% | 18.98% | 81.02% | 18.58% | 81.41% | 20% | 80% |
| 3. | RQ3 | 89% | 11% | 87.34% | 12.65% | 89.74% | 25.00% | 90% | 10% |
| 4. | RQ4 | 74% | 26% | 69.62% | 30.37% | 75.00% | 25.00% | 90% | 10% |
| 5. | RQ5 | 84% | 16% | 70% | 30% | 80.76% | 19.23% | 100% | 0% |
| 6. | RQ6 | 64% | 36% | 59.49% | 40.50% | 62% | 38.00% | 70% | 30% |
| 7. | RQ7 | 62% | 38% | 60.75% | 39.24% | 61.53% | 38.46% | 60% | 40% |
| 8. | RQ8 | 68% | 32% | 67.08% | 32.91% | 66.66% | 33.33% | 70% | 30% |
| 9. | RQ9 | 69% | 31% | 69.62% | 30.37% | 54.48% | 45.51% | 80% | 20% |
| 10. | RQ10 | 68% | 32% | 54.43% | 45.56% | 72.43% | 27.56% | 90% | 10% |

## 4. Results and Data Analysis

After all the above questions were collected, the total response (yes/no) percentage of all the dichotomous questions was calculated and is presented in Table 3.

*Table 3 - Total yes/no percentage of three level respondents from all questions*

| Entry Level | | Mid-Level | | Top Level | |
|---|---|---|---|---|---|
| Yes | No | Yes | No | Yes | No |
| 60.93% | 39.07% | 64.40% | 35.60% | 76% | 24% |

Figure 4 shows the bar graph of the total yes/no percentage of all the questions from three levels of employees of various RMG factories in Bangladesh:

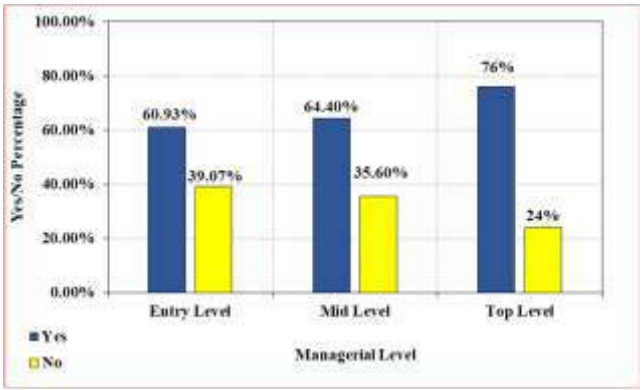


*Figure 4 - Bar diagram of the total yes/no percentage of all respondents*

### 4.1 Statistical analysis of the survey questionnaire

The assessment of the compliance status of RMG industry ROMC and Decent Work indicators required to achieve SDG-8 status was performed by analysing the categorical variables of the survey questionnaire through the chi-square test.

The following formula is used to compute the chi-square statistic:

$\chi 2 = (O-E)2/E$

Here,

O = Observed value

E = Expected value

- The cross-tabulation approach yields the expected value, which is subsequently subtracted from the observed count to determine the difference between the two. Next, to eliminate the negative values, the square of the difference is computed. Next, the expected count is divided by the square of the difference.
- We must ascertain the experiment's degrees of freedom (df) before moving forward. A basic guideline for comparing samples is to use the following formula:

  **df = (number of columns -1) × (number of rows -1)**

  [The rows and columns that contain the total are not included]
- After that, the chi-square ($\chi 2$) value was calculated. If the ($\chi 2$) value is less than the critical value or the P value is greater than the significance level, then the null hypothesis cannot be rejected. This means that we will accept the null hypothesis. The critical value is obtained by observing the table of chi-square distributions for a certain df (degree of freedom). The P value was measured at a significance level of 0.05 by the chi-square test.

The assumed hypothesis of the research is as follows:

- Null hypothesis (H0): Since the variables have no discernible relationship with each other, feedback from the entry, middle, and top level respondents is not relevant for determining the RMG factories in Bangladesh's current state of compliance.
- Alternative hypothesis (H1): There are significant relationships among the variables, which means that the feedback of the respondents (entry level, mid-level, top level) is useful for assessing the current status of compliance with RMG factories in Bangladesh.

The respondents' (entry level, mid-level, top level) feedback from all the questions regarding compliance was calculated to assess the respondents' current status of compliance. For that reason, observed and expected values were determined to determine the significance of the relationship. The P value was measured at a significance level of 0.05 by the chi-square test. Finally, the measurable chi-square ($\chi 2$) value was compared with the critical value to measure the acceptability of the null hypothesis.

Below, the observed values in the tables are given to determine the expected values of ten questions via the cross tabulation method, after which the chi-square values are calculated for comparison with the critical values and P values:

Rq1: Is there any punishment in your company/industry as a penal offense for illegal exaction of forced or compulsory labor?

Table 4 describes the different values of a particular RQ from the feedback of the respondents needed to calculate the value of the chi-square for the hypothesis test:

Here, the degree of freedom is (3-1) × (2-1) = 2

Significance level=0.05, so the critical value is 5.99 [from chi-square table].

The aforementioned chart indicates that the P value is less than the threshold of significance (0.040 < 0.05) and that the chi-square value is greater than the threshold for significance (6.432 > 5.99).

**Comment:** Null hypothesis is failed to be accepted. This is why the alternative hypothesis is accepted. According to the responses, the possibility of a punishment system for illegal exaction of forced or compulsory labor in factories is satisfactory.

*Table 4 - Observed, expected and chi-square values from the feedback of question 01*

| Observed values (O) | Feedback from Question-01 | | |
|---|---|---|---|
| **Job position** | **Yes** | **No** | **Grand Total** |
| Entry level | 41 | 38 | 79 |
| Mid-level | 98 | 58 | 156 |
| Top level | 09 | 01 | 10 |
| Grand Total | 148 | 97 | 245 |
| **Expected values (E)** | **Feedback from Question-01** | | |
| Job position | Yes | No | Grand Total |
| Entry level | 47.722 | 31.277 | 79 |
| Mid-level | 94.236 | 61.763 | 156 |
| Top level | 6.040 | 3.959 | 10 |
| Grand Total | 148 | 97 | 245 |
| **Chi-square value $[(O-E)^2/E]$** | **Feedback from Question-01** | | |
| Job position | Yes | No | Grand Total |
| Entry level | 0.946 | 1.444 | 2.391 |
| Mid-level | 0.150 | 0.229 | 0.379 |
| Top level | 1.449 | 2.211 | 3.661 |
| **Chi-square value** | | | **6.432** |
| Critical Value | | | **5.99** |
| Value of P | | | **0.040** |

Here, the degree of freedom is (3-1) × (2-1) = 2
Significance level=0.05, so the critical value is 5.99 [from chi-square table].

The aforementioned chart indicates that the P value is less than the threshold of significance (0.040 < 0.05) and that the chi-square value is greater than the threshold for significance (6.432 > 5.99).

Comment: Null hypothesis is failed to be accepted. This is why the alternative hypothesis is accepted. According to the responses, the possibility of a punishment system for illegal exaction of forced or compulsory labor in factories is satisfactory.

## 5. Discussion and Implications

Like for the first dichotomous binary question, the remaining nine questions were evaluated by the same methodology as that used in Figure 1.

The chi-square test was performed for all the questions concerning the acceptance status of the null hypothesis, and the alternative hypothesis can be found here in the following Table 5 [the critical value is 5.99 according to the chi-square distribution at a significance level of 0.05]:

In this table, the following symbols are used for the critical value, chi-square value, P value and significance level.
Critical value: α  Chi-square value: β
P value: ρ  Significance level: μ
After the respondents responded to all ten questions, the null hypothesis was rejected; therefore, there were significant relationships among the variables for these four questions, as illustrated in Figure 5.

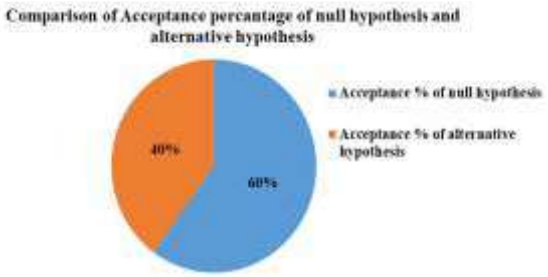


*Figure 5 - Comparison of acceptance percentages between the null hypothesis and alternative hypothesis*

## 6. Conclusion and recommendations

The whole compliance effort demonstrates that national settings do not prioritize fundamental labor regulations in the same manner. Regarding efficacy and accessibility, certain requirements under specific rights contexts are widely promoted, while others are not. In this paper, we can see that most of the companies in Bangladesh are trying to maintain compliance with the ILO standards by maintaining the fundamental rights of both male and female workers, which is one of the key indicators of SDG-8.

### *6.2 Limitations and future scopes of the study*

There are a few limitations to take into account when analysing the study's findings. The results might be inaccurate due to the reserveness and indecisiveness of the respondents when talking about their company polcies. Thus, there might have been some limitations in this study that affected the accuracy of the results. Moreover, some of them lacked knowledge about the questions.

*Table 5 - Comparison of the null hypothesis and alternative hypothesis*

| Sl. No. | Questions | Chi square value | P value | Comparison among the values | Acceptance status of null hypothesis | Acceptance status of alternative hypothesis | Significant relation between categorical variables (with comment) |
|---|---|---|---|---|---|---|---|
| 1. | RQ1 | 6.432 | 0.040 | β: 5.99 > α: 5.99 and ρ: 0.040 < μ: 0.05 | Rejected | Accepted | (Yes) |
| 2. | RQ2 | 0.0937 | 0.954 | μ: 0.954 > ρ: 0.05, β: 0.0937 < μ: 5.99. | Accepted | Rejected | (No) |
| 3. | RQ3 | 0.32 | 0.852 | α: 0.32 < β: 5.99 and ρ: 0.852 > μ: 0.05 | Accepted | Rejected | (No) |
| 4. | RQ4 | 2.19 | 0.326 | α: 2.19 < β: 5.99 and ρ: 0.326 > μ: 0.05 | Accepted | Rejected | (No) |
| 5. | RQ5 | 6.741 | 0.034 | α: 6.741 > β: 5.99 ρ: 0.034 < μ: 0.05 | Rejected | Accepted | (Yes) |
| 6. | RQ6 | 0.430 | 0.806 | α: 0.4305 > β: 5.99 ρ: 0.806 < μ: 0.05 | Accepted | Rejected | (No) |
| 7. | RQ7 | 0.019 | 0.990 | α: 0.019 < β: 5.99 ρ: 0.990 > μ: 0.05 | Accepted | Rejected | (No) |
| 8. | RQ8 | 0.070 | 0.965 | α: 0.070 < β: 5.99 ρ: 0.965 > μ: 0.05 | Accepted | Rejected | (No) |
| 9. | RQ9 | 6.694 | 0.035 | α: 6.694 < β: 5.99 ρ: 0.035 < μ: 0.05 | Rejected | Accepted | (Yes) |
| 10. | RQ10 | 10.164 | 0.006 | α: 10.164 < β: 5.99 ρ: 0.006 < μ: 0.05 | Rejected | Accepted | (Yes) |

The questionnaire used in this study was developed specifically on the basis of five, seven and eight no. targets of SDG-8 among the twelve indicators. However, there are additional critical problems related to the other SDG-8 indicators, such as maintaining per capita economic growth, enhancing productivity through technological innovation and diversification, enhancing the strength of local banking systems, and creating and implementing an international plan for hiring young people.

It would be convenient if there were some options to answer the questions in a descriptive manner by implementing descriptive research so that the respondents could answer the questions properly and effectively.

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# Dyeing Behavior of Banana Sap Treated Cotton Fabrics in the Presence of Reactive Dyes

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**Abstract**

*The textile chemical processing industry is a major contributor to environmental pollution. To reduce the environmental impact, an alternative approach is to incorporate bio-based substances in the dyeing process. In this study, banana pseudostem sap (BPS) solution was utilized due to its unique property of staining cotton material, which is challenging to remove and requires more washing. This characteristic was leveraged to treat the cotton fabric and assess its suitability for dyeing with reactive colors while minimizing the use of salt and other chemicals, thus reducing the overall effluent load. Fresh banana sap extract was collected, purified, and added to a reactive dye bath at varying concentrations and dyeing was continued for 60 minutes at 60°C. A total of 48 samples were prepared by keeping the temperature constant and examined under a spectrophotometer for the color strength values. Interesting results were obtained and show that material to sap ratio of 1:25 has a considerable influence on the color strength values out of other combinations. To further investigate the influence of temperature on the color uptake the temperature was varied and samples were developed. Spectrophotometric investigation on color strength observed that samples dyed at 80°C have a considerable impact on K/S values at material to sap ratio of 1:25 at a 50gpl concentration of salt.*

**Keywords:** *Banana Pseudostem Sap, cotton fabric, effluent, reactive dyes, Spectrophotometric*

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## 1. Introduction

The textile chemical processing industry significantly contributes to environmental pollution, with nearly 70% of the total pollution stemming from the industry. Chemical usage in this industry has adverse effects on the environment and human health [1]. These chemicals, such as alkali, acids, surfactants, inorganic salts, and dyes, are present in the wastewater, leading to pollution [2]. Additionally, the high energy consumption in heating dye solutions exacerbates environmental problems [3-5]. Numerous approaches have been devised to minimize both energy and water consumption [6]. In cotton processing industries using reactive dyes, the discharged wastewater is highly polluted, with a heavy oxygen demand, salinity, and color. Treatment is crucial before releasing it into nearby water sources. However, due to high costs, many industries can't afford proper treatment. Advancements in chemical processing technology, like machinery design and eco-friendly auxiliaries, are necessary to reduce the wastewater load. Reactive dyeing in cotton consumes large amounts of water and salt, leading to salinity and the presence of alkali and organic matter in the wastewater [7].

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Dye particles that remain attached to the fiber are considered fixed and create covalent bonds with the fiber. Under optimal dyeing conditions, approximately 50-80% of the dye is fixed to the fiber, while the remaining color is released into the effluent water [8]. Reactive dyeing of cotton necessitates a substantial amount of salt to aid in the exhaustion process, which varies based on shade depth, dye structure, and application method. The use of alkali depends on the dye type and pH requirements for dye fixation in the fiber. However, both the salt and alkali used in the process are non-biodegradable and toxic. Consequently, the wastewater remaining after dyeing contains these chemicals, along with high levels of biological oxygen demand, organic and inorganic solids [9, 10]. Researchers are exploring new technologies in the chemical processing of textiles to address ecological issues associated with conventional dyeing systems. These systems typically require large quantities of water and chemicals, resulting in highly polluted wastewater. The aim is to develop methods that reduce the use of chemicals and water, improving the overall sustainability of the textile industry [11, 12]. Researchers have introduced various approaches in dyeing, including the use of reactive dyes without salt [12], pretreatment of cotton fabric with EDTA [9], treatment with chitosan and its derivatives [13], cellulose grafting with cationic agent [14], microwave-assisted low material to liquor ratio dyeing [15], natural dyeing using mordants [16, 17]. Banana pseudostem sap (BPS) is a plant extract rich in phenolic and aromatic amino compounds. It offers properties like permanent staining,

antioxidants, and anti-bleeding. BPS shows promise as a fixation agent in textile dyeing, especially for mordanting cotton fabric with natural dyes. Previous research indicates enhanced fastness properties post-dyeing with BPS [18]. The primary objective of this study is to treat the pretreated cotton fabric with BPS and analyze its dyeing behavior using different concentrations of salt.

## 2. Materials & Methodology

### *2.1 Materials*

The 100% bleached cotton fabric was selected for this study. Banana SAP was collected from the stem part of the banana tree and it was filtered and used without any further additions. Universal padding mangle was used to treat the cotton fabric with sap at 100% expression. Reactive dyes of Corafix Red ME3B was used to dye the cotton fabric supplied by Color Tex Industries Pvt. Ltd., Surat, India. Other chemicals like salt and soda ash of laboratory grade were used.

### *2.2 Methodology*

To analyze the effect of SAP treated cotton fabric on the dyeing behavior with reactive dyes, the design of the experiment was planned and is given in Table 1. The samples to banana sap ratio varied from 1:15 to 1:125 and then dyed in the presence of reactive colors by changing the salt ratio from 10 to 70gpl. There is no water is used in the dyeing process except for the standard sample. The entire dyeing process was carried out using 20gpl soda ash at 60°C for 60 minutes. A total of 48 samples were developed, and the color strength values were compared with the standard samples by spectrophotometer.

***Table 1 - Experimental design for dyeing of cotton fabric with Reactive dyes in the presence of banana SAP solution***

| Sr. No. | Sample Name | Material to Sap ratio | Dye Conc. in % | Salt Conc. in GPL | Soda Ash Conc.in GPL | Temperature in ℃ | Time in Min |
|---|---|---|---|---|---|---|---|
| 1 | Standard Sample S15W | - | 2 | 70 | 20 | 60 | 60 |
| 2 | Sap15 Salt10 | 01:15 | 2 | 10 | | | |
| 3 | Sap15 Salt20 | | | 20 | | | |
| 4 | Sap15 Salt30 | | | 30 | | | |
| 5 | Sap15 Salt40 | | | 40 | | | |
| 6 | Sap15 Salt50 | | | 50 | | | |
| 7 | Sap15 Salt60 | | | 60 | | | |
| 8 | Sap15 Salt70 | | | 70 | | | |
| Material Sap ratio | | 1:15, 1:25, 1:50, 1:75, 1:100, 1:125 | | | | | |
| Reactive Dye type | | Hot Brand dye | | | | | |

### *2.3 Evaluation*

The main objective of this work is to assess the banana sap treated cotton fabric and its suitability to apply reactive dyes onto it. Therefore, the treated fabrics were examined under a Premier color scan spectrophotometer for its color values and to optimize the best combinations.

## 3. Results & discussion

The dyeing experiments were designed in such a way that the cotton fabric was dyed with reactive dyes by varying material to sap ratios i.e., 1:15, 1:25, 1:50, 1:75, 1:100, 1:125 and also by varying the salt concentrations from 10gpl to 70 gpl as mentioned in Table 1. A total of 48 samples were developed and evaluated for the L*, a*,b*, and K/S values after soaping using a Premier color scan spectrophotometer 5100H at maximum wavelength, and the results are given in Table 2.

In the material-to-sap ratio of 1:15, a total of seven samples were developed by changing salt concentration and dyed with reactive dyes at 60°C for 60 min. The results were compared with a standard sample (S15W) developed with material to liquor ratio of 1:15. It was evident from the K/S results that there was no considerable effect of sap presence in the dye bath. Similarly, samples were developed with a material-to-sap ratio of 1:25 (25SP 10SL to 25SP 70SL) and compared with the standard sample (S25W). Interesting results were obtained in this combination. By increasing the salt content from 10gpl to 70gpl along with the sap content increasing pattern of K/S values was observed. The increasing pattern started early at 40gpl salt and in the presence of sap and continued. In the case of 50 gpl salt and 25 parts of sap (25SP50SL), the K/S value is 11.35, higher than the standard sample of 10.92. This is because the strong crosslinking of sap with cotton fabric results in more color uptake, even with low salt concentration [19]. This trend was not observed in other combinations of material to sap ratio i.e. 1:50, 1:75, 1:100 and 1:125 and might be due to an increas in material to sap ratio results in lower dye uptake.

***Table 2 - L, a, b, and K/S values of banana sap treated cotton fabrics at varying salt concentrations***

| S. No | Sample Name | L* | a* | b* | K/S values |
|---|---|---|---|---|---|
| 1 | S15W | 35.109 | -8.992 | -18.083 | 10.21 |
| 2 | 15SP10SL | 33.172 | -7.71 | -14.144 | 3.98 |
| 3 | 15SP20SL | 33.586 | -8.29 | -14.532 | 4.62 |
| 4 | 15SP30SL | 34.515 | -8.94 | -16.325 | 5.84 |
| 5 | 15SP40SL | 34.937 | -9.23 | -17.01 | 5.98 |
| 6 | 15SP50SL | 35.049 | -9.485 | -17.087 | 6.98 |
| 7 | 15SP60SL | 34.693 | -8.408 | -17.824 | 8.23 |
| 8 | 15SP70SL | 35.021 | -9.048 | -17.952 | 10.54 |
| 9 | S25W | 34.466 | -9.356 | -17.994 | 10.926 |
| 10 | 25SP10SL | 34.732 | -9.605 | -17.83 | 5.23 |
| 11 | 25SP20SL | 34.565 | -9.281 | -18.293 | 7.92 |

| S. No | Sample Name | L* | a* | b* | K/S values |
|---|---|---|---|---|---|
| 12 | 25SP30SL | 34.885 | -9.703 | -18.249 | 9.12 |
| 13 | 25SP40SL | 34.443 | -9.351 | -18.19 | 10.243 |
| 14 | 25SP50SL | 34.178 | -8.952 | -18.131 | 11.354 |
| 15 | 25SP60SL | 34.273 | -8.963 | -18.315 | 11.804 |
| 16 | 25SP70SL | 34.322 | -9.155 | -18.421 | 11.331 |
| 17 | S50W | 36.044 | -9.564 | -18.483 | 9.825 |
| 18 | 50SP10SL | 32.436 | -6.882 | -12.062 | 4.52 |
| 19 | 50SP20SL | 32.595 | -6.613 | -13.274 | 5.96 |
| 20 | 50SP30SL | 33.403 | -7.575 | -13.965 | 6.32 |
| 21 | 50SP40SL | 33.87 | -7.932 | -15.152 | 6.98 |
| 22 | 50SP50SL | 34.466 | -8.397 | -16.083 | 7.82 |
| 23 | 50SP60SL | 34.703 | -8.074 | -17.293 | 8.68 |
| 24 | 50SP70SL | 35.051 | -8.281 | -18.198 | 9.12 |
| 25 | S75W | 37.013 | -9.875 | -18.499 | 9.208 |
| 26 | 75SP10SL | 35.801 | -8.687 | -16.796 | 3.913 |
| 27 | 75SP20SL | 36.711 | -9.749 | -17.558 | 5.439 |
| 28 | 75SP30SL | 36.005 | -8.979 | -17.111 | 4.812 |
| 29 | 75SP40SL | 36.397 | -9.139 | -17.951 | 6.439 |
| 30 | 75SP50SL | 36.444 | -9.353 | -17.506 | 5.889 |
| 31 | 75SP60SL | 36.195 | -9.041 | -17.764 | 6.237 |
| 32 | 75SP70SL | 36.395 | -8.926 | -18.414 | 7.524 |
| 33 | S100W | 41.686 | -10.361 | -18.436 | 6.554 |
| 34 | 100SP10SL | 37.238 | -8.29 | -7.101 | 2.109 |
| 35 | 100SP20SL | 37.918 | -8.565 | -8.693 | 2.437 |
| 36 | 100SP30SL | 38.772 | -9.141 | -10.794 | 2.734 |
| 37 | 100SP40SL | 39.481 | -9.648 | -12.204 | 3.846 |
| 38 | 100SP50SL | 39.686 | -9.901 | -12.427 | 3.767 |
| 39 | 100SP60SL | 40.246 | -9.882 | -14.236 | 3.715 |
| 40 | 100SP70SL | 39.959 | -9.27 | -14.74 | 3.03 |
| 41 | S125W | 40.638 | -10.319 | -18.345 | 7.05 |
| 42 | 125SP10SL | 37.889 | -7.838 | -13.274 | 1.695 |
| 43 | 125SP20SL | 38.222 | -7.997 | -14.261 | 1.747 |
| 44 | 125SP30SL | 38.234 | -8.267 | -13.799 | 2.144 |
| 45 | 125SP40SL | 38.119 | -8.229 | -13.897 | 2.496 |
| 46 | 125SP50SL | 39.091 | -8.931 | -15.544 | 2.76 |
| 47 | 125SP60SL | 39.633 | -9.18 | -16.554 | 2.737 |
| 48 | 125SP70SL | 39.696 | -9.364 | -17.007 | 3.511 |

Note: S-Standard sample, SP-Sap solution, SL- Salt

The K/S value effect plot of dyed samples is depicted in Fig. 3. The illustration distinctly indicates that the influence of sap on K/S values initially leads to an increase in color strength up to a ratio of 1:25. However, beyond a 1:50 sap ratio, there is a decrease in color strength values. In contrast, the impact of salt on color strength values demonstrates a consistent Increase pattern, as clearly depicted in the figure. The interaction plots for color strength values are shown in Fig.2. The interaction of sap & salt together leads to an increase in the color values then there is a drop in the color values. This may be due to the high Sap ratio leading to more dilution of dye particles and results in less exhaustion.

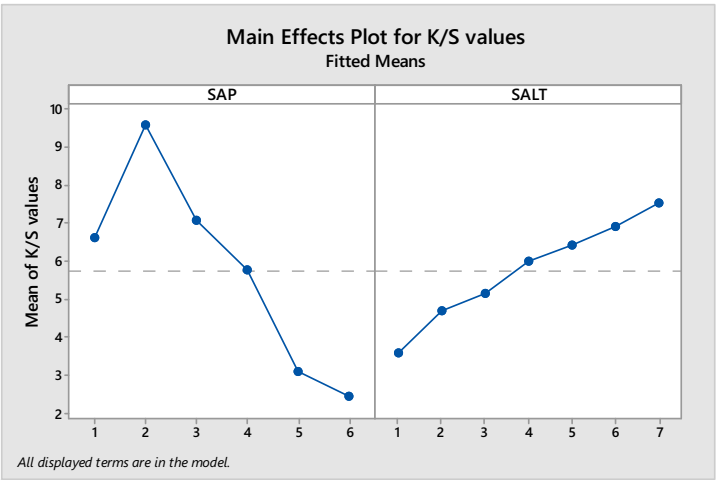
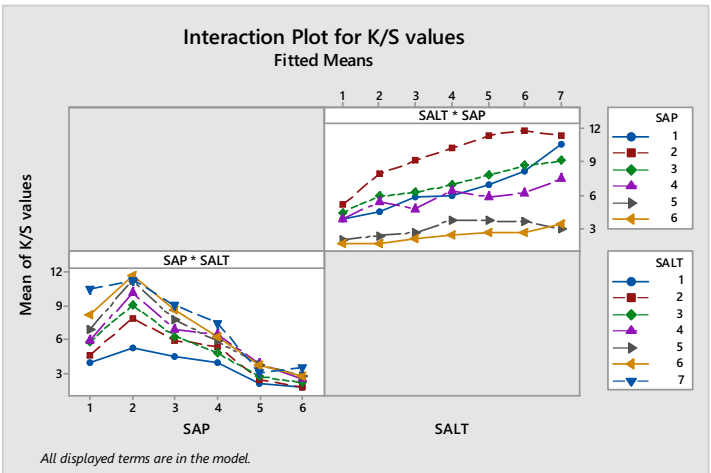



*Figure 1 - Main effect plot for K/S values of dyed samples*




*Figuure 2 - Interaction plots for K/S values in fitted means*

All the results depicted from the designed experiment were conducted at 60°C temperature. Further, to analyze the effect of temperature on the dyeing behavior of cotton fabric in the presence of sap, trials were conducted at 60°C, 80°C, and 100°C by keeping a time of 60 min as constant. Also, the earlier studies found that the best results were obtained with a material-to-sap ratio of 1:25. So this combination was chosen for further investigations along with 1:50 and 1:75 for in-depth analysis. Accordingly, the design of the experiment was planned as given in Table.3, and a total of 27 samples were developed, and the results are given in Table. 4.

*Table. 3 Experimental design for dyeing of cotton fabric by varying sap content, Salt and temperature*

| S. No. | Material to Sap ratio | Salt (gpl) | Temp . ? | Soda ash (gpl) | Time (min) |
|---|---|---|---|---|---|
| 1 | 1:25 | 40 | 60 | 20 | 60 |
| 2 | | 50 | 80 | | |
| 3 | | 60 | 100 | | |
| 4 | 1:50 | 40 | 60 | 20 | 60 |
| 5 | | 50 | 80 | | |
| 6 | | 60 | 100 | | |
| 7 | 1.75 | 40 | 60 | 20 | 60 |
| 8 | | 50 | 80 | | |
| 9 | | 60 | 100 | | |
| | | | | | |
| ***Dyeing time: After adding soda ash, maintain 60 min time*** | | | | | |

It was evident from the results that the sample 50SL80T has shown a K/S of 11.14, which is close to the S25W at 80°C temperature. This means that temperature influences the dye uptake by the fiber in the presence of sap, even at low salt concentrations. It was also observed that increased temperature from 60°C to 80°C resulted in an initial rise in K/s value but again started reducing when the temperature increased to 100°C. Experiments were carried out at material-to-sap ratios of 1:50 and 1:75 while altering the temperature. However, as indicated in Table 2, minimal variations in the color strength values were observed. This observation strongly suggests that there is no notable impact when increasing the sap ratio beyond 1:25. This could be attributed to the fiber reaching its maximum dye uptake capacity.

Based on the results obtained from the experiments, it is clear that, sap has a considerably influence in the dyeing behavior of cotton fabric in the presence of reactive dyes even at reducing salt concentrations.

