K.S. RANGASAMY COLLEGE OF TECHNOLOGY

(Autonomous)

TIRUCHENGODE – 637 215

COURSE MODULE

50 TT 604 – TECHNICAL TEXTILES

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Unit I

Introduction, Fibres & Structures Technical Textiles: Introduction - Definition, Scope of technical textiles, Classification & Application of Technical textiles. Fibres– Conventional Fibres, High Strength & High Modulus Fibres, High Performance fibres, Ultra-fine and Novelty fibres in Technical textiles. Engineering Textile Structures for Technical Textiles.

Unit II

Medical Textiles Medical Textiles: Introduction, Materials used & its requirements. Classification of Medical textiles - Textiles for implantations, Non-implantations textiles, Extra-corporeal devices, Healthcare & Hygiene Products.

Unit III

Geo & Agro Textiles Geo Textiles: Geo textile, Geo synthetics, Fibres and its selection for Geo textiles, Functions of Geo textiles, Engineering properties of Geo textiles, Geo textile structure, Applications for natural Geo textiles. Agro Textiles - Textiles in Agriculture - Fibres details & Properties, Applications of Agro textiles

Unit IV

Protective & Smart Textiles Protective Textiles: Introduction, Selection of protective clothing materials, fibres and fabrics for Protective Textiles, Textiles for environmental protection; Thermal insulation materials; Biological and chemical warfare protection, Nuclear protective fabrics. Smart Textiles - Role of smart materials in textiles, Shape Memory Fibres, Shape Memory Material, Concepts associated with shape memory materials, SMM in smart fabrics and garments.

Unit V

Miscellaneous Industrial applications of textiles Textiles in Electronics, Textiles for Banners and Flags., Canvas Covers and Tarpaulins, Ropes and Nets, Home and Office Furnishings, Textiles in sportswear - Fabrics for sportswear and recent developments in sportswear.

Technical Textiles

Unit-I

Introduction of Technical Textile:

Introduction:

Technical textiles are generally recognized to be one of the most dynamic and promising areas for the future of the textiles industry. Technical textiles are textile material and products manufactured primarily for their performance and functional properties rather than aesthetic or decorative purpose. Aesthetic properties are not much important for the Technical Textiles.

Although 'technical' textiles have attracted considerable attention, the use of fibres, yarns and fabrics for applications other than clothing and furnishing is not a new phenomenon. Nor is it exclusively linked to the emergence of modern artificial fibres and textiles. Natural fibres such as cotton, flax, jute and sisal have been used for centuries (and still are used) in applications ranging from tents and tarpaulins to ropes, sailcloth and sacking. There is evidence of woven fabrics and meshes being used in Roman times and before to stabilise marshy ground for road building – early examples of what would now be termed geotextiles and geogrids. What is relatively new is a growing recognition of the economic and strategic potential of such textiles to the fibre and fabric manufacturing and processing industries of industrial and industrialising countries alike. In some of the most developed markets, technical products (broadly defined) already account for as much as 50% of all textile manufacturing activity and output. The technical textiles supply chain is a long and complex one, stretching from the manufacturers of polymers for technical fibres, coating and speciality membranes through to the converters and fabricators who incorporate technical textiles into finished products or use them as an essential part of their industrial operations. The economic scope and importance of technical textiles extends far beyond the textile industry itself and has an impact upon just about every sphere of human economic and social activity.

And yet this dynamic sector of the textile industry has not proved entirely immune to the effects of economic recession, of product and market maturity, and of growing global competition which are all too well known in the more traditional sectors of clothing and furnishings. There are no easy paths to success and manufacturers and converters still face the challenge of making

economic returns commensurate with the risks involved in operating in new and complex markets. If anything, the constant need to develop fresh products and applications, invest in new processes and equipment, and market to an increasingly diverse range of customers, is more demanding and costly than ever. Technical textiles have never been a single coherent industry sector and market segment. It is developing in many different directions with varying speeds and levels of success. There is continual erosion of the barriers between traditional definitions of textiles and other 'flexible engineering' materials such as paper and plastics, films and membranes, metals, glass and ceramics. What most participants have in common are many of the basic textile skills of manipulating fibres, fabrics and finishing techniques as well as an understanding of how all these interact and perform in different combinations and environments. Beyond that, much of the technology and expertise associated with the industry resides in an understanding of the needs and dynamics of many very different end-use and market sectors. It is here that the new dividing lines within the industry are emerging. An appreciation of the development and potential of technical textile markets therefore starts with some clarification of the evolving terminology and definitions of scope of the industry and its markets.

Technical or industrial textiles: what's in a name?

For many years, the term 'industrial textiles' was widely used to encompass all textile products other than those intended for apparel, household and furnishing end-uses. This usage has seemed increasingly inappropriate in the face of developing applications of textiles for medical, hygiene, sporting, transportation, construction, agricultural and many other clearly non-industrial purposes. Industrial textiles are now more often viewed as a subgroup of a wider category of technical textiles, referring specifically to those textile products used in the course of manufacturing operations (such as filters, machine clothing, conveyor belts, abrasive substrates etc.) or which are incorporated into other industrial products (such as electrical components and cables, flexible seals and diaphragms, or acoustic and thermal insulation for domestic and industrial appliances).

If this revised definition of industrial textiles is still far from satisfactory, then the problems of finding a coherent and universally acceptable description and

classification of the scope of technical textiles are even greater. Several schemes have been proposed. For example, the leading international trade exhibition for technical textiles, Techtextil (organised biennially since the late 1980s by Messe Frankfurt in Germany and also in Osaka, Japan), defines 12 main application areas (of which textiles for industrial applications represent only one group):

- agrotech: agriculture, aquaculture, horticulture and forestry
- buildtech: building and construction
- clothtech: technical components of footwear and clothing
- geotech: geotextiles and civil engineering
- hometech: technical components of furniture, household textiles and floorcoverings
- indutech: filtration, conveying, cleaning and other industrial uses
- medtech: hygiene and medical
- mobiltech: automobiles, shipping, railways and aerospace
- oekotech: environmental protection
- packtech: packaging
- protech: personal and property protection
- sporttech: sport and leisure.

The search for an all embracing term to describe these textiles is not confined to the words 'technical' and 'industrial'. Terms such as performance textiles, functional textiles, engineered textiles and high-tech textiles are also all used in various contexts, sometimes with a relatively specific meaning (performance textiles are frequently used to describe the fabrics used in activity clothing), but more often with little or no precise significance.

Definition, Scope of technical textiles:

Technical Textiles are defined as Textile material and products manufactured primarily for their Technical performance and functional properties rather than aesthetic and decorative characteristics.

The Definition of Technical Textiles adopted by the authoritative *Textile Terms and Definitions*, published by the Textile Institute. "Materials and products intended for end-uses other than non-protective clothing, household furnishing, and floor covering, where the fabric or fibrous component is

selected principally but not exclusively for its performance and properties as opposed to its aesthetic or decorative characteristics" (Textile Terms and Definitions, TI, Manchester, 10theEd.)

Such a brief description clearly leaves considerable scope for interpretation, especially when an increasing number of textile products are combining both performance and decorative properties and functions in equal measure. Examples are flame retardant furnishings and 'breathable' leisurewear. Indeed, no two published sources, industry bodies or statistical organisations ever seem to adopt precisely the same approach when it comes to describing and categorising specific products and applications as technical textiles.

It is perhaps not surprising that any attempt to define too closely and too rigidly the scope and content of technical textiles and their markets is doomed to failure. In what is one of the most dynamic and broad ranging areas of modern textiles, materials, processes, products and applications are all changing too rapidly to define and document. There are even important linguistic and cultural perceptions of what constitutes a technical textile from geographical region to region in what is now a global industry and marketplace.

Scope of Technical Textiles:

According to the recent reports, there has been a sharp Increase in the global demand for Technical Textiles in various application areas namely Meditech, buildtech, Mobiletech,Protech, Indutech, Hometech, Clothtech, Sporttech, Packtech, Oekotech, Defence, Geotech.These applications have provided scope for making various products – from Car Upholstrey to Parachutes,Shelter Fabric to Home furnishing, Infrastructure to Environmental and even to Hospitals.The WORLD TRADE in technical textiles is believed to be over USD 50 Billion per annum and it isgrowing at an accelerated pace. It is expected to increase to USD 127 Billion by 2010 and drivers of future growth of this industry is expected to be Asian countries like India and China. The new promise of technical and performance textiles is an emerging generation of products combining the latest developments in advanced flexible materials with advances in computing and communications technology, biomaterials, nanotechnology and novel process technologies such as plasma treatment. These will eventually have a direct impact upon all sorts of consumer textile markets, including both clothing and furnishings. The field of 'wearable electronics' has already captured the imagination of many researchers and large corporations and, although most products on the market today are relatively

unsophisticated 'implants' of conventional electronics and wiring, the prospect of truly 'interactive textiles embodying sensors, actuators and logic circuits built into the structure of the fibres, yarns and fabrics themselves is not impossibly far- fetched.

The term "technical textiles" was coined in the 1980s to describe the growing variety of products and manufacturing techniques being developed primarily for their technical properties and performance rather than their appearance or other aesthetic characteristics. It largely superseded an earlier term "industrial textiles" (still widely used in the USA) which had become too restrictive in its meaning to describe the full complexity and richness of this fast growing area. A major international exhibition, Techtextil, was launched in 1985 to reflect the growth of technical textiles and soon developed a simple taxonomy that has been used ever since to describe the scope of this new industry and market sector.

Agrotech - agriculture, horticulture, forestry and aquaculture textiles
Buildtech - building and construction textiles
Clothtech - technical components of shoes and clothing e.g. linings
Geotech - geotexiles and civil engineering materials
Hometech - components of furniture, household textiles & floorcoverings
Indutech - textiles for industrial applications filtration, conveying, cleaning etc
Medtech - hygiene and medical products
Mobiltech- automobiles, shipping, railways and aerospace
Oekotech - environmental protection
Packtech - packaging materials
Protech - personal and property rotection
Sporttech- sport and leisure

Within each of these headings are literally hundreds of products and applications for textiles, some traditional, some replacing other well-established materials and techniques, and some that have been newly created by the unique properties and capabilities of textile materials and structures. The automotive industry is not only one of the largest single markets for technical textiles but also one of the most diverse. Applications range from tyre cord, hose and drive belt reinforcements to thermal and sound insulation, safety belts and airbags, filters, cable harnesses and textile reinforced composites for body and suspension parts. Even the internal furnishings of a car headliners, seating, carpets, parcel shelf and trunk liners are all regarded as technical textiles because of the extremely demanding specifications to which they are made and

tested. As just one other example, the medical and hygiene textiles market ranges from high volume disposable products for babies' nappies, feminine hygiene and adult incontinence through to extremely specialised and high value textile products for use in blood filtration, surgical sutures, prostheses and, most recently, scaffolds for new tissue growth.

Technical Textiles has tremendous growth scope in India: As the importance of Technical Textile is rising day by day, market opportunities are increasing and thus the usage of the same is growing rapidly. Currently, approximately US $120 billion worth of Technical Textiles is consumed world over and in India it is just $6 billion. Though India has a significant presence in some segments of Technical Textiles such as Automotive and Industrial textiles, it is yet to make a presence in other segments of Technical Textiles.

Government has taken initiatives to promote Technical Textiles through fiscal support, research spending and inter-departmental co-ordination. This is expected to stimulate domestic consumption in the coming years. Besides, going by the past trends as shown in the developed countries, one can anticipate higher per capita consumption of Technical Textiles as the Indian economy continues to grow despite current slowdown.The other major segment that is expected to stimulate the demand will be medical textiles, as India is fast emerging as a centre for medical tourism.Indian Government is rightly increasing the spending on infrastructure significantly and this is expected to result in the growth of geo-textiles applications in roads, airports, dams, sea erosion control and solid waste management systems.

Agrotech is another area which promises a huge growth for Technical Textiles. Indian agriculture practices are presently not sufficiently modern. But with increasing awareness of advantages such as productivity and quality improvement due of use of woven, coated and non-woven textiles in agriculture, high growth is anticipated in this segment.

Present Scenario of Technical Textiles:

Global Scenario:- India is the world second largest producer of textile and garments. The textile industry in India contributes 14 % towards the GDP of USD 1.18 billion. This market itself being so big, there is tremendous potential for technical textiles as well. Currently the consumption of technical textiles in India forms only 3 % of the total world consumption; however, it is growing at a rate higher than most developed countries. The reasons for low penetration in this market are several, such as scattered production structure, inadequate

research and development (R&D), lack of skilled personnel. Another major contributing factor is that there is lack of awareness about the benefits of using technical textile and therefore leading to low consumption. So, India still has to make its presence felt in the world technical textiles market, which earns that a highly unexploited market is waiting to be explored. The economic importance of technical textiles

The new promise of technical and performance textiles is an emerging generation of products combining the latest developments in advanced flexible materials with advances in computing and communications technology, biomaterials, nanotechnology and novel process technologies such as plasma treatment. These will eventually have a direct impact upon all sorts of consumer textile markets, including both clothing and furnishings. The field of 'wearable electronics' has already captured the imagination of many researchers and large corporations and, although most products on the market today are relatively unsophisticated 'implants' of conventional electronics and wiring, the prospect of truly 'interactive textiles embodying sensors, actuators and logic circuits built into the structure of the fibres, yarns and fabrics themselves is not impossibly far- fetched.

Market Size of Indian Technical Textile Industry:

India is emerging as a significant player in technical textiles. The fast-paced economic growth leading to infrastructure creation as well as higher disposable income has made India a key market for the technical textile products. Moreover, the country has developed a foothold in the production of technical textiles owing to its skilled and technical manpower as well as abundant availability of raw- material. More investments are underway in this sector; as per the Ministry of Textiles, as on September 2010, 26,163 applications for technical textile projects with a project cost of US$ 14.5 billion were disbursed under Technology Upgradation Fund Scheme (TUFS).

Indian Technical Textile industry is estimated at Rs 41,756 Crore (2007-08), with domestic consumption of Rs. 38,835 Crore. The Industry has witnessed a significant growth of 16% from 2001-02 to 2009-10 and, is expected to grow at a rate of 11% year-on-year and reach a market size of Rs. 70,151Crore by the year (2012-13), with domestic consumption of Rs. 65,722 by the year 2012-13.

Classification of Technical Textiles:

Classification of Technical Textiles:Technical textiles can be divided into many

categories, depending on their end use. The classification developed by Techtextil, Messe Frankfurt is widely used

The classifications and its applications are shown in Fig

The classifications of Technical Textiles:

Agrotech (Agro-textiles):Textiles used in Agriculture are termed as agro textiles. They are used for crop protection, fertilisation, ... The essential properties required are strength, elongation, stiffness, and bio-degradation, resistance to sunlight and resistance to toxic environment. All these properties help with the

	Agrotech Horticulture + landscape gardening, agriculture + forestry, animal keeping		**Meditech** Hygiene, medicine
	Buildtech Membrane, lightweight + massive construction, engineering + industrial building.		**Mobiltech** Cars, ships, aircraft, trains, space travel
	Clothtech Garments, shoes		**Oekotech** Environmental protection, recycling, waste disposal
	Geotech Road infrastructure, Railways, Irrigation and Hydraulic structures, Waste Landfills, Dams etc.		**Packtech** Packaging, protective-cover systems, sacks, big bags, container systems
	Hometech Furniture, upholstery + interior furnishing, rugs, floor coverings		**Protech** Person and property protection
	Indutech Filtration, cleaning, mechanical engineering, chemical industry		**Sporttech** Sport and leisure, active wear, outdoor, sport articles.

growth and harvesting of crops and other foodstuffs. There is a growing interest in using materials which gradually degrade (biodegradables).

Buildtech (Construction Textiles):;Textiles used in construction - concrete reinforcement, façade foundation systems, interior construction, insulations, proofing materials, air conditioning, noise prevention, visual protection, protection against the sun, building safety.An interesting and astethic appealing application is the use of textile membranes for roof construction. This area is also referred to as textile architecture. PVC coated high tenacity PES, teflon coated glass fibre fabrics or silicone coated PES are used for their low creep properties. Splendid examples of such construction are found in football stadia, airports and hotels.

Clothtech (Clothing Textiles):Technical textiles for clothing applications.

Geotech (Geo-textiles):These are used in reinforcement of embankments or in constructional work. The fabrics in geo textiles are permeable fabrics and are used with soils having ability to separate, filter, protect or drain. The application areas include civil engineering, earth and road construction, dam engineering, soil

sealing and in drainage systems. The fabric used in it must have good strength, durability, low moisture absorption and thickness. Mostly nonwoven and woven fabrics are used in it. Synthetic fibers like glass, polypropylene and acrylic fibers are used to prevent cracking of the concrete, plastic and other building materials. Polypropylene and polyester are used in geo textiles and dry/liquid filtration due to their compatibility.

Hometech (Domestic Textiles):Textiles used in a domestic environment - interior decoration and furniture, carpeting, protection against the sun, cushion materials, fireproofing, floor and wall coverings, textile reinforced structures/fittings.In the contract market such as for large area buildings, ships, caravans, busses, fire retardant materials are used. Fire retardant properties are obtained either through the use of inherent fire retardant fibres such as modacryl or through the application of a coating with fire retardant additives (bromide of phosporus compounds).

Indutech (Industrial Textiles):Textiles used for chemical and electrical applications and textiles related to mechanical engineering. Silk-screen printing, filtration, plasma screens, propulsion technology, lifting/conveying equipment, sound-proofing elements, melting processes, roller covers, grinding technology, insulations, seals, fuel cell.

Medtex (Medical textiles):These are commonly used in bandages and sutures (stitching the wounds). Not all the textile fibers can be used here, because their performances depend upon interaction with the cells and different fluids produce by the body. Sutures and wound dressing uses fibers like silk and other synthetic fibers. Hollow synthetic fibers are used with nano or very small particles are used for the delivery of drugs to any specific part of the body to prevent over dosage. Cotton, silk polyester, polyamide are also used in medical applications.Medical textiles also cover surgical gowns and drapes. There are two classes of materials: reusables and non-wovens. Reusable are either PES or PES-cotton woven materials or laminates. Also non-woven materials are used in the operating theater.High performance non-wovens are usually laminated with a plastic foil in order to provide for sufficient barrier properties to reduce wound infection.

Mobiltech (Textiles used in transport):These textiles are used in the construction of automobiles, railways, ships, aircraft and spacecraft. Examples are Truck covers (PVC coated PES fabrics), car trunck coverings (often needle felts), seat covers (knitted materials), seat belts, non- wovens for cabin air filtration (also covered in indutech), airbags, parachutes, boats (inflatable), air ballons.

Oekotech or Ecotech (Environmentally-friendly textiles):New applications for textiles in environmental protection applications - floor sealing, erosion protection, air cleaning, prevention of water pollution, water cleaning, waste treatment/recycling, depositing area construction, product extraction, domestic water sewerage plants.

Packtech (Packaging textiles):Packaging, silos, containers, bags, canvas covers, marquee tents.

Protech (Protective textiles):Protection against heat and radiation for fire fighter clothing, against molten metals for welders, for bullet proof jackets etc, all these things are obtained by usage of technical textiles with high performance fibers. In bullet proof jackets, special fiber aramid are used which have high tenacity, high thermal resistance and low shrinkage. Glass fiber is also used in fire proof jackets due to its high strength, chemical and flame resistance. Protective clothing is also used by the astronauts when they go in space. It was used by the astronauts when they went on moon, their suits where covered with special chemicals including lead to protect them from suns heat, their suit not only made from special fibers but their airship was also lined with special fabric.

Sporttech (Sports textiles):Shoes, sports equipment, flying and sailing sports, climbing, angling, cycling, winter and summer sports, indoor sports wear

Specific areas of application

Conveyor belts:For industrial applications and in power transmission, technical textiles are used in conveyor belts. Carcass is a fabric inside the conveyor belt, which is responsible for the strength and stretch properties of the belt. This carcass is made with layers of woven fabrics bonded together.

Electronics in textiles:It has been heard that soon textiles will be merged with electronics in all areas. In future wearable computers would be launched, these will not be like advance wrist watches etc, they will contain IC s in fabric to develop fabric keyboards and other wearable computer devices. These types of products are known as Interactive electronic textiles (IET). Research to support IET development is being conducted in many universities. Growing consumer interest in mobile, electronic devises will initiate the demand for IET products .

Application of textiles:

Introduction: Textiles are everywhere in modern society; Worn as protection and self-expression on the human body, used as decoration and comfort elements in homes, offices, hospitals, hotels or public buildings, as interior components in cars, buses, trains, ships

and airplanes, or structural elements for tents, roofs, bridges, or as reinforcements for roads, and dikes but also as bags, nets or artificial turf in sports and outdoor activities. In spite of the fact that normally the textile industry is considered a traditional sector, today it has become one of the main test-beds regarding new business strategies. The new market standards, achievable with process innovations, which on one hand reduce costs, whereas on the other hand allows to distinguish oneself from the other competitors, have become a very important competitive factor. Ever since the mid 80's, the market of textile products started to change radically, and it was divided between: Standard productions, identified with a low innovation and technology level, medium to low quality, weak customer service - complex productions identified with a high product innovation level, with the use of state-of-the-art process technologies and product research, a strong aesthetic element, as well as certain and high quality levels, quick timing addressing requirements, production flexibility and customer service. As well as the above, currently there is a new phase in the textile field in which new materials allow to make dynamic and interactive products, able to offer protection, comfort and performance. The textile materials are therefore becoming the basis for a completely new range of new applications.

Innovative and technical textiles: A sector of niches with high added value:

Today it's needed to adopt a different approach to textiles; Fabrics have to be regarded not only just as a surface, to be interpreted graphically, but as a material to all intents and purposes, with its own intrinsic structure and performance. In the sector of technical textiles there are a large number of niches and products, often highly technological and where the end user requires specific requirements, and for which the cost is no longer the only parameter taken into consideration. Regarding innovative textiles the market is growing rapidly and many developments of new products and applications are underway. The technological evolution which transversally integrates human science, materials and information technology, does allow to foresee positive perspectives in the approach towards development of new products and applications. The general trend is therefore towards high tech, high performance fabrics designed not just to look attractive, but to offer a significant added value in terms of functionality.

Application field of technical textiles In the field of specialised applications, the technological assets are those that provide the highest performance and comfort

standards, and ensure a better quality of life. Already there are fabrics capable of reducing risks (eg, antibacterial, mite-proof, insect proof, odourless, flame retardant, soil-resistant, anti-UV and anti-electromagnetic radiation, etc). Other fabrics function actively (eg, heat-regulating, with new visual features, or

providing cosmetic-medical effects, and so forth)

Application Functions

1. Mechanical functions
2. Exchange functions
3. Functionalities for living beings
4. Protective functions

1. Mechanical functions
   - Mechanical resistance
   - Reinforcement of materials
   - Elasticity
   - Tenacity
2. Exchange functions
   - Filtration
   - Insulation and conductivity
   - Drainage
   - Impermeability
3. Functionalities for living beings
   - Antibacteria
   - Antidustmites
   - Biocompatibility (hypoallergenic textiles)
   - Biodegradability / bioresorption
4. Protective functions
   - Thermal
   - Fire
   - Mechanical
   - Chemicals
   - Impermeable - Breathable
   - Antistatic
   - Particles antirelease
   - Electrical insulation,
   - IR and UV rays,
   - NBC (Nuclear, biological and chemical)
   - High visibility
   - Electromagnetic fields

Applications of Technical Textiles

Agrotech (Agro-textiles):

Agro-textiles, also known as Agrotex, that are used in agricultural applications related to growing and

harvesting of crops and animals. Not only crop production, they are also used in forestry, horticulture, as well as animal and poultry rearing including animal clothing. Agro-textiles have to be strong, elongated, stiff,
bio-degradable, resistant to sunlight and toxic environment. The essential properties required are strength, elongation, stiffness, and bio-degradation, resistance to sunlight and resistance to toxic environment. All these properties help with the growth and harvesting of crops and other foodstuffs. There is a growing interest in using materials which gradually degrade (biodegradables). Applications for technical textiles in agriculture include all activities concerned with the growing and harvesting of crops and animals. The principal function of most agricultural textiles relates to the protection of either food produce, animals or land. Enduses range from crop production, through forestry and horticulture, to animal and poultry rearing and fishing. The fishing segment is a large consumer of textile materials Fishing methods are becoming more industrialised, replacing older small net and line fishing techniques.
Some of the examples of agro textiles are preventing erosion and paving way for afforestation in greenhouse cover and fishing nets. For Layer separation in fields, in Nets for plants, rootless plants & protecting grassy areas As sun screens (since they have adjustable screening)and wind shields As packing material and in bags for storing grass (that has been mowed) Controlling stretch in knitted nets Shade for basins Anti-birds nets Fabrics for sifting and separation, for the phases of enlargement of the larvae Materials for ground and plant water management at the time of scarcity and abundance of water.

Buildtech:

These are the Construction Textiles, also known as Buildtex, used in construction and architectural applications, such as for concrete reinforcement, facade foundation, interior construction, insulation, air conditioning, noise prevention, visual protection, protection against sun light, building safety etc. The field of textile architecture is also expanding as textile membranes are increasingly being used for roof construction. Such fabrics as PVC coated high tenacity PES, teflon

coated glass fiber fabrics or silicone coated PES are used extensively in football stadia, airports and hotels.

Clothtech:These are the Clothing Textiles, also known as Clothtex, including all those textile products that represent functional, most often hidden components, of clothing and footwear such as interlinings, sewing thread, insulating fibrefill and waddings. They are the 'high performance' garment fabrics whose demand is increasingly rising with the time. The skin is the principal element that separates and protects the human body from the environment around it. It is also acts as a major exchange system of energy (eg, heat) and matter (fluids and gases such as water, oxygen etc) between body and environment. Clothing as an artificial second skin has always been used by humans to enhance the protective function of their own skin. However such additional protection often has a negative effect upon the exchange functionality of the human skin, in certain cases very severely like in the case of full body armour, fire-fighters, uniforms or diving suits. Functional and smart or intelligent clothing are the innovative response to such limitations. Functional clothing refers to products in which one or several specific functionalities are emphasised like strong insulation, water or fire resistance, breathability, wear resistance etc. Smart clothing takes (multi) functionality one step further as it refers to products that can offer their functions in a more adaptive way in response to stimuli from the environment or the wearer.

Smart garments can for instance:

- Adapt their insulation function according to temperature changes.
- Detect vital signals of the wearer's body.
- Change colour or emit light upon defined stimuli.
- Generate or accumulate electric energy to power medical and other electronic devices.

Geotech:These are the Geotextiles, also known as Geotex, which are woven, nonwoven and knit fabric used for many functions such as support, drainage and separation at or below ground level. Their application areas include civil and coastal engineering, earth and road construction, dam engineering, soil sealing and in drainage systems. Geotech have good strength, durability, low moisture absorption and thickness. Synthetic fibers such as glass fiber, polypropylene and

acrylic fibers are used to prevent cracking of the concrete, plastic and other building materials.

Hometech:These are the Domestic Textiles, also known as Hometex, used in making of many home furnishing fabrics including carpet backings, curtains, wall coverings, etc. They are mostly fire retardant fabrics whose properties are derived either by using fire retardant fibers such as modacrylic fiber or by coating the fabrics with fire retardant additives such as bromide of phosphorus compounds.

Traditionally textiles have been an important part of the interior of human habitations, as well as human transportation systems such as cars, buses, passenger trains, cruise ships or airplanes. In that respect textile served three basic purposes:

a) Decoration (carpets, wall coverings, curtains & drapes, table cloths, etc).
b) Comfort (upholstery, seat covers, mattresses, bed sheets, blankets, carpets etc).
c) Safety (safety belts and nets, airbags).

Textile Structures for building Textiles have in the past been predominantly confined to the interior decoration; They are now increasingly becoming part of these constructions themselves. Thanks to better performance characteristics in terms of their strength-weight ratio, durability, flexibility, insulating and absorption properties, and fire and heat resistance, they are in a position to replace more traditional construction materials such as steel and other metals, wood and plastics. Examples of such innovative uses of textiles include

- Lightweight textile roofing.
- Textile-reinforced concrete.
- Fibre and textile-based bridging cables and elements.
- Erosion and landslide protection systems.
- Textile reinforcement of dykes and other water management systems.
- Fibre-based light, flexible and durable piping and canalisation.

