

High technology fibers



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HIGH TECHNOLOGY FIBRES FOR TECHNICAL TEXTILES 1 INTRODUCTION

Human life is surrounded by hundreds of textile fibres either in the form of clothes, interior textiles or in the form of high performance technical textiles made of conventional or high technology fibres for various applications. A textile fibre is usually defined as a flexible, macroscopically homogenous cylindrical body mainly with circular cross-section having a high ratio of length to diameter (typically 100-3000: 1). Textile fibres are derived both from natural and synthetic origins.

Natural fibres such as cotton, wool etc. are often found with lengths 1000-3000 times their diameter. On the other hand coarser natural fibres such as jute, flax, ramie, etc. have lengths 100- 500 times their diameter. However man-made fibres can be made in any desired ratio of length to diameter. The technical textile industry uses both natural and man-made fibres in manufacturing a variety of products.

Natural fibres mainly come from agricultural and animal sources; (although asbestos is a natural fibre coming from mineral sources, but this fibre is banned in many countries from being used due to health hazards) whereas the production of man-made fibres is an important activity of the world-wide chemical industry involving largely natural polymers and synthetic polymers (derived from petrochemical by-products). There are also a limited number of man-made fibres such as glass, metal and ceramics are produced using inorganic materials. Although natural fibres are extensively used in the technical textile industry, a serious manufacturing of technical textiles only started about thirty years ago with the inception of man-made fibres. Over the last twenty, years, the man-made fibre industry has seen a radical

growth in terms of fibre consumption for the technical textile industry. In general, the man-made fibre industry achieved a vast expansion between 1940 and 1970, creating a new spectacular look for the clothing and fashion trade, but today it is showing signs of maturity. Multinational fibre producers have, therefore, turned their attention to a new dimension, which is technical textiles, to fuel the next major wave of creativity, innovation and growth.

It will thus open-up the possibility of a major growth of particularly high tenacity and high technology man-made fibres for the technical textile industry. The growth is also expected to be fuelled by the significant global economic upturn in the first half of 2000. The estimated total of world production of the major textile fibres (including both natural and man-made) for 1998 was over 55 million tonnes, of which approximately 20% was used in the production of technical textiles. It is anticipated that by 2001, nearly 25% of the global fibre production will be used in technical textiles.

Of course, the major breakthrough in this growth will come from 'New Technical Textiles and New Technologies' replacing the traditional linear concept of material production.

2 CLASSIFICATION OF FIBRES

In general, textile fibres are classified into two main groups: natural and man-made. Virtually all kinds of fibres (both natural and man-made) are used in technical textiles. However, for market structural requirements, fibres used in technical textiles can be divided into two main classes, namely: commodity fibres; and high-technology or speciality fibres.

Although by market perception, commodity fibres are those which are extensively used for traditional textiles, such as apparel and clothing,

household textiles, carpets etc. , but contrary to this, today the majority of technical end-uses of textiles are based on commodity fibres. A high degree of engineering ingenuity is, however, often devoted to the design of the item constructed from such fibres. Commodity fibres can be sub-classified into two other groups: conventional fibres such as cotton, wool etc.

and high-tenacity fibres, such as polyester, polypropylene etc. In Western Europe, almost 95% of technical textile products are currently made by commodity fibres (—67% by conventional fibres and —28% by high-tenacity fibres). Although tl commodity fibres grossly dominate the technical textile markets, but due to the defined scope of this chapter specific features of popular commodity fibres are not included here. High technology or speciality fibres are those which very often are made involving novel materials and sophisticated manufacturing techniques.

These fibres are normally characterised for their specific performance enhancing properties. High technology fibres normally add value to the finished products. A number of publication& ° on the subject and related topics have appeared in the last few years. The introduction of high-technology or speciality fibres in technical textiles has allowed us to enter a new era of materials revolution. ‘ These fibres are used for special requirements demanded by certain types of technical textiles. Such technical requirements are high temperature protection, high impact and dynamic energy absorption capacity, high cut-through resistance etc.

