Introduction

1. INTRODUCTION

The Indian Textile Industry is one of the leading textile industries in the world. The significance of this industry to the Indian economy is manifested in terms of its contribution to the industrial production, employment generation and foreign exchange earnings. Indian textiles have always been a major player in global trade over the past few decades. It is an independent industry, starting from the basic requirement of raw materials to the final products, with huge value-addition at every stage of processing. The strengths of the Indian Textile Industry are vast textile production capacity coupled with flexible and efficient multi-fibre manufacturing systems, good entrepreneurial capabilities, skilled and cheap work force, enormous export potential, very little import content and large domestic market. The opening up of the economy gave the required thrust to the Indian Textile Industry, which has now successfully become one of the largest in the world. The forecast for textiles by the Government along with the industry and Export Promotion Councils, is to attain double the GDP, exports to reach eighty five billion U.S. dollars, with the generation of twelve million jobs in various sectors, by 2010 - http://ezinearticles.com/?Textile-Industry-in-India&id=373841.

Indian knitwear has made a good mark in exports because of its comfort and demand in other western countries. Indian exports for knitwear are already quite phenomenal because it provides reasonably priced fashion knits for the world markets. While India has to compete with Hong Kong, Taiwan and Bangkok in the export of cotton knits, it had managed to carve a special niche for itself because of its innovations in styling and quality control. With the body conscious look very much in vogue all over the world, knitwear becomes the ideal form of clothing that can achieve the look that is so much aspired for by designers and the fashion elite. In the early days of the knitwear evolution, Ludhiana and Calcutta were the prime production centres in India. Today Tirupur, which is a small town in South India, has developed into a major production centre and accounts for nearly Rs.1000 crore of knitwear exports, amounting to nearly 40% of India's total knitwear outflow. Various important buyers like JC Penney, Philips Van Heusen Corporation, Kellwood Company and management consultants like McKinsey and Company have projected that India could be the next biggest winner after China due to abundant raw material availability, IT industry support, constantly improving technology and design capabilities - http://www.indiantextilejournal.com/articles/FAdetails. asp?id=292.

Weft knitting has become very popular because of low cost of production, excellent output turnover and different varieties. Weft knitting is a method of fabric formation in which the loops are made in a horizontal way from a single yarn and the intermeshing of loops takes place in a circular or flat form on a course wise basis. Weft knit structures possess widthwise and lengthwise extensibility which distributes the stress on the garment making it difficult to be torn. Lower flexural rigidity of weft knits results in soft draping quality and fullness. Weft knits provide higher comfort as they are air permeable, soft and absorbent, making them ideal for summer and for intimate wear. During wear, weft knitted fabrics accommodate all types of bending and extensions but retain their appearance due to better crease resistance. Excellent comfort properties, greater inherent resilience and lower cost of weft knits have made their entry into outer wear for men, women and children.

Cotton is the most important of all natural fibres, accounting for half of all the fibres used by the world's textile industry. The Cotton Economics Research Institute has estimated that global cotton production will reach 140.5 million bales in 10 years, up from 109.9 million bales in the current marketing year. The average yield per acre globally may reach 1.66 bales in the year through July 2019, up from 1.43 bales currently, as countries such as India plant more genetically modified crops. Trade in cotton will accelerate by 55 per cent over the next 10 years - http://www.bloomberg.com/apps/ news?pid.

Cotton has many qualities that make it the best choice for countless uses. Cotton fibres have a natural twist that makes them so suitable for spinning into a very strong yarn. The ability of water to penetrate right to the core of the fibre makes it easy to remove dirt from the cotton garments, and creases are easily removed by ironing. Charges of static electricity do not build up readily on the clothes. Cotton fabric is soft and comfortable to wear close to skin because of its good moisture absorption qualities.

The trade name 'Lycra', otherwise known as spandex, was the first manufactured elastic fibre, introduced by DuPont in 1958. It has become so popular that all the varieties of spandex are popularly referred to as Lycra. Lycra has gained interest quickly due to its superiority to the strength and durability of rubber. The most significant characteristic of Lycra is its stretchability, to almost 500 per cent of its length, and recovery to near original shape. It is lightweight, soft, smooth, supple and durable. When Lycra is used for making any clothing, it gives the best fit and comfort and also prevents bagging and sagging of the garment. It is also heat-settable which means that it facilitates transforming puckered fabrics into flat fabrics, or flat fabrics into permanent rounded shapes. Lycra fibres or fabrics can be

easily dyed and they also resist damage by body oils, perspiration, lotions or detergents- http://www.fabrics.net/amyLycra.asp.