Indutech:These are the Industrial Textiles, also known as Indutex, used in different ways by many industries for activities such as separating and purifying

industrial products, cleaning gases and effluents, transporting materials between processes and acting as substrates for abrasive sheets and other coated products. They range from lightweight nonwoven filters, knitted nets and brushes to heavyweight coated conveyor belts.

Medtech:These are the Medical Textiles, also known as Medtex. They include all the medical fabrics that are used in health and hygiene applications in both consumer and medical markets. They are generally used in bandages and sutures that are used for stitching the wounds. Sutures and wound dressing uses fibers like silk fibers and other synthetic fibers. Hollow synthetic fibers are used with nano particles (very small particles) for delivery of drugs to any specific part of the body. Cotton, silk, polyester, polyamide fabrics are also used in medical applications. Innovative textile products can both add significantly to effectiveness of medical treatments as well as patient comfort at the same time, new medical textiles, may contribute to cost containment. Such innovative products:

- Provide new treatment options (textile based implants instead of scarce donor organs; artificial tissues, joints and ligaments).
- Speed up recovery after medical treatment (innovative wound dressings; Light, breathable orthoses/protheses).
- Enhance quality of life of chronically ill people (functional clothing).

Mobiltech:These textiles, also known as Mobiltex, are used in transport industry, such as in construction of automobiles, railways, ships etc. Truck covers and restraints are significant textile end-uses in the transportation sector. They can range from simple ropes and tarpaulins to highly engineered flexible curtain systems and webbing tie-downs. Other examples include seat covers, seat belts, non-wovens for cabin air filtration, airbags, parachutes, inflatable boats, air balloons etc.

Oekotech:These are the Eco-friendly Textiles, also known as Oekotex or Ecotex. They are mostly used in environmental protection applications - floor sealing, erosion protection, air cleaning, prevention of water pollution, water cleaning, waste treatment/recycling, depositing area construction, product extraction, domestic water sewerage plants. They are even gaining unimaginable popularity in other sectors of textile industry. Clothing, home furnishings, fashion accessories etc. all now come in eco-friendly versions made of oekotech.

Packtech:These are the Packaging Textiles, also known as Packtex. Textiles have been used for packaging since ages. It ranges from heavyweight woven fabrics used for bags, packaging sacks, Flexible Intermediate Bulk Carriers (FIBCs) and wrappings for textile bales and carpets to the lightweight nonwovens used as

durable papers, tea bags and other food and industrial product wrappings.

Protech:These are the Protective Textiles, also known as Protex, that are used in the manufacturing of protective clothing of different types. Protection against heat and radiation for fire fighter clothing, against molten metals for welders, for bullet proof jackets or for chemical protective clothing- all depend on the use of protech. The main target of the technical protective fabrics is to improve people safety in their workplaces. A technical protective fabric can save a worker's life, that's why, most of them are mainly used to manufacture PPE (personal protective equipment). The demand of these fabrics is growing around the world thanks to the sensibilitization of the society, requiring more safety at work. The aim of a technical protective fabric isn't fashion, they are designed to have extra values in protection, against some hazards. The protective textiles are made with the help of specialty fibers such as aramid fiber used in making of bullet proof jackets, glass fibers used in fire proof jackets etc. Sometimes the protective textile is also coated with special chemicals, for example, when used in manufacturing astronauts' suits. The main end use segments include:

- Chemical protection.
- Flame retardant.
- Cut resistant.
- Outdoor protection, hi-visibility.

Manufacturers of protective clothing are also realising the need to supply workers with comfortable garments. In fact although guaranteed high levels of performance will remain critical for protective garments, increased emphasis is being placed on wearer comfort, and design aesthetics.

Sporttech:These are the Sports Textiles, also known as Sporttex, used mainly for making sports wear including sports shoes and other sports accessories. Increasing interest in active sports and outdoor leisure activities such as flying and sailing sports, climbing, cycling, etc. has led to immense growth in the consumption of textile materials in manufacturing sporting and related goods and equipment. Synthetic fibers and coatings have largely replaced traditional cotton fabrics and other natural fibers in the making of sporttech.

Fibres:

Conventional Fibres:

Natural Fibers:

Cotton accounts for half of the world's consumption of fibres and is likely to remain so owing to many of its innate properties. The length of the chains

determines the ultimate strength of the fibre. The unique physical and aesthetic properties of the fibre, combined with its natural generation and biodegradability, are reasons for its universal appeal and popularity. High moisture absorbency, high wet modulus and good handle are some of the more important properties of cotton fibre.

Wool, despite its limited availability and high cost, is the second most important natural fibre. It is made of protein: a mixture of chemically linked amino acids which are also the natural constituents of all living organisms. Keratin or the protein in the wool fibre has a helical rather than folded chain structure with strong inter- and intrachain hydrogen bonding which are believed to be responsible for many of its unique characteristics.

Flax, jute, hemp and ramie, to name but a few of the best fibres, have traditionally taken a secondary role in terms of consumption and functional requirements. They are relatively coarse and durable, and flax has traditionally been used for linen making. Jute, ramie and to a lesser extent other fibres have received attention within the geotextile sector of the fibre markets which seeks to combine the need for temporary to short-term usage with biodegradability, taking into account the regional availability of the fibres.

Silk is another protein-based fibre produced naturally by the silkworm, *Bombyx Mori* or other varieties of moth. Silk is structurally similar to wool with a slightly different combination of amino acids which make up the protein or the fibroin, as it is more appropriately known. Silk is the only naturally and commercially produced continuous filament fibre which has high tenacity, high lustre and good dimensional stability.

Regenerated Fibers:

Viscose rayon was the result of the human race's first attempts to mimic nature in producing silk-like continuous fibres through an orifice. Thin sheets of cellulose are treated with sodium hydroxide and aged to allow molecular chain breakage. Further treatment with carbon disulphide, dissolution in dilute sodium hydroxide and ageing produces a viscous liquid, the viscose dope, which is then extruded into an acid bath. The continuous filaments that finally emerge are washed, dried and can be cut to staple lengths. The shorter cellulose molecules in viscose and their partial crystallisation accounts for its rather inferior physical properties relative to cotton.

Lyocell, is the latest addition to this series of fibres, commercially known as Tencel (Acordis), has all the conventional properties of viscose in addition to its

much praised environmentally friendly production method. The solvent used is based on non-toxic *N*-methyl morpholine oxide used in a recyclable closed loop system, which unlike the viscose process avoids discharge of waste. Highly absorbent derivatives of Tencel, known as Hydrocell are establishing a foothold in wound dressing and other medical-related areas of textiles.

Synthetic Fibers:

The first synthetic fibre that appeared on the world market in 1939 was nylon 6.6. It was produced by DuPont and gained rapid public approval. A series of nylons commonly referred to as polyamides now exists in which the amide linkage is the common factor. Nylon 6.6 and nylon 6 are most popular in fibre form. They are melt extruded in a variety of cross-sectiona shapes and drawn to achieve the desired tenacity.They are well known for their high extensibility, good recovery, dimensional stability and relatively low moisture absorbency Nylon was later surpassed by the even more popular fibre known as polyester, first introduced as Dacron by DuPont in 1951. Polyester is today the second most used fibre after cotton and far ahead of other synthetics both in terms of production and consumption. Polyethylene terephthalate or polyester is made by condensation polymerisation of ethylene glycol and terephthalic acid followed by melt extrusion and drawing. It can be used in either continuous form or as short staple of varying lengths.The popularity of polyester largely stems from its easycare characteristics, durability and compatibility with cotton in blends. Its very low moisture absorbency, resilience and good dimensional stability are additional qualities Wool- like properties are shown by polyacrylic fibres which are produced by the polymerisation of acrylonitrile using the addition route into polyacrylonitrile. They can then be spun into fibres by dry or wet spinning methods. Orlon14 was produced by DuPont. It had a distinctive dumbbell shaped cross-section and was extruded by the dry process in which the solvent is evaporated off.

Polyolefin fibres include both polyethylene and polypropylene made by addition polymerisation of ethylene and propylene and subsequent melt extrusion, respectively. Polyethylene has moderate physical properties with a low melting temperature of about 110 °C for its low density form and about 140 °C for its high density form which severely restricts its application in low temperature applications. Polypropylene has better mechanical properties and can withstand temperatures of up to 140 °C before melting at about 170°C.

High Performance fibres:

Any fibre that consists of organic chemical units, where carbon is linked to hydrogen and possibly also to other elements, will decompose below about 500°C and cease to have long-term stability at considerably lower temperatures. For use at high temperatures it is therefore necessary to turn to inorganic fibres and fibres that consist essentially of carbon.

Glass, asbestos and more recently carbon are three well-known inorganic fibres that have been extensively used for many of their unique characteristics.Use of glass as a fibre apparently dates back to the ancient Syrian and Egyptian civilizations which used them for making clothes and dresses. Their good resistance to heat and very high melting points has also enabled them to be used as effective insulating materials.

Ultra fine and Novelty fibres:

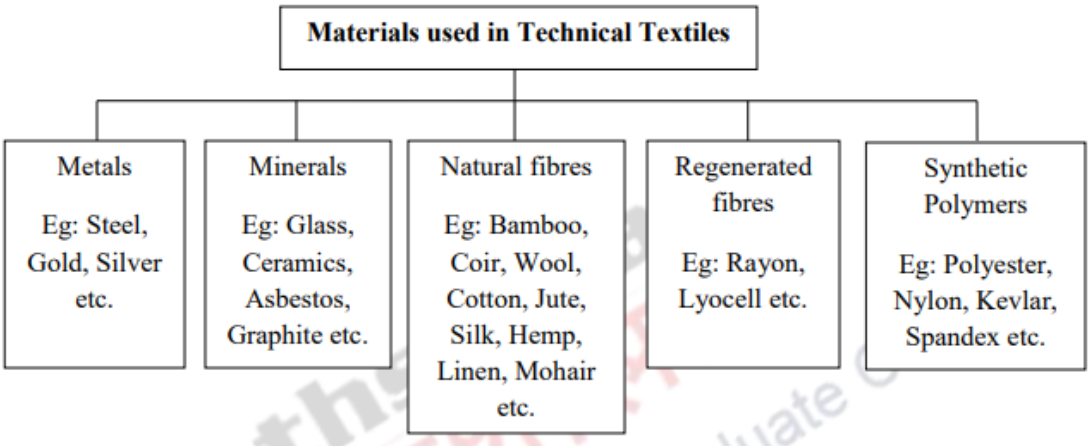
Ultra-fine or microfibres were developed partly because of improved precision in engineering techniques and better production controls, and partly because of the need for lightweight, soft waterproof fabrics that eliminate the more conventional coating or lamination processes. As yet there are no universal definitions of microfibres. *Textile Terms and Definitions* simply describes them as fibres or filaments with linear densities of approximately 1.0 dtex or less. Others have used such terms as fine, extra-fine and micro-fine corresponding to linear densities ranging from 3.0 dtex to less than 0.1 dtex. They are usually made from polyester and nylon polymers, but other polymers are now being made into microfibres. The Japanese first introduced microfibres in an attempt to reproduce silk-like properties with the addition of enhanced durability. They are produced by at least three established methods including island-in-sea, split process and melt spinning techniques and appear under brand names such as Mitrelle, Setila, Micrell, Tactel and so on. Once in woven fabric form their fine diameter and tight weave allows up to 30000 filaments cm-2, making them impermeable to water droplets whilst allowing air and moisture vapour circulation. They can be further processed to enhance other characteristics such as peach-skin and leather-like appearances. The split technique of production imparts sharp-angled edges within the fibre surface, which act as gentle abraders when made into wiping cloths that are used in the optical and precision microelectronic industries. Microfibres are also used to make bacteria barrier fabrics in the medical industries. Their combined effect of low diameter

and compact packing also allows efficient and more economical dyeing and finishing.

Finally, constant pressure to achieve and develop even more novel applications of fibres has led to a number of other and, as yet, niche fibrous products. In principle, the new ideas usually strive to combine basic functional properties of a textile material with special needs or attractive effects.

Engineering Textile Structures for Technical Textiles:

PROCESS USED IN TECHNICAL TEXTILES



Metals

Braiding: Braiding is considered as one of the simplest way of fabric formation involving diagonal interlacing of yarns. Braiding does not require shedding, filling, insertion and beat-up.

Regenerated fibers

Wet laying

A modified paper making process is termed as wet – laid nonwovens. Three main characteristic stages in the manufacture of nonwoven bonded fabrics pertain to swelling and dispersion of the fibre in water, filtration, drying and bonding of the web.

Thermal bonding

Heat is identified to be a main element in thermal bonding which involves heating of the thermoplastic fibres to its melting point in order to resist mechanical deformation. Thermal bonding could be further classified into hot calendaring, belt calendaring, through-air thermal bonding, ultrasonic bonding and radiant-heat bonding.

Chemical bonding

Structural integrity in nonwovens is achieved by the use of chemical binders. The construction of a nonwoven with suitable binders is to achieve improved characteristics such as strength, softness, adhesion, firmness, durability, stiffness, fire retardance, antimicrobial properties, and resistance to wash and acid.

Needle punching

One of the oldest methods of producing non woven products using needle loom is termed as needle punching. Needle punching system is used to bond dry laid and spun laid webs. Needle punched fabrics are produced by entangling some fibres when barbed needles are pushed through a fibrous web. The areas of application include blankets, shoe linings, paper makers, felts, heat and sound insulation, medical fabrics and geotextiles.

Spun lacing

A nonwoven fabric produced by entangling fibres in a preformed web using high pressure, columnar waterjets is termed as spunlacing.

Stitch bonding

Stitch bonding refers to a bonding technique for nonwovens in which the fibers are connected by stitches sewn or knitted through the web.

Natural fibers

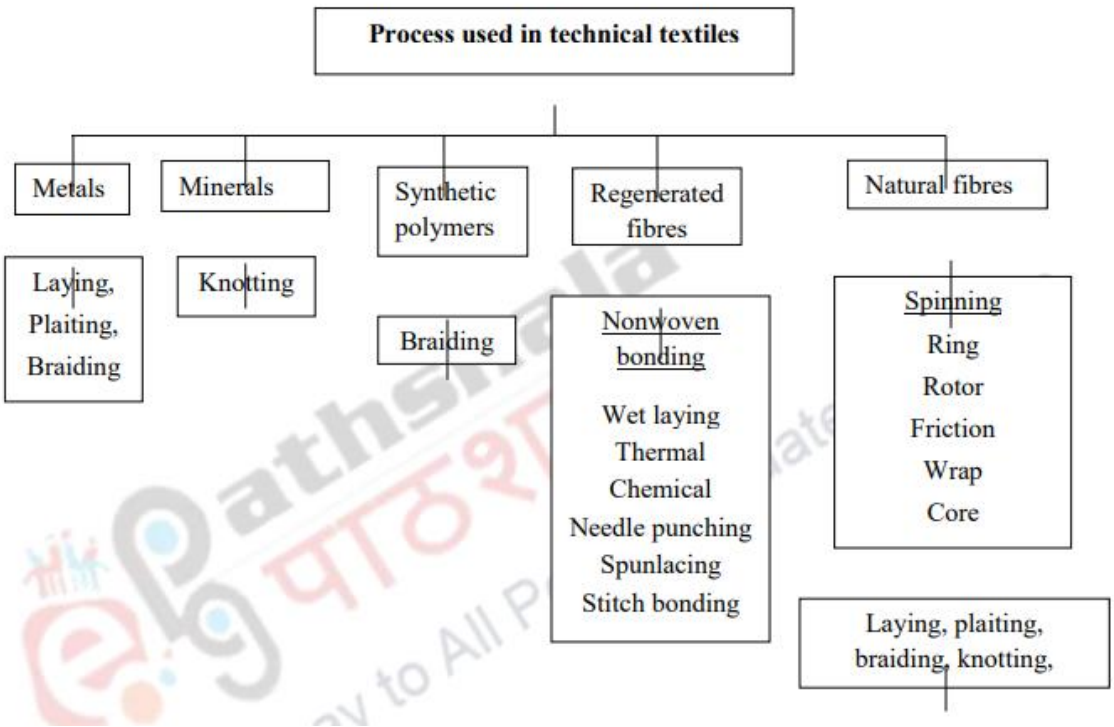
Weaving

The interlacement of warp and weft yarns is called weaving. Different interlacement techniques results in different fabric structure.

Knitting

Interloping of one yarn system into vertical columns and horizontal rows of loops called wales and courses respectively is referred to as knitting. Weft and warp knitting are the main classifications of knitting.

PRODUCTS USED IN TECHNICAL TEXTILES



Rope

Ropes made of steel have high breaking strength and is used for heavy duties such as mining and bridge construction.

Net

Net is any textile resulting in open spaces between the yarns that are looped or knotted at their intersections. Its usage can vary depending on its characteristics and durability

Threads

Threads are used in garments, upholstery, air supported fabric structures and geo textiles to join different components by forming a seam.

Technical Fabrics

Technical textiles are materials designed for specific applications requiring concrete and demanding properties. They are expanding in areas such as reinforcement, drainage, filtration, protective textiles, sports textiles, agro, medi and so on.

Wadding

Furnishings have been increasingly using fiberfill products and wadding. Fibres used for this purpose are commonly bonded using self-cross linking styrene co-polymers which have good chemical resistance and ageing properties.

Woven Fabrics:

Plain Weave:

A basic structure where each yarn crosses over and under the other, creating a simple, strong fabric.

Twill Weave:

Yarns are interlaced in a diagonal pattern, resulting in a more durable and resistant fabric.

Satin Weave:

Yarns float over several others, creating a smooth, lustrous surface.

Triaxial Weave:

A more complex weave that uses three sets of yarns, offering greater strength and dimensional stability.

3D Weaving:

Creates three-dimensional structures with enhanced mechanical properties, like improved impact resistance and load distribution.

Knitted Fabrics:

Weft Knits:

Loops are formed by passing one yarn through the loops of another, resulting in a fabric with good elasticity and drape.

Warp Knits:

Loops are formed by a series of needles, creating a fabric with more stability and less elongation.

Spacer Fabrics:

These fabrics consist of two layers connected by vertical fibers, creating a lightweight, breathable material.

Nonwoven Fabrics:

Needlepunched/Felt:

Fibers are mechanically interlocked using needles, resulting in a dense, durable fabric.

Spunlace:

Fibers are bonded together using water jets, creating a soft, absorbent fabric.

Spunbond:

Fibers are extruded and then bonded together using heat, creating a strong, waterproof fabric.

Felt:

A nonwoven fabric made by matting fibers together without weaving or knitting.

Composite Materials:

Laminates:

Two or more layers of fabric or film are joined together to create a single, composite structure.

Coatings:

A protective or functional layer is applied to a fabric, such as a waterproof coating or a flame-retardant finish.

Unit-II

Medical Textiles

Introduction:

An important and growing part of the textile industry is the medical and related healthcare and hygiene sector. The extent of the growth is due to constant improvements and innovations in both textile technology and medical procedures. Combination of textile technology and medical sciences has resulted into a new field called medical textiles. New areas of application for medical textiles have been identified with the development of new fibers and manufacturing technologies for yarns and fabrics.

Textile materials and products that have been engineered to meet particular needs, are suitable for any medical and surgical application where a combination of strength, flexibility, and sometimes moisture and air permeability are required. Materials used include monofilament and multifilament yarns, woven, knitted, and nonwoven fabrics, and composite structures. The number of applications are huge and diverse, ranging from a single thread suture to the complex composite structures for bone replacement,

and from the simple cleaning wipe to advanced barrier fabrics used in operating rooms. Although textile materials have been widely adopted in medical and surgical applications for many years, new uses are still being found. Research utilising new and existing fibres and fabric-forming techniques has led to the advancement of medical and surgical textiles. At the forefront of these developments are the fibre manufacturers who produce a variety of fibres whose properties govern the product and the ultimate application, whether the requirement is absorbency, tenacity flexibility, softness, or biodegradability. Development in the field of textiles, either natural or manmade textiles, normally aimed at how they enhance the comfort to the users.

Some Vital Features of Medical Textiles

1. Textile materials must be non-toxic.
2. Must be resistant to allergens and cancer.
3. Medical textiles must have the ability to disinfect without any structural or chemical changes.
4. Textile materials must be biologically compatible.
5. Complete good dimensional stability.
6. It has air permeability and waterproofing properties.
7. Resistant to acid and alkali.
8. Must be capable of anti-microbial activity, i.e., must be resistant to microorganisms.
9. The quality of the fabric should be good.
10. Re-wash and reusable.
11. It should be free size.

Materials used & its requirements:

All types of material are used Medical tex in the following:

1. Fibers

Natural fibers, like **cotton**, are short and called staple fibers. **Synthetic fibers** can be long filaments or cut into short lengths for various medical uses. They can be arranged neatly, randomly, or in soft masses for different applications, such as filters, non-woven fabrics, or medical implants.

2. Yarn

Yarn can be continuous filaments or staple fibers. Continuous filaments are twisted into multi-filament yarns. Staple fibers are carded, spun directly for a soft yarn, or combed for a firm yarn. Yarns can be twisted together for evenness and strength, creating two-fold or threefold yarns. Yarn is also classified by manufacturing method and linear density,

measured in tex.

3. Woven Fabric

Woven fabrics, widely used in hospitals for bedding and clothing, have yarns interlaced at right angles. The fabric's flexibility increases diagonally. Traditional woven fabrics like plain weave or 2×2 twill meet clothing and bed linen requirements. 3D woven fabrics have diverse applications in healthcare.

4**. Knitted Fabric**

Weft-knitted fabrics have horizontally interlinked loops, providing notable extensibility. Despite this, weft-knitted fabrics provide high compression and support, making them suitable for medical applications like hernia treatment. They are also used as scaffolds for tissue regeneration due to their positive effects on cell growth.

5. Nonwoven Fabric

Non-woven fabrics are efficiently produced without traditional yarns. Non-woven find extensive use in healthcare, including PPE and technical fields like dressings and filters. Environmental concerns lead to a shift toward semi-durable or recyclable non-woven items, challenging the disposable trend in medical textiles.

6. Braided Fabric

Braids, woven structures of interlaced threads, offer extensibility and varied applications. Tubular braids for implants emphasize packing tightness and resistance to kinking. Braided medical textiles include sutures and stents, with materials like polymeric and metal wires, as well as antibacterial-coated options.

7. Finishes

Textile finishing is important for defining or adjusting fabric properties, including the removal of impurities. Techniques like surface application, modification, and coating, along with heat treatment, enhance fabric properties. So, using these methods can make the fabric antimicrobial or antiviral, suitable for medical textiles.

Classification of Medical Textiles:

1. Implantable Materials: There is a special type of textile structure that is used for various purposes inside the human body. The use of implantable material can be observed in closure or replacement surgery. For example: Satures, Soft tissue implants, Orthopedic implants, cardiovascular implants, etc. are used in textiles.

Product Applications: Artificial Tendon, Artificial Ligament, Artificial Skin, Artificial Bone, Artificial Cornea, Vascular Grafts, Heart Valves etc.

2. Non-Implantable Materials: Non-implantable medical textiles are used for external application of the body i.e. it is used to help in the recovery of various wounds on the outer part of the body. These textile materials must be non-toxic and resistant to allergens and cancer-causing influencers.

Product Applications: Absorbent Pads, Wound Contact Layers, Bandages, Plasters, Gauze Pads, Lint, Wound Dressing etc.

3. Extra Corporal Devices: Such devices are widely used in modern medical science. This

modern textile material is used to replace various organs inside the body of infected people. These devices must have non-toxic, non-carcinogenic, bio-compatibility properties.

Product Applications: Artificial Kidney, Artificial Lung, Artificial Liver etc.

4. Health Care & Hygienic Products: An important area of medical textile is healthcare and hygiene assurance. These textile materials are used to protect physicians and health workers and to equip wards when treating patients in the hospital and will have non-toxic, non-carcinogenic etc. properties.

Product applications: Surgical masks, PPE, caps, gowns, bed sheets, curtains, protective clothing, baby diapers, sanitary napkins, etc.

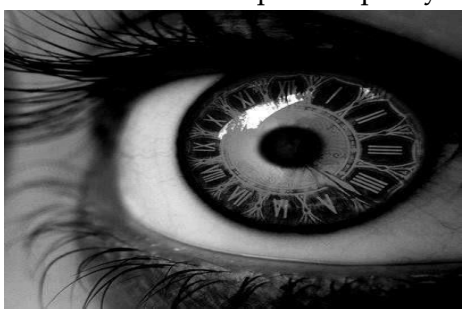
Fibers Used in Different Purposes in Medical & Health Care

Fiber Types	Applications
Cotton	Surgical clothing gowns, Beddings, Sheets, Pillow cover, Uniforms, Surgical hosiery, Lint etc. Sustainable clothing
Viscose	Caps, Masks, Wipes, PPE, Plasters, Bandages, Wound care pad etc.
Hollow viscose	Artificial Kidney. Artificial Liver.
Polyester	Gowns, Surgical cover, drapes, Blankets, Cover stock, Surgical hosiery, Sutures, Artificial tendon etc.
Hollow polyester	Artificial Kidney.
Polyamide	Surgical hosiery, Bandages, Wound care pad etc.
Polypropylene (PP)	Protective Clothing, Sutures Plasters etc. Sustainable clothing
Polyethylene (PE)	Surgical Covers, Drapes, Artificial joints/bones etc.
Polytetrafluoroethylene (PTFE)	Heart valves, Vascular grafts, Bio-degradable Sutures etc.
Carbon	Artificial tendon, Artificial bones etc.
Glass	Caps, Masks, Plasters etc.

Collagen	Artificial skin, Ligament, Lumen, Sutures
Silicone	Artificial joints/bones, Artificial lumen, Artificial skin etc.
Hollow silicone	Artificial Lung
Steel	Non-biodegradable sutures.
Elastomeric	Surgical hosiery, Gloves etc.

Applications of Medical Textiles ,Sustainable clothing

Contact Lenses: Contact lenses are one of the most widely used textile technologies in modern times. Contact lenses changes the color of the eyes to make them more beautiful. It is made of textile materials with water absorption capacity.



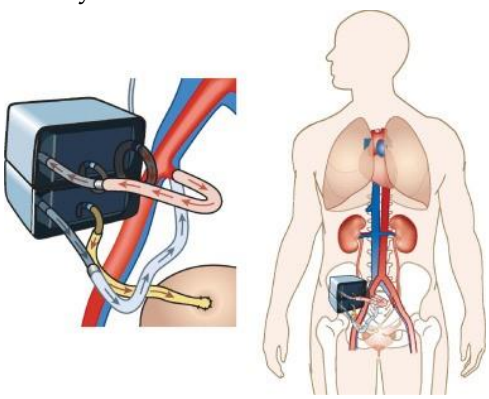
Contact Lenses

Artificial Cornea: This technology is used to recover from blindness. The textile materials used in this case should be flexible and sufficient mechanical strength.

Artificial Cornea

Artificial Kidney: Artificial kidney is used to remove wastes like urea from the blood. Artificial Kidney is a device which artificially purifies the blood on the base of dialysis. Generally, hollow membrane fibers like hollow viscose, triacetate, polyvinyl alcohol,

polyester fiber are used in this system.

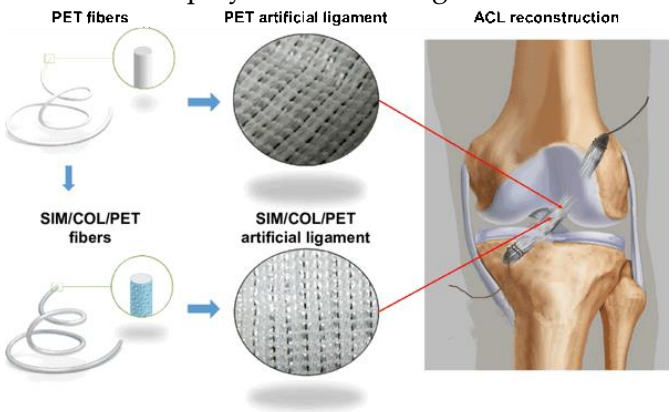


Artificial Kidney

Artificial Lungs: Artificial lung removes carbon dioxide from the blood and helps in transporting clean oxygen. It is made using hollow fibers like hollow viscose whose pore size is less than one micro meter.