In other words, high-technology or speciality fibres are normally chosen for their particular suitability to an end-use such as protective clothing for

ballistic body armour, for high-risk jobs and sports (Figure 1), lightweight textile-reinforced structural components for aircraft, high-performance ropes for marine applications (Figure 2), structural panels (reinforced with fibres) for building construction and so on. Aramids (Kevlar, Nomex, Twaron etc.), glass, carbon, polyethylene, polyphenylene sulfide, polyetheretherketone (PEEK), polytetrafluoroethylene (PTFE) etc. are some of the popular high-technology fibres frequently used for technical textiles. High-technology fibres are expensive (10 to 500 times more expensive than commodity fibres) and are often known as 'Premium Fibres'.

Currently high-technology fibres have about —5% of the total market in technical textiles in Western Europe, but the global market of these fibres is growing rapidly. FIBRE PRODUCTION: SPINNING AND DRAWING Other than inorganic fibres, all man-made fibres (both commodity and high technology) are spun either from natural polymers or from synthetic polymers. It is necessary either to melt the polymer at an elevated temperature or to dissolve it in a solvent to form a fibre from a polymer. The most extensively used commercial spinning techniques are melt spinning, dry spinning and wet spinning. Other techniques which are used mainly to spin certain types of high technology fibres are gel spinning, liquid crystal spinning, emulsion spinning etc. Both dry and wet spinning processes are technically known as 'Solution Spinning'.

The technology of solution spinning is highly specialised for the individual fibre industry and some of the techniques are described in the patents and in the published literature. Many high-technology fibres are spun using solution spinning techniques. Figure 3 shows the schematic diagram of the three

principal methods of spinning fibres. Most of the thermoplastic polymers which do not degrade in their molten state are normally extruded by the melt spinning process.

The process is considered as safe, simple and cost effective. The molten polymer is extruded through a nozzle, called a spinneret. Extruded fibre is then passed through a chamber to cool and solidify. Thereafter, the spun material is drawn and wound on a bobbin. Nylon 6, polypropylene, polyethylene terephthalate (PET) etc. are the typical examples of melt-spun fibres.

Dry spinning is the process whereby the dope (polymer solution) is passed through a spinneret and solvent is flushed off the resultant fibre in the spin heated chamber, also known as the spin column, before winding the fibre on a bobbin. A high technology fibre from the meta-aramid group, known as Kevlar [poly (m-phenyleneisothalamide)] is a popular example of a dry-spun fibre. Wet spinning was the first process to produce a man-made fibre. The process involves a liquid polymer solution which is pumped through the spinneret into a coagulating chamber.

The coagulated fibre is then washed to complete the solvent removal process and often drawn and latter wound on a bobbin Acrylic fibres (polyacrylonitrile) are primarily spun by this method. However, they also can be spun by the dry spinning technique. Gel spinning and liquid crystal spinning are two other processes, which are becoming commercially more promising for high technology fibres. Some scientists believe that gel

spinning perhaps is the only way to produce ultra high strength polyethylene fibre. However, both the processes are still in the development stage.

Depending upon the polymer and the spinning system, commodity fibres are commercially spun at a speed of 1000-5000 metres per minute, although research work has been undertaken on melt-spun fibres produced at a speed of 12000 metres per minute. Most of the high-technology fibres are spun at a reasonably lower speed compared to the speed used to spin a commodity fibre. Spun yarn is often subjected to a process known as drawing. A schematic diagram of the drawing process is given in Figure 4. Drawing introduces orientation and in some cases crystallinity too, into the molecular structure of the fibre and converts the undrawn extruded yarn into a commercially useful material.

The degree of stretch technically known as the draw ratio is set by adjusting the surface speeds of input and output rollers (v and v_1 respectively in the Figure 4) and its magnitude depends on the end use of the material. Drawing is normally accomplished at a temperature above the glass transition point of the spun material.

