MED

(2007 - 2013)

TEXtile and apparel MEDiterrannean heritage for INnovation

Priority-Objective 1-1

Axe 1: Strengthening innovation capacities

Objective 1.1: Dissemination of innovative technologies and know-how

COMPONENT 3: Integrated Knowledge-base

Deliverable: Assessment report on T&A materials

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Introduction

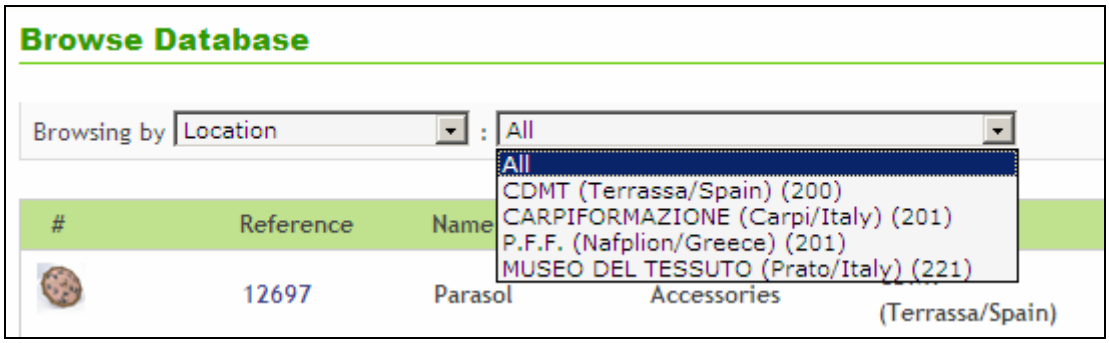
TEXMEDIN digital library consist of textiles and apparel objects, addressed to young stylist, designers, fashion schools and textile enterprises.

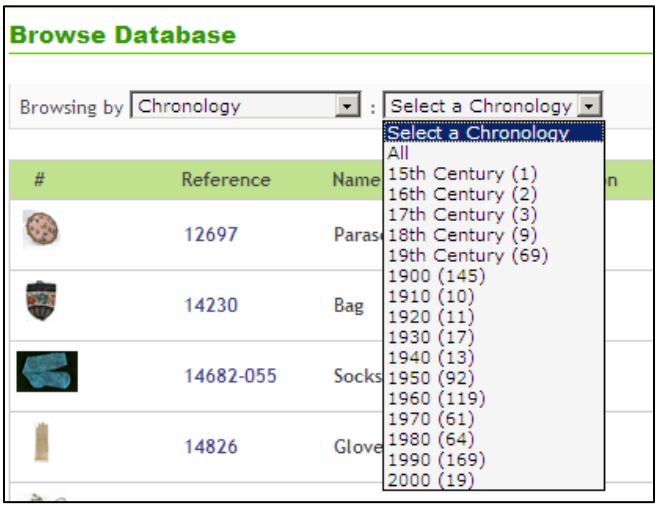
One of the objectives of TEXMEDIN project is to identify, share and exploit the creative heritage and productive know-how of the T&A sectors in partners' territories through a digital collection of objects related to these sectors. In the context of the project the library will be used from young stylist, designers and any other person who will participate in the design contest as a source of inspiration. The digital library will be also one of the tools provided on Inspiring Labs, where the users expect to find information (e.g. high resolution images, historical references, colourways, technical data sheets) and ideas for their work according to their specific needs.

This last need for “information” is decided by the partnership to be enriched with additional data covering materials used, techniques and processes, European legislation for textiles and Green textiles with a special focus on modern technological evolutions and regulations and the application of research results in textile and apparel products. The above information is presented in the current report entitled “Assessment report on T&A materials” but it will be integrated also in the online library.

1 Statistics of the TEXMEDIN digital library

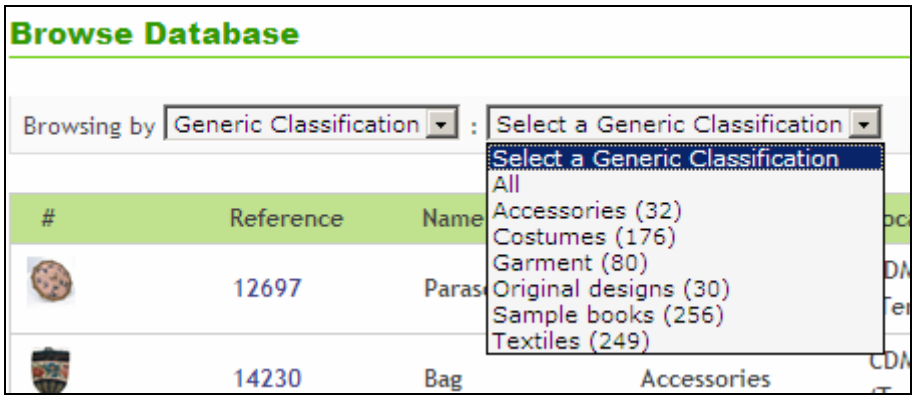
The objects of the digital library where selected, according to specific criteria, from the partners shown in the following image.



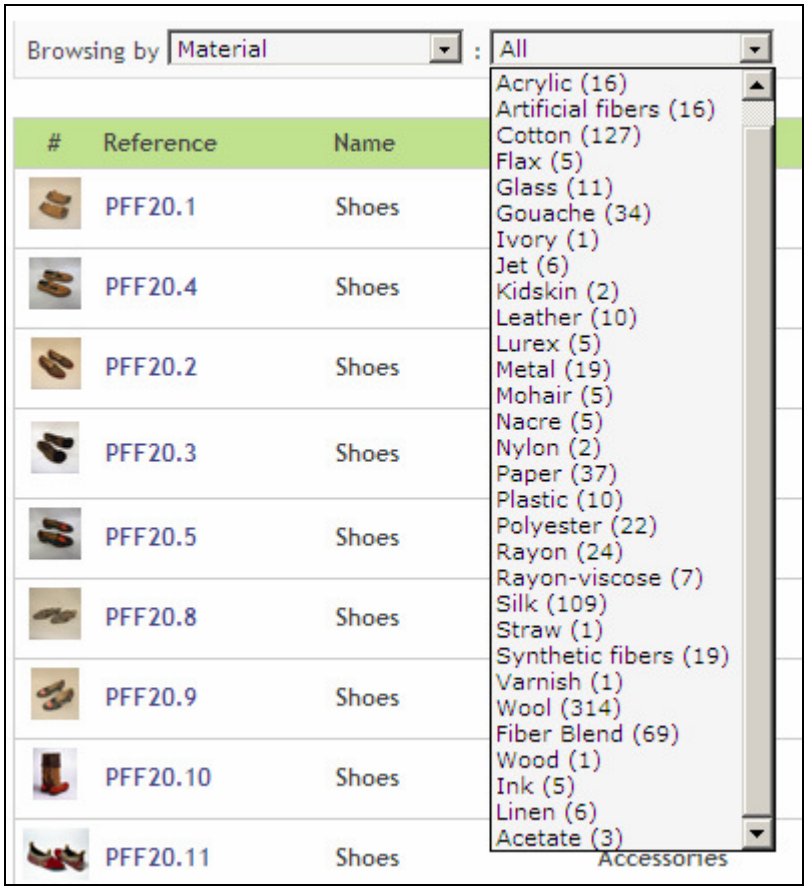


Although there are three museums that offered objects, more than the half of them are dated after 1960 up to laqst decade, meaning that most of them are an industrial production.

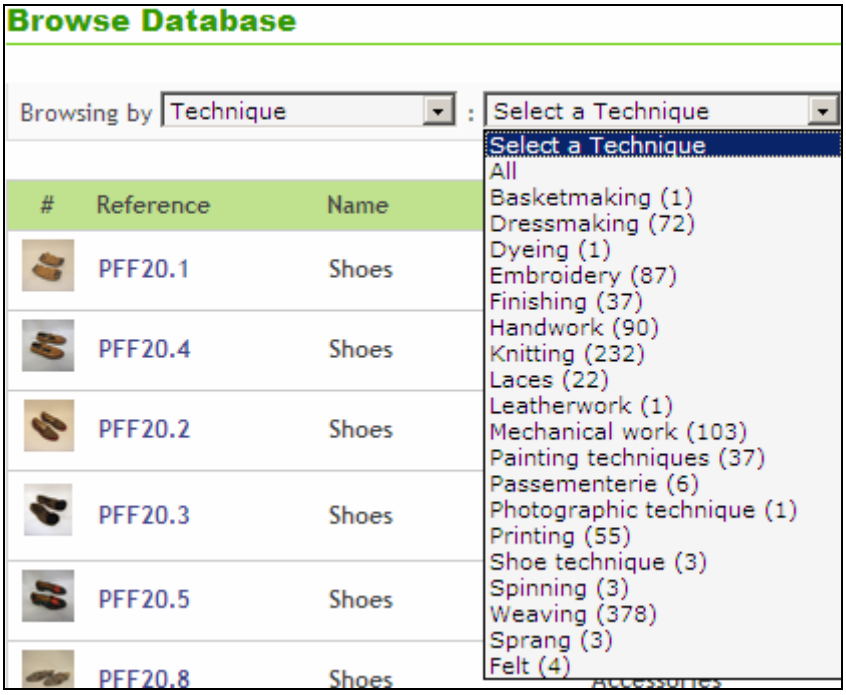
Regarding the type (Generic Classification) of the objects there is a relatively big number of costumes (traditional costumes coming mainly from the Peloponnesian Folklore Foundation), Sample books and Textiles. We can also notice thirty two Accessories (gloves, shoes, parasols, fans, shocks, bags, scarf etc.) that can be considered textile related objects as there is a fabric part on them.



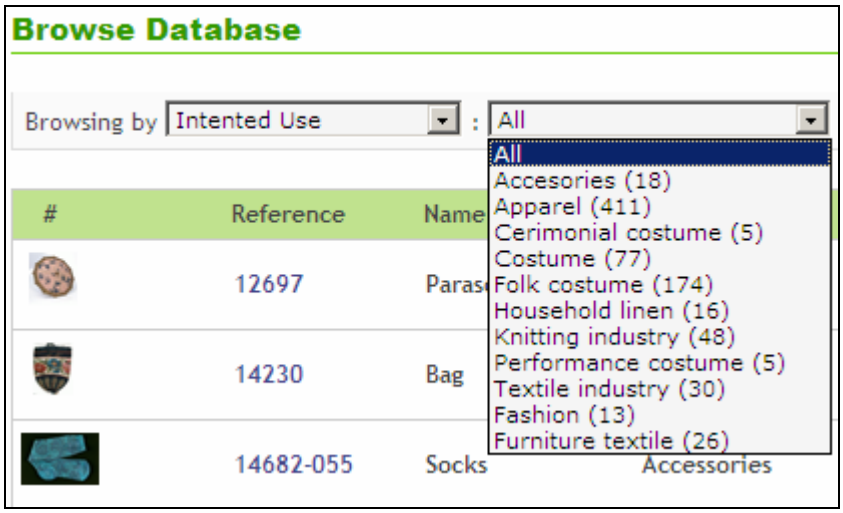
The materials used are mainly wool (314 objects), cotton (127 objects) and silk (109 objects) that are the primary materials used in Mediterranean region in textiles and clothing. There is also a number of other materials like acrylic, rayon, polyester or metal threads that generally where used, in most cases in small quantities together with the primary materials to give special characteristics to the textile and apparel objects.



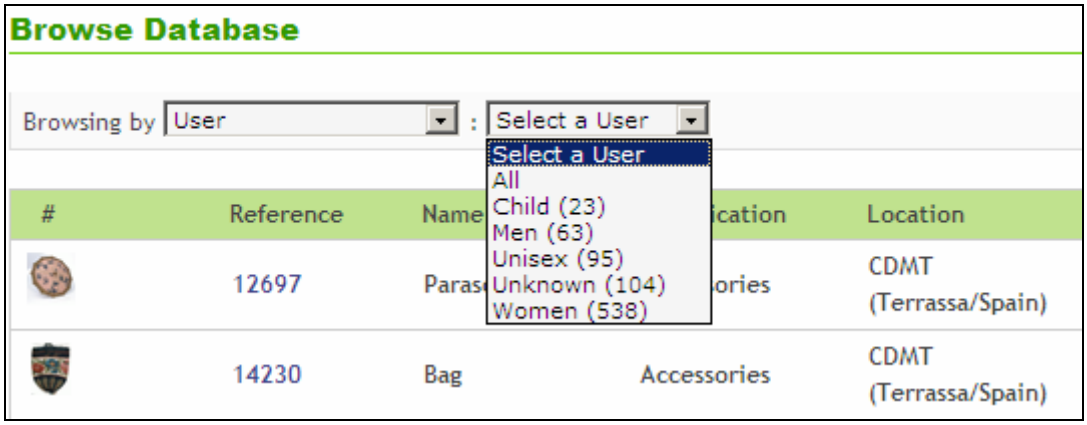
The two main techniques for manufacturing the digital library objects are, weaving and knitting as most of them are fabrics or costumes. There are, of course many other techniques used like embroidery, finishing, dyeing or dressmaking.



The techniques used are almost all the process used for object with intended use like apparel (411 objects) or costumes (261 objects) as we can see in the following picture.



Finally as for the persons who use the objects, we can observe that 558 objects are made to be used by women, 63 from men, 23 from children, 95 are unisex and the user for 104 objects is unknown.



2 Report on T&A materials

2.1 Cotton

Cotton is a cellulosic fiber and is still the most important apparel fiber. It has a unique combination of properties, including comfort, pleasing appearance, easy care, moderate cost, and durability, that renders it ideal for warm-weather clothing, activewear, work clothes, upholstery, towels, and bedding. Even though other fibers have encroached on the markets that cotton once dominated and despite some disadvantages of cotton fabrics, like susceptibility to abrasion and shrinkage, the cotton look is maintained.

Uses – Cotton is used to make a number of textile products. These include terrycloth for highly absorbent bath towels and robes, denim for blue jeans, socks, underwear, etc. Most T-shirts and high quality bed sheets are made from cotton. Cotton also is used to make yarn used in crochet and knitting. While many fabrics are made completely of cotton, some materials blend cotton with other fibers, including rayon and synthetic fibers such as polyester. It can either be used in knitted or woven fabrics, as it can be blended with elastan to make a stretchier thread for knitted fabrics, and apparel such as stretch jeans.

All-cotton fabrics are used when comfort is of primary importance and appearance retention and strength is less important, or when a more casual fabric is acceptable. Cotton blended with polyester in wrinkle-resistant fabrics is easy to find on the market. These blends retain cotton's pleasant appearance, have the same or increased durability, are less comfortable in conditions of extreme heat and humidity or high physical activity and have better appearance retention as compared with 100 % cotton fabrics.

Cotton is an important furnishing fabric because of its versatility, natural comfort and ease of finishing and dyeing. Towels are mostly cotton - softness, absorbency, wide range of colors and washability are important in this end use. Even in blended (e.g. cotton/polyester) towels, the loops are 100 % cotton so

that the maximum absorbency is retained. Cotton is also used in draperies, curtains, upholstery fabrics, rugs and wall coverings.

