Chapter 6
Textile Fibers for Automobiles

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Abstract The role of the textile fibers in various components of automobiles has evolved in order to meet the demand of high fuel economy without compromising the durability. The conventional natural and synthetic fibers, along with high-performance fibers, are used to develop woven, knitted, nonwoven, and composite structures for different components of the automobiles. This chapter describes the applications of textile fibers in different automobiles. Moreover, some advantages and limitations of these fibers are also highlighted. The composites made from natural fibers are frequently used for interior of the vehicles such as car seats, door panels, and door liners. The natural fibers are eco-friendly and have better comfort properties, but their low mechanical strength and low resistance to UV light are the major drawbacks. The synthetic fibers are also used in automobiles which have good mechanical properties, high abrasion resistance, and sound insulation.

Textiles are the necessary part of human life which used to protect and provide comfort to humans. The functions of protection and comfort are achieved and classified in the forms of clothings and technical textiles [1–3]. The technical textiles are applied to perform certain functions rather than aesthetic such as construction buildings, agriculture, medical, packaging, sports, and automobiles [4]. The automobile textiles are one of the most distinctive and flourishing class of technical textiles which deals with cars, buses, trains, aircrafts, and other vehicles. The different components of automobiles are produced from various textile assemblies like fibers, filaments, fabrics, and composites. These assemblies are employed into different vehicles for passenger seats, safety belts, thermal insulation, acoustic, filters, hoodliner, and carpets. The automotive components which are made from textile materials are described in Table 6.1 [4, 5]. The weight of these components is around 20 kg in a single car which are mostly used in the interior of cars. The properties and application of these automotive components are mainly depending upon the fibers used to constitute these components The physical and mechanical

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Table 6.1 Automotive components made from textiles

Vehicle component	Textile assemblies
Airbags	Fabrics for automotive airbags
Seat covers	Woven and knitted seat covers and backing fabrics
Seat belts	Narrow woven safety belt fabric
Tire cords	Fabric reinforcement for vehicle tires
Drive belts	Fabric reinforcement for automotive drive belts
Automobile carpets for interior	Tufted or needle punched fabrics
Trim	Woven, knitted and nonwoven fabrics based trims for boot liners, headliners, parcel shelves, and door panels
Filters	Filtration media for engine, air intake, fuel filtration
Hose	Fabric reinforcement for automotive hoses

properties of these automotive components, mainly depend upon the type of fibers used to produce these component [[6]. Textile fibers are the building blocks of any textile assembly. Therefore, the choice of textile fibers is very important in order to achieve desired properties from any conventional or technical textiles like automotive textiles. Both natural and synthetic fibers are used in pure and blend form to produce automotive textiles [7, 8]. In this chapter, we present the utilization of various natural and synthetic textile fibers in automobile industry.

6.1 Natural Fibers

Textile fibers are the fundamental units of any textile product which are defined as materials that have flexibility and have high length to width ratio. Natural fibers are the materials which have source from plants, animals and minerals. The most commonly used natural fibers are flax, sisal, hemp, cotton, wool, silk and jute which exist in fibrous or filament forms. These fibers are easily convertible to yarns for fabrics or structured directly into fabrics which are called nonwovens. The structural property relationship of these fibers is key to develop any textile product which mainly depends upon the chemical composition of these fibers. The major component of the plant-based fibers is cellulose, which is an organic material that contains thousands of glucose units. The lignocellulosic polymer is also obtained from the cellulosic source like stalk, husk, bast, fruits and grass. The animal fibers like wool and silk constitute from keratin and fibroin [9–11].

6.1.1 Applications

The first natural fiber used for technical textiles was plant straws which combined with clay for construction building about 3000 years ago in Egypt. The use of hemp fiber in China was also reported by the archaeological department. The first four-wheeled vehicle was developed in 2600 BC which was built with wood and leather. The current automotive industry is expanding rapidly, which is expected to reach 2 billion vehicles by 2030. One of the major demands inside the structure of modern vehicles is the fuel economy, whereas the aesthetics and comfort of the interior of the vehicles are also essential. The natural fibers have good mechanical and comfort properties to meet the demands of modern vehicles. Additionally, the new regulations for automobile industry encourage the use of eco-friendly materials which are recyclable and cut down carbon oxide emissions. The automobile industry adds around 25% of the total greenhouse gas emissions in industrialized countries. Therefore, the textile fibers from natural sources are good choice for the automotive industry to improve the fuel efficiency and fulfill the aesthetic appeal. These fibers are mostly used in the interior of the different vehicle components like seat covers, seat belts, door panels, dashboards, back cushions and boot lining [12, 13]. The various components of a car made from textile materials are shown in Fig. 6.1.