4 USEFUL FIBRE PROPERTIES FOR TECHNICAL TEXTILES
The long-term durability, dimensional stability, etc.

of technical textiles are functions of many fibre properties. For example, thermal and thermomechanical responses of fibres describe the usefulness of the longterm utilisation of a fibre in a technical textile particularly to be used in a hostile environment such as hot gas or liquid filtration, welders' suits or even textiles used in tyres. The knowledge of various fibre properties thus allows the manufacturers of technical textiles to have a logical

estimation of the suitability and subsequently the durability of the materials used in a particular environment so as to minimise the risks of unwanted failure due to the interaction of stress-deformation-temperature and degradative chemical reactions. Specific fibre properties are measured for the specific technical applications. However, such properties can be grouped into the following classes: (a) mechanical properties: strength or tenacity, extensibility, modulus or stiffness, elastic recovery etc.

b) thermal and thermomechanical responses: melting temperature, high temperature mechanical properties etc. (c) chemical characteristics: resistance to various inorganic and organic chemicals etc. (d) electrical properties: static electricity build-up, dielectric behaviour, insulating nature etc. (e) abrasion and ageing behaviours (f) surface properties: adhesion, moisture transport behaviour etc. (g) optical properties (h) other special properties Tailor-made special properties are very often the features of high-technology fibres.

For example, fibres can be engineered into hollow structures that are capable of providing the varying degree of porosity and strength needed in medical applications such as synthetic blood vessels, controlled drug release etc. ; in chemical/water industry applications such as purification, filtration etc. ; in civil engineering and many other applications. There are many such-tailor made special properties which are developed in a wide variety of high technology fibres.

Table I highlights some attributes of high-technology fibres for technical textiles. These are successfully exploited on a wide variety of technical

textile products to enhance performance. 5 SPECIFIC FEATURES OF SOME HIGH TECHNOLOGY FIBRES

5. 1 Aromatic polyamides (Aramids) A class of aromatic polyamides distinctly different in properties from the conventional aliphatic polyamide was given the name of 'Aramid' by the Federal Trade Commission of the USA in 1974. The first aramid fibre was developed by the Dupont company in USA and was introduced in the market in 1965. This was a meta-orientated aramid called Nomex.

There are two types of commercially successful aramids available.

Technically both types can be classified as high technology fibres. The first type of fibres have high temperature resistance and belong to the meta aramid group. They have moderate tenacity and low modulus but excellent resistance to heat. Their utility is largely based upon combustion.

The fibres in this class show high melting/decomposition points (600-800°C). meta-aramids are extremely useful when outstanding thermal protection (e. g. protective apparel) and electrical insulation properties are required.

Examples of meta-aramids, which are commercially available and widely used

for various applications, are Nomex produced by Dupont and Conex from

Teijin. Figure 5 shows chemical structures of meta and para-aramids. Para-

aramids are mechanically much stronger and stiffer than meta-aramids.

Dupont is the major global producer of para-aramid fibres with a trade name of Kevlar. Currently Kevlar is available in a number of grades (e. g.

Kevlar 29, Kevlar 49 etc.) which have a wide spread of properties. The other

producers of similar kinds of material is AKZO and the trade name of their para-

aramid is called Twaron. Teijin in Japan have developed a copolymer based

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paraaramid like fibre commercially known as Technora. The common feature of all of the above mentioned commercially available para-aramid fibres (irrespective of their total polymeric constitutions) is the presence of the para-orientated phenylene unit in their molecular structures. Normally aramid .

fibres are produced involving a dry-jet wet spinning process as shown in Figure 6. Aramid fibres have tensile strengths at 300°C that are characteristic of high tenacity commodity fibres at room temperature. Para-aramid fibres have even very useful tenacities well above 300°C. In contrast nylon 6.

