HIGH-TECH APPAREL

Growing Area For Knit Applications

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We are living now in a high-tech age, when almost every new product is a result of combined sophistication in technology, R & D effort and manufacturing process. Apparel fabrics are no exception as evidenced by the frequent introduction of new articles endowed with some novel and valuable property, characteristics or performance.

The definition of high-tech is really subjective. One person's mundane or pedestrian may be another's high-tech. This author designates a fabric as high-tech if it has been constructed, finished or processed in a way that imparts to it certain innovative, unusual or hard to achieve qualities not normally available with existing products.

For example, cotton jersey is not a high-tech fabric, but when made with Nomex heat resistant yarn, it becomes one. Also, a nylon tricot cannot be described as high-tech. However, when bonded to a vapor permeable, but water impermeable membrane, it turns into one.

Many common fabrics have been transmuted into high-tech by suitable coating, lamination, calendering, irradiation, etc. or by making them with advanced yarns such as Kevlar, Nomex, PBI, Spectra, etc., which impart superior strength or resistance to penetration, heat, corrosive chemicals, radiation, toxic fumes and other stressful factors.

In many cases, the addition of spandex yarns upgrades the fabric to a status of high-tech. Some new high-tech fabrics, like the two-faced spacers, came into being with the development of sophisticated two needle bar knitting technology and machines.

High-tech products were made a long time before this designation was ever coined. Nearly a century and a half ago, foundation garment fabrics were made using the so called "India Rubber", or as some called it then "Caoutchouc", in the form of elastic sheets or strips bonded to or inserted into knit or woven cloths.

Soon thereafter, a truly high-tech glove fabric was introduced made on a Simplex machine (two needle bar warp knit). It was knit with a high count cotton, then shrunk in caustic soda treatment and sueded to resemble fine leather.

At the turn of the century rainwear appeared made with tightly woven cotton cloths, which when wet caused the yarn to swell so as to close the fabric interstices making it shower-proof, but still permeable to the transmission of perspiration vapor. For this reason they were called "ventile" fabrics.

Fire hoses were made on the same principle. When water was pumped into such a hose, it would leak until thoroughly wet and, as the yarn swelled, the leakage stopped.

Yet another example of high-tech rainwear fabric, decades old, is a product coated with a microporous layer or membrane featuring a network of tiny orifices or pores, too small for water to penetrate, but large enough for vapor to escape.

Finally, the early high-tech thermal fabrics, the Raschel knit "Waffle Cloth" and "Brynje" mesh which were developed almost 50 years ago, long before the designation "high-tech" came into vogue, should be mentioned here.

The term "apparel" encompasses many forms of garments, not just underwear, outerwear, sportswear and the like, but also of the protective kind like bulletproof suits, firemen's gear, toxic chemical outfits, forestry workers chaps, etc.

Then, there are many types of uniforms like military, police, prison guard, aerospace, car and boat racers, mountain climbers and others. Further, there are special outfits for diverse sporting activities like jogging, working out, aerobics, biking, skiing, skating, boating, etc.

Specialty garments such as hunting, hiking and camping outfits, divers' "wet suits", team sports apparel, etc., should also be included here.

Space does not permit enumerating here all the diverse garment types, most of which make use of some form of high-tech fabric. We can only consider some of them, as follows.

Activewear Fabrics: The designation activewear usually applies to garments worn for some form of mild or strenuous athletic activity, be it jogging, golfing, biking, skiing, sailing, skating, etc. In order to perform satisfactorily in these demanding end-uses, the fabrics must combine several qualities:

•Have good moisture management and breathability by removing the perspiration from the skin and transporting it through the wicking action to the surface of the fabric to be evaporated.

•Keep the wearer comfortable by being either cool or warm, depending on the type of garment and its use.

•Provide resistance to the elements like wind or rain.

•Be lightweight.

•Be hardwearing.

•Be flexible to afford freedom of movement.

These requirements are achieved by constructing, treating or assembling the fabric through one or more of several proprietary processes. Most have in common the following elements:

•An inner layer of fabric that absorbs and wicks away perspiration from the skin.