The natural fibers are usually structured into the composites with various resins to impart into the interior of automobiles. The natural fibers are usually structured into textiles composites by using different resins and these composites are used in the interior of automobiles. The natural fibers reinforced composites also flexible with good tensile strength and these have the ease of converting into complex vehicle

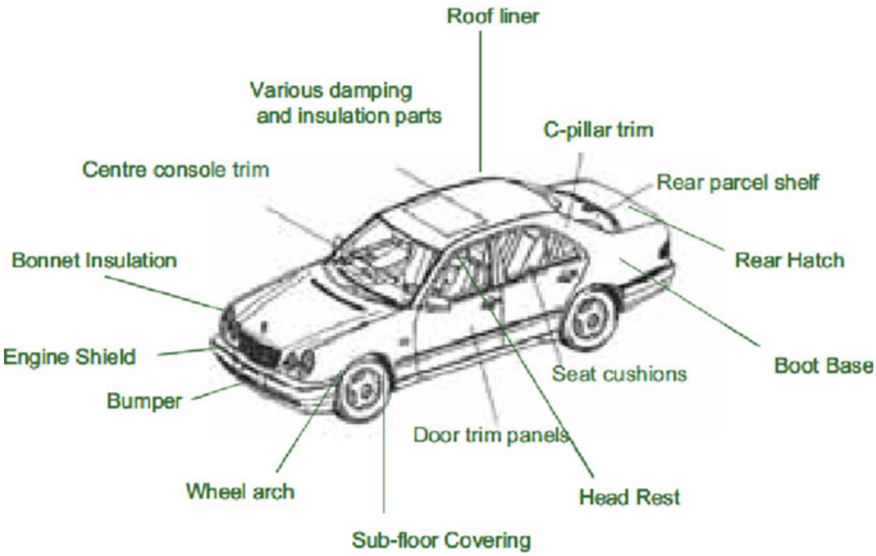

Fig. 6.1 Components of a car made from textile materials

Table 6.2 Natural Fibers based vehicle components

Company	Model	Vehicle components
Honda	Pilot	Cargo compartment
Toyota	Brevis, Raum, Harrier	Seat covers, mats, door panels
BMW	3, 5, 7 series	Acoustic panel, seat covers, door panels, headliner panel
Ford	Mondeo CD 162, Freastar	Door panels, boot liner,
Volkswagen	GolfA4, Bora, Passat, Variant,	Door panels, boot liner, seat covers,
Audi	A2, A3, A4, A6, A8	Seat backs, door panels, boot liner
Rover	2000	Thermal insulation, storage area
Volvo	C70, V70	Seating pad, cargo floor
Diamler AG	A, C, E, S series	Door panels, pillar covers, dashboard
Lotus	ECO Elise	Seats, carpets, body panels
Mitsubishi	Space star, Colt	Door panels, cargo compartment floor,
Fiat	Punto, Brava, Marea,	Door panel
Renault	Clio, Twingo Rear	Parcel shelf
Opel	Astra, Vectra, Zafira	Door panels, headliner panel,
Saturn	L3000	Door panels

interior shapes. Therefore, the automotive textile industry is one of the largest user of natural fibers reinforced composites. The utilization of natural fibers in various components of automobiles is summarized in Table 6.2. The cotton and jute nonwovens fibrous composites are considered to be highly efficient for sound absorption in modern automobile industry. Moreover, coir fiber is also reported as good acoustic material for the vehicles.

The natural fibers such as jute, hemp, sisal and coir are also used as interior fillers in various automobiles which reduce the cost of the vehicle. The door panels of different cars are prepared by natural fibers which reduced the weight of the car door. A car manufactured by Mercedes has used fibers made from wood pulp in car doors which reduced the weight around 20%. The car seats are the most important component of any vehicle which demands strength, comfort and aesthetic. The car seats are also produced by natural fibers like wool for commercial purpose. [14–16].

6.1.2 Advantages and Drawbacks

The use of natural fibers in automobile industry carries a lot of advantages such as biocompatibility, biodegradability and nontoxicity. Moreover, the vehicle components made from natural fibers are lightweight, which contributes to the fuel economy of vehicles. The natural fibers are low-cost material and are easy to assemble into complex structures of the vehicle's interior.

