Holy Cross Home Science College, Thoothukudi – 03

Department of Fashion Designing and Apparel Making

Semester V - Major Elective - Technical Textiles – SEFD5A

Syllabus

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Unit – I **(12L)**

Technical Textiles – Definition and Scope, Categories of Technical Textiles

Unit – II **(12L)**

Medical Textiles – Classification, Fibers used and their properties required, Medical textile Products – Properties, functions.

Unit – III **(13L)**

Geo Textiles – Definition, Fibers used in geo textiles – requirement of fibers.

Functions of Geo Textiles – Separation, Filtrations, Drainage, Reinforcement

Unit – IV **(11L)**

Textiles for automotive industry. Suitable fibers for automotive industry

Safety devices – Airbags – Materials used – Types of fabric – Seat belts – Types, Fabrics used.

Unit – V **(12L)**

Brief study on Protective textiles – Bullet Proof fabrics – fire retarding fabrics – high temperature fabrics – High visibility clothing. Fibers used and properties of fabrics, smart textiles and intelligent textiles.

Unit – I

TECHNICAL TEXTILES

Definition

Technical textiles are textile material and products manufactured primarily for their performance and functional properties rather than aesthetic or decorative purpose. The performance and functional properties are in sense with the agricultural to aerospace application.

Scope of technical textiles

- Increased number of textile product for performance, decorative properties and functions in equal measure (eg) fire retardant, furnishing and breathable leisure wear.
- Technical textiles is one of the most dynamic and broad ranging areas of modern textiles, materials, processes, products and applications.
- Now a demand in global market in various application namely, eco, defence, geo, protect, industry, home tech, cloth tech, sports, packs, medical, build, mobile.
- The applications provided scope for making various products (eg) car to parachute, shelter fabric to home furnishing infra-environment, hospitals.
- The usage is growing at an accelerated pace
- Latest developments in advanced flexible materials, like computing and communication, biomaterial, manotech and novel process such as plasma treatment.
- Implant, electronic, wiring, interactive, sensor materials.
- There is a growth in product and manufacturing technical.
- Their application range from tyre cord reinforced composites for body, medical.

Categories of technical textile

Agriculture textiles

Textiles used in agriculture is termed as agro textiles. The essential properties required are strength, elongation, stiffness, porosity, bio-degradation, resistance to sunlight and resistance toxic environment. The applications include all activities concerned with the growth and harvesting of live products and foodstuffs, such as gardening and landscaping, agriculture, forestry, animal husbandry and in fences.

Industrial textile

For industrial applications and in power transmission technical textiles are used in conveyer belts. Carcass is a fabric inside the conveyor belt, which is responsible for the strength properties of the belt. The carcass is made with layers of woven fabrics bonded together. Skim an adhesive layer used between the plies and carcass to enhance the bonding, which is made up of open weave fabric. High strength, shape retention, abrasion resistance and good UV resistance are required properties for carcass and skim.

Geo textiles

Woven and nonwoven materials used by the civil engineering industry to provide support, stability, separation and drainage or below ground level. The application areas included are civil engineering, earth and rode construction, dam engineering, dump construction, soil sealing and in drainage systems. Strength, extension, durability, low moisture absorption, puncture resistance, thickness, good hydraulic properties and transmission properties, biological heat and chemical resistance are the essential properties for the geo textiles.

Protective clothing

Protection against heat, flame, water and hazardous environment are obtained by suitable usage of the technical textiles with high performance fibers. Based in usage chemical resistance, durability, moisture absorption comfort, cut resistance and impact properties are required.

Mobitech

The scopes of mobiltech are plenty. Application areas are : construction, shipbuilding, aerospace, rail vehicles, motorcycles bikes, air bags, tyres. Each car has to utilizes at least 17 kgs of materials. Essential properties are good sound absorbency, UV resistance, strength retention durability, formability, filtration efficiency and abrasion resistance, bursting and degradation resistance.

Buildtech

Textile and composites materials used in the construction of building, dams,tunnels and roads. The application are in form of membranes, lightweight solid constructions (awning and canopies), civil and industrial engineering, temporary construction, interior constructions, on earth, in water and traffic road construction. Glass, polypropylene and acrylic fibers are used to prevent cracking of the concrete, awning is an architectural projection that provides weather protection, is an identity or decorative and wholly supported by the building to which is attached. Canopy is also an architectural projection comprises of a rigid structure by the building to which is attached. Fabrics used for roofing needs, some special quality like whether resistance, UV resistance. A range of coated fabrics used for roofing purpose coated roof over a play ground with a capacity of 64000 seats stadium is one of example for new technocrats visin.

Hometech

Textile and composites used in the furniture, upholstery and interior furnishing, carpets, floor coverings. Depends on the environment and place, the selection of the fibric has to be made.

Medical textiles

The applications are in health, hygiene and rescue services. It is commonly used as sutures and bandages. The properties required are bio-degradability, fungal and microbial resistance and suitability to human body. Biotextiles is a term used in the medicals textiles applications, these are textile elements used in terms biological environments. This performance depends on the interaction with the cells and biological fluids in terms of bio-stability and biocompatibility. The bio textiles classified in to following in main classes. 1. Grafts 2. Implants 3. Protheses 4. Sutures and wound dressings 5. Slow release drug delivery systems.

Grafts are the structure placed inside the body to the damages or malformations. Grafts are made from variety of materials ranging from silk protein to modern synthetic polymers. Examples of grafts are vascular grafts and stent grafts. Implants are textile structure used for tissue reconstructions and growth. It is used in hernia repair and pelvic injury repair this are made from woven, knitted and braided structures.

Prostheses used to replace damaged body parts such as teeth, limps or eyes. Sutures part wound dressing used for a very long times. It passed through wide revolutionary stage from silk to synthetic fibers. Slow drug delivery system are gradually gaining importance over the conventional dosing systems. Hollow fibers with nano particle based system used for the delivery of drug to a specific part of a body prevent over dosage.

Oeko textiles (eco)

These are the ecofriendly textiles, known as oeko or eco textiles. They are mostly used in environmental protection applications floor sealing, erosion protection air cleaning, prevention of water pollution, water cleaning, waste treatment, recycling, product, extraction, domestic water servage plants (eg).

Packing textiles

Known as packing textiles these have been used for packing. It ranges from heavy weight woven fabrics used for bags, sacks, wrapping for textiles baler and carpets to the light nonwens used as durable papers, tea bags and the food industrial product wrappings.