Artificial Lungs

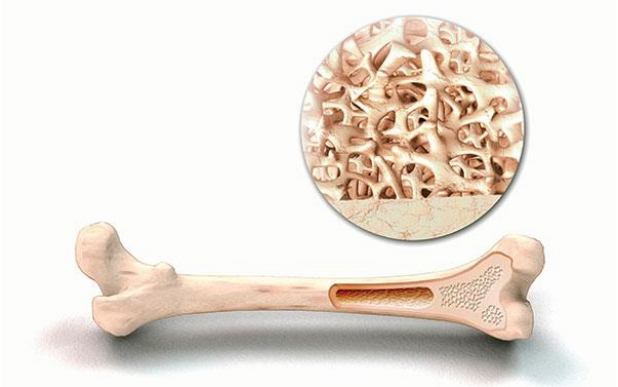
Artificial Ligaments: It is used to join the two ends of the bone. Artificial ligaments can be made using man-made fiber like polyester and collagen.



Artificial Ligaments

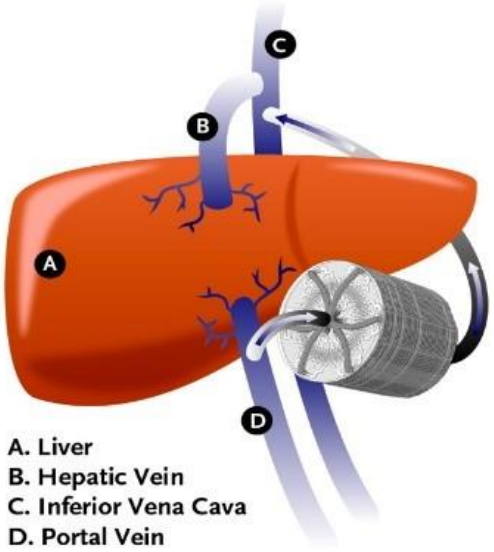
Artificial Bones: A group of scientists from Deakin University in Australia are claiming that artificial bones will be made from used Denim fabric which is used in human body. Denim is basically made from cotton and cotton (cellulose) is a versatile renewable material that can be used to regenerate aerogel by using various liquid solvents on used

denim. Aerogel is low density advanced material, due to its low density, Aerogel is often referred to as solid smoke.



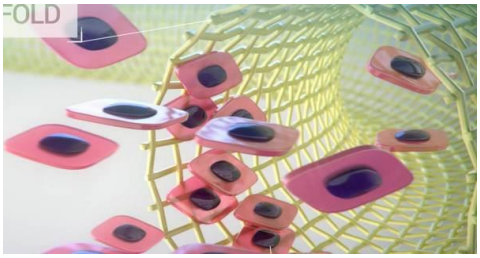
Artificial Bones

Artificial Liver: Artificial livers are recently developed. All types of biochemical reactions occur in this liver. So, in particular, it is a complex device because the body's biological reactions take place here. This device is used to separate and dispose of patient's plasma and supply fresh plasma.



Artificial Liver

Artificial Blood Vessel: Medium and large diameter artificial blood vessels are made with PET fabric or Polytetrafluoroethylene membrane. Biocompatible elastic polymers are used to prevent the blood leakage.



Artificial blood vessel

N95 Mask: The Covid-19 issue has introduced us to a special type of mask called N95. It is

a special type of respiratory protection product. N95 has its own unique meaning, 'N' stands for "Non-Oil" meaning that if no oil-based particle is present anyone can use this mask in that environment. And '95' means the mask has 95% efficiency. A drop of 3 microns or larger cannot penetrate the wall of the mask. This mask is made with multiple layers of non-woven fabric which is mostly made of polypropylene.

N95 masks

Surgical Mask: Surgical masks are made with non-woven fabric while maintaining filtration and air permeability properties. It is mostly made of polypropylene with a density of 20-25 GSM. Polystyrene, polycarbonate, polyester can also be used. It is made by combining multiple non-woven layers, which is effective in resisting bacteria/viruses above 1 micron.

You may also like: Surgical Mask: Types, Manufacturing Process and Uses

Surgical Masks

Surgical Gown: The main raw materials for making surgical gown are non-woven fabric. The complete gown is made by combining three separate layers of non-woven fabric. The outer layer is a Polypropylene non-woven of 30 GSM. The middle layer is 15 GSM Polytetrafluoroethylene (PTFE) fabrics and the inner layer is about 25 GSM Polyester non-

woven. Polypropylene has a moisture recovery capacity of 0% so, it is suitable for outer layer. On the other hand, polyester has a moisture recovery ability of 0.4%, so it is suitable for inner layer, helps to absorb sweat when the gown used for a long time.

Surgical gown

Sanitary Napkin: Sanitary napkins are produced by using three layers of textile materials. The inner layer which contacts with human body is made of nonwoven. The inner layer should have some special characteristics like quick transfer of menstrual blood from inner layer to center layer, comfortable, softness feels, pliability and sustainability against blood. The center layer of sanitary napkin composed of special polymer which has super absorbent properties. And the outer layer is composed of polyethylene.

Sanitary napkin

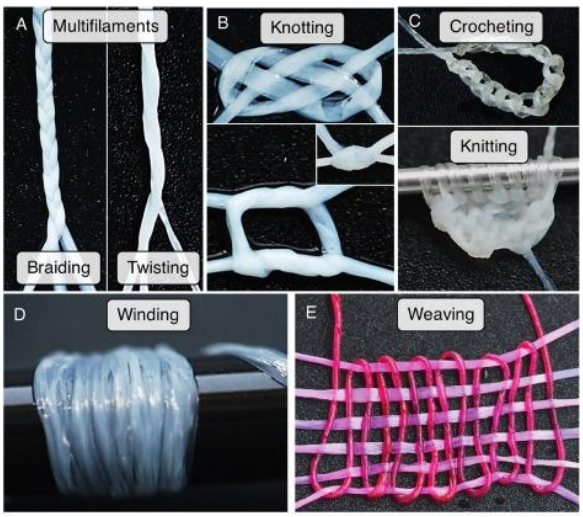
Diaper: Diapers are generally of two types, 1) Pants type & 2) Pad type. Diapers are primarily designed for babies & adults. Diapers like sanitary napkins also have three layers. Nonwovens are used to make diapers.

Diaper

Bandages: Bandages are used to place the wound care layer in the correct position. Wound care prevents the body from becoming infected and absorbs blood from the wound site. Woven, non-woven and knitted fabrics are used to make bandages.

Bandages

Human Textile: If there is any wound in the human body, it can be treated with human textile. The wound part is filled up with artificial yarn and the fall merges with the body. In this case artificial yarn is made from human cells.



Human Textiles

Unit-III

Geo & Agro Textiles

Geo Textiles: Geotextiles were one of the first textile products in human history. Excavations of ancient Egyptian sites show the use of mats made of grass and linen. Geotextiles were used in roadway construction in the days of the Pharaohs to stabilise roadways and their edges. These early geotextiles were

made of natural fibres, fabrics or vegetation mixed with soil to improve road quality, particularly when roads were made on unstable soil. Only recently have geotextiles been used and evaluated for modern road construction. Geotextiles today are highly developed products that must comply with numerous standards. To produce tailor-made industrial fabrics, appropriate machinery is needed.

Geotextiles have been used very successfully in road construction for over 30 years. Their primary function is to separate the sub base from the sub grade resulting in stronger road construction. The geotextile perform this function by providing a dense mass of fibres at the interface of the two layers.

Geotextiles have proven to be among the most versatile and cost-effective ground modification materials. Their use has expanded rapidly into nearly all areas of civil, geotechnical, environmental, coastal, and hydraulic engineering. They form the major component of the field of geosynthetics, the others being geogrids, geomembranes and geocomposites. The ASTM (1994) defines geotextiles as permeable textile materials used in contact with soil, rock, earth or any other geotechnical related material as an integral part of civil engineering project, structure, or system. Geotextiles should fulfill certain requirements like it must permit material exchange between air and soil without which plant growth is impossible, it must be penetrable by roots etc. and it must allow rain water to penetrate the soil from outside and also excess water to drain out of the earth without erosion of the soil. To obtain all these properties in geotextiles, the proper choice of textile fibre is of paramount importance. The different synthetic fibres used in geotextiles are nylon, polyester, polypropylene while some natural fibres like ramie, jute etc. can also be used.

Important Characteristics Of Geotextiles

The characteristics of geotextiles are broadly classified as:

1. Physical properties:
   a) specific gravity
   b) weight
   c) thickness
   d) stiffness
   e) density.
2. Mechanical properties:
   a) tenacity

b) tensile strength
c) bursting strength
d) drapability
e) compatibility
f) flexibility
g) tearing strength
h) frictional resistance

3. Hydraulic properties:

a) porosity
b) permeability
c) permittivity
d) transitivity
e) turbidity /soil retention
f) filtration length etc.

4. Degradation properties:

a) biodegradation
b) hydrolytic degradation
c) photo degradation
d) chemical degradation
e) mechanical degradation
f) other degradation occurring due to attack of rodent, termite etc.

5. Endurance properties:

a) elongation
b) abrasion resistance
c) clogging length and flow etc.

Geo synthetics:

These are flexible textile fabrics of controlled permeability used to provide filtration, separation or reinforcement in soil, rock and waste material.

Geomembranes- These are impermeable polymeric sheets used as carrier for liquid or solid waste containment.

Geogrids- Stiff or flexible polymer grid like sheets with large aperture used primarily as reinforcement of unusable soil and waste masses.

Geonets- Stiff polymer net like sheets with in plane opening used primarily as a drainage material within landfills or soil and rock masses.

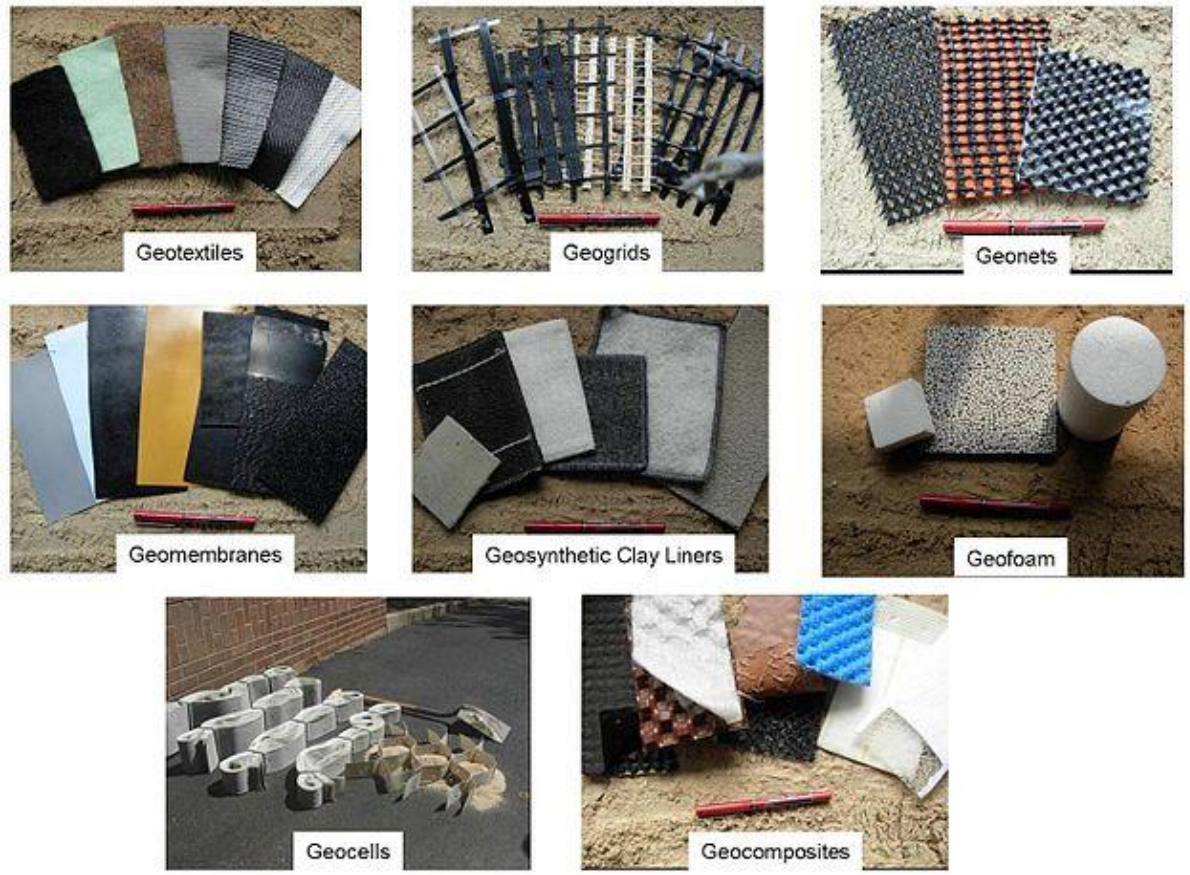
Geosynthetic clay liners- Prefabricated bentonite clay layers incorporated between geotextile and geomembrane and used as a barrier for liquid or solid waste containment.

Geopipes- Perforated or solid wall polymeric pipes used for the drainage of various liquids.

Geocomposites- Hybrid systems of anyor all the above geosynthetics types which can

function as specifically designed for use in soil,rock, waste and liquid related problems.

Geofoam- A newer category of product is geofoam. Which is the generic name for any foam material utilized for geotechnical application. Geofoam is manufactured into large blocks which are stacked to form a light weight thermally insulating mass buried within a soil or pavement structure.



Different categories of geosynthetics

Fibres and its selection for Geo textiles:

Different fibres from both natural as well as synthetic category can be used as geotextiles for various applications.

Natural fibres: Natural fibers in the form of paper strips, jute nets, wood shavings or wool mulch are being used as geotextiles. In certain soil reinforcement applications, geotextiles have to serve for more than 100 years. But bio-degradable natural geotextiles are deliberately manufactured to have relatively short period of

life. They are generally used for prevention of soil erosion until vegetation can become properly established on the ground surface.

The commonly used natural fibres are –

Ramie: These are subtropical bast fibres, which are obtained from their plants 5 to 6 times a year. The fibres have silky luster and have white appearance even

in the unbleached condition. They constitute of pure cellulose and possess highest tenacity among all plant fibres.

Jute: This is a versatile vegetable fibre which is biodegradable and has the ability to mix with the soil and serve as a nutrient for vegetation. Their quick biodegradability becomes weakness for their use as a geotextile. However, their life span can be extended even up to 20 years through different treatments and blendings. Thus, it is possible to manufacture designed biodegradable jute geotextile, having specific tenacity, porosity, permeability, transmissibility according to need and location specificity. Soil, soil composition, water, water quality, water flow, landscape etc. physical situation determines the application and choice of what kind of jute geotextiles should be used. In contrast to synthetic geotextiles, though jute geotextiles are less durable but they also have some advantages in certain area to be used particularly in agro-mulching and similar area to where quick consolidation are to take place. For erosion control and rural road considerations, soil protection from natural and seasonal degradation caused by rain, water, monsoon, wind and cold weather are very important parameters. Jute geotextiles, as separator, reinforcing and drainage activities, along with topsoil erosion in shoulder and cracking are used quite satisfactorily.

Furthermore, after degradation of jute geotextiles, lignomass is formed, which increases the soil organic content, fertility, texture and also enhance vegetative growth with further consolidation and stability of soil.

Synthetic Fibres: The four main synthetic polymers most widely used as the raw material for geotextiles are – polyester, polyamide, polyethylene and polypropylene. which was discovered in 1935. The next oldest of the four main polymer families relevant to geotextile manufacture is polyester, which was announced in 1941. The most recent polymer family relevant to geotextiles to be developed was polypropylene, which was discovered in 1954.

Polyamides (PA): There are two most important types of polyamides, namely Nylon 6 and Nylon 6,6 but they are used very little in geotextiles. The first one an aliphatic polyamide obtained by the polymerization of petroleum derivative ε- caprolactam. The second type is also an aliphatic polyamide obtained by the polymerization of a salt of adipic acid and hexamethylene diamine. These are manufactured in the form of threads which are cut into granules. They have more strength but less moduli than polypropylene and polyester They are also readily prone to hydrolysis.

Polyesters (PET): Polyester is synthesised by polymerizing ethylene glycol with

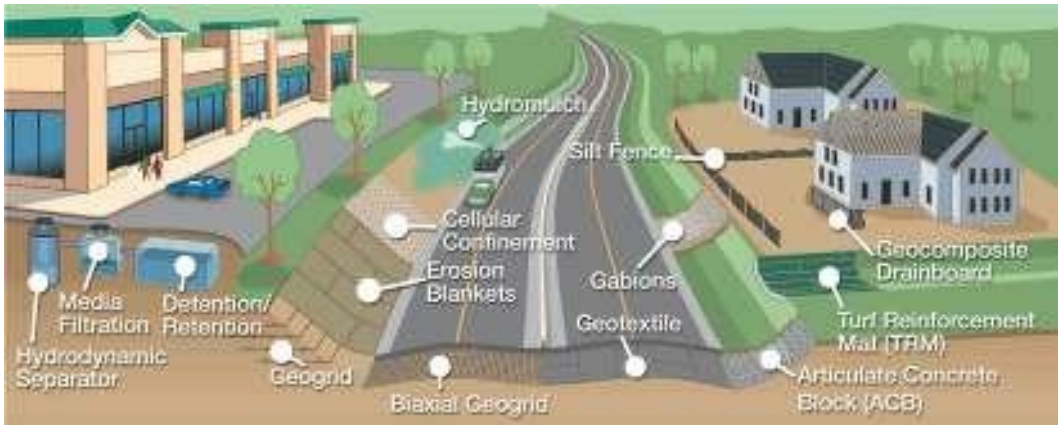
dimethyle terephthalate or with terephthalic acid. The fibre has high strength modulus, creep resistance and general chemical inertness due too which it is more suitable for geotextiles. It is attacked by polar solvent like benzyl alcohol, phenol, and meta-cresol. At pH range of 7 to 10, its life span is about 50 years. It possesses high resistance to ultraviolet radiations. However, the installation should be undertaken with care to avoid unnecessary exposure to light.

Polyethylene (PE): Polyethylene can be produced in a highly crystalline form, which is an extremely important characteristic in fiber forming polymer. Three main groups of polyethylene are – Low density polyethylene (LDPE, density 9.2- 9.3 g/cc), Linear low density polyethylene (LLDPE, density 9.20-9.45 g/cc) and High density polyethylene (HDPE, density 9.40-9.6 g/cc).Polypropylene (PP): Polypropylene is a crystalline thermoplastic produced by polymerizing propylene monomers in the presence of stereo-specific Zeigler- Natta catalytic system. Homo polymers and copolymers are two types of polypropylene. Homo polymers are used for fibre and yarn applications whereas co-polymers are used for varied industrial applications. Propylene is mainly available in granular form. Both polyethylene and polypropylene fibres are creep prone due to their low glass transition temperature. These polymers are purely hydrocarbons and are chemically inert. They swell by organic solvent and have excellent resistance to diesel and lubricating oils. Soil burial studies have shown that except for low molecular weight component present, neither HDPE nor polyethylene is attacked by micro-organisms.

Polyvinyl chloride (PVC): Polyvinyl chloride is mainly used in geo membranes and as a thermo plastic coating materials. The basic raw materials utilized for production of PVC is vinyl chloride. PVC is available in free- flowing powder form.

Functions of Geo textiles:

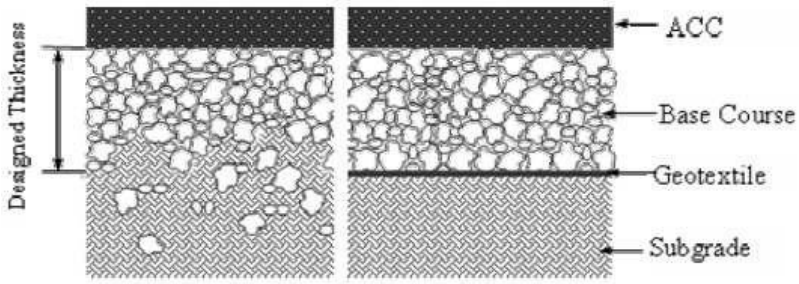
Every textile product applied under the soil is a geotextile. The products are used for reinforcement of streets, embankments, ponds, pipelines, and similar applications (Figure 3.5). Depending on the required function, they are used in open-mesh versions, such as a woven or, rarely, warp-knitted structure, or with a closed fabric surface, such as a non-woven. The mode of operation of a geotextile in any application is defined by six discrete functions: separation, filtration, drainage, reinforcement, sealing and protection. Depending on the application the geotextile performs one or more of these functions simultaneously.



Functions of Geo Textiles

The principle functions performed by geo-textiles are given below.

Confinement/ Separation: Confinement provides a media between the aggregate and the subsoil which absorbs the load in the form of tension and prevents change in alignment of the aggregate. Geo-textile economically helps the separation concept of keeping two dissimilar apart to maximize the physical attributes of each of those materials. (Fig 3.6)



Concept of Separation function

Reinforcement: The purpose of geo-textiles in the reinforcement function is to teinforce the weak subgrade or subsoil.It helps to strengthen the soil surface and to increase the soils ability to stay put especially on the slopes. This functions is important in wall embankments, foundations and slops. There is no problem of corrosion and there is minimum excavation behind the face of the wall when geo- textiles fabrics are laid.

Filtration: The purpose of geo-textiles with reference to drainage and filtration is simply to retain soil while allowing the passage of water. When geo-textiles are used as drains, the water flow is within the plane of the geo-textile itself i.e., they have lateral permeability. Adequate dimensional stability becomes an important factor to retain their thickness.

Drainage: Use of Geo-textiles in drainage has outstanding advantages. They eliminate the filter sand with the dual media backfill. In some cases, they eliminate the need for

perforated pipes. They are used as a chimney drain or a drainage gallery in an earth dam as a drain behind wall or beneath railroad ballast, athletic fields and for salt migration in arid areas.

Protection: Geo-textiles are used with geo-membranes to provide long term protection of geo-membranes used for applications such as land fill and waste containment from puncture or training by sharp stone or stress. Typical application areas are highway tunnels, landfills, water and sewage tunnels, railroads and subway tunnels and reservoirs.

Engineering properties of Geo textiles:

Geotextiles are a permeable synthetic material made of textile materials. They are usually made from polymers such as polyester or polypropylene. The geotextiles are further prepared in three different categories – woven fabrics, non- woven fabrics and knitted fabrics.

Woven fabrics: Large numbers of geosynthetics are of woven type, which can be sub-divided into several categories based upon their method of manufacture. These were the first to be developed from the synthetic fibers. As their name implies, they are manufactured by adopting techniques which are similar to weaving usual clothing textiles. This type has the characteristic appearance of two sets of parallel threads or yarns --.the yarn running along the length is called warp and the one perpendicular is called weft. The majority of low to medium strength woven geo synthetics are manufactured from polypropylene which can be in the form of extruded tape, silt film, monofilament or multifilament. Often a combination of yarn types is used in the warp and weft directions to optimize the performance/cost. Higher permeability is obtained with monofilament and multifilament than with flat construction only.

Non-woven: Non woven geo-synthetics can be manufactured from either short staple fibre or continuous filament yarn. The fibers can be bonded together by adopting thermal, chemical or mechanical techniques or a combination of techniques. The type of fibre (staple or continuous) used has very little effect on the properties of the non – woven geo synthetics. Non-woven geotextiles are manufactured through a process of mechanical interlocking or chemical or thermal bonding of fibres/filaments. Thermally bonded non-wovens contain wide range of opening sizes and a typical thickness of about 0.5-1 mm while chemically bonded non-wovens are comparatively thick usually in the order of 3 mm. On the other hand mechanically bonded non-wovens have a typical thickness in the range of 2-5 mm and also tend to be comparatively heavy

because a large quantity of polymer filament is required to provide sufficient number of entangled filament cross wires for adequate bonding.

Knitted fabrics: Knitted geosynthetics are manufactured using another process which is adopted from the clothing textiles industry, namely that of knitting. In this process interlocking a series of loops of yarn together is made. An example of a knitted fabric is illustrated in figure. Only a very few knitted types are produced. All of the knitted geosynthetics are formed by using the knitting technique in conjunction with some other method of geosynthetics manufacture, such as weaving. Apart from these three main types of geotextiles, other geosynthetics used are geonets, geogrids, geo-cells, geo membranes, geo composites, etc. each having its own distinct features and used for special applications.

Geo textile structure:

Geo-textiles are a differentiated synthetic material made with textile materials. These are usually made from polymers like polyester and polypropylene. There are four main types of geo-textiles-

1. Woven Geotextiles:

These types of textiles perform the function of separation and increase the strength of the soil. As the yarn strength of their warp is much higher, they have more tensile strength. As a result, it is able to take much more load. There are various types of woven geo textiles like woven monofilament, woven multifilament, woven slit-film monofilament and slit-film multifilament.

Woven Geotextile

2. <u>Nonwoven Geotextiles</u>:

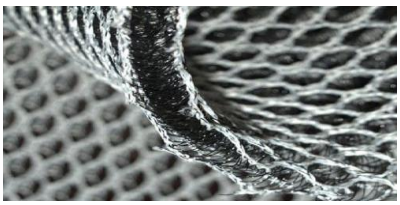
In case of nonwoven geotextiles, tensile strength is not very high, but their Separation, Drainage and Filtration ability is better than others. Non-woven geo textiles are permeable geosynthetics, usually made by synthetic fibers. Thermal and chemical bonding are also used to make non-woven geo textiles. There are various types of nonwoven geo textiles like continuous filament heat bonded, continuous filament needle punched, staple needle

punched, resin bonded.

Non-woven Geotextiles

3. Knitted Geotextiles:

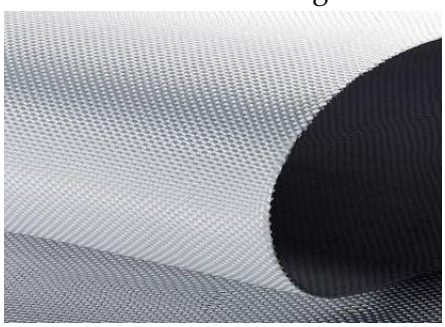
These types of textiles have good flexibility and are economically profitable. Although its use is less, but the demand for "Drainage and Soil Erosion Control" is increasing day by day. Knitted geo textiles are made by using knitting technology, sometimes weaving is used to make these products.



Knitted Geotextile

4. Spunbonded Geotextiles:

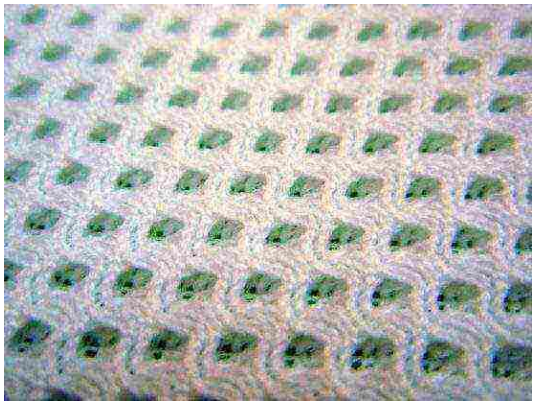
In the world of fabric production, the spunbonded process is considered as the fastest production method for non-woven fabrics. During the process, the extruded filaments are cut into the belt and the rolls are heated and held together.



Spunbonded geotextile

5. Braided Geotextile:

Braiding is generally used for producing narrow rope-like materials by interlacing diagonally three or more strands of filaments or yarns. The topology of strand interlacements in braided structures is similar to that of woven structures.



Braided Geotextile

In addition to these type of geotextiles, other geo-textiles products are geo-nets, geo-grids, geo-cells, geo-membranes, geo-composites etc. Each of these has its own characteristics and is used for special applications.

Applications for natural Geo textiles:

Geotextiles are used in various infrastructural works, which increase the strength of weak nature soils and prevent erosion. As a result, unsuitable places become suitable for building / civil construction.

Some of the notable uses of geotextiles-

1. Temporary & Permanent Roadways, Parking lots & Construction sites.
2. River, Canals & Coastal works.
3. Filtration& Drainage
4. Separation
5. Agriculture
6. Railway works
7. Reinforcement
8. Protection& erosion control
9. Retaining wall structures
10. Embankments etc.