## 4. Conclusions

In this study BPS was collected and purified and used in the dyeing of cotton fabrics with reactive dyes. The dyeing was carried out with varying material to sap ratios i.e 1:15, 1:25, 1:50, 1:75, 1:100, 1:125 at varying concentrations of salt from 10gpl to 70 gpl. Temperature and time of the treatment was kept constant to understand the influence of sap in dye uptake. A total of 48 samples were developed and examined under spectrophotometer for its color values. Interesting results were obtained with a sap ratio of 1:25, 60 gpl compared to sample dyed at same ratio with water. Other combinations does not have much influence on the color strength. To further understand the influence of sap in dye uptake, temperature was varied at three stages i.e. 60°C, 80°C and, 100°C and studied the color strenght. Interesting results were obtained with varying temperatures in dyeing. The

*Table 4 . Experimental results of varying material to sap ratio, dyeing time, and salt concentration*

| Material to Sap ratio | Sample name | L* | a* | b* | K/S |
|---|---|---|---|---|---|
| 01:25 | 40SL60T | 33.047 | -8.721 | -17.922 | 10.43 |
| | 40SL80T | 33.051 | -8.174 | -18.629 | 10.51 |
| | 40SL100T | 32.363 | -7.935 | -17.853 | 9.69 |
| | 50SL60T | 33.224 | -8.662 | -18.168 | 11.02 |
| | 50SL80T | 32.884 | -7.699 | -18.877 | **11.14** |
| | 50SL100T | 31.884 | -6.938 | -18.33 | 10.593 |
| | 60SL60T | 34.919 | -8.301 | -20.617 | 11.60 |
| | 60SL80T | 33.837 | -7.706 | -20.51 | 11.71 |
| | 60SL100T | 33.092 | -6.904 | -20.032 | 10.22 |
| 01:50 | 40SL60T | 36.595 | -9.341 | -18.693 | 7.12 |
| | 40SL80T | 36.059 | -8.681 | -18.039 | 8.72 |
| | 40SL100T | 36.376 | -8.984 | -18.99 | **8.10** |
| | 50SL60T | 36.97 | -8.776 | -19.803 | 7.49 |
| | 50SL80T | 37.102 | -8.95 | -20.246 | 8.791 |
| | 50SL100T | 35.892 | -8.994 | -17.963 | **8.41** |
| | 60SL60T | 37.172 | -8.509 | -20.679 | 8.48 |
| | 60SL80T | 36.906 | -8.432 | -20.096 | 9.12 |
| | 60SL100T | 37.903 | -8.767 | -21.929 | 7.158 |
| 01:75 | 40SL60T | 36.22 | -9.091 | -19.803 | 6.643 |
| | 40SL80T | 36.038 | -9.501 | -18.808 | 7.543 |
| | 40SL100T | 35.686 | -8.998 | -18.83 | 7.215 |
| | 50SL60T | 36.372 | -8.986 | -20.171 | 5.923 |
| | 50SL80T | 36.291 | -9.16 | -19.917 | 7.124 |
| | 50SL100T | 36.205 | -9.185 | -19.72 | 6.941 |
| | 60SL60T | 36.672 | -8.626 | -21.265 | 6.683 |
| | 60SL80T | 36.537 | -7.932 | -22.316 | 7.287 |
| | 60SL100T | 36.574 | -8.279 | -21.536 | 7.135 |

comprehensive study on dyeing with Sap solution demonstrates a notable absence of water usage, thereby markedly reducing the environmental pollution load. Furthermore, the utilization of BSP derived from waste resources exemplifies a sustainable approach within the textile industry. This study is dedicated to exploring the integration of bio waste resources into the reactive dyeing process, with the aim of diminishing salt content and consequently mitigating effluent discharge. Subsequent research avenues may delve into kinetic studies and computerized color matching analyses to offer novel perspectives on this matter.

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TECHNICAL TEXTILE

# Development of Kapok/Polyester Nonwovens for Building Insulation Application

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**Abstract:**

*In this study, needle punched kapok/polyester (PET) blended nonwovens were prepared and characterized for building insulation applications. Nonwovens were manufactured by blending kapok fibres with polyester at three blend ratios (20%, 30%, & 40%). The developed kapok/polyester nonwovens were characterized by thermal insulation applications. Also, the influence of PET blend ratio on the thermal insulation performance of the developed kapok/polyester nonwovens was investigated. There was a reduction in thermal resistance value observed with an increase in polyester percentage in kapok/polyester nonwovens. The performance of kapok/polyester needle punched nonwovens compared with conventional insulation materials. The developed kapok/PET nonwovens had a thermal insulation value on par with that of conventional insulation materials.*

**Keywords:** *Kapok, needle punching, nonwoven, polyester, thermal insulation*

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## 1. Introduction

In recent years, the usage of natural fibres such as kenaf, banana, pineapple, bagasse, etc. has increased. These natural fibers are used in the form of short fibres or nonwovens. Because of their excellent balanced properties and biodegradable nature, there is lots of research going on in the technical textiles area. Kapok is a silky fiber that encloses the seeds of kapok trees (Ceibapentandra), and the color is yellowish or light-brown with a silk-like lustre. In contrast to cotton fiber, kapok fiber is made of single-celled plant hairs. It has a hollow lumen (or structure) and a sealed tail with an external radius of 8 ± 3 mm, an internal radius of 7 ± 3 mm, and a length of 20 to 32 mm, which indicates that the lumen makes up 77% of the fiber volume (Figure 1). Kapok fiber has low thermal conductivity and decomposes at a temperature of 296°C. Kapok fiber is comprised of 43% alpha-cellulose, 24% pentosan, 15% lignin, and 6.6% Uronicanhydride. Because of its hollow nature, kapok fiber is commonly used as stuffing material for bedding and pillows. Recently, kapok fiber- based structures have been used for insulation applications. Because of its excellent buoyancy properties, kapok fiber was also used in water safety equipment.

A lot of research has been carried out on kapok fibers for oil absorption and sound insulation applications. But very few studies have been carried out on kapok fibres for thermal insulation applications. Cui, Wang, Wei, and Zhao manufactured wadding by blending kapok fibers with down feather fibers and studied the developed waddings for cold weather protective clothing. They found that the thermal insulation performance of the developed wadding increased with an increase in the kapok fiber blend percentage [1]. Wang compared the thermal insulation performance of kapok coats and traditional down coats. He found that kapok

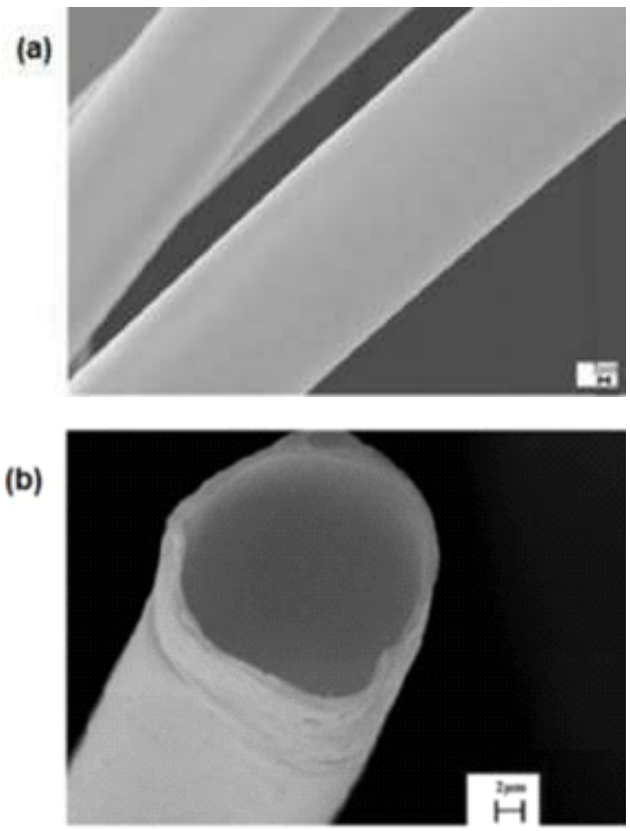


***Figure1 - SEM images of kapok fibre (a) longitudinal view (b) cross sectional view***

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coats have comparable thermal insulation performance to traditional duckling down coats [2]. Udaya, Karthick, and Gobi manufactured thermal bonded kapok/PP blended nonwoven fabrics and studied the influence of polypropylene blend percentage on the thermal insulation value of kapok/PP blended nonwoven fabrics [3].

Patnaik et al. developed new insulating materials using recycled polyester (rPET) and waste wool fibres for building insulation application. He showed that the developed waste wool/recycled polyester (rPET) nonwovens have good thermal and acoustic insulation properties. The developed nonwovens also had good moisture absorption, flame resistance, and biodegradation behavior [4]. Duran has manufactured needle punched nonwovens from recycled wool and jute fibers. He has studied the thermal insulation properties of the developed nonwovens for building insulation applications [5]. El Wazna et al. manufactured nonwovens using textile waste for building insulation applications. They investigated the influence of nonwoven density and porosity on the thermal insulation performance of needle-punched nonwoven fabrics [6]. Hadded, Benltoufa, and Fayala manufactured needle punched nonwovens from textile fibers waste and studied the thermal insulation performance of the developed nonwovens for building insulation applications [7]. They found that the developed nonwovens have good thermal insulation properties and can be used for the building insulation applications. However, no such work has studied the thermal conductivity behavior of kapok needle punched nonwovens for building insulation applications.

We have manufactured needle punched nonwovens by blending flax fibers with low melt polyester fibers for insulation applications. The effect of needle punching parameters and blend percentage on the insulation properties of the flax/PET nonwovens has been studied [8]. In our previous study, we manufactured needle punched nonwovens by blending pineapple fibers with low melt polyester fibers. The sound and thermal insulation performance of the developed nonwovens have been studied [9]. We are working on natural fibres for their thermal characteristics. Among the natural fibres, kapok fibres have low thermal conductivity and can be used as insulation material in buildings. However, kapok fibers have poor inter-fiber cohesion due to their short length, smooth surface, and low density. Hence, the processing of the kapok by machines is difficult. In this study, polyester fibre was blended with the kapok fibres to improve the process ability. In this study, we have manufactured kapok/PET nonwoven fabrics by needle punching technique for the thermal insulation application. Nonwoven fabrics were manufactured by blending kapok fibres with polyester fibers at three blend ratios (20%, 30%, and 40%). We have studied the effect of blend percentage of polyester on the thermal insulation performance of the developed kapok/ polyester nonwovens.

## 2. Materials and Methods

Kapok fibers having a length of 26.32 mm and a fineness of 0.71 denier have been sourced in and around Coimbatore, India. Polyester fibers having a length of 38 mm and a fineness of 0.80 denier have been sourced from Reliance Fibers, India.

### A. *Nonwoven manufacturing*

For nonwovens manufacturing, kapok fibers were blended with polyester fibers at three blend ratios (20%, 30% and 40%). The web preparation was done using a laboratory-scale carding machine. Needle punched nonwovens were developed using the needle loom - DI-Loom OUG-II 6. Nonwovens were developed with a punch density of 70 punches/cm2 and 10 mm needle penetration depth.

### B. *Characterization methods*

The thickness of the developed nonwovens has been measured under a 2 kPa load using a fabric thickness gauge as per the ASTM D-1777 standard [10]. The kapok/polyester nonwovens have been characterized for areal density, which has been measured as per ASTM D-1910 standard using an electronic balance [11]. The kapok/polyester nonwovens have been characterized for air permeability according to the ASTM D 737 standard using the air permeability tester with a 100 Pa pressure drop [12]. The kapok/polyester nonwovens have been characterized for thermal resistance according to ISO 8301:1991 standards using the heat flow meter apparatus. Five measurements were taken for each test, and the average value was determined.

## 3. Results and Discussion

### *3.1 Physical characteristics of Kapok/Polyester nonwovens*

The characteristics of the obtained nonwoven specimens are shown in Table 1. The kapok/ polyester nonwovens had thickness in the range of 7.19–7.73 mm. The random distribution of fibers during nonwoven formation creates this variation in the thickness of the nonwovens. The developed nonwovens had a density in the range of 79.12– 88.63 (Kg/m3). It was noticed that the areal density of the samples decreased when the content of polyesterfiber in the nonwoven increased from 20 to 40%.

*Table 1 – Characteristics of Kapok/Polyester Nonwovens*

| Sample | GSM | Thickness (mm) | Density ($Kg/m^3$) | Air permeability ($cm^3/cm^2/s$) | Thermal conductivity (W/ mK) | Thermal resistance ($m^2$ K/W) |
|---|---|---|---|---|---|---|
| 80/20 (Kapok/PET) | 419.22 | 4.73 | 88.63 | 57.6 | 0.0166 | 0.446 |
| 70/30 (Kapok/PET) | 373.22 | 4.40 | 84.83 | 62.2 | 0.0213 | 0.388 |
| 60/40 (Kapok/PET) | 331.52 | 4.19 | 79.12 | 87.2 | 0.0221 | 0.350 |

The effect of polyester blend percentage on the air permeability of the developed kapok/ polyester nonwovens is shown in Figure 2. With the increase in polyester blend

percentage in kapok/polyester nonwovens, an increase in air permeability value was observed. This may be due to a decrease in thickness and basis weight with an increase in PET %. It was noticed that the variable in the regression equation has a positive co-efficient value, which confirms that the increase in polyester blend percentage increases the air permeability value of the kapok/ polyester nonwovens. The linear regression curve has a coefficient of determination (R2) of 0.914, indicating its goodness of fit.

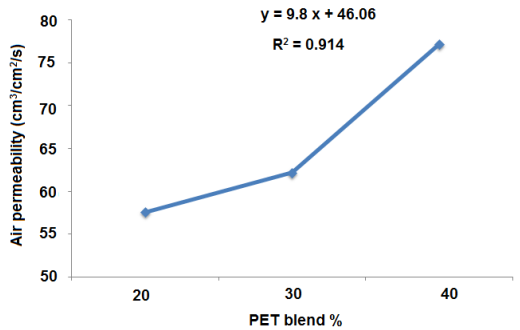


*Figure 2 - Influence of polyester blend % on air permeability of kapok/polyester nonwovens*

### *3.2 Thermal insulation properties of Kapok/Polyester nonwovens*

Thermal resistance expresses the ability of the material to prevent heat flow through its thickness over a unit surface area. The influence of polyester blend percentage on the thermal resistance value of the developed kapok/ polyester nonwovens is shown in Figure 3. It was noticed that the thermal resistance value of the kapok/polyester nonwoven decreases with an increase in the polyester blend percentage. In general, polyester fibres have a higher thermal conductivity value compared to kapok fibres. Hence, the increasing polyester blend percentage in the kapok/polyester nonwoven increases the thermal conductivity of the nonwoven and decreases its thermal insulation. It was noticed that the variable in the regression equation has a negative co-efficient value, which confirms the increase in polyester blend percentage decreases the thermal resistance. The linear regression curve has a coefficient of determination (R2) value of 0.985, indicating its goodness of fit.

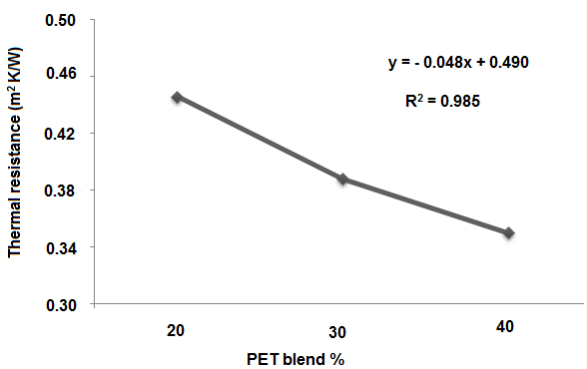


*Figure 3 - Influence of polyester blend % on thermal insulation properties of nonwovens*

### *3.3 Comparison of the developed kapok/PET nonwovens with commercial products*

*Table 2 – Comparison of the manufactured Nonwovens and commercially available insulators*

| Insulators | Density (Kg/m$^3$) | Thermal conductivity (W/ mK) | Thermal resistance (m$^2$ K/W) |
|---|---|---|---|
| Kapok/PET nonwovens | 79.12–88.63 | 0.0166–0.0221 | 0.350-0.446 |
| Rockwool(rock wool) | 40-1200 | 0.037-0.040 | 0.27-0.25 |
| Perlite(natural glassy volcanic rock) | 32-176 | 0..04-0.06 | 0.250-0.166 |
| Vermiculite(natural mineral) | 64-130 | 0.063-0.068 | 0.158-0.147 |
| Glass wool | 24-112 | 0.032-0.035 | 0.312-0.285 |
| Expanded polystyrene | 16-35 | 0.037-0.038 | 0.270-0.263 |
| Extruded polystyrene | 26-45 | 0.030-0.0320 | 0.330-0.312 |
| Polyurethane foam | 30-80 | 0.02-0.027 | 0.50-0.37 |

The performance of the kapok/ polyester needle punched nonwovens has been compared with commercially available building insulation products and is given in Table 2. The developed kapok/polyester nonwovens have a thermal conductivity in the range of 0.0166–0.0221 W/mK, which is lower than that of the commercially available insulation materials. The developed kapok/polyester nonwovens have better thermal insulation values compared to commercially available insulating materials. Also, the nonwovens developed in this study are eco- friendly, and their production does not contribute to environmental pollution.

## 4. Conclusion

For insulation applications, nonwovens materials are ideal because of their porous structure and unique fibre orientation. In this study, nonwovens were manufactured by blending kapok fibers with polyester for building insulation applications. The nonwovens developed with a higher polyester blend percentage showed a higher air permeability value. The nonwovens developed with higher polyester blend percentage showed a lower thermal insulation value. The developed nonwovens have a thermal insulation value in the range of 0.350-0.446 (m2K/W), which is better than that of commercially available products. The kapok/polyester nonwovens developed in this study are low-cost and environmentally friendly and can be used for building insulation applications.

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# Electrical conductivity of Embroidery Design for Wearable Applications

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**Abstract:**

*The smart textiles and allied wearable products increased their potential application in health care and device/system monitoring application. The emerging technology and traditional technology involved in such kind of new product development. The components involved in smart application devices are made with different kind of materials including flexible and hybrid materials from textiles. The traditional techniques, embroidery applied enormously for designing of smart components. Smart devices from embroidery technology satisfy the future requirements in terms of safety, control, fulfilment and entertainment. This first step of this investigation is aimed to optimize the parameters used for electrically conductive embroidery design by varying embroidery stitches, conductive yarn and total stitches in embroidery design. Computerized embroidery machine is used for the embroidery design development in a fabric. The electrical conductivity of the twenty five embroidery designs tested and analyzed using Design-expert-v12 software. The results revealed that the variables selected for the embroidery design having strong relationship with the electrical property of the fabric.*

**Keywords:** *Conductive embroidery, conductive textiles, textile sensor, wearable electronics, computerized embroidery, filling stitches*

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## 1. Introduction :

Smart textiles products realized through the developments in materials, processing and designing of a device components. The smart wearable system configuration facilitated by the industry and scientific community. For improving the functionality and usefulness, smart textile extends their application through passive smart textiles, active smart textiles and very smart textiles. The application of embroidery technology is higher in sensing and circuit integrations. The use of embroidery as single component or as a part of the device may reduce the cost involved in the whole system [1]. The polymeric materials can be made as sensors, actuators etc., called as electomechanical systems. The usage of textile components in smart system is increasing their potential applications. The conductive yarn usage and the level of stitch control with the specific combination pattern brings the possibilities of alternate source for the usage of electrical components such as capacitors, resistors etc., The conductive yarns used in embroidery process enables the integration with a device to study the electrical properties. The yarns used for embroidery process for the designing of conductive application, which allow the integration of yarns with various electrical properties.

The electrically conductive textiles includes interactive electronic textiles, location/position, infotainment, environmental response, biophysical monitoring (strategic/qualitative assessment only), government/public sectors, medical, commercial, industrial etc., the significant potential scope for the industrial sewing machines in wearable technology and e-textiles [2]. The cover stitch and over lock stitch is used to develop the sensor for the spinal bend measurement using 2-ply, 4-ply and 5-ply yarn. Wilcom ES, Ces_2000, Tajima DG/ML and Pre-design software used for the embroidery design punching for computerized embroidery machine. The angle of stitch, embroidery thread length in the design, stitch density and width of the filling are the properties of stitch category. Each running stitch used in embroidery machine has derivative stitches like simple stitch, straight stitch and walk stitch. Based on the contour of the embroidery pattern the properties of the filling stitch varied. The filling stitches are satin, tatami and zigzag stitches which also have same properties [3]. The electrical conductivity of the closed circuit element developed with embroidery technique, the electrical conductivity of this system influenced by the form of design element, material property, direction of filling embroidery, process variables involved in embroidery process [4].

The embroidery technique preferred for the integration of flexible electronic modules. The metal and coated filaments are satisfying the integration conditions. Silver-coated polyamide yarn is used with linear stitch. The multiple sewing contacts were more beneficial for the reduction of yarn resistance compared to single stitch [5]. The simple line stitch, two line stitch and zig-zag stitch are developed for electrical path between press-studs. The silver yarn used with cotton yarn for developing electrical path to conductivity purpose. The zig-zag pattern consists of two line stitch used for the interconnection in smart T-shirt development [6]. The responsive key pad of the musical denim jacket adopted with embroidery technique. The conductive stainless steel wire

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and polyester composite thread used for developing the electrodes. The multiple interconnections of the single embroidery stitched electrodes increase the resistivity of the circuit and the use of tatami or satin stitches reduces the resistance per trace length [7]. Electrisola e-threads consist of seven filaments with 0.12 mm diameter used for the development of conductive dipole geometry textile antenna. The conductive threads used as a bobbin thread to achieve the conductive property and the needle thread acting as a couch for conductive thread [8]. The geometry shape embroidery antenna with higher accuracy developed by the author with fine details and proposed various shapes such as archimedian, toothed, sinusoidal and trapezoidal. Such kind of E-fiber antenna provides excellent performance with more flexibility [9]. The load current value for silver filament yarn and silver coated yarn used as heating element studied by the researchers and found that the fabric made with silver coated yarn load less than 0.1 A current, where as silver filament load over 0.3 A current [10].

In this direction, this fundamental preliminary work is focusing on the development of conductive embroidery design with various embroidery parameters. By analyzing the electrical property- Resistance (R) of the conductive embroidery design the optimized results were revealed.

## 2. Materials and Methods

The proposed/selected embroidery design and passage for the unbreakable needle thread were finalized based on various trials conducted during the conductive design production. The table1 and figure 1 shows the computerized embroidery machine particulars used for the development of conductive embroidery design.

### *2.1 Materials*

The bleached woven fabric with plain weave used as ground fabric. The fabric made with the yarn linear density for the warp (Ne) =20, weft (Ne) =19.5, warp yarn density (epi) =46, weft yarn density (ppi) =45, linear weight of the fabric (gsm) =154 and cloth cover factor (K) =16.73 is used for the embroidery design development. The yarn particulars used in the embroidery process is tabulated in table 2.

*Table 1- Computerized embroidery machine detail*

| Embroidery M/c | Computerized Embroidery machine |
|---|---|
| Make | M/s Barudan, Japan. |
| Model | BEVT-Z1501CBII |
| No. of Head | Single head |
| Embroidery Area | 330X500/500 |
| Number of needle used | 1/15 |
| M/c Speed (rpm) | 20 rpm |

*Figure 1 - Computerized embroidery machine*

*Table 2 - Yarn used in Embroidery*

| Yarn type | Application | Yarn linear density |
|---|---|---|
| Copper coated yarn | Needle thread | 3.8 Tex |
| Silver coated yarn | | 3.8 Tex |
| Zari coated yarn | | 3.8 Tex |
| Poly- yarn | Needle thread & bobbin thread | 2/120 Denier |

### *2.2 Methodology*

The filling stitches in computerized embroidery machine satin, tatami and zigzag stitches used for the conductive fabric development with variation in number of stitches. The embroidery geometry design punching carried out using software (Wilcom ES). The figure 2 shows the two-step process for conductive embroidery fabric production. Three independent variables with its range and levels followed for the experimental study is tabulated in table 3. The zari, copper-coated and silver-coated yarns were sourced from woven fabric manufacturers around edappadi in Salem, Tamil Nadu, India. The current conductivity (mA) and electrical resistance (Ω) of the embroidery designed fabric studied to optimize the embroidery parameters.

The Design-expert-v12 software used to investigate the experiment efficiently with respect to mentioned variables to create respective response surface equation.

*(a) Design punching*

*(b) Conductive embroidery design*

*Figure 2 - Conductive embroidery design production*

*Table 3 - Range of Variables*

| Parameters | Levels | | |
|---|---|---|---|
| Number of Stitch (A) | 1000 | 2000 | 3000 |
| Conductive thread (B) | Zari coated (ZC) | Copper coated (CC) | Sliver coated (SC) |
| Stitch type (C) | Tatami | Satin | Zig-zag |

### *2.3 Testing*

The electrical properties such as current conductivity and electrical resistance of the embroidery fabrics analyzed based on the procedure given in section 2.3.1 and 2.3.2 respectively. The test result for the individual embroidery fabrics consolidated in table 4.

#### *2.3.1 Current conductivity (I)*

The rate at which the charge flows through the material is termed as electric current. The current conductivity of the embroidered fabrics is tested using Keithley Model 6517A Electrometer. 4Volt input is used to test all the embroidery samples. The average results for the each conductive designed fabric taken for the analysis.

#### *2.3.2 Electrical Resistance (R)*

Make current flow through a resistance there must be a voltage across that resistance. Ohm's Law shows the relationship between the three quantities such as voltage, current and resistance [11] is shown in equation (1).

Resistance (R) = V/I..... (1)

Where,

V= Volt

I = Current (Amps)

*Table 4 - Design of experiments- 2FI model and Response*

3. Results and Discussion

| Run | A-Stitches (Total numbers) | B-Conductive Thread (Type) | C-Stitch category (Type) | Resistance (Ω) | Current Conductivity (mA) |
|---|---|---|---|---|---|
| 1 | 1000 | ZC | Tatami | 0.04 | 0.1 |
| 2 | 1000 | ZC | Satin | 0.01333 | 0.3 |
| 3 | 1000 | ZC | Zigzag | 0.02857 | 0.14 |
| 4 | 2000 | ZC | Satin | 0.00333 | 1.2 |
| 5 | 2000 | ZC | Satin | 0.00333 | 1.2 |
| 6 | 2000 | ZC | Zigzag | 0.02857 | 0.14 |
| 7 | 2000 | ZC | Zigzag | 0.02857 | 0.14 |
| 8 | 3000 | ZC | Tatami | 0.00333 | 1.2 |
| 9 | 1000 | CC | Tatami | 0.00049 | 8.1 |
| 10 | 1000 | CC | Zigzag | 0.00059 | 6.8 |
| 11 | 2000 | CC | Tatami | 0.00047 | 8.5 |
| 12 | 2000 | CC | Satin | 0.00043 | 9.3 |
| 13 | 2000 | CC | Satin | 0.00043 | 9.3 |
| 14 | 3000 | CC | Tatami | 0.00036 | 11 |
| 15 | 3000 | CC | Satin | 0.00031 | 12.7 |
| 16 | 3000 | CC | Zigzag | 0.00042 | 9.4 |
| 17 | 1000 | SC | Tatami | 0.00057 | 7 |
| 18 | 1000 | SC | Satin | 0.00053 | 7.5 |
| 19 | 1000 | SC | Zigzag | 0.00055 | 7.3 |
| 20 | 2000 | SC | Tatami | 0.00044 | 9 |
| 21 | 2000 | SC | Satin | 0.0004 | 10 |
| 22 | 2000 | SC | Satin | 0.0004 | 10 |
| 23 | 2000 | SC | Zigzag | 0.00051 | 7.8 |
| 24 | 2000 | SC | Zigzag | 0.00051 | 7.8 |
| 25 | 3000 | SC | Tatami | 0.00048 | 8.4 |

### 3. Result and Discussion

The results of the conductive embroidery fabric with respect to electrical property analyzed statistically. The model selected based on the highest order polynomials; in this the additional terms were significant.

The correlation coefficient R2 value was important for validation of the model developed. The final empirical formula model for the response interms of coded factors is represented in equation [2]. The R2 values for the response current conductivity (I) and the adjusted R2 value are 0.9935 and 0.9859 respectively. The ANOVA values clearly indicate that the regression 2FI-model based on the equation it is significant (Fcrit> Factual) with actual F values. The model F value 130.09 for Current conductivity (I) is shown in table 5. The electrical property of the embroidery design imply the model is significant and the value of "F" is greater than 0.05 level.

Current Conductivity (I)= +6.11+1.27*A-5.33*B[1] +2.81*B[2] -0.1169*C[1] +0.8235*C[2] -0.5932*AB[1] +0.6764*AB[2] -0.3720*AC[1] +0.9946*AC[2] -0.0108*B[1]C[1] +0.3995*B[2]C[1] -0.1434*B[1]C[2] -0.2887*B[2]C[2] ..... (2)

*Table 5 - ANOVA analysis for Current Conductivity (mA)*

| Source | Sum of squares | Degree of freedom (DF) | Mean square | F value | Prob>F |
|---|---|---|---|---|---|
| Model | 407.03 | 13 | 31.31 | 130.09 | < 0.0001 |
| A-Stitches | 14.91 | 1 | 14.91 | 61.96 | < 0.0001 |
| B-Conductive Thread | 325.2 | 2 | 162.6 | 675.6 | < 0.0001 |
| C-Stitch category | 6.94 | 2 | 3.47 | 14.41 | 0.0008 |
| AB | 3.09 | 2 | 1.54 | 6.41 | 0.0142 |
| AC | 3.58 | 2 | 1.79 | 7.43 | 0.0091 |
| BC | 1.74 | 4 | 0.4349 | 1.81 | 0.1978 |

### *3.1 Current Conductivity*

The current conductivity of the embroidery fabric samples is evaluated and the 2FI model is achieved the 3D surface plots, the effect of conductive thread, stitch category on resistance (R) of surface embellished fabric at various stitch level has discussed. The significance and adequacy of the model justified through analysis of variance. The results are plotted in table 5 and figure 3, the model P-value (0.0001) less than 0.05 indicates terms are significant. The significant model terms are stitches (A), conductive thread (B) and stitch category (C). The embroidery design parameters A, B, C, AB and AC are significant model terms. The current conductivity of the embroidery design is more influenced by conductive yarn and stitch density (p-value = 0.0001) than stitch class (p-value = 0.0008). This may be the coated yarn conductivity property influences more significantly than stitch type. Irrespective of stitch level, the conductivity of the fabric produced with CC and SC produces higher conductivity (I) value than ZC conductive yarn.