Sports technical textiles

Sports technical textiles used mainly for sportswear including shoes and other sports accessories. They are used for flying and sailing sports, climbing, cycling etc. has bed to the immense growth in the consumption of textile materials in sports related goods and equipments. Synthetic fibers counting and have replaced traditional cotton and other material fibers.

Cloth textiles (footwear & cloth)

This include all those textile products that represent functional, most hidden components of clothing and foot wear such as interlining. Sewing threads, insulating fiber fill and wadding. They are the high performance garment fabrics whose demand is on the increase.

Intelligent textiles

Textile products, which are, respond to the external stimuli for specific purpose are called intelligent textiles. These are classified as

Textiles incorporating phase change materials (PCM)

These materials used in clothing as encapsulated from to change from it phase, from solid to liquid and to vice versa to maintain a comfortable body temperature in sever conditions. The energy stored or related by the phase change materials (e.g. paraffin) depending on the activity of wearer. This may be used in the car seat covers, gloves boots and hates. It is used to prevent them from over cooling.

Textiles incorporating chromic materials

Shape memory materials are those, which can revert from the current shape to previously held shape, usually due to the heat, these shape memory polymers properties below and above its standard temperature. These materials are used in medical applications, for maintains of body temperature.

Textiles incorporating chromic materials

Materials, which are changing chromic color reversibly according to the external environment conditions. These are photo chromic and thermo materials. Photo chromic is a chemical process in which a compound under goes a reversible change between two states having separate absorption spectra. Thermo chromic system heat change the color of chromophore. On removal of heat source the color reverses to it thermally more stable state. Photo chromic and the chromic materials are used for fashion and military clothing.

Unit – II

Medical Textiles

Introduction

The textile products are used in medical and healthcare sector in various forms. The complexity of applications has increased with research and development in the arena of medical textiles. The surgical gown, operating room garments and drapes require special antibacterial properties combined with the wearers comfort.

The scope of medi-tech embraces all textile materials used in health and hygiene applications in both consumer and medical markets. Depending on the nature of application many medical products are disposable and made out of nonwoven fabrics.

Definition

A woven material or a material suitable for weaving which can be used in the medical sphere.

Classification of Medical Textiles

The medical textile products can be classified as

- **Non-implantable materials** – Bandages, Wound Care, Plasters, Gauze
- **Healthcare / hygiene products** – Surgical Clothing, Covers, Beddings
- **Implantable materials** – Sutures, Soft tissue implants, Hard tissue implants
- **Extra corporeal materials** – Artificial Kidney, Artificial Liver, Mechanical Lungs

The majority of the healthcare products manufactured worldwide are disposable, while the others can be reused.

I. NON IMPLANTABLE TEXTILE MATERIALS

1. Bandage

A bandage is a piece of material used either to support a medical device such as a dressing or splint, or on its own to provide support to the body. It covers and protects an injured part of the body. They are available in a wide range of types, from generic cloth strips to specialized shaped bandages designed for a specific limb or part of the body

2. Gauze Bandage

It is made of thin and loosely woven plain fabric with a very open weave which is air permeable and absorbent

Gauze Bandage

In the medical sense, gauze is a highly absorbent material, classically made from cotton. Medical gauze is often saturated in an anti bacterial solution to reduce the risk of infection, also treated with clotting agents, to stop bleeding on wounds. “It is used primarily on wounds of fingers, hands, feet, toes, eyes, ears and head.

Absorbent pads are also available as individual single use items. They are cotton pads covered with a gauze cloth. Non-adherent dressing are applied to avoid adhesion when dealing with large area wounds such as burns and skin grafts. They are paraffin gauze dressing having a soft paraffin base. These dressing are also medicated with an antibiotic or any topical antiseptic or any topical antiseptic.

Perforated films or also available as individual singe use items. They are cotton pads covered with a gauze cloth. Non adherent dressing are applied to avoid adhesion when dealing with large area wounds such as burns and skin grafts. They are paraffin gauze dressing having a soft paraffin base. These dressing are also medicated with an antibiotic.

Inelastic bandage are medication cloth bandages. These two bandages are grouped together as adhesive bandages and they have a layer of adhesive impregnated on the cloth layer. Orthopedic cushions are made of cotton and synthetics. These bandages retain their cushioning effect in the moist atmosphere between skin and plaster.

Lint is used as wipes or swabs for primary cleaning of wounds before applying the dressing. Wadding is single use cotton pieces in demand abroad. In India for clinical practice as well as domestic purpose cotton rolls are preferred pieces of cotton are removed as and when required. In the foreign countries sterile single use cotton wadding are highly popular.

3. Support Bandage

A support bandage is a form of bandage that assists the healing of injured muscles and bones, helps to reduce bleeding from a wound, or provides support to prevent injuries from occurring. First aid kits consist of a variety of supportive bandage like elastic bandage, adhesive bandages, compression bandages, etc typically made of materials such as cloth or elastic.

The type that should be used varies based on the situation and on the intended purpose of the dressing. A bandage should not replace medical treatment, but rather offer support to the affected area until the injured person can been seen by a doctor.

Different types of supportive bandage

a. Compression bandage

This bandage is made up of a stretchable fabric that is wrapped multiple times around a body part and can be secured with metal clips. It can be used to restrict the blood flow to an injured area. It can also be used on other areas of the body to secure a splint.

b. Cloth compression bandage

It is often used to offer support against injuries to various body parts while participating in sports or exercising. These supportive bandages can help to prevent damage and injury to the area in which it is applied. Many athletes use cloth bandages to cover areas most likely to be harmed, such as the joints.

c. Pressure bandage

It is a form of support bandage that can provide assistance in decreasing the amount of blood loss caused by an injury. In extreme cases, a pressure bandage is applied over gauze in order to apply extra pressure, to stop blood flow from a wound. Small adhesive bandages can also be considered pressure bandages, as they help to stop the bleeding of minor cuts and abrasions. They also act as a sterile bandage to keep the area free of germs and infection.

d. Crepe Bandage

Cotton crepe bandage consists of characteristic fabric of plain weave in which the warp thread are of two fold cotton threads, “Crepe twisted to contain not less than 17 turns per cm” and the weft threads are of cotton, of viscose or of combined cotton and viscose yarn. “The warp threads are arranged two threads S twist and two threads Z twist repeated”.

