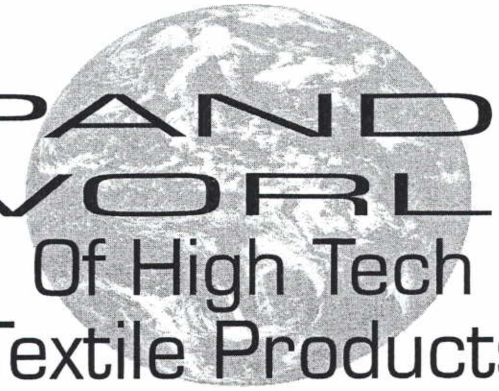

The Expanding World Of High Tech Textile Products

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The high tech fabric sector is increasingly regarded as the Promised Land by many textile manufacturers anxious to lessen their dependence on traditional apparel markets. The lifting of all tariffs and quotas on imported wearing apparel and other textile products, now only a few years away, will further reduce the already shrunken market share of the domestic garment makers and the fabric producers supplying them.

While the U.S. apparel industry is very susceptible to the ravages of foreign imports, the high tech sector seems to be almost immune to them. This is understandable comparing low skill, labor intensive garment manufacture with advanced skill, capital intensive development and production of high tech articles.

Knitters are well aware of the rewards of getting into the high tech products market and many of them attempted to enter it, but mostly with little success. Their failure resulted mostly from their unwillingness or inability to make the difficult transition from apparel fabrics to the manufacture of sophisticated high tech articles, which requires a very substantial investment in R&D, equipment and human resources.

The majority of would be entrants into the high tech fields were discouraged by the long gestation terms of the new developments and the difficulties in meeting involved product specifications, A number of American and foreign knitters, however, persevered in a stressful transition process and weaned themselves away from general apparel in favor of high tech manufacture. Most of them are now enjoying profitable business, virtually invulnerable to predatory foreign competition.

DEFINING HIGH TECH

Let us now attempt to define, if only subjectively, the term "High Tech" that is used with increasing frequency in the industry. What this term essentially refers to is a product involving yarns, structure forming and processing that are not commonly used in textile manufacture, and which must conform to stringent performance requirements, not normally expected with conventional wearing apparel.

A few examples should make this concept clear: A business suit is not a high tech article, but a ballistic suit or vest made with exotic, super-strong yarns, is. A workwear garment is not high tech, but a chemical spill or fire-resist protective garment, is. A walking canvas sneaker is not high tech, but one for athletic performance made with sophisticated components, is. A woolen ski-suit is not high tech, but one made with micro-denier yarns and given special finish for protection against wind and snow, is. Cotton sails are not high tech, but those laminated to a film and reinforced with ultra-tenacity yarns, are.

There are many such examples of regular use articles and their high tech versions for specialty applications. But, high tech products need not necessarily be an improved embodiment of the low tech ones. They can exist on their own merits.

For example, the very light and enormously strong carbon yarn composites for aerospace and engineered components, or polypropylene geotextiles, have no low tech precedents. The same applies to many other sophisticated industrial, medical, protective, architectural, military, marine, sporting, automotive and other fields.

THE HIGH TECH TEXTILE MARKETS (1)

These are growing at a rapid pace. According to one market authority, the world-wide 1995 sales amounted to some $50 billion and are expected to reach $70 billion by the year 2000.

This represents an attractive market with markups significantly higher than those realized in apparel or home furnishings. However, the costs of R & D, marketing, long product testing and evaluation period, liability insurance and high new product failure rate substantially offset the profits.

The importance of the existing and emerging high tech textile markets gave rise in 1986 to an annual exhibition named Techtextil, which attracts hundreds of exhibitors and tens of thousands of visitors from all over the world. It has become a forum for launching new high performance yarns, fabrics, products, coatings, treatments, etc.

Also, special magazines and publications have appeared to service this industry, like: "Industrial Fabric Products Review", "Fabrics & Architecture", "Composite News International", "High Performance Composites", "World Textiles Industry Development", "Technical Textiles" and several others from which much valuable information

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may be gleaned. This also applies to the many patents taken out in the last several decades that an interested reader may peruse with advantage.

Statistics covering the volume and sales value of high tech products are difficult to come by since they are included in the general industrial fabrics market data. According to IFAI (Industrial Fabrics Association International) estimates, the five largest U.S. and Canadian fabric markets in 1994 were: Geotextiles with 435 million square yards; Automotive with 310 million square yards; Safety & Protective, 300 million square yards; Roofing, 115 million square yards; Tarpaulins, 112 million square yards.

