Chapter 3
Classification of Technical Textiles

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Abstract The textile products are broadly divided into two groups, i.e., conventional textiles and technical textiles. Conventional textile products are designed, developed, or used for the common, decorative, or aesthetic applications, whereas technical textile products are those which are used in the functional applications. Technical textile products are usually classified into twelve groups, i.e., Mobiltech, Indutech, Medtech, Hometech, Clothtech, Agrotech, Buildtech, Sportech, Packtech, Geotech, Protech, and Oekotech. This classification of the technical textile products is based on the area of application. For example, products related to the medical and health care are a part of Medtech which stands for medical textiles. This classification has two drawbacks. First, several segments of the technical textile do not have clear boundaries and overlap with the other segments. For example, Oekotech overlaps with Indutech (filtration), Geotech (erosion protection), and Agrotech (water efficiency). Secondly, this classification does not help much to an entry level manufacturer of technical textiles. The reason is that each segment has a large variety of products made of diversified fibers/raw materials using divergent manufacturing techniques and equipment. In addition to that, the products have to fulfill varied testing requirements as well. Therefore, it is almost impossible to figure out a certain type of manufacturing facility to fulfill the needs of one segment. Keeping in view the very fact, technology-based classification of the technical textile products has also been proposed in this chapter.

3.1 Introduction

Textile materials or products can be divided into two parts; conventional textiles and technical textiles. The products which are used for common applications and decorative or aesthetic purposes are commonly known as conventional textiles. Conventional textiles are usually made of conventional fibers which are most of the times natural fibers. Technical Textiles, on the other hand, are defined as "materials

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and products manufactured primarily for their technical and performance properties rather than their aesthetic or decorative characteristics" [1]. The technical textile is a very vast domain. Before the advent of technical textiles, the textile products were only limited to apparel and home textiles. Now the technical textile products are everywhere around us. For example, there are protective clothing for protection against fire, cold, impact, microbes, etc. Further, textile products are being used in automobiles, industries, hospitals, agriculture construction, packing, sports, etc.

The ever-growing human needs have pushed the researchers to develop technical textile products. The technical products can not be developed without special fibers having specific properties for a certain application. Therefore, this very fact has forced the researchers to work for the development of new fibers. The development of fibers like carbon, glass, and HDPE is the result of this phenomenon.

The technical textile products are mostly made by using high-performance/technical fibers. Further, all types of fabrics (i.e., knitted, woven, nonwoven, braided, tufted, etc.) are used in technical textile products. The selection of the fabric structure is chosen based on the required properties of the product. Various types of finishes are also contributing toward the development of these products. Coating technique is very commonly used for the application of such finishes. Some of the examples of these finishes are water repellant, antistatic, antimicrobial, etc. Joining techniques other than stitching are used to make the technical products. The examples of such techniques are ultrasonic welding and thermal bonding.

The world Textile and clothing market is about US$ 750 billion [2]. The current estimate of technical textile market is about US$ 180 billion which is expected to reach US$ 250 billion in 2026 with an average 5% growth [3]. Technical textile is one of the most rapidly growing sectors of textiles.

3.2 Classification of the Technical Textiles

Techtextil, one of the largest trade exhibition of technical textiles, classify technical textile products into 12 main areas of application which are depicted in Fig. 3.1, [4].

3.2.1 Mobiltech

The textile products which are used in the transportation (automobiles, railways, ships, aircrafts, and spacecrafts) are known as mobiltech. Some of the examples of mobiltech products are parachutes, inflatable boats, air balloons, automobile covers, etc. Some of the textile products are used as a component in an automobile. These components can be classified into two, i.e., visible components and concealed components. Some of the examples of visible components are:

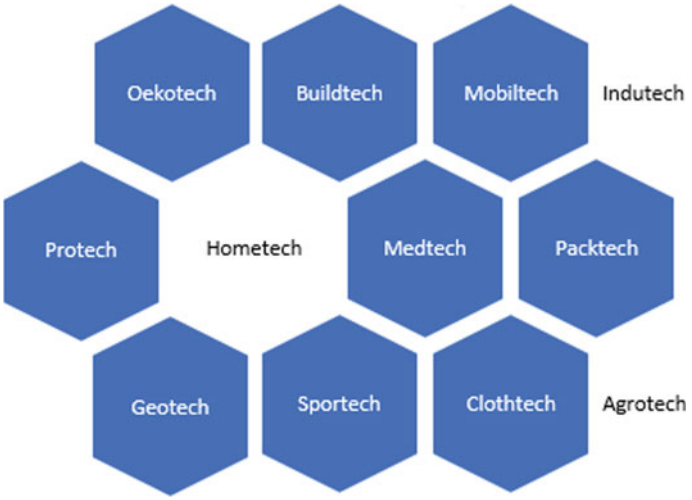

Fig. 3.1 Branches of technical textiles

- Seat covers.
- Seat belts.
- Carpet.
- Foot mats.

The concealed components may include:

- Airbags.
- Tyre cords.
- Insulation felts.

The mobiltech products are used in interior, engine, and body of the automobiles. The average weight of the mobiltech products used in the interior of an automobile is around 20 kg [5]. The mobiltech products are used for several functions which include transportation, filtration, insulation, protection, etc.

3.2.2 Indutech

Indutech stands for industrial textiles. These are the textile products which are used in the industrial/manufacturing sector. The most commonly used examples of indutch products are:

- Conveyer belts.
- Ropes.
- Filters.
- Composite materials for industrial use.

These products are usually made by using nonwoven or woven textile structures. The application areas include filtration, purification, and transportation. Filters are used for air, water, or oil filtration. Conveyer belts are used for transportation of materials. Ropes are used in shipping, ports, oil rigs, and defense areas [6]. The most commonly used fibers for indutech products are synthetic, e.g., polyester, polyamide, polypropylene, and nylon, etc.

3.2.3 Medtech

Medtech is a short form of medical textiles. These are the products used for healthcare and hygiene sectors. This domain has a wide product range. These products can be divided into two categories; wearables and non-wearables. Some examples of the wearable products are:

- Face mask.
- Diapers.
- Patient gown.
- Doctor's gown.
- Pressure garments.
- Protective suits.

Non-wearable products may include:

- Wipes.
- Bandages.
- Gauzes.
- Sutures.
- Scaffolds.
- Artificial body parts.

Medtech products are developed by using both natural (cotton, silk, wool, etc.) and synthetic (polyester, rayon, etc.) fibers. The selection of the fiber is based on the requirement of the final product. For example, natural fibers may be used for high absorbency and biodegradability whereas synthetic fibers find their use for strength and elasticity [7]. Almost all types of textile structures are used in medtech. For instance, yarn (sutures), woven structures (patient gown, doctor gown, bandages, etc.), nonwoven structures (facemask, diapers, wipes, etc.), and Knitted structure (pressure garments, etc.) are used in medtech. Some of the functions of medtech products are cleaning, absorbency, filtration, protection, etc.

3.2.4 Hometech

The technical textile products which are used inside buildings are known as hometech. It consists of household textiles and upholstery (sleeping bags, cushions, and bedding, etc.). Some examples of the hometech products are:

- Blinds.
- Floor covering.
- Wall covering.
- Cushions.
- Shower curtains.
- Towels.
- Cooking aprons.
- Oven mittens.
- Table covers.
- Bread baskets/covers.

Both natural and synthetic fibers are used in the development of these products. The end use dictates the type of fibers to be used. For example, wool may be used for insulation and cotton may be used for absorbency. Most of the products are made of woven (shower curtain, towel, etc.) or multilayer composite structures (oven mittens, etc.). Coating fabrics are very commonly used in these applications (shower curtains, table covers, etc.). These products are usually used for waterproofing, fireproofing, insulation, absorbency, protection from sun, protection from harsh weather, and leisure. Most of these products are made fire retardant to minimize the harm in case of a fire incident [8].

3.2.5 Clothtech

The textile products used to satisfy the functional requirements of apparels are called Clothtech. These are basically the components of garments or shoes which are most of the times concealed. some of the examples of Clothtech are:

- Interlining.
- Underlining.
- Velcro.
- Fasteners.
- Elastics.
- Labels.
- Sewing thread.
- Shoelaces.
- Draw cords.