Shiny cotton is a processed version of the fiber that can be made into cloth resembling satin for shirts and suits. However, it is hydrophobic (does not absorb water easily), which makes it unfit for use in bath and dish towels (although examples of these made from shiny cotton are seen).

2.2 Wool

Wool is taken from animals in the Caprinae family, principally sheep, but the hair of certain species of other mammals is also sometimes called "wool", including cashmere from goats, mohair from goats, vicuña, alpaca, and camel from animals in the camel family, and angora from rabbits.

Wool has several qualities that distinguish it from hair or fur: it is crimped, it has a different texture or handle, it is elastic, and it grows in staples (clusters).

The high initial cost and the cost of care of wool garments and wool furnishings has encouraged its substitution by acrylic, polyester or wool/synthetic blends in many products. However, wool's properties are not equaled by any manufactured fiber: ability to be shaped by heat and moisture, good moisture absorption without feeling wet, excellent heat retention, water repellency, feltability and flame retardancy. Wool was one of the earliest fibers to be spun into yarns and woven into cloth and was one of the most widely used textile fibers before the Industrial Revolution.

Uses – The most important use of wool is for adult apparel. Wool suits perform well and look great. They fit well because they can be shaped through tailoring. The durable fabrics drape well. They are comfortable under a variety of conditions and retain their appearance during wear and care. Suits are usually dry-cleaned to retain their appearance and shape. Suit materials are also made of synthetic fiber/wool blends.

Even though the amount of wool used in furnishings is low, wool constitutes the standard by which carpet appearance is judged. A major use of wool is in

carpets and custom rags, often special order or one-of-a- kind. Wool rugs can be machined-woven, hand-woven or hand-hooked. They are more expensive than those made from other fibers because the rich color, texture and appearance of wool are appreciated and valued. Wool carpets and rugs account for less than one-fifth of the floor coverings market.

Both wool and wool blends are used in upholstery because of their aesthetic characteristics, good appearance retention, durable nature, and natural flame resistance. For residential use no additionally flame retardant treatment is necessary but for many commercial and contract uses wool and wool blend upholstery fabric may require a flame retardant finish.

Handcrafted wall hangings and woven tapes-tries are often made of wool because textile artists like the way the fiber handles. Designers, artists and consumers appreciate the way the finished item looks and wears. Many school laboratories have fire-safety blankets made of wool. Stadium blankets and throws are often made of wool for warmth and an attractive appearance.

In addition to clothing and upholstery, wool has been used for blankets, horse rugs, saddle cloths, felt and wool insulation. Wool felt covers piano hammers, and it is used to absorb odors and noise in heavy machinery and stereo speakers. Ancient Greeks lined their helmets with felt, and Roman legionnaires used breastplates made of wool felt.

Wool has also been traditionally used to cover cloth diapers. Wool fiber exteriors are hydrophobic (repel water) and the interior of the wool fiber is hygroscopic (attracts water); this makes a wool garment able to cover a wet diaper while inhibiting wicking, so outer garments remain dry. Wool felted and treated with lanolin is water resistant, air permeable, and slightly antibacterial, so it resists the buildup of odor. Some modern cloth diapers use felted wool fabric for covers, and there are several modern commercial knitting patterns for wool diaper covers.

Initial studies of woolen underwear have found it prevented heat and sweat rashes because it more readily absorbs the moisture than other fibers.

Merino wool has been used in baby sleep products such as swaddle baby wrap blankets and infant sleeping bags.

2.3 Silk

Silk is a natural protein fiber. It is similar to wool in that it is composed of amino acids arranged in a polypeptide chain, but it has no crosslinks. It is produced by the cocoon of a moth. Silk is universally accepted as a luxury fiber and has a combination of properties not possessed by any other fiber. It has a dry tactile hand, unique natural luster, good moisture absorption, lively suppleness and draping qualities and high strength. The beauty and hand of silk and its high cost are probably responsible for the development of the manufactured fiber industry. In fact it is the physical nature of silk that some manufactured fibers attempt to duplicate.

Uses –Because of its unique properties and high cost, silk is used primarily in apparel and furnishing items. Silk is extremely versatile and can be used to create a variety of fabrics from sheer, gossamer chiffons to heavy, beautiful brocades and velvets.

Because of silk's absorbency it is appropriate for warm weather wear and active sportswear. Because of its low heat conductivity it is also appropriate for cold-weather wear. In fact, silk's absorbency makes it comfortable to wear in warm weather and while active, while its low conductivity keeps warm air close to the skin during cold weather. It is often used for clothing such as shirts, ties, blouses, formal dresses, high fashion clothes, lingerie, pyjamas, robes, dress suits, sun dresses and kimonos. Silk underwear, socks, and leggings are popular due to silk's soft hand, good absorbency and wicking characteristics. Silk is available in a range of apparel from one-of-a-kind designer garments to low priced discount store T-shirts.

Silk's attractive luster and drape makes it suitable for many furnishing applications. Silk is frequently used in upholstery, wall covering fabrics, and wall hangings. Occasionally, beautiful and expensive handmade rugs are made of

silk. Liners for sleeping bags, blankets and bedsheets of silk feel warm, soft, and luxurious next to the skin.

While on the decline now, due to artificial fibers, silk has had many industrial and commercial uses; parachutes, bicycle tires, comforter filling and artillery gunpowder bags.

A special manufacturing process removes the outer irritant sericin coating of the silk, which makes it suitable as non-absorbable surgical sutures. This process has also recently led to the introduction of specialist silk underclothing for children and adults with eczema where it can significantly reduce itch.

2.4 Rayon (Viscose Rayon)

Of all fibers, rayon is probably the most perplexing to the consumers. It can be found in cotton-like end-uses, as well as sumptuous velvets and taffetas. It may function successfully in absorbent hygiene and incontinence pads and equally well providing strength in tire cords…

Rayon is a manufactured regenerated cellulose fiber and was in fact the first manufactured fiber. It is produced from naturally occurring polymers, and therefore is neither a truly synthetic fiber nor a natural fiber; it is a semi-synthetic or artificial fiber and it is known by the names viscose rayon and art silk in the textile industry.

It usually has a high luster quality giving it a bright sheen. The fiber was sold as artificial silk until the name rayon was adopted in 1924. Rayon was produced as a filament until 1932 when machinery was designed to crimp filament tow and cut it into staple fiber.

Its physical properties remained unchanged until 1940 when high tenacity rayon was developed. Continued research and development led to high wet modulus rayon. Rayon is no longer the inexpensive fiber it once was – now it is generally comparable in price to cotton.

Viscose rayon has a silk-like aesthetic with superb drape and feel and retains its rich brilliant colors. Its cellulosic nature contributes many properties similar to

those of cotton or other natural cellulosic fibers. Rayon is moisture absorbent (even more than cotton), breathable, comfortable to wear and easily dyed in vivid colors. It does not build up static electricity and it does not pill unless the fabric is made of short, low-twist yarns. It is soft to the skin and has moderate dry strength and abrasion resistance. Like other cellulosic fibers it is not resilient and wrinkles. It withstands ironing temperatures slightly lower than those of cotton and generally resists insect damage. One of its key advantages is its versatility and ability to blend easily with many fibers, sometimes to reduce cost, or to induce luster, softness, absorbency and comfort.

Controlled variations in certain characteristics of viscose rayon are possible. Illustrative of these are:

- The luster can be regulated from bright to semi-dull or dull depending upon the amount of delustering agent that is added to the viscose solution before extrusion through the spinneret.
- Dyes may be added to the solution to produce solution-dyed filaments which have a high degree of color permanency.
- Variations in the chemical composition of the coagulating bath cause different rates of coagulation n the inside and the outside of the fiber; this in turn provides a latent crimp that will emerge when the fiber is immersed in water.
- A degree of molecular blending may be used to increase absorbency. An alloy of natural and synthetic polymers may be engineered to form the viscose solution for the desired higher absorbency.

The future of rayon is bright. Not only there is a growing demand for rayon worldwide, but there are many new technologies that promise to make rayon even better and cheaper. For a while in the 1970s there was as trend in the clothing industry towards purely synthetic materials. However, since those materials do not breathe like natural materials, these products were not well received by consumers. Thus, today there is a strong trend towards blended fabrics that combine the best characteristics of different fibers.

Uses – Some major rayon fiber uses include apparel (e.g. blouses, dresses, jackets, lingerie, linings, scarves, suits, neckties, hats, socks), furnishings (e.g. bedspreads, bedsheets, blankets, window treatments, upholstery, slipcovers), industrial uses (e.g. medical surgery products, non-woven products, tire cord), and other uses (e.g. yarn, feminine hygiene products, diapers, towels).

2.5 Polyester

Polyester is the most widely used synthetic fiber today. Polyester fabrics resist wrinkling, are easy to launder, they dry quickly and are resistant to stretching and shrinking. The polyester polymer is endlessly engineerable with many physical and chemical variations possible, which provides high versatility to fibers and yarns manufacturers. Polyester can be used in textile applications either as filament or staple fibers and very often it is blended with other types of fibers, natural or synthetic.

In fact, its versatility in blending is one of the unique advantages of polyester. While synthetic clothing in general is perceived by many as having a less-natural feel compared to fabrics woven from natural fibres (such as cotton and wool), polyester fabrics can provide specific advantages over natural fabrics, such as improved wrinkle resistance, durability and high color retention. As a result, polyester fibres are sometimes spun together with natural fibres to produce a cloth with blended properties. Synthetic fibres also can create materials with superior water, wind and environmental resistance compared to plant-derived fibres. Thus, blended fabrics are attractive, durable, and comfortable, retain their appearance well and are easy care. Their excellent performance has resulted in their wide-spread use and continued popularity. Frequently, spun yarns blended with cotton or rayon are finished to be durable press.

Uses – Polyester is used for the manufacture of both woven and knitted fabrics designated for a variety of applications. Woven fabrics are used in apparel, sheets, blankets, curtains and draperies, mattress ticking, table linens and upholstery fabrics. Filaments are used in sheer curtains.

Knit fabrics of polyester wear well, are comfortable, retain their appearance and are easy care. The first use of polyester filaments was in knit shirts for men and blouses for women. The use of filament polyester increased tremendously when textured yarns were developed. Both smooth and textured filaments are used in such career apparel as uniforms and in such furnishings as wrap-knit upholstery.

A third important use of polyester is in fiberfill, used in pillows, comforters, bedspreads, furniture padding and winter apparel. Industrial polyester fibers, yarns and ropes are used in tire reinforcements, fabrics for conveyor belts, safety belts, coated fabrics and plastic reinforcements with high-energy absorption. Other uses of polyester include nonwovens, tents, sails, seatbelts, etc.

2.6 Nylon

Nylon fiber was intended to be a synthetic replacement for silk and substituted for it in many different products after silk became scarce during World War II. For example, it replaced silk in military applications such as parachutes and flak vests, and was used in many types of vehicle tires.

Today, nylon has become one of the most widely used textile fibers due to a combination of properties that include: high strength and resistance to abrasion, excellent elasticity, light weight and resistance to chemicals. However, as nylon entered more end-use markets, problems became apparent – static buildup, poor hand, poor comfort in skin contact fabrics and low resistance to sunlight. As each problems appeared, solutions were developed and a number of different nylon grades are today available in the market.

Uses - The single most important use of nylon fibers is for carpets. Tufted carpets are an excellent end-use for nylon because of its aesthetic appearance, durability, appearance retention and ability to be cleaned in place.

A second important use of nylon is for apparel. Lingerie fabrics are an end-use for which nylon is an important fiber. The fabrics are attractive and durable, retain their appearance well and are easy to care for. Panties, bras, nightgowns and lightweight robes are frequently made from nylon.

Women's sheer hosiery is an important end use of nylon. No other fiber has the combination of properties that make it ideal for that use. Short socks or knee socks are sometimes made from nylon. Frequently there are nylon blends with cotton or acrylic. Nylon adds strength and stretch. Active sportswear and active wear in which comfort stretch is important – leotards, tights, swimsuits and ski wear – are other end uses for nylon. Nylon taffeta windbreakers and parkas are common in cool and windy weather. Lining fabrics for jackets and coats can be made of nylon.

Industrial uses for nylon are varied and include tire cords, car interiors, parachute fabrics, cords and harnesses, ropes, etc.

Some performance nylon fibers are modified to have a cotton-like hand with improved pilling resistance and are used in the inner layers of workwear, hunting apparel, and mountaineering apparel. Other nylons have been modified to be stain and tear resistant, quick drying and warm or antibacterial.

2.7 Mohair

Mohair usually refers to a silk-like fabric or yarn made from the hair of the Angora goat. It is composed mostly of keratin, a protein found in the hair, wool, horns and skin of all mammals. While it has scales like wool, the scales are not fully developed, merely indicated. Thus, mohair fibers are smoother and more lustrous than wool fibers.

Mohair fiber is approximately 25-45 microns in diameter and is one of the oldest textile fibers in use. It is notable for its high luster and is often used in fiber blends to add this quality to a textile. Mohair is also warm as it has great insulating properties. It is durable and resistant to moisture-wicking, stretch,

flame and creases. It is considered to be a luxury fiber, like cashmere, angora and silk, and is usually more expensive than most wool that comes from sheep.

Uses – Mohair is used in scarves, winter hats, suits, sweaters, coats and socks. Because it resists crushing and pilling, it is used in flat and pile upholstery fabrics and hand-produced floor coverings. Its natural flame resistance, insulation, and sound absorbency make it ideal for specialty drapery applications. Blankets of mohair blends retain heat well. Mohair is often blended with wool to add sheen and texture to apparel and furnishing fabrics.

2.8 Leather

Leather is derived from the skins and hides of animals, reptiles, fish and birds. Skins go through many processes to become leather, including salting, cleaning to remove the hair and epidermis, tanning, bleaching, stuffing, coloring or dyeing, staking, and finishing. The many processes required explain the high cost of leather.

It should be noticed that leather varies greatly in uniformity and quality – not only from skin to skin but within one skin – and may have a noticeable odor.

Uses – The main applications of leather include apparel, upholstery, wall coverings, athletic gear (balls, gloves, and saddles), luggage, bags and accessories. Leather laminated to a porometric film and lining fabric is available for rain-repellent outwear. Another leather laminate product combined leather with a fabric backing containing spandex for shoes, gloves, and apparel with better fit and comfort. Product design is limited by the size of the skins; therefore, leather products usually have more seams as compared with other materials. Reconstituted leathers have been made by grinding up leather, mixing it with urethane and forming it into sheets. These products are uniform in thickness and quality and are unlimited in length and width.

2.9 Kidskin

Kidskin is a variety of leather made from the hides of goats. As the name implies, kidskin is often made from the hides of baby goats, or kids, but it may

also be made from the pelts of fully-grown goats. This type of leather is lightweight, supple and strong. Although it may be made into almost any kind of leather clothing or accessory, it is most often seen on ladies' dress shoes and is also often used to make gloves for both men and women.

