

Introduction

1. INTRODUCTION

Today's textile industry trend is towards manufacturing high tech, high performance fabrics designed not just to look attractive, but to offer a significant added value in terms of functionality. The two main reasons which make the Indian textile industry strong are, export earnings and employment opportunities. The Indian textile industry is the second largest provider of employment after agriculture offering direct and indirect employment to millions of people. The competitive advantage that India had in terms of its labour cost has been eroding slowly and smaller nations such as Bangladesh and Vietnam due to cheaper labour and trade agreements with the US and Europe are gaining advantageous positions with regard to foreign trade. More recently, the decreases in the consumer spending and the global economic recession have forced the Indian textile industry to start thinking seriously about technical textiles.

Marwaha et al. (2006) express that man has been using textiles since the primitive age and as the civilization progressed, the applications also expanded due to the globalization of science and technology, which propelled three emerging technologies, through biotechnology, micro electronics and materials science. Many products have been developed which are used in greater volumes as "technical textiles". Technical textiles are the fastest growing area of textile consumption in the world. The definition of technical textiles, adopted by the authoritative textile institute are textile materials and products manufactured primarily for their technical use and performance rather than their aesthetic and decorative characteristics.

Technical textiles are semi finished or finished textiles and textile products manufactured for performance characteristics ; they are used in industry, civil engineering, medical, protective, institutional and leisure applications. The most common textile products in this category include high performance fibres, ropes, webbings, tapes, filter media, paper making felts and fabrics, heat and sound insulators, coated fabrics, protective clothing, composites, agro textiles, geo textiles and medical and hygiene products. Audet and Safadi (2004) express that technical textiles are growing roughly twice the rate of textiles for the clothing industry, where growth rates have been about two per cent a year in recent years. In areas such as

ecological protective textiles, geo textiles or protective textiles the growth rate may be twice that of the clothing sector or even more.

Technical textile is also known as industrial textiles, functional textiles, performance textiles, engineering textiles, invisible textiles and hi-tech textiles (www.fibre2fabric.com/industry-article/29/2857/applicationtechtext). The technical textile consumption would grow to Rs.78,060 crores by 2014-2015 with an annual growth rate of 14 per cent. Till date Indian textile industry is barely able to support the country's demand, express Rakshit et al. (2007). Technical textiles offer new ways, means and opportunities to Indian textile industry to sustain the present growth and thrive in the near future. Present product mix and traditional textiles are not remunerative enough and therefore, more and more ideas of value addition to textile products is gaining momentum. Technical textiles in this context are just perfect. Growing awareness about risk to health and damages to the environment have been noticed in the last few years and particularly in the past one decade all over the world, which has necessitated eco-friendly approaches in production of articles of use in day-to-day life, express Muthumanickam and Prasad (2005).

Natural fibres can be defined as bio-based fibres or fibres from vegetable and animal origin, globally the natural fibre industry provides employment to millions of people. Natural fibres play a key role in emerging green economy. Natural fibres are more environment friendly than synthetic fibres both in terms of production and disposal due to their biodegradable property. Unlike synthetic fibres which are largely produced from crude oil, a non renewable source of energy, natural fibres are renewable resources. Natural fibres are carbon neutral, they absorb the same amount of carbondioxide that they produce. Also the wastes produced during processing of natural fibres are mainly organic wastes and residues that can be further processed to generate electricity or make ecological housing material.

The major plant based natural fibres includes cotton, banana, pineapple, palm, sisal, hemp, flax, ramie, bamboo, screw pine and water hyacinth. Cotton, the King of fibres is a unicellular fibre obtained from the seed of cotton plant which belongs to Malvaceae family. Cotton is the backbone of the world's textile trade. It is the oldest textile fibre with great economic importance as a raw material for textiles. In recent years, the increasing demand for pollution free and eco-friendly textile

goods has put more pressure on cotton textiles. In this context, jute being a natural fibre has a lot of potential to supplement cotton wherever there is possibility of using it. Natural fibres, jute, sisal and kapok are considered for use in seats as alternatives to polyurethane foam due to the benefits related to moisture absorbency and environmental advantages, suggest Fung and Hardcastle (2001).