At 1000 stitch among all conductive yarns, it is evident from the result the conductive design produced with ZC yarn have higher resistance (R) in conductivity. The satin stitched embroidery design provides higher current conductivity (I). This may be the closed stitches in density inside the contour design. The zigzag stitch produces wider in density of stitches than other filling stitches. Higher the density increases the number of contact point in yarn length, so current conductivity (I) also increased. The density characteristics of filling yarn influence the electrical conductivity of the design element [6]. The CC and SC yarns provide lower resistance value. This is because of resistivity of the material. The resistivity of copper and silver is 1.68x10-8 ρ (Ωm) and 1.59x10-8 ρ (Ωm) [11, 13].

In all stitch classes, when stitch density increases from 1000 to 3000 stitches, the closeness of the conductive yarn and the length of the yarn used for filling contour design also increased. So the resistance of the coated yarn increases linearly for CC, SC and ZC conductive embroidery fabrics. When increases in stitch density, electrical conductivity of the yarn and stitches type also influencing the electrical conductivity of the embroidery design. There is significant difference observed in between A and C, A and B parameters (p-value: 0.0091 and 0.0142 respectively which is <0.05 level). Satin stitch in an embroidery design contour produces closer and parallel stitches with each other. Whereas, tatami stitch provides closer stitches with the gap between stitch at the design contour. Therefore, the length of the conductive thread consumed by the satin and tatami stitches also varied as 49.99 ft and 49.06 ft respectively for 1000 stitch density. The conductive fabric produced with satin stitch provides closer and more contact point between yarns. The author reported in their study, increases in stitch density and contour width, obtained stronger electrical conductivity [4].

The electrical property of the conductive samples produced with ZC yarn with zigzag stitch produces higher resistance (R) followed by tatami and satin stitched fabrics. The fabric produced with satin stitch combination produces lower resistance value. The satin stitch produces more parallel and closer stitches compared to other filling stitches. The number of stitch in a design, type of filling stitch and its geometry also influences the resistance of a conductive fabric.

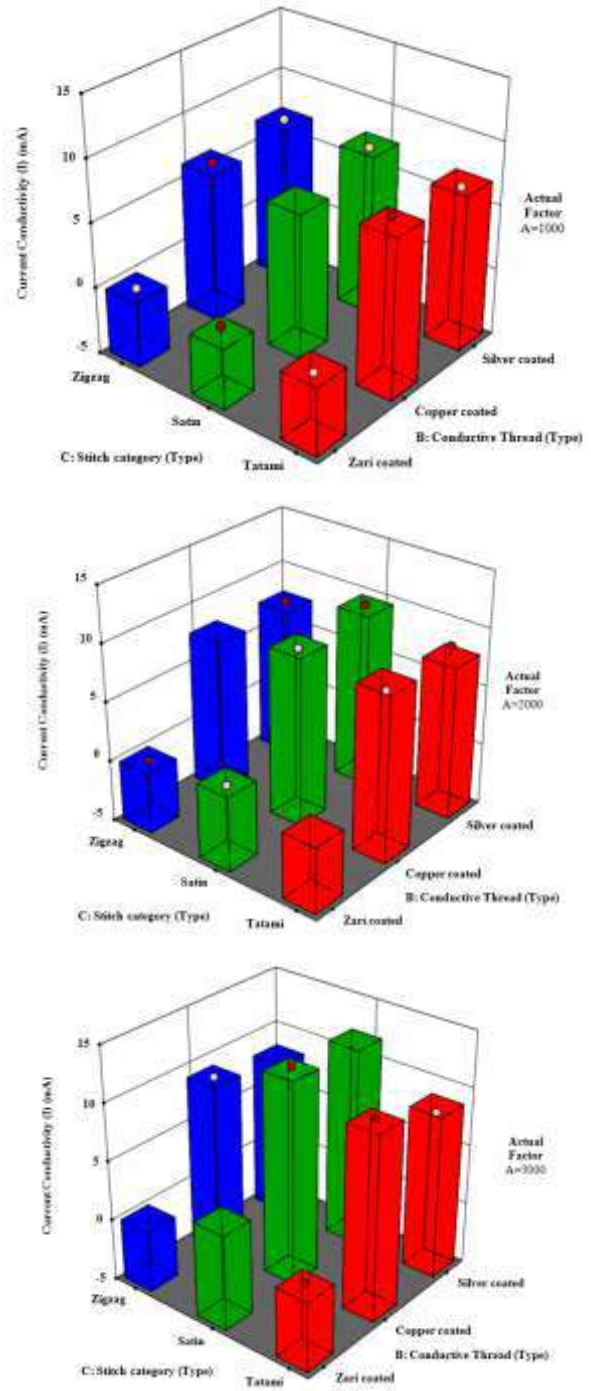


*Figure 3 - Electrical conductivity of embroidery design fabric*

### *3.3 Optimization of Embroidery Parameters*

The objective of the experimental design was to find the optimum embroidery parameters required for higher current conductivity through the embroidery design. The

conductivity of the embroidery geometry design increased with increases in stitch density and vice versa. The target was set in design expert statistical software with higher electrical current conductivity. The optimum parameter was selected based on highest desirability. The figure 4 shows the optimum electrical conductivity value with suitable embroidery parameters as 3000 -stitch density, Satin -stitch type and Copper coated -conductive thread reveals highest desirability for the target.

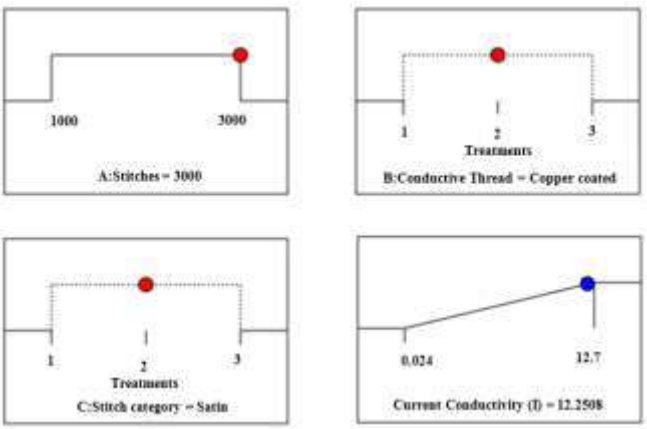


*Figure 4 - Optimized embroidery parameter*

## 4. Conclusion

The embellished design in a fabric with conductive threads were developed using embroidery technique. The electrical conductivity of the developed fabric analyzed through the resistance and current conductivity of the embroidered article. The influence of embroidery stitch type, conductive threads at various stitch density studied and reveals the following conclusions.

- The current conductivity value of the embroidered design has significantly influenced by the selected embroidery parameters.
- At same design contour, increases in stitch density, electrical conductivity of sample influenced by the type of filling stitch and conductivity property of the embroidery yarn.
- Increases the stitch density from 1000 to 3000 stitches, the CC conductive thread with satin stitch combination provides higher current conductivity.

This kind of proposed surface embellished conductive fabric may suitable for low electrical conductivity application (4mA – 20mA) such as wearable sensors for measuring temperature, pressure, depth and humidity.

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# Influence of Slub Yarn Characteristics on Yarn Properties

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**Abstract:**

*In the dynamic landscape of the textile industry, particular varieties of fancy yarns are witnessing a surge in demand, with slub yarn emerging as a prominent player. Slub yarn offers an appealing aesthetic demand that resonates with fashionable market preferences. Generally, slub yarn production involves altering the speed of back and middle rollers while overfeeding fibers into the main drafting zone, maintaining the speed of the front roller constant. The resulting yarn properties are intricately linked to the overfeeding rate, influencing its appearance and performance characteristics.*

*In this paper slub yarn parameters like slub per metre and slub count are taken as variables to study its effect on strength, elongation, unevenness, imperfection value and hairiness index of yarn. The measurements of the yarns were made on the fancy yarn profile Uster Tester 5 and the Uster Tensojet devices. The values of the test result were analyzed and evaluated statistically. The experiment showed that the above variables of slub shows significant effect for all the properties except breaking elongation%.*

**Keywords:** *Imperfection Value, Slub count, Slub per metre, Slub population, Unevenness*

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## 1. Introduction :

Slub yarn, a distinctive variant in the realm of textile engineering, has garnered significant attention for its irregular texture and unique aesthetic appeal. Characterized by intermittent thickened sections along its length, slub yarn deviates from conventional yarn structures, offering designers and manufacturers a versatile tool for creative expression in fabric design. As the textile industry continues to evolve, slub yarn has emerged as a sought-after choice, aligning with shifting consumer preferences towards novel and visually intriguing textiles.

The production of slub yarn involves deliberate manipulation of the spinning process, typically achieved by varying the speed of back and middle rollers while overfeeding fibers into the main drafting zone, while maintaining the speed of the front roller constant. This controlled irregularity results in the formation of slub intervals within the yarn, imparting it with a distinctive tactile and visual texture. Various production techniques, including traditional methods and modern advancements such as air-jet spinning and core-spun yarns, contribute to the diversity of slub yarn types available in the market.

The significance of slub yarn in the textile industry is underscored by its ability to enhance fabric texture, appearance, and overall tactile experience. Its irregular structure introduces depth and dimensionality to fabrics, transforming ordinary textiles into captivating pieces of art. Furthermore, slub yarn's versatility extends beyond aesthetics, influencing performance properties such as abrasion resistance, pilling propensity, and dye absorption, thereby impacting the functionality and durability of the end product.

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## 2. Material and Methods

### *2.1 Materials*

For this experiment roving of 1.0 hank, 65/35 polyester-cotton blend with staple length of 29mm-cotton and 38mm-polyester is procured for the trial.

### *2.2 Methodology*

Using modern fancy attachment device attached to drafting system of ring frame, nine samples as per the market trends were produced for the study by developing electronic programme (EP) compatible with ring frame machine parameters.

***Table 1: Process Parameters on Ring Frame***

| | |
|---|---|
| Speed (RPM) | 9000 |
| Twist per inch | 20.98 |
| Traveller weight | 2/0 LRT |

***Table 2: Design of Experiment to produce slub yarn***

| | | | |
|---|---|---|---|
| Slub Count (Ne) | 12 | 14 | 16 |
| Slub/mtr | 4 | 6 | 8 |

Taugachi Design was used to study the main effect of above factors on yarn properties. With 2 factors (slub count and slub/mtr) having 3 levels each, 32 Factorial experiment with L9 orthogonal design was planned. Accordingly nine slub yarns as shown in table 3 for the study were manufactured keeping slub length of 4 cm constant.

### *2.3 Testing*

Strength & elongation were measured on Uster tensojet testing instrument. Total 100 measurements of each combination of samples (10 tests from 10 cops) were taken for the study to see the effect. Fancy yarn structural properties were measured on Uster 5 with fancy profile module. The results obtained were analyzed using the technique General Linear Model (GLM) and graphs were obtained by Minitab software.

## 3. Result & Discussion

After manufacturing the yarn samples as per the Taguchi design, samples were, evaluated for different properties as tabulated in table 3.

*Table 3: Yarn properties of slub yarn*

| Slub / mtr | Slub count (Ne) | Slub distance (cm) | Count base (Ne) | Avg count (Ne) | Rkm | Elon-gation% | U% | Imperf-ection value (IPI) | Hairi ness index (HI) |
|---|---|---|---|---|---|---|---|---|---|
| 4 | 12 | 20.69 | 37.84 | 27.43 | 20.02 | 9.92 | 34.29 | 23014 | 6.72 |
| 4 | 14 | 20.46 | 35.78 | 27.61 | 21.37 | 10.16 | 32.36 | 18196 | 6.74 |
| 4 | 16 | 20.36 | 34.66 | 27.76 | 21.65 | 10.50 | 29.62 | 16948 | 7.08 |
| 6 | 12 | 12.22 | 39.42 | 27.27 | 18.56 | 10.12 | 37.27 | 23329 | 6.45 |
| 6 | 14 | 13.34 | 36.52 | 27.48 | 19.61 | 10.14 | 33.81 | 20886 | 6.49 |
| 6 | 16 | 13.77 | 35.72 | 27.56 | 21.18 | 10.18 | 31.52 | 18435 | 6.56 |
| 8 | 12 | 7.86 | 42.43 | 27.09 | 16.96 | 9.42 | 42.00 | 27717 | 6.24 |
| 8 | 14 | 8.89 | 39.08 | 27.28 | 17.32 | 9.47 | 36.62 | 24055 | 6.35 |
| 8 | 16 | 8.24 | 37.32 | 27.37 | 19.11 | 9.52 | 32.82 | 20466 | 6.46 |

### *3.1 Effect on average count of slub yarn*

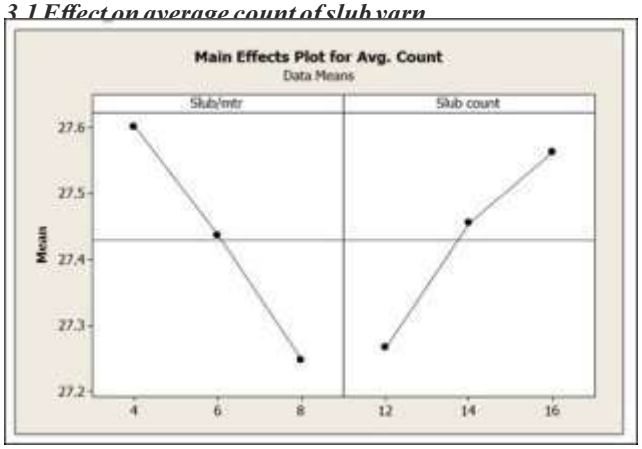


*Figure 1: Average count of slub yarn*

From the above graph, it is clear that as the slub/mtr increases the average count of yarn goes on coarser side due to increase in the fibre content in the yarn. It is also clear that as slub count increases, yarn becomes finer and fibre mass in yarn decreases therefore average yarn count goes to finer one. Statistically analysis shows that both the factors have significant effect on average count of yarn.

### *3.2 Effect ofon tenacity (Rkm) of slub yarn*

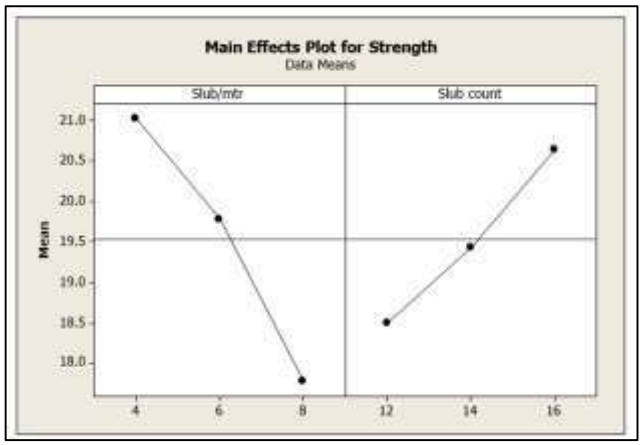


*Figure 2: Tenacity of slub yarn*

Slub/mtr and slub count has significant effect on breaking strength of yarn. As the slub per metre increases, proportion of thin place before and after slub increases causing decreases in the strength of yarn. As the slub count becomes finer increasing trend in the strength of yarn due to proper binding of fibers at slub region gives more compact yarn sustaining more load. More the fibre friction more increases in the yarn strength. It is seen from less number of slubs and finer slub in the yarn.

### *3.3 Effect on elongation of slub yarn*

Statistically there is no significant effect of slub count and slub per metre on breaking elongation percentage of slub yarn. From figure 3, it is seen that as the slub/mtr increases elongation percentage of yarn reduces as the base yarn contribution will be less and also base yarn count goes on finer side introducing weak places. Increases in slub count increases the elongation % of the yarn as number of fibres in the cross section will be less and contributes better twist which gives more breaking elongation.

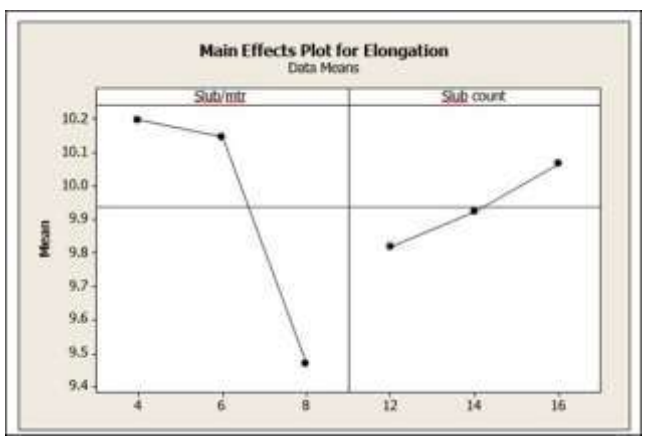


*Figure 3: Breaking Elongation of slub yarn (%)*

### 3.4 Effect on Unevenness of slub yarn

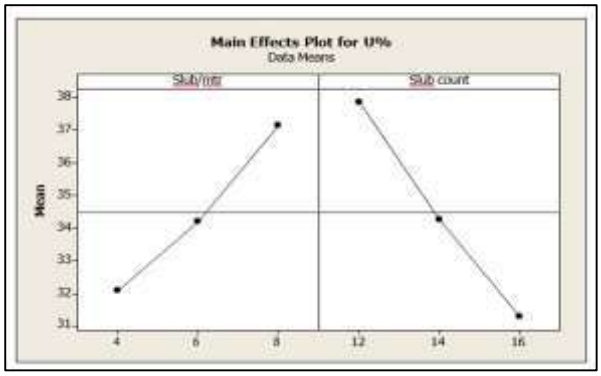


*Figure 4: Unevenness of Slub Yarn*

Statistically slub per mtr and slub count has significant effect on U% of the yarn. From figure 4, it is clearly seen that as the slub/mtr increases U% of the yarn increases. During base yarn and slub part formation change in draft force is there, which causes unevenness is more. As the slub population increases the number of change in draft from base to slub will increases giving raise to uneven yarn.

Increases in slub count from coarse to finer gives reduction in U % of the yarn. Finer slub having more twist propagation than the coarser slub, gives yarn compactness and fibre strand consolidation effect. This effective cohesion of finer slub gives better U% as compare to coarser slub.

### 3.5 Effect on Imperfection of slub yarn

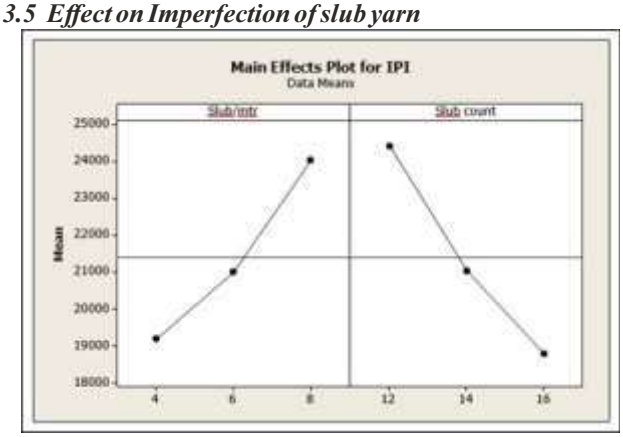


*Figure 5: Imperfection value of slub yarn*

From figure 5, it is clear that as the slub per metre increases the IPI value increases. As the slub per metre increases the base yarn count goes on finer side, so during base yarn count formation as there is more reduction in mass per unit length & also the twist propagation is also more. As slub frequency increases the variation in draft also increases i.e frequency of acceleration & deaccleration will be more so this frequent variation in drafting determines thin places in yarn.

As the slub count goes finer side the IPI value is going to decreases. With finer slub count, less number of fibres in cross section gives better fibre cohesion and twist insertion with less imperfection value. Slub per metre & slub count have significant effect on IPI value of yarn.

### 3.6 Effect on hairiness index of slub yarn

Here from figure 6, it is clear that as the slub per meter increases the hairiness index of the yarn increases. For hairiness particularly twist plays an important role and as the frequency of slub per meter increases the acceleration and deceleration of rollers for overfeeding of fibers at slub part will be more and the amount of twist with inserted will be vary as the size of the yarn i.e. no. of fibers in yarn cross section vary for slub part & base part. As slub part is less twisted part as compare to base part, so with higher no. of slubs fiber in slub part will be more which is less twisted & the base part is highly twisted. So with less twist the fibre arrangement will not be proper & more twist concentrated in base part there will be possibility of fibre breakage which contribute to the yarn hairiness. From figure 6, it is clear that with finer slub count hairiness index reduces. For hairiness twist plays an important role as with finer slub count there is better twist propagation which gives less hairiness.

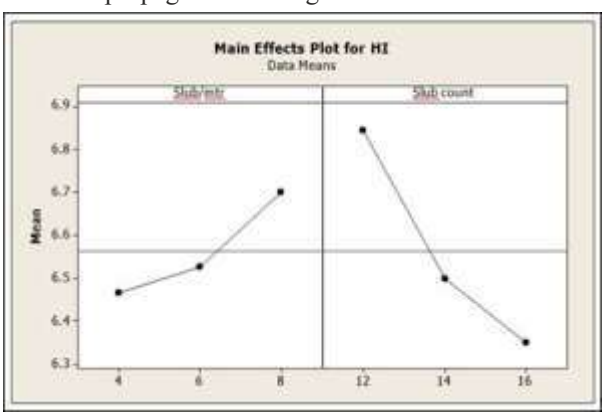


*Figure 6: Hairiness Index of slub yarn*

## 4. Conclusion

We can conclude that the fancy slub yarns particularly with less slub population & finer slub count contributes with better yarn properties in terms of strength, elongation, unevenness ,imperfection value & hairiness index. Equally it is well known for its appearance, so the slub yarn with coarser slub count & maximum slub population gives better view & appearance in the fabric.

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Journal of the TEXTILE Association



# One Step Treatment of Polyester Fabrics by Alkali and TiO2 NPs and its Effect on their Functional Performance and Dye-ability

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**Abstract:**

*This article is aiming to study the effect of simultaneous treatment of PET and PET/C blended fabrics with sodium hydroxide and TiO2 nanoparticles (NPs) on their functional performance and dye-ability. The advance of the suggested method is production polyester fabrics imparted new and better functional performance (antimicrobial activity and ultraviolet protection) properties durable in their repeated laundering processes. The modified and dyed fabrics will be investigated by using: SEM, EDX, FTIR. The color strength (K/S) and the fastness properties of dyed PET and PET/C blended fabrics samples were assessed. The obtained results showed that, dyeing polyester fabrics after treatment with alkali and NPs simultaneously have a tangible effect on both % reduction of colony forming unit (% CFU) and ultraviolet protection factor (UPF) properties. The dyed samples appeared enhancement in the color strength and fastness properties. The suggested approach is facile and benign to apply on industrial scale without cost investment.*

**Keywords:** *Alkali Hydrolysis, Antimicrobial, Dyeing. PET and PET/C Fabrics, TiO2 NPs, UV Protection*

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## 1. Introduction :

Textiles may be treated with antimicrobial agents for a range of reasons depending on the market sector and application area. Antimicrobials are typically applied to give textiles improved resilience against microorganisms (e. g. preventing destruction of polymers, discoloration) and increased durability of the textile leading to longer lifetime of use [1-2]. Antimicrobials can also be used to protect textiles against colonization of odor-forming bacteria [3-4]. They may also be applied to textiles to play a role in addressing hygiene in clinical and sensitive environments by minimizing the chances for microbial colonization of textiles and the potential for transfer from fabric surfaces [5-6].

However antimicrobial treatments can provide consumers with an option to consciously reduce the frequency and/or intensity of laundering which can give potential for significant savings in water use, energy consumption and reduced need for chemical consumables in textile care. Considering that the majority of resources used in the life of a textile occurs in the use and care phase this can be a significant environmental benefit. For consumers looking for ways to reduce environmental footprint in daily life, textiles that require less intensity of care can provide a way to contribute to this goal [6].

Nano-metal oxides have created a new approach for remarkable applications as an attractive multi-functional finishing material. TiO2 NPs have unique properties such as higher stability, long lasting, safe and broad-spectrum antibiosis. This makes TiO2 NPs applicable in many fields such as: self-cleaning [7], antimicrobial [8], UV protecting [8], purification the environment [9], gas sensors [10], high efficient solar cell [11], and Dye degradation in textile effluent due to their photo-activity property [12].

Industrial wet processing line for natural and man-made fabrics includes desizing and scouring steps in alkaline medium [13], which may be lead to the creation of additional functional groups (COOH and OH) in PET macromolecules, it seems of a great interest to clarify the possibility of adding TiO2 NPs in alkaline treatment bath as a practical alternative to traditional approach [14].

It is known that, the wet processing line in dyeing and finishing factories consists of these main stages (Desizing-Scouring - Bleaching - Dyeing - Finishing). Sizing and scouring are used for removing the starch in case of PET/C blended fabrics or polyvinyl alcohol in case of PET fabric. These stages are processed in an aqueous alkaline medium. The idea of the research lies in the possibility of adding nano-metal oxides in the alkaline medium so that the removal of the sizing agents takes place and at the same time, the finishing process is carrying out. This reduces the cost and may be paves the way for the direct use of nano-metal oxides easily and conveniently on the production line without any technological investment. Therefore, this article is concerning with studying the effect of simultaneous

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treatment of polyester fabrics with sodium hydroxide and TiO2 NPs simultaneously on their functional performance and dye-ability. This technique is paving the way for NPs to be widely implemented on a wet processing line in industry and became more economic for the textile finisher.

## 2. Materials and Methods

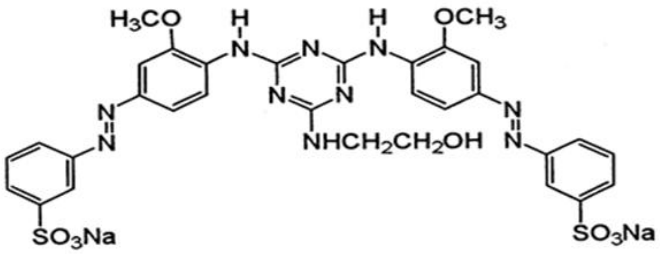
### *2.1 Materials*

- Desized and Bleached polyester (PET) 100% Trevira (165 gr/m2) and polyester / cotton (PET/C) blended 50/50 (236 gr/m2) woven fabrics were used throughout this work provided by local textile industries. The fabrics before use was washed in a aqueous solution containing 2.0 g/L nonionic detergent for 30 min at 60°C with liquor to goods ratio (M : L) of 1: 40, then rinsed with distilled water and dried at ambient temperature.

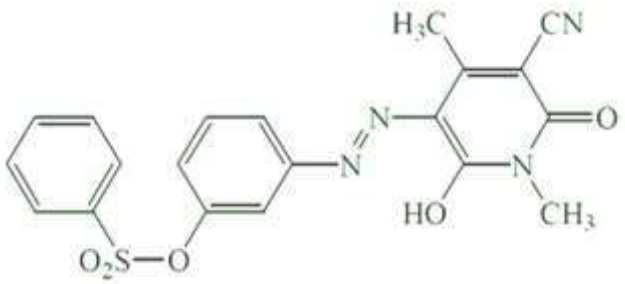
- All chemical used in this work [Titanium dioxide nanoparticles (TiO2NPs) emulsion (aqueous, 30%) – Sodium Hydroxide (NaOH), hydrochloric acid (were purchased from Fluka and have been used as received.

- Bacillus mycoides (B. m) (Gram positive bacterium), Escherichia coli (E.c) (Gram negative bacterium), and Candida albicans (C.a) (nonfilamentous fungus) were used for estimation of antimicrobial potency of control and treated samples. Microorganisms were obtained from the culture collection of the Microbial Chemistry Department, Division of Genetic Engineering and Biotechnology, National Research Centre of Egypt.

Disperse dye (Dianix Yellow E3GE), direct dye (Sirius S-2G) and soaping agent (Sera Fast), were kindly supplied by Dye Star Company. Acetic acid, Dispersing agent, Sodium acetate, Sodium carbonate, non-anionic agent, Sodium sulphate and sodium sulfite were purchased from Fluka and have been used as received.