Applications :

- General surgical, orthopedic and sports injuries
- Extremely convenient as a pressure dressing and for skin grafts
- Can be used for sprains, aches, dislocation, painful joints, veins cramps
- Very useful for muscular support

4. Elasticated tubular bandages

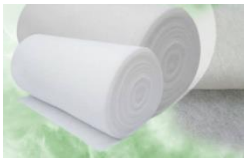
Elasticated tubular bandage consists of knitted fabric of 1:1 ribbed structure, in tubular form, into which elasticated threads comprising a core of 50s lycra, double covered with multifilament crimped polyamide or polyester, are laid in the ratio of one elasticated thread to two or more courses of singles yarn spun from cotton or a blend of cotton and viscose fibers. It is manufactured on a circular knitting machine.

5. Stretch Bandage

Stretch bandages are made of the fabric which is slightly stretchy so that it can wrap easily around difficult to bandage areas, such as elbow or knee joints. It can be classified into two types in relation to amount of stretch i.e. Short stretch bandage and long stretch bandage.

5. a. Short Stretch Bandage

This kind of bandage puts pressure on the skin and muscles to improve absorption of fluids. As the person moves the injured limb, usually an arm, leg, or hand, the bandage provides a massaging action on the muscles that could speed up the healing process. It is generally comfortable for long term wear and do not have to be removed overnight.

a) Tube Fabric b) Padding c) Short Stretch d) Wrapping of short

Uses of stretch bandage

- A short stretch bandage is a used to reduce swelling in a limb
- Short stretch bandages are often used as one layer in a system of three or four layers of bandaging for compression treatment of patients with chronic swelling issues
- Short stretch bandages are also used in the treatment of lymphedema, which is swelling caused by a blockage in the lymphatic system.

5. b. Long stretch bandages

Long stretch bandages have the ability to stretch quite far, usually more than twice their original size. However, they also have a very high resting pressure and must be removed at night or if the patient is in a resting position. “Long stretch bandages do not provide the massaging effect that the short stretch bandages do”.

Application of Long Stretch Bandage

Uses of stretch bandage

- Long stretch bandages are used for athletic injuries. They are used to wrap sprains or other soft tissue injuries

e. Unconventional bandages

Unconventional bandages are those which are designed and engineered to meet specific requirement. Recent advances in bandages are antibacterial bandages, drug releasing bandages, specially coated or treated bandages, smart bandages and so on.

f. War bandage

“Unstoppable bleeding is one of the leading causes of death on battlefields”. For this reason, war bandage is specially developed which contain shrimp based chitosan molecules. The chitosan has a positive charge. The outer membranes of our red blood cells have negative charge which is attracted to the positive charge of the chitosan. As soon as they touch, the red cell fuses and forms a clot against the chitosan, which forms a very tight, adherent clot, and a tight adherence to the surface of the wound in one to five minutes. The Food and Drug Administration approved these bandages for human usage, but presently they are exclusively sold to the Army.

g. Drug releasing bandages

These are the adhesive bandage specifically designed to provide medication through skin, rather than protecting a wound. It is also called transdermal or skin patch. Skin is the largest and most accessible organ of the human body. Transdermal drug delivery is the non invasive delivery of medications from the surface of the skin through its layers, to the circulatory system. Drug releasing bandage is a medicated adhesive pad that releases the active ingredient at a constant rate over a period of several hours to days after application to the skin. It uses a special membrane to control the rate at which the drug contained within the patch can pass through the skin and into the bloodstream. Medical patches includes nicotine patch (help smokers to quit smoking), scopolamine (for motion sickness), estrogen (formenopause and to prevent osteoporosis after menopause), etc. Non medicated patches include thermal and cold patches, weight loss patches, nutrient patches, skin care patches (therapeutic and cosmetic), aroma patches, etc.,

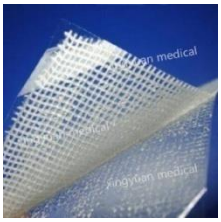
h. Plaster of Paris Bandage

The plaster of Paris bandages are made of cotton gauze material of leno weave cloth. The interlocking thread is impregnated in the plaster of Paris solution and dried to get the bandages. Traditionally cotton gauzes were used for dressing because of their good absorption property and softness. Even today hospitals use the gauze for dressing purpose mostly in layers to form swabs for better and higher absorption

6. First Aid Dressings

A first aid dressing consists of an absorbent pad covered with an anti-stick material fixed to a self adhesive plaster. The pad and the adhesive margin are covered with a suitable protector. The pads are medicated with any permitted antiseptic. The dressing may be sterilized or medicated. The self-adhesive plaster can be film or fabric based. If it is film based, it should be perforated throughout and if fabric based, it may be perforated and the edges shall not show fray. The fabric shall be plain woven and made from cotton rayon or a blend of cotton and rayon.

7. Paraffin Gauze Dressings



The paraffin gauze dressing is fabricated using open weave leno gauze with interlocking threads. The paraffin acts as a soothing agent and it contains antibiotic / antiseptic that helps in the healing process. Coated with soft paraffin jelly, it is mainly used on the uncovered areas. These dressing is gamma sterilized, non allergenic and non adherent, that helps in the speedy recovery of wounds. These are mainly used for the treatment of wounds such as burns, scalds, skin grafts etc.

Wound Care Products

Wound care products include wound contact layer / absorbent pad / base material / perforated films, while bandages include inelastic bandages / elastic bandages / light support bandages / orthopedic cushion bandages / plasters / wadding / gauzes lint.

Wound healing is a dynamic process and the requirements of dressing change as the wound healing progresses and no single dressing is universally available for all types of wounds. Wound dressings were some of the earliest forms of medical textiles and lately have witnessed rapid developments. Wound healing depends not only on medication but also on the use of a proper dressing technique and settable dressing material.

The prerequisite of wound dressing are : ease of application, good padding characteristics, non-sticking nature of the wound and painlessness on removal creation of an optimal environment for wound healing, softness, pliability, high absorbency etc.

Modern wound dressing are composed of absorbent layers held between the wound contact layers and a base material. The wound contact layer is generally placed directly over the wound and covered with an absorbent pad and the whole dressing retained with a base material. The wound contact layers has low adherence and can be easily removed without disturbing new tissue growth. The wound contact layers made of silk polyamide, viscose, polyethylene is of woven or non woven material, The absorbent layers is of non-woven type made of cotton, viscose, acrylic etc. Viscose helps to absorb the fluid while acrylic the fluid while acrylic helps to maintain the thickness of pad even after absorbing the fluids. The base material is non woven or woven type made of viscose or is a plastic film.

Plasters

Medical plasters are being produced in different forms and sizes. Non-woven textile (resistant to X-rays) and woven textile (silk, cotton or viscose fabric) as well as plastic foils are used as underlying material for plasters. The coating can be made of hypo allergic and Zinc-oxide glue. The plasters can be made with or without anti-septic pad.