Jute is extracted from the bark of the white jute plant *Corchorus capsularis* and to a lesser extent from *C. olitorius* (Tossa jute). Jute fibre, also called as golden fibre is one of nature's strongest vegetable fibres and has high insulating and antistatic property, moderate moisture regain and low thermal conductivity. Bangladesh and India are the main producers of jute in the world. It is also blended with other fibres and used in making cushion covers, wall hangings and toys. Geo textiles are also made from jute.

Hemp fibre is obtained from the bark of the plant *Cannabis sativa* L., it grows to a height of four metres without agro chemicals and captures large quantities of carbon. Currently India is strongly present in the map of hemp producing countries. Hemp fibre is a good conductor of heat. It resists mildew, obstructs ultra violet rays and has natural antimicrobial properties. It is very stiff and strong and used to make ropes, canvas and paper, it can also be woven into fabric for clothing and home furnishing. It is also used to reinforce moulded thermoplastics in automobile industries.

Coir is extracted from the tissues surrounding the seed of coconut palm *Cocos nucifera* and is of two types, white coir and brown coir. Coir has high concentration of lignin making it stronger but less flexible than cotton and unsuitable for dyeing. It has good resistance to microbial action and salt water damage. White coir is used in the manufacture of ropes and fishing nets, while brown coir is used in making brushes, door mats, rugs, mattresses, insulation panels and packaging materials.

Sisal is a leaf fibre of *Agave sisalana*, a plant which can withstand extreme climatic conditions and grow in drought prone, uncultivable, arid and mountainous conditions. Sisal industry in India is largely unorganized. It is grown in arid and

semiarid regions of Andhra Pradesh, Bihar, Orissa, Karnataka and West Bengal. These fibres are hard, coarse, strong, durable and accept wide range of dyes.

Agave americana plant of Mexican origin belongs to Agavaceae family has powdery blue-grey leaves, produces a gigantic flower after attaining full height, the size of the plant is 5-7 feet high, spread over 8-12 feet. These fibres are stiff, strong and used for making ropes and handicraft items. *Agave americana* plant has more than 200 species all over the world. *Agave americana* is very large plant and will take up an area of at least two by two metres in a garden, once it has reached maturity. The best thing about *Agave americana* is that it thrives with no care at all. It handles drought and needs only little irrigation. Apell and Garden (2001) express that *Agave americana* the bold and brassy Mexican succulent is a classic architectural plant. It is silvery blue-green in colour with stiff needle protruding at the leaf apex.

Blending of fibres is now one important growth area of textile production as it leads to improvement in properties.

Kaplan (2002) is of the opinion that fibre blending facilitates processing, improves properties, increases absorbency, adds warmth, improves dimensional stability, resists wrinkling and adds in producing multi-colour fabrics. Singh and Goel (2001) express that a mixture is a combination of different yarns along the length and width of the fabric which helps in exploiting the outstanding positive attribute of each fibre and at the same time offers an effective means of minimizing the negative characteristics of individual component.

Enzymes are complex protein ferments secreted by living organisms capable of catalyzing chemical reaction of nature. Enzymes accomplish their work quietly and efficiently without leaving any pollutant behind. Enzymes for textile use include amylase, lipases, pectinases, cellulases, proteases and catalases. Biopolishing is an important finishing treatment carried out on cellulosic fabrics using acid cellulases to impart gloss, luminosity, colour, resistance to pilling, cooler feel and clean surface. Many of the enzyme applications have become well established but not yet been successfully industrialized due to technical or cost constraints.

The main environmental problems associated with the textile industry are typically those associated with water body pollution due to the synthetic chemical used in wet processing, air emission, excessive noise or odour and workspace safety. The natural dyes are non-pollutant, non-allergic, eco-friendly, shade rich and warm. They are soft in colour, cool to the eyes and good to the skin. Madder is considered the 'Queen of Reds'. It has an extensive history in Turkey, India and Iran where it is still used. Lac was used for centuries in India which is widely used in England. Catechu is known as Cutch was first introduced around 1800 in Germany. It gives shades of brown (<http://www.techexchange.com/thelibrary/naturaldyes.html>). Mordant is a chemical that aids attachment of a dyestuff to fibres by bonding to both the fibre and the dye and affects the hue produced with certain dye stuffs. Mordants are necessary for dyes that have very low or no natural affinity for the fibre. Mordants can be applied before, with, or after the dye depending on the nature of the dyeing the fibre and the mordant, says Duerr (2011).