*Chemical Structure of C.I. Direct Dye Yellow*




*Chemical Structure of C.I. Disperse Dye Yellow*

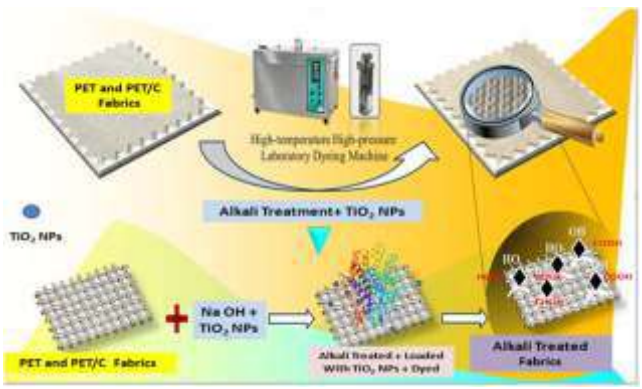
### *2.2 Methods*

#### *2.2.1. Alkaline Treatment of Polyester Fabrics*

The alkaline treatment of PET and PET/C blended fabrics was carried out according to the method described in [13], using a high temperature, high pressure laboratory dyeing machine. Required volume from the prepared and calibrated of alkali aqueous solution was placed in stainless-steel bowl. The fabrics samples were immersed in the solutions and the sealed bowls were rotated in a closed bath containing ethylene glycol at selected temperature. The liquor- to-fabrics ratio (M: L) was 1:50. The bath temperature increased at rate of 2°C/min. After the predetermined durations, the samples were removed from the bath, rinsed repeatedly with distilled water, neutralized with a solution of 1% hydrochloric acid and rinsed. The samples were then dried at 100°C, cooled in a dessicator, and weighed [14].

#### *2.2.2. Polyester Fabrics Loaded by TiO2 NPs*

The simultaneous treatment of polyester fabrics with NaOH and TiO2 NPs was carried out as follows: The required volume from the prepared and calibrated of alkali aqueous solution was placed in stainless-steel bowl in presence TiO2 NPs by using 1.0 g/l (Scheme 1). The fabrics samples were immersed in the solutions and the sealed bowls were rotated in a closed bath containing ethylene glycol at selected temperature. The liquor- to- fabrics ratio (M: L) was 1:50. The bath temperature increased at rate of 2°C/min. After the predetermined durations, the samples were removed from the bath, rinsed repeatedly with distilled water, neutralized with a solution of 1% hydrochloric acid and rinsed. The samples were then dried at 100°C, cooled in a dessicator, and weighed.




***Scheme (1): The simultaneous treatment of polyester fabric with NaOH and TiO2 NPs***

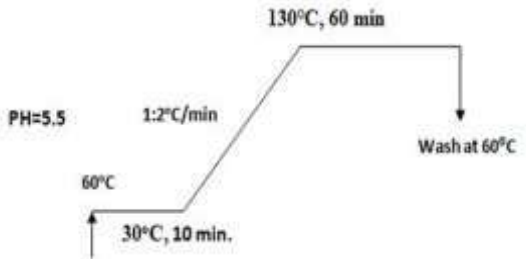
#### *2.2.3. Durability Testing Method*

In order to evaluate the Ti2O NPs adhesion to the polyester fabrics, the treated fabric was washed five times according to a standard method AATCC Test Method (61-1989). One such test takes about 45 min under the action of detergent solution. Every one washing cycle represents that of five typical home launderings. In our approach, washing of textiles was performed at washing temperature settings of 71°C. After this process, the textiles were dried at 105°C.

*2.2.4. Dyeing Procedure*

2.2.4.1. Dyeing of PET Fabrics

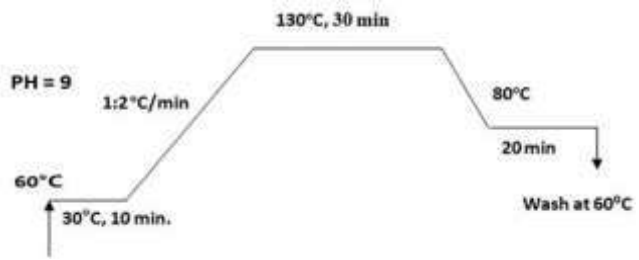
The dyeing bath with disperse dye (1.0%) set as shown in scheme (1). The pH was adjusted at 5-5.5, dyeing was performed at 30oC for 10 minutes and the temperature was gradually raised by 1:2 oC/min, 130oC, then dyeing was continued for 60 min at 130oC, and then thoroughly rinsed and washed in a wash bath containing 1.0g/l sodium sulfite (reduction clearing) for 20 min at 70oC and finally rinsed with hot and cold water then dried in air.




***(1%Dye+ water+ Acetic Acid+ 1%Dispersing Agent+ 2g/l Sodium Sulphate)***
***Scheme (2): Dyeing Method of PET Fabric***

2.2.4.2. Dyeing of PET/C blended fabrics (One Step)

The dyeing bath with disperse and direct dyes was set as shown in scheme (2). The pH was adjusted at ٩.٠, dyeing was performed at 30oC for 10 minutes and the temperature was gradually raised by 1:2 oC/min, 130oC, then dyeing was continued for 30 minutes at 130oC, and Reduce temperature to 80oC contain the dyed samples for 20 minutes, and then thoroughly rinsed and washed in a wash bath containing 2.0g/l detergent (Soaping) for 10 min at 60oC and finally rinsed with hot and cold water then dried in air.




***(0.5% Direct Dye+ 0.5% Disperse Dye +Water+ Acetic Acid+1% Dispersing Agent+ 2%Sodium Acetate+2% Sodium Sulphate)***
***Scheme (3): One step Dyeing Method of PET/C Blend Fabrics 2.3***

**Analysis**

*2.3.1. Carboxylic content*

Carboxylic content was determined according to the method described in [15].

2.3.2. Antimicrobial Activity

Antimicrobial activity of PET fabrics loaded with TiO2NPs was quantified using the following method: Shake Flask method expressed throughout (%) reduction of bacterial count by calculated colony forming unit (CFU). In this method the antimicrobial activity of immobilized antimicrobial samples is determined under dynamic contact conditions according to ASTM standard test method 2149 (2001) [16].

*2.3.3. Surface Morphology*

The structures and surface morphology of the alkali treated polyester fabrics and loaded with TiO2 NPs were characterized by scanning electron microscopy (SEM, JEOL JSM T2O). Electron dispersive Emission X-ray. EDX mode was applied for the elemental composition analysis. Gold layer was coated on the fabrics surfaces before the examination.

*2.3.4. The surface Chemistry*

The surface chemistry of the PET and PET/C blended fabrics, partially hydrolyzed and loaded by TiO2NPs were investigated using the Fourier Transformation Infrared (FT-IR) spectrometer, model NFXUS 670, NICLET USA. The measurements were carried in the spectral range from 4000 to 500 cm-1. Reflection percentage measurement technique (R %) was applied to all investigated samples.

*2.3.5. Ultraviolet Protection Factor (UPF)*

UPF was determined using UV-Shimadzu 3101 PC Spectrophotometer. It is a double beam direct ratio measuring system. It consists of photometer unit and a PC computer. The UPF values were automatically calculated on the basis of the recorded data in accordance with Australia/ New Zealand standard AS/NZS 4395:1995 [17].

***Table 1 - UV protection and classification according to AS/NZS 4395:1995***

| UVP | UPF classification |
|---|---|
| Excellent | 40, 45, 50, 50+ |
| Very good | 25, 30, 35 |
| Good | 15, 20 |
| Non- ratable | 5, 10 |

*2.3.6. The Color Strength*

The effect of loading by TiO2 NPs on the dye-ability of PET and PET/C blended fabrics partially hydrolyzed were investigated. The color strength (K/S) of dyed polyester fabrics were evaluated by Ultra scan pro-spectrophotometer, Hunter Lap, by light reflectance technique. The K/S values of the dyed samples were automatically calculated according to Kubelka-Munk equation (1) [18].

$$\text{Color strength } K/S = (1 - R)2/(2R) \quad (1)$$

Where, K, S, and R are the absorption coefficient, scattering coefficient, and reflectance, respectively.

2.3.6.1. Color Fastness

2.3.6.2. Color Fastness to Washing

It was determined according to the AATCC test method 61-1996 (150). The specimens were sewed between two pieces,

one piece made of the same kind of fiber as that of the textile to be tested, the second piece made of cotton or wool in the case of polyester. The composite specimen was immersed into an aqueous solution containing 5.0 g/l soap and 2.0g/l sodium carbonate at 60°C for 15 minutes. The samples then were rinsed with warm water, and neutralizing with acetic acid. Evaluation of the wash was established using the gray scale reference for color change [19].

2.3.6.3. Color Fastness to Crocking

The color fastness to crocking was determined according to the AATCC test 8-1996 [19]. This designated for determining the degree of color which may be transferred from the surface of the colored fabric to other surface by rubbing. Dry and wet crocking tests were applied.

2.3.6.4. Color Fastness to Perspiration

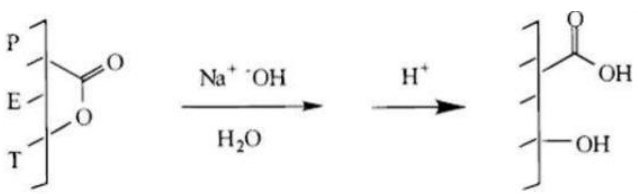
Two artificial perspiration solutions were made as follow, acidic solution and alkaline solution, this test was carried according to the AATCC test method 15-1997 [19].

2.3.6.5. Color Fastness to Light

This test was evaluated according to the BS (test no: 1006-1978) in order to determine the degree of color resistance to photo degradation.

**3. Results and Discussion**

Alkali treatment of polyester fabrics has been used to enhancement the dye-ability, wet-ability, and modification the surface properties of PET fabrics. This treatment leads to a partial hydrolysis of surface fabric and produces new properties on PET [19].




*Effect of Alkali on Polyethylene terephthalate (PET) [20]*

To study the effect of suggested method applied here for the ability of activated surface on binding efficiency of NPs (Simultaneous treatment of polyester fabrics in the presence of sodium hydroxide and $TiO_2$ Nps). PET fabrics were initially treated by alkali solutions, before loading with $TiO_2$ NPs. It well known that, alkali treatment causes a significant increase of OH and COOH groups on the surface of polyester fibers. These data were experimentally proved by the estimation of functional groups creating on the surfaces of polyester fabrics before and after the alkali treatment through carboxylic content measurement.

It was found (Table 1) that the surface of alkali treated fabrics in general, PET have an increase in its carboxylic content rather than parent. Alkali treatment causes outstanding increase in carboxylic content from 3.5 to 13.1 meq/100gr fabric and 6.2 to 22.4, irrespectively. Therefore, the interaction between the activated textile surface by alkali and $TiO_2$ NPs is electrostatic in its nature, since the textile surface is negatively charged as a result of the activation and formation of COOH and OH groups on the surface. This may be enhancement the loading and binding of TiO2 NPs onto the fabrics surfaces, similar observations after partial hydrolysis of polyester fabrics were reported [13-14; 21].

Alkaline treatment (at constant concentration from $TiO_2$NPs 0.2 g/l) of both PET and PET/C blended fabrics leads to a loss in weight of the fabrics (Table 2). Hydrolysis was found to proceed, but with a low weight loss (PET = 1.5%, PET/C = 1.9 at 60 min. and 90°C) when fabrics were treated with aqueous NaOH solution having low concentration (0.5N). The weight loss increased with increasing NaOH concentration, irrespective of the type of treated fabrics. However, a high level of weight reduction occurs in the case of PET fabric.

However, a high level of weight reduction occurs in the case of PET, than in the case PET/C blended fabrics, especially at high concentration of NaOH solution (2.0 mol/l). For instance, a weight loss of 7.9 % was obtained in the case of PET fabric at sodium hydroxide concentration equal to 2.0 mol/l. This contrasts with a weight loss of 7.1 % after alkaline treatment of PET/C blended fabric under the same conditions.

*Table (1): Carboxylic Content of Bleached (H) and Hydrolyzed (H) Polyester Fabrics*

| Fabrics | Carboxylic Content (meq/100 gr. Fabric) |
|---|---|
| PET→B | 3.50 |
| PET→B→H (Weight loss % = 6.6) | 13.1 |
| PET/C→B | 6.20 |
| PET/C→B→H (Weight loss % = 5.5) | 22.4 |

*Table (2): Effect of NaOH Concentration on the Weight Loss % of Alkali Treated Polyester Fabrics*

| Treatment Time (min.) | Dependence of Weight Loss % for polyester Fabrics on Sodium Hydroxide Concentration (mol/L) at: | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0.5 | | 1.0 | | 1.5 | | 2.0 | |
| | PET | PET / C | PET | PET/C | PET | PET/C | PET | PET/C |
| 10 | 1.9 | 1.5 | 2.7 | 2.1 | 3.0 | 2.7 | 5.0 | 3.1 |
| 20 | 3.5 | 2.5 | 4.4 | 2.8 | 5.2 | 3.1 | 5.5 | 3.5 |
| 30 | 4.3 | 3.1 | 4.8 | 3.7 | 5.4 | 3.6 | 6.1 | 4.0 |
| 45 | 5.1 | 4.1 | 5.6 | 4.5 | 6.2 | 4.5 | 6.6 | 5.0 |
| 60 | 5.4 | 4.3 | 5.9 | 4.9 | 6.6 | 5.5 | 7.9 | 7.1 |

Treatment Conditions: [$TiO_2$ Nps], 0.2 g/l; Temperature, 90°C; M : L, 1 : 50.

***3.1. Characterization of polyester Fabrics Loaded with $TiO_2$NPs***

*3.1.1. Scan Electron Microscope (SEM)*

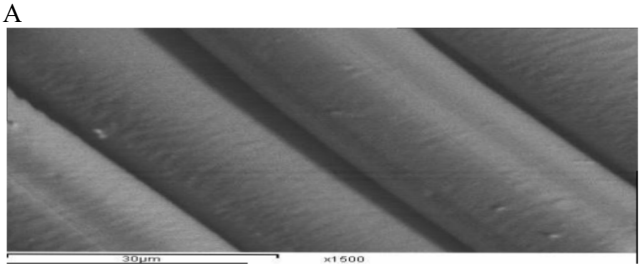
SEM was used to investigate the presence of TiO2 NPs and/or incorporate NPs on the surfaces of fabric (Fig. 1). It was shown that the surface structure of parent fabrics was

retained stable. At higher magnification, the surfaces of the fabric is more distinguished. The parent fabrics (Fig. A and D) has smooth, round, clean and without any pits can be seen on its surface.

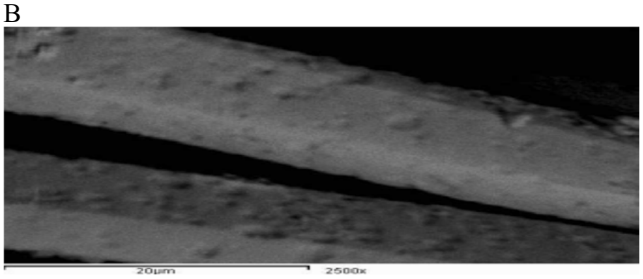
The effect of alkali treatment on the surface of fabric was clarified in the micrographs (B) and (E), where the surfaces of partially hydrolyzed fabrics became pitted with holes distributed randomly on the fabric surfaces. The surface of alkali treated fibers were rough that can be due to etching of the NaOH to the fabric surfaces which resulting from hydrolysis of the short chains and amorphous regain in the polymer matrix. A few numbers of pits on the fiber surface can be observed on the fabrics by adding $TiO_2$ NPs to the reaction medium. Also, some fibers started to link to each other and a thin film were covering the structure of fabrics surfaces. Fig. C and F reveals the unevenly distributed aggregates of $TiO_2$ NPs with dimensions on the surface of the modified PET fabric.

Figures C and F show $TiO_2$ NPs coated the surface of partially hydrolyzed polyester fabrics, at higher magnification we showed a random distribution of $TiO_2$ NPs on the surface of alkali treated fabrics compared to the hydrolyzed fabrics in absence NPs, which had some cracks and voids produced on its surface under the effect of alkaline hydrolysis, these cracks contained more $TiO_2$ NPs entrapped inside them. The particles have large size could be easily removed from the fiber surface, whereas the small one could penetrate the polymer matrix and adhere more strongly to the fabric. EDX micrographs (C and F) that confirmed the deposited materials on the polyester fabrics surfaces was $TiO_2$ Nps.

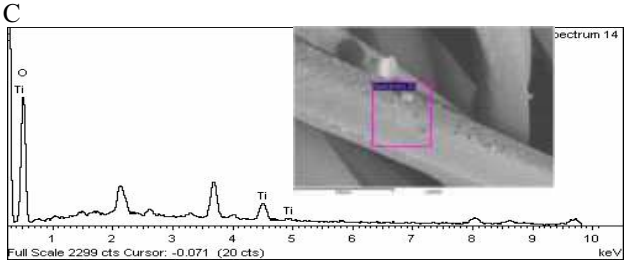
A



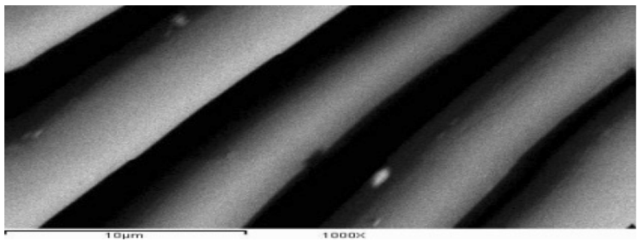

B



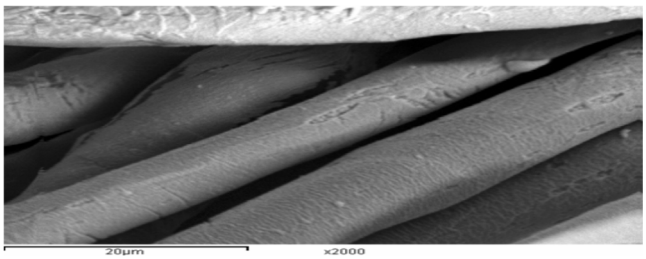

C




D




E




F

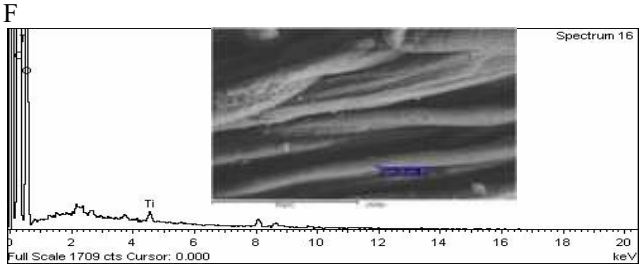



***Figure (1): SEM and EDX Micrographs of Bleached, Partially Hydrolyzed and Dyed PET Fabrics Loaded with TiO2 NPs* (X2000)***
***[A] PET→B→H→D (Blank)***
***[B] PET→B→H+TiO2***
***[C] PET→B→(H+TiO2)→D***
***[D]PET/C→B→H→D (Blank)***
***[E] PET/C→B→H+TiO2***
***[F] PET/C→B→H+TiO2→D*After One Washing Cycle; AATCC Test Method (61-1989).***

*3.1.2. EDX*

EDX spectra of the polyester fabrics coated with $TiO_2$ NPs after one washing cycle are shown in fig. (1). On the basis of these spectra, we can conclude that, the atomic structure of coated material consisted of Ti and $O_2$. This finding is proved even after one washing cycle (5 home washings), $TiO_2$ is still bind to the polyester fabrics surface (Table 3). EDX investigation also appeared higher atomic weight % of Ti on partially hydrolyzed PET and PET/C blended fabrics and loaded Ti NPs, (Ti atomic weight % was 2.39 and 3.31 respectively). This is more conformation that $TiO_2$ NPs have good adhesion to the alkali treated polyester fabrics.

***Table (3): Ti Content of Polyester Fabrics and Loaded with Nps***

| No. | Fabrics | Atomic % on Polyester surface of Ti: |
|---|---|---|
| 1 | PET→B (Blank) | 0.00 |
| 2 | PET→B→H | 0.00 |
| 3 | PET→B→H+ $TiO_2$ 1 g/l | 2.39 |
| 4 | PET→B (Blank) | 0.00 |
| 5 | PET/C→B→H | 0.00 |
| 6 | PET/C→B→H+ $TiO_2$ 1 g/l | 3.31 |

**After One Washing Cycle; AATCC Test Method (61-1989).*

*Table (4): FT-IR Absorption Bands of Bleached, Partially Hydrolyzed and Dyed (D) Polyester Fabrics and Loaded with TiO2 NPs**

| No. | Fabrics | Absorption Bands of Functional Groups (>C=O —OH) Affected After Treatment with $TiO_2$ NPs | | | | New Absorption Bands Appeared | |
|---|---|---|---|---|---|---|---|
| | | >C=O | | —OH | | | |
| | | Position ($Cm^{-1}$) | Intensity | Position ($Cm^{-1}$) | Intensity | Position ($Cm^{-1}$) | Intensity |
| 1 | PET→B→H→D (Blank) | 1714.7 | 91.4 | 3321.7 | 98.7 | - | - |
| 2 | PET→B→H →$TiO_2$→D | 1712.2 | 95.3 | 3300.2 | 94.2 | 764.9 | 99.1 |
| 3 | PET/C→B→H→D (Blank) | 1715.6 | 93.3 | 3327.4 | 99.1 | - | - |
| 4 | PET/C→B→H→$TiO_2$→D | 1711.4 | 98.4 | 3323.4 | 93.2 | 702.2 | 93.0 |

**After One Washing Cycle; AATCC Test Method (61-1989).*

*3.1.3. FTIR*

Table (4) shows the characteristic peaks attributed to >C=O and - OH groups of parent, alkali treated and dyed fabrics. the intensity of characteristic peaks ascribed to OH at 3300 and 3332.4 $cm^{-1}$ and the peak attributed to C=O (carboxylic acid) at 1714.7 and 1715.6 $cm^{-1}$ was detected, but no change was observed at other peaks. The intensities of the peaks ascribed to OH and COOH increased for polyester treated with NPs compared with parent fabrics. Also, comparing partially hydrolyzed polyester, and alkali treated in presence $TiO_2$ NPs and dyed with parent fabrics indicated a decrease in the intensities of the peaks ascribed to C=O (carboxylic acid) at 1714.7 and 1715.6 $cm^{-1}$ to 1712.2 and 1711.4 cm-1 respectively. This is prove the possibility of reaction between $TiO_2$NPs and polymer chains [21]. The FTIR charts of alkali treated PET fabrics showed appearing new peaks at the position 764.9 and 702.2 $cm^{-1}$ with PET, which proves the ionic interaction between carboxylate groups existed on the fabric surfaces and Ti present in the reaction medium, similar finding was reported [22].

***3.2. The Functional Performance of PET fabric***

*3.2.1. Antimicrobial Properties*

Fig. 2 and 3 indicated that, all fabrics showed, after one washing cycle, a high antimicrobial activity. In fact, the % CFU for all tested polyester fabrics samples are significant, whereas it is null for all the blank samples. The role of activation of polyester fabrics with alkali hydrolysis in presence TiO2 NPs on the antimicrobial activity seems to be more significant as the samples were laundered repeatedly in launder-Ometer.

It was found that, the bioactivity of the substrates activated by alkali hydrolysis in presence NPs became significantly different (Fig. 2 and 3). The decrease in antimicrobial activity of PET and PET/C fabrics activated occurred progressively as the number of washes increased. Under these activation conditions both PET and PET/C fabrics has lost about 9.0 % and 11.0 %, respectively, its antimicrobial activity against Gram-positive bacteria B. mycoides after 5 Launder- Ometer washes.

In contrast, in case of dyed PET and PET/C blended fabrics after loading with TiO2 NPs, the antimicrobial functions were slightly reduced to certain level. After 5 washing cycles the dyed PET and PET/C fabrics could still provide 70.0 % and 80.0 % microbial reduction against B. mycoides. This proves that, the feasibility of applying simultaneous treatment of polyester fabrics with sodium hydroxide and TiO2 NPs as finishing method to prepare polyester fabrics imparted antimicrobial property.

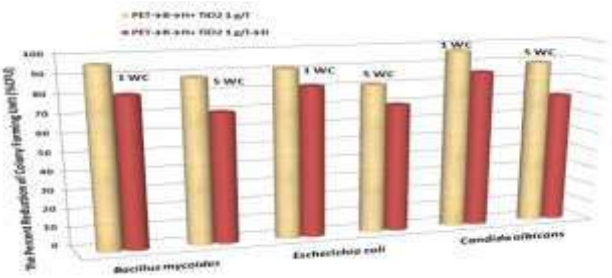


***Figure (2): Antimicrobial Activity of PET Fabric and Loaded with TiO2 NPs, Determined by Shake Flask Method. (WC = Washing Cycle by AATCC Test Method (61-1989)***

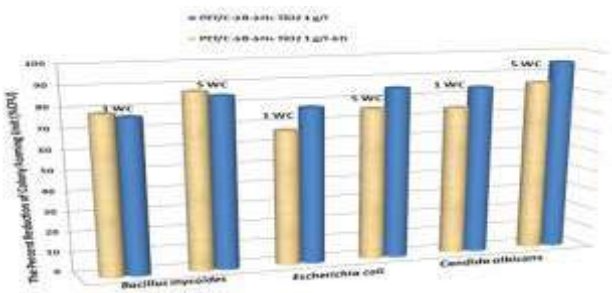


***Figure (3): Antimicrobial Activity of PET/C Blended Fabric and Loaded with TiO2 NPs, Determined by Shake Flask Method. (WC = Washing Cycle by AATCC Test Method (61-1989)***

*3.2.2. Ultraviolet Protection*

Inorganic UV blockers are more preferable to organic UV blockers as they are non-toxic and chemically stable under exposure to both high temperatures and UV. Inorganic UV blockers are usually certain semiconductor oxides such as TiO2, ZnO, SiO2 and Al2O3 [23]. Among these semiconductor oxides, TiO2 and ZnO are commonly used. Titanium dioxide and zinc oxide NPs were more efficient at

absorbing and scattering UV radiation than the conventional size, and were thus better able to block UV [24]. This is due to the fact that NPs have a larger surface area per unit mass and volume than the conventional materials, leading to the increase of the effectiveness of blocking UV radiation. For small particles, light scattering predominates at approximately one-tenth of the wavelength of the scattered light [25].

Rayleigh's scattering theory stated that the scattering was strongly dependent upon the wavelength, where the scattering was inversely proportional to the wavelength to the fourth power. This theory predicts that in order to scatter UV radiation between 200 and 400 nm, the optimum particle size will be between 20 and 40 nm. The effect of activation of simultaneous treatment of PET and PET/C blended fabrics with sodium hydroxide and TiO2 NPs, on UV protection efficiency was investigated. The rate of UV protection was quantified and expressed via UPF values that are given in Table (5). It was found that, the UPF factors for parents PET and PET/C blended fabrics are equal to 11.2 and 14.5 respectively. Activation with alkali treatment in presence TiO2 NPs leads to deposition onto the above mentioned polyester fabrics surfaces NPs leading to a significant increase in UPF factor to the level corresponding to UPF rating of 40+ which assigns the excellent UV protection.

After five washing cycles the UPF values for PET and PET/C blended fabrics were decreased to 51 and 50+ respectively, which assigns excellent UV protection, respectively. These results show good laundering durability of PET fabrics and excellent laundering durability of PET and PET/C blended fabrics activated with alkali and loaded with $TiO_2$ NPs. The UPF values of the nano-$TiO_2$ treated PET and PET/C blended fabrics and dyed revealed that, dyeing causes decrease in the UPF values; but all samples still provide UPF.

***Table (5): Ultraviolet Protection Factor (UPF) of Polyester Fabrics and Loaded with TiO2 Nps***

| Fabrics | Number of Washing Cycles: | | | |
|---|---|---|---|---|
| | 1* | | 5* | |
| | UPF | UPF Rating | UPF | UPF Rating |
| PET→B (Blank) | 11.2 | Poor | 11.0 | Poor |
| PET→B→H | | | | |
| PET→B→H+ $TiO_2$ 1 g/l | 51.0 | Excellent | 33.5 | Very good |
| PET→B→H+ $TiO_2$ 1 g/l→D | 32.9 | Very good | 28.7 | Very good |
| PET/C→B (Blank) | 14.5 | Poor | 14.2 | Poor |
| PET/C→B→H | | | | |
| PET/C→B→H+ $TiO_2$ 1 g/l | 50+ | Excellent | 50+ | Excellent |
| PET/C→B→H+ $TiO_2$ 1g/l→D | 46.5 | Excellent | 41.4 | Excellent |

*3.2.3. Effect of Alkali Treatment and NPs on the Color Fastness*

Comparing with traditional dyeing of polyester fabrics the color strengths obtained from dyeing of treated fabrics with NaOH in the presence of $TiO_2$ NPs leading to increase in wet-ability [26]. In higher concentrations of nano $TiO_2$, the oxygen vacancies (COOH and OH) are more accessible, resulting in higher capacity for water absorption. The higher wet-ability of the polyester fabrics treated improved the dye-ability [27]. Moreover, the wet-ability was more prominent in fabrics dyed with disperse dye due to presence of more hydrophilic groups in the dye structure. Dye-ability has been related to crystallinity since decreasing crystallinity improves dye diffusion into the fiber and dye molecules penetrate much easier through amorphous regions, consequence results to effect of alkaline treatment conditions [28].

Therefore, a sufficient amorphous region was generated by alkaline treatment accompanied by enhancement in the dye-ability of treated polyester fabrics. In addition, NPs were chemically bonded on the fabric surfaces and acted as an adhesive agent between dye and fiber. Hence, large amount of dye molecules may react with the fabric [29]. Moreover, improved wet-ability of nano-treated fabrics can be directly assumed as an effective factor in higher dye adsorption [30]. The more nano $TiO_2$ on the fabric led to the higher dye uptake. Improving the color strength (K/S) of treated polyester fabrics dyed were also showed in Tables 6 and 7. This confirms the results obtained through absorbance spectra. Furthermore, superior changes in the hue, brightness, chroma, and color strength of all the samples, i.e. dyed and dyed pre-treated fabrics with sodium hydroxide in the presence of $TiO_2$ NPs [31].