2.10 Lurex

Lurex is the brand name for a type of yarn with a metallic appearance. The twine is most commonly a synthetic fibre, onto which an aluminium layer has been vaporised. "Lurex" may also refer to cloth created with the yarn.

2.11 Glass

Glass is composed of sand, silica, and limestone, combined with additives of feldspar and boric acid and can be processed into textile fibers. In fact, the process of drawing glass into hairlike strands dates back to ancient times. It is thought that the Phoenicians produced the first glass fiber.

However, the problem of severe skin irritation from tiny broken fibers has limited the use of glass fibers in apparel. Machine washing of glass textiles is not recommended because it causes excessive fiber breakage. Tiny glass fiber bits in the washing machine will contaminate the next load and irritate the skin of people who use those textiles. Even hand washing may produce severe skin irritation. Glass textiles do not require frequent washing, however, because they resist soil. Spots and stains can be wiped off with a damp cloth. No ironing is necessary. Items can be smoothed or hung to dry.

Uses – Glass fibers are inherently incombustible and therefore suitable for end uses where the danger of fire is a problem – such as in draperies for public buildings. Glass has wide industrial use where noise abatement, fire protection, temperature control (insulation) and air purification is needed. It is also found in ironing-board covers and space suits. Flame resistance glass mattress covers are produced for hotels, dormitories and hospitals. A lightweight, durable, water

resistant material in fashion colors is used to support broken bones as they heal.

2.12 Flax (Linen)

Flax fibers are composed by 70 % of cellulose and are used for the manufacture of linen fabrics. The unique and desirable characteristics of flax are its body, strength, durability, low pilling and linting tendencies, pleasant hand and thick-and-thin texture. Due to their cellulosic nature, linen fabrics do not provoke allergies, they absorb humidity and allow the skin to breathe. Therefore, they are suitable for the manufacture of summer articles. Linen is thermo-regulating, non allergenic, antistatic and antibacterial. It can absorb up to 20 times its weight in moisture before it feels damp, which makes it cool and dry to the touch. They are very resistant, particularly when wetted, and can be washed many times without deteriorating; rather they become softer which is very important for articles of clothing and for daily use that require frequent washing. The main limitations of flax are low resiliency and lack of elasticity.

Uses – Today, flax is a prestige fiber as a result of its limited production and relatively high cost. Over the past 30 years the end use of linen has changed dramatically. Approximately 70 % of linen production in the 1990s was for apparel textiles whereas in the 1970s only 5 % was used for fashion fabrics.

Linen apparel includes items for warm-weather use, high fashion, casual, and professional wear. A linen handkerchief, pressed and folded to display the corners, was a standard decoration of a well-dressed man's suit during most of the first part of the 20th century. It was also the preferred yarn for hand-sewing the uppers of moccasin-style shoes (loafers), but its use has been replaced by synthetics. Currently researchers are working on a cotton/flax blend to create new yarns which will improve the feel of denim during hot and humid weather.

Linen is also used in bed, table, and bath items, in other furnishing items for home and commercial use and in industrial products. Linen fabrics are ideal for wall paper and wall coverings because their irregular texture adds interest,

hides nail holes or wall damage and muffles noise. Industrial products include luggage, bags, purses and sewing thread.

2.13 Acrylic Fibers

Acrylic fibers are synthetic fibers that are made of any long chain synthetic polymer composed of at least 85 % by weight of acrylonitrile units. The clear liquid acrylonitrile was first made in Germany in 1893, but it was the research at DuPont that produced the first acrylic fiber in the mid 1940s.

Acrylic textiles are lightweight, soft and warm with a wool-like feel. In fact, the marketing of acrylic fibers frequently takes advantage of their wool-like characteristics. The polymer is colored before it is turned into fibers as it does not dye very well but has excellent colorfastness. Acrylic is inherently resistant to moths, oils, chemicals and is very resistant to deterioration from sunlight exposure. The key factor that lends acrylic fabric its quality of comfort is its ability of moisture transportation and wicking. Acrylic fiber is characterized by inherent polarity, i.e. the ability to attract and convey moisture. Due to this quality, acrylic fiber gives lifetime wicking capability to fabrics made of it. The key advantages of acrylic fibers can be summarized as follows:

- Due to its wicking ability and other characteristics, the fabric designers all over world are opting acrylic fabrics for manufacturing garments for all seasons.
- Not only the acrylic fabrics are high in performance but also they have a luxurious feel and they also drape very well.
- They are lightweight but have more bulk. This is due to their quality of lower specific gravity.
- They are comfortable to wear due to high moisture management.
- They have high colorfastness.
- They are odor, moth and mildew resistant too.

- In cold weather acrylics provide excellent insulation and warmth without any extra weight.

The disadvantages of acrylic are that it tends to fuzz or pill easily and that it does not insulate the wearer as well as wool or cashmere. Moreover, acrylic has a bad reputation amongst many knitters - however cheap the yarn is, its performance does not come near natural fibers. Also, some knitters complain that the fiber "squeaks" when knitted. It is also mentioned that acrylic can irritate the skin of people with eczema.

Uses - Acrylic fiber has replaced wool in many major applications, particularly in hand knitting and hosiery garments. It has also recently been used in clothing as a less expensive alternative to cashmere, due to the similar feeling of the materials. Many products, like fake pashmina or cashmina, use this fiber to create the illusion of cashmere.

The major application of acrylic fibers is in apparel. In fact, acrylic fabrics can be used all the year round due to their comfort factor. Inspired from the consumers' demands and a wide range of advantages, the apparel manufacturers utilize it for making various clothing regardless of any specific season. Thus, acrylic fabrics are mostly used to make such garments that need to make the wearer more and more comfortable through moisture management such as outwear pile fabrics, thermal underwears, socks and tights, sweaters and sleepwear. Knitted apparel items of acrylic include fleece fabrics, sweaters and socks. Although being replaced by less expensive polyester, fleece fabrics of acrylic are used for coats, jackets, linings or soft stuffed animals. Antistatic acrylics are used in apparel for computer clean rooms.

Craft yarns, another important end use of acrylic fibers are often made of a heavier denier (5-6 denier). Many sweaters, baby garments, vests and afghans are knitted or crocheted with these yarns. Acrylic yarns are also used in embroidery , weaving, and other crafts.

Upholstery fabrics have a wool-like appearance and may be flat woven fabrics or velvets with good durability and stain resistance. Drapery fabrics of acrylic are resistant to sunlight and weathering. Acrylics are used in lightweight and winter-weight blankets. Carpets and rugs of acrylic or blends look more wool-like than several other synthetic fibers. Acrylic blankets, carpets and rugs have easier care requirements and cost less than those of wool.

Today, acrylics are found in a number of industrial uses for which their chemical and abrasion resistance and good weathering properties make them suitable: awnings and tarpaulins, luggage, boat and other vehicle covers, outdoor furniture, tents, room dividers, and sandbags. When exposed to chemicals, fibers with good chemical resistance show little or no loss of physical structure or fiber properties. Sunbrella mass-pigmented acrylic awnings by Glen Raven Mills, withstand exposure to sun, wind and rain for years without fading, cracking, hardening, peeling or rotting. A crosslinked superabsorbent acrylic, Oasis, is used in nonwovens filters to remove water from fuels, solvents and other organic lilquids, in gaskets and seals.

2.14 Artificial fibers (Synthetic fibers)

Synthetic or artificial fibers are made of polymeric compounds using particular spinning procedures and include polyester, polyamide fibers, etc. Such fibers may have a negative image in the minds of some consumers due to a variety of reasons: inappropriate end-uses, poor fashion image, impact on the environment and poor comfort characteristics. However, marketing strategies have strengthened the industry and changed the perception of these fibers. Synthetic fibers offer much in terms of high-tech versatility, easy care, durability and high fashion appeal, while research and development efforts continue to improve their performance and expand their end-uses.

Today, synthetic fibers account for about half of all fiber usage, with applications in every field of fiber and textile technology. Although many classes of fibers based on synthetic polymers have been evaluated as potentially valuable commercial products, four of them – nylon (polyamide), polyester, acrylic and

polyolefin - dominate the market. These four account for approximately 98 % by volume of synthetic fiber production, with polyester alone accounting for around 60 %.

3 Report on T&A techniques

3.1 Weaving

Weaving is the most basic process in which two different sets of yarns or threads are interlaced with each other to form a fabric or cloth. One of these sets is called warp which is the lengthwise yarn running from the back to the front of the loom. The other set of crosswise yarns are the filling which are called the weft or the woof.

Preparing Warps and Wefts for Weaving

The warps form the basic structure of fabrics. As such, they are made to pass through many operations before actual weaving is done. These operations include spooling, warping and slashing. In spooling, the yarn is wound on larger spools, or cones, that are placed on a rack known as creel. From the creel, the yarns are wound on a warp beam, which looks like a huge spool. These lengths of hundreds of warped yarns lie parallel to one another. These yarns are unwound for slashing, or sizing. The yarn is coated with sizing with the help of slasher machine. Slashing prevents chafing or breaking of yarns during weaving process. Sizing is either starch based or a synthetic like polyvinyl alcohol or a water soluble acrylic polymers. The sized yarns are then wound on a final warp beam and are ready for the loom.

The filling yarns experience less strain during the weaving process. Their preparation includes spinning them to the required size and giving them just the right amount of twist desired for the kind of fabric they will be used.

Basic Weaving Operations

No matter what type of weaving is being done, four major operations are performed in sequence and are continuously repeated.

Shedding

In shedding, alternate warp yarns are raised to insert the filling yarn into the warp to form a shed. Shedding is automatically performed by the harness on

the modern weaving looms. Harness is a rectangular frame to which a series of wires, called heddles, are attached. As each warp yarn comes from the warp beam, it passes through an opening in the heddle. The operation of drawing each warp yarn through its appropriate heddle eye is known as drawing in.

Picking

As the warp yarns are raised through shedding, the weft yarn is inserted through the shed by a carrier device. A single crossing of the filling from one side of the loom to the other is called a pick. Different methods are used for carrying the filling yarn through the shed in different kinds of looms. There are many types of looms including shuttle loom, shuttle-less loom, and circular loom.

Shuttle Loom

The shuttle loom is the oldest type of weaving loom which uses a shuttle which contains a bobbin of filling yarn that appears through a hole situated in the side. The shuttle is batted across the loom and during this process it leaves a trail of the filling at the rate of about 110 to 225 picks per minute (ppm). Although very effective and versatile, the shuttle looms are slow and noisy. Also the shuttle sometimes leads to abrasion on the warp yarns and at other times causes thread breaks. As a result the machine has to be stopped for tying the broken yarns.

Shuttle-less loom

Many kinds of shuttle less looms are used for weaving such as Projectile Looms; Rapier Looms; Water Jet Looms; and Air Jet Looms.

Projectile Loom

It is sometimes called missile loom as the picking action is done by a series of small bullet like projectiles which hold the weft yarn and carry it through the shed and then return empty. All the filling yarns are inserted from the same side of the loom. A special tucking device holds the ends of the wefts in place at the edge of the cloth to form the selvage. This

loom needs smooth, uniform yarn which is properly sized in order to reduce friction. Projectile loom can produce up to 300 ppm and is less noisy then the shuttle loom.

Rapier Loom

Rapier loom comes in many types. Early models of it use one long rapier device that travels along the width of the loom to carry the weft from one side to the other. Another type of rapier loom has two rapiers, one on each side of the loom. They may be rigid, flexible or telescopic. One rapier feeds the weft halfway through the sheds of warp yarns to the arm on the other side, which reaches in and carries it across the rest of the way. Rapier looms are very efficient and their speed ranges from 200 to 260 ppm. These looms can manufacture a variety of fabrics ranging from muslin fabric to drapery fabrics and even upholstery fabrics.

Water Jet Loom

In water jet loom, a pre measured length of weft yarn is carried across the loom by a jet of water. These looms are very fast with speeds up to 600 ppm and very low noise. Also they don't place much tension on the filling yarn. As the pick is tension less, very high quality of warp yarns are needed for efficient operation. Also, only yarns that are not readily absorbent can be used to make fabrics on water jet looms such as filament yarn of acetate, nylon, polyester, and glass. However, it can produce very high quality fabrics having great appearance and feel.

Air Jet Looms

In the air jet weaving looms, a jet of air is used to propel the weft yarn through the shed at speeds of up to 600 ppm. Uniform weft yarns are needed to make fabrics on this loom. Also heavier yarns are suitable for air jet looms as the lighter fabrics are very difficult to control through shed. However, too heavy yarns also can't be carried across the loom by air jet. In spite of these limitations, air jet loom can produce a wide variety of fabrics.

Circular Looms

These looms are particularly used for making tubular fabrics rather than flat fabrics. A shuttle device in it circulates the weft in a shed formed around the machine. A circular loom is primarily used for bagging material.

Beating Up

This weaving operation is also called battening. In it, all warp yarns pass through the heddle eyelets and through openings in another frame that looks like a comb and is known as reed. With each picking operation, the reed pushes or beats each weft yarn against the portion of the fabric that has already been formed. It results in a firm and compact fabric construction.

Taking Up and Letting Off

As the shedding, picking and battening processes are being operated, the new fabric is wound on the cloth beam. This is known as 'taking up'. At the same time, the warp yarns are released from the warp beam which is known as 'letting off'.

The pattern of the weave depends on the manner in which groups of warped yarns are raised by the harnesses to allow the insertion of the weft yarn. These differences are responsible for producing different types of fabric weaves. Weave patterns can create various degrees of durability in fabrics apart from their utility and looks.

Types of Fabric Weaves

Fabric weave is the pattern for manufacturing a fabric. The yarns are used in different ways to produce various effects or weaves. These weaves can be plain and simple, as well as artistic and decorative.

Plain weave is the most simple and common type of construction which is inexpensive to produce, durable, flat having tight surface on which printing and other finishes can be easily applied. The examples of plain weave fabrics are

crepe, taffeta, organdy, cotton calicos, cheesecloth, gingham, percale, voile and muslin.

Satin weave, although more complicated, is a flexible type of weave than the plain weave. It is called 'satin' when filament fibers such as silk or nylon are used and is called 'sateen' when short-staple yarns like cotton is used to make it. The satin weave is lustrous with a smooth surface and it drapes in an excellent manner. The examples of satin weave fabrics are bocade, brocatelle, crepe-satin, satin, peau de soie, velvet satin etc.

Twill weave is somewhat similar to plain weave. Twill weave is durable, heavier, wrinkle and soil resistant, and is more flexible than plain weave. The examples of twill weave fabrics are covert cloth, drill, jean, jersey, tussah, velvet, worsted cheviot etc.

Basket weave is a variation of plain weave in which the fabrics have a loose construction and a flat look. It is more flexible and stronger but less stable than a plain weave. This weave is used in composites industry, outerwear, monk's cloth and drapery fabrics etc.

Jacquard weave is for creating complex patterns on fabrics and is woven on jacquard loom. The fabrics made through this weave have floats, luster, and are more stable and stretchy than the basic weaves. Some of its examples are matelasse, satin Faconne etc. It is used for upholstery and drapery.

Rib weave is a basic weave which produces ribs on the fabric. Resulting fabric is abrasion and tear resistant, examples of which are broadcloth, cord fabric, faille, poplin, taffeta etc.

