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## Use of recycled cotton for making composite material used for different applications: An overview

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### Abstract

Textile preforming plays an important role in composite technology that is widely used as reinforcing materials. The main advantages of woven composites are their cost efficiency and high process ability, particularly in lay-up manufacturing of large-scale structures. Textile reinforced composites based on natural fibers have been studied by many research groups in recent years due to their good mechanical performances, easy to handle, excellent integrity. Natural fiber composites help in preserving the fast depleting non renewable resources (petroleum feed stocks), which are the main source for practically every material used in present applications. Thus, the Natural fiber composites have come to bridge this gap and take materials closer to Green Composites (GC) for the future in view of their complete or partial bio degradable nature. Natural fibres are rich in cellulose and they are cheap and available in abundant for polymer reinforcement and it is also a potential alternative to the fibers of glass, carbon and other synthetics materials used for the manufacturing of composites. For reinforcement of natural fibre in composites, several problems occur along the interface due to the presence of hydrophilic hydroxyl groups on the fibre surface. This hydrophilic nature hinders effective reaction with the matrix. In addition to this, pectin and waxy substance covers the reactive functional groups of the fibre and act as a barrier to interlocking with the matrix. To optimize effective interfacial bonding between fibre and matrix, the fibre surface needs to be modified with different chemical treatment, reactive additives and coupling agents. Chemical treatments expose more reactive groups on the fibre surface and thus facilitate efficient coupling with the matrix. As a result, better mechanical and thermal properties of the composites can be achieved.

**Keywords:** Composite, Natural Fibres, Textile, Reinforcement, Cellulose.

### Introduction

Cotton accounts for 40% of the total global fibre production and is the most important fibre in the world. Cotton as a crop as well as a commodity plays an important role in the agrarian and industrial activities of the nation and has a unique place in the economy of our country. Each part of cotton plant is used for various purposes. Cotton linters are used in making banknote and security paper, tea bags, filters, sausages casing and electrolyte condenser. Cotton stalk is used for making particle boards preparation of pulp, paper, hard board, corrugated boards, boxes and for growing edible oyster mushrooms. Cotton seed is used for animal feed. In India cotton is used extensively for apparel purpose. It has many qualities which make it suitable for apparel purpose such as absorbency, strength, easily spinnable, washability, good conductor of heat which leads to comfort in wear during hot weather. A significant amount of fibrous waste from the textile industry during textile processing and post-consumer product is disposed worldwide. This is not only a cause for environmental concern, but also represents a waste of useful resources. For economic and environmental reasons, in recent years, increased emphasis has been placed on reusing techniques for various fibrous waste products from textile industries and industries and research organizations are now looking for applications where waste materials may represent an added-value material. Though a variety of technologies have been developed in response to customer demands for recycled products and as alternatives to land filling. The cotton pipeline has a significant environmental responsibility to fulfill.

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**Some important facts****Waste**

- 10-20% of all textiles in the fashion industry are estimated to be wasted.
- About 15% of fabric intended for clothing ends up on the cutting room floor. This waste rate has been tolerated industry-wide for decades.

**Used Clothing**

- Over 70% of the world's population use second hand clothes.<sup>4</sup>
- The world supply of used women's clothing is at least seven times that of men's.<sup>6</sup>

**Recycling**

- Using recycled cotton saves 20,000 liters of water per kilogram of cotton, a water-intensive crop.
- Up to 95% of the textiles that are land filled each year could be recycled.

Recycling of textile waste gives fibre a second life in a rejuvenated life cycle and thus increases the total value of the fibre. Much recycled fibre ends up in low value products. The development of new, higher value products from recycled fibres will encourage utilisation of the fibres and contribute to the future sustainability of the cotton industry. Therefore, the reuse and recycling of fibers provide environmental and economic benefits, for instance:

- ❖ Reducing cost of purchasing materials.
- ❖ Increasing profitability.
- ❖ Minimizing costs of disposal and treatments.
- ❖ Minimizing environmental impacts by reducing use of new raw materials and producing products from earlier one.
- ❖ Textile recycling requires less energy than any other type of recycling.
- ❖ Textile recycling does not create any new hazardous waste or harmful by-products.