## 4. Conclusion

This study describes a facile and benign approach for attaching $TiO_2$ NPs to the surfaces of PET and PET/C blended fabrics, as well as the effect of NPs on functional performance and dye-ability. This method involved simultaneously treating polyester fabrics with NaOH and $TiO_2$ NPs. The atomic % of Ti loaded on the dyed fabrics was determined using EDX analysis. The finished and dyed fabrics were characterized using SEM and FT-IR. Both color fastness and color strength (K/S) were evaluated. The results showed that even after five washing cycles, the $TiO_2$ NP loaded polyester fabrics had high antimicrobial and UV protection properties, indicating excellent laundering durability. The dye-ability and colorfastness measurements of PET and PET/C blended fabrics improved after dyeing. There is no doubt that, the results obtained in this research paving the way for the possibility of using metal oxides NPs on the production lines of dyeing and finishing factories. Also, in this research, a one-step dyeing technique was used for dyeing PET/C blended fabric in an alkaline medium, which means the possibility of adding metal oxides NPs to the dyeing bath (dyeing and finishing in one step), which is the research that is currently being worked on.

*Table (6): Effect of Alkali Treatment and loading TiO2 NPs on the Color Fastness of PET fabrics*

| Sample dyed | k/s | Color Fastness to Wash | | | Color Fastness to crocking | | | Color Fastness to perspiration | | | Color Fastness to light | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Change Value | Staining Value | Remark | Change Value | Staining Value | Remark | Change Value | Staining Value | Remark | Change Value | Staining Value | Remark |
| **Blank** | 7.9 | 5 | 4 | Fast Good | 5 | 4 | Fast Good | 4 | 3 | Average | 6 | 5 | Good |
| **0.2** | 8.3 | 5 | 4 | Fast Good | 5 | 4 | Fast Good | 4 | 3 | Average | 6 | 5 | Good |
| **0.4** | 8.6 | 5 | 4 | Fast Good | 5 | 4 | Fast Good | 4 | 3 | Average | 6 | 5 | Good |
| **0.6** | 8.8 | 5 | 4 | Fast Good | 5 | 4 | Fast Good | 4 | 3 | Average | 4 | 5 | Good |
| **0.8** | 9 | 5 | 4 | Fast Good | 5 | 4 | Fast Good | 4 | 3 | Average | 4 | 5 | Good |
| **1.0** | 9.6 | 5 | 4 | Fast Good | 5 | 4 | Fast Good | 4 | 3 | Average | 4 | 5 | Good |

*Table (7): Effect of Alkali Treatment and loading TiO2 NPs on the Color Fastness of PET/C Fabrics*

| Sample dyed | k/s | Color Fastness to Wash | | | Color Fastness to crocking | | | Color Fastness to perspiration | | | Color Fastness to light | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Change Value | Staining Value | Remark | Change Value | Staining Value | Remark | Change Value | Staining Value | Remark | Change Value | Staining Value | Remark |
| **Blank** | 7.5 | 5 | 4 | Fast Good | 5 | 4 | Fast Good | 4 | 3 | Average | 6 | 5 | Good |
| **0.2** | 7.9 | 5 | 4 | Fast Good | 5 | 4 | Fast Good | 4 | 3 | Average | 6 | 5 | Good |
| **0.4** | 8.2 | 5 | 4 | Fast Good | 5 | 4 | Fast Good | 4 | 3 | Average | 6 | 5 | Good |
| **0.6** | 8.5 | 5 | 4 | Fast Good | 5 | 4 | Fast Good | 4 | 3 | Average | 4 | 5 | Good |
| **0.8** | 8.8 | 5 | 4 | Fast Good | 5 | 4 | Fast Good | 4 | 3 | Average | 4 | 5 | Good |
| **1.0** | 8.9 | 5 | 4 | Fast Good | 5 | 4 | Fast Good | 4 | 3 | Average | 4 | 5 | Good |

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# Opportunities and Advancement in Pugal Embroidery of Western Rajasthan

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**Abstract:**

*Pugal Embroidery unfolds a narrative steeped in culture, history, and artistic ingenuity, emerging as a cherished traditional craft originating from the captivating desert city of Bikaner in the northwest Indian state of Rajasthan. This magnificent form of embroidery, a testament to the dedication of artisans preserving its heritage, has traversed generations, embodying a tale of skill and innovation. Celebrated for its intricate and vibrant designs, Pugal Embroidery graces various fabrics, predominantly clothing and accessories. The meticulous process commences with the careful selection of high-quality materials, such as wool, silk, or cotton, onto which skilled needle workers meticulously hand-embroider with precision. Drawing inspiration from regional flora, fauna, and traditional themes, these designs form a visual symphony mirroring Bikaner's arid terrain. Executing this craft demands time, skill, and an innate sense of color and composition. The fabric comes to life through the interplay of textures and reflective features created by threads, beads, sequins, and mirrors. Pugal needlework, often depicting images from Rajasthani history and mythology, plays a pivotal role in preserving indigenous tradition. Recently, it has garnered attention not only for its aesthetic allure but also for its economic significance, as artisans explore new domestic and international markets to sustain their livelihoods. This study meticulously traces the evolution of Pugal embroidery's traditional craft, motifs, and materials, delving into the history, conservation, and economic importance of this art form. Recent advancements have ushered in a new era for Bikaner's Pugal embroidery, with artisans incorporating contemporary technologies to enhance their traditional craftsmanship. Collaborations with modern fashion designers and companies have propelled this ancient art form into the global spotlight, enriching fashion and lifestyle items with a sense of exclusivity and luxury through the exquisite and distinctive designs of Pugal embroidery.*

**Keywords:** *Contemporary Adaptations, Needlework, Pugal Embroidery, Product Diversification Traditional Craft, Sustainable Practices*

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## 1. Introduction :

The land of royalty, Rajasthan is the largest state of India. This little piece of heaven on earth is rich in culture. It has something for everyone, be it exquisite monuments, remarkable palaces and forts, lively folk dances, alluring handicrafts, mouth-watering food which attracts not only Indians but also tourists from around the globe. Besides the forts, palaces and deserts. The state is a treasure trove of handicrafts and textiles such as blue pottery, marble works, lac bangles, leather wear, inlay work on brass and wood, terracotta sculptures, tie and dye, block printing, embroidery, carpets and durries. Grounded to their roots, people of Rajasthan are very welcoming and reflect their colourful heritage with pride.

With the motive to record the craft of Pugal embroidery, this study compresses the journey of exploring the handwork of artisans. Located at Pugal, Bikaner district, houses incredibly talented and skilled artisans executing rich embroidery (Kashidakari). The Pugal embroidery is exercised by simple people, who pour their hearts out in doing the intricate embroideries with so much passion, and resilience that has helped in keeping it alive. The beauty of such precision shines bright in the products of kashidakari. Passed on, by generations before them, the embroidery now progresses towards the future with added help from various non-profit organizations reaching out to the artisans, offering them work and raw materials, further introducing the craft to a newer market, and widening the customer base. It's fascinating to note that the village's embroidery work has garnered attention from notable brands like IKEA, Fab India, Rangsutra etc.

### *1.1 Literature Review*

Embroidery is an expression of self, rendered with patience and dedicated hard work. It is an art rightly described as "image by needle". The term "Kashidakari" literally means 'needle work'. Kashidakari is an age-old practice of producing exquisite clothing items by using a needle and thread. The embroiders of this beautiful craft migrated to western Rajasthan, Gujarat and adjoining areas at the time of India- Pakistan separation in 1971. Meghwals are an ethnic tribe in northwest India and Pakistan, considered descendants of Saints who brought rain. They belong to the Schedule Caste social class and are known for their vibrant jewelry and clothing. They coexist with other desert tribes like Rabari and Bhil in remote communities in the Thar Desert, sharing vocabulary, sensibility, and visual cultural identification. Both embroideries are exquisite and unique. The pugal embroidery started as a traditional way of reusing fabrics. To give the old and ragged clothing a new look, the poor community started doing embroidery on them. Separating yarns from waste pieces of fabrics, spinning them together and using for embroidery. This is how Kashida was born. Initially, it was done for dowry purpose only but soon after migrating, the Meghwal community realised its prominence and converted it into a source of income.

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Pugal block in Rajasthan is a significant cluster of embroidery craft, with approx. 2000 artisans engaged in ethnic work. The finest work comes from Bikaner and Barmer Districts, and features floral patterns, human and animal figures, and abstract designs. Embroidery items include women's wear, kurtas, cushion covers, dress material, bed covers, and bags. Pugal region in Bikaner, Rajasthan, is known for its traditional Meghwal embroidery work, primarily done by girls and women. The villages of 8AD, 9AD, and 2AD offer unique experiences and unique names due to their proximity to the India-Pakistan border [1].

*Figure 1: Geographical Indication of Embroidery*

Pugal embroidery, primarily produced in the Pugal region of Bikaner, Barmer district of Rajasthan, and Kutch region of Gujarat, features vibrant color schemes and intricate geometric patterns. This needlework, known as Kashidakari, includes Pakke ka kaam, Mukke ka kaam, and various forms, with each region showcasing unique techniques and raw materials. The Pugal region of Bikaner specializes in Kashida, using kharak, Sindhi, and Kambiri stitches and embellishments. The Barmer district of Rajasthan uses mukke ka kaam, featuring metallic threads couched with embroidery thread. Gujarat's Kutch area focuses on Pakke ka kaam, using embroidered threads twice to strengthen and make Kashidakari more durable. These regions use different techniques to create visually appealing and intricate designs.

Kashidakari, a popular needlework in Kashmir Valley, is believed to have been introduced by Persian Sufi saints. Its intricate patterns and style are reminiscent of Persian influences. Unlike Pugal needlework in Rajasthan, Kashidakari in Kashmir and Pugal needlework in Rajasthan share similarities in name and effort, but are distinct and unique [2].

## 2. Methodology

This research is grounded in fieldwork, secondary data, and conversations with Pugal craftsmen.

### *2.1 Raw Materials*

Pugal embroidery is majorly done on cotton linen, Kota doria, khadi (cotton & Wool), silk and Mangalgiri fabric. Interlining (Astar), a fabric used for lining is also used in some of the products. There is a 60:40 ratio, where 60% of the embroidery is done on stitched clothes and 40% is done on unstitched fabric. An embroidery threads (rangoli and anchor), gold & silver threads for mukka work, and embellishments like Sitaar, miniya, kungri and kaanch are utilised to beautify the embroidery. Singhare and supari are covered with fancy threads a used for decorating various products. Phunde (Tassels) are also used to decorate the edges of the products. Now a days, Kaanch ka kaam(Mirror work) is seen on the fabric with a very minimalistic embroidery to meet customer requirements and be aesthetically pleasing. Needle, scissors, blades, thread cutters are used for cutting & finishing. The original artisans are so skilled that they do not use an embroidery ring or frame whereas the learners and new artisans do use them.

### *2.2 Process*

There are the following processes steps required for pugal embroidery such as mentioned below

- **Pattern Cutting:** The fabric is cut into the size of the resultant product. If the embroidery is being done for brands, the trusts provide them with the already cut and checked pattern piece.
- **Tracing:** Traditionally, no tracing or sketching of design on cloth is done. Women used to draw whatever they felt like. Original Meghwal descendants still follow this rule whereas the new artisans prefer tracing the design first. The design is printed on a sheet of paper and holes are punched through. A mixture or paste of ash and chunna powder is dabbed onto the fabric.
- **Embroidery:** After the tracing, embroidery starts. For Sindhi embroidery, square motifs are first created and then other parts. For kharak, the borderlines are created first, then further it is divided into four boxes. First, the borders are completed using chain stitch and then alternate boxes are filled. At last, finishing is done, cutting the loose threads and redoing if something comes out wrong or undone.
- **Stitching:** The stitching can be done either before or after embroidery. Very few of the artisans do know how to stitch, so that part is taken care by the organisations.
- **Finishing:** The quality of the final products is checked through different parameters like smooth, uniform and neat stitch, accuracy of motif placement, cleaned under layer of the fabric and uncut threads, no errors and omissions in the motif with advised colour. Additionally, careful monitoring can prevent missing elements and ensure even and well-defined borders, resulting in high-quality hand-embroidered products that meet the desired standards and showcase the artistry and beauty of this traditional craft.

## 3. Types of Embroidery Practice in Pugal

The harshness of the desert of Rajasthan is balanced by the brilliant colors used in the Kashidakari like Soof, Pakka, Kharak, Kambiri, and Sindhi. They are typically used to make a wedding bridal goods.

*Figure 2: Soof Embroidery*

### *3.1 Soof*

Fine, delicate stitching with geometrical motifs is known as soof. Soof is of two types: Kachcha soof are borderless, parallel, equal filling stitches that run vertically, horizontally, and diagonally. Pakka soof is the same as kachcha soof; the only difference is that it is with boundaries.

**Figure 3: Kharak Embroidery**

### *3.2 Kharak*

The geometric needlework technique known as kharak was developed by counting the structural elements of the cloth and, as the name suggests, is reminiscent of the tactile qualities of the date tree. In this style, the artisan works out the structure of geometric patterns with an outline of black squares, then fills in the spaces with bands of satin stitching that are worked along the warp and weft from the front.

*Figure 4: Mukee Ka Kaam*

### *3.3 Mukke ka kaam*

Mukke ka kaam is a type of embroidery technique used in the kharak kashida which includes the extensive use of gold and silver zari or metallic thread. The couching is done through buttonhole stitch, so that the aesthetic appearance of the metal threads does not get disappeared.

*Figure 5: Sindhi Embroidery*

### *3.4 Sindhi*

The interlacing stitch used in Sindhi embroidery is executed over a laid-out foundation of threads. Sindhi embroidery is commonly used on garments, home decor items, and accessories, reflecting the rich cultural heritage of the Sindhi people.

*Figure 6: Kambiri Embroidery*

### *3.5 Kambiri*

An ascending or descending pattern can be seen in kambiri kashida, mostly geometrical motifs are embroidered. Nowadays, it is not practiced much. It is a durable embroidery as pakke ka kaam is done where a tight square of chain and double buttonhole stitch is supplemented with the satin stitch that are used to create dense pattern on the cloth. Mostly fly and satin stitches are used in this embroidery. The color palette mostly comprises of shades of red, dark green, gold or yellow with a relatively black or white background.

## 4. Designs & Motifs of Pugal Embroidery

Pugal, Barmer and Kutch regions, they carried various motifs and designs with themselves which then became a very vital part of the embroidery. The dominance of geometric patterns in all three types of kashida along with the substantial usage of floral designs, various motifs that can be seen in the embroidery are Hunnuji, Kaanch or teek, Peendi, Moriyo and Chokdi etc. Apart from these, there is no particular story or inspiration behind these motifs and the artisans present their skills with the help of their creative mind and embroider the designs which they know or generally see around themselves. The use of mirrors in the Pugal embroidery helps to ward off the evil eye and is considered as a symbol of protection.

To make the product as attractive as possible, the artisans use a range of designs and brilliant colors. On the items the craftsmen create for their own use, you can see the use of vibrant embellishments, along with plenty of beading, sitara, and other sequins with elaborate and specially designed patterns. However, as the years went by and each new generation had less and less time to devote to it, the degree of intricacy and complexity decreased. Modern designs are based on the preferences of the younger generation, and minimalism and soft hues are crucial. The filling inside the designs has names like Tardo, koth, kando, Bakhiyo, Pakko, and Ghodo. They draw inspiration for their motifs from the environment around them such as flora, fauna, houses etc.

*Table 1: List of Motifs of Pugal Embroidery*

| Name of Motif | Pictorial | Name of Motif | Pictorial |
|---|---|---|---|
| Chokdi |  | Floral |  |
| Moriya |  | Sindhi Pancholi |  |
| Hunnuji |  | Geometric Motifs |  |
| Kaanch (Mirror) |  | Penndi |  |

**5. Types of Stiches in Pugal Embroidery**

The different categories of pugal embroidery employ number of distinct techniques which differentiates them from one another, and the intricate geometric patterns include a variety of stitches which are used in the production of embroidery. Utilizes fine and delicate thread work, often employing intricate stitches like satin stitch, cross stitch, running stitch for a gracious appearance [3].

*Table 2: List of Stiches in Pugal Embroidery*

| Type of Stitch | Type of Stitch |
|---|---|
| *Feather Stitch (Dantiya)*<br>Feather stitch is a stitch resembling overlapping feathers. | *Pakka Kanera*<br>A zig-zag stitch, with loops at the corners. |
| *Tipiya*<br>French Knot stitch. | *Keelne*<br>A double sided blanket stitch. |
| *Cretan Stitch*<br>Cretan stitch is an embroidery stitch consisting of a series of diagonal stitches arranged in a zigzag pattern, resembling the peaks and valleys of the Cretan landscape. | *Pankhiya (fly stitch)*<br>It is a V shaped stitch which can be done singularly or detached in rows. |
| *Cross Stitch (Bachda)*<br>Cross stitch is a basic embroidery stitch that forms X-shaped stitches and is commonly used for creating intricate designs and patterns. | *Buttonhole Stitch*<br>Buttonhole stitch is a looped embroidery stitch used to secure the edges of fabric or create a buttonhole-like border. |
| *Chain Stitch (Lath)*<br>Chain stitch is a looped embroidery stitch formed by linking individual stitches, creating a chain-like appearance. | *Soof(satin)*<br>It is a filling stitch which gives a sense of satin like appearance, and it is one of the most used stitches in Kashida. |

| Type of Stitch | Type of Stitch |
|---|---|
| *Back Stitch (Bakhiya)*<br>A Backstitch is a stitch that creates a solid line by stitching backward and then forward. The reverse of this stitch is stem stitch. | *Zarda (zardozi)*<br>Use of metallic threads and embellishments in the embroidery |
| *Running Stitch (Moriyo)*<br>Running stitch is a basic hand-sewing stitch that creates a straight line of small, even stitches used for various sewing and embroidery purposes. | *Koot (knot stitch)*<br>This stitch is used to place small, filled circles at equal intervals to increase the aesthetic appeal. |
| *Choon*<br>Small decorative triangles. | *Cording*<br>Kaccha tanka done over chaandi. |
| *Pakka Soof*<br>It is the same as kachcha soof; the only difference is that it is with boundaries. | *Kacha Soof*<br>These are borderless, parallel, equal filling stitches that run vertically, horizontally, and diagonally. |
| *Single Dantiya (Blanket Stitch)*<br>This stitch is used to give an edge to something, maybe a mirror or border to the embroidery. | *Double Dantiya*<br>Double sided fly stitch. |
| *Aadhi Chain*<br>Variation of chain stitch, in which each chain has a gap between each other. | *Purri Chain*<br>It is a type of stitch which forms small loops one by one and is used to enhance the motif. |
| *Chain kaccha taaka*<br>A combination of chain stitch and running stitch. | *Lace Kashida*<br>It is a twirl like stitch, which has a thick dense structure. |
| *Herringbone Stitch (Kanado)*<br>Herringbone stitch is a decorative embroidery stitch that forms a series of slanted parallel lines resembling the bones of a herring fish. | *Chune wala Dantiya*<br>It is chain stitch which is used to give a proper finishing border to animal motifs. |
| *Kaccha Tanka*<br>Raw stitch/running stitch | *Kaccha Kanera*<br>Herringbone stitch. |

### 6. Color of Pugal Embroidery

Pugal embroidery is bright and playful. The colours used are vibrant and contrasting. It's colour palette mostly consists of red, blue, green, yellow and orange. The base fabric colour is usually in contrast with the colour of the embroidery threads. It's amusing that the use of all bright colours is not hard on the eye and creates harmony. The artisans skilfully blend a wide range of hues, including red, orange, green, blue, and yellow, to adorn fabrics with eye-catching and joyful embroidery. The result is a visually stunning and culturally rich textile art form that celebrates the essence of Indian craftsmanship.

### 7. Product Ranges of Pugal Embroidery

As there is a custom in Pugal region that marriages, this craft was initially performed to fulfil dowry requirements and as souvenir when she leaves her home to join another family. Later, this craft began to benefit them financially, and the artists were able to support themselves and make a living.

The product selection for embroidered goods is extensive and varied, including a wide range of things from different industries. Embroidery gives a sense of elegance and individuality to clothing and accessories, including intricately embroidered garments like blouses, kurtas, etc., and elegant home textiles like embroidered bed linens, curtains, and ornamental cushions. On handbags, backpacks, and clutches, delicate stitching is on display. Keychains and patches are examples of personal accessories that have exquisitely stitched patterns. In the worlds of fashion, home design, and branding, embroidery is a highly sought-after ornament due to its adaptability. The Meghwal artisans who live in the Pugal villages of 8AD, 7AD and 2AD create things for both the commercial market as well as for their personal needs.

- Rumal: During the marriage ceremony, the bride holds the self-embroidered rumal and it is a mandatory ritual. It takes 2-3 months to complete.
- Indrani/Hinduni: A sturdy circular base, which is placed on the top of head, over which earthen pots are placed. It helps in creating a balance while walking with a pot on head, over long distances. Brides are expected to bring their own hinduni when they arrive at their in-law's house.
- Surma Dani: A beautiful container used by women of the house to keep their traditional Surma bottle.
- Choti Khali: Cover to decorate supari.
- Cushion Cover: A long cushion cover is made according to the length of the bed.
- Khalichi: A small embroider Purse.
- Bigna/Pankhi:A traditional hand fan having a metallic frame covered with cloth attached to a handle. The fan is used in a swinging motion.

- Kanghi: A pocket size comb is decorated with pearls and beads.
- Gochna: Newly married woman used to carry chapattis in a heavily embroider piece of fabric to the farm to show respect towards their husbands.
- Thaal Posh: Used to cover pooja ki thaal

### 8. Recent Product diversification in Pugal Embroidery

There is no certain change in the type of stitches used in this embroidery, but the designs have evolved over time. Around in 4 decades, the designs were spread all over the products and one can see excessively elaborate designs, but nowadays a minimalistic approach is applied to meet the current market demands. There is no change in the motifs as well, just the confined version of same old motifs can be seen in cushion cover, bedsheet, kurta, sarees, shrugs, kaftans, tops, bag etc. However, the people of Pugal generally make products for selling purpose only but there are some products which are still embroidered for dowry purpose.


*Figure 7: Modern Products by Pugal Embroidery*

### 9. Market of Pugal Embroidery

The complexity of the design determines the production cost. Although this needlework is hard to get in Bikaner's local market places, other companies like Ikea and Jaypore do demand it. Hand embroidered products specialized and luxurious appeal define the market environment. Consumers that value artisanal craftsmanship, originality, and personalized touches in their purchases are catered to by hand embroider goods. But the availability of hand embroidered goods is constrained due to problems with scalability and mass production, keeping their exclusivity. The complexity of the design and the quantity of items that the artisans produce determine the daily wages that are paid to them.

A Self-Help Organization famous for its solar looms is located in the Napasar town under Bikaner. The Napasar Hathkargha Vikas Samiti (NHC) is known for weaving and embroidery. Shanti Maitri Mission Sansthan (SMMS), a voluntary NGO, presently working in Pugal tehsil and adjoining areas of Bikaner district since 1996.To increase sales, SMMS has been organizing an annual event called "HUNAR BAZAAR" to support indigenous artists and entrepreneurs. It is an effort to introduce the crafts done in Bikaner to local people. Overall, SMMS has been like a torch in the dark for artisans by providing them with regular work, raw material supplies and business strategies [4]. Some of the established brands like Fab India, IKEA, Swadesh C&N etc generate the demand for pugal embroider products and communicate through NGOs or the people involved in communicating to artisans.

### 10. Present Scenarios of Pugal Embroidery

In the present, this embroidery craft is facing challenges such as limited market demand, a lack of awareness, financial struggles, and difficulty in preservation due to dwindling interest and inadequate training opportunities. Access to resources is also a concern, along with competition from mass-produced goods, which leads to cultural erosion. Being located near a border presents numerous challenges, including the necessity for individuals to obtain government permissions. This lengthy process discourages people from visiting the area, leading to a decline in their interest.

However, there are opportunities for growth and recognition, including leveraging online platforms, collaborating with designers, tapping into ethical and sustainable trends, participating in craft tourism, organizing workshops and exhibitions, incorporating the craft in education, and receiving local support. By embracing these opportunities and addressing the challenges, the craft can gain visibility, preserve its heritage, and secure a place in the creative landscape.

### 11. Future Scope of Pugal Embroidery

In the future, this embroidery crafts have the potential to experience a remarkable revival and gain widespread recognition. As people increasingly seek genuine and handcrafted products, the cultural significance and craftsmanship of these traditional techniques will be appreciated. Looking at the future through the lens of creative ideas, the embroidery has stood the test of time, breathing its way through what every age had its changes to offer. Keeping the roots and the heritage intact, the Pugal embroidery has flourished by expanding its threads to stitch the designs of a new era. Talking about the embroidery itself, the motifs, colours and most importantly the execution has maintained its rhythm throughout the years in traditional embroidery. Major options such as generation reluctance or adaptation, providing sufficient education & awareness, minimalistic approach, experimentation with raw material, collaboration with Brands/Designers and end uses shift from home textile to apparels.

Efforts to preserve cultural heritage will lead to increased awareness and support for these crafts in specific regions and communities. Digital platforms will connect artisans with a global audience, fostering knowledge exchange and sustainable livelihoods. Social media platforms will serve as showcases for artisans and enthusiasts, attracting a broader audience to appreciate and celebrate these crafts. Specialized exhibitions and cultural events will provide exposure and opportunities for artisans to connect with enthusiasts and investors.

*Table 2: SWOT analysis of Pugal Embroidery*

| SWOT | Description |
|---|---|
| Strength | 1. The original embellishments that artisans create are exceptionally unique and distinctively their own.<br>2. Compared to other craftsmen, these artisans are skilled to execute embroidery on every material.<br>3. Their years old experience has helped them in gaining interpersonal skills and complete the work in short time frame |
| Weakness | 1. Artisans are not able to connect directly to the market and face several transportation difficulties.<br>2. Lack of awareness about the craft among the localities and hence not recognised widely.<br>3. Insufficient knowledge among artisans on how to benefit from Government schemes. |
| Opportunity | 1. Well execution and accuracy of the geometric patterns can be their distinctive feature as motifs are crafted with perfect symmetry.<br>2. The craft could be combined with different crafts like block printing, tie and dye and others. The artisans are inclined towards creative exploration of the craft.<br>3. Receive assistance & funding from the government's Ministry of Textiles and NGO's.<br>4. Connecting artisans to global customers to e-commerce is a lifeline for many. |
| Threats | 1. Ongoing trends of minimalistic designs can lead to the extinction of traditional embroidery designs.<br>2. Lack of awareness among young generations.<br>3. Lack of a GI tag prevents them from receiving many government benefits and recognition.<br>4. Due to limited recognition, companies and designers have little to no engagement with them, which prevents their growth.<br>5. Health of artisans is affected. |

## 12. Conclusion

Pugal embroidery is a delicate textile technique that is rich in color, texture, and patterns, much like any other ancient craft. Even though most people, including those who reside in the surrounding areas of this craft cluster, are unaware of this craft, the embroidery is so distinctive in terms of its complex geometric patterns that it merits recognition as a well-known craft and should be valued more due to the artisans' meticulous skills. It is ideal to acquire momentum in the present market and can compete with the ongoing trends because of the brilliant colors and the neatness of the handmade work. Discovered a lot of fascinating information while conducting research for this field, including the fact that artists are eager to raise awareness of their handicrafts and possess a willingness to develop their own identities via their exceptional skill set. The interplay of tradition and proficient embroidery in their lives, a narrative of perseverance despite change. Their commitment persisted in the face of obstacles like sustainability and market access because they were encouraged by organisations that integrated tradition with modernization.

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Journal of the TEXTILE Association



# Reshaping the Block Patterns for Circular Economy - A Review Study

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**Abstract:**
*The Fashion Industry plays a key role in generating designs to meet the growing demand of consumers. Block pattern is a key feature to amalgamate the pattern with design elements (colors, prints, fabric, and textures) creating mesmerizing designs to take fashion to new horizons. Blocking the pattern with different mediums can make the possibility of designing for different occasions. Application and Experimentation with Different color combinations, prints, fabrics, textures, and Decorative details will add to the aesthetics of the wearer. Color Blocking is the most adaptable and takes the creditability of this original concept. This can serve the purpose of the design industry to enrich design concepts with the Circular economy. Pattern makers and Designers' effective coordination can serve the interest of society and withstand the challenges prevailing in the industry. Pattern makers as Technical Engineers can create endless possibilities for design endeavors. Most notable is the designs evolve with the major Pattern-making principles and accentuate the wearer's desire to retain the fit involved in the garment.*

**Keywords:** *Block Patterns, Circular economy, Colour blocking, Pattern makers, Reshaping*

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## 1. Introduction :

Block patterns are foundation patterns used to develop varied styles of tops and dresses. The urge for something new has been existing for ages and meeting the demand of people has been a major concern of designers. They are accentuated for developing varied styles of patterns through different design concepts. Blocking the patterns through colors, prints, and textures can meet the growing demands of the Fashion Industry. The prevailing economic situations have centred designers on creating designs that are economical and sustainable. The concept of Redesigning bodice blocks with colors, prints, and textures can serve the requirement of designers to create innumerable designs for the Industry. Revival of past concepts is the need for a circular economy. Thought to create the patterns with usage of colors, prints, and textures in generating new designs can supplement the concept of remake and reuse in Fashion.