6 and polyester (PET) lose almost all of their strength at about 220°C. Also aramid fibres retain useful tensile properties after heat-ageing at 300°C for 1-2 weeks. Heat-ageing lifetime of para-aramids are superior than metaaramids. Aramid fibres characteristically burn only with difficulty and they do not melt like nylon 6, 6 or polyester fibres.

They are useful in a number of applications requiring high flame resistance. Upon burning, the aramid fibre produce a thick char which acts as a thermal barrier and prevents serious burns to the skin. Aramid fibres have high volume resistivities and dielectric strengths. They also retain these properties at elevated temperature. Accordingly, the fibres have considerable potential as high temperature dielectrics particularly for use on motors and transformers. Table.

It illustrates some useful properties of para and meta-aramid fibres. Para-aramid fibres are not only very strong and stiff, they also have high dynamic
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energy absorption capacity. High strength, stiffness, excellent dynamic energy absorption behaviour with high fracture toughness of paraaramid create an ideal combination of this material's suitability in ballistic performance. Figure 7 shows the design of a multilayer bullet-proof vest made of Kevlar fabric. Scientists and Technologists have found numerous applications of aramid fibres since their inception and more new and novel applications are being reported regularly. Table III shows some technical applications of meta and para-aramid fibres.

5. 2 Aromatic polyamide-imide Very few polymers suitable for fibre extrusion belong to the chemical family of polyamide-imide. The successful fibre in this category is called Kermel and is introduced in the market through a joint venture between RhonePoulencFibres and Amoco Fabrics. Kermel fibre has excellent inherent fire retardant and dimensional stability, good abrasion resistance and resistance to fraying. It is light and soft.

11 " s average moisture absorption capability and good antistatic qualities. Some useful properties of Kermel fibre are as follows: Amongst suitable applications, the fibre is used in a wide variety of personal protective equipments including the underwear component of racing drivers' suits, fire fighter's vests etc. 5. 3 CarbonThe existence of carbon fibre became known to mankind in 1879 when Thomas Edison took a patent for the manufacture of carbon filaments suitable for use in electric lamps.

However, the actual history of carbon fibre in manufacturing high performance preforms for advanced composites to meet the needs of the aerospace industry began in late 1950s. In the early 60s, a successful

commercial production process for carbon fibre was developed by William Watt and his team at the Royal Aircraft Establishment at Farnborough in the UK. Since then, the carbon fibre market and that of composite products made from it have both been consistently expanding due to the attractive technical properties and excellent performance of the fibre. Carbon fibre is described as a fibre containing at least 90% of carbon obtained by controlled pyrolysis of appropriate fibres.

A large variety of such appropriate fibres which are known as precursors, is used to produce carbon fibres of different morphologies and different specific characteristics. The most prevalent precursors are polyacrylonitrile (PAN), cellulosic fibres (viscose, cotton etc. , pitch and certain phenolic fibres.

Different routes are followed to develop carbon fibres either by manufacturing from fibrous precursors or by the extrusion of pitch. Acrylic precursor produces strongest carbon fibre.

In general, following are three successive stages in the conversion of fibrous precursors into high technology carbon fibres; I. Oxidative stabilisation between 100-400°C depending on the precursors II. Carbon isation between 700-1500°C III. Graphitisation between 1500-3000°C according to the type of final fibre required Carbon fibre is exceptionally strong and stiff.