Medical plasters are widely used for healing and protection of the smaller wounds, burns, corns, relieving rheumatic diseases/pains, as well as for hospital usage for fixing bandage materials, compresses, injection needles, cannulas, catheters

II. HEALTHCARE AND HYGIENIC PRODUCTS

1. Baby Diaper

Diaper is used for wrapping the newly born or young children, who have not developed the fixed routine for making water or latrine. Diapers retain the liquid for about two hours or so. First and foremost, to absorb the urine during the miction, is the key requirement of material.

Composition of diaper

Core (70%) : It consists of mainly pulp and a super absorbent material. Polypropylene (10%) : Most diapers have a PP top sheet which protects the baby's skin from re-wetness. Polyethylene (13%) : The back sheet of diapers consists mostly of polyethylene and provides leakage protection for the baby clothes. Other Components (7%)

Important properties required for the baby diaper

- Diapers should be soft
- It should have high absorbency while creating little or no irritation to babies. Diapers should absorb 30-60 grams urine without feeling wet. The desired rate of absorption should be very fast. i.e. within 5 to 7 seconds
- It should provide protection against leakage and it should not re-wet.
- It should be comfortable and should have good fit and it should be environment friendly disposable

2. Incontinence diaper

Incontinence diaper also known as adult diapers are for people with loss of bladder control which typically applies to people in the age group of 70 years and more. Incontinence diapers are disposable single use products specifically designed to absorb and retain fluids. The diapers are typically made of the absorbent material of cellulose with poly beads to convert fluid into gel. The non woven material is placed on top for dry feeling.

3. Sanitary Napkin

During menstruation, use of some kind of a protection in the form of a pad or napkin is mandatory. The kind of sanitary protection practiced during menstruation can determine the hygiene status of a woman, which can affect her reproductive health levels. A sanitary napkin basically comprises of three layers; top layer, absorbent layer and barrier sheet. The absorbent layer is the key component of the napkin and the extent to which this layer is able to absorb and retain the fluid determines the efficiency of the napkin

Sanitary napkin is a hygiene absorbent product used by women during menstrual periods. Sanitary napkins are essentially made by a sandwich of an absorbent paid between fabric sheets. The technical textile component of the diaper is the non woven fabric which prevents fluid leakage. The non woven fabric is 18-20 GSM and accounts for around 11-12% by weight of the sanitary napkin i.e. around 0.95 to 1 grams per napkin.

4. Surgical Gown

Surgical Gown is a medical device intended to be worn by operating room personnel during surgical procedures to protect both the surgical patients and operating room personnel from transfer of microorganism, body fluids, and particulate material. Two kinds of surgical gowns are being used which come under the categories of disposable i.e., single use type, made up by nonwoven techniques and other type of surgical gowns comes under reusable category and normally developed through weaving.

Surgical gowns are considered one of the most important protective items during surgical procedures. Sterile surgical gowns play an essential role in maintaining aseptic conditions by blocking the transfer of harmful microorganisms and chemicals to and from the patient, and reducing the transfer of bacteria from the skin of the surgical staff to the air in the operating room.

Wearing surgical gowns and other medical apparel (e.g. surgical masks, gloves, etc.) is of utmost importance as there will always be microorganisms present on or in the human skin, even after conducting strict hygienic and surgical scrubbing procedures. The purpose of surgical gowns and other protective clothing is not only to keep bacteria from entering surgical wounds, but to also protect the surgical staff from bodily fluids, secretions or excretions like blood, urine, saline, or chemicals used and during surgical procedures.

Types of surgical gowns

a) Surgical Gowns

1. Usually packaged as sterile products or designed to be sterilized
2. Some are disposable and others are made of fabric that is labeled as washable for multiple use
3. Come in various sizes, including one-size-fits-all
4. Made of fluid-resistant materials to reduce the transfer of body fluids

b) Isolation gowns

1. not sold as sterile products
2. usually intended to protect the wearer from the transfer of microorganisms and only small amounts of body fluids

c) Gloves

Gloves are the most common type of personal protective equipment (PPE). Gloves are considered a barrier protecting both you and your patient from the transfer of harmful microorganisms. Always use gloves when you work on a patient. Hygienically prepare your hands before gloving and clean your hands again after removing the gloves and before moving on to your next patient. Gloves are absolutely essential when you have an existing cut or small wound on your own hand and when you are touching any bodily fluid/secretion/excretion.

Requirements for surgical gowns and drapes

General requirements	**General requirements from the perspective of users**	**Requirements from the perspective of surgeons**	**Requirements from the perspective of patients**
Barrier function (against the penetration of germs)	Protective function	Germ barrier	Protective function
Prevention of germ transmission	Liquid tightness (resistance to liquid penetration)	Protection against injuries to the patient	High cut resistance
Protection of the patient	High cut resistance, tensile strength and tear propagation resistance	High tensile strength	Liquid tightness
Protection of the user and Skin compatibility of the tapes	Well sealed seams	Good adhesiveness of the tapes	High tensile strength and tear propagation resistance
Can be processed without losing quality	High product safety	Liquid tightness including in operations with large quantities of blood	Good stretch ability when dry and wet
Sets can be composed individually	Low flammability limit (when working with electricity, especially in HF surgery)	Absorbency/high liquid absorption with the drapes	Good adhesiveness of the tapes including when drenched
Good drapability	Easy handling and Easy storage and Easy to remove packaging		Easy to remove the tapes
Antistatic properties and Low flammability	Practical composition/correct sequence of the sets		Prevention of cooling and Delay of heat loss
No unpleasant odors	Easy to remove the protective adhesive strip		