•A layer of microporous coating or membrane to allow evaporation of moisture while keeping out the wind and rain.

•A shell fabric resistant to abrasion and weather.

For cold weather outfits, a layer of insulation in the form of urethane foam or a napped liner is added. The ability to transport moisture away from the skin is essential for the comfort factor.

Du Pont offers several products to achieve this. The best known are Coolmax, ThermaStat and Thermax. For the outer layer, usually hard wearing nylon fabrics in Du Pont's Tactel or Supplex nylon are used. These are often coated with Teflon for protection against rain and stains.

Knit fabrics are the preferred material for one or more components of these products. There are a number of them available on the market on a proprietary basis.

Some of the better known are Darlexx by Darlington Fabrics Corp., Breath-Tex by Aldan Rubber Co., Hydromove by Comfort Technologies, Sympatex by AKZO and Akwatek. (1 - 8).

Rainwear and All-Weather Fabrics: In addition to raincoats, capes, hats, etc.,

there is hunting and hiking clothing, skiwear, fishing, mountaineering outfits, foul weather crewmen uniforms, etc., all calling for effective protection from rain, spray and wind.

The fabrics going into them must be watertight and breathable to a greater measure than those used in activewear. This is accomplished with the aid of membranes permeable to vapor, but non-permeable to rain water.

These membranes are laminated to shell fabrics in a number of ways depending on the proprietary process used. They must maintain their properties through a number of laundering and dry cleaning cycles. Some of the better known products of this type include Goretex, Ultrex, Flametex, BiTech and Versatech. (9 - 12).

Swimwear and Water Sports Fabrics: Modern swim and water sports suits certainly qualify for the designation high-tech. The new swimwear fabrics, mostly warp knits, combine spandex with Tactel or Supplex nylon or other types of polyamides. They are engineered to exacting standards of elongation, power and recovery to assure a flawless fit of the swimsuit. These fabrics must retain their characteristics while exposed to the action of strong sunlight, chlorinated pool water, brine, skin lotions and sand abrasion.

An interesting new development here is the patented Miratex fabric knit with high Lycra spandex content to lend it a much greater constrictive power than normal swimwear materials to shape and sculpt the wearer's figure for a slimmer silhouette. The makers claim the suit will help the wearer look 10 pounds lighter.

Another new fabric, called SunSelect, permits tanning while wearing a swimsuit. It is made with yarn, which lets through the tanning rays while screening out the harmful components.

Yet another high-tech fabric is Microstop made with yarns containing antimicrobial agents to prevent the buildup of mildew.

The growing popularity of scuba diving brought a number of innovative fabrics into this sport. The most important, perhaps, are those used in "body skin" suits worn either alone to protect against the stinging corals or under a traditional "wetsuit" for added warmth and ease in pulling the suit on. Body skins are usually nylon/Lycra warp knits. (13, 14).

Included in the water sport apparel category are the life vests or as they are called now, personal floatation devices (PFD's), which are mandatory to wear in such activities as boating, sailing, water skiing, white water rafting, etc.

There are five basic types of PFD's depending on the particular application or service. Their construction and performance requirements are regulated by the U.S. Coast Guard. Kapok, rigid foam, flexible foam and air bladder provide the buoyancy. The fabrics covering them are in nylon, polyester and coated materials. Certain quantities of Raschel knit mesh fabrics are used in PFD'S. (15 - 18).

Artificial Suede and Leather Materials: Suede-like products came into being in the early 1970s when Toray Industries launched its enormously successful "Ultrasuede" product selling at about $1 an inch at retail.

This became a tempting "knock off" target for warp knitters. They soon developed surface loop fabrics which were sueded into a short pile and crushed in wet processing to simulate the suede esthetics.

Simulated leather is created by coating fabrics with a solid or permeable urethane foam layer. Knit fabrics frequently provide the substrate for such products used in jackets, coats, skirts, pants and boots. (19 - 21).