Natural fibres are used in the field of technical textiles in the form of woven, knitted or nonwovens. The nonwoven fabric preparation requires less time, fibre, labour and equipment than weaving. It is cost advantageous. Kothari (2004) stresses that the fastest growing family of manufacturing methods for technical products in nonwovens which covers a wide range of technologies like dry laying of webs, thermal means, entanglement needle punching, wet lying, spun lying, blowing and bonding.

The weave describes how the warp and weft yarns in the fabric are interlaced. Weave determines the ability to drape and isotropy of strength. The plain weave is highly interlaced and is consequently, one of the tighter fabric constructions and very resistant to in-plane shear movement. It has good stability and reasonable porosity, stress Balaguru et al. (2008). Ribbed weave is one of the plain weave variations, which is formed by using heavy yarns in the warp or filling direction. It is characterized by slight ridge effect in one direction usually in the filling, feels Operath (2006).

Nonwovens are produced by various techniques namely needle punching, stitch bonding, thermal bonding, hydroentangling and spun bonding of which needle punching is the oldest technique.

The nonwoven processes utilize fibres as fabric forming material and so the sequence of operations is usually very much reduced as compared to weaving and knitting. Nonwovens have many advantages of resistance to tears, soil, chemicals, puncture, UV light exposure, mildew, rot, freeze, excellent strength, breathability, barrier properties and being cost effective for the applications in textiles. Needle punching is a process of bonding nonwoven web structures by mechanically interlocking the fibres through the web. It is the oldest and well established method of forming nonwoven textile materials. Needle punching refers to mechanical bonding, strengthening the web interfibre friction as a result of the physical entanglement of the fibres.

The machine direction of grain of felt fabric in the length which comes out perpendicular from the machine is synonymous to warp in woven material and the dimension at right angles to the machine is cross grain in synonymous to weft grain in woven material. The manufacturing cost of needle punched nonwoven fabric is much lower in comparison with other methods of fabric manufacture as the production rate of needle punched nonwoven fabric is many times more in comparison to woven.

Technical textiles can be divided into many categories depending on their end use which are, agro tech, mobil tech, build tech, cloth tech, geo tech, home tech, indu tech, oeko tech, pack tech, pro tech and sport tech. Clothing textiles, also known as cloth tex, including all those textile products that represent functional, most often hidden components of clothing and foot areas, such as interlining, sewing threads, insulating fibrefill and maddings. Rapid modernization and changing preferences of consumers, exporters of buyer of higher quality of products has transfigured. The Indian Home tex the industry where fashion and performance play a crucial role. The fact changing dynamics of the industry has given rise to opportunity for high fashion and technical homal textile products. Domestic textiles, also known as home tex, used in making of many home furnishing fabrics including carpet backings, curtains, wall coverings and cushion materials. It also includes table linen like table cloths, runners, place mats and table napkins. A major technical apparel fabrics application area is personal protective wear such as outer garments for the services industry for foul weather or protection against petrol, blood and body fluids and chemicals.

Inherently fire-retardant fibres make up the fabric for appropriate enduses, suggests Buckley (2003).

Textiles used in agriculture are termed as agro textiles. They are used for crop protection and fertilization. The essential properties required are strength, elongation, stiffness and biodegradation, resistance to sunlight and resistance to toxic environment. All these properties help with the growth and harvesting of crops and other food stuffs. There is a growing interest in using materials which gradually degrade (biodegradables). Mulch increase yield, water use efficiency and profitability, while simultaneously decreasing weed pressure. They also express that through proper mulching, the problems of surface evaporation and soil moisture deficit in dry season can be solved to a great extent, recommend Sarangi et al. (2010). Haque et al. (2003) say that natural mulches that are abundantly available and cheaper were found better than synthetic mulches, further adds that transparent polythene mulch had negative effect on growth. Kumar and Singh (2010) express that weeds compete with crop plants for soil moisture, nutrients, light and space. When improved production technology is adopted the weed management becomes more important so as to improve the efficiency of applied inputs. Although weeds emerge simultaneously with crop plants due to their better adaption and survival mechanism under adverse conditions and also due to their fast growing habit they over power crop plants.