Dobby weave, a decorative weave results in small designs or geometric figures all over the woven fabric. It is done through dobby machines. This weave uses various yarns from very fine to coarse and fluffy yarns to produce a variety of fabrics. The standard dobby weave fabrics are flat and comparatively fine. Some examples are moss crepe, matelasse etc. Heavy dobby fabrics are used for home furnishings and for heavy apparel.

Leno weave fabric is transparently thin, durable, strong and permits passage of both light and air through it. Examples of fabrics with leno weave are gauze, net, tulle etc. The leno weave fabrics are used for light-weight membrane, laminating fabrics, making medium weight blankets etc.

Oxford weave fabrics are made with modified plain weave or basket weave and are generally used for apparels, particularly cotton shirting materials. The fabric is fine, soft and lightweight.

Cut pile is a carpet fabric in which the surface of the carpet is made of cut ends of pile yarn. It is durable depending upon the kind of fiber used, density of the tufts and the number of twists in the yarn. Examples of cut pile are cisele velvet, velour , saxony etc.

Uncut pile, also called loop pile or rounded loops, produces fabric without cutting the ends of yarns as opposed to cut pile. The resulting fabrics are very strong with which very strong carpets are made. They are also used for making towels. Examples are terry cloth, terry velour, moquette, etc.

Chenile fabric is usually a soft wool, silk, cotton, or rayon yarn with protruding pile having fur-like texture which resembles velvet. It is generally used for making sweaters, outerwear, upholstery, curtains, rugs, throws and blankets etc.

3.2 Industrial Knitting Process

The main material for fabric construction is yarn. Knitting is the second most frequently used method, after weaving, that turns yarns or threads into fabrics. It is a versatile technique that can make fabrics having various properties such as wrinkle-resistance, stretchability, better fit, particularly demanded due to the rising popularity of sports wear and casual wears. As of present day, knitted fabrics are used widely for making hosiery, underwears, sweaters, slacks, suits and coats apart from rugs and other home furnishings.

Knitting Industry

Knitting industry is a very complex one. It has two primary areas having their own sub divisions of specialization. One of the key segment of knitting industry manufactures knitted goods for garment manufacturers, sewing centers, and consumers among others. The other one produces finished apparels such as hosiery, sweaters, underwear etc.

Basic Principle of Knitting

A knitted fabric may be made with a single yarn which is formed into interlocking loops with the help of hooked needles. According to the purpose of the fabric, the loops may be loosely or closely constructed. Crocheted fabric is the simplest example of knitting where a chain of loops is constructed from a single thread with the help of a hook. As the loops are interlocked in a knitted fabric, it can stretch in any direction even when a low-grade yarn having little elasticity is used.

Basic Construction Process of Knitted Fabric

The construction of knitted fabric is assessed by the number of stitches or loops per square inch. When the interlocking loops run lengthwise, each row is called a wale that corresponds to the direction of warp in woven fabrics. When the loops run across the fabric, each row is called a course that corresponds to the filling or weft in woven fabrics. A knitted fabric having 50 loops or stitches in one inch of width and 60 loops in one inch of length will be said to have 50 wales and 60 courses.

Importance of Needles in Knitting Process

The needle quality also affects the knitted fabric's quality. If the thickness of the hook differs from one needle to another then the stitches will also vary in width. Same is the case with loops which will vary in length with the needle lengths. Various types of needles are used for making different knitted fabrics including latch needle, spring-beard needle, and compound needle. Latch needle has a latch or swinging finger that closes onto the hook of the needle as it pulls the yarn through a loop in order to form a new loop. It is used for jersey and rib

knitting. A spring-beard needle has a fine, springy hook looking like a beard. This hook has to be used with a sinker to hold the fabric down and a presser to close the hook as it forms the loop. It is used for making more fine fabrics with smaller loops. A compound needle made up of a hook and a sliding closing element is used for faster knitting with lesser fabric distortion.

Types of knitted Fabrics

There are various types of knitted fabrics and each type has different appearance and characteristics. The construction of a knitted fabric depends upon the type being constructed. A knitted fabric that has more wales will be rigid and stable in width while a fabric that has more courses will be rigid and stable in length. A fabric having many wales and courses per area will have better recovery from stretching than a fabric having lesser wales and courses. Such fabric that will have fewer wales and courses will be less rigid, stretch more easily, fit to body shape in a better way but will have poorer recovery ability. All the knitted fabrics are classified into two general categories:

- Weft knit fabric, where one continuous yarn forms courses across the fabric.
- Warp knit fabric, where a series of yarns form wales in the lengthwise direction of the fabric.

Weft Knitting

There are three basic stitches in weft knitting

- Plain-knit stitch
- Purl stitch
- Rib stitch

Any other stitch is a variation of these three stitches. Hand knitting is basically weft knitting. When done on weft knitting machines, individual yarn is fed to a single or multiple needles at a time.

Plain-knit stitch: Plain knit, the basic form of knitting can be produced in flat knit or in tubular (or circular) form. It is also called jersey stitch or balbriggan

stitch. A row of latch or beard needles is arranged in a linear position on a needle plate or in a circular position on a cylinder. The side by side evenly spaced needles are moved by cams, which act on the needle butts. The spacing of the needles is called gauge, gage or cut which refers to the number of needles in one and a half inches, for example, a 60 gauge machine will have 40 needles per inch. The needles intermesh loops drawn to one side of the fabric, forming vertical herringbone like ribs or wales on the right side or technical face of the fabric. On the reverse side or the technical back, courses are visible as interlocking rows of opposed half circles. These fabrics have the tendency of curling up at the edges which is controlled to a level through certain finishes.

Plain knit allows the use of single or plied yarns produces comparatively lightweight fabrics than produced by other stiches. The production rate is higher, about 5 times more than weaving. It is inexpensive and a variety of designs may be produced including stripes, multicolored patterns, textured surfaces produced by raised designs and pile effects. Plain-knit fabrics stretch more in the width than in the length and as such, they are widely used for making underwear, gloves, hosiery and sweaters.

Purl stitch: Purl stitch, also called link-and-link stitch, is made on flat bed knitting machines and circular machines by needles using hooks on both ends to alternately draw loops to the front of the fabric in one course and to the back in the next course. The fabrics look similar on both the sides resembling back of the plain knit. Heavy, jumbo stitch is also possible which gives a bulky effect to the fabrics. However, It is comparatively slower and a costly technique. The fabric doesn't curl at the edges. Purl stitch is widely used in infant wear and kids clothing due to its crosswise stretch and excellent lengthwise stretch.

Rib stitch: Rib stitch produces alternate lengthwise rows of plain and purl stitches and as such the face and back of the fabrics are a lookalike. Rib stitch can be produced on a flat rib machine as well as circular rib machine. In the flat rib machine, one set of needles is placed opposite the other set of needles in an inverted V position. In the circular rib machine, one set of needles is placed

vertically in a cylinder and the other set of needles is placed horizontally on a dial. In both the machines, one set of needles pulls the loops to the front and the other set of needles pulls the loops to the back of the fabric. Each set of needles alternately draws loops in its own direction, depending on the width of the rib desired. For instance, rib stitches can be 1X1, 2X2, 2X1, 3X1, and the like. Accordion rib is the combination of 1x1 and 2X2. As a greater amount of yarn is required for rib stitch and the rate of production is also slower, it is an expensive method of fabric construction. The fabric doesn't curl at the edges and as the fabric possess an excellent widthwise elasticity, it is widely used for making such clothing that needs an excellent fit such as wristbands of sleeves and waistbands of garments, underwear and socks for men and children.

Warp Knitting

Warp knitting is different from weft knitting in the sense that in it each needle loops its own thread. The needles of warp knitting machines produce parallel rows of loops that are interlocked in a zigzag pattern. The stitches on the front side of the fabrics appear vertically having a slight angle. The stitches on the backside appear horizontally as floats at a slight angle. These floats are called laps or underlaps and are a distinguished feature of warp knit fabrics.

Warp knitting machine may be flat or tubular that can produce a variety of patterns. It is a very fast technique that can produce fabric with a dimensional stability almost equal to that of a woven fabric. It can also use yarns of man made fibres very efficiently. There are basically seven types of warp knitting- Tricot knit; Milanese knit; Simplex knit; Raschel knit; Ketten Raschel knit; Crochet and Weft-insertion warp. Warp knit fabrics are very popular due to their many properties such as smoothness, sheerness, wrinkle resistance, shrink resistance, strength and abrasion resistance.

Comparison of Weft Knitting and Warp Knitting

Warp knit fabrics have certain advantages over weft knits

- Warp knit fabrics do not ravel easily.
- They are less prone to sagging.

- Quality is generally better than weft knits.
- Stitch definition, texture and fabric cover are also usually better than weft knits.
- Warp knits have superior dimensional ability.

3D woven and knitted fabrics

3-d textiles are those materials which have a system or systems in all the three axes of plane. These fabrics offer particular properties, such as interlaminar shearing force, and mechanical and thermal stability along all three axes of space, which are not achievable with other reinforcements.

Three-dimensional (3-D) textile fabrics hold a promising future. The demand for these types of fabrics is expected in to increase, especially in the area of high performance composites in housing, automobile industry, construction and reinforcement materials.

However, the reduction in the cost of manufacturing and raw materials has to be brought about in order to make these goods competitive in the current & future markets. In this context nonwovens, which are a major constituent of this class of textiles are becoming important because of their ease of manufacture and low production cost.

3.3 Dyeing

Dyeing is the process of imparting colors to a textile material through a dye by applying various colors and their shades on to a fabric. Dyeing can be done at any stage of the manufacturing of textile- fiber, yarn, fabric or a finished textile product including garments and apparels. The property of color fastness depends upon two factors- selection of proper dye according to the textile material to be dyed and selection of the method for dyeing the fiber, yarn or fabric.

Dyes are molecules which absorb and reflect light at specific wavelengths to give human eyes the sense of color. Dyes are obtained either from natural

sources, such as flowers, nuts, berries and other forms of vegetables and plants, as well as from animal and mineral sources. These are known as natural dyes.

The other class of dyes is known as synthetic dyes. These are based on a particular type of chemical composition. Some of these dyes are- Acid (Anionic) dyes, Basic (Cationic) dyes, Neutral Premetalized dyes, sulfur dyes, vat dyes, reactive dyes, pigment dyes etc. Synthetic dyes are classified based upon their chemical composition and the method of their application in the dyeing process.

Dyeing Methods

Colour is applied to fabric by different methods of dyeing for different types of fiber and at different stages of the textile production process. These methods include Direct dyeing; Stock dyeing; Top dyeing; Yarn dyeing; Piece dyeing; Solution pigmenting or dope dyeing; Garment dyeing etc.

Direct Dyeing

When a dye is applied directly to the fabric without the aid of an affixing agent, it is called direct dyeing. In this method the dyestuff is either fermented (for natural dye) or chemically reduced (for synthetic vat and sulfur dyes) before being applied. The direct dyes, which are largely used for dyeing cotton, are water soluble and can be applied directly to the fiber from an aqueous solution. Most other classes of synthetic dye, other than vat and sulfur dyes, are also applied in this way.

Yarn Dyeing

When dyeing is done after the fiber has been spun into yarn, it is called Yarn dyeing. There are many forms of yarn dyeing- Skein (Hank) Dyeing, Package Dyeing, Warp-beam Dyeing,and Space Dyeing.

Skein (Hank) Dyeing

The yarns are loosely arranged in skeins or hanks. These are then hung over a rung and immersed in a dyebath in a large container. In this method, the colour penetration is the best and the yarns retain a softer, loftier feel. It is mostly used for bulky acrylic and wool yarns.

Package Dyeing

The yarns are wound on spools, cones or similar units and these packages of yarn are stacked on perforated rods in a rack and then immersed in a tank. In the tank, the dye is forced outward from the rods under pressure through the spools and then back to the packages towards the center to penetrate the entire yarn as thoroughly as possible. Mostly, the carded and combed cotton which are used for knitted outerwear is dyed through this method.

Warp-beam Dyeing

It is similar to package dyeing but more economical. Here, yarn is wound on to a perforated warp beam, immersed in a tank and dyed under pressure.

Space Dyeing

In this method, the yarn is dyed at intervals along its length. For these two procedures- knit- deknit method and OPI Space-Dye Applicator- are adopted. In the first method, the yarn is knitted on either a circular or flat-bed knitting machine and the knitted cloth is then dyed and subsequently it is deknitted. Since the dye does not readily penetrate the areas of the yarn where it crosses itself, alternated dyed and undyed spaces appear. The OPI Space-Dye Applicator technique produces multi coloured space- dyed yarns. The yarns are dyed intermittently as they run at high speeds of upto 1000 yards (900 m) per minute through spaced dyebaths with continuous subjection to shock waves produced by compressed air assuming supersonic velocities.

Top dyeing

Top is the combed wool sliver. It is wound on perforated spools and the dye solution is circulated through it. This method results in very even dyeing. In this method, the fiber is dyed in the stage just before the appearance of finished yarn.

Solution pigmenting or dope dyeing

Dye is added to the solution before it is extruded through the spinnerets for making synthetic filaments.

Stock dyeing

Stock dyeing is used to dye fibers even before they are spun. In this process, the staple fibers are packed into a vessel and then dye liquid is forced through them. Although the dye solution is pumped in large quantities, the dye may not penetrate completely into the fibers and some areas may be left without dyeing. However, the following blending and spinning processes mix up the fibers in such a thorough way that it results in an overall even color. Woolens are usually stock dyed.

Piece Dyeing

In this method small batches of constructed natural colored fabric are dyed according to the demands for a given color. The constructed fabrics are piece dyed for the flexibility they provide. The textile manufacturer can dye the whole fabric in batches according to the fashion demands of the time thus avoiding wastage and resultantly loss. There are several methods prevalent or piece dyeing.

Beck dyeing

It is used for dyeing long yards of fabric. The fabric is passed in rope form through the dyebath. This rope of the fabric moves over a rail onto a reel which immerses it into the dye and then draws the fabric up and forward and brings it to the front of the machine. This process is repeated many times until the desired color intensity is obtained.

Jig dyeing

It is similar to the process of beck dyeing with a slight variation. The fabric in jig dyeing is held on rollers at full width rather than in rope form as it is passed through the dyebath.

Pad dyeing

Padding is also done while holding the fabric at full width. The fabric is passed through a trough having dye in it. Then it is passed between two heavy rollers which force the dye into the cloth and squeeze out the excess dye. Then it is passed through a heat chamber for letting the dye

to set. After that it is passed through washer, rinser and dryer for completing the process.

Jet dyeing

Fabric is placed in a heated tube where jets of dye solution are forced through it at high pressures. The fabric also moves along the tube. The solution moves faster than the cloth while coloring it thoroughly.

Solution pigmenting or dope dyeing

This is a method applied for dyeing the synthetic fibers. Dye is added to the solution before it is extruded through the spinnerets for making synthetic filaments. This gives a colorfast fiber as the pigments are used which are the fastest known colors.