The typical functions of these products include insulation (interlining), garment stability (underlining), tactile comfort (underlining), ease in wearing (Velcro,

fasteners, elastic, and shoelaces, etc.), protection (drawcord), and joining sewing thread. Various types of fibers (cotton, polyester, nylon, elastane, etc.) are used to make these products. The selection of the fiber is dependent on the end use of the product. Almost all types of textile structures are used in these products. For example, the applications of yarn (sewing thread), braided (drawcord, shoelaces), nonwoven (interlining), woven (interlining, underlining, elastics, labels, etc.), and knitted (interlining) structures can be found in clothtech [9, 10].

3.2.6 Agrotech

The technical textile products used in agriculture, horticulture, fisheries, and forestry are known as Agrotech. These products are used for growing and harvesting of crops. This is a very wide domain of technical textiles. Some of the common examples of the Agrotech products are:

- Shade nets.
- Crop covers.
- Bird protection nets.
- Anti-hail nets.
- Fishing nets.

The use of Agrotech products improves the quality of crops, controls the weed, enhances and accelerates the yield. Both natural and synthetic fibers may be used in aggrotech products depending upon the requirement of the product. The common functions of these products are protection from extreme weather, protection from mosquitos, protection from birds, insulation, packing, etc. The textile structures like knitted (packing materials and nets), woven/nonwoven (mulch mats, sapling bags, shades, and ground covers), and knotted (fishing and other nets) can be used to make these products. [11]

3.2.7 Buildtech

These are the products which relate to the construction and architectural application for temporary or permanent structures. The material/structures used may be in the form of textile alone or multilayer composites reinforced with a textile material. The common examples of buildtech are:

- Hoardings and signage.
- Canopies.
- Tarpaulins.
- Shades.
- Textile reinforcements for concrete.

- Sound absorption sheets.
- Thermal insulation sheets.

The requisite properties of buildtech products are lightweight, strength, water resistance, chemical resistance, weather resistance, aging, concrete reinforcement, facade foundation, interior construction, insulation [12], noise prevention, visual protection and protection against sun light, etc.

3.2.8 Packtech

Packtech are the textile products which are used for packaging. They can be found in the packing of agriculture, industrial, and consumer products. Some of the examples of Packtech products are as follows:

- Bags/Sacks.
- FIBC (flexible intermediate bulk container).
- Tea/coffee bags.
- Courier envelops.
- Adhesive tapes.
- Electrical insulation wraps.

Conventionally natural fibers (jute, etc.) were used to make bags and sacks which are now been replaced with the synthetic fibers (polypropylene). These products are used for packing grains, vegetables, fruits, clothing, shoes, and electronic appliances, etc. The major objective of these products is to improve the shelve life of a product which is usually carried out by controlling the temperature and moisture transport of a product. The other function of such products is the easy transportation of the packed materials. Woven (bags/sacks), plastic sheets (wrapping sheets), nonwoven (tea/coffee bags), and leno nets (for packaging of fruits and vegetables) are the most commonly used structures. [13].

3.2.9 Sportech

The technical textile products used for sports and leisure like running, cycling, swimming, indoor sports, and outdoor sports are known as Sportech. Thanks to the increasing interest of people in outdoor leisure activities and sports there has been enormous growth in the consumption of sportech materials [14]. Commonly used products include:

- Climbing ropes.
- Tracksuit.
- Running shoes.
- Helmets.

- Artificial turf.
- Parachute fabrics.
- Sleeping bags.
- Swimwear.
- Football.
- Sports equipment (hockey sticks, racket, cricket balls, etc.)

Sportech contains the products for almost all kind of sports. Protection from extreme weather, protection from injury/impact, strength, water resistance, good comfort properties, stretch, and recovery are some of the functions needed in different sportech products. Some products, i.e., helmet, rackets, etc., are made using textile reinforced composite materials. The particular objectives of such products are strength, protection, and light weight structure. The other products (swimwear, sleeping bags, track suits, ropes, etc.) are made purely from textile materials. The sportech products are made of synthetic fibers due to their superior properties (wicking, strength, etc.) than the natural fibers [15].

3.2.10 Geotech

Geotech stands for geotextile products. According to ASTM "A permeable geosynthetic comprised solely of textiles is called a geotextile product" [16]. These products are made to be used in geotextile applications. The examples of some geotech product are:

- Geo-grids.
- Geo-nets.
- Geo-composites.