As most of the natural fibers used in automotive textiles are cellulose-based materials so their ability to absorb high moisture is a disadvantage for the vehicle components. The presence of moisture in the fibrous structure decreases their strength and their degradation period is shortened. The moisture swells the fibers which results in the change of the shape and dimension of the automotive components. Therefore, few chemical treatments need to be applied to these fibers to improve their mechanical properties which ultimately increase the cost of the material [13, 17, 18].

6.2 Synthetic Fibers

The safety and comfort of automobiles are the basic requirements for users of any kind of a vehicle. These two parameters become more important for the selection of material to be used in the interior of the vehicles. The synthetic fibers like polyester, polyamide, acrylic, and polypropylene are considered to the right selection to fulfill the requirements of safety and comfort of any automobile. These synthetic fibers have the advantages of high mechanical strength, thermal resistance, dimensional stability, abrasion resistance, moisture resistance, and UV resistance over natural fibers. The most used synthetic fiber is polyester which has a big share of 42% in automobile industry while 26% of polyamide 6.6 is used. These fibers are also low cost and very easy to shape into any structure of automotive component [18, 19].

6.2.1 Applications

The seats of a car or other passenger vehicles are the most attractive part of the interior, which demand durability and aesthetics in their shapes and structures. A fabric of 5 to 6 m^2 is usually used in the car upholstery and seats. The car seats made from textile fabric are shown in Fig. 6.2. The car seats are mostly prepared by polyester fiber which is fabricated by weaving or circular and warp knitting. The vehicle's seats are also manufactured from acrylic, PVC, and viscose fibers. The acrylic fiber-based car seats have the advantage of very high resistance to UV light which is a critical parameter as the vehicles have longer exposure to the sunlight. [20, 21].

The carpets (Fig. 6.3) inside the interior of the cars are usually prepared by polyester and polypropylene as these materials have good soil and abrasion resistance. The polyester and polypropylene needle punched nonwoven or felts are used for carpets which also have good acoustic properties. The sound insulation is a key requirement for vehicles. Therefore, those textile fibers are selected for the interior of the automobile, which provide good sound insulation.. The polyester-based nonwovens are reported as good sound insulation materials and their blend with hollow polyester improved their sound insulation properties. Therefore, PET nonwovens are

Fig. 6.2 Car seats prepared from textile fabric

Fig. 6.3 Carpet for car interior made from textile fabric

used in door panels, headliners, boot liners, and parcel shelves as sound absorbers [22, 23].

The carpet for the interior of the automobile made from recycled polyester was reported in literature. The recycled PET fibers were obtained from PET bottles and needle punched nonwoven carpet was produced for automotive. The recycled PET nonwoven fabric showed a good abrasion resistance which was comparable with virgin PET nonwoven fabric [24].

The door panels of cars are important components of the interior of the vehicles which are usually divided into two parts. The fabric at the lower part of the panel is connected with floor fabric while the upper part contains upholstery fabric. The door panel fabric is commonly produced from PET nonwoven which has better mechanical properties. Additionally, the PET fibers are also dyed with appropriate chemicals to minimize the effect of UV light on door panels. The polypropylene fiber-based fabrics are also employed in these door panels which have superior abrasion resistance than dyed PET fabrics [19, 22].

The boot liners or cargo liners are the assemblies inside the boot space to protect the cargo or luggage from mechanical stress and dust in the vehicles. These boot liners are usually manufactured from polypropylene or PET-based fabrics. The major requirements for boot liners are flexibility, dimensional stability, and moisture resistance so the PET is preferred over PP as PET has higher mechanical strength [22].

The roof headliners are most used textiles automotive components of the interior of the vehicles. These contribute about 13% of the textile materials used for automobiles. The fabric for headliner (Fig. 6.4) is manufactured by using polyester needle punched nonwoven. The PET nonwoven fabric has good abrasion resistance, good sound absorption, and smooth appearance. Moreover, this PET fabric is coated with various chemicals like phenolic resins and the face of the fabric is covered with polyurethane foam [25].

The tires are the essential part of any vehicle which play a vital role in safety and economy. A tire contains various components like sidewall, tread, ply, apex, bundle,

Fig. 6.4 Textile fabric-based headliner

and inner liner. The automotive tires are mostly prepared by steel and rubber. The synthetic textile fibers like polyacrylate, nylon, polyester, rayon, and Kevlar are also structured into ply cords of the tires. The major requirements for tires ply cords are high tensile strength, flexibility, heat resistance, and abrasion resistance [22, 26, 27].