Inspirations and themes can be part of this design process. An application or Experimentation with colors, prints, and textures can create unique designs for different categories of wear. Dart manipulations and style lines can be supportive to retain the fit of the bodice or dress. Blocking the patterns or creating designs with prints and colors can develop styles for casual, resort, and leisure wear. Application of Textures and ornamentation with embroidery in these blocks can generate designs for evening and luxury wear. The utility of leftover pieces at production labs is more prominent in reshaping blocks for Sustainable Fashion.

### *1.1 Color Blocking & Fashion*

Color Blocking in Fashion is the skill of wearing different solid structures of colors as a silhouette to create bold and mesmerizing looks. The concept applies to Fashion accompaniments as well [1].

Color Blocking was initiated with the idea of experimenting with colors in silhouettes to create fascinating looks. It became a source for design explorations. Origin is from the artwork of Dutch painter, Piet Mondrian. Geometry was an inspiration to develop styles with the use of primary colors as a base from the color wheel. It included the composition of contradictory colors in an outfit to emphasize the dark and compact colors and become an eye-catching detail [3]. It resembled an abstract form of art and was quite simple to develop designs. As per norms, certain principles have to be followed in the planning of colors to balance and create harmony in designs. Color theories and color wheel play a vital role in the planning of colors.

***Figure 1: Collection of Yves Saint Laurent Mondrian [1].***

A pattern is a basic model of a silhouette or an accessory to develop the outcome. Color blocking allows the utilization of the scraps of fabrics that remained as waste and unutilized. It

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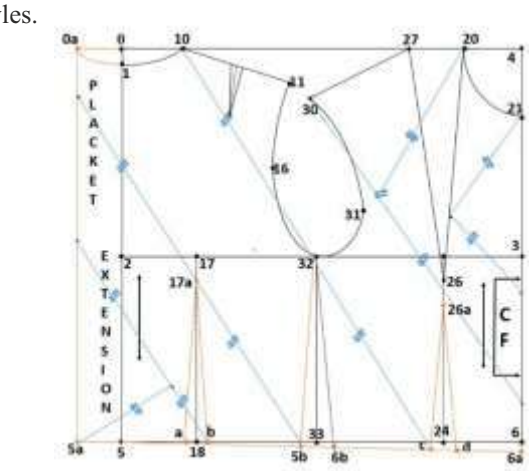
became a utility for designers and pattern makers to regenerate various styles at a minimal cost. Pattern makers technically consider these as style lines for dart manipulation. It is related to TR pattern cutting by Shingo Sato a truly inspirational Japanese artisan [2,3].

This color-blocking strategy or approach can bring advances in designing for Sustainable Fashion. Designers and Fashion Brands will be able to generate fashion goods in large quantities and make them more affordable and accessible. Easy patterns with simple blocks for garments and accessories can be supportive in this process. It generates a source of employment for the majority of people and benefits society.

## 2. Materials and Methods

### *2.1 The Working process for CB*

Experimentation done with the inspiration of Geometric design, from floor designs, at pattern making lab is illustrated below Designs can be preplaned, inspired by the desired source, or could be experimented with to create unique styles.




(2a)

(2b)

(2c)

***Figure (2a). Drafting pattern No.1***
***(2b). Geometric design inspiration for drafting pattern (a) Made you Look 7 Cut Design Black-7X8. [4]***
***(2c). Geometric design: 3Triangullation Series 2022 #1 Mona Mark [5].***

In the process of planning, can take desired silhouettes like tops, skirts, pants, sleeves, and dresses.

Drafting Pattern 1 "Fig. 2a" Illustrates trace the basic bodice pattern as shown. Asymmetric designs need an open lay of pattern for design application. Division of Spaces can be uniform with planning or can be random to create abstract designs or set geometric patterns. "Fig.2b" and "Fig. 2c" represent a source of inspiration to form geometric designs. Design choice can be based on the category of wear, age group, and overall look desired. Plot the pattern with the design of choice. Label it. Symbolize for Identification of all the segregations. Identification points assist in matching the pattern and completing the sewing accurately. Sewing skills and expertise are essential in such design elevations. Any mismatch can distort the shape of the silhouette and fit involved in it. The study states that this experiment can be conducted in two ways. The former method is to place the front and back bodice together at the side seam and chart the divisions. Symbolize the fabric segments and cut the pieces with a seam allowance of 1cm, match and sew. Notches are essential at pivot points and if any curved areas. Press the seams open at the inside part after joining the two pieces together. After accomplishing the desired pattern, the finishing of other prominent areas like the Neckline, shoulder joint, side seams, hem finishing with facings, and fasteners at the center back of choice can enhance the garment.

As similar to color blocking in a pattern color could be replaced with prints. Small prints are more suitable for block divisions as a balanced look could be achieved.

Solid colors could be paired with prints and textures. Stripes can also accentuate the complete look as the effect of the grain line is more visual.

### *2.2 Different Techniques of CB*

*2.2.1 CB Technique with Solid Colors ("Fig. 3", "Fig. 4a,4b", "Fig. 5")*

Solid colors create a set of harmony with its application. Color wheel with a set of colors, color schemes, and color theories guide in the selection of colors. Monotonous and contrasting effects could be achieved based on their combinations.

Fabrics applied have the same weight. Opaqueness and Transparency are two vital tools to create an unusual impact. Design planning can be structured or soft as per the needs of the user.

(3)

(4a) (4b) (5)

***Figure (3) &(5): final design outcome of Solid color fabrics (4a), (4b): Front design and back design top with stiff organza transparent fabric***

(6a) (6b)

***Figure (6): Drafting No.2: Initial Working step process of Figure No. 3 design with Muslin stitched 3d pattern***

Figure (6) Drafting No.2 illustrates the design plan for "Fig. 3". This developed design has continuity in design flow from front to back. We can introduce style lines passing through the apex point and thereafter as desired. It has been worked by using a 3d block. This developed design has continuity in design flow from front to back. Fabric leftovers have been utilized to cut pattern pieces and join them to form a design.

(7a) (7b)

***Figure (7a): Front Draft (7b): Back Draft***

Drafting No.3 : Working step Process of design Figure (4a &4b) are illustrated on the paper pattern

Drafting No.3 Illustrates the block design plan initiated to construct the "Fig.4" design. Design planning has been done on the front bodice and back bodice paper pattern separately. These are represented as style lines of pattern making and pass through the bust points to retain the fit and get accustomed to the stitching process easily. Templates are cut after labelling them and with indication marks to guide during the construction to match the seam lines. They are cut as individual pieces and scraps of fabrics are used to lay and cut them. A seam allowance of 1cm is taken on all sides of the fabric directly.

Figure (8a): Step 1

Figure (8b): Step 2

***Figure (8c): Step 3 & 4***

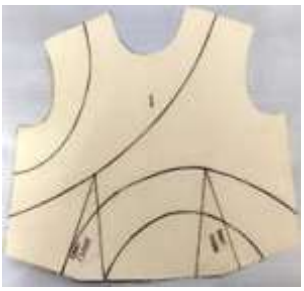
***Figure (8a), (8b),(8c) Drafting No.4 : Working Process of Figure 5 is illustrated***

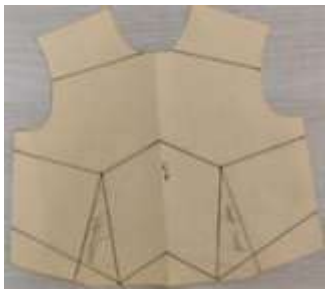
Drafting no.4 illustrates the working process of Image 6. Design planning has been done on paper as per the dimensions of the bodice and initiated in the fabric. Scraps of fabric have been joined.

*2.2.2 CB with Solid colors and prints ("Fig. 9a", "Fig 9b", "Fig.9c")*

This combination accentuates the fabric composition of solid-colored fabric and printed fabric. The visual impact of this combination creates attention to the pattern and gives a balanced effect to the silhouette.


***Figure (9a), (9b), (9c): Final design outcome of a combination of Solid Color & Printed fabrics***


(10a)


(10b)


(10c)

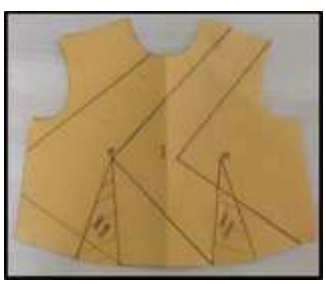
***Figure (9a), (9b), (9c): Final design outcome of a combination of Solid Color & Printed fabrics***

Figure (10a) , (10b), (10c) are Drafting No.5, 6,7 of design (9a) ,(9b) (9c) respectively

*2.2.3 CB technique with two printed fabrics*

Coordinating two prints in the same silhouette is quite challenging. The combination of small and large print breaks the monotony and adds to fabric depth. Prints with similar sizes give a well-coordinated look. Mixing of bold and small prints creates a very strong visual effect and balances the contrast.


(11a, 11b)


(12)


(13)

***Figure 11a, 11b : Final design outcome with printed fabrics***
***Figure 12 : Drafting No. 8 of design 12 worked on front bodice paper pattern***
***Figure 13 : Drafting No. 9 of design 13 worked on front bodice paper pattern***


(14a)


(14b)

***Figure 14a,14b : Front & back top final outcome with pleats decorative detail***


(15a)


(15b)

***Figure 15a, 15b : Drafting No.10 of design 14a &14b Front & back pattern respectively***

***** Self Conducted experimentation on the blocking concept with the assistance of students at Hamstech College of Creative Education, Hyderabad 2023.***

***Materials used for Pattern Drawings were soft lightweight color papers, marker pens, L-scale, Pattern master curve, and French curve, Gateway sheets. Experimentation at the lab was done with cotton-blended solid color fabrics ,printedfabrics & stiff dyed organza fabric for sewing convenience.***

***2.3 CB -2D versus CB-3D***

Pattern-making offers innumerable ways to complete the pattern as per the design choice and convenience of the field worker (sewers). Any application does not hamper the fit and look of the silhouette. Fabric pieces could be assembled accurately to obtain the desired look and accentuate the body curve to create an overall impact on the wearer. Tops can be paired with any bottom of choice to complete the outfit look in monotone colors or complementary colors as per design and utility.

Designers have used geometric shapes in color blocking with 3D look to create desired effect as shown below:

(16)

**Fig: No. 16 [6]**

There are innumerable design inspirations to plan the divisions in a garment. Close-fitted, Semi-fitted, and Flared silhouettes can be worked with the color-blocking concept using the different methods and techniques discussed above.

***Table 1: COMPARATIVE ANALYSIS OF 2D AND 3D BLOCKS***

| S. No. | Reshaping 3d blocks | Reshaping 2d blocks |
|---|---|---|
| 1. | Dress form or a person is essential to visualize and plot the pattern. | The pattern can be plotted on the 2d pattern of a garment. |
| 2. | Stitched garments can be used for design plans and the same as templates for cutting the pattern pieces. | Paper patterns can be used for design plan & and cutting. |
| 3. | Further alterations in the garment are not possible. | An alteration option is available. |
| 4. | Fabric consumption for laying is more due to style continuity. | Looks more adaptable with the use of the fabric consumption |
| 5. | Dart closures are not required. Greater scope for design innovations | Darts have to be closed or eliminated from the patterns to complete the design innovations. |

*2.3.1 A comparative study in the application of the concept is done in 3 ways:*

Firstly, Working with 3D patterns has continuity and flow in front and back design without regular seams, style lines are sewn together to complete the look of the outfit as per design.

Secondly working with a 2D pattern that enables divisions which can give a scope of alteration for the fit required as regular seams exist.

Thirdly and lastly traditional technique was used. The fabric was created from leftover scraps and thereafter pattern placed gave freedom to set design within the frame only.

These divisions in a block converting darts into style lines retain the fit of the garment. Identification marks guide to match the seams during the assembling of these pieces. Joining and matching of seams.

The traditional System of joining scrap pieces and forming a cloth is quite universal and has its own do's and don'ts.

## 3. Results and Discussion

Designs Working with CB had a great impact as designs were found unique and endless possibilities for ascertaining them. The pattern retained its original fit after construction and was the most liked by the designers and end users. The idea was to experiment directly on tops as it would establish the basis to implement on various types of garments and fashion accompaniments. The concept was found to be more sustainable as it utilized the scrap pieces and supported in development of designs for different fashion products. The first and second drafting techniques (Ref: Drafting 2&3) are considered the most suitable which had negligible or minimal wastage. There was a great metamorphosis with the application of color blocking in designs and it truly represented the original creation of the creator. As experimentation with solid colors was inclined towards casual wear designs, the combination of printed fabrics with plain-colored fabrics developed for formal wear. Texture application or G.C. detailing techniques (eg. Tucks, pleats, gathers, ruffles, smocking, or embellishments can be accentuated for evening wear. Students were fascinated with mesmerizing designs obtained through innovations and it was quite easy to develop the patterns for the user needs. Fitted silhouettes can opt for block patterns to generate designs with CB. Digital patterns were applied with the idea of augmenting the design usage for both mass and High Fashion industries. Designers have always been in the limelight for their creations in Industry. Creditability for pattern makers is more in as they are the backbone for design development.

## 4. Conclusion

Blocking of patterns has laid endless possibilities for Design innovations. Every design can be unique in its aspect. This technique stands ideal for Sustainable Fashion. Generates a source of employment for the industry to collect the scraps of materials and make productive use of them for Design innovations. The Role of Pattern Making and Construction is crucial for the growth of Industry as it supports designers to build their designs and explore new creations. Designs developed by blocking the pattern have vast scope as they meet the needs of all the wear categories. Fashion is an art and Pattern Making techniques are a medium to innovate in the field of Design Education.

**Acknowledgment**

** Garment Samples showcased are the outcome of Self-conducted experimentation on the blocking concept with the assistance of students at Hamstech College of Creative Education, Hyderabad 2023, and Mody University Pattern Making lab team 2023.

** Drafting of patterns for the analysis of color blocking was self-designed to experiment at the Lab Mody University Science and Technology.

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Journal of the TEXTILE Association

DYEING

# Study on Effects of Mordants on Dyeing of Cotton using Tesu Flower Natural Dye

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**Abstract:**

*This research paper deals with the use of natural dye made from Tesu flower extract to colour cotton cloth. This study involves extracting the dye from the petals of the tesu flower, dyeing cotton fabric with alum, ferrous sulphate, and myrobalan (harda) mordant, and then assessing the fastness properties and colour strength of dyed fabric samples. Extraction, pre-mordanting, and dyeing of cotton fabric using an aqueous extract of Tesu flower petals using various types of mordants was carried out to observe the impact on the dyed fabric's colour strength and fastness characteristics. In this paper, the effect of premordanting on colour strength and fastness properties was studied.*

**Keywords:** *colour strength, fastness properties, mordants, natural dye, Tesu flower*

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## 1. Introduction :

Since natural dyes are more expensive and harder to obtain, they aren't as commonly employed in industries as synthetic dyes despite being the environmentally safest option. But, one of the major drawback of synthetic dyes is that they are made from petrochemical sources using hazardous chemical procedures and they pose a threat to environmental sustainability [1-2]. Plant parts that contain tannin, flavonoids, quinonoid, etc. are used to extract natural dyes. Examples of these parts include bark (e.g., purple bark, Sappan wood, Shillicorai, Khair, Red, and Sandalwood), leaves (e.g., Indigo, Henna, Eucalyptus, Tea, Cardamon, Coral Jasmine, Lemon Grass), roots (e.g., Turmeric, Madder, Onions, Beet-root), fruits or seeds (e.g., Latkan, pomegranate rind, Beetle nut, Myrobalan), and flowers (e.g. Marigold, Dahlia, Tesu, Kusum) [3]. The colour and fibre being used determine which mordant is best in the context of colour strength and fastness properties. Various mordants react differently with different natural dyes. [4-6] The ability of a dyed or printed material to retain its colour against different external influences, such light, washing, rubbing, perspiration, etc., is known as colour fastness. It gauges how long a colour will last before fading, bleeding, or spreading to adjacent surfaces. Since colour fastness affects how long and durable a colour will last in textiles, it is a crucial quality factor. A variety of tests are performed to evaluate a dyed textile material's colour fastness [7-9]. Light fastness, washing fastness, rubbing fastness and perspiration fastness are the most common tests. Numerous procedures, such as optimal dye selection, pre-treatments, the use of suitable mordants or fixing agents, and optimised dyeing or printing methods, can lead to improved colour fastness.[10-12]. This paper is a step towards understanding the effect of premordanting on colour strength and fastness properties of cotton fabric dyed with Tesu flower natural dye.

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## 2. Material and Methods

### *2.1 Materials*

100% cotton fabric, procured from local market, was used in this study. The purity of the fabric is confirmed through solubility and burning test. Laboratory Grade reagents like alum, ferrous sulphate and myrobalan (Hardan) was used as mordanting agent. Tesu flower (Butea Monosperma) also known as Flame of the Forest, was used for dye extraction. LR grade Sodium carbonate (Na2CO3) was used in dyeing for pH adjustment, dye fixation, enhanced dye solubility and dye levelling. Common salt (NaCl) was used as for enhancing the affinity of the dye towards the fabric. Turkey red oil (TRO) was used to reduce surface tension which results in reduction of time of the dyeing process and consequently its energy consumption, and thus reduces the amount of effluent generated while improving hydrophilicity and fastness properties.

### *2.2 Fabric Specification*

| **Fabric Type** | **Cotton Fabric** |
|---|---|
| **Conformity Test** | **Test Procedure** |
| Burning test | Burning test was done to check for 100% cotton. Fabric burnt with paper like smell and forms grey ash. |
| Solubility test | Warp and weft yarns from the fabric was taken and dissolved in 75% $H_2SO_4$ solution and kept for 30 mins. The yarns were completely dissolved in solution thus validating the fabric is 100% cotton. |

| **Fabric Type** | **Specifications** |
|---|---|
| 100% cotton Fabric | Warp count – 16.49 Ne |
| | Weft count – 22.14 Ne |
| | EPI- 128 |
| | PPI- 96 |
| | GSM – 157 g/m$^2$ |

### 2.3 Machines

**I. Water bath**

A water bath is a scientific equipment used to maintain a steady temperature for a prolonged time when incubating samples. It is employed to enable some chemical reactions at high temperatures. A big container filled with warm water makes up a hot water bath. A laboratory water bath's container capacity ranges from 12 to 32 litres for a standard model and 50 to 100 litres for a large water bath.

**ii. HTHP dyeing machine**

HTHP (High-Temperature High-Pressure) dyeing machines are specialized dyeing equipment used in textile dyeing processes. These machines are used for dyeing at elevated temperatures and under high pressure, which helps in achieving faster and more uniform dye absorption by the fibres.

**iii. Visible Spectrophotometer**

A spectrophotometer is a device commonly used in color measurement and analysis. It measures the intensity of light at different wavelengths, allowing for the characterization of the spectral properties of an object or a sample's color.

**iv. Launder-o-meter**

Washing Fastness Tester (Launder-o-meter), is used to determine color fastness to washing. The washing fastness tester uses stainless steel rotor to holds washpots on each of four sides and rotates at a constant 40 rpm (+/-2 rpm). Washpots are preheated in appropriate test solution.

**v. Crock meter**

Crock meter is an instrument used to determine color fastness to wet and dry rubbing.

### 2.4 Methods

***Extraction Process***

The Tesu flower was plucked manually at its blooming season (spring season). The petals are separated from flower and kept under sun for 2-3 days until they got completely dried. Further the dried petals are grinded in dry mixer grinder and made into fine powder. Tesu powder, prepared after grinding the sun-dried petals of palash flower, was taken in hot water for extraction of its color component under such conditions i.e. time 60 min, temperature 90°C, MLR 1:20 and pH 11. Detail recipe of Tesu dye extraction process is shown in the table1.

*Table 1: Detail recipe for Tesu dye extraction process*

| S. No. | Component | Quantity |
|---|---|---|
| 1 | Dye Source (Tesu Powder) | 4 g |
| 2 | Extraction Medium (RO Water) | 80 ml |
| 3 | Material to Liquor Ratio | 1:20 |
| 4 | Temperature | 90°C |
| 5 | Time | 60 Min |
| 6 | pH | 11 |

***Pre - Mordanting Process***

In this process silk is pre mordanted with different mordants (1% OWF) viz. alum, ferrous sulphate and myrobalan (Harda) in a water bath at 100°C for 30 minutes in aqueous medium. Mordanted fabric samples were finally dried in air without washing to make them ready for subsequent dyeing.

***Dyeing Process***

Dried pre-mordanted cotton fabric samples is put in the extracted dye solution kept in dye pot. Common salt & sodium carbonate was added to improve and facilitate dyeing process. Dye pots ware then placed in HTHP dyeing machine for 60 min at 90ºC. Detail recipe for dyeing cotton fabric samples is shown in the table 2.

*Table 2: Detail recipe for dyeing cotton fabric samples*

| S. No. | Component | Particular |
|---|---|---|
| 1 | Fabric samples | 100% cotton |
| 2 | Dyeing Medium | water |
| 3 | Material to Liquor Ratio | 1:40 |
| 4 | Temperature | 90°C |
| 5 | Time | 60 Min |
| 6 | pH | 11 |

The dyed cotton fabric samples were washed with cold water and then dried. K/S value of dyed cotton samples were tested for colour strength in spectrophotometer (Model – SS5100A) in reflectance mode. The value of colour strength (K/S value) of the cotton fabric samples was measured through the well-known Kubelka – Munk theory. The theory shows the relationship between reflectance (R), scattering (S) and its light absorption (K) which are given below in equation (1):

$$\text{Colour strength } \mathbf{(K/S) = (1-R)^2/2R} \quad \ldots\ldots\ldots\ldots (1).$$

***Colour fastness tests***

The colour fastness of dyed cotton sample with respect to washing and rubbing were measured.

***Washing fastness***

The washing fastness of dyed cotton fabric samples were measured as per the IS/ISO 105 C01 A1:2006 specifications. The testing method is as follows:

The washing fastness was tested using Launder-o-meter of AATCC. It consists of a water bath which rotates the shafts at 40+2 rpm. A layer of dyed fabric (10 cm×4 cm) was sewed between cotton and polyester fabric samples. The specimen was treated with 5 g/l standard soap (containing not more than 5% moisture) at 40ºC for 30 minutes. The material to liquor ratio is 1:50. After treatment, the composite is rinsed twice in cold distilled water and then with cold running water for 10 minutes and then squeezed. The composite specimen is opened out by removing stitches from all sides except one shorter side. It is then dried at a temperature lower than 60ºC. The change in colour in the samples was assessed by Grey Scale.

***Rubbing fastness***

Dry and wet rubbing fastness of the dyed cotton fabric samples were tested using a crock meter as per Indian Standard IS 766:1988 (Reaffirmed 2004) based on ISO 105-X12:2001. The crock meter has a finger of 1.6 meter diameter which can move two and fro in a straight 10 cm track on the specimen. The rubbing is carried out by moving 10 times in 10 seconds with a downward force of 6 N. Undyed unfinished cloth is cut into pieces of 5×5 sq. cm and placed on the finger. Two pair of specimens not less than 14×5 sq. cm are cut. One pair is for dry rubbing test and one for wet rubbing test. In wet rubbing test, the rubbing cloth is wetted and squeezed until it contains its own weight of water. The staining of the rubbing cloth is assessed by Grey Scale.

## 3. Result and discussion

Effect of three different mordants on colour strength (k/s value) of cotton fabric.

The colour strength (K/S value) of cotton fabric dyed with Tesu flower dye using three different mordants viz. alum, ferrous sulphate and Harda after applying pre-mordanting methods is shown in table 3 and fig 1.

***Table 3: Colour strength (k/s value) of cotton fabric dyed with Tesu flower dye with three different mordants***

| Mordant | Mean k/s Value |
|---|---|
| Without Mordant | 51.571 |
| Alum | 45.073 |
| Ferrous sulphate | 74.89 |
| Myrobalan (Harda) | 70.504 |

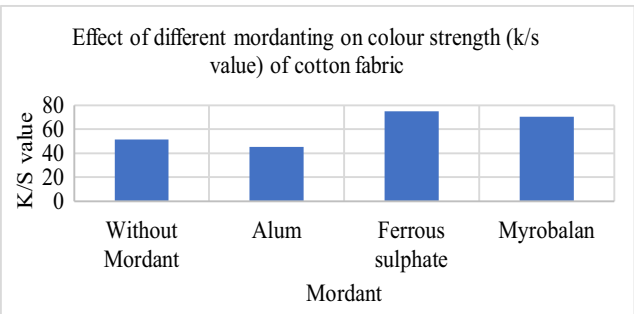


***Figure 1: Colour strength (K/S value) of cotton fabric dyed with Tesu flower dye with three different mordants***

Figure 1 explains the effect of different mordants on the colour strength (K/S value) of cotton fabric. It was observed that when cotton fabric samples dyed with Tesu flower dye with three different mordants, colour strength (K/S value) of the dyed cotton fabric sample using ferrous sulphate as a mordant shows maximum colour yield followed by the fabric samples dyed with Tesu flower dye with harda then without mordant and then with alum.

***Effect of three different mordants on washing fastness of dyed cotton fabric***

For washing fastness naturally dyed fabrics are softly handled so they are washed in mild soap solution with 5gpl for 30min. at 40 + 2 without putting steel balls. First cut sample of dyed fabrics, cotton fabric & PC fabric of same fabric. Stitch them together. Prepare washing bath solution with 5 gpl of detergent in 1 Liter water. Keep samples in mild washing solution for 30min. at 40°C and then dry them. Rating of washing fastness was measured by visible spectrophotometer and was given on the basis of AATCC Evaluation Procedure 7/ ISO 105 – A05 and is depicted in the table no. 4 and fig 2.

***Table 4. Washing fastness rating of cotton fabric dyed with Tesu flower dye using three different mordant***

| S. No. | Type of mordant | Rating | Remark |
|---|---|---|---|
| 1 | Without Mordant | 2 | Average |
| 2 | Alum | 1 – 2 | Poor to average |
| 3 | Ferrous sulphate | 3 | Good |
| 4 | Myrobalan (Harda) | 2 | Average |

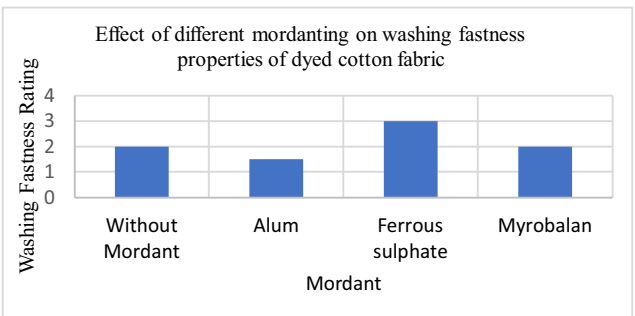


***Figure 2: Washing fastness rating of cotton fabric dyed with Tesu flower dye using three different mordant***

Figure 2 explains the effect of different mordants on the washing fastness properties of cotton fabric. It was observed that when cotton fabric samples dyed with Tesu flower dye with three different mordants one by one, washing fastness properties of the cotton fabric sample using Ferrous sulphate as a mordant shows maximum washing fastness rating followed by the fabric samples dyed with Tesu flower dye without mordant and with harda and alum mordant.

***Effect of three different mordants on rubbing fastness (Dry and Wet) of dyed cotton fabric***

For rubbing fastness naturally dyed fabrics was cut into appropriate sizes, typically 10 cm x 4 cm. 10 number of strokes are performed at the specified pressure. After completing the rubbing process, the fabric sample was carefully removed from the crock meter. Rating of rubbing fastness was given on the basis of the standard of staining scale AATCC evaluation procedure 12/ISO 105 – A034 and is depicted in the table no. 5 and fig 3.

Figure 3 explains the effect of different mordants on the rubbing fastness (dry and wet) properties of cotton fabric. It was observed that when cotton fabric samples dyed with Tesu flower dye with three different mordants one by one, rubbing fastness (dry and wet) properties of the cotton fabric sample using Ferrous sulphate as a mordant shows maximum

washing fastness rating followed by the fabric samples dyed with Tesu flower dye without mordant and with alum mordant and harda. Overall dry rubbing fastness is better than the corresponding wet rubbing fastness properties of the dyed cotton fabric.

*Table 5. Rubbing fastness (Dry and Wet) rating of cotton fabric dyed with Tesu flower dye using three different mordant*

| S. No. | Mordant used | Rubbing fastness - Dry | Rubbing fastness - wet |
|---|---|---|---|
| 1 | Without Mordant | 4-5 | 1-2 |
| 2 | Alum | 4-5 | 1-2 |
| 3 | Ferrous sulphate | 5 | 2-3 |
| 4 | Myrobalan (Harda) | 2-3 | 1 |

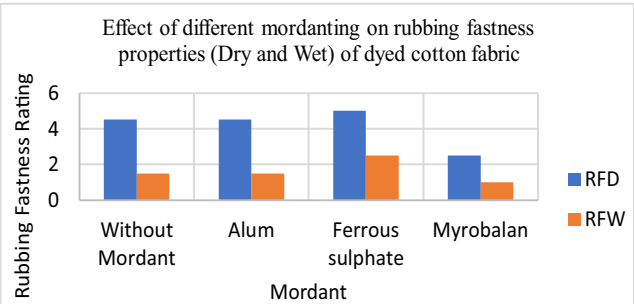


*Figure 3: Rubbing fastness (Dry and Wet) rating of cotton fabric dyed with Tesu flower dye using three different mordant*

## 4. Conclusion

Different mordants have the significant influence of the colour yield of dyed cotton fabric dyed with Tesu flower dye extracts. Out of all the three mordant used ferrous sulphate mordant shows maximum colour yield followed by the fabric samples dyed with Tesu flower dye without mordant and with alum mordant and harda. As far as fastness properties are concerns, washing fastness properties of the cotton fabric sample using Ferrous sulphate as a mordant shows maximum washing fastness rating followed by the fabric samples dyed with Tesu flower dye with harda then without mordant and then with alum and for rubbing fastness properties (dry and wet) Ferrous sulphate as a mordant shows maximum rubbing fastness rating followed by the fabric samples dyed with Tesu flower dye without mordant and with alum mordant and harda. Overall dry rubbing fastness is better than the corresponding wet rubbing fastness properties of the dyed cotton fabric.