A balanced match between high strength and high specific stiffness makes carbon fibre undoubtedly an ideal material for aircraft structural composites. The primary reasons for the popularity of carbon fibres and their dominance in the aerospace industry are considered to be as follows: a) Relative to weight, carbon fibres are about 7 times as strong as most metals with

respect to specific strength and about 5 times as strong as most metals with respect to tensile strength. b) They have low expansion and contraction over a very wide range of temperatures. c) They have a higher resistance to fatigue than steel and aluminium. d) they provide a better airworthiness and crashworthiness structure and offer a significant gain in fuel economy.

e) Carbon fibre composites used in aircraft construction reduce overhaul and maintenance costs as metal structures are said to be more prone to cracks and corrosion in service. The main applications of carbon fibres are in the composites used in the following areas: • aircraft and space shuttle (Figure 10) • automotive (Figure 11) • sports and recreational equipment (Figure 12) • marine high performance structures (Figure 13) and general engineering • medical implants (Figure 14) Many of the carbon reinforced composite structures are made from three dimensional woven or knitted preforms. Some of the useful properties of carbon fibres produced from polyacrylonitrile and pitch precursors are as follows: 5. 4 Glass Glass as a material is perhaps as old as civilisation itself, but the use of glass as a high technology fibre is relatively a modern idea.

Glass used as a high technology fibre is made from similar ingredients to any other glass material. Silica is the basis for all commercial glass. They are obtained by fusing a mixture of various metal oxides at temperatures ranging from 1300 to 1600°C. There are different types of glass fibres commercially available all of which have different compositions and very often specific technical significance. Following is an outline of some of the popular varieties of glass: 1.

' A' glass has an alkali-containing composition, sometimes used for fibre manufacture, 11. ' AR' glass is alkali-resistance glass used in the form of fibres for reinforcing cement, 111. ' C' glass has a composition that provides resistance to most of the chemicals, IV. E' glass has an almost universally acceptable formulation and has become a standard for most of the uses in fibre and related 1)10dtlCtS. The letter ' E' stands for electrical, as the composition has the high electrical resistance, V. ' HS' glass is a magnesium-alumina-silica glass contains small amounts of a number of other oxides.

HS stands for high strength. VI. ' S' glass has a composition similar to ' HS' glass which, in fibre form, possesses high strength; the growth of this material in advanced composites is increasing rapidly. High technology glass fibres are normally made in the form of continuous strands. Over 90% of all continuous glass fibres produced are of E' glass composition.

Figures 15 and 16 shows schematic diagram of ' two-stage' and ' one-stage', production processes respectively for continuous glass fibres. Glass fibres are strong, stiff, non-flammable and heat resistant. They are also highly resistant to chemicals, moisture and attack by micro-organisms. The strength of glass fibre can be easily lost by surface damage. In most cases the high performance characteristics are maintained by embedding or coating the fibre in a protective resin.

Glass fibre also suffers from static fatigue i. e. the measured strength decreases with increasing time to failure. Some important properties of glass fibres are given below in Table VI: Glass fibre is extensively used in reinforced plastics (commonly known as GRP) for aircraft and aerospace;

appliances and equipment; construction; consumer goods; corrosion resistant products; land transportation; and sports and leisure items.

Glass fibre is an excellent substitute for asbestos as they are non-combustible, rot resistant, highly stable and do not represent a health hazard. Glass fibre is used in both radial and bias-ply automotive tyre reinforcement. When it is used as a breaker or belt in bias or bias-belted construction in tyre, it provides a softer ride, greater resistance to damage, better stability and lower reinforcement cost. It performs extremely well in long distance driving. Glass is also an attractive additive to cement as it is cheap and easy to blend. Glass fibre is capable of improving the flexural strength of the composite structure.

Glass reinforced cement is used in highway overlay (to provide crack-resistant surface), in architectural building panels, in roofing tiles, in drain pipes (as a replacement for steel-mesh reinforcement). It is also used as a reinforcing material for high speed roadways (Figure 17). A major breakthrough in glass fibre application came, when the material established its potential for use as optical frequency communication wave guides conveniently known as 'optical fibre'. Optical fibres are made from extremely pure silica produced under controlled process conditions.

'They are extremely delicate and need to be handled very carefully (Figure 18). Normally fibre optic cables are reinforced (for protection purposes) with Kevlar yarn. Glass fibres suitable for optical transmission material should not have a transmission loss of more than 20 dB/km. Optical fibres used in

satellite and telecommunication systems are claimed to have transmission loss less than 5 dB/km.