The top traditional industrial fabrics in 1994 came to: Awnings, 20 million square yards; Marine, 19.2 million square yards; Tents, 10.5 million square yards; Truck Covers, 18.5 million square yards.

The top specialty industrial fabrics were: Soft Sided Luggage, 56 million square yards; Dry Filtration, 52 million square yards; Casual Furniture, 52 million square yards. U.S. sports apparel, much of which is today classed as high tech, came in 1989 to $11.6 billion at wholesale. Athletic footwear, most of which is considered high tech, amounted that year to nearly $7 billion at wholesale.

HIGH TECH FIBERS (2)

The advanced products are now mostly constructed with high tech fibers, but not always so. In many applications, conventional yarns or staples are used to create a high tech article through certain mechanical or chemical processing or both. Thus, for example, most geotextiles are made in the form of needled felt using polypropylene staple as raw material. Even such common yarns as nylon or polyester may be transformed into high tech variety by mechanical or chemical treatment.

For instance, by stretching the yarns in their drawing stage, it is possible to substantially increase their tenacity and reduce extensibility. By modifying their polymer chemistry, the yarns may be rendered much more flame or UV light resistant. They may also be coated with acrylic to improve their weathering properties. Nylon fibers used for carpeting are now provided with a chemical system designed to make the pile water cleanable, soil shedding, antistatic and recoverable from crushing and matting. The new pillow filler and thermal insulation polyester staple has a hollow, multilobal cross-section to enhance its heat retentive and recovery from compression properties. The list of such examples goes on.

However, the variants, derivatives and modifications of common fibers can only go so far in their quest of high performance. To go beyond their limitations, a new high tech family of "super" yarns has been created by the fiber producers in the last 30 years or so. Such yarns have been engineered to provide exceptional strength, impact or thermal resistance, inertness to corrosive chemicals, weathering, body fluids, low friction, minimal extensibility and other characteristics.

The best known high temperature fibers are DuPont's Nomex and Kevlar, used where exposure to fire, molten metals and other intense heat sources is of consideration in such products as firemen's uniforms, protective suits, outfits for tank crews and racing drivers, thermal insulation, gaskets, and, missile nose cones, among others.

There are at least 15 diverse groups of such fibers, each designed for a specific performance and application. Some have formidable sounding names such as Polybenzimidazole (PBI), Fluorocarbon (PTFE=Teflon), polyetherether (PEEK), Polyacrylate, and PAN/Carbon, among others. Their cost may be very high, with some exotic varieties priced up to $50 a pound. These are used in critically important components where performance, not economics, is the decisive factor. At the lowest end of the cost scale are the glass fibers ($1.50-$5 a pound) widely used in such applications as construction, filtration, plastic reinforcement, fire barriers protective gloves, aprons, and coated fabrics, among others.

Perhaps the most interesting of all the exotic yarns is the carbon variety, which holds the promise of replacing many automotive, aerospace, marine, sports, engineering and construction components, now using traditional metals, concrete and other heavy, corrosion or weathering-prone materials.

Carbon fibers are exceptionally strong. Their tenacity is about 24 gram/denier versus 3.7 gram/denier for nylon. They are much stronger than steel, non-corrosive and can resist much higher temperatures. Carbon yarn uses will be discussed further on.

HIGH TECH FABRICS

There are a number of high tech fabric types and groups used in various fields of the industry. Their diversity is expanding at a fast pace. These fabrics may be either woven, knitted, braided or non-woven. Let us review their main groups in some detail.

Protective Clothing (3): This refers to garments designed either to protect the workers from the hazards of environment or protect the environment from human detritus such as hair, dandruff, bacteria, etc., in the so-called "clean rooms" used in electronic or pharmaceutical manufacture and operating theaters, among other venues.

The protective clothing industry is fragmented and secretive, which makes reliable statistics hard to assemble. It is estimated that this market consumed in 1990 about 120 million square yards of fabric with 65% of them being non-woven, 30% woven and 5% knit. This does not include medical apparel, which consumed 270 million square yards.

The fire and chemical protection segments are growing at a rate of 10% annually. The main categories of protective clothing are those catering to the hazards of fire, extremes of heat and cold, harmful chemicals and gases, bacteria and viruses, ballistic and mechanical penetration, radiation and contamination prevention (clean rooms and asbestos removal).

Of course, not all fabrics going into protective garments are of a high tech nature, but as OSHA, EPA, fire and insurance codes are continuously being tightened, the fabrics are getting more sophisticated and must use exotic yarns or treatments to meet the increasingly stringent

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performance requirements. In addition to using such yarns, the fabrics may be either coated with special compounds or laminated to a film to further enhance their protective characteristics.