Recycling the solid waste may be defined as the recycling of material and its reuse which could include repair, re-manufacture and conversion of materials, parts and products. Traditionally solid waste management has evolved as mainly the removal of municipal wastes by hauling them out of the city boundaries and dumping them "there". This is in conformity with the „out of sight out of mind“ philosophy. However, recycling is currently accepted as a sustainable approach to solid waste management. Recycling of material from solid wastes helps the community economically, environmentally, socially and ecologically. Recycling is a key concept of modern waste management. Recycling is the reprocessing of waste materials into new or reusable products. Ninety-nine percent of used textiles are recyclable.

The pre-consumer textile waste in India has a number of applications based on the fibre composition. Cotton waste has a number of applications like paper making, surgical products like bandages and pads, Open End spinning, automobile industry, tissue paper manufacturing or in the nonwoven industry, bedding, manuring for mushrooms, and more. Cotton waste is also exported to other foreign countries from India after it is cleaned and the required standard is attained. V P Udyog Limited, Kolkata, India is an exporter of refined cotton waste from comber noil and card, yarn waste, hosiery waste from India to countries like England, France, Malaysia, Thailand, China, Taiwan, Hong Kong and Singapore. Anandi

Enterprises of Tirupur, India manufacture and export quality certified recycled dyed and mélange yarns and recycled fabrics from cotton and polyester. Industries like this produce contamination free waste that has varied applications across key industries.

Post-consumer textiles wastes are also up-cycled in small Indian clusters. Traditionally, fabric from old cotton *sarees* are made into layers and stitched together using run stitches, to give a unique design effect. This product termed as "Kantha" is used for infants and children as blankets and wraps as it is soft and suitable for the Indian climatic conditions. *Kantha* work is famous in the eastern states of India like Bihar, West Bengal, Assam and Orissa.

**Composites****Definitions**

1. "A composite can be defined as a material having two or more chemically distinct phases, which at the microscopic scale are separated by a distinct interface."

Or

2. "A composite material (also called a composition material or shortened to composite) is a material made from two or more constituent materials with significantly different physical or chemical properties that, when combined, produce a material with characteristics different from the individual components. The individual components remain separate and distinct within the finished structure, differentiating composites from mixtures and solid solutions."

We can also say that a composite is a combination of properties of two or more components held together by the same type of matrix. In essence, a composite is a commodity having superior properties than the individual constituents. Composites, the wonder materials with light weight, high strength to weight ratio and stiffness properties have come a long way in replacing the conventional materials such as metals and wood.

Composites can be mainly categorized on the basis of matrix and type of reinforcement. The classifications according to matrix type are ceramic matrix composites (CMC), polymer matrix composites (PMC) and metal matrix composites (MMC). The classifications according to type of reinforcement are particulate composites (composed of particles), fibrous composites (composed of fibres) and laminate composites (composed of laminates). Fibrous composites can be further sub-divided on the basis of natural/biofibre or synthetic fibre. Biofibre encompassing composites are referred to as biocomposites. Biocomposites can be again divided on the basis of matrix i.e. non-biodegradable matrix and biodegradable matrix. Biocomposites made from natural/biofibre and biodegradable polymers are referred to as green composites. These can be further sub-divided as hybrid composites and textile composites. Hybrid composites comprise of a combination of two or more types of fibres.

**Natural Fiber Composites**

The bio-composites referred to herein are composites that combine natural fibres such as kenaf, jute, hemp, and sisal with either biodegradable or non biodegradable polymers. In terms of the reinforcement, this could include plant fibres such as cotton, flax, hemp and the like, or fibres from recycled wood or waste paper, or even by-products from food crops.

The usage of natural fibre as reinforcement for composites application is receiving increased attention. Natural fibres are lighter, less expensive, have superior specific strength, require comparatively less energy to produce, good for the environment, biodegradable. Natural fibers combined with traditional plastics offer good performance at lower prices creating huge potential to replace competing materials in automotive applications where even a fractional weight saving can make a significant contribution to energy savings with reduced gasoline consumption and with added advantages of ecofriendliness. Natural fiber production has lower environmental impact compared to traditional synthetic fiber production. The light-weight natural fibre composites can help in improved fuel efficiency and reduced emission in the use phase of the component especially in automotive applications. As well, end of life incineration of natural fibres results in recovery of energy and carbon credits.