5.5 Polyethylene High technology polyethylene fibres, with exceptionally high strength and stiffness together with unique strength-to-weight ratios are now commercially available from several companies world-wide. The process that dominates current commercial method of producing ultra-high strength and modulus polyethylene fibres follows the solution spinning route. The spinning method for high technology polyethylene uses very high molecular weight polymer and the process is technically called 'gel spinning'. The reason of calling the process gel spinning is the gel-like appearance of the filaments after spinning and cooling.

The process comprises of three main stages; I. the continuous extrusion of the solution of ultra-high molecular weight polyethylene, II. spinning of the solution followed by gelation/crystallisation which can be done either by cooling and extraction or by evaporation of the solvent, and III. ultradrawing and removal of remaining solvent.

A line diagram of the gel spinning process is given in Figure 19. Polyethylene fibre is also produced using melt spinning process. The usage of high strength and high modulus polyethylene fibre is growing rapidly, particularly in certain areas of technical textiles and also in composites. The main attributes of high technology polyethylene fibres are as follows: • high strength and specific modulus together with high energy to break, • low specific gravity, • very good abrasion resistance, • excellent chemical and electrical resistance, • good UV resistance, and low moisture absorption,

Some useful properties of both gel-spun and melt-spun high performance polyethylene fibres are given in Table VII: An impressive combination of fibre properties contribute to the market thrust in terms of the enormous potential application areas of high performance polyethylene fibre.

Some of the growing application areas include sail cloth; marine ropes and cables; protective clothing; composites e. g. sports equipment, pressure vessels, boat hulls, impact shields etc. ; concrete reinforcement; fish netting; and medical implants etc.

5.6 PVAPolyvinyl alcohol fibre has been used in technical textiles since late 80s for its high tenacity, good dimensional stability and high resilience. However, the traditionally spun fibre never received wide acceptance in a wide range of product applications because of its strength retention in presence of water particularly at a high temperature. However, the Japanese manufacturer Kuraray and Unitika have come up with high strength and high modulus gel-spun PVA fibres.

Apart from its high strength and good dimensional stability, the fibre offers good thermomechanical responses at temperatures as high as 170°C. It also provides excellent resistance to flex fatigue and creep. Gel-spun PVA also offers high stability in the presence of water even at high temperature. The gel-spun version of PVA is quite new to the market and is being commercially tried in various products.

The most promising area of gel-spun PVA appears to be in tyres for belt reinforcement and in mechanical rubber goods. Some useful properties of gel-spun PVA fibre are given in Table VIII: 5.7 Spandex fibres This is a class of

synthetic elastomeric fibres (elastomeric fibres are those which have mechanical properties characteristic of rubber). Spandex fibres are manufactured from long-chain polymers composed of at least 85% of a segmented polyurethane.

The segments are based on low molecular weight polyethers or polyesters. The generic name Spandex was given by the Federal Trade Commission of USA. Lycra was the first spandex fibre introduced in the market by Dupont Company in 1960. Today several kinds of Spandex fibres with different trade names are available in the market.

The method of manufacturing spandex fibre depends on the chemical structure of the long chain molecule. Commercially melt, dry and wet spinning techniques are used. Lycra for example is known to be made by dry spinning systems. In wet spinning the reaction to complete the formation of the elastomeric fibre takes place in the coagulation bath (Figure 3). That is why this system of manufacturing spandex fiber is also known as the reaction spinning. Strength (tenacity), breaking extension, power (it is defined as the stress in the material after being held for sometime, normally 5 minutes, at an extension of 300% relative to the un stretched dimensions) and elastic recovery are the novel properties of typical spandex fibres.