Garment dyeing

Dye is applied to finished products, such as apparels and garments. When the finished textile product such as hosiery or sweaters are dyed, it is called garment dyeing. A number of garments are packed loosely in a nylon net and put into a dyestuff filled tub with a motor driven paddle. The dye is thrown upon the garments by the moving paddles' effect.

Synthetic Dyes

Basic (Cationic) Dyes

Basic (Cationic) Dyes Basic dyes are water-soluble and are mainly used to dye acrylic fibers. They are mostly used with a mordant. A mordant is a chemical agent which is used to set dyes on fabrics by forming an insoluble compound with the dye. With mordant, basic dyes are used for cotton, linen, acetate, nylon, polyesters, acrylics and modacrylics. Other than acrylic, basic dyes are not very suitable for any other fiber as they are not fast to light, washing or perspiration. Thus, they are generally used for giving an after treatment to the fabrics that have already been dyed with acid dyes.

Direct (substantive) Dyes

Direct (substantive) Dyes Direct dyes color cellulose fibers directly without the use of mordants. They are used for dyeing wool, silk, nylon, cotton, rayon etc. These dyes are not very bright and have poor fastness to washing although they are fairly fast to light.

Mordant Dyes

Mordant Dyes The mordant or chrome dyes are acidic in character. Sodium or potassium bichromate is used with them in the dyebath or after the process of dyeing is completed. This is done for getting the binding action of the chrome. They are mostly used for wool which gets a good color fastness after treatment with mordant dyes. They are also used for cotton, linen, silk, rayon and nylon but are less effective for them.

Vat Dyes

Vat Dyes Vat dyes are insoluble in water and cannot dye fibers directly. However, they can be made soluble by reduction in alkaline solution which allows them to affix to the textile fibers. Subsequent oxidation or exposure to air restores the dye to its insoluble form. Indigo is the original vat dye. These dyes are the fastest dyes for cotton, linen and rayon. They are used with mordants to dye other fabrics such as wool, nylon, polyesters, acrylics and modacrylics.

Reactive Dyes

Reactive Dyes Reactive dyes react with fiber molecules to form a chemical compound. These dyes, they are either applied from alkaline solution or from neutral solutions which are then alkalized in a separate process. Sometimes heat treatment is also used for developing different shades. After dyeing, the fabric is washed well with soap so as to remove any unfixed dye. Reactive dyes were originally used for cellulose fibers only but now their various types are used for wool, silk, nylon, acrylics and their blends as well.

Disperse Dyes

Disperse Dyes Disperse dyes are water insoluble. These dyes are finely ground and are available as a paste or a powder that gets dispersed in water. These particles dissolve in the fibers and impart color to them. These dyes were

originally developed for the dyeing of cellulose acetate but now they are used to dye nylon, cellulose triacetate, and acrylic fibers too.

Sulfur Dyes

Sulfur Dyes are insoluble and made soluble by the help of caustic soda and sodium sulfide. Dyeing is done at high temperature with large quantities of salt so that the color penetrates into the fiber. After dyeing the fabric is oxidized for getting desired shades by exposure to air or by using chemicals. Excess dyes and chemicals are removed by thorough washing. These dyes are fast to light, washing and perspiration and are mostly used for cotton and linen.

Pigment Dyes

Pigment Dyes Although pigments are not dyes in a true sense, they are extensively used for coloring fabrics like cotton,wool and other manmade fibers due to their excellent light fastness. They do not have any affinity to the fibers and are affixed to the fabric with the help of resins. After dyeing, the fabrics are subjected to high temperatures.

3.4 Embroidery

Embroidery is the art of decorating fabric or other materials with designs using thread or yarn along with a needle. Embroidery may also use other materials such as metal strips, pearls, beads, quills, and sequins.

Machine embroidery is performed by special machines which automatically create a design from a pre-made pattern that is fed into the machine. Most embroidery machines are operated through computers that read digitized embroidery files created by special software.

In Machine embroidery, the designs are "digitized" with Embroidery Software. Almost all basic types of embroidery can be created with Machine Embroidery. These include: Applique, Free Standing Lace, Cutwork, Cross-stitch, Photo Stitch, and Basic Embroidery. Most often this type of embroidery is associated with business shirts, gifts, team apparel and commercial use.

Some embroidery machines are specifically built for industrial purposes. These are tough and can do several stitches in short span of time. Those who are into the embroidery business, should make themselves aware of the newest technologies and designs available as the fast changing fashion makes designs old very fast. The newest technology does not always demand a new machine. Instead new software design can be installed according to the requirements. Many of the softwares designed for embroidery lets a person change an image in digital form to a pattern for embroidery that can be uploaded on the machine.

Embroidery digitization

Digitizing is the process that changes an image file into a workable embroidery file. Today embroidery is done by stitching machines that must have a proper embroidery format to complete the task. Many types of formats are available. These can be classified into two groups: Bitmap art & Vector art types.

Bitmap Artwork is very common through out the Internet. The definition of bitmap is: "The method of storing information that maps an image pixel, bit by bit". Bitmap image are simply pixels or dots used to create an image. Bitmaps are very good for websites. However, they are not very useful in print work as they cannot be resized with efficiency. Jpeg is a common format for bitmap artwork.

Vector Artwork is a much more recent technology. The definition of vector artwork is: "Artwork that uses a mathematical language to describe color, shape, and placement information of the individual components of an image". Vector uses math to create its images. Therefore it can resize an image and can make it smaller or longer without losing its quality. This makes vector the perfect medium for print work as a single original design of artwork can be used for business cards as well as for billboards. EPS is a common format for vector artwork.

Vector artwork is preferred in the embroidery image as it can be imported into the digitizers software very easily. All images - bitmap or vector -must be manually converted into a stitch file. A stitch file actually contains the stitch patterns and thread colors for the sewing. This process is called digitizing.

3.5 Printing Process

Applying coloured patterns and designs to decorate a finished fabric is called 'Printing'. In a proper printed fabric, the colour is affixed to the fiber, so that it may not be affected by washing and friction. Whether a fabric is dyed or printed can be known by examining the outline of the design. On a printed fabric, the outline of a design is sharply defined on the outer side. The design generally does not penetrate to the back of the cloth. However, the design may show up on the reverse side of transparently thin fabrics. These fabrics may be confused with the woven designs where yarn dyed warp and filling are used. If the design is printed on such a fabric, the yarns will show some areas on which colour is not equally distributed.

The Dyes used for printing mostly include vat, reactive, naphthol and disperse colours which have good fastness properties. The pigments are also used extensively for printing. These colours are fixed to the fiber through resins that are very resistant to laundering or drycleaning. Pigments are among the fastest known colours and are effective for light to medium shades. If used for applying dark colours, they may crock or rub off. Improved resins, better pigments or more effective anticrock agents must be used to solve this problem. Cheap prints are made from basic colours mixed with tartar emetic and tannic acid but they are not acceptable in todays market.

For cotton printing vat and reactive dyes are generally used. Silk is usually printed with acid colours. Wool is printed with acid or chrome dyes but before printing it is treated with chlorine to make it more receptive to colours. Manmade fibers are generally printed with disperse and cationic dyes.

Methods of Printing

Three different approaches or techniques are prevalent for printing colour on a fabric: Direct, Discharge and Resist

Direct Printing

It is the most common approach to apply a colour pattern on fabric. It can be done on white or a coloured fabric. If done on coloured fabric, it is known as

overprinting. The desired pattern is produced by imprinting dye on the fabric in a paste form. To prepare the print paste, a thickening agent is added to a limited amount of water and dye is dissolved in it. Earlier corn starch was preferred as a thickening agent for cotton printing. Nowadays gums or alginates derived from seaweed are preferred because they are easier to wash out, do not themselves absorb any colour and allow better penetration of colour. Most pigment printing is done without thickeners as the mixing up of resins, solvents and water itself produces thickening.

Discharge Printing

In this approach, the fabric is dyed in piece and then it is printed with a chemical that destroys the colour in the designed areas. Sometimes, the base colour is removed and another colour is printed in its place. The printed fabric is steamed and then thoroughly washed. This approach is on decline these days.

Resist Printing

In this technique, a resist paste is imprinted on the fabric and then it is dyed. The dye affects only those parts that are not covered by the resist paste. After dyeing, the resist paste is removed leaving a pattern on a dark background.

There are various methods of printing in which one of the above three techniques is used - Block Printing, Roller Printing, Duplex Printing, Stencil Printing, Screen Printing, Transfer Printing, Blotch Printing, Jet Spray Printing, Electrostatic Printing, Photo Printing, Differential Printing, Warp Printing, Batik Dyeing, Tie Dyeing, Airbrush (Spray) Painting and Digital printing.

Block Printing

The designs are carved on a wooden or metal block and the paste dyestuff is applied to the design on the face of the block. The block is pressed down firmly by hand on the surface of the fabric.

Roller Printing

In this machine counterpart of block printing, engraved copper cylinders or rollers are used in place of handcarved blocks. With each revolution of the roller, a repeat of the design is printed. The printed cloth is passed

into a drying and then a steam chamber where the moisture and heat sets the dye.

Duplex Printing

Printing is done on both sides of the fabric either through roller printing machine in two operations or a duplex printing machine in a single operation.

Screen Printing

It is done either with flat or cylindrical screens made of silk threads, nylon, polyester, vinyon or metal. The printing paste or dye is poured on the screen and forced through its unblocked areas onto the fabric. Based on the type of the screen used, it is known as 'Flat Screen Printing' or 'Rotary Screen Printing'.

Stencil Printing

The design is first cut in cardboard, wood or metal. The stencils may have fine delicate designs or large spaces through which colour is applied on the fabric. Its use is limited due to high costs involved.

Transfer Printing

The design on a paper is transferred to a fabric by vaporization. There are two main processes for this- Dry Heat Transfer Printing and Wet Heat Transfer Printing. In Conventional Heat Transfer Printing, an electrically heated cylinder is used that presses a fabric against a printed paper placed on a heat resistant blanket. In Infrared Heat Vacuum Transfer Printing, the transfer paper and fabric are passed between infrared heaters and a perforated cylinder which are protected from excessive heat by a shield. The Wet Heat Transfer Printing uses heat in a wet atmosphere for vaporizing the dye pattern from paper to fabric.

Blotch Printing

It is a direct printing technique where the background colour and the design are both printed onto a white fabric usually in a one operation. Any of the methods like block, roller or screen may be used.

Airbrush (Spray) Painting

Designs may be hand painted on fabric or the dye may be applied with a mechanized airbrush which blows or sprays colour on the fabric

Electrostatic Printing

A dye- resin mixture is spread on a screen bearing the design and the fabric is passed into an electrostatic field under the screen. The dye-resin mixture is pulled by the electrostatic field through the pattern area onto the fabric.

Photo Printing

The fabric is coated with a chemical that is sensitive to light and then any photograph may be printed on it.

Differential Printing

It is a technique of printing tufted material made of yarns having different dyeing properties such as carpets. Upto a ten colour effect is possible by careful selection of yarns, dyestuffs and pattern.

Warp Printing

It is roller printing applied to warp yarns before they are woven into fabric.

Tie Dyeing

Firm knots are tied in the cloth before it is immersed in a dye. The outside of the immersed portion is dyed but the inside is not penetrated. There are various forms of Tie dyeing like Ikat Dyeing where bundles of warp and/ or weft yarns are tie dyed prior to their weaving. In Plangi Dyeing the gathered, folded or rolled fabric is usually held with stitching to form specific patterns.

Batik Dyeing

It is a resist dyeing process. Designs are made with wax on a fabric which is then immersed in a dye. The unwaxed portion absorbs the colour.

Jet Spray Printing

Designs are imparted to fabrics by spraying colours in a controlled manner through nozzles.

Digital printing

In this form of printing micro-sized droplets of dye are placed onto the fabric through an inkjet printhead. The print system software interprets the data supplied by an image file. The digital image file has the data to control the droplet output so that the image quality and color control may be achieved. This is the latest development in textile printing and is expanding very fast.

New trends in digital printing

The development of digital textile printing technology has challenged today's artists, designers and craftsmen to rethink how they will move forward within the textile design field. A large number of these individuals are experimenting with the latest innovations in inkjet technology and combining print innovation with traditional surface design technique.

The following are techniques that make good candidates for interface with digital print technology. These innovations represent the beginning stages of a new phase of textile design technology, the direction of which will be determined by the discoveries made by individual artists.

Silk Painting: a patterning style in which color is applied to a fabric and usually fixed by steaming or curing. The fabric base is usually white or previously dyed or painted. The challenge of combining this technique with digital printing is retaining the strength of the two methods while

making them work together. The integration of these techniques opens up many options, for example, to digitally print, steam or apply hand dying, which should be left to artistic interpretation. Exciting results can be found in any combination of these approaches, and the artist will come to discover the ideal effect after the process has been repeated several times. Fabric must be rinsed free of all old dye in order to accurately judge the final results. The objective is making sure that pretreatment is applied to both techniques, thus insuring color fastness.

Resist Dying: tie-dyeing and batik are examples of this method that juxtaposes organic natural textures with patterns of a more mechanical nature. Techniques like shibori dyeing, batik or paste resist may be added in combination with digital printing.

Discharge: a chemical process used to remove or strip color from cloth, which is normally achieved through immersion or printing techniques. Most color removal methods will lighten the cloth to a value that could allow for over-dying or printing. Digital printing combined with discharging creates a very interesting surface quality, exploiting the use of the original cloth color.

Devore: also known as burn-out technique, this method is used to produce a pattern on cloth by printing with a chemical paste that destroys one or more of the fiber contents. This embossed affect works surprisingly well, the relief texture created by removing the pile cloth and exposing the backing is very interesting. However, this technique is very labor intensive and cloth must be thoroughly cleaned before being run through a digital printer. If fibers are not removed from the cloth, nozzles could be clogged. Be forewarned that experimentation in this area requires a great deal of testing.

Silkscreen Printing: an analog printing method that designates each color position in a design to a screen. When using this with digital printing, find an approach that allows the natural quality of the image,

texture and color of the hand screen method to distinguish itself from the digital file and its inherent characteristics.

3.6 Finishing Processes

After construction of fabric through one of the many techniques described above, it is known as greige good or gray good. This simply denotes any unfinished fabric. Many finishing processes are employed for improving the appearance, feel and durability of the fabric. These processes are broadly classified as Preparatory Processes, Stabilizing Processes, and Textural Processes.

Preparatory Processes

The unfinished fabric or the gray good may contain many impurities such as dirt, soil, sizing, oils and other additives. As such, they need to be cleaned before proceeding towards finishing of the textile.

Singeing or Gassing

In this process one or both sides of a fabric are passes rapidly over a gas flame to burn off the protruding fibers. For thermoplastic fibers other methods including infra-red or heat is used. Thermoplastic fibers are harder to singe as compared to cotton or other such fibers because they melt and form hard residues on the fabric surface. When singeing is done in the yarn stage, it is called gassing.