#### **Use of Recycled Cotton for Making Composite Materials**

The composites reinforced by the recycled fibres show similar mechanical properties as those reinforced by virgin plant fibres such as cotton and flax that are traditionally used in composites. Natural fiber composites have gained considerable value in the current market because of their "green" recyclable tag as well as the set of engineered properties they present. Since the early 1900's researchers have attempted to make composites from polymers reinforced with cotton and paper. Only recently have the natural fiber reinforced polymer composites gained more interest and importance than the traditional glass and mineral reinforced composites due to the increasing environmental pollution and stricter environmental policies. Glass fiber or minerals increases the density of the composites, and as such the part specific weight, leading to an increase in energy consumption especially in the automotive and transport industry and not self decomposing or biodegradable which hinders their disposal at the end of their life cycle poses a serious environmental problem. The incineration as well as land dumping of these composites causes air and land pollution which is not desirable in the present or for the future. In view of these concerns considerable research has expanded in the field of making green composites reinforced with fibers obtained from natural resources. For fiber reinforcement, normally scientists prefer thermoplastic polymeric matrices than thermosets due to the low production cycle, lower cost of processing and high reparability of thermoplastics. The largest single category of nonwoven textiles is for personal care and hygiene products. The short life cycles (many are single-use products) enable large production volumes and reliable revenue flows. Cotton fiber properties are excellent for these types of products and are compatible with some of the major technologies used to produce them.

Spinning is one of the vital industries of India and the 4000 ginning factories around the country produce considerable amount of waste during cotton ginning operation. Most of the mills, recover the useful short fibers from the blow room waste by passing them through willow machines, that in-turn leaves a non resalable residue called "willow waste". The scope of the waste from cotton industry extends its products to upholstery cloth, curtain cloths, cover cloths, blanket, towels, shirting, quilts, underwear, carpet, industrial roller cloth, electric cabling, hosiery and in the manufacture of asbestos yarn, paper, linoleum, plastic and regenerated fibers. Focusing on willow waste, it is too short a fiber, to be used for any textile application and thus disposed off in the

landfills. An investigation report denotes that, the total amount of willow waste generated in India is about 80, 000 to 85, 000 tons per annum, and this obviously needs proper treatment apart from disposal as landfill.

There is good opportunity to utilise low value virgin and waste cotton fibre, cotton stem fibres and even gin trash as the fibre reinforcement in composites for a range of applications. Several studies have been carried out in order to investigate the mechanical behaviour of textile waste fiber based composites. The usefulness of cotton waste as a source of reinforcing fibers for the preparation of cost-effective and biodegradable composites has also been studied. The most common textile waste is denim. Denim is very strong, stiff and hard wearing woven fabric. The fabrics used for today's denim jeans vary. The widely used denim jeans are 100% cotton, 60% cotton/40% polyester, 50% cotton/50% polyester and 60% polyester/40% cotton. Some denim used for jeans is a blend of cotton, nylon and polyester. Denim is twill weave fabric that uses colored warp and white weft yarn. From a previous investigation, it was observed that denim fabrics have high rigidities, better tear characteristics, moderately sufficient tensile and elevated performance. It is estimated that about 2.5 billion yards of denim is produced every year all around the world. Approximately 1600 pieces of denim will divert 1 ton of waste from the landfill, when recycled. The weight of 1.2 metres of denim is approximately 1.0 kg, therefore the wastage factor for the garment manufacturers is 253 kg for 4000 kg of material processed, or 6.3%. So, the recovery and reusing of denim wastes help to maximize the economics and opportunities by applying this to the supply chain from denim manufacture through to the finished garment. In current researches, waste denim fibers have been used as the reinforcement element to develop a new set of polypropylene matrix composite. The novel and environment friendly composites have been developed to study the mechanical and thermal properties of the new composites.

Agricultural fibres such as cotton has been used to produce hardboards and have shown better properties compared to the rice straw composition boards. The following are the advantages if cotton stalks are used for the purpose of preparing composite boards:

- ❖ Additional income to farmers
- ❖ A new material for composite board industry
- ❖ Avenues for setting up rural industry
- ❖ Employment opportunities for rural youth
- ❖ Conservation of forest resources

Cotton has long been a dominant natural fiber in the textile industry. Low quality greige fibers or low value textile wastes predominantly consisting of cotton fibers that could not be used directly in the apparel industry, have a high potential in the manufacturing of composite nonwovens that are quite promising materials in the insulation market, especially in the automobile insulation market.