Benefits of Using Geotextiles

1. Geo textiles are used to protect coastal property from sand waves and floods. Geo textiles can improve the soil strength at a lower cost than the conventional pipes.
2. Geo textiles have been used to protect the hominid footprints of Laetoli's fossils in Tanzania from the rains and tree roots.
3. Geotextile plays an important role in drainage and are used in playgrounds.
4. Coir geotextiles are popular for corrosion control and biotechnology, due to the significant mechanical strength of the fabric. To enrich the soil, the product moisture is reduced.
5. Geo textiles are used extensively as separators of the two layers of soil. Jute geo textiles are used to prevent mountain landslides.

Main Functions of Geotextiles:

Geo-textiles are commonly used to improve the soil on which roads, dams, pipelines and large infrastructure are built. There are different geotextile materials for different properties like separation, filtration and protection.

1. Geo-textiles for Separation:

To maintain the properties of two different types of soil, geo-textile plays an important role in this separation. The main purpose of this type of geo-textile is that when water enters the soil layer, the geo-textile will prevent water from mixing with the soil. Also, during road construction, it helps to keep fine sub-grade level soil separate from the lower coarse soil.

Geotextiles for Separation

2. Geotextiles for Reinforcement:

When geo-textiles are used to improve soil properties, its design is based on a number of basic factors, such as abrasion-capable, load-bearing, etc. As a result, it strengthens the soil by mixing with the soil. So, these types of textile materials are used to build embankments/roads on very poor graded soil. There are various types of reinforcement composites like knitted reinforcement, braided reinforcement, woven reinforcement etc.

Geotextile for soil reinforcement

3. Geotextiles for Filtration:

Geotextile plays an important role in filtration. Filtration is one of the most important functions of textiles used in civil engineering earthworks. Depending on the permeability of the material, geo-textiles increase the lateral flow of drain water, developing the kinetic energy of groundwater. Also helps to solve drainage problems around the house or on the street.

Geo-textiles for Filtration

4. Geotextiles for Sealing:

A non-woven geo-textile fabric capable of restricting fluid flow from both sides.

Impermeable geo-textiles are used to prevent contamination of pollutants above foul-smelling soils or groundwater.

Geotextiles for Sealing

5. Geo-textile in Drainage System:

A geotextile acts as a drain when it collects and transports the liquid or gas towards the outlet. Dense non-woven geo textiles provide an opportunity for water flow through three-dimension flat surface.

Geotextiles for Drainage

Agro Textiles:

Agriculture, forestry, horticulture, floriculture, fishing segments, landscape gardening, animal husbandry, aquaculture and agro-engineering all these sectors combined together are popularly called as Agro-tech sector. Agro textiles are the application of textile materials in those sectors. It is a very much important segment of **Technical Textile**. The word "AGRO TEXTILES" is now used to classify the woven, non-woven and knitted fabrics, applied for Agro tech industries including livestock protection, shading, weed and insect control and extension of the growing season. With the continuous increase in population worldwide, stress on agricultural crops has increased. So it is necessary to increase the yield and quality of agro-products. But it is not possible to meet fully with the traditionally adopted ways of using pesticides and herbicides. Today, agriculture and horticulture has realized the need of tomorrow and opting for various technologies to get higher overall yield, quality and tasty agro-products.

Textiles in Agriculture Fibres details & Properties:

Fibers Used in Agro Textiles:

Man made (synthetic) fibers are preferred for agricultural product than the natural fibers due to their high strength, durability and other suitable properties of agricultural applications. On the other hand natural fiber based agro-textiles not only serve the specific purpose but also after some year degrade and act as natural fertilizers.

Fibers used in agro tech industries are as follows:

1. Nylon
2. Polyester
3. Polyethylene
4. Polyolefin
5. Polypropylene
6. Jute
7. Wool
8. Coir
9. Sisal
10. Flax
11. Hemp

Though **man made fibers** (like poly-olefins) are preferred for agro-textiles than the natural fibers mainly due to their favorable price performance ratio, light weight with high strength and long service life, but natural fibers can be used in agro-textiles in some specific arena where characteristics like high moisture retention, wet strength, biodegradability are effectively exploited.

Properties Required for Agrotextiles:

1. Tensile Strength: The tensile strength of shade nets can be a deciding factor of its long term durability and service life. Hence good tensile strength is necessary parameter for shade nets.

2. Withstands solar radiation: Agro textiles are laid over the cultivated areas immediately after sowing or planting. For such application Agro-textiles has to withstand solar radiation with varying surrounding temperature.

3. Withstands ultraviolet radiation: The Non visible radiations include ultraviolet radiations (UV) radiation leads to degradation of molecular chains. No single material is resistant to all radiations .polypropylene and polyester are more resistant to UV radiations when used as an outdoor material, polyethylene is treated with the appropriate UV stabilizers. Potential to reduce the impact of UV radiation on plants by light absorbing or light-reflecting non-woven (light permeability: 80 to 90% to allow photosynthesis to take place).

4. Bio degradability: Natural fibers like wool, jute, cotton are also used where the bio-degradability of product is essential. Natural polymer gives the advantage of bio-degradation but has low service life when compared to the synthetics.

5. Abrasion Resistance: The abrasion to which a shade net is subjected may be of the material itself (material to material) or stray animals. Abrasion of the shade net would result in holes though which animals and pests could enter the structure and harm the crops .good abrasion resistance is required of shade nets.

6. High potential to retain water: This is achieved by means of fiber materials which allow taking in much water and by filling in super-absorbers. While non-wovens meant for the covering of plants show a mass per unit area of 15 to 60 gm/m2, values between 100 and

500 g/m2 are reached with materials for use on embankments and slopes.

7. Protection property: It must have the properties of protection from wind and creation of a micro-climate between the ground and the non-woven, which results in temperature and humidity being balanced out. At the same time, temperatures in the root area rise. This is what causes earlier harvests, sufficient stiffness, flexibility, evenness, elasticity, biodegradability, dimensional stability and resistance to wetness. Fungicidal finish (up to 2% of the total mass), which avoids soil contamination.

8. Resistance to microorganisms: It must resistant to microorganism to protect the living being.

9. Stable construction: The construction must be such that it must be stable for any application.

10. Lightweight: The weight of the fabric should be such that it will bare by the plant.

Manufacturing Processes of Agro Textiles:Several techniques of fabric production can be used to produce agro-textiles. Each method offers specific advantages for particular product. The techniques are: Weaving and woven produc: Woven products are manufactured by using weaving machines especially Sulzer projectile weaving machines. The range of light to heavy and wide width fabric production is possible with Sulzer projectile weaving machine. The machines with weaving width of 540 cm to 846 cm are available for the production of agro-textiles. The nets with a mesh width of 1.8 mm to 40 mm can be produced. Other methods of fabric manufacturing such as air-jet and rapier weaving machines are not preferred for the manufacture of such fabrics as they do not have required weaving width.

Knitting:Warp knitting technique is most widely used in comparison to weft knitting. Warp knitted protective nets are used in different sectors, which are produced on Raschel machines. Agro nets are produced in various constructions or lapping. Here, the construction or lapping is a way in which individual yarn systems are converted into fabrics.

Non-woven:There are many techniques to produce non-woven fabrics.

Spun bonding and needle punch techniques are mainly used for the production of non-woven agro-textiles. The spun bonded fabric has high and constant tensile strength in all directions. It has also good tearing strength.

Needle punched fabric plant bags provide advantages over conventional fired clay pots. All natural fibers offer an added advantage of that the container decomposes after being planted in the ground. Thermal Bonding, Stitch-bonded, Hydro entangled & Wet non-wovens are also used.

Advantages

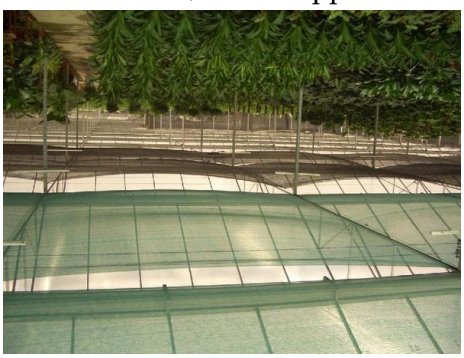
Agro-textiles decrease the requirement of fertilizers, water, harmful pesticides and herbicides and render a healthy farming culture and are an eco-friendly technique. They prevent the soil from drying out increase crop yield. Thermal protection textiles are treated with ultraviolet ray stabilizers & it can save up to 40% on energy in heating

greenhouses. Their use prevents staining and improves uniformity of color. They increase the early maturing of crops and non seasonal plants & protect from climatic changes and its effect. Agro textiles avoid branches from breaking, increase the cleanliness of the crop, make harvesting easy & give large space. Agro textiles for its excellent environmental resistance, mechanical properties, easy process ability and durability characteristics can improve quantity, quality and safety of agricultural products.

Applications of Agro textiles:

Agrotextiles for Production of Crops: The selection of Agro-textile product is depends on crop needs. Selection of the agro textiles is also greatly influenced by the geographical location. Some of the applications of agro textiles are as follows:

Sunscreen net: The Warp-knitted nets are used in order to protect fields and greenhouses from the intense solar radiation for healthy plant growth and good harvest. Sunscreen nets with open mesh construction are used to control sunshine and amount of shade required. These net fabrics allow the air to flow freely. So the excess heat does not built up under the screen. The percentage of shadow varies according to the density of threads. The current offer 45%, 65% & approximately 85% shadow.



Sunscreen net

Bird protection nets: Knitted monofilament nets (Open knitted nets for crop protection) offer effective passive protection of seeds, crops and fruit against damage caused by birds and a variety of pests. Open-mesh net fabrics are used as a means of protecting fruit plantation. The special open structure repels birds, provides minimal shading and excellent air circulation - allowing plants to flourish, whilst avoiding the risk of dangerous mold developing on the fruit. These net are strong yet lightweight and protect the fruit without restricting plant growth. The use of polyethylene tape yarns or mono filament yarns makes the net extremely durable and hard-wearing.

Bird protection net

Plant net: Fruits, which grow close to the ground, can be kept away from the damp soil by allowing them to grow through vertical or tiered nets in order to keep the amount of decayed fruit to a minimum. These are made from polyolefin type of fiber.

Plant net

Ground cover net: Ground cover is an extremely versatile landscaping and horticultural fabric for long-term weed control, moisture conservation and separation. It effectively suppresses competitive weed growth, conserves ground moisture, maintains a clean surface, protects from UV rays and creates a favorable environment for healthy plant growth. Ground covers can reduce the costs and minimizes undesirable herbicide use. It is mainly used in Borders & rockeries, nursery display areas, greenhouse floors, soft fruits beds & orchards, paved areas, horse bridleways & seed harvesting areas. 100% polypropylene is used.

Ground cover net

Windshield /Wind protection nets/Wind-breaks: Windshields are used in farming to protect fields of young plants, fruits, trees or the harvest from being damaged by the wind. Erecting wind-breaks at right angles protects the young seedlings and the mature plants from dying out and being broken. The nets used here reduce the effects of high winds and even help to keep out airborne sand and salt in areas close to the sea. Protecting plants from high winds also encourages plant growth and reduces the number of irrigation cycles required. It also prevents plants being cooled by wind too.

Wind protection nets

Root ball net: It is extremely important for safe and speedy growing of young plants such that root system is not damaged when they are dug up, transported or replanted. Normally the root balls are wrapped in cloth. Elastic net tubes are alternative to this. When the plants are transplanted, the nets on the outside do not have to be removed since the roots can protrude through the nets.

Root ball net

Insect meshes net: Various pests like Whitefly, scale insects attack some ornamental plants and vegetables frequently. Clearly, woven and knitted polyethylene monofilament meshes to exclude harmful insects from greenhouses and tunnels, or to keep pollinating insects inside, The fine woven screens protect plants from insect attack (without the use of insecticides).

Insect meshes net

Mulch mat: Mulch mats are used to suppress weed growth in horticulture applications, It covers the soil, blocking of light and preventing the competitive wheat growth around seed links, This also reduces the need for herbicides required for weed control Needle punched non-woven and black plastic sheet are used for this application, Bio degradable

and non-biodegradable types of mulch mats are available.

Mulch mat

Monofil nets: Tough, knitted Monofil, nets for windbreak fences and shading/ privacy screens, A suitable windbreak, set at a right-angle to the prevailing wind, will protect plants against the harmful effects of blustery weather - which can break young branches, damage flowers and cause leaves to dry or tear. The nets also protect against frosts and help enhance the micro-climate. This not only safeguards the current harvest but also benefits future crops, since the woody part of the plant are protected too.

Monofil nets

Cold and frost control fabrics: Cold and frost fabric can be laid directly on the plants, unlike plastic covers that can attract frost, and burn any leaf that touches them. These fabrics protect the plant from frost kill during unexpected late cold snaps and unexpected early ones.

Cold and frost control fabrics

Nets for covering pallets: For safe transportation of fruits and vegetables to the market the boxes are covered with large mesh nets and pallets to stop the boxes being turned upside

down. This prevents damage of goods during transportation.

Nets for covering pallets

Anti-hailstone nets: Anti-hailstone nets are used to cover plants and fruit orchards to protect them from being damaged by hailstones, but does not restrict their growth. The nets are primarily made from polyethylene monofilaments.

Anti-hailstone nets

Harvesting net: It is extremely helpful to those countries where labour charges are costlier. With the application of such nets for harvesting purpose, the labour cost could be reduced considerably. They are laid on ground or tied under the trees so that fruits fall directly on to them.

Harvesting net

Packing materials for agricultural products: Nets can be used for packaging of farm products for many end uses. It includes packing sacks for vegetables, tubular packing nets for fruits and wrappers for Christmas trees, Net structures are preferred because of their high strength, low weight, air permeability and cheapness.

Packing materials for agricultural products

B. Agro Textiles for Horticulture and Floriculture: Application of textile materials in horticulture is growing fast. Nets, non-woven mats, movable screens for glass/poly houses, non-woven sheets, mixed bed for mushrooms, cordage and strings are used in horticulture. Nets are also used for protection against hailstorms, intense sunrays, etc. Light resistant woven and non-woven polyester fabrics are used in the inside of green house to protect the plants from extreme hot or cold conditions. They are also used on the outside of the green houses as screen to control sun light.

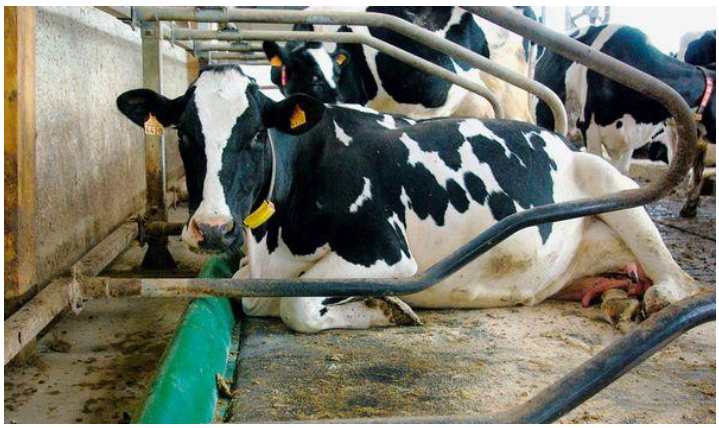
Horticulture net & Floriculture net

Some of the agro-textiles that are used frequently for horticultural & floriculture use are as follows:

- Hail protection fabrics
- Mulch net
- Rain protection fabrics
- Wind control fabrics
- Harvesting nets

C. Agro Textile for Animal Husbandry: Nylon and polyester identification belts are used

for cows. Textile nets are used to support the large udders. Non-woven fabrics are used to filter the milk in automatic milking systems and as an underlay to reduce mud on cattle paths and trails.



Cow mattress

D. Fishing and Aquaculture Nets: Fishnets are used for fishing and in fish farming. Warp knitted knotless nets results in low energy expenditure when the net is used for fishing. They are mainly produced from Nylon monofilament, multifilament or HDPE.

Fishing net & Aquaculture net

Unit-IV

Protective & Smart Textiles

Protective Textiles:

Protective textile or Protech is a collection of various fiber, yarn or textile products, and

garments exclusively manufactured to safe one from different type of climatically conditions and on the other side ease the working conditions and also to protect them from any type of miss happening. Protective textiles include products used to help the worker to complete his assigned job without much difficulty in hazardous environment and his clothing and accessories**.**

Selection of protective clothing materials, Fibres and fabrics for Protective Textiles:

Protective textiles have several important features that should be present in every garment based on the workplace.

Sustainable clothing

1. Light weight and good Handle and Drape features
2. High durability
3. Water and wind resistant
4. Resistant to bacteria and microorganisms
5. Thermal insulation
6. Ultraviolet (UV) resistant
7. Air permeability
8. Resistant to fire and flame
9. Bulletproof
10. Resistant to chemicals
11. Provide protection from radar spectrum.

Raw Materials Used in Protective Textiles

1. Meta-Aramid Fiber: Meta-Aramid fiber is used to make industrial protective clothing, racing driver's suit, filter bag for hot gas, cargo cover, boat cover, fire hose etc.

2. Pera-Aramid Fiber: Used to make tire cords, radiator hose, racing car brake shoes, strong combinations for aircraft, high-speed boat components, etc.

3. Carbon Fiber: Carbon fiber is used in the manufacture of aircraft and space shuttles, industrial textiles, medical implants and marine textiles.

4. Glass Fiber: It is used in consumer products, corrosion resistant materials used in road covering, materials used in aircraft and aerospace systems etc.

5. Polypropylene Fiber: Polypropylene is also called PP. This fiber is used to make marine ropes and cables, boat sail protective clothing, boat or ship structure etc.

6. Spandex Fiber: Spandex is one kind of synthetic fiber which is used in clothing, hose, sportswear etc. Due to its elasticity, it is used to make many stretchable clothing.

7. PBI: Polybenzimidazole fiber is a one kind of synthetic fiber. It is used in making hot gas filtration, thermal protective clothing, racing driver's suit etc.

8. Tencel Fiber: Tencel is made from plant materials like bamboo, cotton etc. Tencel fiber is used in the oil industry for filtration, medical textiles and industrial fabrics.

9. Inorganic Fiber: Inorganic fibers are made from inorganic materials. Glass fiber,

alumina fiber, carbon fiber is called inorganic fiber, which is used in aircraft, automobiles, sports, electrical and **military applications**.

10. Fluorine Containing Fiber: It is used for corrosive filtration media, refrigeration and packing materials.

Textiles for environmental protection, Thermal insulation materials, Nuclear protective fabrics:

Classification and Application of Protective Textiles:Protective textiles have numerous applications. Protective textiles are used in almost all work situations for special purposes and to protect workers. The following vital 17 key application areas of protective textiles are discussed below-

1. Flame Retardant Textiles:These types of garments are made using cotton/nylon as well as special fibers (carbon, glass, aramid, PBI) and chemical finishes, which reduce the combustion rate of the fabric. Workers in industries such as metals, aluminum and steel are often exposed to heavy molten metal splashes and work at very high temperatures there. Therefore, wearing flame resistant clothing is mandatory for them. So, in such an environment they wear flame resistant clothing.

Flame Retardant Textiles

2. Chemical Protective Textiles:Activated Carbon used to be used in this type of clothing but now three layers of clothing are used, the outer layer protects from liquid chemicals, the middle layer absorbs liquid and gaseous chemicals and the inner layer provides comfort to the wearer. Workers in various chemical industries wear a special type of clothing / suit to protect themselves from hazardous chemicals, be they liquids/powders/gases.

Chemical Protective Textiles

3. Biological Protective Textiles:Microorganisms are microscopic organisms that include all unicellular organisms and can form an endosymbiotic relationship with the organism. This is why microorganisms act as effective agents in many infectious diseases. Biological Protective clothing protects against such infections, preventing the movement of bacteria / microorganisms.

Biological Protective Textiles

4. Mechanical Protective Textiles:Mechanical performance of fibers, in their interlacing mode, hybrid yarns reach the textile material. This includes Ballistic, Blade cuts, Puncture, Projection of Fragments, Knives, Slashing etc. Acts as a personal defense against various risks such as. This type of textile product is made of a combination of glass fiber, HT polythene and various high-performance fibers, such as: Anti-cut Gloves.

Anti-cut Gloves

5. Electrical Protective Textiles:There are basically two types of protection from electrical hazards, Electromagnetic and Electro Static protection. Utility workers working near power lines and electrical equipment may face the risk of electric shock and intense flammability, requiring electrical protective clothing for those working in the vicinity of very high voltage equipment. Also, these garments must be flame resistant, resistant and comfortable to wear.

Electrical Protective Textiles

6. Ballistic Protective Textiles: Ballistic protection of a soldier involves protection of body and eyes. The most widely used materials for ballistic protection today are aramid, ultra-high molecular weight polythene and liquid crystal polymer-based fibers. The use of hybrid fiber in ballistic defense systems is increasing day by day. It can be both Woven, Non-woven.

Ballistic Protective Textiles

7. Bulletproof Jacket:A bulletproof jacket, bulletproof vest, ballistic vest or bullet-resistant vest is a personal weapon or item that helps absorb projectile-driven projectiles and the effects of explosions. The soft jacket is made from multiple layers of woven or laminated fibers and is able to protect small garments from small caliber handguns and shotgun projectiles from explosives such as hand grenades. These textiles are usually worn by police forces, private citizens who are at risk of being shot, bodyguards and bodyguards. Fibers like Polyester, Kevlar, Spectra, Twaron, Bynema etc. are used to make

it.

Bulletproof Jacket

You may also like: Manufacturing and Working Process of Bulletproof Jacket

8. Space Suits:Special types of suits (space suits) are made for them keeping in mind some of the issues (heat / Cold, Pressure fluctuations, Chemical, Micrometeoroids, Balance etc.) while in space and space shuttle. Nylon, Dacron, Nomax, Kevlar, Teflon, Carbon fibers are used to make space suits.

Space suits

9. Fire Fighting Suits:Firefighting suits have been tested from 56 types of fiber for fire-fighting performance. The suite is designed to protect firefighters from the flames. The suits allow better evaporation of sweat and are well ventilated to reduce the risk of burns. A firefighter suit includes coats, pants, underwear, helmets, boots, gloves, station wear uniforms, and breathing apparatus. Structurally this protective clothing is made up of three layers: Outer layer, Vapor Barrier and Thermal Barrier.

Fire Fighting Suits

10. NBC Suits:NBC suits i.e., Nuclear, Biological and Chemical which are also called bio-chemical suits. It is a kind of military and personal protective equipment. NBC suits are capable of direct contact with radioactive, biological or chemical substances and provide protection against contamination. It is designed to provide protection from the effects of radioactive substances and certain radiations, depending on the type of defense.

NBC Suits

11. Mosquito Repellent Textiles:Mosquito repellent textiles are classified as pesticide-infested nets, curtains, home textile materials, military uniforms etc. Also, used as protective barrier against adult mosquito bites. To protect against mosquitoes, we usually spray pesticides inside homes and buildings, known as indoor residual spraying, air shields, ultrasonic radiation and so on. Of all the methods of protection from mosquito bites, the textile-based protection method is the most important, as the textile material protects the skin from harsh weather and also acts as a barrier to harmful airborne micro-organisms.

Mosquito Repellent Textiles

12. High Temperature Protective Textiles:This type of textile product is also used at a temperature of about 200 degrees Celsius, leaving the properties unchanged. Here are a few things to consider when choosing a high-temperature fiber for a specific application:

- Type/nature of application
- Temperature range and heat generation
- Environmental conditions
- Special needs (special examination, cover etc.)

High Temperature Protective Textiles

13. Radiation Protective Textiles: Protective clothing is used to prevent the body from being exposed to radioactive substances in a radioactive environment. These are commonly used for professional staff at cancer treatment centers, nuclear plants.

Radiation Protective Textiles

14. Ultraviolet Protective Textiles:The main role of UV protective clothing is to protect the skin against the harmful effects of the sun. Nowadays skin cancer is one of the most common cancers in the world, so changing the surface of textiles against UV radiation has become important especially for children's clothing, sportswear, workswear. The UV protection effect of textiles depends on the fiber, fabric construction techniques, dyeing and finishing agents.

UV protective clothing

15. Waterproof Breathable Textiles:Lightweight fabric coated with polyvinyl chloride, polyurethane and other synthetic rubber has become increasingly popular for cold weather clothing. Although garments made from these fabrics provide protection against rain and somewhat less exceptional. Air penetration, condensation can accumulate on their inner surface and moisture vapor inside the garment can cause discomfort. Breathable polymer coatings are now used to overcome this problem which has greatly improved the comfort of such garments.

Waterproof Breathable Textiles

16. High Visibility Textiles:High-visibility textiles are colored fabrics that are easily perceptible or highly reflective in any environment. High-visibility clothing can serve as a distinctive mark to indicate the presence of wearers and is widely used for public safety, emergency services, personal protection applications and other professional use purposes. Various road or railway workers, traffic police are seen wearing such clothes.

High Visibility Textiles

17. Protective Health-care Textiles:The purpose of protective healthcare clothing is to protect healthcare professionals from contamination by blood and other infectious fluids. Protective healthcare textiles include Emergency room Textiles, Barrier Products, Breathable Membranes, Surgeon & Nurse's Caps, Masks, Footwear etc. Protective clothing in the medical field should be affordable, breathable, comfortable, reliable and effective.

Protective Health-care Textiles

1. Radiation Protection

A. Civilian Radiation Protection

- Application: Protects against microwaves and X-rays in healthcare and communication environments.
- Examples: X-ray aprons and electromagnetic shielding fabrics.
- Materials: Lead-based fabrics, aluminum-coated textiles, carbon composites etc.

B. Nuclear Protective Textiles

- Application: Shields against nuclear radiation in industrial and military scenarios.
- Examples: Nuclear suits and blankets.
- Materials: High-density polyethylene (HDPE), boron-containing fibers, lead-embedded textiles etc.

2. Thermal Insulation Protection

A. Cold Protection

- Application: Maintains body warmth in cold climates or extreme winter conditions.
- Examples: Insulated jackets and Arctic wear.
- Materials: Wool, hollow fibers, Thinsulate™, aerogel-based fabrics etc.

B. Heat Protection

- Application: Shields against high temperatures and heat sources.
- Examples: Firefighter suits and molten metal splash protective gear.
- Materials: Kevlar®, Nomex®, aluminized fiberglass fabrics etc.

3. Biological Protection

A. Medical Textiles

- Application: Used in healthcare to prevent exposure to biological hazards.
- Examples: Surgical gowns and face masks.
- Materials: Nonwoven polypropylene, polyethylene films, antimicrobial coatings etc.

B. Biological, Military, and Security Suits

- Application: Protects against biological threats in military and security settings.
- Examples: Hazmat suits and bio-protective overalls.
- Materials: Laminated fabrics with PTFE membranes, activated carbon layers etc.

4. Chemical Protection

A. Specific Chemical Protective Clothing

- Application: Shields against hazardous chemical spills and vapors.
- Examples: Chemical-resistant suits and gloves.
- Materials: Polytetrafluoroethylene (PTFE), butyl rubber, polyurethane-coated fabrics etc.

B. Oil and Water Protective Clothing

- Application: Repels oil and water to maintain cleanliness and safety.
- Examples: Aprons for industrial kitchens and oilfield uniforms.
- Materials: Teflon™-coated fabrics and polyester.

C. Pesticide Protective Clothing

- Application: Protects agricultural workers from pesticide exposure.
- Examples: Pesticide-resistant coveralls.
- Materials: Nonwoven polyethylene and hydrophobic-treated fabrics.

5. Electrical Protection

A. Electromagnetic Protection

- Application: Shields against electromagnetic radiation in sensitive environments.
- Examples: Faraday cages and shielding fabrics for electronic equipment.
- Materials: Conductive fibers made of copper, silver, or stainless steel.

B. Electrostatic Protection

- Application: Prevents static electricity buildup in sensitive industrial settings.
- Examples: Anti-static overalls and ESD (Electrostatic Discharge) gloves.
- Materials: Polyester with conductive fiber blends and carbon-coated fabrics.

6. Mechanical Impact Protection

Mechanical impact protection textiles are designed to absorb, distribute, and mitigate impact energy, reducing the risk of physical injuries in various high-risk scenarios.

A. Industrial Protection

- Application: Shields industrial workers from injuries.
- Examples: Cut-resistant gloves and safety helmets.
- Materials: Steel-reinforced fabrics, Kevlar®, and polycarbonate composites.

B. Military Protection

Ballistic Vests and Helmets

- Application: Protects soldiers from ballistic threats.
- Examples: Bulletproof vests and combat helmets.
- Materials: Kevlar®, Twaron®, and ceramic composites.