Lycra has become one of the most preferred blended fabrics due to its excellent resiliency, dimensional stability and elastic recovery. It enhances the features of every fabric it is blended with to create a stronger, more versatile piece of clothing. Lycra is being used in a continually widening array of clothing articles, including wovens and knits, and synthetic and natural fibres. Due to the comfort, stretch and wickability, they are commonly used in conjunction with cotton for comfortable knitwear. Many of the fabrics use around 3 - 30 per cent Lycra content, depending on the type of the garment. These types of demographic and physical changes have given Lycra a new fame - one that is synonymous with comfort and flexibility- http://www.dupont.com.

Ring Spinning, the oldest, most universally applicable technology for yarn manufacture, continues to meet today's high technological requirements. Natural and synthetic fibres of varying staple lengths are spun by this method to produce yarns of highest quality. This system allows various types and lengths of fibres (natural, man-made) to spin on a wide count range from 6 tex to 118 tex. In general, the processes involved are preparation of homogeneous mixing, blowing, carding, doubling and drafting, preparation of roving and spinning. In ring spinning, the roving is first attenuated by using drawing rollers, then spun and wound around a rotating spindle which in its turn is contained within an independently rotating ring flyer.

The card is the most important machine in the yarn manufacturing process. It performs second and final level cleaning functions in an overwhelming majority of cotton textile mills. The card is composed of a system of three wire-covered cylinders and a series of flat, wire-covered bars that successively work small clumps and tufts of fibres into a high degree of separation or openness, remove a very high percentage of trash and other foreign matter, collect the fibres into a rope-like form called sliver and deliver this sliver in a container for use in the subsequent process. Carding removes the tangles from the fibres but does not align the direction of the fibres evenly, leading to a fluffy or airy yarns more suitable for knitting.

The comber is a complicated machine composed of grooved feed rolls and a cylinder that is partially covered with needles to comb out short fibres. Combing removes the shortest, additional fibres, straighten and align each individual fibre parallel to the direction of spinning. This results in clean, lustrous, high-quality, extra soft yarns with excellent

strength and softness, making them more expensive than the carded yarns. Both carded and combed yarns are used extensively in manufacturing cotton and lycra cotton knits.

Textile wet processing comprises of mainly three operations: pretreatment, colouration and finishing. Most of the fabric that is dyed, printed or finished must first be prepared. The preparation process is a universal requirement since natural impurities are present in the fibrous materials which cause hindrance to the absorbency. It is a process with the highest volume in a textile mill without which no further processing is possible. During preparation of the textile material, the contaminants that may interfere with further processes are removed. Although preparation is crucial to every subsequent wet process, it is underestimated as a source of getting quality product, at the same time causing major pollution problems. Often it receives little attention and the personnel in the industry, are more concerned with the so called more important requirements such as good uniform dyeing, good penetration in printing and best quality after finishing, not understanding that for all these achievements, quality preparation is the basic essential requirement.

The traditional method of preparing cotton and its blends to achieve uniform absorbency is to scour the substrate with strong solutions of sodium hydroxide that additionally contain wetting, dispersing and chelating agents. The strong alkaline solutions are applied at high temperatures and this process attacks the primary wall matrix of the cotton fibre resulting in a very high removal of the non-cellulosic components. The cotton fibre may be damaged during scouring process by the formation of oxycellulose. Caustic scouring develops a harsh hand due to the removal of the natural lubricating wax in the fibre. The high temperature strong alkali scouring is nonspecific and cannot discriminate between the natural cotton lubricants and the manufacturing introduced lubricants. Further, the conventional scouring process can cause environmental problems due to the highly alkaline effluent from these processes.

Alaton *et al.* (2006) highlight that traditional scouring also contributes significantly to both suspended and soluble organic impurities, high biological oxygen demand (BOD) and chemical oxygen demand (COD). The large amount of water used to rinse and neutralize the alkali scoured and bleached textiles is ecologically disputable. Due to high working temperatures, a large amount of energy is consumed. Auxiliary chemicals added into the bath increase the total organic carbon and the chemical oxygen demand values of the effluents. Upon neutralization of the highly alkaline baths, large amounts of salts are produced.

The textile manufacturing process is characterized by high consumption of resources like water, fuel and variety of chemicals in a long process sequence that generates a significant amount of waste. The common practices of low process efficiency result in substantial wastage of resources and a severe damage to the environment. The main environmental problems associated with the textile industry are typically those associated with water body pollution, air emission, excessive noise or odour and workspace safety.

The pollutants in waste water are toxic in nature and also deplete the oxygen of receiving water by chemical reducing agents, biological liable substances and surface active agents. Some of the impurities present in the water prevent the penetration of light into the water hampering the photosynthetic reactions carried out by microorganisms. The harmful pollutants will make water unfit for use and also destroy the vegetation and crops in the place of discharge proving to be fatal to the invertebrate life in the water.