#### **Use of cotton blends in composite materials:**

The demand for natural cotton fibres and poly/cotton blend fibres have increased significantly in the past decade Novolac type phenolic composites reinforced with jute/cotton hybrid woven fabrics was fabricated and its properties were investigated as a function of fibre orientation and roving fabric characteristics. The researchers are of the opinion that jute fibre promotes a higher reinforcing effect and cotton fibre avoids catastrophic failure. Therefore, this combination of

natural fibres is suitable to produce composites for lightweight structural applications.

The thermal diffusivity, thermal conductivity and specific heat of Jute/cotton, sisal/cotton and ramie/cotton hybrid fabric-reinforced unsaturated polyester composites were investigated. These properties were measured both parallel and perpendicular to the plane of the fabrics. The results obtained show that higher values were obtained parallel to the plane of the fibres. Sisal/cotton composites showed a particular behavior, with thermal properties very close to those of the resin matrix.

Bio-composites have been used widely for making building products such as window, door, siding, fencing, roofing, decking, and so on. Bio-composites have been classified with respect to their applications in building industry into two main groups: structural and non-structural bio-composites. A structural bio-composite can be defined as one that is needed to carry a load in use. For instance, in building industry, load bearing walls, stairs, roof systems, and subflooring are examples of structural bio-composites. Structural bio-composites can range broadly in performance from high performance to low performance materials. A non-structural bio-composite can be defined as one that is not needed to carry a load in use. Materials such as thermoplastics, wood particles, and textiles are used to make this kind of biocomposites. Non-structural bio-composites are used for products such as ceiling tiles, furniture, windows, doors, and so on.

India is basically an agricultural country. Around 70% people make their living on agricultural related work. But in past few years there is a rapid migration of population from villages towards big cities. This has caused social imbalance along with crowding of cities thereby putting thrust on basic amenities in big cities, namely food, cloth and shelter. Demand of shelter has given rise to demand of building materials like bricks, cements, steel, etc. Since, the production of building materials is limited, their prices are sky touching and due to fast production, quality is being also suffered bricks made up from paper mill sludge and cotton waste can reduce the above problem to some extent by using this composite bricks. This will also produce economical building material since the waste is reused which would otherwise have been wasted. Recent trend indicates that there is a continuous doubling of rates of building materials in a span of five years. The composite bricks which made from paper mill sludge and cotton waste have many advantages like-Economical, Environmental friendly, equal compressive strength, water absorption and bulk density as compared with traditional clay bricks.

### Applications of Composite Materials

These composites are being used increasingly in:

- ❖ Automotive Parts
- ❖ Furniture
- ❖ Building
- ❖ Packaging Materials

### Conclusion

Textiles in India are recycled both for the domestic and the global market. In the domestic market recycled textile products are generally found in the form of floor mats, wipes and rugs. The fibres extracted during recycling of clothing are converted into recycled yarns and it is used in different textile products and also as fillers. The pre-consumer cotton wastes are a source of raw material for the paper industry. Today, in

the world of modern technologies, the demand for production is increasing so rapidly in all aspects of the required living commodities. In order to meet all the required demands, over production and utilization of all resources seem not enough. Therefore, the increasing demand for textile making huge clothing production is not only based on demand for more population but it's also changing new fashion habits as well. Improving raw material exploitation has become the most important challenge facing scientific and industrial community. Textile production wastes are undesirable but inevitable by-products in many manufacturing process (spinning, weaving, knitting, or garment manufacturing) and are frequently undervalued. However, if one can convert such wastes into useful product economically, there will be great contribution to the market. bio-renewable resources offer an almost limitless supply of renewable and potentially sustainable raw materials for the production of bio composites. Although in its infancy, there is a growing market for bio composite-based products and with further development a whole host of new applications can be envisioned. There is a huge range of potential reinforcing fibres/fillers and an extensive range of processing options to ensure the right fibre at the right price.

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