Composites (4): Perhaps the most exciting and rapidly growing high tech products are the composites—combination of fibers or fabrics reinforcing the platic matrix. In most cases, composite products feature great strength, corrosion, temperature and chemical resistance at a low weight.

They are much stronger than steel and lighter than aluminum, which renders them eminently suitable for specialty applications in engineering, aerospace, automotive, bridge building, military, sporting, structural, marine and other areas.

Composites consist of layers of fibers or fabrics bonded into sheets with plastics or resins. The fabrics or fibers bear the mechanical load or stress, while the plastic or resin distribute it over the entire area of the part. Composites may be formed into almost any shape and the size of the parts is limited only by the dimensions of pressurized curing ovens needed to bond the materials together. For example, entire aircraft wings are now made with carbon yarn composites, which are extremely strong, light and require no rivets, internal braces and other parts to be assembled.

When optimum strength to weight ratio is essential, then carbon yarns are the obvious option for the engineers. But, for less critical applications, other high performance fibers such as Kevlar (aramid), boron, glass, etc., are frequently employed.

Fabrics for composites may be woven, non-woven, braided and knit. The latter have scored only a modest penetration despite being well suited for many applications involving three dimensional components.

The 1994 U.S. shipments of composite products came to 1.38 million tons as against 1.15 million ton in 1992, according to the Composite Institute. Much information on the subject of composites may be derived from Composites News International published at Solana Beach, Calif.

Architectural and Construction Textiles (5): High tech fabrics are now widely used as the "envelope" of large buildings such as airports, stadiums, sports and exhibition halls, and storage bases for industrial and military supplies, among other types of buildings.

The fabrics are designed to resist extremes of temperature, the effects of sunlight, wind, rain, snow and biological attack. There are several advantages to using textiles in building construction. The biggest are weight and cost. The weight of the fabric "envelope" can be one-third of conventional reinforced concrete or bricks. Building time is much shorter and there is less labor involved.

The textile structures also provide large obstruction-free spans, highly desirable for public gatherings and sporting events.

They are resistant to earthquakes, an important consideration in some geographic locations.

The best known are the so-called membrane or tension structures where the fabric "envelope" is suspended from cables. Most fabrics are woven with polyethylene, polypropylene or acrylic yarns. Some are warp knits using vinyl coated polyester.

Another structural application of high tech textiles is in roofing systems. This is a very large market, almost taken over by single-ply membranes, in most cases reinforced with weft inserted warp knits. Additional information on this subject may be obtained from the Fabrics and Architecture magazine.

Geosynthetics (6): The largest member of this group of high tech fabrics are the geotextiles. These are permeable structures designed to control soil erosion, stablize beaches and riverbanks, reinforce road beds, rail tracks, runways, parking lots, and provide drainage and support for earthworks. Most of the fabrics are polypropylene needle-punched non-wovens. Limited quantities of warp knits of the stitch-through type are used here, but their acceptance is growing.

Another member of geosynthetics is the so-called geomembrane. This is an impermeable, coated fabric designed to serve as a moisture and seepage barrier for lining of landfills, waste ponds and pits, sewage processing installations, settling basins for chemicals and factory effluents, environmental protection and water reservoirs. Warp knit fabrics are used here on an increasing scale because of their availability in very wide widths.

This is a fast growing market because of public support for the ever tightening EPA regulations and also because of the need for containment and clean up of thousands of toxic chemical dumps scattered all over industrial America, many of which are decades old and leaching their poisonous contents into the aquifers and thence into drinking water.

Military and Defense Textiles (7): With the end of the cold war, military strategies are evolving away from massive armies in favor of rapid deployment of specialized strike forces armed with sophisticated weapons and gear.

Many high tech fabrics, products, coatings and treatments have been developed to serve the needs of such forces and turn-of-the-century military in general. Textiles for the military and defense applications may be grouped into two main categories.

1). Protective clothing and equipment, which include battledress and general purpose uniforms, ballistic vests and helmets, aircraft, tank and other fire-resist outfits, chemical and gas protective uniforms, field packs, underwear, equipment belts, masks, gloves, boots, etc.

2). Textiles used in defense systems and weapons, which include tents, parachutes, tarpaulins, cargo and camouflage nets, medical and hospital supplies, sandbags, ammo pouches, blankets, cots, and flags, to name a few.

According to the DPSC (Defense Personnel Support Center) in Philadelphia, the weight of clothing and gear per soldier comes to about 85 pounds and costs $1,452 (in 1991). Some 10,000 items in the armed forces inventory are made entirely or partially from textiles, which the military

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ranks second only to steel in importance to the national defense.