Fabrics for Protective Clothing: The designation "protective clothing" encompasses a large variety of garments designed to protect the wearer from the action of harmful or life-threatening factors such as toxic gases, fire, heat or cold, hazardous chemicals or waste, medical contamination, bullets or shrapnel, radiation, vacuum or high pressure, cutting slashing or abrasion, dangerous spills, etc.

Garments are also available to protect the work environment itself from the harmful human influence in electronic, computer, pharmaceutical and other industries sensitive to contamination by people-borne bacteria, dust, dandruff, hair, makeup particles and other detritus.

The protective clothing fabric market is quite large and rapidly growing. It is estimated that the current consumption (excluding medical and hospital apparel) is close to 300 million square yards and expanding at a rate of 10-15 per cent per year.

About 30 per cent of the fabrics are woven, 65 per cent non-woven, but only 5 per cent knit. This excludes work gloves, which could increase the knit share by perhaps another percent.

Why do knits have such a modest share in this valuable market? There are several reasons:

•Garment manufacturers are used to working with wovens.

•Knitters have not made a sustained effort to really penetrate this trade.

•Product liability, unlike in fashion apparel, is a real issue here and mandates carrying costly insurance.

•In a number of applications, knits, by virtue of their natural permeability, are just not a suitable material for the purpose. (22 - 28).

Let us review now some of the segments of the protective clothing trade.

Heat and Fire Protection: This applies to firemen's uniforms as well as for workers employed near blast furnaces or other metal smelting activities where there is also a danger of fiery scattering or contact with red-hot bars, plates, etc.

Included in this category are car racing suits to protect the driver from gasoline fires in the event of collision. The tank crew uniforms perform a similar function.

The protective garments are made with fabrics in Du Pont's Nomex, Kevlar and Hoechst's PBI. Knit Nomex underwear is frequently worn under the suits to enhance comfort. (29).

Chemical Protection: There is a vast number of chemicals that present hazards to personnel who work with them and those who clean up spills and toxic waste sites. OSHA estimates that more than 14 million U.S. workers regularly come in contact with hazardous chemicals with some 1.1 million exposed to toxic waste.

In many instances, the chemical protective clothing serves as the only buffer between the workers and serious injury,

sickness or even death.

Chemical protective clothing materials include fabrics, plastics, elastomers and various combinations of these. Knit fabrics are used as reinforcing scrims for elastomerics and plastics. The function of the clothing dictates which materials are used.

Protective suits that must prevent intrusion of chemicals in liquid or vapor form are constructed of thick plastic films, often supported with knit substrates. For maximum protection there are the totally enclosed encapsulating suits made from complex laminates, including several coatings on one or more fabric substrates of knit or woven types.

All materials are tested for resistance according to methods developed by the ASTM (American Society for Testing and Materials). These check for such critical factors as degradation — fabric damage caused by the chemicals; penetration — seepage of liquid or gas through the fabric; permeation — diffusion and adsorption of the chemicals into the fabric exterior. (30 - 32).

Radiation Protection: There are several types of radiation hazards. The best known are the medical and industrial X-ray protection garments or aprons worn by patients and doctors or technicians operating the equipment. The usual shielding material is lead sandwiched inside a fabric or plastic envelope.

Another form of harmful radiation is of the gamma type emitted by radioactive substances present in medical treatment devices, research, nuclear reactors and power generating stations. Again, lead is the most commonly used shielding material.

Finally, there is the non-ionizing radiation hazard encountered by the microwave communication relay towers, high-voltage transmission lines and stations and even around some computer and other electronic equipment. Here, protection is afforded by using metallized fabric substrates. The metal coating absorbs and dissipates the harmful radiation energy. Some warp knit fabrics have been used for this purpose.

Ballistic Protection: Known once as body armor, ballistic jackets, vests and suits have come into wide use by the police, military, and politicians or business executives fearing assassination attempts. They provide significant protection against penetration by bullets or shrapnel.

Originally, ballistic garments were made with nylon, but now the yarn of choice is Kevlar, which affords equal protection with one-third the weight and thickness of the nylon products. The Spectra yarn (high density polyethylene by Allied-Signal) is also used.