Geo textiles have four primary uses in foundation engineering namely drainage, filtration, separation and reinforcement. Drainage-fabrics can rapidly channel water from soil in various outlets thereby providing a higher soil shear strength and hence stability, filtration – when placed between two soil layers, one coarse grained and another fine grained, the fabric allows free seepage of water from one layer to the other, separation – geo textiles help keep various soil layers separate after construction and during the projected service period of the structure and reinforcement – the tensile strength of geo fabrics increases the load bearing capacity of the soil, expresses Das (2010). When a geo textile is placed between the subsoil and the granular sub-base of an unpaired road, it prevents the aggregate from being punched down into the soil during initial compaction and subsequently from the dynamic loading of vehicles. A geo textile made from natural fibres such as

jute, coir and so on would be more suitable for such applications, because it would be biodegradable and hence more environmentally friendly, feel Pariti et al. (2006).

The surface laid natural geo textile contribute nothing to soil strength, but once they degrade and the fibres are incorporated into the soil, they may then reinforce the soil, narrates Calkins (2009). Geo textiles are permeable fabrics and are used with soils having ability to separate, filter, protect or drain. The applications include civil engineering, earth and road construction, dam engineering, soil sealing and drainage systems. The fabric used in it must have good strength, durability, low moisture absorption and thickness. Mostly nonwoven and woven fabrics are used for this. Geo textiles include ground retaining, biodegradable matting designed to prevent soil erosion especially to stabilize new plantings while they develop root systems along steep highways banks to prevent soil slippage or ground cover designed to reduce weeds in planting beds.

Asifhanif et al. (2005) emphasize that the water from the agricultural fields contain certain chemicals which are taken off by the storm runoff water. This water mixes with the river causing pollution. This could be prevented by filtration methods. The natural biodegradation of the lignocellulosic fibres can be considered to be an important advantage in temporary applications. Geosynthetics need to be removed after a period of time as these ensure considerable disturbance and are relatively expensive. These drawbacks are avoided in natural geo textiles. Clark and Deswarte (2008) say that biodegradable jute geo textile left to rot on the ground keeps the ground cool and is able to make the land more fertile.

Marsalek et al. (2001) say that the treatment process applicable to a small scale is filtration storm water sand filters which were introduced in USA and found effective in removing pollutants. They also recommend fibre cloth for separation layer between soil and crushed bricks to allow plant growth. The global water situation is steadily worsening because polluted ground water, rivers and lakes over-enriched and dirty seas, and water shortages within the growing populations of the less developed world. Metals and their compounds persists in the environment and can be a serious problem in raw water treatment, especially from ground water sources or surface water with a high proportion of agricultural run-off content. They may

accumulate in organisms particularly those near the top of the food chain, and cause a range of toxic effects, says Sutherland (2008).

Agave americana, cotton, jute and hemp fibres are all natural fibres, biodegradable, having salient individual properties ; when combined, these would yield positive attributes thereby overcoming negative ones. Keeping all the above factors in mind the researcher decided to take up a study on “**EXTRACTION AND FABRICATION OF *Agave americana* FIBRES INTO WOVEN AND NONWOVEN STRUCTURES, WITH COTTON, JUTE AND HEMP FOR SELECTED TECHNICAL TEXTILES**”.

Hence the objectives of the study were

- Separation of fibres from *Agave americana* leaves
- Conversion of *Agave americana* fibres into yarns and fabrics.
- Fabrication of *Agave americana* fibres into needle punched structure by blending
- Application of special finishes on fabrics and evaluation
- Construction of selected fabric structure into apparels
- Creation of enduses for selected fabrics in home textiles
- Application of the selected structure in the field of agro textiles and
- Test the utility of selected fabrics for geo textiles.