The major functions that Geotech products perform are reinforcement, stabilization, separation, drainage, and filtration. The application areas could be civil engineering (roads, tunnels, bridges, dams, and buildings), irrigation (canals and rivers), and environmental engineering (landfills and waste management). These products should have good strength, durability, and low moisture absorption. Therefore, synthetic fibers are used to manufacture these products most of the times. Majority of the products are nonwoven however; woven products are also used in some applications [17].

3.2.11 Protech

Protech is one of the largest groups of technical textile products. The products used for personal or property protection are considered under the umbrella of Protech. Some of the relevant products include:

- Cut/stab resistance clothing.
- Firefighter clothing.
- Antimicrobial clothing.
- Waterproof clothing.
- High-visibility clothing.
- NBC (nuclear, biological and chemical) protective clothing.
- High altitude clothing.
- Bulletproof vest.
- UV protective clothing.
- Clean room clothing.

As all of these products have to provide protection, therefore most of the times synthetic or high-performance fibers are used in these products. Aramids are used for protection against fire (firefighter clothing), impact (bullet proof vest), cut (butcher's gloves), and abrasion (biker's clothing). Other fibers may include carbon, glass, stainless steel (clean room clothing), etc.

3.2.12 Oekotech

Oekotech contains the technical textile products related to the protection of environment and ecology. The most common application areas are filtration, recycling, erosion control, and water efficiency. This is not a well-defined segment yet rather it overlaps with many other segments, i.e., Indutech, Geotech, and Agrotech. Most of the times it is focused on environment protection, waste management, and recycling [4, 18]. Filtration is the most important function dealt by oekotech.

It is evident from the discussion earlier in this chapter that the current classification of the technical textiles is based on the application areas. It has basically two problems. First of all, several segments of the technical textile do not have clear boundaries and overlap with the other segments. For example; Oekotech overlaps with Indutech (filtration), Geotech (erosion protection), and Agrotech (water efficiency) [18]. Another example is that Protech overlaps with almost all other segments (hometech, clothtech, sportech, etc.). For example, helmets are a part of Protech as well as Sportech at the same time.

Secondly, this classification does not help much to an entry level manufacturer. It is almost impossible to figure out a certain type of manufacturing facility to fulfil the needs of one segment. The reason is that each segment has a large variety of products made of diversified fibers/raw materials using divergent manufacturing techniques and equipment. In addition to that, the products have to fulfil varied testing requirements as well. Keeping in view the facts explained, there is a need to classify the technical textile products in a different way.

3.3 Components of a Technical Textile Product

Any of the technical textile products has three components, i.e., material(s), structure, and design. For example; if someone wants to develop a suit for firefighters, the first step will be the selection of the raw materials. For that, the developer must understand the requirements of the product. The most important and premier requirement will be the protection from fire (high temperature) for a certain time period. Further, requirements comprise of cut resistance (protection from sharp edges and glass etc.), impact resistance (the firefighter may have to break a glass window), and moisture management (the firefighter will sweat heavily due to the high temperature which needs to be sent out of clothing to achieve thermal comfort). So the developer will have to choose the right materials for the exact level of protection.

Secondly, the developer will have to finalize the structure of the product. Normally, such products have to fulfill complex and multifunctional requirements to meet the goal of their existence. Therefore, complex and multilayer structure are commonly used. For example a common firefighter suit will consist of a three layer structure, i.e., outer shell, moisture barrier, and thermal barrier. Thermal barrier layer is the most important part as the firefighters are exposed to extremely high thermal energy in case of a fire incident. Moisture barrier has to protect the firefighter from hot water, chemicals, and other liquids. The outer layer's function is to protect the other layers of the suit [19].

Thirdly, the design of the garment must be finalized. For example, the developer must understand the requirements of the firefighter during a fire incident. The firefighter needs some tools (to facilitate his work) and a radio (to stay connected outside). These things must be present at a place where they are easily and quickly reachable by the firefighter. Further, his dress must have reflective tape (front and back side) so that he could stay visible to others in smoke. Therefore, the design of such products is equally important as the material and structure of the product. The product will only be useful if all the three components are equally efficient.