Some useful properties of spandex fibres are as follows: Spandex fibres have low tenacities, high extensibilities, low power requirements for large deformations and relatively low specific gravity. Spandex yarns have about the same breaking extension as the natural rubber yarns but they are twice as strong. Also elastic recovery (it is defined as the recovered extension as a

percentage of the imposed extension) of spandex fibres is excellent although actual recovery depends on the amount of stretch, the time for which the specimens are held in the stretched state and the time allowed for recovery. Typical elastic recovery behaviour of spandex fibres after holding specimen in extended condition for 60 seconds at ambient conditions is given below: Spandex fibres are extensively used in sports and leisure garments, foundation garments, support hose etc.

5. 8 Fluorine-containing fibre – The only important fibre in this category is made of polytetrafluoroethylene (PTFE) introduced in the market by the Dupont Company under the trade name 'Teflon'. PTFE was discovered by Dupont Scientist Dr Roy Plunkett shortly before World War II. This polymer is insoluble virtually in all known solvents and, therefore, cannot be solution spun. Also the polymer has high melting point which poses serious problems to produce melt-spun fibre.

The fibre is produced using a novel technique called emulsion spinning. PTFE fibres have high chemical stability, low frictional characteristics, extremely high thermal and electrical insulating power, and very high melting point. PTFE provides excellent resistance to heat over an extremely useful thermal window covering 190°C to 260°C.

It also provides high resistance to fungus and biological agents. PTFE is also well known for its non-sticking behaviour. Apparently it is the most inert material known to man. PTFE fibres are used in highly specialised applications such as high temperature and high voltage (including a wide range of frequencies) electrical insulation, filtration medium for corrosive

chemicals, packing materials for expensive items to avoid frictional damage etc.

Apart from Dupont, Hoechst and ICI also produce PTFE and market them under the trade names Hostaflon (Hoechst) and Fluon (ICI). 5. PBZT and PBO These two fibres have emerged from a class of heterocyclic polymers with some outstanding qualities. Chemically two fibres are poly(p-phenylene benzobisthiazole) [PBZT] and poly (p-phenylene benzobisoxazole) [PBO]. Both the fibres have excellent strength, stiffness, thermal, chemical and environmental stability. However, the compressive strength of these fibres is low.

Some useful properties of PBZT and PBO fibres are as follows: Extremely high thermal and mechanical performance of these two fibres are particularly interesting for high performance structural applications.

Currently the fibres are known to be produced by Dow Chemical Company of the USA. 5. 10 PBI Polybenzimidazole (PBI) was first commercialised by the Hoechst Celanese company in 1983. PBI was initially developed to be used by NASA for nonflammable space research articles.

PBI has since been adopted for other applications and is used either alone or in blends with other fibres. PBI is a high regain and low modulus fibre which is very similar to cotton. It has excellent thermal stability, good insulative qualities and excellent static charge dissipation behavior. PBI fibre does not burn in air (it has limiting oxygen index above 41) nor does it melt or drip. It has good pilling, abrasion and flex resistance and good resistance to chemicals. Some useful properties of the PBI fibre are given in Table XII:

Current applications of PBI fibres include racing drivers' suits, thermal protective clothing for high intensity heat (Figure 20), hot gas filtration.

It is also used to make protective equipment for utility workers exposed to electrical arc flashes, inflammable chemicals and oils etc. It is expected to make inroads into the industrial, civil aviation and fire fighting markets.

5.11 Copolymer polyester fibre The random copolyesters of hydroxybenzoic acid and hydroxynaphthoic acid have been produced commercially by Hoechst Celanese and the fibre is marketed under the trade name Vectra.

The fibre is also produced under a very similar trade name Vectran by the Kuraray Company of Japan. The fibre is melt spun and has a distinct fibrillar structure. Some typical properties of Vectra/Vectran fibres are given below: Vectra and Vectran resist water and assure low-creep characteristics. They provide high wear and bending fatigue resistance.