The desired characteristics of surgical gowns should be

1. Should be resistant to penetration by blood and other body fluids as necessitated by their intended use (data verifying that the gown materials are protective barriers against the transfer of microorganisms, particulates, and fluids to minimize strike-through and the potential for personnel contamination should be obtained from the manufacturer)
2. Should be durable
3. Should be constructed of materials that are appropriate to the method(s) of sterilization (e.g., radiation, steam, and ethylene oxide)
4. Should be resistant to tears, punctures, and abrasions
5. Should be durable enough to last the intended useful life of the garment, be that single or multi use.
6. Should be designed to fit a diversity of body shapes and sizes with a limited range of sizes as hospitals will only stock limited quantities.
7. To have an acceptable level of quality (i.e., be free of holes and/or defects)
8. To resist combustion, i.e., gowns selected for use should be consistent with accepted flammability standards that will provide the safest environment for patients and health care workers
9. To be comfortable
10. To contribute to maintaining the wearer's desired body temperature, i.e., have the ability to maintain an isothermic environment for the wearer
11. To be as lint-free as possible
12. To be free of toxic ingredients and allergens (patients and/or health care workers may experience untoward reactions to toxic ingredients and/or allergens)
13. To be flexible, i.e., the gown conforms loosely to the wearer's body
14. To have limited memory
15. To be of adequate size to allow for complete closure in the back
16. To be of adequate sleeve length to prevent cuff exposure outside the sterile glove
17. To have a favorable cost-benefit ratio, i.e., cost should not be the primary consideration in the selection process.
18. To control the bacteria released into the theater and aid in maintaining the sterile zone required for patient safety.
19. To provide for easy donning and doffing without contamination, yet not have openings where the barrier might be breached.
20. To maintain their integrity
21. To fit closely but not restrict movement. Since there is generally excess fabric, the gowns must withstand constant pulls on the fabric during routine movements.

22. Surgical gowns must repel diseases and infections yet provide adequate freedom to move.
23. It should allow necessary mobility without rubbing and chafing, and must resist tearing and linting.

d) **Boots**

Theater boots

The operating theater can be a messy/bloody/gutsy place. Surgeons often wear waterproof boots as a protective measure from contamination with blood, puss, amniotic fluid etc**.**

Boots for emergency workers

Boots should protect your feet. Steel toe are best for this purpose. It should be water-proof, flexible and they must be exactly the right size. They should also be able to protect you against cold weather and punctures. The soles of your boots must provide good traction to prevent you from slipping and sliding down slopes.

e) **Shoes**

Shoe covers are important as they help maintain a sanitary environment by eliminating tracked-in dirt and microbes and they protect the wearer from accidental spills and bodily fluids. Always use shoe covers when entering the operating room or Intensive Care Unit. Alternatively use dedicated surgical boots or shoes.

f) **Surgical caps**

Even clean recently washed hair is contaminated with loads of bacteria. The surgical cap minimizes the risk of hair falling into the sterile area during surgery. Ensure that all your hair is covered by the surgical cap before proceeding with scrubbing for surgery!

g) **Masks, Visors/glasses**

A face masks is worn as a barrier to protect the patient against the transfer of harmful microorganisms present in the healthcare professional saliva, nasal discharge and facial hair, and to protect the healthcare professional from being infected by microorganisms present in puss, blood, other body fluids, secretions (e.g. saliva) or excretions (e.g. feces) by the patient.

Medical professionals should wear a mask and eye protection or a visor (face shield) to protect mucous membranes of the eyes, nose and mouth during procedures and patient-care activities that are likely to cause splashes or sprays of blood, body fluids, secretions or excretions. Masks should be worn at all times in restricted areas of the Operating Room – where sterile supplies are opened and at scrub sinks. Masks with face shields or masks and protective eyewear are required whenever splash, spray or droplets of blood or other potentially infectious materials may be generated.

h) **Apron**

Some surgical procedures may become really 'messy' – thus the surgeon needs to protect him/herself by wearing a waterproof apron. Surgical procedures where a lot of bleeding of spill of bodily fluids like amniotic fluid e.g. during a Caesarian section are examples where an apron is needed.

i) Bedding

Antibacterial, anti allergic and anti dust mite textiles are extensively used to manufacture hygienic bedding for hospitals and domestic use.

The common products in this category include Pillow Encasing, Allergy Resistant Mattress Covers, Comforters and Mattress Cushions, Comforter Covers & Inter liners, Washable Pillows, Blankets, Quilts. These textiles are usually made from Polypropylene, Trevira CS Bioactive, a specialty polyester fiber, nylon, cotton mixed with acrylic or polyolefine yarn etc are being used to produce antibacterial, anti allergic fabrics. The textiles are often coated with silver due to its medical and therapeutic benefits.

Unique features of technical textiles used for making bedding are-

- Posses high antibacterial activity while maintaining wide-range biocidal properties.
- High absorption capacity
- Create a zone of inhibition beyond the surface of the fiber.
- It inhibits the growth of odor causing and numerous other bacteria and fungi.
- It lasts wash after wash for the life of the product.

III. IMPLANTABLE MEDICAL DEVICES

1) Surgical Sutures

The surgical suture is used for stitching together skin deformations, open wounds, organs and blood vessels. The surgical sutures are classified into two categories

- Absorbable suture - These get dissolved in the body and do not require removal
- Non –absorbable suture - These are sterilized sutures which need to be removed after a specified time

The type of suture used depends upon the location of the required surgical intervention. The raw material for suture ranges from bovine intestine tissues to Poly glycolic acid (PGA), collagen, mono filament polyester / polypropylene and multifilament nylon / polypropylene / polyamide.

Sutures for wound closure are either monofilament or multifilament threads that are categorized as either biodegradable or non biodegradable. Biodegradable sutures are used mainly for internal wound closures and non biodegradable sutures are used to close exposed wounds and are removed when the wound is sufficiently healed.

2) Soft –tissue implants

- The strength and flexibility characteristics of textiles materials make them particularly suitable for soft-tissue implants.
- A number of surgical applications utilizes these characteristics for the replacement of tendons, ligaments and cartilage in both reconstructive nad corrective surgery.
- Artificial tendons are woven or braided porous meshes or tapes surrounded by a silicone sheath. During implantation the natural tendon can be looped through the artificial tendon and then sutured to itself in order to connect the muscle to the bone.
- Braided polyester artificial ligaments are strong and exhibit resistance to creep from loads.
- Braided composite materials containing carbon and polyester filaments have also been found to be particularly suitable for knee ligament replacement.
- Low density polyethylene is used to replace facial, nose, ear and throat cartilage; the material is particularly suitable for this application because it resembles natural cartilage in may way.
- Carbon fiber-reinforced composite structure are used resurface the defective areas of articular cartilage within synovial joints.

3) Hard - Tissue implants

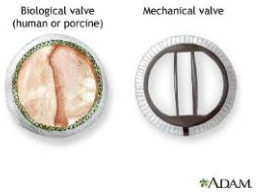
- Orthopaedic implants are those materials that are used for hard tissue applications to replace bones and joints.
- Fiber-reinforced composite materials may be designed with the required high structural strength and biocompatibility properties.
- To promote tissue in growth around the implant a non-woven mat made from graphite and PTFE (e.g. Teflon) is used, which acts as an interface between the implant and the adjacent hard and soft tissue.
- The composite can be formed into shape during surgery at a temperature of 60^{o}C and is used for both hard and soft tissue applications.