3.4 Classification of Technical Textiles Based on Technology

It will be more logical to classify the technical textile products based on the manufacturing technology. This kind of classification will be useful for the small scale/new manufacturers. Following are the technologies that could be used to make different types of technical textile products. Most of the products need multiple technologies to develop a complete product.

3.4.1 MM Fiber/Filament Development Technology

The major raw material for the technical textile products is the manmade fibers. The manmade fibers can be made by using melt spinning or wet spinning. Different types of monomers can be used to make manmade fibers. The required monomer(s) are converted into a long chain polymer with the help of polymerization process. The polymer is collected in the form of chips/granules. Then these polymer chips are passed through the process of melt spinning. In melt spinning process, the polymer chips are melt keeping in view the glass transition temperature of the polymer. Then the molten polymer is passed through a spinneret. The spinneret is usually a machine part which contains several small wholes through which polymer is extruded. After the polymer strands leave the spinneret, they are drawn to align the polymer chains. Then the polymer is cooled down and collected.

Wet spinning process is almost similar to the melt spinning process to accept two things. Firstly, the input of wet spinning is polymer solution while in melt spinning polymer chips are used. Secondly, the fibers are collected in a solution (wet environment) while in melt spinning the fibers are collected in a dry environment. After that the fibers are drawn, washed, dried, and collected.

With the help of manmade fiber manufacturing techniques, it is possible to make fine, continuous, and uniform fibrous strands with large surface areas compared to the natural fibers. The large surface area can be beneficial in several applications, e.g., wicking, moisture transport, etc. Further, it is also possible to mix several materials/polymers and convert them into filaments (e.g., bicomponent, tricomponent, etc.). This way multifunctional filament can be created which can then be used in different technical applications. E.g., metallic particles can be mixed with a polymer to make it antibacterial.

3.4.2 Yarn Manufacturing Technology

Unlike conventional yarns, technical yarns can be developed using the similar manufacturing setup using small attachments. Technical yarns have several applications in technical textiles. E.g. technical sewing threads, conductive yarns, etc. Corespun yarn is one of such examples. A core spun yarn has comparatively better strength than a similar staple spun yarn. In addition to that, two different materials can be used in core and sheath. This way, an advantage of both the materials can be taken at the same time. Further, sewing threads, which need more strength, elongation and twist balance to run smoothly during stitching process, are made by using the processing doubling and twisting. Normally, more than one yarns are taken and twisted together. It is made sure that the twist is given in the opposite direction, i.e., if we have Z twisted yarns then we will twist then in S direction during the process of doubling to balance the twist and avoid snarling.

3.4.3 Fabric Manufacturing Technology

The most commonly used fabric manufacturing techniques in conventional textiles are weaving and weft knitting. Other techniques like nonwoven, braiding, 3D weaving, and warp knitting have a large number of technical applications.

There are two major steps in the manufacturing of nonwoven fabrics, i.e., web formation and web consolidation. The web for nonwoven fabrics can be made by using dry laid or wet laid techniques. Dry laid and wet laid have several manufacturing techniques but those are not in the scope of this chapter. Once the web is formed, it can be bonded using mechanical, thermal, or chemical bonding techniques. The advantages of using nonwoven fabrics are high production speed, low cost, versatility, etc. Synthetic fibers are mostly used to make nonwoven products. These products may be used for absorbency, filtration, insulation, and packing. Some of the nonwoven products are as follows:

- Bags/sacks.
- Face mask.
- Diapers.
- Protective suits.
- Wipes.

Braiding is a technique in which multiple strands of yarn are interlaced with each other to make a cord. The cord may either be flat or circular. Braids are made of using almost all types of fibers (cotton, polyester, jute, Kevlar, etc.). Some of the braided products are as follows:

- Jumping rope.
- Climbing rope.
- Parachute links.
- Draw cords.
- Shoelaces.
- Cable covering.
- Hoses.
- Bracelet and accessories.

Three-dimensional weaving (3D weaving) is a type of weaving in which fabrics reasonable thickness are developed. In this type of weaving, there are yarns which pass through thickness of the yarn sheet and interlace them to make a 3D structure. The biggest application of these structures is in composite materials. Three-dimensional woven structures are used as a reinforcement in the composite materials. All types of fibers can be converted into 3D woven structures. The selection of the fiber is dependent on the end use of the product.