Bleaching

It is the process of decolorization for removing all natural colors from the gray good. It is a chemical based process. Bleaching is further classified into oxidative bleaching and reductive bleaching. Natural fibres are all generally bleached with oxidative methods using such chemicals as sodium hypochlorite, sodium chlorite or hydrogen peroxide. Fibers like Polyamide, Polyacrylics and Polyacetates are generally bleached using reductive bleaching technology using sodium hydrosulphite, a powerful

reducing agent. In addition to bleaching, Optical Brightening Agents (OBA) are also applied to give the textile material a brilliant white look.

Stabilizing Processes

Stabilizing processes are required for improving properties such as strength, luster, and other qualities of the fiber.

Mercerization

This process is important for cotton fabric which is treated with a caustic solution for improving properties such as fiber strength, shrinkage resistance, luster, and dye affinity. The yarn or fiber is dipped in a solution of sodium hydroxide and then treated with water or acid to neutralize the sodium hydroxide. A variation of this process is hot mercerization. It adds more value to the fabric. This process involves saturation of fabric in caustic soda solution at higher temperatures and then cooling, stretching and final washing.

Ammoniating

It is done for increasing luster, affinity for dyes, abrasion resistance, smoothness etc. particularly of cotton and rayon fabrics. The yarn or fabric is passed through a weak solution of ammonium at such temperatures at which swelling and shrinkage occur. Then it is rapidly passed through hot water and dried in hot air.

Shrinking

The fibers have tendency of reverting back to their natural state, thus causing shrinkage of the fabric. To avoid the subsequent shrinkage, the process of shrinking the gray good is carried out through different methods such as immersion in cold water, followed by hot water, steaming, resin or a chemical treatment.

Tentering

The main purpose of tentering is drying and making the fabric even for further processing. The tenter frames consist of two endless chains

having an adjustable distance within them. The fabric runs through this frame and is carried into the heated housing where a blast of hot air removes any moisture present in the fabric.

Decating

Improves luster, appearance, feel as well as preshrinks the fabric. It may be applied to woven as well as knitted fabrics. Wet decating and dry decating are the two methods adopted. Wet decating is generally used for woollen fabrics. The fabric is wound on a perforated roller and treated in hot water or steam boiler. In dry decating, the fabric is passed together with a blanket around a perforated cylinder. The moist heat causes the fibers to become wrinkle free.

Enzyme Washing

Sometimes enzymes are used to produce stone washed effects on fabrics. Enzymes are organic catalysts that are used for speeding up a chemical reaction. This process is less damaging to fabrics than actual stone washing. Also, it gives a very soft feel to the treated fabric

Textural Processes

Textural processes are meant for improving the texture of the fabric such as stiffness, smoothness, weight or strength.

Temporary Stiffening

Fabrics, particularly cotton and linen, are given a temporary stability and stiffness by application of a firming agent which is often a solution of starch. It is commonly known as 'starching' or 'temporary stiffening'. When this process is done while preparing warp for weaving, it is called 'sizing' and 'dressing'. The term 'dressing' is generally used for the warp of wool. Other than starch, the substances used for stiffening fabrics are flour, dextrine, glue, shellac, fats, wax, and paraffin. Sometimes clay, chalk, barium sulfate, calcium sulfate or magnesium sulfate are also used for stiffening cotton fabrics. At times back starching is also done in which only the back side of the fabric is starched. Temporary stiffening is

required to retain the freshness of the fabric till it is not used for making any product. Stiffening also allows the fabric to be cut more easily into patterns for the textile products.

Permanent Stiffening

The fabrics which are permanently stiffened usually need less laundering and therefore become more durable. Permanent Stiffening is done by chemical processes that change the cellular structure of the fiber. This process makes the fabric smoother and dirt resistant as the dirt tends to slide off rather than cling onto the fabric. Some of the permanent finishes are Ankord, Basco, Clearight, Kandarized, Saylerizing, Sheercroft, Staze- Right and Turbenizing. They all give the fabric such properties as tensile strength, luster, shrinkage resistance, crispness, abrasion resistance and improve the appearance of the fabrics. Turbenizing is done to avoid the need of starching fabric for its life. This can be done through three methods. The parts to be stiffened like collar, cuffs, belts are interlined with a thermoplastic fiber or with cellulose acetate or the fabric may be coated with synthetic resin. The thermoplastic fibers melt and bonds with the garment when pressed with a hot iron producing a stiffened fabric. When cellulose acetate is used, it is softened by acetone which is also heat pressed on to the fabric giving permanent stiffness. A coating of resin is also heat pressed on to the fabric.

Weighting

Sometimes the weight of certain fabrics, such as silk, is increased to improve its feel and draping quality by immersing it in a solution having metallic salts. Low-grade wool fabrics are also weighted sometimes by felting short wool fibers into the fabric. These fibers, called flocks, are obtained by washing, brushing and sheering the wool fabrics. Excessive weighting tends to weaken the fabric.

Calendering

Calendering is done to add luster to fabrics. Calenders are heavy machines made up of at least two rollers that can go upto seven in number. Alternately, one roller is made of steel and the other is made of softer material like wool paper, cotton fiber and corn husks. The steel rolls may be equipped to be heated by gas or steam. The fabric passes rapidly between the rolls and then wound up on the back of the machine.

Glazing

The Glazing process consists of treating the fabric with glue, starch, paraffin, shellac, or resin and then moving it through hot friction rollers. This process gives the fabric qualities such as luster, resistance to dust, spots and shrinkage.

Embossing

Through embossing, raised figures or designs are produced on the surface of the fabrics. This is done by passing the fabric between heated engraved rollers. This process can be applied to all the fabrics except wool. When the process is combined with certain chemical resins, the embossing becomes permanent.

Moireing

Moireing is done through ridged rollers that produce a waved or watered effect on a textile fabric. The design becomes permanent when heat-set. A moire pattern obtained on a rayon fabric is not permanent. On silk, it comparatively remains for a longer time but diminishes gradually. Moireing is permanent on acetate, nylon or other thermoplastic fibers because these fabrics have the tendency to melt when subjected to heat. When cooled down, the pattern is conformed and hardened on the fabric.

Beetling

Beetling process is applied to linen or cotton. The fabric is beaten with large wooden blocks in order to produce a hard, flat surface with sheen. Only table linen is put through beetling and not the dress linen. When applied to cotton fabrics, beetling gives it the feel and appearance of

linen. This process permanently flattens the yarns of the fabric on which it is applied.

Raising

For giving a hairy surface to a fabric, several methods are adopted for pulling fiber ends to its surface. This fabric is then known as raised fabric. It is different from pile construction (such as tufting) which is woven or knitted with extra yarns placed on the fabric. Some of the methods of raising are Napping, Sanding, Gigging and Tigering.

Napping

It is done to get a deep hairy surface. The fabric is passed under a roller having fine steel wires with small hooks on the ends. The hooks scrape the surface of the fabric pulling up the fiber ends. It produces a soft fabric with air trapped in the cells lending warmth to the fabric. Flannellete and wool flannel are the examples of napped fabrics. When both sides of a fabric are napped in one direction, it is called single napping. When both surfaces are napped in opposite directions, it is called double napping.

Sanding

When a fabric is passed through a series of emery-covered rollers, it gets a suedelike surface. This is known as sanding or emerizing. A soft nap is produced by this process.

Gigging

This raising process is applied to wool fabrics. The raised fibers of wet fabric are brushed in one direction which gives a smooth and lustrous appearance to the fabric.

Tigering

A tigering finish is given to a fabric already having naps. This improves the height of the raised naps and removes the loose fibers. The tiger roll, with long fine wires, pulls up the fibers that are not raised by the process

of napping. This process is generally applied to such fabrics as velour, plush and imitation fur.

Shearing

Shearing refers to the process of trimming the pile on a fabric to a desired height. This process gives an attractive and smooth surface to the fabric. Patterns can also be made by shearing through high and low surface levels. It is done by a machine having rotating cylinders with spiral blades. Its action resembles that of a lawn mower.

Crepe and Crinkled Effects

Some of the finishing processes impart crepe or crinkled effects to the fabric. This is done through various methods. One method involves the use of engraved rollers. In another method, cotton is treated with caustic soda which is applied in the form of stripes and then the fabric is washed. The portions having soda shrinks and the remaining parts gather into small wrinkles. In yet another method, wax is used in place of caustic soda. Silk is sometimes given a crepe effect by carefully applying sulfuric acid to it.

Finishing Processes for Functionality of Fibers

The finishing processes that have been described in the above section improve the appearance and feel of the treated fabric. There are other finishing processes that give special properties to the fabric for particular functions.

Water Repellency

The fabrics that do not allow absorption or penetration of water for a fixed period of time are said to be water-repellent fabrics. As opposed to waterproof fabrics, these fabrics are porous for allowing body perspiration to escape and therefore are more comfortable. Some fibers such as nylon and polyester do not readily absorb water where as other fibers such as cotton and rayon can absorb water easily. Therefore, often the fibers of water absorbent fabrics are preferred for making items such as rain coats. As the times of water resistance differ, the

garments too differ in their properties. The shower-resistant garments are effective for light rains only and rain-resistant garments for moderate rains where as storm-resistant garments can resist water penetration for many hours and are suitable for heavy rains.

There are generally three types of finishes given to water repellent fabrics. These are nondurable, semidurable and durable finishes.

Nondurable Finishes

These finishes are based upon a paraffin wax-aluminum acetate emulsion. This emulsion is applied through padding and drying operations. Sometimes zirconium salts are used instead of aluminum which gives better water repellency. These fabrics loose water repellency if subjected to heavy washing or dry cleaning.

Semidurable Finishes

Wax and salt solutions are used for these types of finishes. However, they can not stand laundering but are resistant to dry cleaning.

Durable Finishes

There are many approaches for producing flame retardant fabrics such as application of chemical finishes, manufacturing of modified manmade fibers or new flame retardant fibers. The chemicals mostly used for giving flame retardant finishes include ammonia cured tetrakis – hydroxymethyl - phosphonium hydroxide (THPOH), decabromo-diphenyloxide (DBDPO), halogen phosphorous, nitrogen phosphorous, boron phosphorous, inorganic salts and others. Sometimes, flame retardant fibers are created by adding certain chemicals to existing solutions for making fibers. They are more stable and safer for human health.

Special flame retardant fibers are also developed which are more flame resistant than the other two types.

Flame Retardants

Wax and salt solutions are used for these types of finishes. However, they can not stand laundering but are resistant to dry cleaning.

Slip Resistance

Other than rough surfaced fabrics with hard twisted yarns, some fabrics have the tendency of slipping. Permanent firmness is given to such fabrics by immersing them in synthetic resins, then stretching and drying them under tension.

3.7 Sewing Process

The basic process of sewing involves fastening of fabrics, leather, furs or similar other flexible materials with the help of needle and threads. Sewing is mainly used to manufacture clothing and home furnishings. In fact, sewing is one of the important processes in apparel making. Most of such industrial sewing is done by industrial sewing machines. The cut pieces of a garment are generally tacked, or temporarily stitched at the initial stage. The complex parts of the machine then pierces thread through the layers of the cloth and interlocks the thread.

Industrial Sewing

Although it seems to be a simple process, industrial sewing is quite a complex process involving many preparations and mathematical calculations for the perfect seam quality. Good quality sewing also depends on the sound technical knowledge that goes into pattern designing and making. Flat sheets of fabric having holes and slits into it can curve and fold in three-dimensional shapes in very complex ways that require a high level of skill and experience to manipulate into a smooth, wrinkle-free design. Aligning the patterns printed or woven into the fabric also complicates the design process. Once a clothing designer, with the help of his technical knowledge, makes the initial specifications and markers, the fabric can then be cut using templates and sewn by manual laborers or sewing machine.

While handling the fabric and in the process of sewing, the cloth must be held stiff and unwrinkled. The seam quality is very sensitive to cloth tension that varies from time to time in the whole sewing process. These undesirable variations in the cloth tension affect the product quality. Therefore, there arises the need of strict control over the whole process. The work of sewing is focused on the handling of fabrics lying on the working table and guide them towards the sewing machines needle along the seam line. The attention is equally focused on the control of appropriate tensional force so as to maintain high quality seam.

Pre sewing functions

Before the actual task of sewing begins, there are certain other tasks that have to be taken care of which can be termed as fabric handling functions- Ply separation; Placing the fabric on working table; Guiding the fabric towards sewing needle; and tension control of fabric during the sewing process.

While ply separation, stacks of fabric plies are sequentially positioned with the help of some feeding apparatus in an unloading position. The uppermost ply in such a stack is individually and sequentially separated from the stack. In the process, an edge of the separated fabric is presented between the jaws of a gripping device. A proximity switch determines the spacing between the gripper jaws. When this spacing confirms that only one fabric ply is in place between the jaws, the single ply is transferred over onto the receiving end of a conveyor for further processing. In aerodynamic technique, the uppermost ply of fabric is lifted by suction from the remainder of the stack.

When the fabric is placed on the working table, the tasks that are performed before the sewing process include - recognizing the fabric's shape, edges that will be sewn, planning of the sewing process and identification of the seam line.

Recognizing the fabric's shape: The appropriate tensional force depends on the fabric properties. So the fabrics have to be identified into categories like knitted fabrics, woven fabrics etc. depending on their physical properties. Various shapes of the fabrics such as, convex, non-convex, with straight or curve edges, also have to be considered and each of them require different

handling strategies. In brief, the sewing methods done by automatic systems require classification of fabrics into various categories and certain preliminary scheme of the path that the fabric must follow so as to produce the required stitches.

Fabric Edges to be sewn: There are two basic types of stitches- one is that are for joining two parts of cloth together and the second one is done for decorative purposes. Sometimes, both types of stitching have to be done on some parts of cloth, for example, a pocket has to be joined on three sides with the apparel as well as it may be given some decorative stitches too. At what points and which type of stitching has to be done- all such information is stored digitally on automated devices through Computer-Aided Design (CAD) and accordingly sewn.

Planning of sewing process: Sequence of seams to be stitched is determined before the sewing starts. Which part will be joined first, what stitches will follow one another, etc. are decided. However, some stitches have to be necessarily done before or after another stitch. In the example above, the decorative stitches must be done first followed by the joining stitches. Embroidered patterns also follow the same sequence but sometimes in clothing items like hats, decorative stitches or embroidery is done after the production of hats and with the help of embroidery machine.

Identification of seam lines: Sewing process is performed on seam lines situated inside the fabric edges, some millimeters inside the fabric's outer line. For the straight lines, the seam line is found by transferring the outer lines inside the fabrics and the intersection of these lines makes the vertices of the seam line. Therefore, the seam line is parallel to the outer edge and the distance between the two has to be determined as it is different for different parts of the cloth. This distance is greater for trousers legs than for a shirt sleeves. Seam allowance is the area between the edge of the fabric and the line of stitching. It is usually 1,5 cm away from the edge of the fabric. Seam allowance is usually 2,5 cm or more for standard home dressmaking. Industry seam allowances vary but they are usually 0,6 cm.