4) Cardiovascular implants

- Vascular grafts are used in surgery to replace damaged thick arteries or veins of 6mm, 8mm, or 1cm in diameter.
- Polyester vascular grafts can be heat set into a crimped configuration that improves the handling characteristics.
- Knitted vascular grafts have a porous structure which allows the graft to become encapsulated with new tissue
- In an attempt to reduce the risk of haemorrhage, knotted grafts have been developed with internal and external velour surfaces in order to fill the interstices of the graft.
- Artificial blood vessels with an inner diameter of 1.5mm have been developed using porous PTFE tubes. The tube consists of an inner layer of collagen and heparin to prevent blood clot formation and an outer biocompatible layer of collagen with the tube itself providing strength.
- Artificial heart valves, which are caged ball valves with metal struts, are covered with polyester (e.g. Dacron) fabrics in order to provide a means of suturing the valve to the surrounding tissue.

IV. EXTRA CORPOREAL DEVICES

1. Artificial Heart Valves

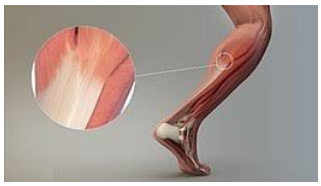


Artificial heart valves are implanted in the heart of the patients who need treatment for valve related diseases. The natural heart valve needs a replacement when two or more valves stop functioning properly. The mechanical heart valve consists of Ultra High Molecular weight polyethylene (UHMW-PE) disc, Low density polyethylene plastic with knitted polyester sewing ring and a metallic housing. The sewing ring is fabricated from extensively implant tested, 100% polyester material. The heart valve market in India is approximately Rs.74 crore.

2. Artificial Vascular Grafts

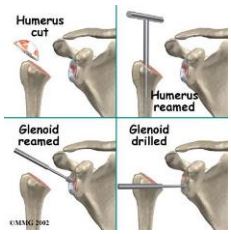
Most textile grafts for large and medium artery replacement are made of either PET or PTFE.

3. Artificial Tendon (Mesh)



Artificial Tendons or meshes are used in hernia repair and abdominal wall replacement, where mechanical strength and fixation are very important. The mesh could either be woven or knitted based on the requirement of strength. Polypropylene, Polyester mesh is primarily used in hernia repair as it is resistant to infections.

4. Artificial Joints



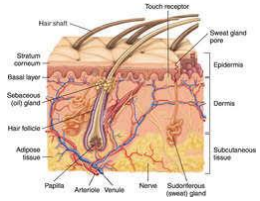
The orthopedic joints are used for patients suffering from arthritis and accidental damage of joints. The technical textile component in joints is Ultra High Molecular Weight High Density Polyethylene (UHMWHDPE) material.

5. Artificial Ligaments

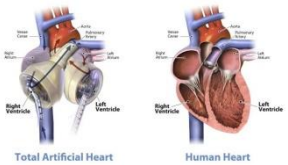
An artificial ligament is medical device for joining ends of two bones. The artificial ligaments are made from manmade fibers like polyester. Polyethylene Teraphthalate (PET) is primarily used for manufacturing artificial ligaments. The artificial ligament must be bio compatible in contact with blood and tissue and should have good bonding strength. The artificial ligaments market in India is small and primarily artificial ligaments are imported.

6. Artificial Skin

Skin grafting is the procedure of replacing dead skin with live skin. The artificial skin is used in the skin grafting process. After removing burnt / damaged skin, surgeons blanket the wound with a covering (artificial skin) before applying a skin graft on top of this biomaterial to encourage the growth of new skin to close the wound. Artificial skin consists of two layers. The bottom layer, which is designed to regenerate the lower layer of real skin, is composed of a matrix of interwoven bovine collagen and a sticky carbohydrate molecule called glycosaminoglycan, which mimics the fibrous pattern of the bottom layer of skin.



7. Artificial Heart



The artificial heart is intended for use in patients whose hearts have been irreparably damaged left and / or right ventricles, and for whom, existing methods of surgical intervention and / or drug therapy are inadequate.

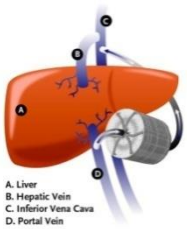
8. Artificial Kidney / Dialyzers

Kidney serves the filtering mechanism of the blood. The kidney has a mechanical substitute in kidney dialysis machine. The kidney dialysis machine is outside the body and purifies the blood using a filter called the haemodialysor. The haemodialysor is made primarily of polysulphone and polyacetate. The primary function of the artificial kidney is to purify the blood. The filtration medium used is hollow viscose or hollow polyester fiber. An external artificial kidney, a hemodialyser, is used which can perform many of the functions of a kidney. It is attached to the blood circulation via, an artery and a vein. It is made up from a bundle of hollow fibers through which the blood circulates.

9. Artificial Lungs

The artificial lung device is connected to the heart's right ventricle. It relies on the heart not a mechanical pump to send blood through the lung, where it receives oxygen (and offloads carbon dioxide) as it flows through the arrays of microbibers or membrane exygenators. Oxygen rich blood passes from the device into the left atrium and then to the rest of the body. The micro fibers or the membrane oxy-generator are the technical textile component in the device.

10. Artificial Liver



The major artificial liver support systems are – Peritoneal dialysis, Haemodialysis, Hemofilteration, Continuous renal replacement therapy, Charcoal Haemoperfusion, Plasma exchange. In this system, patient's blood or plasma is pumped into bioreactors, which are hollow fiber devices.

FIBERS FOR MEDICAL TEXTILES AND THE PROPERTIES

Textiles materials that are used in medical applications include fibers, yarns, fabrics and composites. Depending upon the application, the major required properties for medical textiles are **absorbency, tenacity, flexibility, softness and at times bio-stability or bio-degradability**. Fibers used in medical field may vary from natural fiber such as cotton, silk, regenerated wood fluff (absorbent layer), to manmade fibers like polyester, polyamide, polyethylene, glass fiber etc.

The various applications of different fiber in medical field are shown as follows:

Sl No.	Fiber	Application in medical field
1	Cotton	Surgical clothing gowns, Beddings, Sheets, Pillow cover, Uniforms, Surgical hosiery
2	Viscose	Caps, Masks, Wipes
3	Polyester	Gowns, Masks, Surgical cover drapes, Blankets, Coverstock
4	Polyamide	Surgical hosiery
5	Polypropylene	Protective clothing
6	Polyethylene	Surgical covers, Drapes
7	Glass	Caps mask
8	Elastomeric	Surgical hosiery

There is general move towards an increased use of natural polymers that are biocompatible, biodegradable and nontoxic.