The air filters and fuel filters are also important segments of the automobiles. An air filter provides the dust free air inside the vehicle while fuel filter protects the engine from various contaminations present inside the fuel. The textile fibers like polyester, polyacrylate, which are converted into laminates and nonwovens structures which have the excellent ability to hinder dirt and dust particles.

The fuel filters are prepared from polyacrylate fibers which are imparted between fuel tank and engine. These filters are used to remove dirt and other contamination from fuel. The PET fibers based filters are also used, but these filters have lower impact resistance as compared to polyacrylate fuel filters. The multilayer polyacrylate fibers based fuel filters are also manufactured, in which the fibers are embedded between plastic layers [28–30].

Airbags are the gas pillows which contribute about 3.7% of the textiles used for automotive textiles. The airbags used for safety purpose are shown in Fig. 6.5. These airbags are the safety components inside the vehicles which protect the passengers in the event of any collision. The airbags are placed for driver, front passengers, and back passengers. The airbags are prepared by using nylon 6.6. They are usually treated with silicone to improve the impact resistance.

The knitted and nonwoven nylon 6.6 fabrics are designed for the safety airbags. The major requirements for airbag's fabric are tensile strength, good impact resistance, and high tear strength. The fabrics for airbags also need to have good packability and coating adhesion [31, 32].

The safety belts are another important component assembled inside the vehicles to ensure the safety of drivers and passengers during the event of any dangerous collision. These belts are manufactured from nylon, polyester, or polyacrylate fibers. The fabric used for seat belts is manufactured from nylon or polyester fibers. It has

Fig. 6.5 Airbags of nylon 6.6

high tensile strength, good elongation, UV resistant, and high abrasion resistance which are the important requirements for seat belts.

The helmet is a safety component which is used by the motorbikers. The helmets are usually prepared from synthetic materials like polypropylene foam or polystyrene foam imparted inside the outer layers of glass or acrylonitrile butadiene styrene fibers [19, 25].

6.2.2 Advantages and Drawbacks

The biggest advantages of synthetic fibers are their availability and cost effectiveness. The synthetic fibers also have excellent properties like abrasion resistance, chemical resistance, and have good thermal resistance and sound insulation. Moreover, these fibers also have the ability to form blends and easy to shape into various composites. These are also low-density materials like polypropylene which reduce the weight of the automotive components. The automotive components made from polyester and acrylic have high UV resistance. The low moisture absorbency of synthetic fibers is their major drawback. Moreover, fibers like polyamide 6 and 6.6 consume huge amount of energy during their manufacturing.

6.3 High-Performance Fibers

High-performance fibers are the materials which are manufactured for functional applications, so these fibers have ultra-high tensile strength, high modulus, high impact strength, good thermal, and chemical resistance. Therefore, the high-performance fibers like carbon, glass, Kevlar are used in the automobile industry in various components of vehicles. These high-performance fibers in the multifilament roving form are used which are usually twisted or untwisted. The improvement in fuel efficiency of automobiles is a big challenge for the manufacturers. So the availability of carbon and glass fibers provided a good alternative for the automotive industry to replace steel and aluminum.

These high-performance fibers are lightweight and give better mechanical properties than steel and aluminum. The use of high-performance fibers can reduce the weight of automobiles from 50 to 80%. It was reported that the fuel economy of the automobile improves by 7% for every 10%, approximately weight reduction from a vehicle's total weight. Therefore, the use of high-performance fibers has grown rapidly in recent years in the automotive industry. These fibers are used in their composite form for sports cars, air crafts, and boats. The Airbus A380 and Boeing 787 Dreamliner have manufactured by using carbon-based composites in the aircraft structures which reduced the overall weight and ultimately cut down the utilization of fuel which is also a useful contribution to reduce the air pollution.

The glass fiber-based polymer composites are also used in automobile industry. These composites are employed to prepare the vehicle's outer body panels, air ducts, bumper beam, and engine parts which are lighter than conventional materials. The glass fibers based clutches and brake pads of cars are also manufactured as glass fiber has good abrasion resistance. The glass fiber reinforced composites are also applied to prepare wings of air crafts.

The manufacturing of glass/carbon fibers based composite for the car bumper beam was reported. The composite was 33% lighter and had good impact strength as compared to the conventional bumper beams.

Though the high-performance fibers have several advantages but their availability and high price are big issues for the automotive industry. Therefore, the attempt has been made to replace them with natural fibers like curana, sisal, and hemp [19, 22, 25, 33]

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