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# Indian Garment industry for 2025-26

***Mr. V. V. Gharat***
MD, Gharat & Associates
Board Members of Trustee – TAI – Mumbai
Mentor of Change – Atal Innovation Mission, NITI Aayog, GoI

Predicting the future of the Indian garment industry for 2025 involves looking at current trends, government policies, technological advancements, and market demands. Here are some key aspects that could shape the industry:

**Sustainability and Eco-Friendly Practices**

An increasing global awareness of environmental issues is pushing the textile and garment industry towards more sustainable practices.

By 2025, we can expect a significant number of Indian garment manufacturers to adopt eco-friendly materials and processes. Organic cotton, recycled fabrics, and water-saving dyeing.

**Technological Advancements**

Technology will play a pivotal role in transforming the Indian garment industry. Automation, artificial …

Expanding global market reach by 2025 requires Indian garment manufacturers to adopt strategic, innovative, and sustainable practices that cater to the changing dynamics of the global apparel market. Here are key strategies that can help accomplish this goal:

*Embrace Sustainable and Ethical Manufacturing*: With a significant global shift towards sustainability, Indian manufacturers should focus on sustainable production methods. Utilizing organic materials, reducing water consumption, and minimizing carbon footprints could become key selling points. Ethical labor practices will also attract more global buyers looking to invest in responsible sourcing.

*Enhance Quality Standards*: Competing on an international level means matching or surpassing global quality standards.

Indian garment manufacturers have multiple opportunities to explore niche markets that can significantly enhance their global footprint and profitability. Here are some potential niche markets worth considering:

*Ethical and sustainable fashion:* With an increasing global emphasis on sustainability, there is a growing demand for garments made from organic, recycled, or eco-friendly materials. Indian manufacturers could leverage their

**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)

*he Markets Globally*

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

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

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

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

Mr. Vilas Gharat was a President of The Textile Association (India) - Mumbai Unit during 2017-2019 and 2019-2021. Now he is on the Board of Trustees of TAI – Mumbai Unit.

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access to organic cotton and traditional, eco-friendly dyeing and weaving techniques.

- Performance and technical wear:* This includes sportswear, active wear, and clothing designed for specific environmental conditions or activities. Given India's advancements in textile technology, there is potential to develop garments with unique properties (such as moisture-wicking, temperature regulation, or antimicrobial).

- Plus-size fashion:* The demand for plus-size clothing is rising globally, offering a significant market opportunity. Indian manufacturers could cater to this segment by producing fashionable, well-fitting, and diverse clothing options.

- Handcrafted and artisanal products:* There is a niche but growing international market for handcrafted garments that showcase traditional Indian craftsmanship, such as handloom weaving, block printing, and embroidery. These products can command a premium in markets appreciative of artisanal quality and cultural value.

- Virtual fashion for digital platforms:* As digital and virtual platforms grow, so does the demand for virtual fashion, including garments designed for use in digital environments and social media. Indian manufacturers could explore this futuristic market by partnering with tech companies.

- Adaptive clothing for the differently-abled:* There's an increasing awareness and demand for fashion that caters to people with disabilities or body shapes that require specially designed clothing. This includes garments with easy-to-use closures, adjustable features, and comfortable fits.

- Maternity and nursing wear:* While not entirely niche, there is always a steady demand for maternity and nursing wear that combines comfort, functionality, and style. Innovative designs that cater to pre and post-pregnancy needs can capture a loyal customer base.

- Heritage revival:* Focusing on reviving ancient Indian techniques and textiles, but with modern designs that appeal to the contemporary market. This can include using rare fabrics, traditional methods, or regional designs that have lost prominence.

- Tech-integrated wearable:* Garments integrated with technology for health monitoring, connectivity, or enhanced convenience. Although a highly specialized field, it's burgeoning, with applications ranging from sports to daily health management.

- Limited edition and collaboration collections: * Creating limited edition collections or collaborating with designers, artists, or celebrities can generate hype and exclusivity, appealing to premium markets.

For Indian garment manufacturers, success in these niches depends on a combination of innovation, understanding market needs, quality production, and effective marketing. Leveraging India's rich cultural heritage and recent advancements in textile technology can create a unique selling proposition in these niche markets.

# Are PET Fibers ... Blessings or a Curse?

**Mr. Avinash Mayekar**
Managing Director, Suvin Expo LLP

Fast changing fashion dynamics, sometimes keep us wondering the way we follow fashion trap. Nowadays Viral is trending… is today's reality but are we so soaked and dependent on it, that we are not making the effort to understand the technical and environmental impact of these trends or counterparts for usability? We just flow with the stream…

We must agree that there is a necessity for recycled fibers and recycled fibers are the only way forward and a major step to save our environmental balance. The simple question is adopting to RPET fibers that are available in the market with recycled term and creating textiles from it. Is this our way to a greener future?

My personal opinion of whether PET fibers are recycled textiles or not. With facts and theory so through this article I will simply break down the concept into 4 aspects:

- Recycling
- PET Recycled textiles
- Circularity
- Sustainability
- Recycled

**Definition**

"Recycling is the process of converting waste materials into new materials and objects"
So PET bottles when they are converted to fibers, technically we can call them recycled. Let us now see the second part of recycling – "Products should only be recycled if they cannot be reduced or reused". Here is where the catch - We often know how many Indian homes are reusing pet bottles to either water the plants, store garage oil, or create decorative items. Also today these bottles are simply being taken back by the manufacturer to meet his sustainability goal by reusing them in its production. So consider this by converting pet bottles into fibers, if these fibers are not going to be environmentally friendly in the near future, Can we term it as recycled?

Moreover, the recent factual information received from various converters during the recent Gartex/Technotex and fibers and yarn exhibition in Mumbai I was shocked to know that the shortage of pet bottles has forced the manufacturers to use fresh (raw) unused bottles to meet the demand. So if actual used bottles are not being converted into fibers then can they be called recycled? Moreover, aren't we forcing more production of a product that is not needed? The recycling need arises only because the waste is generated. One more aspect is that if we produce pet bottles out of used pet bottles then we can recycle them 5 to 6 times as informed by some sources. Whereas if we convert them into textiles then they have only one time use. Here we are creating an artificial need for green labels, is it a right thing to do?

**PET Recycled Textiles**

Now once these PET fibers are converted into recycled textiles…what then? We all know garments are having end of their life. They will also land up in landfills at the end of their life cycle. So are we are not converting one type of waste into other type of waste in one step? So our biggest problem of garment textile waste remains unaddressed. Unfortunately, we are somehow taking waste from other sectors and multiplying the waste generated by our sector. So are PET recycled textiles deserving the green label?

**Circularity**

Definition: "Circularity is a practice which focuses on reducing waste as much as possible while keeping a product's value intact for a longer period of time."
The definition itself emphasizes "keeping a product's value intact for a longer period of time". So by definition, the bottles were never part of our textile cycle how can pet recycled textiles be the end product that retains the property of the original product?

Moreover, we have our own textile waste like pre-consumer waste – fiber stage waste, yarn waste, Chindi -trimmings, fabric rejects, cuttings, unsold garments, and rejects. Post-consumer waste – used clothes, rugs etc. All pet bottle waste can be easily converted into recycled bottles which can then be used as recycled bottles. Similarly all types of textile waste can be reused for making textiles. This will be the true recycling meeting circularity. Take back what we produce to make products keeping their value intact and the ones that will last longer.

**Sustainability**

Simplest definition: "Meeting the needs of the present without compromising the ability of future generations to meet their own needs."
Often the term compromising is been left out and that is where the whole problem arises. So just having the label "recycled" should not be the end goal. We must deliberately work on creating products that will not hamper the existence of our future generation. Circularity is the only practical goal for sustainability. One can achieve sustainability only through the practice of circularity. So PET bottles recycling into textiles destroys the circle of recycling. Figure 1 is the pet fiber value chain development reference image used by one of the leading manufacturers in a recent show.

Here if u see closely it is not a complete circle. The chain ends with pet fiber garments. Isn't it self-explanatory to not be circular?

**Changing Norms & Regulations**

During my recent moderation at the ITAMMA conference in Ahmedabad one of the speakers from Netherland informed me of how European associations are not terming this as circularity and are making laws for the traceability & circularity of fibers more strict and compulsive for the products that will enter their market.

**Conclusion**

One might argue then what will happen to the pet bottle converters in the market. The pet bottle converters will always remain as pet bottle recycled chips and granules can be converted back to products of a similar nature like bottles, hard surfaces, and plastic products. Moreover, they must be converted into products like road pavements, and paver blocks/ bricks whose lifespan is much longer than the original product.

As far as introducing recycling labels to textiles is concerned we can easily do this by recycling textile waste which is produced in abundance. e.g. In cotton Ring Spinning process the waste is almost close to 30% . Textile waste can be converted into recycled garments by using good-length recycled fibers whereas recycled short fibers are excellent inputs for converting into technical textile products like geotextiles, certain automotive applications, insulations fabrics, etc. by using needle-punching and spun-bond technology.

Time has come to avoid short cuts and reduce landfill waste of textiles by reusing textile pre-consumer & post-consumer waste into recycled fibres which have a great demand in near future. Let us open our eyes and start producing recycled fibres which can be used in textile value chain.

# Post Event Report - International Conference
# "77th All India Textile Conference"
## Post Pandemic on Global Vision of Textile Industry

The Textile Association (India) – Delhi Unit established in the year 1965, having more than 2800 strong membership. After the enormous success during 1968, 1987 & 2011, The Textile Association (India) – Delhi Unit has successfully hosted 77th All India Textile Conference on the theme "Post Pandemic on Global Vision of Textile Industry" on 16th & 17th March, 2024 at IIT Delhi. The conference was attended by eminent businessmen, technical experts and Students.

Mr. Madhu Sudhan Bhageria, Chairman - Filatex India Limited was the Chief Guest on the occasion. Mr. Anil Jain, Chairman - Jain Cord Group of industries also graced the occasion as Guest of Honor. Other dignitaries present during the Inaugural session includes Mr. R.K. Vij, President – Emeritus of TAI Central office; Mr. T. L. Patel, National President of TAI; Mr. Ritesh Gupta, President of TAI Delhi; Mr. D. K. Singh, Conference Chairman, Prof. (Dr.) B. K. Behera, IIT Delhi, Conference Knowledge Partner; Dr. R. Alagiruamy, HoD, IIT Delhi; Dr. V. D. Gotmare, Chairman, TAI and Mr. Mahendrabhai G. Patel, Hon. Gen. Secretary, TAI

*Dignitaries on the dais during inaugural session*

*Mr. D. K. Singh Conference Chairman briefing about the Conference*

Dr. R. Alagiruamy, HOD – Department of Textile and Fibre Engineering, IIT Delhi briefed the delegates of conference about facilities available at IIT Delhi. Prof. B.K. Behera IIT Delhi, Knowledge Partner of the conference spoke on the theme of the conference, i.e., Post Pandemic Scenario in the Textile industry.

*Shri Madhusudan Bhageria is receiving Honorary Membership Award by the hands of Shri T. L. Patel, President TAI*

*Shri Anil Jain is receiving Award by the hands of Prof. B. K. Behera*

On behalf of the Textile Association (India), prestigious awards awarded during the event. Shri Madhusudan Bhageria, has been awarded Honorary Membership Award; Dr. Bhuvanesh Gupta has been awarded Honorary Fellowship Award; Shri A. V. Mantri has been awarded Service Gold Medal; Shri Jayantibhai H. Patel has been awarded Service Memento; Shri A. T. Shahani has been awarded Service Memento and TAI Ahmedabad Unit has been awarded Best Unit Trophy.

Also on behalf of TAI Delhi Unit prestigious awards were felicitated to the members during the event for their contribution to the association.

Shri R. K. Vij was honoured with Lifetime Achievement Award for his Social Services for Textile and other fraternity. Besides, Shri T. K. Sengupta for his services to the textile industry; Prof. G. K. Tyagi, for Education & Research in Textile field; Late Shri H. N. Jain (Posthumously) for selfless services to TAI were felicitated with respective Awards.

***Dr. Bhuvanesh Gupta is receiving Honorary Fellowship Award by the hands of Prof. (Dr.) B. K. Behra, IIT Delhi, Conference Knowledge Partner***

***Shri A. V. Mantri is receiving Service Gold Medal Award by the hands of Shri Anil Jain, Chairman - Jain Cord Group of Industries***

***Shri Jayantibhai H. Patel is receiving Service Memento by the hands Shri R. K. Vij, President, Emeritus, TAI***

***Shri A. T. Shahani is receiving the Service Memento by the hands of Shri R. K. Vij, President – Emeritus of TAI***


***Office Bearers and representatives of TAI Ahmedabad Unit is receiving the Award by the hands of Chief Guest Shri Madhusudan Bangeria***

***Conference Souvenir and book of Papers is being released by the Chief Guest and the Dignitaries***

In the Valedictory Session held on 17th March, Shri Rohit Rishi, Executive Director, Bank of Maharashtra was the chief guest. This was two-day Conference where industry delegates from all over India, Research experts from IIT Delhi and other Institutes brainstormed over emerging trends in textile arena. About more than 350 delegates attended the Conference. There were very important topics, viz, Sustainability, Technical Textiles, Protective Textiles, etc. which are as in Context of today's requirement of Textile industry.

## *GLIMPLESS OF CONFERENCE*

# UNITS ACTIVITY

## TAI Ahmedabad Unit

**3rd November, 2023: Raas Garba Function to Celebration of Sharad Utsav 2023**

The Textile Association (India) Ahmedabad Unit arranged a Raas Garba Function to Celebrate Sharad Utsav 2023 for the Members, Office Bearers, Managing Committee members and their families. In the function there were prizes for different categories Like: Dress with best garba performer (Male & Female), Wearing Best Dress (Children, Male & Female). All the under 5 years' age children also awarded consolation prize.e Valedictory Session held on 17th March, Shri Rohit Rishi, Executive Director, Bank of Maharashtra was the chief guest.

**12th December, 2023:**

**A Full day Technical Seminar was organized for Quality Control Personnel of Agro & Medical Textile Industry jointly with BIS, Vadodara Branch.**

The Textile Association (India), Ahmedabad Unit and Bureau of Indian Standards, Vadodara Branch organized one full day Program for Quality Control Personnel of Agro & Medical Textile Industry at Dinesh Hall.

**13th December, 2023:**

A full day industrial visit was organized for Quality Control personnel at three units located in Ahmedabad. More than 20 participants from industry took part in the visit.

**15-16th December, 2023: Hashya Darbar Program**

The Textile Association (India) Ahmedabad Unit organized Hashya Darbar program at Dinesh Hall For the celebration of Diwali Get-together for its members and family members. The two days shows were fully houseful and before starting the program high-tea also arranged for the members. Both the days were fully entertained for the members.



**A 5 full days' series of Technical Program on Technical Textile** (Jointly with GCCI) was organized at Dinesh Hall. Entrepreneurs took part in the program. Very eminent speakers across the country were invited to deliver speeches.

**Day 1 - 16th December, 2023:**
Renowned speakers delivered talk on Overview of Technical Textile, Nonwovens and Composites.

**Day 2 - 17th December, 2023:**
Eminent speakers delivered talks on Woven Technical textile and Arvind's technical textile market.

**Day 3 - 5th January, 2024:**
A Full day industrial visit to Arvind, Technical Textile Division was organized. The visit included composites and woven technical textile facilities of Arvind Ltd.

**Day 4 - 6th January, 2024:**
Industry leaders were invited to deliver various aspects of Needle punching, woven geo textile and GFRP products.

**Day 5 - 7th January, 2024:**
Industry leaders delivered talks on important aspects of various woven products, preparatory solutions, Govt. schemes for technical Textile

**26th December, 2023 to 6th January, 2024: Groundnut oil tin distribution among the needy members**

The Textile Association (India) Ahmedabad Unit distributed Groundnut Oil Tins among the needy members with 30-35% subsidy on market rate of each tin (15Kg). Total 3339 tins distributed among the 843 members. Such type of member's welfare activity has been running by the association since last 4 years for the benefits of the members.

**26th December, 2023 to 6th January, 2024: Groundnut oil tin distribution among the needy members**

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**6th February, 2024: Full Body Health checkup (Blood & Urine Test)**

The Textile Association (India) Ahmedabad Unit arranged full body health checkup (Blood & Urine Test) for members & their family members. The Sun Pathology Laboratory & Research Institute manage by Shree Shreeji Charitable Seva Trust offered a special package rate for the said program and around 82 tests included with this package. Total 525 members and their family members have taken this special package rate advantage.

**20th February, 2024:**

Chairman of the unit Dr. Ashwin Thakkar attended half day seminar organized by USTER on "Weaving Consistent Quality with Optimum Performance".

**21st February, 2024:**

President of the unit Shri H. S. Patel inaugurated International Exhibition of Textile Machinery "ITMACH" at Helipad Ground, Gandhinagar.

**14th to 28th February, 2024: "PRADHAN MANTRI TB MUKTH BHARAT ABHIJAN"**

TAI-Ahmedabad Unit drove "PRADHAN MANTRI TB MUKTH BHARAT ABHIJAN" in associate with the Ahmedabad Municipal Corporation and distributed free TB nutrition kits having groceries to all the invited TB patients in different locations. Shri Hasmukhbhai S. Patel, President inaugurated the said function which was arranged in Vatvagam, Ahmedabad and other office bearers also were present in the said function.

The Pradhan Mantri TB Mukth Bharat Abhijan function carried on between 14th – 28th February, 2024 and covered 9 places in surrounding Ahmedabad city which are Vatva, Amraiwadi, Odhav, India colony, Viratnagar, Bhaipura, Naroda, Ramol-Hathijan and Kaligam. Around 500 kits handed over to the TB patients in 9 locations.

**23rd February, 2024:**

ASSOCHAM and Govt. of Sharjah, UAE in association with The TAI, Ahmedabad Unit organized an Interactive Session on Expanding Your Business Globally with SAIF Zone.

Dr. Ashwin Thakkar, Chairman and Shri Hitesh Trivedi, Hon. Jt. Secretary attended the function on behalf of the Ahmedabad Unit. Also Dr. Thakkar delivered a speech on the subject matter at the program.



**7th March, 2024:**

A half day technical program "Managing Stress in Textile Technician's Life" was organized from 3.00 to 6.00 PM. The program was conducted by Sun to Human Foundation.

**7th March, 2024:**

A half day Technical Seminar on "Industrial Awareness cum Technical Program on QCO in Textile" was organized in association with BIS, Ahmedabad from 06.00 to 09.00 PM. Jt director of BIS, Ahmedabad and Regional Sales Manager of SGS India delivered lectures.

**9th March, 2024:**
All committee members of the unit attended an International Conference on **"Textile Engineering Eco Systems for ATMANIRBHAR Bharat- Ready for the World"** organized by ITAMMA and MoMSME, GoI. TAI was supporting association for the event. National President of TAI Shri T. L. Patel graced the occasion as a special guest.

**13th March, 2024:**
Chairman of the unit Dr. Ashwin Thakkar attended half day seminar organized by MARZOLI on "Challenges & Opportunities in the Spinning Industry: The Role of Technology"

**14th March, 2024:**
A half day Technical Seminar on **"Warping for Technical Textile"** was organized. Eminent speakers from Prism Group of Industries, Eleics etc. delivered talks which was appreciated by the audience.

**22nd March, 2024:**
Three office bearers Dr. Ashwin Thakkar, Shri J. H. Patel and Shri Hitesh Trivedi attended "Sneh Milan", a get together organized by Gujarat Chamber of Commerce & Industries (GCCI).

**31st March, 2024:**
The Textile Association (India) Ahmedabad unit donated 15 Tricycles and 15 Wheel Chairs to Divyang people at a function organized jointly by The Textile Association (India), Ahmedabad Unit and Bharat Vikas Parishad.

# Interview with Lovis Kneisel, CEO of FUSE

**Exciting prospects for composites**

Interview with Lovis Kneisel, CEO of FUSE, about an alpine ski made from hemp-based composites

FUSE is one of the main players in a current project to develop an alpine ski with an overall more sustainable and ecological production process than before. Specifically, the CO2 footprint is to be significantly reduced. To achieve this, the value chain is to be converted to a circular economy and production is to be switched to processing the renewable raw material hemp in composite production. FUSE is working together with KARL MAYER Technische Textilien on the latter task.

Ulrike Schlenker from Corporate Communication team at the KARL MAYER GROUP spoke to Lovis Kneisel, Managing Director of FUSE GmbH, about the background and expectations surrounding the project.

**US: Why did you choose to build an alpine ski for the joint project?**

**LK:** We had already been working on the development of adapted semi-finished products for biocomposite products in various market sectors for some time before the start of the project. Alpine sports is an industry that is fundamentally very open to innovations in the field of sustainability and, due to the many small players, provides rapid feedback on the suitability of new material systems and process approaches. Alpine skiing as such is an enormously exciting product, as the focus here is very much on performance. In close cooperation with SPURart in particular, our team has succeeded in substituting 100% of the glass fiber used and still developing an extremely high-performance ski. Even the SPURart pros are impressed by this innovation both on and off the slope.

**US: Flax fibers are already being processed in the composites sector. What fascinates you about hemp? Are there any concrete figures on the benefits of this natural fiber in terms of environmental impact?**

**LK:** Flax and hemp are largely related in terms of their performance in composite materials. The advantage of hemp over flax lies in its ecology, but also in its economy. Unlike flax, hemp can be grown completely without chemical pesticides and is also available in good quality outside Belgium and France. As we consistently rely on secondary fibers - the so-called value fibers - for our semi-finished products, we are not in the usual procurement competition with the clothing industry for flax long fibers and can therefore pass on a very attractive cost structure to our customers.

**US: What are the main advantages of using natural fiber tapes compared to natural fiber yarns in terms of the process chain and impregnation behavior?**

**LK:** The tapes are produced directly from the fiber as a flat


structure, which saves the entire spinning process and also parts of the subsequent surface formation. The advantage of this is an essentially streamlined process.

**US: What impact do you expect the project to have? What potential is there for the composites industry in other market segments? In your opinion, what other applications are possible apart from sports and automotive?**

**LK:** Natural fiber composites can be used in many different areas of application. The focus is not only on mobility or sports applications. They also offer advantages when used in load-bearing components in the building and construction sector or in the logistics sector. We are currently working together with a Swiss start-up to develop a circular Euro pallet.

**US: How can natural fiber-based composites be paved the way for widespread applications? What challenges are there?**

**LK:** The industry's interest in bio-based materials is very high and growing rapidly in light of the urgent need to decarbonize the industry. Biogenic raw materials in general, and fibers in particular due to their high performance requirements, are growth-dependent in terms of their qualitative and quantitative character. The main challenges are therefore always the reliable provision of high-quality and homogeneous materials and the continuous reduction of supply costs for industrial semi-finished products.

**US: Let's talk about the cooperation with KARL MAYER Technische Textilien. How long have you been working with this partner in the composites industry and what do you value about them?**

**LK:** The cooperation with KARL MAYER developed in the course of initial preliminary investigations for the HempSki project described above and has been steadily expanded since then. We value the company for its innovative spirit and its constant willingness to try out new things.

**US:** Thank you very much for this interesting interview.

# Interview on launch of IDF 3 Vortex Spinning

**IDF VORTEX SPINNING - Meeting True Experts with the recent launch of our new IDF 3, Eva Trenz, Product Manager Spinning Preparation, spoke with our Senior Expert in R&D Technology, José Guadalupe Flores Molina, about the short preparation process IDF VORTEX SPINNING and its advantages.**

**L to R: Eva Trenz, Product Manager Spinning Preparation & José Guadalupe Flores Molina, Senior Expert in R&D Technology**

**Q: José, what does IDF VORTEX SPINNING mean?**

A: Thanks to the IDF, it's possible to cut down the number of draw frames used in airjet spinning. For rotor spinning, it is already standard practice to only have cards with IDF directly before the spinning machines.

For airjet spinning, however, it is normal to have one card and three draw frames. By using the IDF and a 12-fold creel finisher, customers are able to shorten the preparation process – so they now only need one card with IDF and one finisher before spinning. That means they save space and energy because they need two fewer draw frames.

**Q: José, what does IDF VORTEX SPINNING mean?**

A: Thanks to the IDF, it's possible to cut down the number of draw frames used in airjet spinning. For rotor spinning, it is already standard practice to only have cards with IDF directly before the spinning machines. For airjet spinning, however, it is normal to have one card and three draw frames. By using the IDF and a 12-fold creel finisher, customers are able to shorten the preparation process – so they now only need one card with IDF and one finisher before spinning. That means they save space and energy because they need two fewer draw frames.

**Q: Sounds great, but is it really that simple?**

A: Yes and no... We started our research project in this area during 2015, conducting a huge number of trials at our R&D center in Germany and on-site at Trützschler customers around the globe. We collected a lot of knowledge, insights and experience. As a result, we knew that the short preparation process for airjet would work reliably when we introduced it at ITMA Asia in 2018 and ITMA 2019. We've seen a continuous flow of orders for new airjet spinning projects using the short process since then. And in India, demand for this has boomed.

**Q: How would you respond to concerns regarding the shorter process?**

A: The outcome depends on the specific situation. Together with the customer, each application is technologically evaluated in advance. We get the best results with synthetics and yarn counts up to Ne 40 so far, and we have not seen any difference in the quality of the final fabric.
I'll always remember one customer who switched their production line to the short process using cards with IDF and 12-fold creel finishers. After one year, they hadn't noticed any change in quality – so they placed a new order for a mill with IDF VORTEX SPINNING.

**Q: What will the future bring for short spinning processes with IDF?**

A: We're always looking for new possibilities to expand the field of application. Our innovators are running tests to achieve finer yarn counts, while also working with different raw materials like Lyocell and blends. That's what makes this project so much fun for me as an R&D technologist. There are still so many potential applications for airjet spinning where the short preparation process can be used to its full potential. And I believe it will become even more fun with the new IDF 3.

We look forward to seeing the results in the future – and we are proud that IDF VORTEX SPINNING customers can now benefit from the impressive features of our new IDF 3!

**What our partner Murata says:**

"We enjoy working with Trützschler and applying their technology in VORTEX plants. We're already operating more than 200 spinning machines with IDF+1 pass. From the first stage of the trial, it was interesting to see that the yarn cut level in IDF+1 pass is less than in the conventional three passage process. This improves spinning machine efficiency a lot. The yarn data shows some small differences between one pass and three passes, but it is difficult to see the difference in knitted fabric. Our target is now to focus on intimate blends. We believe the T-Blend system, IDF and one finisher from Trützschler are a great fit for our sustainable and smart VORTEX factory!" says Mr. Masazumi Shigeyama, VORTEX Product Manager.

## More working width, more design flexibility

**STOLL launches the new CMS 503 ki L, 50″ for the volume market**

Nothing is more volatile than fashion. Manufacturers must react to rapidly changing trends and are under immense price pressure, especially in the volume market, including the knitting sector.

For the specific requirements of an economical and yet flexible production of knitted goods in high quantities, STOLL offers the cost-effective-range of its CMS series. The Performer machines impress with an excellent price-performance ratio and enable an unlimited variety of patterns for a variety of Fully Fashion applications. New models further increase flexibility in article design.

Only in mid-March 2024, STOLL launched the CMS 503 ki L, thereby complementing the proven CMS 503 ki with a machine featuring a wider working width. The "L" in the name stands for "Large" in terms of patterning potential: With a 50" working width, designs with extensive motif formats as well as articles with an extended size range can be realized. A plus especially for global players! International brands in particular need to flexibly respond to a growing variety of sizes.

"In America, but also in Asia and Europe, the trend is towards larger sizes. For this development, manufacturers are well equipped with our CMS 503 ki L. The first machines are already going to Vietnam for the American export business, but we also receive numerous inquiries from Türkiye," says Michael Händel, Vice President Sales & Service at the KARL MAYER STOLL Textilmaschinenfabrik GmbH.

Proven technology, highest performance
The highly productive and versatile CMS 503 ki L is available with a gauge range of E5 - E18 / E2.5.2 - 8.2 and a working width of 50"/127 cm.

The technical features of the newcomer include the Multiflex® take-up from STOLL and spring-loaded latch needles used as standard in all STOLL machines. The patented take-down ensures optimum width fixation of the knitted fabric and therefore less waste and costs. The spring-laded latch needles also contribute to a reduction in costs and defect rates, but also result in a uniform loop structure and fabric surfaces with clear textures. The basis for this is a well-thought-out design: a latch spring installed under the needle latch ensures maximum safety during transferring processes and when closing the latch, even when processing many threads or bulky yarns. In addition, the needles are safely opened through the use of needle brushes - an advantage especially with empty needles - and a shorter latch projection enables tighter knitting.