Invisibility Protection

- Application: Provides camouflage and concealment.
- Examples: Ghillie suits and IR-resistant uniforms.
- Materials: Multispectral camouflage fabrics and thermal-resistant coatings.

C. Sports Suits and Protective Materials

- Application: Enhances performance and ensures safety in sports.
- Examples: Body armor for cycling and racing suits.
- Materials: Impact-resistant foams, carbon fiber, and elastomeric materials.

D. Transportation Protective Textiles

- Application: Protects passengers during vehicle collisions.
- Examples: Automotive airbags and seat belts.
- Materials: Nylon 6,6, polyester, and silicon-coated fabrics.

7. Flame Protection

- Application: Resists burning and provides flame retardance in high-risk environments.
- Examples: Firefighter uniforms and flame-retardant military suits.
- Materials: Nomex®, PBI (Polybenzimidazole), and flame-retardant cotton.

3. Classification of Protective Textiles

All textile and clothing materials offers protection only the type and degree of protection differs. Climatically changes require textiles to protective one self. In case of rain a rain coat is used but during snow fall a fur jackets which is specially designed to shed off snow is required. This type of clothing is also protective textiles but the level of protection is low. Since these types of clothing and accessories are used in our day to day life the module concentrates on textiles used in special conditions like accidents and hazardous environments. Protective textiles can be classified based upon the usage, like clothing used in moderate climatically changes eg summer or winter clothing used in case of environments related to the extreme temperature changes, like clothing required at North Pole, mining areas, chemical industries which are specially designed for the comfort of the user.

These clothing can also be classified based on the duration of usage as products used for a short period like in case of fire accidents, the flame proof uniforms used be the firemen or items used for a longer period like glacier caps used during mountaineering. Another classification is based on the need of the product as protective textiles need for the survival at that particular point like nuclear, ballistic biological and chemical jackets or masks and products which ease the environment like gloves used by the farmers while spraying

chemical manure.

Types of Protective Textiles

Based on the need and end uses the types these products are generally made out of specific yarns, with special finishes. These products are covered under all three methods of fabric construction namely woven, nonwoven and knitting. In special cases the fibers are chemically made. Recent researches have given genetically modified fibers to upgrade protective textiles. Nano Technology also plays a very vital role in production protective textiles.

High Altitude Clothing

High altitude clothing or extreme cold climate clothing (ECC) is used for protecting from extreme weather conditions like high velocity winds, extreme low temperature and snow fall specifically in regions like the Everest. These clothing items are well supported with thermal protection devices which are mainly designed for preventing hypothermia, described as the 'killer of the unprepared'. It is a condition that occurs when the heat lost from the body exceeds the heat gained through food, exercise and external sources.

The high-altitude clothing consists of glacier gloves, rappelling gloves, jacket, trousers, glacier cap and waist coat. The characteristics required for this type of clothing are resistance to quick wear and tear, hydrophilic, abrasion resistance, moderate weight and thickness, breathable and maintain high integrity. Mostly thermal insulation properties are incorporated in clothes which are used during work to protect the wearer in case of accidental or emergency immersions in cold water. The thermal conductive yarns are integrated with in the woven structure for clothing used by air lines workers and navy crew travelling to the polar regions. Special finishes for maintaining heat has been imparted to these types of clothes. Micro porous coatings can be made by mechanical fibrillation, solvent exchange, solvent extraction or phase separation. Lamination is another method of coating these fabrics. Specially designed flotation vests are also used during water sports. The properties of these coats are high resistance to tear and wear, abrasion, uv rays, water proof, light weight and breathability. Usually these garments are made with polymers and the given required finishes.

Survival Suits and Bags

Survival suits and bags are made from spun bonded polyolefin fiber after aluminized. In India high altitude suits named Suit Yeti, consists of three layers that conform to an extended cold weather clothing system. All the three different layers can be worn depending on the individual's metabolic response to cold climate and weather conditions. The outermost garment consists of PTFE sandwiched between two layers of nylon fabric which acts as a breathable membrane. It is coated to give a fully windproof and waterproof garment. This helps to keep the inner shell's thermal insulation intact though transmitting the moisture out wards. Wind stopper fleece is used to make the middle layer which is extremely breathable due to PTFE membrane that helps to transmit the body moisture

from inner most layers to outer shell. This middle garment is capable to achieve very high level thermal insulation. The innermost layer made up of knitted polypropylene terry pile fabric enables fast evaporation of sweat by wicking.

For the safety of these suits and easy transport they are packed and stored in special bags. The bags used are also made PVC coated with suitable solvents. The sizes and color of these bags vary. The handles of these bags are made out high quality double plain nylon. There is a small pocket or pouch attached to the sides of the bags to fix the name tags. It is made out of plastic. Some bags have provision to carry papers and some important personal belongs. The major properties of these bags are easy to handle, flexible, light weight, thin and resistance to water and fire.

Ballistic protection

Ballistic protection includes guarding the wearer's body against fragments and projectiles of various size, shapes and impact velocity. The high tenacity, low density and high modulus of elasticity make them capable to absorb large amounts of energy. The ballistic protection clothing is made from natural fibres like silk to metallic fibres like steel. The commonly used fibres are nylon 6.6, glass fibre and aramid (Kevlar and Twaron), aromatic polyamide (Aramid) and Ultra High Modulus Polyethylene (UHMPE). High tenacity polyethylene fibre, are chiefly used to make Blast-proof vests. The outstanding elongation and elasticity of Aramid yarns gives them best resilience to ballistic impact properties. Multiple layers of woven fabric were used in traditional ballistic armour and bullet-resistant vests. The degree of protection is directly proportion to the number of layers. Neoprene coating is also commonly used. Plain square weaves are the most effective weave in ballistic protection.

The bullet-proof jackets made from Aramid, Nylon 66, or Carbon fibres weighs about 5 kilograms. The jackets should be comfortable to wear, able to spread the projectile energy efficiently, light weight and facilitate body movement. Needle punched nonwoven fabric made out of high performance polyolefin fibres and polyethylene is claimed to provide brilliant ballistic protection as well as outstanding protection against sharp fragments by absorbing projectile energy and deformation along with low density, light weight and thin construction.

Very low mass per unit area felts are most effective materials, but, as the mass increases, the woven textiles stand superior to felts in performance. The key manufacturers of bullet-proof jacket in India are Tata Advanced Material Limited (TAML) – Southern Group of Industries Pvt. Limited and Isolar India for Glass based bullet-proof jackets.

Fire Protection Textiles

Textiles themselves are flammable material and can turn into prime source of fire in case of break-out. Flame and heat resistant textiles which are chiefly used to protect fire should prevent fire, flammability, melt, heat conduction and should not emit toxic fumes. This

kind of textiles are largely used by firefighting personnel, offshore oil and gas ring workers and in airlines, ship, railways, office furnishings, hospitals and cinema multiplex The two major classes of fire retardant fabrics are natural fire retardant fabrics like glass and fire retardant coated fabrics. The inherently permanent fire retardant fibres are modified polyester fibre.

Fabric woven with inherently non-combustible glass fibre coated with exclusive water-based polymers is having the characteristics such as, it does not melt, ignite, rot, drip, stretch or shrink. It is also distinguished for its low level toxicity of smoke emissions. Hence it is used during the manufacture of fire and smoke proof curtains in ship, furniture barriers and cargo wraps in air crafts.

Aramid (meta and para), modacrylic and polyamide are the other fire-retardant fabrics.

The ideal features of the fire-retardant fabric are:

- High tear and abrasion resistance
- High dimensional stability
- Anti-decay and Anti mould
- Breathable and comfortable
- Very low fume toxicity in fire
- Crease resistance
- No fading and excellent colour tone

Trevira® a Reliance Netherlands B.V. brand is the world leader in fire retardant fabric. Manufacturers of chemical coated fire-retardant fabrics in India are Rajasthan Weaving and Spinning Mills Limited and Jaya Shree Textile.

Exposure to hazardous environments

Exposure to hazardous environment comprises the long-term exposure to milder conditions that is not normally associated with disasters or accidents. This includes rain, foul weather, wind, extreme cold, high temperatures, nuclear reagents, molten metal splashes, chemical reagents, microbes and dust. Normally modified polyester high performance fibers are used. In some cases even natural fiber like silk blends, wool and glass fibers are also used. These fabrics have woven knitted or non woven structures. The fabrics are usually coated with suitable solvents to resist the hazards conditions.

High-Visibility Clothing

High visibility clothes or Reflective-wear is essential for protecting people working in poorly light workplace like mines, airport runways and high ways. The photo luminescent materials absorb artificial light and emit green-yellow light in the darkness. There are generally three types of high visibility clothing:

- Photo luminescent material which give yellow light in dark
- Reflection materials which shine when struck by light

- Fluorescent material which is more visible even during the day

Non-radioactive and non-toxic Zinc Sulphide crystals are used. Fluorescent materials have the ability to convert non-visible UV ray's energy into visible energy which is useful during daylight. There are two types of high visibility clothing such as suits with plastic tapes and suits with glass beads or retro-reflective tapes, which give visibility up to 600 meters. The technology encompasses of coating highly reflective glass beads with a density of 50,000 tiny glass beads per square inch light.

The characteristics required for ideal high visibility apparel are day and night visibility, light weight, permeability to air and moisture, comfort, universal one-size-fits-all design features, durability and neatness with finished edges. The fabric used for making high visibility clothing is normally fluorescent polyester tricot fabric with 120 GSM with reflective micro sheeting. The typical width of reflective tapes is 5 cm. The fabrics used to manufacture high visibility clothing are imported from China and Korea.

Chemical Protection Clothing

Chemical Protective Clothing (CPC) is used for protecting the whole body from toxic chemicals and physical hazards. The chemicals can be absorbed into the human body either by physical contact or by inhaling, hence chemical protective clothes are specially designed to prevent the physical contact of toxic substances. The chemical protective clothing suits can be of durable type made out of non-permeable textile fabrics such as rubber/ PVC coated fabrics which block the penetration of the chemicals through the fabrics. It is an effective method, but it does not permit moisture and air too thus it leads to stress rather it becomes a non breathable fabric. The next category is air and moisture permeable disposable type made out of non-woven fabric and can be used only for 3-4 times.

Carbon-containing materials were also developed. It includes carbon-impregnated polyurethane foam, carbon-coated nonwoven fabric, activated charcoal cloth and hard carbon microsphere-adhered woven fabric. Durable type chemical protective clothing is having good demand in India. Cotton or polyester cotton base fabric coated with PVC is used in India. The chemical protective clothing is used by workers engaged in petroleum, dyes, paints, chemicals and chemicals products industries.

Industrial gloves

Industrial gloves serve as an item of protective accessories. Cushioning and protection for hand from blows in heavy-duty work for workers in factories, iron and steel industry, welding applications, oil refineries, construction, pharmaceuticals and chemical industries can be obtained from industrial hand gloves. It protects the hands from sparks, heat and rough objects.

They are classified under thermal protection as well as cut-slash protection. Gloves are made out from cotton, asbestos, variety of leather, Spectra and Kevlar (Para-aramid). The

construction methods of gloves vary as construction of leather, knitted, non-latex (nitrile) and rubber or latex gloves. They are also available in varying gauges or sizes.

The characteristics required for gloves are comfortable and durable, mild heat resistance, protection against cut and hot splash, high abrasion protection and better grip with anti-slip coating. Aramid gloves have temperature tolerance from 250 to 750 centigrade and nitrile gloves provide chemical splash protection.

The leading manufacturers of industrial gloves are Mallcom India Limited, Rajda Industries and Exports Pvt. Limited, Lumens India and KDM Impex Pvt.

Industrial Helmets

Industrial helmets are being used for protecting head from exposure to hazardous environments at work places like mines or chemical industries. It consists of two layers, the inner layer made up of polypropylene or foam and an outer layer made out of steel fibres. Its primary function is to protect the skull and brain injury. The two kinds of helmets available are Full face helmet and Open face helmet. The full face helmets have glass or plastic transparent cover across the face so as to enable the wearer to view. It is used while working in under water units, mines, chemical industries and welding units where the workers has more chances of coming in contact with fire or poisonous chemicals and gases. In some helmets provision for light emission in the form of torches are attached at the top to enable the wearer to see his surrounding and work with both his hands. The helmets are bounded to the wearers head by means of a strip of fabrics which is made up of nylon 66 or polyester and its blends. Mostly these strips are braided.

Smart Textiles & Role of smart materials in textiles:

Smart textiles revolutionize the fabric industry by integrating digital technology, sensors, and advanced materials to create interactive and adaptive textiles. This comprehensive guide delves into the evolution, applications, and economic benefits of smart textiles, comparing traditional production with modern innovations and offering insights into IoT integration, material science, and sustainability. By embracing these cutting-edge technologies, manufacturers can enhance product functionality, meet consumer demand for eco-friendly solutions, and secure a competitive edge in the global textile market.

AI in textiles, conductive fibers, digital integration, digital textile printing, eco-friendly textiles, industry standards, interactive textiles, IoT textiles, smart fabric, smart manufacturing, smart textiles, sustainable textiles, textile innovation, textile quality, Wearable Technology , Smart textiles represent a dynamic fusion of technology and fabric, reshaping how we interact with clothing and textiles in everyday life. These innovative materials integrate electronic components, sensors, and smart functionalities directly into the fabric structure, transforming ordinary textiles into interactive, responsive, and adaptive systems. As the textile industry evolves, smart textiles have emerged as a key driver of innovation, sustainability, and enhanced user experience.

Smart textiles leverage modern advancements in the Internet of Things (IoT), artificial intelligence (AI), and advanced material science. They encompass a broad spectrum of applications—from temperature-responsive fabrics that adjust to body heat to garments that monitor health metrics in real time. This article delves into the fundamentals of smart textiles, exploring their evolution, technological components, real-world IoT integration examples, and market forecasts. We will also compare various types of conductive fibers, such as silver-coated versus graphene-based fibers, to provide a deeper understanding of material performance in smart textile applications.

Defining Smart Textiles

Smart textiles are fabrics that can sense, react, and adapt to environmental stimuli. They

combine traditional textile materials with embedded electronics, sensors, and conductive fibers to provide functionalities beyond conventional textiles. These functionalities include monitoring physiological signals, responding to changes in temperature, altering appearance, and even harvesting energy from the environment.

At their core, smart textiles transform passive fabrics into active components of our digital ecosystem. By embedding microelectronics and sensors directly into the textile matrix, manufacturers create materials that interact with the wearer or surrounding environment. This interaction opens up possibilities for innovative applications in areas such as healthcare, sportswear, military, and home automation.

The evolution of smart textiles reflects the convergence of traditional textile craftsmanship with cutting-edge digital technology. As advancements in material science and electronics continue, smart textiles now provide real-time data, enhance user comfort, and offer customized experiences.

Historical Evolution and Emergence

Smart textiles evolved from early attempts to color and pattern fabrics to today's high-tech materials that integrate sensors and connectivity. Traditional textile dyeing and finishing techniques laid the foundation for what we now consider smart textiles. Early innovations, such as thermochromic dyes that change color with temperature, hinted at the potential of interactive fabrics.

Over time, advances in electronics and microfabrication enabled the embedding of sensors and circuits into fabrics. The development of flexible printed circuits and conductive fibers accelerated the transition from concept to commercial reality. Companies began to experiment with textiles that could monitor vital signs or adjust their thermal properties in response to external conditions. Today, smart textiles have moved beyond niche applications to become integral in everyday apparel, healthcare products, and even industrial safety gear.

Categories of Smart Textiles

Smart textiles can be broadly classified into several categories based on their functionality and the level of integration of electronic components:

1. Passive Smart Textiles

These textiles can sense or detect changes in the environment but do not react or adapt. For example, fabrics with embedded sensors can measure temperature or UV exposure and send data to a connected device. Passive smart textiles are commonly used in healthcare monitoring and athletic performance tracking.

2. Active Smart Textiles

Active smart textiles not only sense changes but also respond in real time. They incorporate actuators that can adjust the fabric's properties. A prime example is temperature-responsive fabric that can change its insulating properties based on the wearer's body heat. These textiles are widely used in performance apparel and protective clothing.

3. Intelligent Smart Textiles

Intelligent smart textiles incorporate computational elements and are capable of decision-making. They integrate microprocessors and connectivity to analyze data, process inputs, and perform automated functions. Examples include garments that monitor health metrics, adjust compression levels in sportswear, or even change patterns dynamically. These textiles often employ machine learning and AI to deliver a tailored user experience.

Technological Components and Innovations

Embedded Sensors and Actuators

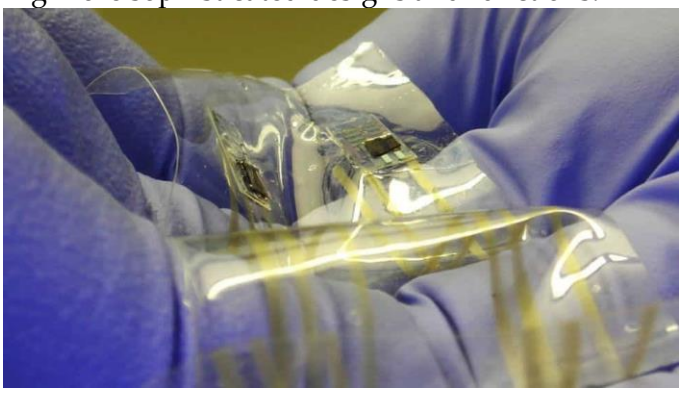
Smart textiles rely on various sensors to gather information. Temperature sensors, pressure sensors, accelerometers, and biometric sensors are integrated into fabrics to monitor parameters such as body temperature, movement, and heart rate. Actuators in smart textiles can trigger changes such as color alterations, adjustments in insulation, or even haptic feedback. The successful integration of these components depends on the development of flexible, durable materials that do not compromise the comfort or aesthetics of the textile.

Conductive Fibers

Conductive fibers serve as the backbone for transmitting electrical signals within smart textiles. They come in different forms, including silver-coated fibers and graphene-based fibers. Silver-coated fibers are known for their excellent conductivity and antimicrobial properties, while graphene-based fibers offer high strength, flexibility, and superior electrical performance. Below is a comparative table of conductive fibers:

Type	Material	Conductivity	Durability	Cost	Applications
Silver-Coated Fibers	Natural fibers coated with silver nanoparticles	High, excellent signal transmission and antimicrobial properties	Good, may degrade over time with washing	Moderate to High	Apparel, healthcare textiles, EMI shielding
Graphene-Based Fibers	Fibers integrated with graphene	Very High, exceptional conductivity with excellent mechanical strength	Superior, highly durable even in harsh conditions	High	High-performance sportswear, technical textiles, wearable electronics

The development of conductive fibers continues to drive innovation in smart textile applications, enabling more sophisticated designs and functions.



IoT Integration in Smart Textiles

The integration of the Internet of Things (IoT) has transformed smart textiles into interactive, connected systems. IoT-enabled smart textiles can transmit data to external devices, such as smartphones and cloud platforms, enabling real-time monitoring and feedback. For example, HeiQ's temperature-responsive fabrics incorporate IoT sensors that adjust the fabric's thermal properties based on environmental and body temperatures. Such innovations not only enhance user comfort but also provide valuable data that can be used to optimize textile performance.

Digital Textile Printing and Customization

Digital textile printing has emerged as a cutting-edge technology in smart textile production. Unlike traditional dyeing methods, digital printing uses high-resolution inkjet printers to apply dyes directly to the fabric. This process allows for rapid customization, precise color matching, and minimal waste. Digital textile printing supports eco-friendly inks and waterless dyeing processes, aligning with the growing consumer demand for sustainable fashion.

Real-World Applications and Industry Examples

Smart textiles have permeated various sectors, offering innovative solutions across multiple applications:

Apparel and Fashion

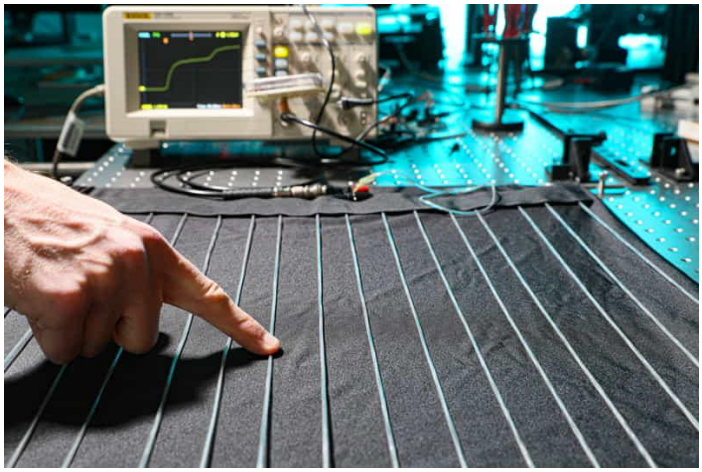
In the apparel sector, smart textiles enable garments that adapt to the wearer's needs. For instance, temperature-responsive sportswear adjusts insulation based on body heat, enhancing performance and comfort. Additionally, smart fabrics that incorporate biometric sensors are used in wearable health monitors, providing continuous tracking of vital signs. Fashion designers are increasingly integrating these technologies to create garments that are not only stylish but also highly functional.

Healthcare and Wellness

Smart textiles in healthcare monitor physiological parameters and improve patient care. Wearable textiles embedded with sensors can track heart rate, blood pressure, and respiration, offering real-time data that is critical in remote health monitoring and rehabilitation. These textiles also play a role in medical diagnostics, where they can detect changes in body conditions and alert healthcare providers.

Technical and Industrial Applications

The industrial sector leverages smart textiles for various high-performance applications. In automotive interiors, smart textiles enhance comfort and durability, while in geotextiles, integrated sensors monitor structural health and environmental conditions. Technical textiles that incorporate smart functionalities are used in protective clothing, reducing risks in hazardous environments and providing real-time monitoring of environmental conditions.



Comparative Analysis: Traditional vs. Smart Textile Technologies

Traditional Textile Technologies

Traditional textiles rely on established manufacturing processes that have been refined over decades. Conventional fabrics often undergo standard dyeing, weaving, or knitting processes without any integrated electronic functionality. While traditional methods excel in producing durable and cost-effective textiles, they lack the interactive and adaptive features of smart textiles.

Traditional techniques have limitations in customization and real-time performance feedback. However, they continue to serve as the backbone for many high-volume textile applications where advanced functionalities are not required.

Smart Textile Technologies

Smart textiles incorporate sensors, conductive fibers, and embedded electronics that allow for real-time interaction and responsiveness. These textiles enable functionalities such as:

- **Temperature Regulation:** Fabrics adjust their thermal properties based on ambient conditions.
- **Health Monitoring:** Embedded sensors track vital signs and physical activity.
- **Interactive Design:** Digital textile printing allows for on-demand customization with minimal waste.
- **Data Connectivity:** IoT integration provides seamless communication between the textile and external devices.

The enhanced capabilities of smart textiles open up new markets and applications that traditional textiles cannot address. Manufacturers that invest in smart textile technology can differentiate their products, offer unique user experiences, and command premium prices.

Comparative Table: Conductive Fibers in Smart Textiles

Fiber Type	Material	Conductivity	Durability	Cost	Applications
Silver-Coated Fibers	Natural fibers with silver	High conductivity; excellent	Good under moderate use; requires care for	Moderate	Healthcare textiles, EMI shielding,

Fiber Type	Material	Conductivity	Durability	Cost	Applications
	coating	antimicrobial properties	longevity		sportswear
Graphene-Based Fibers	Fibers integrated with graphene	Exceptional conductivity and high mechanical strength	Superior durability in harsh environments	High	High-performance apparel, wearable tech, industrial textiles

The table above illustrates the key differences between silver-coated and graphene-based conductive fibers, highlighting their roles in enhancing smart textile functionality.

Quality Control and Testing in Smart Textiles

Ensuring the quality and reliability of smart textiles involves rigorous testing and quality control protocols. Manufacturers use a combination of traditional textile testing methods and advanced digital monitoring techniques to assess:

- **Electrical Conductivity:** Measuring the performance of conductive fibers in transmitting signals.
- **Mechanical Properties:** Evaluating tensile strength, flexibility, and durability.
- **Sensor Accuracy:** Calibrating embedded sensors to ensure reliable data collection.
- **Environmental Resistance:** Testing for durability under various environmental conditions, including moisture, temperature, and UV exposure.

Advanced testing instruments, such as digital multimeters, spectrophotometers, and tensile testers, provide quantitative data that guide process optimization and quality assurance. These quality control measures are essential for maintaining the performance of smart textiles in real-world applications.

Economic and Environmental Impact

The integration of smart textile technology brings significant economic and environmental benefits. While the initial investment in technology and advanced machinery may be high, the long-term gains include increased product differentiation, enhanced market value, and improved operational efficiency.

Economic Benefits

- **Premium Market Positioning:** Brands that incorporate smart functionalities can command higher prices and tap into niche markets.
- **Increased Efficiency:** Automation and digital integration reduce production downtime and waste, resulting in cost savings.
- **Customization:** On-demand production capabilities allow for personalized textiles, opening new revenue streams.

Environmental Benefits

- **Resource Efficiency:** Smart textiles can improve energy and water efficiency in production processes, reducing overall environmental impact.

- **Sustainability:** Incorporating eco-friendly components, such as water-based inks and recycled conductive fibers, supports sustainable manufacturing.
- **Waste Reduction:** Digital textile printing and precise dyeing techniques minimize waste, contributing to a circular textile economy.

Policy and Regulatory Frameworks

Government regulations and industry standards play a vital role in shaping the future of smart textiles. Regulatory frameworks ensure that smart textiles meet safety, performance, and environmental standards, fostering consumer trust and market growth.

Certifications and standards from organizations like ASTM and ISO guide quality control and testing practices in the smart textile sector. Compliance with these standards not only guarantees product quality but also supports global trade and consumer acceptance.

Future Trends and Innovations

The future of smart textiles is promising, driven by continuous technological innovation and increasing consumer demand for interactive and sustainable products.

Emerging Technologies

- **AI and Machine Learning:** Advanced algorithms optimize smart textile performance by analyzing real-time data from sensors.
- **Digital Twin Technology:** Creating virtual models of smart textile systems to simulate and improve performance before production.
- **Advanced Material Science:** Innovations in conductive fibers, such as graphene-based materials, will drive the next generation of smart textiles.
- **Wearable Integration:** Enhanced integration of smart textiles with wearable devices and IoT platforms enables seamless connectivity and data exchange.

Shape Memory Fibres:

Shape Memory Fabrics: Shape memory fabrics/garments so produced are novel fabricswhich respond to the temperature stimulation. The concept of shape memoryfabric is new and these fabrics were prepared by applying waterborne shapememory polymers in Polyurethane series (SMP) onto fabrics through specificfinishing processes.

Shape Memory Polymers (SMP)

SMP generally characterized as a phase segregated statistically block copolymer having a hard segment and a soft segment. The hard segment acts as a frozen phase and the soft segment acts as a reversible phase. This frozen phase helps to memorize the original shape while the reversible phase acts as a switch responsible for shape recovering. Once the shape memory polymer is deformed, the original shape is recovered by heating the SMP at a switching temperature which equals to the melting temperature of soft segment, T ms. Shape memory is the ability of a product to remember its original shape upon application of an external stimulus such as chemicals, temperature, or pH. A change in shape - return to the predetermined shape, caused by a change in temperature is called a thermally induced shape memory effect. To have this smart property in fabrics, a temperature sensitive shape memory polymer (SMP) is used in fabric finishing. There are 3 thermally sensitive cotton fabric shape memory effects.

Thermally Sensitive Shape Memory Effects

Flat appearance:The fabric shape memory effect of flat appearance could be defined as the ability of recovering an original flat shape from a deformed shape, after stimulation at switch temperature in different media.

Crease retention:The fabric shape memory effect of crease retention could be defined as the ability of recovering and retaining an original creased shape from a deformed shape, after stimulation at switch temperature in different media.

Bagging recovery:The fabric shape memory effect of bagging recovery could be defined as the ability of recovering an original flat shape from a deformed shape which likes a bag, after stimulation at switch temperature in different media.

Advantages:

- Temperature Sensitive
- Higher Fabric Breaking Strength and Tearing Strength
- Better Washability & Performance.