Different fibers used in Medical Textiles and their properties

1. **Commodity fibers**
   a) Fibers used in medicine and surgery may be classified depending on whether the materials from which they are made are natural or synthetic, biodegradable or non-biodegradable. All fibers used in medical applications must be non-toxic, non-allergenic, non-carcinogenic, and be able to be sterilized without imparting any change in the physical or chemical characteristics.
   b) Commonly used natural fibers are cotton and silk but also included are the regenerated cellulosic fibers (viscose rayon); these are widely used in non-implantable materials and healthcare / hygiene products.

c) Commonly used synthetic materials include polyester, polyamide, polytetrafluoroethylene (PTFE), polypropylene, carbon, glass.
d) Biodegradable fibers are those which are absorbed by the body within 2-3 months after implantation and include cotton, viscose rayon, polyamide, polyurethane, collagen and alginate.
e) Fibers that are slowly absorbed within the body and take more than 6 months to degrade are considered non-biodegradable and include polyester (e.g.Dacron), polypropylene, PTFE and carbon.
f) In addition to well known cotton, viscose and polyester fibers, some special polymeric fibers have been developed for medical and hygiene applications. Antibacterial synthetic fibers can be produced by bonding the silver or the combination of silver with either copper or zinc ion with the ion exchange group of the fiber.

2. Application of Special Fibers in Medical Textiles

Medical textiles are broadly classified as non-implantable, implantable, extracorporeal devices, healthcare and hygiene products. Fibers used in medical textile devices are classified as biodegradable and non biodegradable fibers. Fibers such as cotton, viscose, alginate, collagen, chitin, chitosan and other protein fibers that can be absorbed by the body within two or three months are called 'biodegradable fibers', whereas synthetic fibers, namely polyester, polytetrafluroethylene (PTFE) and polypropylene, which take more than six months to fibers'.

a) Alginates are natural polysaccharides that occur in seaweed. They are salts of alginic acid present in certain species of brown seaweeds. The yarn made from alginate has a dry strength comparable with that of viscose, but its poor wet strength makes it unsuitable for manufacturing textile materials. Following the 'moist healing' concept, alginate fiber has become one of the most important materials for wound dressing. When alginate dressing absorbs exudates from wound, a jelly like material is formed and a moist environment alginate dressings facilitate a high absorbency of exudates from the wound.
b) Chitin is one of the most abundant natural biopolymers that contains amino sugars. Currently, the commercial source of chitin is from shrimp shells.
c) Chitosan is the partially deacetylated form of chitin. The deacetylated amino groups are responsible for the high positive charge density of chitosan, which makes the polymer soluble in water and reacts readily with a variety of negatively charged materials. Chitosan is now being developed for slow drug-release membranes – deacetylated form of chitin. Melt spun fibers made from lactic acid have similar strength and heat properties as nylon and are also biodegradable.

d) Collagen is a protein fiber obtained from bovine skin. Collagen is the principal structural protein in the vertebrate body. Collagen has an excellent biocompatibility which makes it a popular choice as a major component of artificial tissue and wound dressings. Collagen products such as sutures can readily be a accepted by body because of their low immunogenicity and this favours the development of a series of fibrous collagen surgical implants that resembles host tissues.

e) Catgut, another protein fiber of biological origin, is derived from the small intestines of animals mostly sheep or oxen. Chromic salts are then leached out by a suitable method. Catgut becomes stiff when dry and this poses problem in handling products made from it. The catgut is mainly used for producing sutures.

f) The major fibers used in implants are polylactic acid (PLA), polyglycolic acid (PGA) and polydioxanone (PDO). The fibers made from these biopolymers are biodegradable and bioresorbable. The fibers possess good cell, tissue and blood compatibility as well as resistance to sterilization and sufficient self stability and provide sufficient mechanical as well as physical properties to the textile structure.

g) Branan ferulate is a polysaccharide obtained from corn bran. The fibers produced from branan ferulate enhance wound healing. Superabsorbent (SA) fibers can be made from SA polymers. SA polymers absorb up to 50 times their own weight of water. SA polymers are not used alone but are combined with other materials to form a component capable of absorbing liquids.

h) Carbon is one of high performance fibers used in medical and surgical applications. Today, biomedical carbon fibers possessing low strength and high elongation are obtained from polyacrylonitrile (PAN). These are relatively flexible and are highly absorbent because of their high surface area.

i) Polyelectric medical fibers that help in the treatment of disease by accelerating blood circulation and increasing metabolism can be obtained by adding polyelectric minerals such as tourmaline into the polymer melt before extrusion. Tourmaline emits active ions and the fabric made from tourmaline loaded viscose fibers improves the health as well as subcutaneous circulation of blood.

Medical textile products and functions

Non-implantable materials

Product application	Fiber type	Manufacture system
Wound care absorbent pad wound contact layer	Cotton, Viscose Silk, polyamide, viscose, polyethylene	Nonwoven Knitted, Woven, nonwoven
Base materials	Viscose, plastic film	Nonwoven, Woven
Bandages simple inelastic / elastic	Cotton, Viscose, Polyamide, Elastomeric yarns	Woven, knitted, nonwoven
Light support	Cotton, viscose, elastomeric yarns	Woven, knitted, nonwoven
Compression	Cotton, polyamide, elastomeric yarns	Woven, knitted
Orthopaedic	Cotton, viscose, polyester, polypropylene, polyurethane foam	Woven, nonwoven
Plasters	Viscose, plastic film, cotton, polyester, glass, polypropylene	Knitted, woven, nonwoven
Gauzes	Cotton, Viscose	Woven, nonwoven
Lint	Cotton	Woven
Wadding	Viscose, cotton linters, wood pulp	Nonwoven

Extracorporeal devices

Product applications	Fiber type	Function
Artificial kidney	Hollow viscose, hollow polyester	Remove waste products from patients blood
Artificial Liver	Hollow viscose	Separate and dispose patients plasma and supply fresh plasma
Mechanical Lung	Hollow polypropylene, hollow silicone, silicone membrane	Remove carbon dioxide from patients blood and supply fresh blood

MEDICAL TEXTILES PROPERTIES AND FUNCTIONS

1) Sanitary Napkins

Sanitary napkins are absorbent, disposable, single use products designed to receive absorb and retain body fluids. In the sanitary napkins nonwoven is generally used which is normally made up of polypropylene. However a combination of viscose and polypropylene is also gaining acceptance. Some of the premium brands of sanitary napkins have also started using plastic films instead of non woven

2) Incontinence Diapers

Incontinence diapers are absorbent single use product designed to receive absorb and retain body fluids. The use of incontinence diapers is hygienic as the diapers prevent fungal infection of the skin since the aggressive substance present in the urine does not come in contact with the skin

The diapers are made up cellulose and super absorbent material and cotton having polyester sheet covering. The key performance parameters for incontinence diapers are similar to the other categories of absorbent hygiene products VIZ., high absorption capacity and skin dryness; reduced odor; protection from leakage; maximizing user comfort particularly when saturated with liquid and simple to use.