Warp knitting is a technique in which a warp sheet is prepared (similar to weaving process) and then this sheet is placed on a warp knitting machine which converts it into knitted fabric. Warp knitted fabrics have better dimensional stability as compared the

weft knitted fabrics. Weft knitted fabrics are mostly used in conventional textile products. On the other hand, warp knitted fabrics are used in technical textile products. These fabrics are used in following applications.

- Lingerie.
- Sportswear lining.
- Mosquito nets.
- Bags lining.
- Shoes lining.
- Blankets.

3.4.4 Nanotechnology

Nanotechnology is a new emerging domain. This technology deals with the development and usage of nano materials (nano particles and nano fibers). Nano fibers are developed by using electrospinning. In this technique two metallic plates are electrically charged with opposite charges using a high voltage source. Then solution of a polymer is injected from an electrically charged plate. At the same time the oppositely charged plate collects the fibers due to attraction among opposite charges. As the potential difference between two plates is very high, the developed fibers are of nano size.

The advantage of using electrospinning is that the developed nanofibers have a very high surface area. Therefore, they can be used for absorption, separation, filtration, and drug delivery in the form of a nano web/sheet. Further, multiple polymers can also be mixed together to make multifunctional nano fibers. The disadvantages of this technique are that the fibers developed with this method have poor mechanical properties and the production speed is very slow. Due to slow production speed, it is difficult to make nano fibers in bulk quantities. The scientists are working on different possibilities to increase the production speed of this process. The web/membrane made from electrospinning is used by sandwiching between multilayer structures due to its mechanical properties.

Nanoparticles of several materials are being used by the researchers. The nanoparticles are usually applied on a textile substrate with the help of a binder. These particles may perform several functions, e.g., antimicrobial, self-cleaning, anti-wetting, etc. The advantage of using the nanoparticles is that the surface properties of the substrate are not affected much.

3.4.5 Coating

Coating is a technique in which coating material is applied on a textile substrate to achieve a certain characteristic. The most commonly used coating method is knife coating. In this method, a substrate passes beneath a tilted knife. The coating material

is placed on the fabric. When the fabric passes under the knife, it applies pressure on the substrate and the coating material is penetrated in the substrate. Both single sided and double sided coating machines are used in the industry. Some of the applications of coated fabrics are as follows:

- Shower curtains.
- Car seat covers.
- Airbags.
- Canopies.
- Umbrella.

Almost all types of fibers (cotton, polyester, polyamide, etc.) can be used as substrate for coating. Coated material may also contain certain types of finishes which are applied at the same time. These fabrics are usually used for protection.

3.4.6 Smart Textiles

Smart textile is a newly emerging domain of technical textiles. These are the textile products which can interact with the environment and can respond to the environmental changes. Smart textile products can sense a stimulus, transmit a signal, process the received information about a stimulus and respond according to the situation. Electrical conductivity is the basic function required for such products. Textile materials are usually insulators but flexible. On the other hand, the conductive materials (wires) are conductive but too stiff to be used in textile products. Keeping in view this requirement, scientists have been working to develop flexible conductive materials. The applications of smart textiles can be found in sports, leisure, healthcare, military, and fashion [20]. Some of the example of smart textile products are as follows:

- Smart bed sheet.
- Smart shoe.
- Smart socks.
- Monitoring vest.
- Heating vest.
- Smart football.

All these products have some additional functions which normal products do not have. For example, smart bedsheet can make it up automatically in the morning. Monitoring vest can monitor your body vital signs and send this information to your smart phone/cloud.

3.4.7 Composite Technology

The products made with this technology have two structural parts, i.e., reinforcement and resin. The function of reinforcement is to provide the strength to the structure while the resin, after hardening, provides a certain shape to the product. A number of materials can be used as reinforcement (glass, carbon, etc.) and resin (epoxy, saturated polyester). The choice of material depends on the requirement of the end product. Stronger and light weight products can be made by using high-performance fibers (carbon) but the cost of the product also depends upon the choice of the material. Composites are famous for their strength, durability, and weight. Some of the examples are as follows:

- Shades.
- Automobile bumpers.
- Aeroplan parts.
- Sports goods (hockey, rackets, etc.).
- Safety helmets.
- Luggage bags.

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