Other Features

- Different predetermined fabric shapes, e.g. flat, crease & bagging.
- Formaldehyde level is low in fabric after SMP finishing.
- Finishing formula can be tuned to change the shape recovering temperature of the fabric.
- Different thermal triggering means
    - Hot water washing,
    - Tumble drying,
    - Steaming, etc.
- Fabrics have improved color retention
- Compatible with other softeners, whiteners, antibacterial finishings etc

In general, shape memory fabrics/garments treated with SMP were endowed with excellent hand, shape retention, dimensional stability, good durability, wrinkle free, flat appearance, bagging recovery, comfort to wear and easy care under the water and higher temperature.

The Application of Shape Memory Polymer on Textiles and Apparel

During application of Shape Memory Polymers on textiles and apparel, different types of shape memory polymers should be synthesized using different methods. For fabrics/ garments, different finishing methods will be used for treatment of the fabrics/garments using shape memory polymers under the different processes. For the fiber industry, they can be spun into shape memory fibers. The application fields o. shape memory polymers are:

- Woven fabrics/ garments
- Knitted fabrics/ garments
- Fiber
- Coating
- Film
- Intercalation

For application of Shape Memory Polymer on the fabrics/ garments to develop the smart textiles, it is a very promising area with tremendous potential that has attracted enormous attention, but technologically it is still very challenging. The important achievement and advancement in this field have been made by Shape Memory Research Groups. The applications of shape memory polymer on textiles can bring tremendous value to the Hong Kong Textile and Clothing industry in near and long term future.

Shape Memory Material & Concepts associated with shape memory materials:

Shape Memory Polymers (SMP) are materials that you can deform and then restore to their original shape by providing a stimulus, such heat or light. When not being distorted, a shape memory polymer can transition from a temporary shape that is obtained by deformation to a previous shape that is its permanent shape. To achieve this, a variety of stimuli might be used. Heat, light, infrared radiation, submersion in water, and the application of electric or magnetic fields have all been used to achieve this so far.

Shape Memory Polymer products

Application of Shape Memory Polymer in Textile and Fashion: There are lots of application of shape memory polymer in textile and apparel industry. Here are discussed few major application such as follows-

1. Thermally Formable Yarn:A new substance known as thermo-formable yarn has been created by Luxion Industries NV and Massebeuf. It is a brand-new polymer that, after being spun into a monofilament, turns bi-stable. It becomes flexible and rigid after activation. It can be woven or knitted into yarn for use in clothing. Additionally, it softens when heated for about a minute at 65°C and stiffens when it cools back down. By

reintroducing the heat source, it can be reformed.
Eco-friendly fashion

2. Deodorant Fabrics: These unique fabrics have the capacity to release deodorizing compounds at specific temperatures. By applying a stimuli-responsive polymeric hydrogel to the textile surface, the smart fabric is created. A functional monomer, such as acrylamide, and a cross-linking agent, such as 2-(diethylamino) ethyl acrylate, are used to chemically cross-link the hydrogel to the surface of the textile. Usually, the cross-linking reaction happens during or right after the deodorant is introduced into the hydrogel. Usually, polymeric gel is added to β-cyclodextrin to further improve the controlled release characteristics of textiles treated with hydrogels. The structure of β-cyclodextrin has a hydrophobic internal chamber and a hydrophilic exterior surface.

3. Comfort Fitting Footwear: It is disclosed a dynamic shoe last made of a shape memory polymer (SMP) material. One dynamic SMP footwear last may be repeatedly adjusted to transform into any size and shape with accuracy and dependability, significantly decreasing the total inventory of footwear lasts needed at a specific footwear manufacturing facility.

4. Wound-dressing Products: Chitin and chitosan derivatives are frequently utilized to make wound-dressing products because of their superior antibacterial and wound-healing qualities. When used as a wound dressing, chitosan hydrogel can aid in the restoration of skin architecture. Advanced wound dressings have been created using cotton fabric and alginate filaments coated with chitosan. Different biopolymer-based hydrogel products have also been developed for wound treatment in addition to **chitin/chitosan**. These intelligent wound dressing materials can administer a cutting-edge drug release system in reaction to changes in pH or temperature, allowing wounds to heal more quickly.

5. Damping Fabrics: Fabrics that absorb effect energy include SMPs because they have better damping characteristics at or around Tg. The automotive seatbelt fabric was created by Allied Signal Inc. employing SMP fibres (Securusfibres), which can efficiently increase a passenger's safety by absorbing the kinetic energy. Shape memory poly (ethylene terephthalate)-poly (caprolactone) block copolymers are used to create the Securusfibres. According to reports, the fibre can absorb energy from the body's forward motion, increasing passenger safety in an accident.

6. Self-adaptability of Shape:SMP fibres are used to create self-adaptive textiles that can easily manage their structural changes in response to temperature variations in the environment. Although a fiber's shape memory effect (SME) is typically thought of as a change in length, after being incorporated into fabrics, this SME can take on a variety of shapes, including bending, shrinkage, and thickness growth, which is dictated by the **fabric structures**. The clothing made from SMP fibres can be expanded appropriately to accommodate the wearer's body. According to vertical pressure testing, SMP fiber-made clothing has a lower vertical tension stress than **elastic fiber** made clothing. This is due to the SMP fibres' capacity to deform and fix into temporary shapes, which reduces the unwanted pressure to wearer

Industrial Applications of Textiles

Textiles in Electronics:

E-textiles, also known as electronic textiles or **smart textiles**, are fabrics that enable digital components (including small computers), and electronics to be embedded in them.

Properties of e-textiles:

1. Flexible
2. No wires to snag environment
3. Large surface area for sensing
4. Invisible to others
5. Cheap manufacturing
6. Permeability
7. Strength
8. Thermal Resistance
9. Electrical resistance

Types of electronic textiles: The field of electronic textiles can be divided into two main types:

1. Electronic textiles with classical electronic devices such as conductors, integrated circuits, LEDs, and conventional batteries embedded into garments.
2. Electronic textiles with electronics integrated directly into the textile substrates. This can include either passive electronics such as conductors and resistors or active components like transistors, diodes, and solar cells.

Most research and commercial e-textile projects are hybrids where electronic components embedded in the textile are connected to classical electronic devices or components. Some examples are touch buttons that are constructed completely in textile forms by using conducting textile weaves, which are then connected to devices such as music players or LEDs that are mounted on woven conducting fiber networks to form displays. Printed sensors for both physiological and environmental monitoring have been integrated into textiles including cotton, Gore-Tex, and neoprene.

Manufacturing of Electronic Textiles:A thread can be made to conduct electricity by

either coating it with metals like copper or silver. It can also be made conductive by combining cotton or nylon fibers with metal fibers when it is spun.

Inputs for electronic textiles: To obtain information for wearable devices components such as sensors are often used, for instance, environmental sensors, antennas, global positioning system receivers, sound sensors and cameras. Such sensors can be divided on active and passive (Langenhove & Hertleer, 2004)(Seymour, 2009). Active inputs are controlled by a user via a tactile or acoustic feedback system, which provides an intuitive interaction with the garment. Passive inputs collect biometric data from the human body as well as environmental data collected via wireless transmission system.

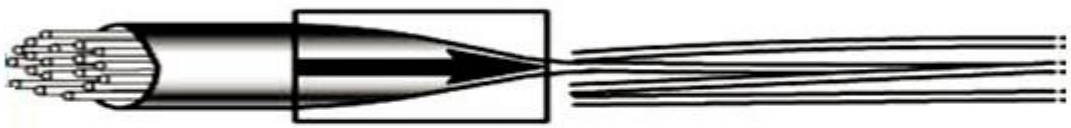
Construction of electronic textiles:

- Lily Pad Arduino
- Fabric kit.
- Aniomagic
- Flora

Conductive fabrics and textiles are plated or woven with metallic elements such as silver, nickel, tin, copper, and aluminum these are: electro-nylon, electr-onylon nickel, clear-mesh, soft-mesh, electro-lycra and steel-cloth. All these textiles show amazing electrical properties, with low surface resistance15, which can be used for making flexible and soft electrical circuits within garments or other products, pressure and position-sensing systems. They are lightweight, flexible, durable, soft and washable (some) and can be sewn like traditional textiles, which makes them a great replacement for wires in computational garments.

Conductive threads and yarns have a similar purpose to wires and that is to create conductive paths from one point to another. However, unlike wires they are flexible and can be sewn, woven or embroidered onto textile, allowing for soft circuits to be created. Conductive threads and yarns offer alternative ways of connecting electronics on soft and flexible textiles medium as well offering traditional textile manufacturing techniques for creating computational garments.

1. Metal coated wire combined in iron tube



2. Several diameter reductions of tube

3. Bundling of tubes

4. Leaching (releasing fibres)

:

Conductive threads

Conductive coatings are used to convert traditional textiles into electrically conductive materials. The coatings can be applied to different types of traditional fibers, yarns and fabrics, without changing their flexibility, density and handling.

Conductive ink is an ink that conducts electricity, providing new ways of printing or drawing circuits. This special ink can be applied to textile and other substrates. Conductive inks contain powdered metals such as carbon, copper or silver mixed with traditional inks.

Other materials are:

- Shape memory alloys (SMA or muscle wire)
- Piezoelectric materials
- Chromic materials
- Photo-chromic (inks and dyes)
- Thermo-chromic inks
- Nano-materials and **microfibers**

Advancement:

Some of the most advanced functions that have been demonstrated in the lab include:

- Organic fiber transistors: The first textile fiber transistor that is completely compatible with textile manufacturing and that contains no metals at all.
- Organic solar cells on fibers

Applications of Electronic Textiles: The use of fabric as station to deploy electrical components results in wearable electrical/ computing devices. Early electric and electronic textiles had components added to existing garments. Later, functionality was added by incorporating conducting yarns into fabrics to produce sensors, switches, and actuators. EXO Technologies has developed heated gloves for use by skiers, motorcyclists, and the military. The heating elements are knitted from novel polymeric FabRoc yarn.

EXO heated glove

The main important stakeholders for wearable electronics in textiles are end users and a short overview of the major application of wearable electronics is given as under:

1. Retailer SupportA successful embedded electronics for retailer support should cover the needs in logistics, such as stock control, quality insurance control and anti-theft protection. For this purpose, there are several integrated RF indent-tags already in use. These tags consist mainly of an RF antenna used to transfer energy to the indent-tag and to establish a communication link between the tag and the control equipment. The most primitive tags consist of a simple antenna-capacitor resonance circuit. The more complex ones contain simple micro-controllers and non-volatile memories.

2. Service Support Service support is more important in developed countries like Europe and United States. Here consumer tends to sort clothes into different categories before washing. Therefore, the **washing machines** are able to treat the clothes in very different ways. Naturally, it happens rarely that a black sock is hiding in a white shirt. This results in coloured shine on the originally white clothes. The consumer can avoid such accidents if the washing machine recognizes type, number and required optimal treatment of the clothes to be washed. In case of conflict, an error message is generated.

Sustainable clothing

3. User Convenience Built-in electronics may control and support more advanced textile functionalities like temperature, moisture, etc. For that purpose, secure heating and cooling elements are necessary.

Smart clothes

4. User Interfacing User interfacing enables the interfacing between the user and electronic belongings or external (out of body) networks and terminals. Sound, gesture and temperature may control such interfaces. Suitable components are microphones, loudspeaker, textile keyboards, flexible displays and more complex devices.

5. Appliance Networking The networking between different electronic modules is a key feature necessary for the application of user interfaces. One scenario might be the connection of a cellular phone ported in the right pocket, with a personal digital assistant (PDA) in the left pocket, Bluetooth interface in the trousers and the user interface integrated into the coat.

6. Networking with External Networks The networking with external networks can be done in real time or by batch processing, online and offline. Another offline method might be the use of exchangeable storage elements like multimedia cards, etc. Wearable computers have the potential to enhance the day-to-day activities of the user.

There are also lots of scopes and application is going on around the globe in the recent area due to its state-of-art and portable quality. Now electronic textiles are widely used in **military applications**, medical applications, **fashion and accessories**. In current pandemic situation (Covid-19) where thermal scanning is an important aspect, temperature sensing integrated textile can be very useful for detecting fever of any individual.

Textile reinforcement products:

Technical Textiles are a significant part of the modern textile industry. It's used **as a reinforcement for composites** in many industries, including construction, medical as well as military. Cause it is an attractive option to provide performance, weight savings, and cost benefits over other options.

Textile Reinforced structures and their composites

This article will focus on using **technical textiles in reinforce composites** to make them

stronger and more durable by manmade Fiber.

Before we enter the main discussion, let's know about; **What is Technical Textile?**

Technical Textile:

The term **Technical Textile** reflects the use of a wide range of fabrics and textiles in various ways to support or enhance performance. Technical textile is a special that has specifically designed for technical purposes. These fabrics are typically made with large percentages of manmade fibers, like nylon and polyester, Polypropylene, and so on, which provide durability and stretchability to the material.

But Technical textiles often have functional properties such as water repellence or insulation qualities, including reinforcement for composites to meet a specific need or provide a particular function. Some special manmade fibers have been used in technical textiles as reinforcement composites.

Sustainable Textile-reinforced composite materials

Different composites of matrix and fiber procurable for textile-reinforced composites in technical textiles. Manmade Fiber has used different manufacturing composites to enhance the properties because of an essential feature of composite materials. These features contrast with the nano-engineering materials, the usual material to produce forming of the desired shape.

Figure: Textile-reinforced composite Structure

The manufacturing industry used S-glass, Fibreglass, carbon fibers, boron, Basalt, ceramic fibers, and aramid fibers, including polyesters and nylons in terms of reinforcements material. Some of the popular are discussed briefly in the following.

a. Glass Fibers:

Glass fibers are the most versatile industrial textile materials. It exhibits beneficial characteristics such as hardness, transparency, stability, resistance to chemical attack, and most importantly, desirable fiber properties. Examples as strength, flexibility, and stiffness.

Glass fibers and fiberglass are usually used to manufacture architectural compositions and to produce versatile products. Mainly the glass composite used in technical textile is called Fibreglass Reinforced Plastic. It is popular in FRP, commonly known as fiberglass. FRP refers to thermoset plastic resin that reinforces with glass fibers.

The plastic resin provides chemical, electrical, and thermal properties in the composite; on the other ways, glass fiber provides strength, dimensional stability, and heat resistance properties to the composite materials. The additive includes color and affects many different characteristics, such as determines surface finish and flame retardancy. The glass fiber and FRP are used in the knitted and nonwoven spun format in composite materials to enhance the reinforcement.

b. Carbon Fiber:

Carbon fiber is a popular reinforcement composites material in technical textiles. Its micrographic crystal structures support to act of fibrous material. Carbon fiber is available by oil or coal pitch after giving specific thermal treatment.

PAN, Pitch-based carbon fiber, Mesophase, isotropic, Rayon, gas-phase-based carbon fibers have mainly been used as **technical fiber in high-performance applications**. Currently, an upgrade version of **Carbon Fiber** was struck out.

Carbon Fiber Reinforced Plastic – CFRP

CFRP is a reinforced material has been increasing demand in the specialized industry such

as aerospace and aviation industry, automotive industry, wind energy sector and shipbuilding industry. Super lightweight material with incredible strength and desirable Textiles made from carbon fiber roving are especially ideal for enhancing the concrete with a load-bearing capability of 3K Newton/ meter^2. And about 1.8 gram/cm^3 makes it much effective than connectional steel-reinforced concrete. It has made exceptional standards as reinforcing materials, especially in concrete structures.

c. Basalt Fiber:

Basalt fiber is popular green garments industrial material. It is informally popular as the 21st-century non-polluting, eco-friendly green material. Basalt is a natural and inert material is found in volcanic rocks. It used its raw form as a building stone since roman. Basalt originated from frozen lava, in melting temperature comprised between 1500 to 1700˚C.

Textiles for Banners:

Textiles for Banners and its Applications:

In marketing and advertising, banners play a crucial role in attracting attention and conveying messages effectively. When it comes to choosing the right banner fabric for your needs, there are various options available, each with its own unique characteristics and uses. In this guide, we will explore different types of banner fabrics, including their features, benefits, and applications.

Vinyl Banners: Vinyl banners are a staple in the world of outdoor advertising for several reasons. Their durability and weather resistance make them ideal for withstanding harsh outdoor conditions such as rain, wind, and sunlight. Constructed from PVC material, vinyl banners are designed to last, ensuring that your message remains visible and vibrant even after prolonged exposure to the elements.

One of the critical advantages of vinyl banners is their versatility. They can be easily customized to suit various applications, from promoting events and sales to showcasing products and services. The printing process for vinyl banners allows for high-resolution graphics and vibrant colors, ensuring that your message stands out and grabs attention.

Whether advertising a grand opening, promoting a special offer, or showcasing a new product, vinyl banners provide a cost-effective solution for reaching your target audience. Their ability to withstand outdoor conditions makes them a reliable choice for outdoor events, trade shows, festivals, and storefront displays.

Polyester Fabric Banners: Polyester fabric banners offer a lightweight and portable solution for indoor and outdoor advertising. Made from polyester fabric, these banners are not only durable but also wrinkle-resistant, making them easy to transport and set up for events and exhibitions.

One of the critical benefits of polyester fabric banners is their excellent color reproduction. The fabric material allows for vibrant colors and sharp graphics, ensuring that your message is displayed with clarity and impact. Additionally, polyester fabric banners can be easily customized to suit your specific design requirements, whether you're promoting a brand, product, or event.

Another advantage of polyester fabric banners is their versatility. They can be used for a variety of applications, including pull-up banners and **roll-up banners**, thanks to their ability to retract into a compact size for easy storage and transportation. This makes them

ideal for trade shows, presentations, conferences, and other events where portability is essential.

In summary, polyester fabric banners offer a lightweight, durable, and customizable solution for indoor and outdoor advertising. Their excellent color reproduction and versatility make them a popular choice for businesses looking to create eye-catching displays that effectively communicate their message to their target audience.
Mesh Banners: Mesh banners are specially designed for outdoor use in windy conditions. Made from perforated vinyl material, they feature tiny holes that allow air to pass through easily, reducing the risk of damage from strong winds. This unique construction makes mesh banners an ideal choice for outdoor events, construction sites, and other windy environments where traditional banners may flap or tear.
Despite their porous nature, mesh banners still offer excellent print quality and visibility. High-resolution graphics and vibrant colors can be printed onto the vinyl material, ensuring that your message remains clear and eye-catching even from a distance. This makes mesh banners an effective advertising solution for promoting events, products, and services outdoors.
Canvas Banners: Canvas banners offer a classic and sophisticated look that is perfect for indoor displays, art exhibitions, and upscale events. Made from durable canvas material, these banners provide a textured surface that adds depth and richness to printed graphics, creating a visually appealing display that captures attention.
One of the key advantages of canvas banners is their versatility. They can be easily customized with your choice of graphics, text, and images to suit your specific design requirements. Whether you're promoting a brand, showcasing artwork, or advertising an event, canvas banners provide a timeless and elegant backdrop that enhances your message.
Additionally, canvas banners can be used for banner for table displays, providing a stylish and professional way to showcase products or literature at trade shows, conferences, and other events. Their durable construction ensures that they can be used repeatedly, making them a cost-effective advertising solution for businesses and organizations.
In summary, canvas banners offer a classic and versatile advertising solution that is perfect for indoor displays and upscale events. Their textured surface and customizable design options make them an attractive choice for businesses looking to create eye-catching displays that leave a lasting impression on their audience.
Satin Fabric Banners: Satin fabric banners are renowned for their luxurious sheen and smooth texture, making them a top choice for upscale events, red-carpet premieres, and corporate functions. Crafted from high-quality satin material, these banners exude elegance and sophistication, elevating the presentation of any message or branding.
One of the standout features of satin fabric banners is their ability to showcase vibrant colors and intricate details with exceptional clarity. The smooth surface of the fabric allows for precise printing, ensuring that logos, images, and text appear sharp and eye-catching. This makes satin fabric banners a preferred option when aiming for a polished and professional appearance.
Moreover, satin fabric banners are highly versatile and can be tailored to various applications. Whether used as backdrop displays, hanging banners, or double-sided

banner stands, they effortlessly capture attention and convey a sense of sophistication. Their versatility extends to trade shows, exhibitions, corporate events, and retail environments, where they serve as captivating marketing tools.

Reflective Fabric Banners: Reflective fabric banners are engineered to command attention, particularly in low-light conditions or high-traffic areas. These banners use specialized materials with reflective properties to ensure maximum visibility and safety, making them indispensable for outdoor advertising, road signs, and event promotions.

The critical advantage of reflective fabric banners lies in their ability to shine brightly when illuminated by headlights or other sources of light. This enhanced visibility enhances safety and ensures that messages remain prominent during nighttime or adverse weather conditions. As such, reflective fabric banners are favored for outdoor applications where visibility is paramount.

Additionally, reflective fabric banners boast durability and weather resistance, ensuring long-lasting performance in various environments. Whether installed along highways, at construction sites, or as part of event signage, these banners maintain their effectiveness and visibility, thereby maximizing exposure and brand recognition.

Backlit Fabric Banners:

Backlit fabric banners offer a visually stunning way to showcase promotional messages, products, or services in indoor environments. Constructed from translucent materials, these banners are designed to be illuminated from behind, creating a captivating visual display that draws attention and enhances brand visibility.

The translucent nature of backlit fabric banners allows light to pass through, illuminating graphics and colors with exceptional brilliance. This results in vivid and vibrant displays that stand out in crowded spaces such as trade shows, retail stores, and exhibitions. As a result, these banners are highly effective at attracting attention and driving foot traffic to specific promotions or products.

Dye-Sublimated Fabric Banners:

Dye-sublimated fabric banners are crafted using a specialized printing process that results in vibrant, long-lasting colors and sharp, detailed graphics. This printing method involves transferring dye onto the fabric using heat, which penetrates the fibers and bonds with them on a molecular level. The result is stunning imagery resistant to fading, ensuring that your message remains vivid and impactful over time.

Eco-Friendly High-Visibility Fabrics:

Eco-friendly high-visibility fabrics are designed with sustainability, utilizing materials that minimize environmental impact while maximizing visibility and durability. These fabrics are often made from recycled materials or sustainably sourced fibers, reducing the carbon footprint associated with their production and disposal.

Textiles for Flags:

Textiles for Flags and its Applications:

Most cloth flags are made of **nylon, polyester,** or **cotton**. (Historically, other flag materials included silk, wool, and linen.) Each of these fabrics has its own characteristics, varying in **thickness, weave, and weight**. And every material was designed for a specific use.

An **indoor flag** will be displayed and viewed up close. In this case you may want a classic, soft, rich, vibrant fabric.On the other hand, maybe your flag will fly behind a boat exposed

to **extreme conditions**: high wind and salt water.
Outdoor flags serve in harm's way. There are many factors at work on an outdoor flag that you may not have considered.

Conditions That May Effect an Outdoor Flag

high wind	low wind	temperature	rain	heat	cold
snow	ice	sun (UV rays)	salt water	chemicals	pollution
insects	birds	Mold	mildew	neglect	humidity

Before we get ahead of ourselves...
Two Types of Flag
Printed Flags are usually one piece of material printed on one or both sides. They tend to be made of thin, lightweight fabric and are most often the **cheapest option**.
Printed flags are thin, flat and one dimensional. The type of ink and method of printing will factor into the vibrance and longevity of printed flags.

Fully Sewn Flags, on the other hand, are made of many pieces of fabric assembled and stitched together. (That's why construction, i.e. lock stitching vs. chain stitching is so important).

Added labor and time makes sewn flags **more expensive**. And since a quality flag is a bigger investment it is helpful to understand how different fabrics perform.
For sake of example, let's consider a **fully sewn and embroidered American flag**.

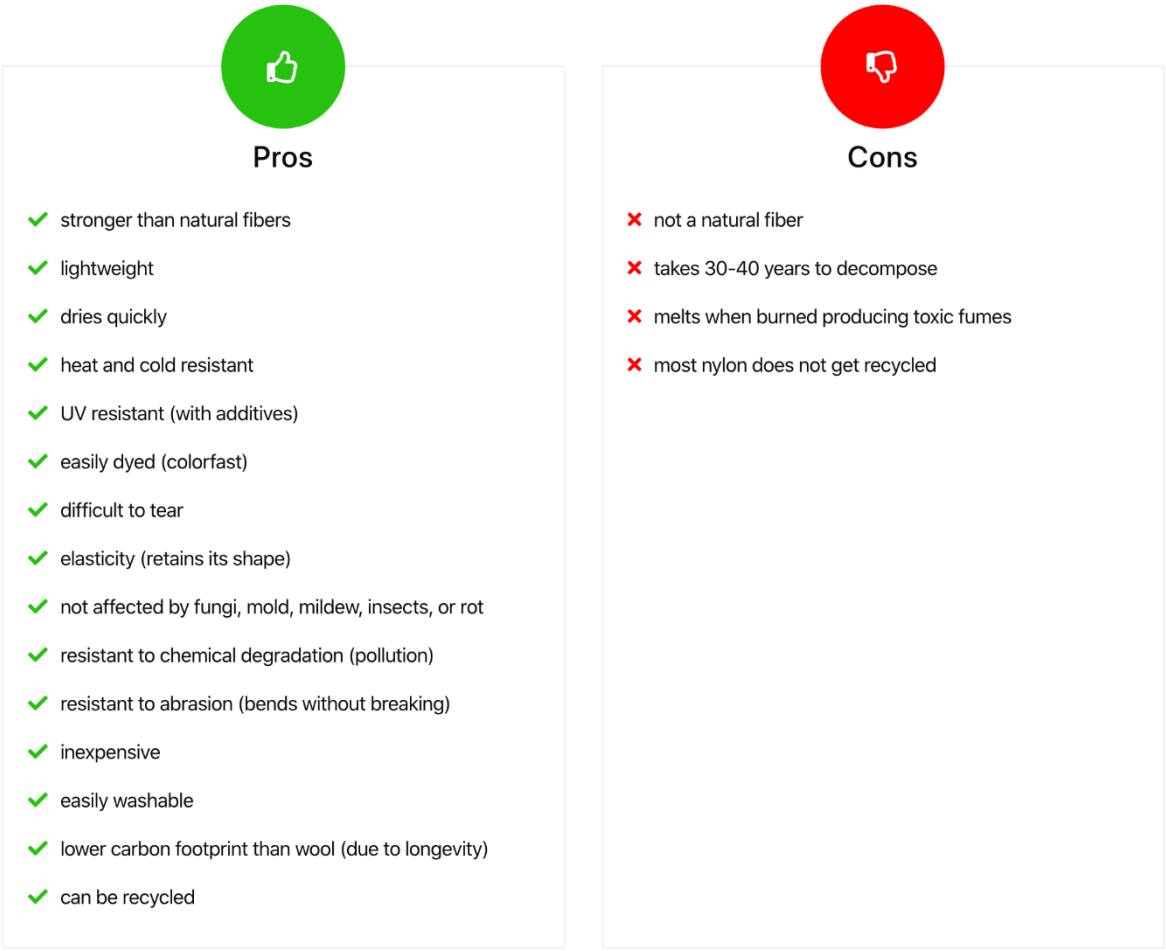
So let's explore each fabric choice and what they have to offer.

Nylon

Nylon (6,6) is a **synthetic polymer** that can be melt-processed into **fiber.** It was the first introduced by DuPont in the 1930s to great success. The first commercial use was for bristles on a toothbrush. Later, nylon became a revolutionary solution for women's stockings. Hence the term **nylons.** They were so popular it eventually led to the **nylon riots.**Anyway, because it is strong and lightweight, during World War II, it was discovered that nylon was well-suited for use in **parachutes** and **para-cord**. This opened up many new applications for the synthetic fiber. Today, nylon is used in clothes, tents, seat belts, tarps, rope, nets, flags, etc.