There were some early attempts by Celanese to develop a ballistic warp knit fabric (U.S. Pat. No. 3,105,372), but nothing commercial ensued. A few years ago, with the advent of multiaxial warp knit technology, some ballistic fabrics in 1000 denier Kevlar inlays appeared.

Also, a warp knit impact resistant product is now available for lightweight police jackets as protection against stones, blows and other crowd control hazards. The main component is a two needle bar Raschel spacer fabric about 0.4 inch thick.

The pervasive insecurity of streets and growing exposure to armed violence, robberies and kidnapping created a market for ballistic protection in the form of business suits tailored to look like ordinary garments without a hint of their bullet stopping capabilities. They are custom-made at special establishments and quite expensive, but what price safety for those who feel vulnerable. (33 - 36).

Anti-Contaminate Protection: Here, the clothing not only protects the wearer from external hazards, but more importantly keeps the workplace and its atmosphere clean to prevent the human-induced contamination of electronic parts, pharmaceuticals, medical or bacteriological research, analytical work and other sensitive pursuits.

The largest market is in uniforms for the so called "clean rooms" where computer chips and other contamination-prone electronic components are manufactured.

Fabrics used here are woven in filament polyester and coated or laminated to a micro-porous material. In many cases the fabric must be antistatic to preempt a potentially dangerous spark discharge.

A new and large market has developed for asbestos abatement and removal. It is estimated that the total bill for it will come to some $100 billion over the next 25 years. Much of it will go into limited use protective suits, which encapsulate the wearer. The fabrics so far used are of the spunbonded type like Du Pont's Tyvek. (37 - 39).

Cut and Abrasion Protection: This is an important niche market involving gloves, aprons, sleeves and chainsaw chaps. There are more than 1,000 types of protective gloves used by the industry. The auto makers alone have some 200 types.

Construction of the gloves and materials used must strike a balance between the ergonomics, amount of protection required and price. All kinds of materials and fibers are used depending on the particular job application.

Many gloves are knit on specialty automatic V-bed machines, while others are sewn with knit cloths of the tricot or Raschel types. For maximum heat protection, Kevlar, Nomex and other high temperature fibers are used. Where optimum protection against cutting, puncture and abrasion is desired in work situations involving metal and glass handling, stamping, shearing, meat or fish processing, etc., knit gloves with stainless steel wire reinforced Kevlar or Spectra yarns are used. Such gloves have many times the cut resistance of those made with leather. (40 - 43).

Chaps and sleeves are used to protect forestry workers who operate chainsaws and are exposed to the hazard of serious injury from the fast moving chain blade. A good measure of protection is afforded by wearing chaps designed to entangle the chain and its driving sprocket with threads drawn from the chap's fabric. (See Patent Evaluation, page 12.)

Such entanglement stops the chainsaw almost instantly before an injury is inflicted. The chaps are made with specially constructed fabric, which releases much of its thread content when engaged by the chain blade so as to stop its rotation.

The fabrics used here are mostly woven and warp knitted and disposed in several layers for greater protection. About six

square yards of fabric are required per chap unit. The yarns used may be high tenacity nylon or polyester, but the best results are obtained with the para-aramid yarns such as Kevlar. (44 - 46).

Military Fabrics: During Operation Desert Storm, U.S. ground troops required some 85 pounds of clothing and gear (tents, blankets, stretchers, camouflage nets and other textile products) per soldier, worth about $1,450.

Some 10,000 items in the armed forces equipment were made either entirely or partially from textiles and thus ranking second only to steel in importance to the national defense.

In addition to the uniforms, there were protective suits against gas attacks, which did not materialize. In future conflicts, however, there is a possibility of chemical and biological weapons coming into use with dire consequences for unprotected personnel.

To prepare for such warfare, the U.S. military developed encapsulating suits, which are expected to provide adequate protection against the array of such weapons in the arsenal of the enemy.

With the exception of underwear, knits have so far not been a real factor in military clothing, especially of the combat type. The only article made in volume was an army Raschel mesh jacket used to carry grenades and ammunition clips. (47-48).

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