Sewing Fabrics

The sewing process consists of mainly three functions- guiding fabric towards needle; sewing of the fabric edge; and rotation around the needle. The fabric is guided along the sewing line with a certain speed that is in harmony with the speed of sewing machine. The orientation error is either manually monitored or if monitored automatically then error is fed to the machine controller so that the machine corrects the orientation of the fabrics. When one edge of seam line is sewed, the fabric is rotated around the needle till the next edge of the seam line coincides with the sewing line. The sewing process is thus repeated until all the edges of seam line planned for sewing, are sewed.

Significant Aspects of Sewing

There are certain aspects that have to be carefully considered while the sewing process as they are very crucial for high quality sewing.

Thread tension and consumption: Correct balancing of the stitch and the tension given to the threads is very important for quality stitch formation. Thread consumption, which is closely associated with correct stitch geometry and thread tension, is usually measured by digital encoders.

Presser- foot displacement and compressing force: Presser- foot is the part of the sewing machine that holds the fabric in place as it is being sewn and fed through by the feed dogs. The feeding system is one of the most important constituting systems of the sewing machine. If this system is not efficient then it results into irregular seams and many other defects, especially when running on high speed. To evaluate feeding efficiency, the force on the presser foot is measured with the help of electric or other sensors.

Needle penetration force measurement: The interaction of needle with fabric is very crucial. Fault-free needle penetration depends chiefly on the properties of fabric and needle choice. Needle penetration force is one of the variables whose measurement is important for the analysis of quality problems or "sewability testing" and also quality monitoring. It takes various factors into

consideration, such as the needle geometry (including the point angle and point length of the needle), the friction between the needle and the fabric, the friction between the needle eye and the thread along with fabrics' property, and the sewing conditions.

3.8 CAD in Textile Industry

CAD or Computer-aided design has brought a revolution in the Textile Industry. The time consuming and cumbersome process of textile designing has been made easier by CAD. Now thoughtful and innovative designs are available to the textile designers and textile manufacturers at the click of a mouse.

When the products in pre-manufacturing stage are designed with the help of computer-based tools, it is termed as CAD or Computer-aided design. Sometimes the acronyms such as CADD or CAID are also used which stand for "Computer-aided design and drafting" and “Computer-aided Industrial Design” respectively. These terms are mostly used in the sectors related to the manufacturing of engineering goods. As far as textile industry is related, CAD is generally used for interpreting computerized designing. It includes both, software and sometimes special-purpose hardware.

Application of CAD

The textile designs are the original works of the designers. CAD helps them to visualize and see their imaginative design in final form without producing any sample swatch. Sometimes, the customers provide ideas for designing according to their particular requirement. These are in the form of painted artwork or fabric samples and sometimes film negatives. The textile designers, with the help of CAD, convert them into workable designs. For this to be done the sample is scanned with the help of either scanners or digital cameras and then they are edited to obtain the final design.

Textile Softwares

The usefulness of CAD has driven the market to produce specific softwares for different aspects of textile and apparel manufacturing. If there are softwares for

designing footwear, caps and bags, there are pattern making software too for fashion industry. There are solutions for sewn goods industry as well as systems for the design of jacquard woven fabrics. The garment pattern designs are even available in home, expert, and professional versions. Precision cutting systems, cutting and plotting systems, pattern design, grading and marker making- you name it and there is software for every textile related work- this is IT revolution in textile industry.

Advantages of CAD

This easy to operate designing system- CAD, has many advantages.

- The expense and time is reduced in a considerable manner when compared to the laborious manual work of designing.
- Designing can be done from anywhere as the customers are able to control the process from remote locations as well.
- The data can be easily stored, transmitted, and transported through computer files.
- Digital swatches can be saved on floppy disks, zip disks, CD-ROM or hard drive thus saving space. Moreover they can be easily organized for fast and easy retrieval.
- The designs can be easily customized and personalized as corrections and editing can be done at any time without significant delays or cost increases.
- The designers don't need to produce swatches all the time as they can now see how a particular fabric or garment looks in different colors and shapes on computer screen itself.

3.9 Lace Techniques

Tatting

Developed as an imitation of point lace, tatting is a form of lace made with a shuttle containing wound thread. The lace is made by constructing a chain of

loops and knots over a core thread: When using a shuttle, a lace maker winds a length of thread around one hand and keeps the shuttle in the other hand, forming a central loop. The shuttle is then passed through this loop from above or below to form knots. Called frivolité in French – a reference to the supposed frivolous nature of its use and possibly even the nature of the activity - tatting emerged in the late 19th century and was used to make doilies, collars, cuffs and other accessories.

Bobbin Lace

Bobbin lace is made by weaving or plaiting threads into a mesh. The thread – linen or cotton for crocheting – is wound onto bobbins at each end to form a pair. Once the required number of pairs has been wound, depending on the width of the lace the maker wishes to create, they are hung from pins stuck into a large flat or sausage-shaped pillow through a cardboard, pre-punched template. The majority of the pairs hang vertically and these regulate the width and the density of the lace. One or more pairs are added, at designated points, to those already hung on the pins and these are the travelling or working pairs. These pairs are intertwined with the vertical pairs in order to form the decorative elements. In Britain, bobbin lace was made in Buckinghamshire, Bedfordshire and Devon (Honiton) and employed thousands of men and women until the mid-19th century.

Needle Lace

Needle lace is made with needle and thread of various thicknesses. When starting a pattern, the lace maker makes the first stitches on a firm background, such as a piece of thick paper, and then fills in the remaining area with hundreds of tiny stitches made ‘in the air’ (not through the paper). Often, the motif will be printed or drawn on the underlying cardboard. There are several different types of stitches used, most being a variety of the buttonhole or blanket stitch. Venice and Alençon (France) have famous traditions of needle lace making.

Carrickmacross Lace

Carrickmacross lace originating in Ireland in the 19th century and is a form of needle lace worked on fine machine made netting. A template of muslin textile is attached to a length of netting and then the outline of the design is stitched through both with a thicker thread ('padding thread'). The unwanted muslin between the motifs is then cut away and the space in between filled with a buttonhole stitch.

3.10 Polymer Processing- Spinning Process of Polymers

Polymer processing is done to increase the value of a polymer in order to obtain the desired shape, properties, and performance for a polymer article. As far as textile industry is concerned, polymer processing can be explained as the spinning process for manufacturing polymer fibers that are commonly known as synthetic fibers.

Spinning of polymers

The polymers of synthetic fibers are almost always derived from by-products of petroleum and natural gas which include nylon, polyethylene terephthalate, as well as other compounds like acrylics, polyurethanes and polypropylene. Synthetic fibers, which are produced from these polymers are used for making various consumer and industrial textile products ranging from clothing, home furnishings to conveyor belts. Most of the cellulosic yarns manufactured from synthetic fibers are produced by extrusion of a thick, viscous liquid through the tiny holes of an equipment called spinneret which forms continuous filaments of semi-solid polymer.

The polymer is at first converted into a fluid state. If it is a thermoplastic polymer then it is just melted otherwise it has to be dissolved in a solvent or has to be chemically treated in order to form soluble or thermoplastic derivatives. The fluid polymer is then forced through the spinneret. The polymer here cools to a rubbery state, and then finally solidifies. For making specialty yarn, certain polymers have been technologically developed that do not melt, dissolve, or form appropriate derivatives. In such cases, the small fluid molecules are mixed

and reacted to form the otherwise intractable polymers during the process of extrusion. There are typically four types of spinning for polymers-wet spinning, dry spinning, melt spinning, and gel spinning. However, before proceeding to know the actual processes of all these four types of spinning, one must know about the basic process of extrusion and the spinneret used for it.

Spinneret and Extrusion

The spinnerets used for manufacturing most of the synthetic fibers have many holes ranging from one to several hundred holes which gives it an appearance similar to that of a bathroom shower head. The fluid polymer is fed into these tiny openings. The liquid polymer emerging out of the holes of spinneret in the form of filaments, is converted first to a rubbery state and then into a solid state. This process of extrusion and solidification of innumerable filaments is called spinning of polymers. This spinning is different from the fiber spinning of plant fibers and animal fibers, that are twisted into yarns.

Extrusion is also of two types- single screw extrusion and twin screw extrusion.

Single screw extrusion: is one of the basic operations of polymer processing. Single screw extrusion process builds pressure onto a polymer melt so that it can be forced through a die or can be injected into a mold. Most of the single screw extrusion machines are plasticating which bring in solids in pellet or powder form and melt them building pressure at the same time.

Twin screw extrusion: is widely used for mixing, compounding, or reacting polymeric materials. The flexibility of twin screw extrusion tool lets this operation to be designed specifically for the formulation that is being processed, for instance- the two screws may be corotating or counterrotating, intermeshing or nonintermeshing. Additionally, the configuration of the screws themselves may be varied using forward conveying elements, reverse conveying elements, kneading blocks, and other designs which can help in obtaining particular mixing characteristics.

Types of Polymer Spinning Processes

There are four types of spinning for polymers- wet spinning, dry spinning, melt spinning, and gel spinning.

Wet Spinning: Of all the four processes, wet spinning is the oldest process. It is used for polymers that need to be dissolved in a solvent to be spun. The spinneret remains submerged in a chemical bath that leads the fiber to precipitate, and then solidify, as it emerges out of the spinneret holes. The name of the process i.e. wet spinning has got its name from this "wet" bath only. Acrylic fiber, rayon fiber, aramid fiber, modacrylic fiber, and spandex fibers, all are manufactured through wet spinning.

Dry Spinning: It is also used for polymers that have to be dissolved in a solvent. However, solidification results from evaporation of the solvent. After dissolving the polymer in a volatile solvent, the solution is pumped through a spinneret. As the fibers emerge from the spinneret, air or inert gas is used to evaporate the solvent which results in solidification of the fibers that can be collected on a take-up wheel. The fibers are stretched which provides for orientation of the polymer chains along the fiber axis. This technique is used only for polymers which cannot be melt spun because of the safety and environmental concerns concerned with solvent handling. Dry spinning may be used for manufacturing acetate fiber, triacetate fiber, acrylic fiber, modacrylic fiber, PBI, spandex fiber, and vinyon.

Melt Spinning: is used for the polymeric fibers or the polymers that can be melted. The polymer is melted and then pumped through a spinneret. The cooled and solidified molten fibers get collected on a take-up wheel. The fibers, when stretched in both, the molten and solid states, facilitate orientation of the polymer chains along the fiber axis. Melt spun fibers can be forced through the spinneret in different cross-sectional shapes such as round, trilobal, pentagonal, octagonal among others. Trilobal-shaped fibers are capable of reflecting more light which give a sparkle to the fabrics. Pentagonal-shaped and hollow fibers are soil and dirt resistant and as such are used for making carpets and rugs. Octagonal-shaped fibers offer glitter-free effects whereas hollow fibers trap air, creating insulation. Polymers like polyethylene terephthalate and nylon 6,6 are

melt spun in high volumes. Nylon fiber, olefin fiber, polyester fiber, saran fiber, etc. are also manufactured through melt spinning.

Gel spinning: It is also known as dry-wet spinning because the filaments first pass through air and then are cooled further in a liquid bath. Gel spinning is used to make very strong and other fibers having special characteristics. The polymer here is partially liquid or in a "gel" state, which keeps the polymer chains somewhat bound together at various points in liquid crystal form.

This bond further results into strong inter-chain forces in the fiber increasing its tensile strength. The polymer chains within the fibers also have a large degree of orientation, which increases its strength. The filaments come out with an unusual high degree of orientation relative to each other, further enhancing strength. The high strength polyethylene fiber and aramid fibers are manufactured through this process.

Whatever spinning process is applied, the fibers are finally drawn to increase strength and orientation. This may be done while the polymer is still in the process of solidifying or after it has completely cooled down. Drawing pulls the molecular chains together and orients them along the fiber axis, resulting in a considerably stronger yarn.

3.11 Basketmaking

Basketmaking is the process of weaving unspun vegetable fibers into a basket or other similar form.

Basketry is made from a variety of fibrous or pliable materials—anything that will bend and form a shape. Examples include pine straw, animal hair, hide, grasses, thread, and wood.

The parts of a basket are the base, the side walls, and the rim. A basket may also have a lid, handle, or embellishments. Most baskets begin with a base. The base can either be woven with reed or wooden. A wooden base can come in many shapes to make a wide variety of shapes of baskets. The 'static' pieces of the work are laid down first. In a round basket they are referred to as 'spokes';

in other shapes they are called 'stakes' or 'staves'. Then the 'weavers' are used to fill in the sides of a basket. A wide variety of patterns can be made by changing the size, color, or by placement of a certain style of weave.

While basket weaving is one of the widest spread crafts in the history of any human civilization, it is hard to say just how old the craft is because natural materials like wood, grass, and animal remains decay naturally and constantly. So without proper preservation (which was not available two hundred years ago, much less two thousand years ago) much of the history of basket making has been lost and is simply speculated upon.

The technique of weaving has been passed along, re-discovered, and expanded upon throughout the years, and is still being expanded upon today. Baskets were at one time used simply for storage and transportation of goods. Decoration was an afterthought at best. Today, functional baskets are still in use, but many are made for more decorative purposes. Patterns and “how to” books are now available for anyone to learn the craft.

The first fully automatic basket-making machine was patented in 1894. Machine-made and later vintage hand-woven baskets are generally lacking in quality workmanship and inspired design.

3.12 Felt

Felt is a non-woven cloth that is produced by matting, condensing and pressing woollen fibres. While some types of felt are very soft, some are tough enough to form construction materials. Felt can be of any color, and made into any shape or size.

Felt is made by a process called wet felting, where the natural wool fibre is stimulated by friction and lubricated by moisture (usually soapy water), and the fibres move at a 90 degree angle towards the friction source and then away again, in effect making little "tacking" stitches. Only 5% of the fibres are active at any one moment, but the process is continual, and so different 'sets' of fibres become activated and then deactivated in the continual process.

This "wet" process uses the inherent nature of wool and other animal hairs, because the hairs have scales on them which are directional. The hairs also have kinks in them, and this combination of scales (like the structure of a pine cone) is what reacts to the stimulation of friction and causes the phenomenon of felting. It tends to work well with woollen fibres, as their scales, when aggravated, bond together to form a cloth.

Needle felting is a popular fibre arts craft conducted without the use of water. Special barbed felting needles that are used in industrial felting machines are used by the artist as a sculpting tool. Using a single needle or a small group of needles (2-5) in a hand-held tool, these needles are used to sculpt the wool fibre. The barbs catch the scales on the fibre and push them through the layers of wool, tangling them and binding them together, much like the wet felting process. Fine details can be achieved using this technique, and it is popular for 2D and 3D felted work.

From the mid-17th to the mid-20th centuries, a process called "carroting" was used in the manufacture of good quality felt for making men's hats. Beaver, rabbit or hare skins were treated with a dilute solution of the mercury compound mercuric nitrate. The skins were dried in an oven where the thin fur at the sides went orange - carrot color. Pelts were stretched over a bar in a cutting machine and the skin sliced off in thin shreds, the fleece coming away entirely. The fur was blown onto a cone-shaped colander, treated with hot water to consolidate it, the cone peeled off and passed through wet rollers to cause the fur to felt. These 'hoods' were then dyed and blocked to make hats. This toxic solution and the vapors it produced resulted in widespread cases of mercury poisoning among hatters. The United States Public Health Service banned the use of mercury in the felt industry in December 1941.