Why Nylon is the Most Popular Flag Material

Nylon can be manufactured in many forms. When woven and blended with other fabrics it has many properties that make it hard to beat when it comes to flag material.
Properties and Characteristics of Nylon



As we mentioned before the most important factor in choosing the **best flag material** is to match the fabric to the intended use. All of the above characteristics make **nylon an ideal fabric for outdoor flags.**

Benefits of a Nylon Flag

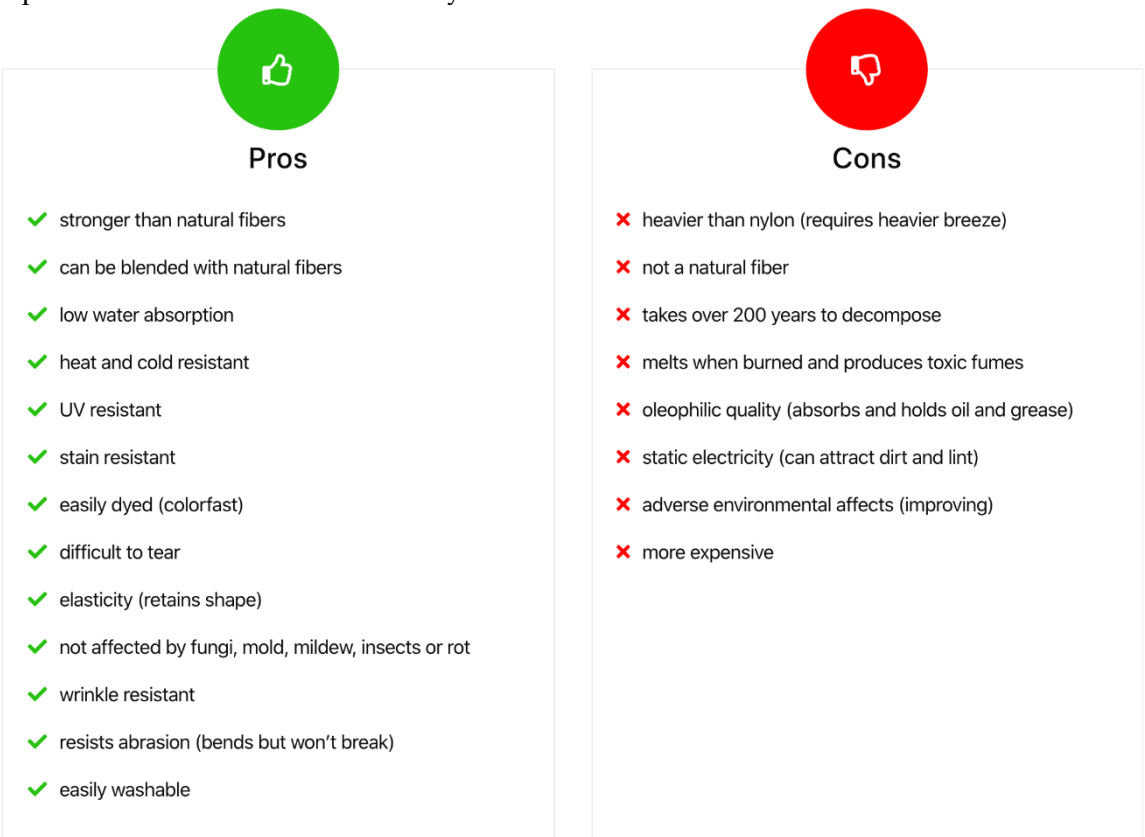
Attribute	**Benefit**
Lightweight	flies in a slight breeze
strength and elasticity	holds up to high winds
fast drying/low water absorption	no mold
heat and cold resistant	all weather/any climate
easily dyed	vibrant color that won't fade
tough and difficult to tear	durability
Inexpensive	value for the money

easy to wash	adds longevity
UV resistant	won't fade in the sun
acceptable outdoor flag	meets U.S. Flag Code

Polyester

Polyester is a synthetic (petroleum based) material. Made from various polymers, it is a material type called polyethylene terephthalate (PET). Discovered while continuing the project that led to nylon, polyester was patented in 1941.Polyesters include naturally occurring chemicals (derived from plants) as well as synthetic chemicals. While natural polys are biodegradable, most synthetic polyesters are **not biodegradable**. It takes more than 200 years to decompose.Basically, polyester is **plastic**.Like nylon, polyester is melt-spun. This process allows the fibers to be made in different shapes and sizes for specific applications.

Properties and Characteristics of Polyester



Polyester In Flags

Polyester has many qualities that are great for flags. It can also be blended with natural fibers to get the benefits of both.One common application is 2-ply poly in an open weave. An open weave allows air to pass through, which reduces friction and lowers fabric stress. Increasing durability and longevity for a flag.

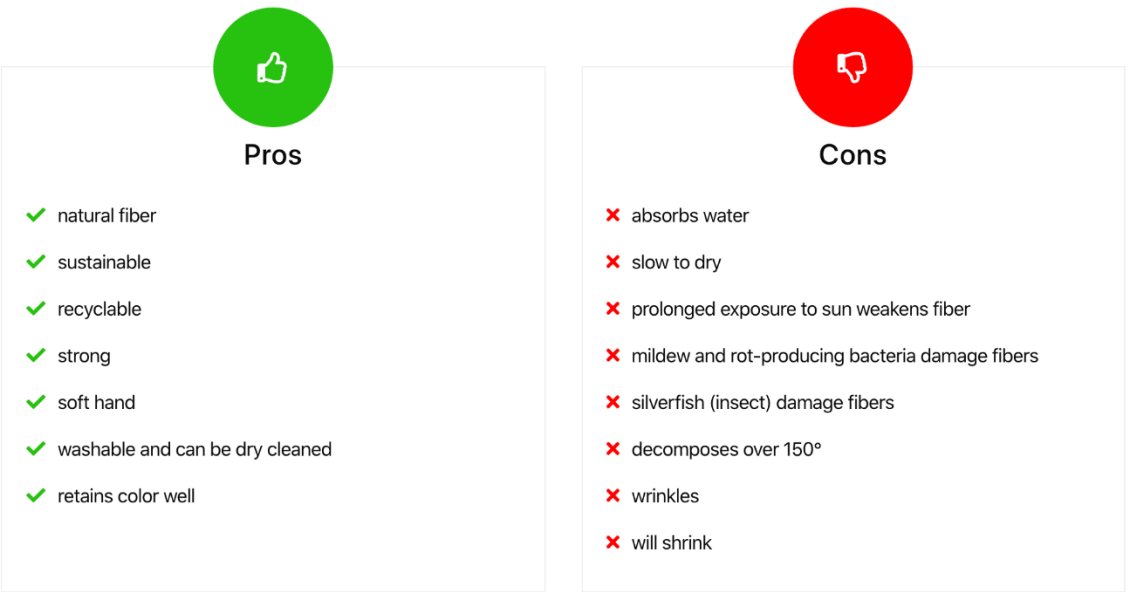
For this reason, Poly is a good choice for large flags, commercial use and ideal for high wind situations.Poly flags are the most durable outdoor flag in most conditions. But durability comes at a cost. Poly flags are also the most expensive.

Cotton

The third option is cotton. Cotton **grows naturally** in the form of bolls on cotton plants. The fiber is spun into yarn or thread and used to make **soft, breathable textiles**. Cotton has been used to make fabric for 1000s of years.

Before synthetic fibers, most flags were made of cotton.

Properties and Characteristics of Cotton



The Majesty of Cotton Flags

Nylon and poly offer advantages for outdoor flags. That is undeniable. Both are more durable, last longer, and easier to maintain than cotton.

That aside, a cotton flag has a certain **elegance** that is undeniable. It is a sentimental favorite among purists.

Both nylon and poly can be made in different **sheen or luster**. **Cotton** maintains a low luster which has a **natural softness.** It also possesses the most natural draping quality which makes it most suitable for indoor display.

Textiles for Canvas Covers and its Applications:

Canvas is primarily made from cotton or linen, though it can also include synthetic fibers like polyester. The traditional canvas is a plain-woven fabric, often made from cotton or linen blend fabric, known for its durability and sturdiness.

Fiber Source	Natural, primarily cotton or linen, sometimes blended with synthetic fibers
Weaving Patterns	Plain, tight weave

Dominant Colors	Natural, earthy tones, can be dyed in various colors
Texture Spectrum	Sturdy, heavier than most fabrics, can be rough or smooth depending on finish
Breathability Index	Medium to high, depending on the tightness of the weave
Strength & Longevity	Highly durable, resistant to wear and tear
Maintenance Needs	Generally machine washable, can shrink, more robust handling required
Primary Applications	Tents, sails, backpacks, shoes, martial arts uniforms, painting canvases
Ecological Impact	More environmentally friendly than synthetic fabrics, biodegradable
Major Exporters	Widespread production, with India and China being significant producers
Comparable Fabrics	Denim, Duck Cloth

1. Types of Canvas Fabric

- **Cotton Canvas**: Utilized in a variety of applications, including canvas bags and artistic canvases.
- **Duck Canvas**: A tightly woven, more durable version of canvas, often used for more robust applications.
- **Acrylic Canvas**: Typically used for outdoor applications due to its weather resistance.
- **Hemp Canvas**: Known for its strength and sustainability.
- **Polyester Canvas**: Offers increased durability and resistance to elements.

Linen Canvas

Linen canvas, made from flax fibers, is another popular variant. It's known for its unique texture and is commonly used in the art world for high-quality canvases. Linen cotton canvas fabric is a blend that combines the durability of cotton with the texture of linen.

2. Uses of Canvas Fabric

Canvas fabric's versatility makes it suitable for a broad range of applications:

- **Artistic Use**: Traditional canvas for painting, particularly popular in linen blend fabric for professional artists.
- **Fashion and Accessories**: Canvas bags, shoes, and other durable fashion items.

- **Home Decor and Upholstery**: Canvas is often used for furniture coverings due to its durability and ease of cleaning.
- **Outdoor Gear**: Tents, sails, and other equipment benefit from canvas's sturdiness and weather resistance.
- **Industrial Applications**: Heavy-duty canvas is used for tarps, covers, and other industrial-grade items.

3. Benefits and Characteristics

Advantages of Canvas Fabric

- **Durability**: Canvas is known for its strength and long-lasting nature.
- **Breathability**: Particularly in cotton and linen blends, canvas allows air to pass through, making it comfortable for wear.
- **Eco-Friendliness**: Natural canvas fabrics are environmentally friendly and often sustainable.
- **Easy Maintenance**: Canvas is generally easy to clean and maintain.

Physical Properties

- **Weight**: Canvas fabric varies in weight, with options like 9 oz canvas offering a lighter alternative to heavier types.
- **Texture**: Canvas has a distinct, rugged texture that can vary depending on the weave and type of fiber used.
- **Appearance**: Canvas can be dyed in various colors and can also be found in a natural, undyed state.

4. Practical Considerations

Canvas is relatively easy to maintain. Most types are washable, though care should be taken with certain finishes like waxed canvas.

Natural canvas fabrics, like cotton and linen, are biodegradable and generally considered environmentally friendly. Recyclable options also add to the fabric's sustainability.

The price of canvas fabric can vary based on the type of fiber used and the fabric's weight and weave. Generally, it is considered a cost-effective material.

Textiles for Tarpaulins and its Applications:

Industrialists often face the challenge of protecting their businesses from extreme weather conditions. Industrial machinery, raw materials, pallets, and finished goods can be heavily damaged by rain, sunlight, storms, and other environmental factors. This is where industrial tarpaulins come into the picture.

Tarpaulins are large solid sheets of flexible, waterproof material that have multiple applications. They are used during construction to prevent the raw materials from getting spoiled, during painting and other similar operations, to protect open loads of trucks and trailers, to store large quantities of dry wood, and to erect temporary structures. It's also used in printing and advertising.

Given the criticality of the applications, getting the right kind of **tarpaulin** is essential. You need to focus on the tarpaulin sizes and price, its grade and the type before buying it for a particular task. Can't decide which is the best-suited tarpaulin for your business? Don't

worry! We've got you covered!

Types of tarpaulins:

Tarpaulins are distinguished based on their sizes. Depending on the requirement, you need to figure out the right size of your tarp. You can refer to various tarpaulin size charts that are available. Further, tarpaulins are graded according to their GSM (grams per square metre) and their type. The GSM redefines the abilities and applications that these tarpaulins can be used for. So, understanding the GSM and the type of tarpaulin is your first step in the buying process. And to make your job easier, here's a list of different types of tarpaulins that you might need.

Poly:

These tarpaulins are most commonly used, lightweight, moisture resistant, and affordable. They are made up of cross-woven strips of polyethene, polypropylene, or other polyolefin plastic and are sealed with a waterproof coating. Given their greater strength and durability, these tarpaulins have various applications ranging from light to heavy-duty tasks. Poly tarpaulins are a common sight on construction sites, in spaces being decorated or redesigned, on farms and even at home.

Canvas:

Canvas tarpaulins are made up of closely-woven hemp, flax, or cotton single duck fabric that's used in sheets and coverings. These tarpaulins have a number of transportation and industrial applications. They are sturdier and provide better wind resistance as compared to poly tarpaulins. Along with strength, these tarpaulins have an aesthetic value to them.

Vinyl:

If your industry involves risks of corrosion or contamination by oil, acid, grease and mildew, vinyl tarpaulins can be your best ally. These tarps are made from heavy industrial-grade material and are often coated with flame-retardant polyvinyl chloride (PVC). They are generally used in situations where more reliable protection is required. That's because they have very special applications and tend to be waterproof and highly resistant to heavy abrasion, abuse, corrosion and contamination.

Mesh tarpaulins:

Mesh tarps are one of the most versatile tarps that can be found. They are extremely durable and strong. These tarps have a wide range of applications in areas that require cooling shade, privacy, freight covers, equipment protection, and drainage. They allow the partial passage of wind and light and are widely used for enclosures, site barriers, constructions, job sites, manufacturing plants, truck beds, and tennis courts, among others.

Properties of tarpaulins:

Now that you are familiar with different types of tarpaulins, let's move on to understanding their properties. Depending on your requirements, you can prioritise these properties.

Water-resistant

Exposure to water and moisture can be extremely damaging for certain industries. If yours is one of them, make sure to buy a tarpaulin that's water-resistant. On the face of it, every tarpaulin is waterproof but different tarps provide varying levels of resistance to water and moisture. These can range from lesser resistance to complete water resistance.

Fire-resistant

Certain industrial materials are extremely sensitive to fire or heat. Exposure to heat might lead to damage and degradation. If you can relate to this, you need to include a fire-

resistant **tarp** on your shopping list.

Corrosion-resistant

Are you worried about your industrial materials getting affected by UV light and other factors such as oils, acids, greases, and mildew? If yes, you definitely need to go for corrosion-resistant tarpaulins.

Strength

Considering the strength of the tarpaulin is extremely important when you use it for protection against heavy objects or other extreme situations. A tarp's strength is determined by the materials used and its weaving design. This further determines its capacity to withstand tearing and breakage caused by heavy rains, winds, and other foreign elements.

Textiles for Ropes and its Applications:

Ropemaking/Manufacturing Methods:

The two basic ropemaking techniques remain twisting and braiding, with a number of variations on these methods. Below we have highlighted some of the ways ropes are manufactured for different uses.

Cordage

Twine, clothesline, sash cord, and marline, a tar-covered hemp line, are all examples of cordage with a diameter less than 0.1875 inches (0.5 cm). These aren't considered genuine rope. Cordage with a diameter of 0.1875 to 0.5 inches (0.5-1.3 cm) is a light-duty rope, also known as "small stuff." True rope is defined as cordage with a diameter of 0.5 to 1.5 inches (1.3-3.8 cm). Cordage with a diameter more than 1.5 inches (3.8 cm) is referred to as a hawser and is used to anchor huge ships.

Twisted Rope

Twisted rope, also known as "laid" rope, is made by twisting fibers together. Fibers are twisted ("spun") into yarns, which are twisted in the opposite direction to form strands, which are twisted in the opposite direction from the twist of the strands to create rope. Twisting yarns and strands in opposing directions helps hold the rope together.

Single Braided Rope

This type of rope is also commonly known as a "solid" braid and is a great option if you need a very durable rope that can withstand the pressure and heavy weight of being used with blocks and pulleys. These ropes do not have any core and are created by braiding instead of twisting the strands together to create the final rope.

Plaited Rope

A plaited braid is made up of four different sets of strands that are weaved and twisted to wrap around the center of the rope. This sort of rope is sometimes referred to as a "square braid" and is much coarser to the touch. It is not nearly as circular as twisted rope, and as a result, it is far less likely to kink and is extremely flexible, making it very easy to knot and handle without difficulty.

Double Braided Rope

A double braid can assist you if you want a rope that will be highly strong and durable. This rope has a braided core with braided rope wrapped around it. Because of the braided core and stability, the rope will keep its shape well.

Hollow Rope

Because this rope has an empty middle, it can be spliced fast and easily. As a result, it is an excellent choice for anchor lines or ski tows. It is a lighter rope that is easier to deal with, especially if you choose a synthetic one that is also water-resistant.

Diamond Braided Rope

This type of rope is created by meticulously and firmly braiding rope around an inner fiber core, resulting in a rope that is extremely strong and durable. One advantage of this form of rope is that it can be quickly spliced, making it much easier to deal with than other types of rope.

Kernmantle Rope

A cover (mantle) is braided over a core (kern) to create these ropes. The core can be made up of fiber filaments that run parallel inside the rope, or twisted or braided into bundles. Kernmantle rope is a hybrid with a twisted core and a tightly braided outer sheath for increased abrasion resistance. A nice example of kernmantle rope is paracord.

Materials Used in Rope Manufacturing:

Though synthetic materials are favored today for their superior strength and durability, natural fiber rope still has its uses. Below we highlight some common materials.

Natural Fibers

The natural fibers most often used to make rope include:

- **Manila**—the classic rope fiber from the leaves of the abaca plant (often erroneously referred to as hemp). Manila rope is strong but tends to shrink when wet.
- **Hemp**—fiber from actual hemp plants. Hemp rope is similar to manila rope but with a smoother feel.
- **Cotton**—from cotton plants, which grow in most regions of the world. Cotton rope lacks strength and durability but is soft and smooth to the touch. It doesn't have much utility except as a clothesline.
- **Sisal**—from the Mexican Agave Sisalana plant. This coarse, strong, and durable fiber is most commonly used to make twine.
- **Jute**—comes primarily from plants native to India and Bangladesh. Jute rope has few uses because, while strong when dry, it weakens when wet and rots easily.

Synthetic Fibers

Synthetic fibers are now predominant in ropemaking. These include:

- **Nylon**—the earliest synthetic rope material and still the most common. It's strong, durable, and has some stretch. Nylon rope tends to weaken a bit when wet.
- **Polypropylene**—the weakest, lightest, and least expensive synthetic fiber used in ropemaking. Floats in water but does not absorb water easily or shrink when wet.
- **Polyethylene**—buoyant and water-friendly, like polypropylene but more resistant to abrasion.
- **Polyester**—similar in strength to nylon when dry and stronger when wet. Like nylon rope, polyester rope has some stretch.
- **High-tech fibers**—stronger than nylon and highly water-resistant but with little stretch. High-tech materials such as Kevlar and high-modulus polyethylene are quite expensive compared to other synthetic ropes

Textiles for Net and its Applications:

Industrial Nets: Applications and Advantages

Industrial nets are essential materials used in various sectors, often requiring high durability and safety. In this blog post, we will explore what industrial nets are, their applications, selection criteria, maintenance, and production. Additionally, we will examine the role of the Netrags brand in industrial net production and why it should be preferred.

What are Industrial Nets?

Industrial nets are types of nets made from various materials that are durable and typically used in large-scale applications. These nets are generally made from high-strength threads or fibers and come in various shapes, sizes, and patterns. Industrial nets serve many different purposes such as transport, protection, security, and organization. Synthetic fibers like polyester, nylon, or polypropylene are commonly used because these materials provide high durability and long life.

Applications of Industrial Nets

The applications of **industrial nets** are quite broad and play significant roles in various industries:

1. Construction Industry: In construction sites, **safety nets** are used to ensure worker safety. These nets prevent workers from falling from heights and protect the surrounding area.

2. Agriculture: In the agricultural sector, various types of nets are used to protect crops and keep pests away. They also help in the efficient distribution of water in irrigation systems.

3. Storage and Transport: Nets are used for the orderly transport and storage of goods. They enhance safety, especially in transporting agricultural products, construction materials, and other large loads.

4. Sports and Recreation: In sports, especially in football and basketball courts, nets are used. Additionally, safety nets are available for various games and activities.

5. Maritime: In the maritime industry, nets are used to secure cargo and prevent maritime accidents. They are also used in fishing as fishing nets.

Selection Criteria for Industrial Nets

When selecting industrial nets, several important criteria should be considered:

1. Material: The durability of nets depends on the material used. Materials like polyester, nylon, and polypropylene offer high strength and long life.

2. Mesh Size: The mesh size of the nets should be chosen based on the intended use. Small meshes hold small pieces, while larger meshes hold larger objects.

3. Net Thickness and Strength: The thickness of the nets determines the load they can carry and their durability. High-strength nets perform better under heavy loads and challenging conditions.

4. Weather Conditions and Environmental Factors: Choose nets that are resistant to UV rays, moisture, and chemicals based on the environmental conditions where they will be used.

Home and Office Furnishings:

Home textile: Home textile or household textile is a segment of **technical textiles** comprises of the textile components used in the domestic environment – upholstery, interior decoration and furniture, carpeting, protection against the sun, cushion materials, fireproofing, floor and wall coverings, textile reinforced structures / fittings, filter products for vacuum cleaners as shown in Figure 1.

They are made of both natural and synthetic fibers. The most modern and most refined development is the addition of temperature phase change materials into such insulation products to provide an additional degree of control and resistance to sudden extremes of temperature, hot or cold

Home textile can be defined as the textiles used for home furnishing. It consists of a various range of functional as well as decorative products mainly used in decorating our houses. The fabric used for home textile consists of both natural and man made fibers. Sometimes we also blend these fibers to make the fabrics stronger. Generally, home textiles are produced by weaving, knitting, crocheting, non-woven, knotting, or pressing fibers together. Home textile is a rather important part of technical textiles which includes but not limited to carpets, rugs, floor coverings, curtains, cushion covers, napkins, towels and toweling fabric, bedspreads, furnishing fabric and upholstery, table linen, bed linen, sheets and pillowcases, blankets, shower curtains, aprons as well as wallpapers.

Home textile includes the following finished articles:

- Bed linens such as sheets and pillowcases
- Other bedding products such as bedspreads, blankets, comforters and pillows
- Toilet and kitchen linens such as towels, wash cloths, aprons, etc.
- Table linens, including tablecloths, cloth napkins, and place mats
- Curtains and draperies
- Hand-woven and needle-worked tapestries and other wall hangings.

In furnishing exposed for sale, whether in piece goods or as window draping or other hangings, three factors attract the eye simultaneously.

- Color
- Design
- Texture

Types, Classification and Uses of Home Textiles:

Bed linens: The textiles used for bedding are classified as bed linens. The following are included in bed linens.

1. Bed sheets: They are more than a utilitarian item for bring style and color to the bedroom, reflecting the personality and moods.

2. Bed skirts: It is also known as a dust ruffle, petticoats and dusters, is designed to hide

the box spring. In addition to being functional, bed skirts also offer a way to introduce an additional color, pattern, and style to the bedroom.

3. Bed spreads: Bed spread is a decorative cover for a bed and is similar to a large blanket, which is placed over the bed. Colors, shapes, fabrics, and sizes play an important role while selecting the perfect bed spreads.

4. Pillow: It is a large cushion used as a support for head while sleeping.

5. Pillow cover: It is used to cover the pillow and avoids stains and dust accumulation. One of the quickest ways to change the feel of a room is to change the pillow cover to create a fresh new color scheme.

6. Throw: They are beautiful home furnishing accessory, are crafted out of exquisite fabrics and will be treasured for years to come. Utilized for both ornamental and functional purposes.

7. Duvet: It is a flat bag which was traditionally filled with down or feather and is used on the bed as blanket. It was originated in Europe.

8. Comforters: It is a type of blanket that is intended to keep the user warm, especially during sleep, although they can also be used as mattress pads. Comforters are generally large and rectangular in shape.

Kitchen linens:

1. Aprons: It is an outer protective garment that covers primarily the front of the body. It may be worn for hygienic reasons as well as in order to protect clothes from wear and tear.

2. Pot holder: It is used to hold hot or cold kitchen vessels like pans, pots, etc. It is generally made up of polyester or P/C blend.

3. Mittens: They are gloves used in kitchen to handle the hot vessels. Gloves have separates heaths or openings for each finger and the thumb.

4. Dish clothes: Dish clothes are widely used to wipe, clean and dry dishes. They are made of wide variety of absorbent fabrics.

Table linens:

1. Runner: A plain table can be transformed into a striking focal point by covering it with fabulous table runners. These are laid across the table rather than lengthwise and their purpose becomes two-fold. They add detail to the table and also serve as place mats.

2. Table skirting: Table skirting refers to the cloth that forms the border or runs along the edge of the table. These make a great difference in the presentation for the banquet, buffet, brunch or business meeting.

3. Table mats: Table mat adds beauty, convenience and effectiveness, wherever they are placed and are definitely one of the most important pieces of table accessories in any home.

4. Tea cozy: A tea cozy is designed to snuggle around the teapot while the tea is steeping. This keeps the tea piping hot and allows the tea to attain its best flavor.

Bathroom linens:

1. Bath towels: Bath towels are used for bathing and the most required bathroom accessory. A bath towel is a piece of absorbent fabric whose chief use is for drying the body, by drawing moisture, usually water into the fabric, through direct contact, with either a blotting or rubbing motion.

2. Bath mats: A bath mat is a device used on the floor of a bathroom to provide a warm non-slip surface and to absorb small amounts of water, much like a towel. Bath mats are similar but smaller than bath rugs and are meant to be kept in front of a tub, shower or vanity to serve as an insulator or slip resistant surface.

3. Bath rugs: Bathroom rugs are an inexpensive and excellent way to give new life to any bathroom and allow creative freedom without going to the extent of putting a fresh coat of paint on the walls.

4. Face towels: Face towels are the smaller version of bath towel that are used to wipe the face after washing it and are also used as handkerchief. The type of face towels available in stores are terry and velour. Cotton terry face towels are woven on a loom and the loops are normally referred to as "pile" or "loop surfaces."

Floors and floor coverings: It binds all the elements of a room together. It holds furniture items, imparts insulation against the earth's coolness and darkness. It gets the greatest wear and the most dust in a room.

A soft floor covering makes a room comfortable and gives it a finished appearance. In winter, it is usually good to have a carpet or a large nig in all the rooms in the house except the kitchen and the bathroom. However, in the summertime, or at any other time in tropics, bare floors appear clean rid cool but the soft floor covering gives an aesthetic appeal.

Textiles in sportswear:

Introduction: Sportswear refers to clothing that has been designed especially for sports purposes. It is also called sports textile or sporttech. The textiles that are used in sports in any form are called as sporttech. Sportswear or active wear is clothing including footwear, worn for sports and physical exercise. Nowadays sophisticated technologies are used in **technical textiles** to produce sportswear. The light weight and safety features of sport tech have become important in their substitution for other materials.

The applications are diverse and range from artificial turf (e. g. in hockey) used in sports surfaces through to advanced carbon fiber composites for racquet frames, fishing rods, golf clubs and cycle frames. Other uses are balloon fabrics, parachute and paraglider fabrics and sailcloth. The demand for sportech is increasing day by day due to the increase of leisure time, people showing interest in health-related activities, increased women participation in sports, increased accessibility and availability of sports such as skiing, golf and sailing and the growth of sports facilities.

Recently the fabrics equipped with sensors have been developed which give complete physiological monitoring of the body during the exercise. The fabrics have also been developed with **phase change materials** which give cooling effect during sports in summer. The New Zealand cricket team wears black kit during sports which provides discomfort as the black color absorbs light and becomes heated. To avoid the heating and to achieve cooling effect, the phase change materials have been incorporated in the fabric for making the sporting kits.

Objectives:

- To know about the raw materials use to produce sportswear.
- To know about the functions of sportswear.
- To know about the properties of the sportswear.
- To know about different types of sportswear.
- To know about other characteristics of sportswear.

Function of Sportswear:

1. Anti-Static performance

2. Heat transport function
3. Ultraviolet performance
4. Moisture transport performance
5. Anti-Microbial performance

Properties of Sportswear:

- Resilience
- Absorptiveness
- Air permeability
- Lightweight
- Stress and strain
- Easy care
- Strength
- Durability
- Tailorability
- Formability

Characteristics for Sportswear on Clothing Comfort:
Expected characteristics for sportswear on **clothing comfort** are:

1. Efficiently moving away sweat from the skin,
2. Quick drying,
3. Breathability,
4. Balancing body heat by moving away moisture and ventilating body's critical heat areas,
5. Not charging electrostatically,
6. Having high strength and abrasion resistance,
7. Not limiting body movements,
8. Being soft and durable,
9. Stitches not causing discomfort,
10. Having a good handle,
11. Having an aesthetic appearance,
12. Improving mental motivation,
13. Providing easy care,
14. Occupying a small place and being light, for both wearing while working out and carrying around.