Industrial use of biotechnology, known as white bio technology, is bringing about new products and processes aimed at the use of renewable resources, as well as the application of green technologies with low energy consumption and environmentally healthy practices. As textile fibres are polymers, mostly natural in origin, the application of bio auxiliaries would open a number of opportunities in textile processing. Enzymes-nature's catalysts and bio auxiliaries are the logical tools for development of new biotechnology based solutions for textile wet processing. It is believed that the replacement of caustic scouring of cotton substrates by bio preparation with selected enzymes will result in many improvements such as lower BOD, COD, TDS, alkalinity, process time, cotton weight loss and harshness of hand. At present a wide variety of enzyme compositions are being employed in textile processing of different fabrics.

The term enzyme is derived from the Greek word 'enzymos' which means 'in the cell or ferments'. They are complex protein ferments secreted by living organisms capable of catalyzing chemical reactions of nature. Enzymes being natural products (proteins) they are easily and completely bio-degradable. They accomplish their work quietly and efficiently without leaving any pollutant behind. Enzymes act as a molecular worker offering an answer to the desire for a cleaner, more gentle, less polluting, non-aggressive and hypo-energetic chemistry with minimum damage to textile substrates and environment.

Enzymes are derived from fungal and bacterial sources and are classified into six major classes based on the reaction they catalyse. Enzymes are grouped into classes based on their reactions to substrates namely, Oxidoreductases, Transferases, Hydrolases, Lyases,

Isomerases and Ligases. Most of the enzymes used in the textile industry belong to the class 'hydrolases' where water insoluble material is converted into soluble products which can be washed away during the treatment process. Enzymes for textile use include amylases, lipases, pectinases, cellulases, proteases and catalases.

Enzymes used for desizing cotton fabrics are amylases which lead to the hydrolysis of starch. Bio scouring is usually carried out with a mixture of enzymes like proteases, lipases, pectinases and cellulases, which enhances the properties of the substrate and make them suitable for the subsequent processes. For bleaching, glucose oxidases are used to achieve controlled production of hydrogen peroxide from oxidation of glucose released during enzyme desizing. Bio polishing, an important finishing treatment, is carried out on cellulosic fabrics using acid cellulases to impart gloss, luminosity of colours, resistance to pilling, cooler feel and clear surface. Bio polishing consists of a cellulase enzyme treatment render a partial hydrolysis of cotton fibre. Knitted fabrics treated with cellulases are free from surface hairiness, neps, fluff, knops and possess improved handle and flexibility. Material texture relaxation takes place and improves sewability. The effect of treatment is long lasting and the colour of the dyed goods become brighter with an improved colour yield.

Raw cotton has contaminants which may originate from the base fibre during cultivation and from spinning preparation, spinning and knitting process. The fabric should be free from all types of contaminants before hydrogen peroxide bleaching. It is a well known fact that over 50% of the defects in finished fabrics can be traced to faulty preparation of fabrics. Losonczi *et al.* (2004), estimate that about 75% of the organic pollutant level arising from textile finishing is derived from the preparation of cotton goods. It would be useful, therefore, to explore an alternative, commercially viable and cost-effective method for preparing cotton and its blends as reproducibility of a processed fabric as per the approved sample by the customer is one of the most serious problems faced by the processor on the shop floor.

Presently a large variety of knitted fabrics are wet processed and converted into apparel for consumer use. Cent per cent Cotton and Lycra Cotton fabrics are most commonly manufactured in Tirupur on a large scale. Around 90 per cent of the industries use chemicals for pretreatment and subsequent finishing. All fabrics undergo pretreatment and it has been estimated that a major share of effluent is from the pretreatment sector in wet processing. Hence there is a need to analyse the effect of bio and chemical pretreatment and its

suitability for carded and combed yarns in different knit structures selected for both Cotton and Lycra Cotton fabrics. This study would also serve as a guide to all the industries that take up pretreatment of raw cotton and its blends and help to suggest an ecofriendly alternative with lower and biodegradable effluent, to control environmental pollution.

The specific objectives of the present study are to:

- conduct an industrial survey to elicit information about commonly used manufacturing and processing techniques for weft knitted fabrics.
- produce ring spun carded and combed cotton yarns for making 100 per cent cotton and lycra cotton weft knitted fabrics
- optimize the enzyme add on used for the bio pretreatment to achieve the essential properties for dyeing
- investigate the effect of bio and chemical pretreatment on the properties of cotton and lycra cotton weft knits after pretreatment, dyeing and wear study
- evaluate the effect of bio polishing on the bio and chemical pretreated cotton and lycra cotton weft knits and
- study the techno economics of bio and chemical pretreatments for cotton and lycra cotton weft knits.