As a representative of the Knitelligence® machine generation, the CMS 503 ki L is also prepared for the special requirements of the modern digital era. It thus offers various advantages, including the possibility of process automation, transparency, short reaction times and production cycles, networking, and the development of new business models.

Based on mature STOLL technology from Germany and the benefits of the KARL MAYER group network, the CMS 503 ki L is a flat knitting machine on the market that combines highest performance with an extremely attractive price and convinces through reliability. In practice, representatives of the CMS series with 100,000 working hours and more ensure satisfied customers worldwide.

At ITMA ASIA + CITME 2024 from October 14 to 18, 2024 in Shanghai, the CMS 503 ki L will demonstrate its performance at the KARL MAYER GROUP booth. Michael Händel and his team look forward to numerous visitors.

***For more details, please contact:Press Release***

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## Rieter received an order for the first batch of Rieter technology

**Rieter Wins Major Order and Enters Strategic Partnership with Shanghai Digital Intelligence World Industrial Technology Group Co., Ltd.**

**On March 6, 2024, Rieter received an order for the first batch of Rieter technology amounting to around CHF 62 million from Shanghai Digital Intelligence World Industrial Technology Group Co., Ltd. (DIW). Rieter also signed a strategic partnership with DIW to develop intelligent yarn manufacturing technology that utilizes digitization and automation to minimize conversion costs and maximize value for customers.**

Rieter and DIW signed a first order in the amount of around CHF 62 million for combers and draw frames that will provide the basis to transform DIW's spinning mills into state-of-the-art industrial textile operations. DIW, a fast-growing company specializing in intelligent manufacturing and industrial operation services, selected Rieter following a competition in which the company's machines achieved better stability and higher production than competitors. The strategic partnership of DIW and Rieter is designed to further enhance the overall operational efficiency of DIW's mills by providing highly efficient machines, automation and digitization technology.

This will also minimize conversion cost and consolidate the sustainable growth of both companies, while contributing to the high-quality development of the Chinese textile industry.


***L to R: Jing Wang, Shenquan Jing, Yifang Liu, Qinghui Zhang, Kuiyong Dong, Yiming Liu, Michael Hubensteiner, Dong Wang,***

Yiming Liu, Chairman, Shanghai Digital Intelligence World Industrial Technology Group Co., Ltd., says: "We have selected Rieter based on its excellent technology and abundant experience. Rieter machines provide stronger stability and higher production efficiency. The strategic cooperation between the two parties is not only a full affirmation of the previous cooperation, but also one with complementary advantages and mutual benefits, which will provide greater possibilities for DIW to reduce costs and increase efficiency. It is believed that the two sides will take this cooperation as an opportunity to further explore cooperation in a wider range of fields, open up new areas for the transformation of the traditional textile industry, and contribute to accelerating the construction of a modernized industrial system."

Michael Hubensteiner, Country Managing Director, Rieter China, says: "We are proud that our technology came out on top in this competition, achieving greater stability and higher production than competitors. We are grateful for the trust that DIW has placed in Rieter and are confident that this partnership will be a gamechanging and unrivalled success while further strengthening Rieter's position in the attractive Chinese market."

For further information, please contact:

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## TRÜTZSCHLER Texnology & Truetzschler Rocks with Needle Punching Demo at TECHTEXTIL 2024

The industry was waiting for the most flexible needle punching line to take care of nearly all of the applications in needle technology. I got the opportunity to witness & see it happening through my own eyes.

Witnessing a needlepunch line running at a very high speed for lightweight products such as 35 gsm and smoothly winding felt even up to 1400 gsm with "absolutely no noise" at all was as if my dream came true as I was involved in nonwovens since the year 1999 and got an accomplishment to see after 25 years of nonwoven experience. I remember how much difficult it was to promote nonwoven technology during those days when it was a stepmother treatment to this industry but now we can see the ease of operation and adaptation at almost all levels of the industry.

Excellent technical features, German metallurgy, state-of-the-art quality parameters, high-level safety standards and "silent" high-speed operation throughout the entire line are the marvels of the line.
I am sure this evolution will bring about changes in the industry. Existing players can think of replacing their old technologies with this super flexible new innovative technology that can reduce operating costs by clubbing different product portfolios into one machine. It will also enable space saving for future expansions or using it for specialized operations.

For new entrepreneurs, this line would be their golden ticket to beat all existing players with higher production and lower operating costs.

At Suvin Expo LLP, we are thankful to Truetzschler Nonwovens for giving us this opportunity to witness this great innovation in the nonwoven industry. Special mention of "Texnology" who have done remarkably well to get established and join hands with reputed brand "Truetzschler" and given special recognition to T- SUPREMA.

Indian technical textile industry can take advantage of this situation and Suvin can help them prepare their business plan and handhold them for project implementation as an advisor to do a remarkable job in this challenging yet promising industry. Let us take advantage of the innovations that are at our doorsteps for reaping profits and entering new business lines...

Suvin is at your service to guide you for feasibility and make it a great success...

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# Elevating Spinning Standards with LMW's Compact Technology @ Zara Yarntex

In collaboration with LMW, Zara Yarntex initiated a transformative project in 2017. This venture saw the installation of 32,640 spindles, equipped to process cotton carded compact yarn anging from counts 26s to 40s Ne, catering to both domestic and international markets with 19 tons production per day.

Zara Yarntex's story in Vietnam epitomizes a steadfast commitment to excellence, innovative thinking, and the expansion of a cherished family legacy. Founded in 2017 by Mr. Duy (Ryan), the company set out on a mission to redefine standards of quality in the textile sector, with LMW standing strong as its trusted ally.

*Mr. Duy Ryan, MD*

"Choosing LMW machines for the spinning project has been one of our major successful milestones. There is no doubt that we will continue to use LMW machines for future projects". Mr. Duy Ryan, MD.

Driven by a vision to expand the family business, which started as OE mills back in 2007, Mr. Duy Ryan, completed his education in the UK and returned to Vietnam with a mission.

With a focus on quality and customer satisfaction, Zara Yarntex aimed to make its mark in the competitive textile market with LMW's state-of-the-art textile spinning machinery.

| Department | Department | Department |
|---|---|---|
| Blowroom | LMW Bale Plucker LA23/S line | 1 |
| Card | LMW LC636 S | 12 |
| Breaker Draw Frame | LMW LD2 | 3 |
| Finisher Draw Frame | LMW LDF3 | 6 |
| Speed Frame | LMW LF 4200/AX | 5 |
| Ring frame | LMW LR 9/AX/AXL (1632 Spindles) (Compact converted) | 14 |
| | LMW LRJ 9/AX/AXL (1632 Spindles) | 6 |
| Compact | LMW New Compact Spinning System – Doffer Machine | 10 |
| SPIN CONNECT | LMW Spin connect | 1 |

Notably, based on the performance of Spinpact, LMW's flagship compact system, Zara Yarntex went ahead with retrofitting their existing non compact machines with Spinpact.

The commissioning of the project marked a significant milestone for Zara Yarntex. The technical team lauded LMW's machinery for its exceptional productivity and user-friendly interface.

*Speed Frame LF 4200/AX*

*The technology team at Zara Yarntex*

Feedback from the team highlighted the seamless support and guidance provided by LMW engineers throughout the process. The partnership with LMW not only met but exceeded expectations, ositioning Zara Yarntex as a leading provider of high-quality cotton-carded compact yarn in Vietnam.

**Technology team** "LMW machines are very user-friendly and competitively priced as compared to the same European machines that we have in OE mills.

LMW spinpact is state-of-the-art for carded cotton spinning, both for knitting and weaving applications. Power consumption per kg was reduced by 15-20%.

Excellent after-sales service, LMW sales & engineers attend to any customer requirements instantly. They visit quarterly to check the mills' working conditions".

With an emphasis on customer-centricity, LMW's pre-sales and post-sales services stood out for their professionalism and dedication.

The synergy between Zara Yarntex and LMW underscores a shared commitment to innovation and excellence.

As Zara Yarntex continues to flourish, the success of its collaboration with LMW serves as a testament to the power of strategic partnerships and technological advancements in driving sustainable growth. With a bright future ahead, Zara Yarntex remains steadfast in its commitment to delivering


superior quality products and setting new benchmarks in the textile industry.

In retrospect, the decision to choose LMW as a partner in the spinning project emerges as a milestone of Zara Yarntex's success story, laying the foundation for future endeavors. With unwavering determination and a spirit of innovation, Zara Yarntex paves the way for a future where excellence knows no bounds, powered by an enduring partnership with LMW.

4S SUSTAINABLE SMART SOLUTIONS FOR SPINNING SUCCESS

LMW's Sustainable Smart Solutions for Spinning Success (4S), supported by a culture of innovation, and empowers mills with a technological and competitive advantage. This is achieved through mission-critical automation, real-time data, analytics from connected machines, compatibility with all applications, and reliable performance under diverse operating conditions.

USTER® Think quality

## Uster offers a solution to upgrade fabric inspection

### Step up to assured fabric quality for technical and

**Uster Technologies offers a flexible solution to upgrade fabric inspection from manual to automate. Integration in existing production lines is quick and easy, and the data flow also brings extra benefits. It means fabric producers can significantly improve their yield with fast, accurate quality monitoring.**

Any change starts with a new thought and a clear intention – but sometimes it takes time to make it happen. That's because issues might be expected during implementation. But that's not the case when switching from manual to automated fabric inspection with Uster. This article presents the key points, and offers further options for total understanding: discussing the benefits with an Uster expert at the upcoming Techtextil or on another occasion; or taking part in a special webinar on April 11.

**The path to automation**

For maximum benefits – up to 50% lead time savings and 80% less waste – automated fabric inspection combines Uster EVS Fabriq Vision with Uster Fabriq Assistant. This integrates a reliable and sophisticated inspection system, delivering vital data, with practical analysis of that data to deliver the best results for users.

Prerequisites for automatic fabric inspection begin with a detailed evaluation of the current process, to identify the critical steps. Typical questions users will be asked include "what kind of optimization do you expect and what changes would you like to make to the production process?" Or "how does your final process step look before you ship the fabric to your customer?"

At the end of this analysis, the steps towards integration are planned, including the choice of the right hardware and software needed to achieve automation in the fabric inspection process.

The Uster Fabriq Vision inspection solution can be integrated into existing production lines – or used as an off-line inspection system. In both cases, the preconditions for optimal results from the optical system are the same: smooth and tension-controlled fabric flow, no creases in the fabric, stable light conditions in the inspection area and no dust or lint on the fabric.

The inspection cameras feature state-of-the-art technology, positioned at various detection angles. Sophisticated illumination makes defects visible and raises detection performance to the maximum. Uster EVS Fabriq Vision provides real-time alerts for operatives, showing all defects and automatically creating roll inspection charts. All detected faults are collected in a dataset and transferred to Uster Fabriq Assistant.

**Data flow**

Data generated by Uster fabric inspection systems feeds to Uster Fabriq Assistant, which creates statistics for quality and process improvement. Its automated features make Uster Fabriq Assistant more efficient and productive, as a reliable and tailored solution for processing, analyzing, and visualizing quality data.

Connecting data is no longer a big deal. The Uster solution offers an open interface to transfer data to the ERP system and to the Optimized Cut Control (OCC), allowing maximized yield. Uster recommends a customer workshop to discuss data requirements, key parameters, data flow in production and how to create a powerful infrastructure.

**Additional benefits**
OCC allows an increased fabric yield after inspection. It is a software tool using the defect map from inspection, enabling automated cut optimization to be installed on any existing debatching or cutting line. It automatically identifies the correct cutting position for maximum fabric yield according to the customer's quality requirements, and makes the cutting process highly efficient.

Invisible synchronization marks (applied during inspection) indicate the position of defects and cut positions in a roll, so these are always under control, allowing the cutting table to run at maximum possible speed.

When color consistency is critical, Uster EVS Fabriq Shade supports fabric producers to deliver a constant shade in end-products. The system provides standard shade measurements with high accuracy and continuously qualifies shade variation, based on a set reference point. To ensure lots have optimal color uniformity, the system offers grouping according to shade, for best fabric yield.
Combining Uster EVS Fabriq Shade and Uster EVS Fabriq Vision in one process provides all relevant quality data in a single operation and increases the efficiency of fabric inspection.

**The change explained**
Automated fabric inspection requires newly-configured logistics as part of the detailed set-up plan – including a clear and traceable data flow for a paperless production. Finally, the calculation of the ROI will assure customers that profitability – as well as efficiency and quality – will also increase.

Ingo Kiefer, Senior Textile Technologist for fabric inspection at Uster Technologies, takes participants through the transition from manual to automated fabric inspection at the upcoming webinar. Ask questions and register at https://webinars.eu.on24.com/Uster/AutomatedFabricInspection.

Uster Technologies also invite interested parties to face-to-face discussions at Techtextil Frankfurt, from April 23 to 26, 2024. Meet their fabric inspection experts at the Elmatex booth D63 (Uster agent for Germany) in hall 12.

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## Singapore Exhibition opening of space application

**Early awaited ITMA ASIA + CITME Exhibition in Singapore gears up for space application**

The ITMA ASIA + CITME, Singapore 2025 exhibition has attracted heightened levels of interest since it was launched in Milan last June. Drawn by the regional market opportunities, many leading textile technology brands are looking forward to apply for their booth space when online space application opens from 9 April 2024.

The Singapore edition is scheduled to be held at Singapore Expo from 28 to 31 October 2025. It is owned by CEMATEX (the European Committee of Textile Machinery Manufacturers), China Textile Machinery Association (CTMA) and Sub-Council of Textile Industry, CCPIT (CCPIT-Tex).

According to the show owners, there is a huge increase in enquiries from machinery manufacturers as the Singapore exhibition targets not only South and Southeast Asia, but also from very important markets in the Middle East.

Mr. Ernesto Maurer, president of CEMATEX, explained, "These regions present vast opportunity for our members as technology buyers from these textile and garment hubs are sourcing cost-effective and sustainable solutions to modernise and upgrade their production.

"The Singapore exhibition complements our ITMA exhibition in Europe and the ITMA ASIA + CITME exhibition in China. The platform will help to broaden our exhibitors' market focus and diversify their reach, enabling them to effectively engage with many of the buyers who were not able to attend these two exhibitions previously. For these buyers, we are convinced, Singapore is more accessible due to its closer proximity to their home countries, but even more so due to its visa-friendly policy."

Mr. Gu Ping, president of CTMA, said: "The combined exhibition in Singapore has opened a new phase of development for CITME. We are excited to bring our members along as we ride the wave of regional opportunities through the Singapore edition."

Mr. Daisuke Murata, president of Japan Textile Machinery Association (JTMA), said: "We congratulate the ITMA ASIA + CITME owners for making the decision to have a second exhibition in Asia. The Singapore exhibition will be useful for our members to better penetrate other regional textile hubs in Asia, and as far as the Middle East."

Prominent textile technology providers are also eagerly eyeing the start of space application for the combined exhibition.

Ms. Rebekka Dilo of Dilo Systems GmbH shared that the group is looking forward to the Singapore edition of ITMA Asia + CITME 2025. She enthused, "As an important gathering of th. whole textile industry, it is a great

opportunity for us to present our latest innovations." Ms Chandrima Chatterjee, secretary general of the Confederation of Indian Textile Industry (CITI), welcomed the staging of the exhibition in Singapore. She said: "This expansion of the exhibition from Shanghai to Singapore recognises the growing needs of the Asian textile industry, especially India. The industry today is looking for technologies to meet its need for optimising production, minimising supply chain risks, better control of quality and finishes, and enhancing sustainability in all aspects of production."

She added: "We look forward to the Singapore exhibition to address these needs and help this biggest textile manufacturing and exporting region of the world leverage the latest in technology and innovations."

***For more information on ITMA ASIA + CITME, please contact:***

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Tel.: 022-2446 1145, E-mail: taicnt@gmail.com

**(Subject to Mumbai Jurisdiction)**

## RESULTS FOR ATA PART I - PASSED/ATAHE CANDIDATES DECEMBER, 2023

| Centre / Result | PASS | ATAHE |
|---|---|---|
| Ahmadabad | 2023/01, 2023/02, 2023/03, 2023/04 | _ |
| Bhilwara | 2023/10 | _ |
| Coimbatore | 2023/20 | _ |
| Delhi | 2023/30 | _ |
| Ichalkaranji | 2023/40 | 2023/41, 2023/42 |
| Mumbai | _ | 2023/50 |

| Total | Registered | Appeared | Passed | ATAHE | PASS % |
|---|---|---|---|---|---|
| | 13 | 11 | 08 | 03 | 72% |

## RESULTS FOR ATA PART II- DECEMBER, 2023

| Centre / Result | PASS | ATAHE |
|---|---|---|
| Ahmadabad | 2023/501, 2023/504, 2023/506 | 2023/502, 2023/505 |
| Bhilwara | 2023/510, 2023/511, 2023/512 | |
| Delhi | 2023/520, 2023/521, 2023/522 | |
| Ichalkaranji | 2023/533 | 2023/532 |

| Total | Registered | Appeared | Results | ATAHE | Passed % |
|---|---|---|---|---|---|
| | 16 | 14 | 10 | 03 | 71%- |

ATA Part II Result is with-hold for want of submission of Industrial Report.

## RESULTS OF ATA PART III - PASSED CANDIDATES DECEMBER, 2023

| Centre | Yarn Manufacture | Fabric Manufacture | Textile Wet Processing | Knitting & Garment Manufacture |
|---|---|---|---|---|
| Ahmedabad | 2023/601, 2023/602, 2023/603 | - | 2023/603, 2023/603 | - |
| Bhilwara | _ | _ | _ | _ |
| Delhi | _ | _ | _ | _ |
| Ichalkaranji | _ | _ | 2023/810 | _ |

ATA Part III Result will be declared after submission of Industrial Report.

| Candidate | Yarn Manufacture | Fabric Manufacture | Textile Wet Processing | Knitting & Garment Mfg. | Total |
|---|---|---|---|---|---|
| Registered | 03 | 0 | 03 | NIL | 09 |
| Appeared | 03 | 03 | 03 | NIL | 09 |
| Results | 03 | NIL | 03 | NIL- | 06 |

Sd/-
**Dr. G. S. Nadiger**
Chairman, P. A. C.

Sd/-
**Mahendrabhai G. Patel**
Hon. Gen. Secretary

# The Textile Association (India) – Central Office

(Registered under the Society's Registration Act XXI of 1860 and under Bombay Public Trust Act XXIX of 1950)
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Tel.: 022-2446 1145, E-mail: taicnt@gmail.com

**(Subject to Mumbai Jurisdiction)**

## Schedule of A.T.A. Part - I, II & III December, 2024

| ATA Part - I | Time 10.00 a.m. to 1.00 p.m. | ATA Part - II | Time: 2.00 p.m. to 5.00 p.m. |
|---|---|---|---|
| **Date** | **Subjects** | **Date** | **Subjects** |
| 21-12-2024 | Basic Engineering Sciences | 21-12-2024 | Principles of Yarn Manufacture |
| 22-12-2024 | General Engineering | 22-12-2024 | Principles of Fabric Manufacture |
| 23-12-2024 | Textile Fibres | 23-12-2024 | Principles of Textile Wet Processing |
| 24-12-2024 | Elements of Textile Technology | 24-12-2024 | Principles of Textile Testing and Statistics |
| 25-12-2024 | Elements of Comp. and its Applications | 25-12-2024 | Industrial Organization and Management |

## ATA Part - III - Time: 10.00 a.m. to 1.00 p.m.

**Compulsory Subjects**

| | |
|---|---|
| 21-12-2024 | Elements of Technical Textiles |
| 22-12-2024 | Man-Made Fibre Technology |

**Optional Subjects**

| Date | Yarn Manufacture Group | Fabric Manufacture Group | Textile Wet Processing Group | Knitting & Garment Manufacture Group |
|---|---|---|---|---|
| 23-12-2024 | Process Control in Yarn Mfg. | Process Control in Fabric Mfg. | Wet Processing-I | Knitting Technology |
| 24-12-2024 | Modern Yarn Manufacture | Modern Fabric Manufacture | Wet Processing-II | Garment Technology |

1. Last Date for receiving applications at unit **25th July 2024.**
2. Last Date for receiving all the applications with late fee at unit **25th August 2024.**
3. Last Date for receiving applications at the central office **25th September 2024.**

Sd/-
**Dr. G. S. Nadiger**
Chairman, P. A. C.

Sd/-
**Mahendrabhai G. Patel**
Hon. Gen. Secretary

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Tel.: 022-2446 1145, E-mail: taicnt@gmail.com

**(Subject to Mumbai Jurisdiction)**

## RESULTS FOR GMTA SECTION A/B/C PASSED CANDIDATES DECEMBER, 2023

| Centre | Section A | Section B | Section C |
|---|---|---|---|
| Ahmadabad | NIL | NIL | 203/AHC/01, 2023/AHC/02 |
| Delhi | NIL | NIL | NIL |
| Ichalkaranji | 203/ICA/01, 2023/iCA/02 | 2023/ICB/01, 2023/ICB/03, 2023/ICB/04, 2023/ICB/05 | 203/ICC/11, 203/ICC/13, 203/ICC/16, 203/ICC/17 |
| Mumbai | 203/MUB/09, 203/MUB/10, 203/MUB/11 | 203/MUB/19, 203/MUB/20, 203/MUB/21 | - |

| Candidates | Section - A | Section -B | Section -C | TOTAL |
|---|---|---|---|---|
| Registered | 05 | 08 | 11 | 24 |
| Appeared | 05 | 07 | 10 | 22 |
| Result | 05 | 07 | 06 | 18 |

**Pass 81.00 %**

## RESULTS FOR GMTA SECTION D & E PASSED CANDIDATES DECEMBER, 2023

| Centre | Section D | | | |
|---|---|---|---|---|
| | Yarn Manufacture | Fabric Manufacture | Textile Wet Processing | Apparel Manufacture |
| Ahmadabad | NIL | NIL | | |
| Delhi | NIL | NIL | NIL | NIL |
| Ichalkaranji | NIL | 2023/ICD/10/FM, 2023/ICD/11/FM, 2023/ICD/12/FM, 2023/ICD/13/FM, 2023/ICD/14/FM | 2023/ICD/10/WP, 2023/ICD/11/WP, 2023/ICD/13/WP, 2023/ICD/14/WP | 2023/ICD/21/AM, 2023/ICD/22/AM |

| Candidates | Section - D | | | | |
|---|---|---|---|---|---|
| | Yarn Manufacture | Fabric Manufacture | Text. Wet Processing | Apparel Manufacture | Total |
| Registered | NIL | 05 | 07 | 04 | 16 |
| Appeared | NIL | 05 | 06 | 04 | 15 |
| Passed | NIL | 05 | 05 | 03 | 13 |

**Pass 86.00%**

| Candidates | Section - E | | | | |
|---|---|---|---|---|---|
| Ahmadabad | 2023/AHE/01 | | | | |
| Delhi | 203/DED/10, 202/DED/11 | | | | |
| Ichalkaranji | 203/ICE/21 | | | | |

| Candidates | Section - E | | | | |
|---|---|---|---|---|---|
| Registered | 06 | | | | |
| Appeared | 04 | | | | |
| Results | 04 | | | | |

Results are withheld for want of submission of the Project Report.

Sd/-
**Dr. G. S. Nadiger**
Chairman, P. A. C.

Sd/-
**Mahendrabhai G. Patel**
Hon. Gen. Secretary

# The Textile Association (India) – Central Office

(Registered under the Society's Registration Act XXI of 1860 and under Bombay Public Trust Act XXIX of 1950)
702, Santosh Apartment, 7th floor, 72-A Dr. M. B. Raut Road, Dadar (W), Shivaji Park, Mumbai – 400 028
Tel.: 022-2446 1145, E-mail: taicnt@gmail.com

**(Subject to Mumbai Jurisdiction)**

## Schedule of G.M.T.A. Examination December 2024

| Section A<br>Date | Time 10.00 a.m. to 1.00 p.m.<br>Subject No. & Title | Section B<br>Date | Time: 2.00 p.m. to 5.00 p.m.<br>Subject No. & Title |
|---|---|---|---|
| 21-12-2024 | A-1 Engineering Physics | 21-12-2024 | B-1 Yarn Manufacture |
| 22-12-2024 | A-2 Engineering Chemistry | 22-12-2024 | B-2 Fabric Manufacture |
| 23-12-2024 | A-3 Engineering Mathematics | 23-12-2024 | B-3 Textile Wet Processing |
| 24-12-2024 | A-4 General Engineering | 24-12-2024 | B-4 Apparel manufacture |
| 25-12-2024 | A-5 Professional Orientation | 25-12-2024 | B-5 Textile Testing |

| Section C<br>Date | Time 10.00 a.m. to 1.00 p.m.<br>Subject No. & Title |
|---|---|
| 21-12-2024 | C-1 Textile Fibre Science |
| 22-12-2024 | C-2 Polymer Technology |
| 23-12-2024 | C-3 Textile Engineering Mechanics |
| 24-12-2024 | C-4 Applied Statistics |
| 25-12-2024 | C-5 Data Management and Information System |

| Date | Section D - Time: 2.00 p.m. to 5.00 p.m. | | | |
|---|---|---|---|---|
| | Yarn Manufacture | Fabric Manufacture | Text. Wet Processing | Apparel Manufacture |
| 21-12-2024 | Short Staple Yarn Mfg. | Advanced Fab. Manufacture | Wet Proc-Pre Treat. & Bleaching | Apparel Technology |
| 22-12-2024 | Long Stap & other Yarn Mfg. | Knitting Technology | Wet Proc.-Dyeing | Supply Chain Mange in Apparel Mfg. |
| 23-12-2024 | Engg Design & Yarn Structure | Engg. Design of Fab. Structure | Wet Proc-Printing & Finishing | Apparel Merchandising |
| 24-12-2024 | Process & Quality Management & Yarn Mfg. | Process Control & Qual. Mrkt in Fab. Mfg. | Analytical Chem. In Textiles | Garment Proce. Tech. |
| 25-12-2024 | Man-made Fibre Technology | Fabric Structure & Design | Processing & Quality Manage In Wet Proce. | Process Control & Quality Manage in Apparel Mfg. |
| **Optional Papers** | | | | |
| 26-12-2024 | Specialty & High Performance Yarns(s) | Non-Woven Technology | Colour Tehory & Col. Matching | Social & Trade Compliances |
| 27-12-2024 | Silk Reeling & Throwing Technology | Technical Textiles | Effluent Treat & Eco Friendly Proce. | Garment Acces. & Fashion Forecasting |
| 28-12-2024 | Quality & Envir. System in Yarn Mfg. | Quality & Environment Systems In Fab. Mfg. | Quality & Environ System in Wet Proc. | Visual Merchandising |

| Section E<br>Date | Time 10.00 a.m. to 1.00 p.m.<br>Subject No & Title |
|---|---|
| 24-12-2024 | E-1 Industrial Engg. & Mill Management |
| 25-12-2024 | E-2 Energy Environment & Efficiency in Textiles |
| **Optional Papers** | |
| 26-12-2024 | EOD-1 International Trade Management |
| 27-12-2024 | EOD-2 Control Systems in Textile Machines |
| 28-12-2024 | EOD-3 Entrepreneurship Development |

1. Last Date for receiving applications at unit 25th July 2024.
2. Last Date for receiving all the applications with late fee at unit 25th August 2024.
3. Last Date for receiving applications at the central office 25th September 2024.

Sd/-
**Dr. G. S. Nadiger**
Chairman, P. A. C.

Sd/-
**Mahendrabhai G. Patel**
Hon. Gen. Secretary

# JOURNAL OF THE TEXTILE ASSOCIATION

**VOLUME 82 – MAY 2023 TO APRIL 2024**

**SUBJECT INDEX**

**FORM IV (See Rule 8)**

Statement about Ownership and other Particulars about Newspaper

**JOURNAL OF THE TEXTILE ASSOCIATION**

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|---|---|
| 1. Place of Publication | : The Textile Association (India), Central Office<br>702, Santosh Apartment, 7th Floor, 72-A, Dr. M. B. Raut Road,<br>Shivaji Park, Dadar (W),<br>Mumbai – 400 028 MS |
| 2. Periodicity of Publication | : Bi-Monthly (Six issues in a year) |
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| 4. Publisher's Name<br>Nationality<br>Address | : Shri J. B. Soma<br>: Indian<br>: 701, C Wing, Kalpak Shrushti,<br>Behind Sun Gloria Complex, Dalvi Nagar,<br>Ambegaon Budruk,<br>Pune – 411 046 MS |
| 5. Editor's Name<br>Nationality<br>Address | : Dr. Aadhar Mandot<br>: Indian<br>: HoD, Textile Dept.,<br>The M. S. University of Baroda,<br>Pratapgunj,<br>Vadodara - 390 002 GUJ. |
| 6. Name and address of individuals who own the newspaper and partners holding more than 1% of the total capital | : The Textile Association (India), Central Office<br>702, Santosh Apartments, 7th Floor,<br>72-A, Dr. M. B. Raut Road,<br>Shivaji Park, Dadar (W),<br>Mumbai – 400 028 MS |

I, J. B. Soma, hereby declare that the particulars given are true to the best of my knowledge and belief.

Mumbai
1st APRIL 2024

(Sd/-)
**J. B. SOMA**
Hon. Asso. Editor & Publisher


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