Knitted products of both the warp and weft variety are extensively used in the military for underwear, hosiery, uniform components, mosquito, cargo and camouflage netting, tarpaulins, medical textiles, air-supported buildings, helmet linings, vests for ammo and grenades, etc.

Sports and Specialty Outdoor Apparel (8): This group includes all kinds of sporting outfits, footwear, gloves, rainwear, hunting and cold weather gear. A great deal of effort is being expended in the development of high tech fabrics used in the dozens of sports apparel types, each with its own specialized needs designed to enhance performance and comfort of the wearer, be it a runner, ball player, skier, swimmer or hunter.

Manufacturers of athletic garments and footwear spared no efforts in making them as comfortable, durable and lightweight as possible, while allowing an unencumbered freedom of movement. Professional, team and recreational sports each require different types of garments and fabrics to provide the requisite performance.

One of the great achievements of recent high tech fabrics is the moisture management of the internal (perspiration) and external (rain) variety. It has the facility of evaporating perspiration from the skin, thus keeping the wearer dry and, at the same time, preventing rain from penetrating the garment.

One of the high tech ways of achieving this is by combining the fabric, whether stable or elastic, with special membranes, which feature a very large number of microscopic pores, too small for water droplets to penetrate, but large enough for moisture vapor to escape through the membrane.

Depending on the end use of the garment, the membrane may be laminated directly to the shell fabric or used as a free hanging inset between the shell and the lining or be laminated directly to the lining. Membranes are now incorporated into such apparel types as running suits, gloves, skiwear, golf, hunting and fishing outfits, as well as some types of military uniforms.

A very good example of an advanced high tech fabric is one used in skiwear, which keeps the wearers warm by absorbing the heat from the sun. Here, the fibers are coated with circonium carbide that enables the fabric to generate heat from the suns' ultraviolet rays, as much as eight degrees more than for conventional outerwear.

Sneakers, especially of the athletic type, are another instance of high tech fabric application. Some sneakers have a number of diverse components, each engineered to produce comfort, stability, sure footing, spring, impact cushioning, breathability and protection from injury, among other features. Many of the fabrics used here are knits, mostly warp.

Sports apparel uses very large quantities of knits of both circular and warp types. It should also be noted that there are many warp knit mesh products employed in the sporting fields such as golf or ball targets, tennis or ping-pong nets, ball protective nets, wind fences, enclosures, and others.

Space limitations do not permit an explanation of other product groups using many high tech textiles. These include: soft sided luggage, automotive and aviation, awnings, marine, medical and hospital, outdoor furniture, filtration, agriculture, packaging, and space dividing products.

High Tech Knitted Fabrics (9): These occupy a growing importance in most of the above mentioned fields, although in some, like geotextiles, marine or composites, the penetration of knits is still modest. In others, however, many new high tech products have already been introduced and even more are in the process of development or market evaluation.

Knits have in many cases an advantage over wovens by being more versatile and offering the engineers more design options in building into the fabrics the desirable mechanical characteristics.

Knits have inherent stretch, bulk, porosity, resistance to tearing, moldability and are available in very wide width, of importance in many applications. If stretch is undesirable, the fabric may be stabilized in width or length or both. To impart the fabric a uniform strength in all directions, a multiaxial technique of weft insertion is used.

Another advantage of knits is their relatively short development time as compared with weaving. A circular knitting machine may be set up much quicker than a loom. A warp knit machine takes longer, but is still significantly faster than a loom. A Raschel machine is uniquely suitable for engineering fabrics because of the very large variety of stitch combinations it can incorporate in the fabric structure.

One of the most promising new high tech knit fabrics is the so-called "spacer", a three dimensional product, which is rapidly gaining acceptance in such applications as sneakers, linings, composites, molded products, automotive, cold weather sportswear and gloves, geotextiles, helmets, rucksacks, medical, padding, hazardous work clothing, etc.

While certain types of spacer fabrics may be made on circular machines, the Raschel equipment specially designed for this purpose is much more versatile and can produce spacers in depth up to 30 millimeters.

The number of high tech knitted fabrics and products has become so large that describing them all in detail would be much beyond the scope of this article. The reader is directed here to some of the references on the subject in the bibliography section.

The reader may obtain a considerable amount of reference material from a quarterly publication "Kettenwirk-Praxis" published by Karl Mayer Corp, Obertshausen, Germany. Dozens of high tech warp knit products have been described in that publication, some complete with fabric samples.

Yet another source of valuable information on the subject is the Patent Gazette published by the U.S. Patent Office and available in major libraries. It provides abstracts of the recently issued patents. The knitting patents may be found under Class 66.■

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