Factors for Designing Sportswear:

1. Comfort
2. Protection / Safety
3. Decoration / Fashion ability
4. Costing
5. Availability of related materials
6. Medically fit and hygiene

7. No medical effect on human body

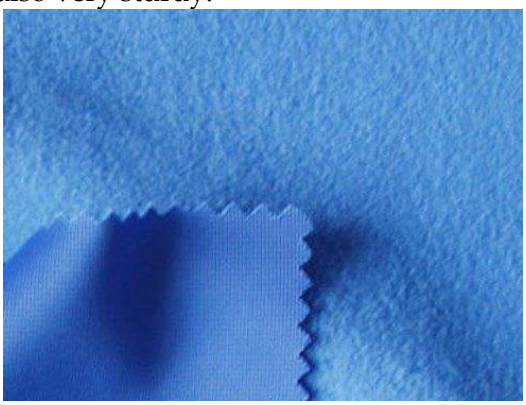
Raw Materials for Sports Textiles:

Fiber used in sportswear textiles: There are different kinds of fabrics, knitted, woven and non-woven are used in sportswear. But polyester is a common type of material used in sportswear. It is basically cloth made out of plastic fibbers making it light-weight, wrinkle-free, long lasting and breathable and comfortable.

- **Natural fiber:** Cotton, wool ,silk etc.
- **Synthetic fiber:** Polyester, polyamide, polypropylene, acrylic, Nylon, spandex etc.
- **Special synthetic fiber:** Micro fiber, **carbon fiber**, Dacron, lycra roica, Leofeel etc.
- **Modified synthetic fiber:** The fiber which is produced by gel spinning, bicomponent spinning, micro fiber spinning.
- **High performance fiber: Aramid fiber**, Novoloid fiber, PPS fiber, PCM fiber, Kevlar etc.

Fabrics used for sportswear:

Tricot Fabric: Tricot fabrics are produced on a **flatbed knitting machine**. They have an excellent wrinkle and run resistance as well as good drape-ability. Tricot fabric has a unique zigzag weave that is textured on one side and smooth on the other. So, this allows the fabric to be soft and also very sturdy.



Tricot fabric

Quilted Fabric: Actually, quilted fabrics are layered materials consisting of two cloths that encase a filling and are stitched together to form a puffy unit. Good quilted fabrics for outdoor use should be wind-resistant for greater protection. This fabric also use for producing sportswear.

Quilted fabric

Mesh Fabric: Mesh is beneficial in sportswear as it gives good comfort and stretch and also allows air to circulate and reach the skin meaning that it is ideal for ventilation areas of a garment, especially for places where heat accumulates very quickly such as on the back.

Mesh fabric

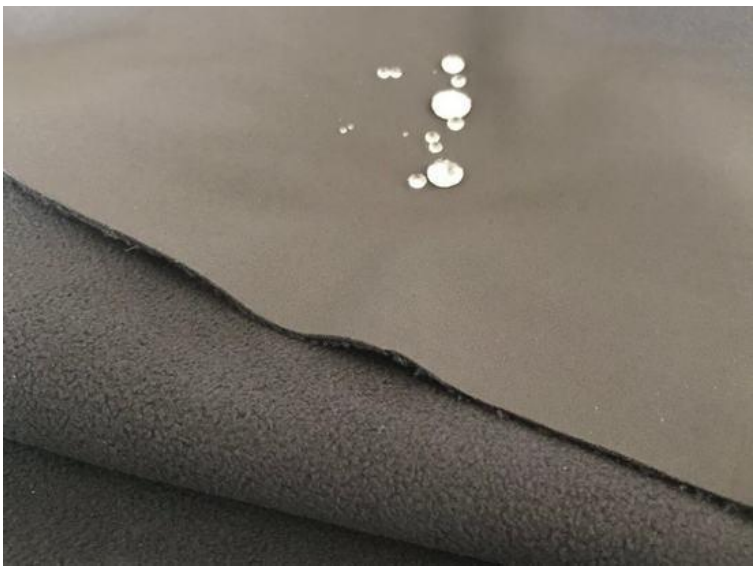
Fleece Fabric: Fleece fabrics are used in sportswear often for tracksuits, hoodies and zip tops. The fabric does not fray making it so easy to sew (Unless it is extremely thick) and the grain line runs parallel to the selvedge.

Fleece Fabric

Micro Fiber Fabric: Micro fiber fabrics are essentially fabrics made from extremely fine usually; **microfiber** fabrics are made from polyesters, polyamides or **polypropylenes**. They are made from **man made fibers** because they are so small that natural fibers cannot be small like them. Microfiber fabrics make useful luxury sport fabrics due to their brilliant properties including being lightweight, having a luxurious drape and are breathable whilst still being resistant to rain and wind.

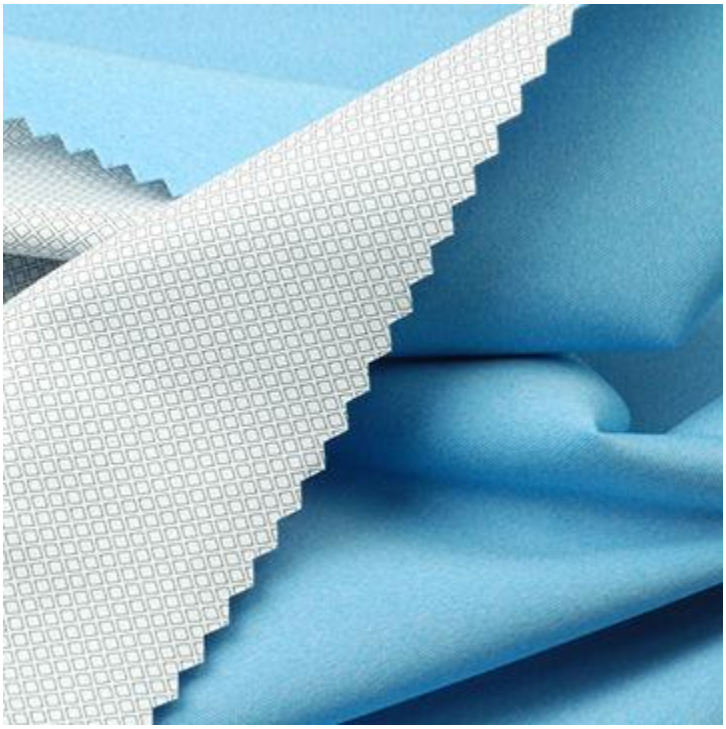
Micro fibre fabric

3-Layer Softshell Fabric: Softshell straightly means "soft shell" and indicates a category of technical fabrics designed to ensure maximum comfort in situations of variable weather. The quality of a softshell product, are **water repellency**, wind resistance and breathability. The 3- layer softshell has been created for use in outdoor winter sportswear, such as skiing and hiking.



3-layer softshell fabric

2.5- Layer Coated Fabric:2.5-layer fabrics have light (dot) coating protecting membrane. This fabric also use for different types of producing sportswear.



.5- layer coated fabric

Different Types of Sportswear: There are different types of sports all over the world. So, different types of sportswear use for different types of sports. Some common types of sportswear are given below:

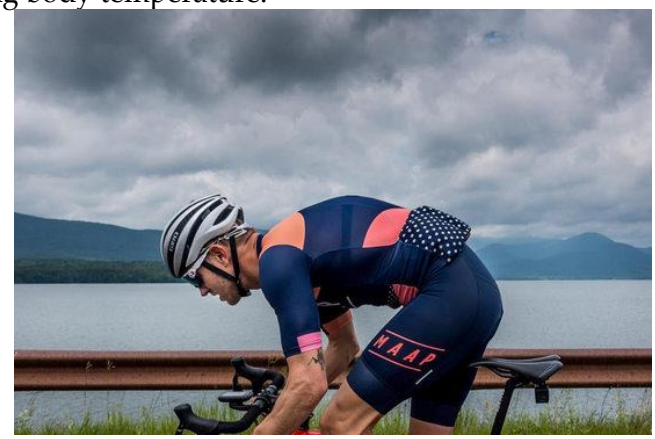
Auto Racing Wear Helmets are very necessary item for auto racing and it should be comfortable. It should have soft padded inside to save the head from impact by breaking and cushioning the fall. Helmets should also have aeration capabilities to avoid profuse sweating at the time of sport. The racing suits should be comfortable.

Auto Racing Wear

Football Wear: Football is the most popular game all over the world. Football wear should be flexible, air permeable, and comfortable. Players should be feeling easy and flexible.

Football wear

Cycling Wear: Cycling wear is another simple and it should not be baggy at all. It should be flexible either because movement is going to be very hard. **Apparel should be fitting** and should not clam to the skin at all. Cycler should feel fresh and uncomfortable because of the rising body temperature.



Cycling wear

Instead, the wear should be light and be able to reduce body heat by providing cooling. Helmets are mandatory for skull protection.

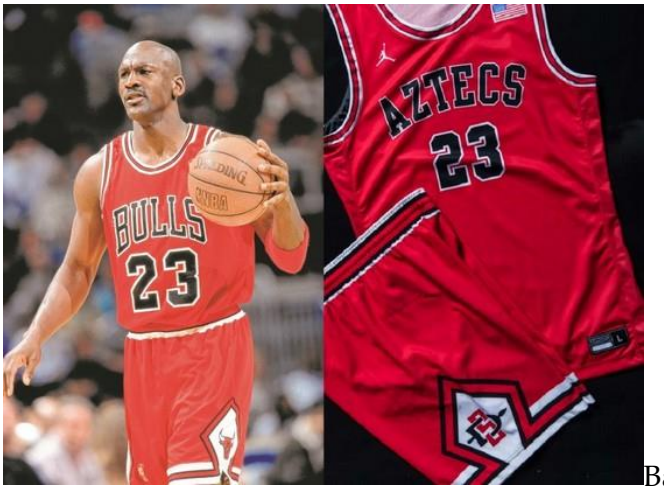
Tennis Wear: Actually, tennis is an intense sport and attention and alertness is very important for the players. That's why a tennis viser is part of the tennis wear. The viser protects the players' eyes from direct sunlight and the same time not blocking his or her view. For men, they get to wear shorts, a t-shirt and shoes. Women have a variety of tennis wear like a tank top and shorts.

Tennis Wear

Baseball Wear: Actually, Baseball wear consists of shoes or cleats, gloves and pro combat gear. The cleats have to be baseball issued so that the player can be able to move with speed. As much as the pro- combat is fitting, it has to be comfortable and not stick to the similarly. A fielding glove is also important and it should be long lasting because of the constant use.

Baseball Wear

Basketball Wear: Basketball players move around the court very much. That's why the surface of the court can be slippery thus the wrong type of shoes can cause fatalities. Standard basketball shoe wear should have proper grip and the standard shoes are court shoes. The foot should be firmly and comfortably support so that the game process can be easy. Fabric for the shorts and t-shirts should be breathable, comfortable and air permeable. It should not accommodate sweat but in turn let it out.



Basketball wear

Yoga Wear: Actually, Yoga is a flexible sport. Those who are enthusiasts choose wear that will not inhibit them from moving comfortably. It involves a lot of posture changing and that means stretching is part of the sport. That is why women decide to wear shorts and capris that stretch and are able to expand.

Yoga wear

Ice Hockey Wear: Ice hockey is an interesting sport. This is the reason why protective gear is very important. The gear should be able to shield the shoulder area, the players chin and neck. So other than a mouth guard, shoulder pads, mouth guards and helmets are very important because every part of the body is always impacted during the game.

Ice hockey wear

Martial Arts Wear: There is wide range of martial arts clothing available in the market suitable for karate, judo, kick boxing, kung Fu. So when buying the clothing it is good to know the specific martial arts sport. The protective gear like hand wraps, knee guards, and groin guards are important for martial arts.

Martial arts wear

Swimming Suit:A swimwear also known as bathing suit is a type of clothing worn by men or women in water- based activities like swimming, diving and surfing. Men wear shorts and Speedos but women have a variety of swimwear. Some women prefer bikinis it all depends on preference. Professional swimwear wears buoyant wetsuit.

Swimming suit

Modification of Fabric Used in Sportswear:

- By making multi layered fabric.
- By improving finishing technology.
- By using microfibers.
- By Laminating technology.
- By making conditions.
- By structurally fit.
- By setting fastness to wash, color and light.
- By resisting physio mechanical properties.

Sewing of Sportswear: Sewing is most popular for joining fabric of sportswear. Alternative method of joining can be used but performance result is not good.

Needle

Microtex sewing needle having size Nm 60 to 90.

Sewing thread: Nylon can be used. But polyester is best.

Sewing after care: After care is done by using seam sealer or seam sealing tape.

List of Top Manufacturing Brand of Sportswear:

1. Nike
2. Adidas
3. Salomon
4. Fila
5. Sky Sports
6. ESPN
7. Under Armour
8. Puma
9. ASICS
10. UFC

11. MLB
12. Reebok
13. Rapha
14. Wilson
15. Brooks sports.

Recent Development in Sports Wear:

Sports have been an integral part of human life since ancient times when the games were staged in Olympia, Greece from 776 BC through 393 AD. While it took another 1,500+ years for Olympics to return on global stage, various sporting games and events continued to demonstrate their popularity in various regions of the world during this period. In the modern age, sports have become more professional, and demand for sporting goods encompassing accessories, equipment, and apparel along with related technology has grown by leaps and bounds. The worldwide popularity of sports like football, cricket, tennis, basketball and other athletic games has only added to the growing demand of sporting goods. In more recent decades, the penchant for healthy lifestyle has added new dimensions to sports market. Throughout its journey, the sporting goods have seen many new innovations, product categories and consumer segments emerging. With passing time each one of them has evolved into a niche market in itself. This feature talks about the global trends in sportswear.

Global Sportswear Market

The global sportswear market is currently estimated at around $200 billion, which is projected to cross $350 billion by 2032. At present, North America leads with 45 per cent of global sportswear market revenues. However, during the next decade, Asia- Pacific region is expected to grow at the fastest CAGR. Emerging markets in Asia-Pacific, the Middle East and Latin America are expected to drive the growth of the sportswear market as they will see the strongest online growth in the broader apparel market, further enabling the growth in the sports apparel market. Brands like Nike and Adidas are likely to continue to lead in online offerings.

Market Dynamics

In many countries across the world, the governments have introduced initiatives to encourage participation in sports and increased investments to strengthen relationships between communities and sports organisations, benefitting the overall sportswear category in the process.

The demand for fashionable and comfortable sportswear is increasing due to an increasing number of people suffering from work-related health problems including stress and obesity, who are shifting to any type of sport or fitness activity to maintain a healthy lifestyle. The segment is undergoing exponential growth, showing its high profit potential and consumer appeal. Since 2010, the sportswear market has been growing through its sub-segments of activewear and athleisurewear as both can be worn during exercise and for general day-to-day wear providing comfort, and physical as well as psychological benefits. Their designing to serve both purpose is not that easy though. Despite the challenge of designing,

the category is in great demand especially in post-pandemic era. The world had slowed down during pandemic and when the markets revived speedily the brands started churning out new styles to keep up with the changing needs of the consumers, resulting in over-production and waste unfortunately. To address this growing problem, brands are shifting to creating more unisex designs adorning male as well female bodies. At the same time, some companies have introduced the rental programmes where customers can rent pieces instead of purchasing them outright – a trend which is expected to grow.

Category Evolution

Thanks to multi-requirement of consumers, the broad but solo sportswear category of past has greatly evolved into sub-segments. It gave birth to new categories – activewear and athleisurewear. Although both the terms along with sportswear are mostly used interchangeably, all three carry distinct specialities and utilities and yet has the flexibility to merge into each other's role seamlessly. The true sportswear is sports-centric and technically developed for a particular game. Traditionally, it is meant for a shorter period wearing, and is professionally designed as per the need to specific sport as well as climatic conditions, to maximise physical performance. The other two are its softer and more versatile versions, and offer wider utility beyond sporting arena. Today's sportswear is not apparel alone but also includes footwear.

Sports aside, when people began becoming more health-conscious and started adopting physical activities such as exercise, jogging, going to gym, yoga, body building etc to keep fit, a part of sportswear transformed into a new category called activewear – a more casual and comfortable clothing specially designed for such activities. The activewear allows active and free movement during strenuous physical activity. Its main aim is to offer functionality hence uses lightweight, quick-drying, airy and figure hugging material resulting in comfort and movement. Comprising fabrics such as nylon, spandex, Lycra and such other softer ones, it is the most popular type of clothing that is worn at the gym today. From the perspective of a simplified identification, activewear falls between casualwear and sportswear. Some of the items representing this category are sports tank tops, shorts, hoodies, aerobic wear, tennis shirts, polo shirts, tracksuits and T-shirts.

Going forward, as the fashion assumed larger proportion in sportswear another segment within activewear emerged as athleisurewear. It is a type of versatile sportswear that combines functionality with fashion which can be worn in daily routine in non-sporting settings as well. As a simplified expression, athleisurewear combines activewear and trendy streetwear and is designed for daytime and leisure activities which are not confined to work outs alone. Belonging to athleisure category are yoga pants, trainers, joggers, stretch chinos, crop tops, tracksuit bottoms, high-waist leggings and capris, and so on.

Celebrity Influence

In recent times, sportswear industry is seen majorly benefiting from celebrity endorsements, and this trend has increased many fold in last few years. Since the celebrities have a massive influence on fashion trends, their endorsing of a

sportswear brand impacts the brand's sales and popularity. Millions of people look up to celebrities as fashion icons and follow their lead. This has made celebrities like Beyoncé, Rihanna and Serena Williams to not only help promote the brands they endorse but also contribute to the product design to make them functional, trendy and fashionable. Reach of celebrities is scaling up due to social media which has further eased celebrities' efforts to promote sportswear brands. Millions of celebrity followers on social media share their pictures and videos showing them wearing sportswear, resulting in a major increase in brand awareness and sales for sportswear companies. However, some experts recommend a cautionary approach to this trend. They feel that the selection of the celebrity must be done carefully as it can have a negative impact on the brand's reputation if endorsement does not align with the brand's values and image. Roping the celebrity for sportswear brand endorsement is nevertheless likely to continue owing to their influencing power, but brands, while hiring celebrities, must consider the expert advice in keeping the endorsements authentic and ensure their alignment with brand's values.

Women Sportswear

While the pandemic accelerated a consumer shift due to work-from-home (WFH) and curtailed outdoor sports activities, the demand for comfortable and functional clothing for home stay spiked. During the same course of time, the demand for athleisurewear and activewear became even stronger and continues to grow since then. Women is the core segment driving this growth. Realising this trend, many sportswear brands have adapted their collections to meet the changing needs of women as in the case of Lululemon which expanded its assortment to include new footwear offerings specifically made for a woman's foot.

Since women are displaying increased participation in domestic and professional sports and fitness activities, the growth in sportswear market is being driven by their increased engagement. Women's sportswear is no longer limited to just workout clothes and gym wear, rather has further evolved into a wide range of stylish and functional clothing that come with multipurpose use. For instance, apparel like yoga pants, running shorts, sports bra, and crop tops have contributed to women's sportswear becoming more diverse than ever before. Today women are wanting to wear their workout clothes beyond gym, pushing the brands to create designs that are both functional and fashionable. These pieces can be easily layered, and mixed and matched, and are therefore high on popularity scale. The desire for such clothing is allowing women to create multiple outfits with few pieces, still making their wardrobe look more versatile and substantially cost-effective.

One key factor driving the increasing demand for women's sportswear is the growing awareness of the benefits that exercise and physical activity offer to women. Besides looking good, women want to feel good too. This is leading to the development of high-performance fabrics and technologies that are designed to enhance comfort and performance. Women get deeply influenced by the fitness influencers active on social media who influence and guide the female consumers on how to live a healthy and active lifestyle.

The year 2023 is seeing increased merging of style and functionality enabling the same apparel to be worn inside and outside the gym. Since women of all sizes and

shapes want to feel comfortable and confident while working out, the inclusive sizing is also making its way in the women's sportswear. Brands are now offering a wider range of sizes to cater to all body types, taking a positive step towards promoting body positivity and inclusivity in the fitness world. Brands are incorporating natural colours and textures into their designs as part of feminine earthiness, as can be seen in Riot Swim's Sculpt Stretch High Rise V Cut Bike shorts that are made from a blend of recycled nylon and spandex featuring a unique V-cut design that flatters the figure. In activewear styles, brands are creating pieces that can be dressed up or down such as leggings with mesh panels or bras with strappy details.

Trending Colours

As usually happens with fashion, the past keeps returning in a new avatar. Nostalgia is driving sportswear season with more and more focus on neon and pop colours, reflecting a throwback trend. Trending colours in sportswear have brought back the neon shades of the 1980s and 90s. Though regulars of whites, greys and blacks still remain hot and first choice in sportswear, a touch of neon adds to the fashion exuberance. The trend can be seen in lines of major sports brands like Nike, Adidas, and Reebok—who all are relaunching their 90's classic style again.

From icy shades to electric hues, blue is emerging as another favourite colour for sports persons, whether it is for a matching set or workout jumpsuit. Brands are mixing and matching shades of blue for a fresh look. The other colours include earthy hues such as sage and evergreen, representing a more grounded palette.

For styling, high waist leggings, sports bra and track-suits with bold logos dominate the sportswear fashion – a spike expected to carry on for years.

Fabrics And Garments in Vogue

Another aspect gaining momentum in addition to functionality and performance of the sportswear fabric is the use of unconventional sustainable materials. The activewear segment is increasingly settling for eco-friendly materials over conventional materials. The garments made from such materials are more odour-free, sweat-resistant and have anti-bacterial properties. Knowing fully well that synthetic polyester – most widely used fabric in sportswear, is made using petroleum, many brands and a large section of consumers are showing inclination towards the use of sustainable materials such as recycled polyester, bamboo and organic cotton. There is growing emphasis on using antibacterial fabrics like sea cell and bamboo charcoal to meet the requirements of rigorous activity of all sports. These fabrics possess higher potency in regard to moisture-wicking, breathability and quick-drying of sportswear, and help to make the garment look stylish and trendy as well. In addition to their eco-friendliness, these materials provide superior comfort and durability too. At the same time, many brands continue to focus on high-tech fabric which are designed to enhance performance and provide comfort during workouts and sporting activities.

The mesh fabric continues to be in great demand. Being a breathable textile, it is a top fabrication in the market for both men and women as it is comfortable and stylish that adds a bit of forward texture to any workout fit. It is already a top trend on the runways and a fan favourite among accessories, tops and bottoms. In addition, sports brands are increasingly using tie-dye to make activewear more eye-catching and vibrant.

Known for their comfort and style, one-piece garments like jumpsuits, rompers and bike-unitards continue to be in demand as usual, as they can be dressed up or down depending upon the occasion and requirement. This makes them extremely practical as far as their wearing for a variety of activities is concerned. This is evident in case of jumpsuits which are perfect for both yoga as well as pilates due to their standard use of multi-way stretch materials that allow a full range of motion. Likewise, rompers are ideal for running and hiking as they provide support and coverage without being too bulky. This explains the popularity of one-piece garments among teenagers.

Third-Kit Collections

The Third-kit in sport of football is an alternative jersey or uniform the team can wear in place of its home or away outfit during games, especially when the colours of their uniform are very similar to the colours of other competing teams. In August, Germany's sports giants Adidas and Puma launched new third-kit collections made with 100 per cent recycled materials for various football clubs in Europe ahead of 2023-24 season:

Puma: The German sports company's new third-kit collection was launched for Italy's AC Milan club. The collection represents a celebration of inclusivity aiming to unite generations of Rossoneri (Italian term for club's red and black colours) fans across the globe, and features a unique ravish fizzy lime, royal sapphire, majestic purple and white combination complementing with a sleek monochrome rendition of the iconic club badge. The Authentic jersey uses cutting-edge technology to provide optimal performance and comfort on the pitch. It is engineered with Ultraweave fabric, and has structured 4-way stretch design that reduces weight and friction thereby allowing players' free and comfortable movement. Integrated with the Drycell technology, the fabric is designed to keep the body sweat-free. Drycell sweat-wicking technology has been used in The Replica version to keep the body dry and comfortable throughout the play time of 90 minutes and beyond irrespective of time, pitch and place. The new third-kit debuted this September during AC Milan's match with Hellas Verona.

Adidas: True to its size and dominance in sporting world, Adidas launched new third-kit collections not for one but four football clubs in Europe: FC Bayern

Munich (Germany), Juventus (Italy), and Manchester United and Arsenal (both England), each drawing inspiration from local elements.

The collection for Bayern is inspired from flowers adorning the Bavarian mountain range, and has designs matching the crest seen on the club's original document. The updated emblem features in burgundy red, applied onto the jersey against an off-white backdrop, complemented by Adidas logo appearing in the same colour. The third-kit for Italian club draws its inspiration from the industrial revolution in the city of Turin and its architecture. The new jersey features a ribbed knit pattern reflecting textures and surfaces found across the city's famed structures, while the base colour of charcoal represents industrial heritage of the city. The design has a retro finish with black Henry buttoned collar and famous Adidas three stripes in grey on each sleeve. The Man U's third-kit celebrates club's famed identity – the Red Devil, drawing inspiration from the jersey worn in 1909 Cup winning season. For the first time, the devil appears singularly on the jersey. The collection for the other English club Arsenal celebrates retro style from 1980s. The kit reinvents a cult classic fit for the present day, sporting a mineral green base with collegiate navy shoulders and off-white stylised crest and sponsor logos. The new kit is meant to be used by both the men's and women's teams but is currently set to be worn on pitch for the first time by club's Women team on 22nd October game against Bristol City.

While the on-field shirt versions in all four collections use Heat.Rdy technology that is optimised to keep players performing on the biggest stage feel comfortable, the fan versions feature Aeroready technology that enables sweat-wicking or absorbent materials to keep the body feel dry. Adidas is ahead of schedule in its journey to replace virgin polyester with recycled polyester in its products wherever possible by the end of 2024.

Exclusive Collections

Even though sportswear deals in technically-developed garments and is a speciality category, it also follows the norms of typical fashion brands such as collaboration with designers and celebrities, developing character-centric range or showcasing experimental future ideas, to come up with their exclusive collections. There are many such stories worth sharing but even few can also give key insights to the prevalent trends:

Nike: In July-end, American sports company Nike launched two collections namely Nike AU and The Nike x Martine Rose. While the former was the first express lane capsule collection inspired by rugged Australian landscape, the latter was designed by designer Martin Rose.

Nike AU – a women's collection, was launched at Nike website and select retail partners including Rebel, JD Sports and Footlocker. The collection reimagines Nike icons with colours and textures drawn from Australia's natural beauty and includes a range of hemp and fleece crews, jackets, tracksuit pants and T-shirts in brown and amber tones, as well as limited-edition versions of the Air Max 270, Dunk Low and Air Max 90.

During the same time, Martine Rose collection was also launched on designer's website, SNKRS and at select speciality stores. The collection – a gender-free tailored player suiting, thaws the boundaries of men and women's football styling and improves sport style and culture for next generation. It effortlessly connects and merges the moments of "getting off the plane" to "arriving on the pitch" and closes the gender gap in crafted tailoring for women's sport. The collection comprises player's suit jacket, trouser, trench and shirt, accessories such as stockings, gloves and sunglasses, and latest Nike x Martine Rose Shox Mule MR4.

Beginning August, another collaborated collection with Yoon Ahn called Nike x AMBUSH was launched that invites an extended audience to the world of football fandom, and celebrates individuality, diversity and community. The collection can be dressed up and down and includes a unisex jersey top; a Nike x AMBUSH Air More Uptempo Low with a luxe leather upper having original graffiti-inspired branding and a rebellious look; and, a metallic silver football.

Puma: Inspired by the American 3D fantasy adventure comedy movie's little blue creatures The Smurfs, Puma launched The Smurfs range in mid-August. It is a fun collection of brand's essential streetwear silhouettes, made of recycled materials alongside bold graphics and fun all-over prints. The collection offers both apparel and footwear in kids' and adults' sizes and features a range of sneakers, each inspired by a different Smurf character. At its core, the collection has specially created graphics featuring The Smurfs frolicking and playing around the PUMA wordmark. The range also includes sets of matching essentials of hoodies and sweatpants, and accessories like Beanie and special backpack – all sprinkled with a bit of Smurf magic.