Knitted woollen garments which shrink in a hot machine wash can be said to have felted but, more accurately, they have been "fulled". Felting differs from fulling in the sense that fulling is done to fabric whereas felting is done to fibres that are not in fabric form. Modern fulling is an example of how the fibres bond

together when combined with the movement of the washing machine, the heat of the water, and the addition of soap.

Cheaper felt is usually artificial. Artificial felt, if made using the wet method, has a minimum of 30% of wool fibres combined with other artificial fibres. This is the minimum required to hold a fabric together with the fibres alone. It would be difficult to achieve a stable fabric by hand at this ratio. All other wholly artificial felts are actually needle-felts.

Loden is a type of felt originally worn in the Alpine regions, which has gained worldwide acceptance as a textile for fine and durable clothing.

An alternative way of creating felt is to have a steam roller go over the unwoven fabrics in a shallow pool of water with the cloths rotating as the steam roller goes over it. This method is widely used in small towns in India where mass manufacturing of clothing is done.

4 Rules in EU

4.1 Mandatory Rules in EU

Public Procurement	Directive **2004/18/EC** of the European Parliament and of the Council of 31 March 2004	*Procedures for the award of public works contracts, public supply contracts and public service contracts*	*http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:134:0114:0240:EN:PDF*
Public Procurement	Commission Regulation (EC) No **1564/2005** of 7 September 2005	*Establishment of standard forms for the publication of notices for public procurement procedures*	*http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2005:257:0001:0126:EN:PDF*
Public Procurement	Commission Regulation (EC) No **2083/2005** of 19 December 2005	*Application thresholds for the procedures for the award of contracts (amending Directives 2004/17/EC & 2004/18/EC)*	*http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2005:333:0028:0029:EN:PDF*
Public	Commission Regulation (EC) No	*Common Procurement Vocabulary (CPV) and Public*	*http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?ur*

Procurement	**213/2008** of 28 November 2007	*procurement procedures (as regards the revision of the CPV)*	*i=OJ:L:2008:074:0001:0375:EN:PDF*

REACH – Restriction on harmful Chemicals	Commission Regulation (EC) **No 1907/2006**of the European Parliament and of the Council of 18 December 2006	*Registration, Evaluation, Authorisation and Restriction of Chemicals*	*http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:396:0001:0849:EN:PDF*
	Commission Regulation (EC) **No 1272/2008** of the European Parliament and of the Council of 16 December 2008	*Classification, labelling and packaging of substances and mixtures*	*http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:353:0001:1355:EN:PDF*
	Commission Regulation (EC) **No 790/2009** of 10 August 2009	*Classification, labelling and packaging of substances and mixtures (valid from 01.12.2010)*	*http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:235:0001:0439:EN:PDF*
REACH – Restriction on harmful	Commission Regulation (EC) **No 552/2009** of 22 June 2009	*Registration, Evaluation, Authorisation and Restriction of Chemicals – Annex XVII (valid*	*http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:164:0007:0031:EN:PDF*

Chemicals (relevancy to textiles)		*from 01.06.2009)*	

MARKET CONTROL – Textile labelling	Directive 2008/121/EC of the European Parliament and of the Council of 14 January 2009	*Textile names (and acceptable tolerances for the declared composition)*	*http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:019:0029:0048:EN:PDF*
	Directive 96/74/EEC	*Naming and labelling of textile products*	*http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31996L0074:EN:HTML*
	Directive 97/37/EEC	*Naming, marking of the fibre composition and labelling of textile products*	*http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31997L0037:EL:HTML*
PRODUCT SAFETY - Rules & Restrictions for	Directive **88/378/EEC**	*Toys for children made of textile*	*http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31988L0378:EN:HTML*

Textile products	Directive **89/686/EEC**	*Essential safety requirements of Personal Protective Equipment and conditions for placing on the market*	*http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31989L0686:EN:HTML*
	Directive **93/42/EEC** [and ammendments 98/78/EEC, 200/70/EEC, 2001/104/EC, 203/12/EC]	*Medical articles made of textile materials*	*http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31993L0042:EN:HTML*
	Directive **93/68/EEC**	*Essential safety requirements of Personal Protective Equipment and conditions for placing on the market*	*http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31993L0068:EN:HTML*
	Directive **93/95/EEC**	*Essential safety requirements of Personal Protective Equipment and conditions for placing on the market*	*http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31993L0095:EN:HTML*
	Directive **94/27/EEC**	*Restrictions on the marketing and use of nickel in accessories*	*http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri*

			=CELEX:31994L0027:EN:HTML
	Directive **96/58/EC**	*Essential safety requirements of Personal Protective Equipment and conditions for placing on the market*	*http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31996L0058:EN:HTML*
	Commission Decision **1999/815/EC** of 7 December 1999	*Toys and childcare articles containing fobidden phthalates*	*http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:1999:315:0046:0049:EN:PDF*
	Directive **2002/61/EC** Directive **2003/3/EC**	*Restrictions on the marketing and use of certain dangerous substances and preparations (forbidden azocolourants)*	*http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2002:243:0015:0018:EN:PDF & http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:004:0012:0015:EN:PDF*
	Directives **2004/96/EC** & **1994/27/EC**	*Restrictions on the marketing and use of nickel in accessories*	*http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:301:0051:0052:EN:PDF*

	Directive **2004/21/EC** of 24 February 2004	*Restrictions on the marketing and use of 'azo colourants' (thirteenth adaptation to technical progress of Council Directive 76/769/EEC)*	*http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:057:0004:0005:EN:PDF*

5 Green Textiles

5.1 Voluntary schemes concerning Green Textiles

Green products – general *(applied also for textiles)*	EC Regulation No **1980/2000** of the European Parliament and of the Council of 17 July 2000	*Eco label award scheme*	*http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2000:237:0001:0012:EN:PDF*
	EC Regulation **No 66/2010** of the European Parliament and of the Council of 25 November 2009	*EU Ecolabel*	*http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:027:0001:0019:EN:PDF*

	EC Regulation (EC) **No 1221/2009** of the European Parliament and of the Council of 25 November 2009	*EMAS - Environmental Management and Audit Scheme*	*http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:342:0001:0045:EN:PDF*
Green Textiles	Commision Decision **No. 598/2009/EC**	*Eco label for bed mattresses – Criteria*	*http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:203:0065:0080:EN:PDF*
	Commission Decision **2009/567/EC** of 9 July 2009	*Eco label – Criteria for Textile products*	*http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:197:0070:0086:EN:PDF*

5.2 Textiles Recycling

Why recycle textiles?

Textiles, particularly synthetics, as well as plastic materials in general, are being increasingly used during the past decades, which, in combination with their relatively short life cycle, has led to a significant increase of textile and plastic wastes in landfills. Since the majority of plastics (including synthetic fibers) are non bio-degradable, they contribute to "permanent" environmental pollution when rejected in landfills.

Besides the aforementioned environmental problems provoked by the extensive usage and rejection of textiles, there are also economical issues that need to be addressed. It is well known that the value of plastics (the raw materials of synthetic fibers) is constantly raising due to the exhaustion of natural resources (fossil fuel). It is worth noticing that the starting materials account for approximately 40-70 % of the total cost of textile and technical yarns, 30-40 % of that of textured yarns, and 60-80 % of the cost of staple fibers. Thus, the problem of economic use of starting materials is and will remain one of the priorities in the production of synthetic fibers.

Summarizing the above, the irrational disposal of textiles in landfills is detrimental from both environmental and economical point of view. Meanwhile, the combustion of textiles is, by no means, the only solution. Apart from the emission of toxic gases, combustion eliminates all the added value of the material and recovers only its energy content. Therefore, the need to recycle or re-use textiles becomes prominent.

Re-using textiles

Unlike plastics from applications such as packaging, which cannot be re-used for safety reasons, post-consumer textiles (e.g. clothing) may be donated to non-profit organizations, given to someone else, remade into other useful items or sold to secondhand stores. Alternatively, they may be used as filling material for mattresses, etc. However, although re-using textiles can postpone their

rejection to landfills, at some point the material will inevitably become too distorted and downgraded to be re-used.

Textiles recycling

Among the various disposal possibilities of textiles and plastics waste, recycling is in a favored position for ecological and economical reasons. Recycling results in less pollution and energy savings and reduces the pressure on virgin resources. Moreover, it may lead to high quality products, with a value comparable to the initial one. Therefore, it has been accepted that recycling is the most efficient and reliable method of dealing with textile and plastic waste.

As a result, many industries (e.g. plastic packaging and automotive industry) are obligated by laws or directives to organize or participate in recycling programs. Even though there is still no strict regulation for the textile industry, environmental legislation is constantly changing and so should the industries of the sector. As landfill costs and environmental regulations increase, technologies to recover and re-use valuable raw materials (i.e. recycle) are attracting the attention. Since the time of strict regulations will most probably come for the textile industry as well, it is in the manufacturers' best interest to be one step ahead of the regulation, if not for the environment, for the continued success of their company.

Recycling Methods

Approaches to textiles recycling mainly include the following recycling options:

- **Fiber Reclamation (Primary Recycling)** – In order to obtain reclaimed fibers, the textile waste is mechanically broken down as far as the fibers. Both the quality and the processability of such fibers depend on the kind of waste. There are many ways open to using reclaimed fibers in both textile and non-textile products. Indicatively, fibers from carpets or other textiles may be used, without further treatment, as fillers for mattresses, puppets, etc, or as reinforcements in polymeric composites. Even though this constitutes re-using rather than recycling, it results in new products of high

value. Moreover, this approach has the advantage of not requiring high fibers purity nor fibers made of a specific polymer. Therefore, fibers of unknown or uncertain composition may be used in such applications.

- **Mechanical or Material Recycling (Secondary Recycling)** – It involves the re-molding of textile wastes through re-melting. Mechanical recycling maintains the entire products value, apart from the molding cost, and it is the most effective, popular, economical and easily applicable recycling method in the case of plastics. Nevertheless, this technology often leads to degraded products of inferior value, because plastics, as organic materials, are subjected to undesirable chemical reactions during their previous processing steps and service life, mainly caused by oxidation and photo-oxidation. On one hand, during their service life, plastics suffer natural aging from the influence of temperature, air, light and weathering, leading to degradation of their visual and mechanical properties. On the other hand, during processing, they undergo preliminary molecular damage, such as chain scission, cross-linking, or formation of double bonds. Therefore, quality improvement of the recycled material becomes a key issue. Industrial companies have applied mechanical textiles recycling, i.e. they re-melt synthetic fibers obtained from the waste stream and re-mold new fibers. Following this approach they retain polymers' value; however, the material suffers some degradation, due to the melting process.
- **Chemical Recycling (Tertiary Recycling)** – Chemical recycling involves the de-polymerization of textiles waste. Following this approach, the monomers are recovered and may be re-used in new polymerization reactions. Therefore, products comparable to the initial ones are obtained. The disadvantage of chemical recycling, compared to mechanical recycling, is that it eliminates the value added during polymerization while being less versatile and easily applicable. International companies have established chemical recycling programs for polyamide fibers. That is, they undertake de-polymerization of polyamide to obtain its monomer (caprolactam), which is re-used in the polymerization process for new fibers preparation.

Open and Closed Loop Recycling

Following a different classification approach, one can distinguish open and closed loop recycling, depending on the application for which the virgin and recycled products are designated for.

- In **closed loop recycling** the recycled product is designated for the same application the initial product had. For example, fibers are produced by fibers recycling.
- On the other hand, in **open-loop recycling** the recycled product is designated for a new application. For example, plastic bottles are recycled to produce synthetic fibers.

6 Application of research results in T&A sectors

6.1 Advancements in textile machines and processes

Innovations that may translate into improved garment construction and faster speed to market constantly introduced to the market. Most technology is related to apparel applications to reduce the time and costs of pushing products through the supply chain.

Dyeing machines are redesigned to shorten cotton yarn processing time, and to reduce electricity and water consumption and chemical cost compared to conventional machines.

Circular knitting machines for creating offering to knitted fabrics the visual impression of woven fabrics, while their elasticity lends an outstanding hand and improved wearing properties. Using top-grade cotton, viscose or polyester yarns, knitters can use these machines to produce fabrics suitable for top-quality underwear, shirts, blouses and outerwear.

Technologies that allow the product to maintain its digital identity up to and including the distribution of the product. There are four major steps in the supply chain for apparel products. They are design/product development, sales/marketing, manufacturing, and delivery. Delivery is complete when the consumer has possession of the product. Digital technologies exist and are being further developed for each of these areas.

Design and product development will make use of 3D tools that allow for garments to be created in 3D and converted automatically to 2D for traditional manufacturing methods. Body scanning systems will be used to create digital body models that allow digital products to be draped over them. Fiber and fabric characteristics will be incorporated into the simulation of these digital products on the body. These avatars will be shared digitally and monitored through the product development process without the need to make a physical sample of either the fabric or the garment.

Manufacturing must become a conversion process from digital to physical. At some point the product must take on a physical form, but today that process is tedious and time consuming. A number of industries have already moved in this direction. Examples can be found in the airline industry, the newspaper industry, the music industry, and the movie industry. In addition, knitting technology already exists that allows the conversion of 3D product data into 3D finished product without intermediate cut and sew steps.

6.2 Innovations in T&A products

Fashion and functionality are converging. Increasingly, consumers expect their clothing not only to look good, but also to provide features once limited to clothing designed for sports, difficult environments or even medical use. Easier access to information on the internet plays a key role in this development. In the past, functional improvements might have had little exposure beyond the specialized niches for which they were originally developed. Today, however, any consumer with a connection to the internet can learn about the latest advances in textile technology.

Innovations allow companies to differentiate their products and become more competitive. Recent developments in fibres, yarns, fabrics and chemicals for performance apparel are now adapted from fashion designers, apparel manufacturers and even home textiles manufacturers.

Water repellent fabrics are now used in many applications in clothing and home textiles sectors. Fabrics that incorporate moisture management technologies and have traditionally been used in active performance wear, are now widely used for clothes that keep the wearers dry not allowing absorption or penetration of water for a fixed period of time permitting body perspiration to escape and not reducing comfort. Wash and wear fabric - wrinkle-free clothing liberates the public from ironing. Fibers modified to be stain and tear resistant, disembarrass from soiled clothing. Other textile treatments render synthetic

fibres hydrophilic, giving much greater comfort during wear. A number of treatments for clothing and medical wear have been developed, which reduces odours. Different fabric finishing processes offer non allergenic, antistatic and antibacterial properties. Certain combinations of fabric construction, chemical finishes, and garment construction can also keep the body warmer or cooler, depending on the environmental conditions. Flame retardant fibers and fabrics for protective clothing or furnishing and curtains offer safety to the consumers.

Finally smart textiles make their first steps to fashion by the use of fabrics that can use our movement or solar power to produce energy to charge a gadget. Special fibers made from chromic materials (that can change their colour) or Shape Memory Materials (that can change their shape) where sometimes used from fashion designers to make clothes that change their colour or form reacting and responding to environmental conditions or stimuli.