These fibres can be used as ideal tension members to optical fibre cables, as the core for heating wires in electric carpets, in lane buoys in swimming pools (Figure 21) in high performance ropes, sporting equipment, fishing nets, protective clothing for high risk jobs etc.

5.12 Melamine-based fibres Although melamine is considered unreactive, its symmetry and functionality make it suitable for use as a synthesis building block in condensation reactions with formaldehyde. Initially in the condensation reaction, methylol compounds are formed which then react with one another to form a three dimensional structure of methylene ether and methylene bridges.

The resulting network gives a material that can be extruded into fibres. This melamine-based fibre is available in various forms but the most successful

fibre in this category is marketed by BASF and is commercially called Basofil. Most melamine-based fibres have high heat stability, high solvent resistance, low flammability and good abrasion resistance. The important characteristics of Basofil fibre are its high Limiting Oxygen Index (LOI), low thermal conductivity, good chemical, hydrolysis and ultraviolet resistance with very little hot air shrinkage. Some useful properties of Basofil fibres are as follows:

5. 13 Miscellaneous fibres The above fibres mentioned under different categories are by no means form an exclusive list of fibres used for technical textiles.

New developments such as gel-spun polyacrylonitrile, ceramics, alumina/carbon composite and metal fibres are being successfully used in many technical textile applications. Very specialized materials such as certain types of polyetherimide fibres (already used for hot gas filtration, structural reinforcement etc.), polyoxadiazole fibres (already used in protective clothing etc.), polyphenylene sulphide, poly (p-xylylene) polyetherketone (PEK), polyetheretherketone (PEEK) fibers etc.

are being successfully implemented in new product developments. More information on some of the above fibres is available in author's article on high-performance fibres. The last thirty years have seen the emergence of a number of commercially- successful high-technology fibres. In spite of the high production costs, the high-technology fibre industry has seen phenomenal growth over the last few years. Both the manufacturing and the consumption of many high- technology fibres are still virtually confined to Western Europe, America and Japan. With regard to volume consumption, aramids and glass fibres lead the high-technology or speciality fibres table.

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In spite of the high price of aramid fibres, a phenomenal growth of this fibre in protective clothing (bullet. proof vests, clothing for high-risk jobs and sports) and other technical applications, has shown the significance and need for new materials for many technical textiles. 6 FINAL REMARKS In production and usage of high technology fibres, each material has its own outstanding qualities and defects. Although the 'fast-pace', 'high-quality' and 'high-tech' lifestyle of today's customers encourage demands for new and improved fibres for high-quality technical textiles but economical new high technology fibres with excellent mechanical and other tailor-made special properties are unlikely to appear in the market in the near future. Therefore, market of technical textiles is to be driven by available high technology fibres with fine-tuning of properties and appropriate application of finishes for enhanced performance. REFERENCES 1.

S. K. Mukhopadhyay, 'High-Performance Fibres', Textile Progress, Vol. 25, No. 3/4, 1993.

2. J. E. McIntyre and P. Daniels (Editors), Textile Terms and Definitions, 10th edition, 1995, The Textile Institute, Manchester, 13K. 3.

S. K. Mukhopadhyay, Textile Horizons, June 1992. 4. S. K.

Mukhopadhyay, Modus, Vol. 4, No. 2, 1996 5. i. F. McIntyre.

Conference Proceedings innovative Technologies in industrial textiles, textile institute, February 1990 and ('omposiws. L IIST, Manchester, 1985. 7. M.

Grayson, (Editor), Encyclopedia of Textiles, Fibres and Nonwoven Fabrics, John Wiley and Sons, New York, 1984. 8. Meredith, R. , Elastomeric Fibres, Merrow Publishing Company, 1971. 9.

F. W. Billmeyer, Jr. , Text book of Polymer Science, John Wiley and Sons, New York, 1971. 10.

J. F. Ford, Textiles, Vol. 17, No.

1, 1988.