3) Baby Diapers

Baby diapers also come under the disposable category and the properties required in diapers are liquid strike though, liquid acquisition, liquid distribution, liquid storage, liquid barrier, surface dryness etc.

Disposable diaper market penetration is very high particularly in 1st world countries. However, the use of this products has been changing very rapidly in the recent years. These people understanding the importance of hygiene and advantages of disposable nappies have taken to the product in a significant way.

4) Surgical dressings

Surgical dressings include wound care products and bandages.

a) Wound care products include wound contact layer / absorbent pad / base material / perforated films, while bandages include inelastic bandages / elastic bandages / light support bandages / orthopedic cushion bandages / plasters / wadding / gauzes / lint
b) Modern wound dressing are composed of absorbent layers held between the wound contact layers and a base material. The wound contact layer is generally placed directly over the wound and covered with an absorbent pad and the whole dressing retained with a base material.
c) In elastic bandage are medication cloth bandages. These two bandages are grouped together as adhesive bandages and they have a layer of adhesive impregnated on the cloth layer. Orthopedic cushions are made of cotton and synthetics. These bandages retain their cushioning effect in the moist atmosphere between skin and plaster

d) Lint is used as wipes or swabs for primary cleaning of wounds before applying the dressing. Wadding is single use cotton pieces in demand abroad. In India for clinical practice as well as domestic purpose cotton rolls are preferred pieces of cotton are removed as and when required. In the foreign countries sterile single use cotton wadding are highly popular. The wound care and wound management industry is distributed between the organized sector.

5) Sutures

Sutures are the simplest example of a textile biomedical device. Sutures are used for wound closure to close cuts and incisions and thus prevent infection and are an integral part of all operations. In fact no surgery can be performed without the sutures. Absorbable sutures are ideal for wounds inside the body as they dissolve and get absorbed into the body after the operation.

6) Medical implants and devices

Medical implants and device cover items like cardiovascular implants (vascular grafts, heart valves etc.,) orthopedic implants (artificial joints) and extra corporeal device (artificial kidney, artificial liver, mechanical lung, artificial heart etc.,)

7) Vascular grafts

Vascular grafts are used to treat hindrances to blood flow caused by vascular and other diseases. A vascular graft replaces the damaged artery or creates a new artery in order to increase blood flow.

The vascular grafts are sterile patient use only. They are of following types : Polyester grafts used to repair thoracic and abdominal occluded arteries. Dacron grafts for aortic surgeries and Polytetrafluoroethylene (PTFE) grafts to repair occluded arteries and veins in the hands and feet and for dialysis treatment of chronic renal failure patients

8) Heart Valves

The heart valves assist cardio thoracic surgeons in treating alular diseases. The heart valves are of two types, namely Mechanical valves and Tissue values. Mechanical values are used for younger patients and require periodical check-ups and after a particular period, the patients need to be operated a second time.

Mechanical values are made of titanium, around which is a knitted fabric to be stitched to the original tissue called as sewing ring. The sewing ring of the caged disc type of prostheses uses a silicon rubber insert under a knitted composite PTEF and polypropylene fiber cloth. Tissue values are uses for slightly aged patients and do not require any periodic checkups.

9) Artificial Tendon (MESH)

The composite meshes made up of polyester, polypropylene and polyester / carbon fiber are used for repairing hernia. The utilization of mesh grafts in hernia operations is based on the fact that during the absorption period a neomembrane is formed at the site where the mesh has been implanted. The mesh graft prevents recurrence of hernia and hence has an advantage over the tissue repair technique practiced for long time in India

10) Artificial Joints

The artificial joints are made of stainless steel, chromium cobalt, titanium or some other inert material. The textile material present in the joints is Ultra High Molecular Weight HDPE (UHMWHDPE). Artificial joints are covered under BIS NO : 5810. The imports of artificial joints have been from Germany, France, Switzerland, USA etc.

11) Artificial Kidney

Artificial kidney consists of a semi permeable membrance on one side of which blood passes while a special dial sate solution is passed along the other. The artificial kidney is made of polyacetate and polysulphoe in equal proportions.

Unit – III

Geo Textiles

Introduction

Geotextiles were one of the first textile products in human history. Geotextiles today are highly developed products that must comply with numerous standards. Geotextiles have been used very successfully in road construction for over 30 years. Geotextiles have proven to be among the most versatile and cost-effective ground modification materials.

Definition

The ASTM defines geotextiles as permeable textile materials used in contact with soil, rock, earth or any other geotechnical related material as an integral part of civil engineering project, structure or system.

SELECTION OF FIBER FOR GEOTEXTILES

Different fibers from both natural as well as synthetic category can be used as geotextiles for various applications.

Natural fibers:

Natural fibers in the form of paper strips, jute nets, wood shavings or wool mulch are being used as geotextiles. In certain soil reinforcement applications, geotextiles have to serve for more than 100 years. But bio-degradable natural geotextiles are deliberately manufactured to have relatively short period of life. They are generally used for prevention of soil erosion until vegetation can become properly established on the ground surface. The commonly used natural fibers are –

- **Ramie:** These are subtropical bast fibers, which are obtained from their plants 5 to 6 times a year. The fibers have silky luster and have white appearance even in the unbleached condition. They constitute of pure cellulose and possess highest tenacity among all plant fibers.
- **Jute:** This is a versatile vegetable fiber which is biodegradable and has the ability to mix with the soil and serve as a nutrient for vegetation. Their quick biodegradability becomes weakness for their use as a geotextile. However, their life span can be extended even up to 20 years through different treatments and blendings. Thus, it is possible to manufacture designed biodegradable jute geotextile, having specific tenacity, porosity, permeability, transmissibility according to need and location specificity. Soil, soil composition, water, water quality, water flow, landscape etc and physical situation determines the application and choice of what kind of jute geotextiles should be used.

In contrast to synthetic geotextiles, though jute geotextileas are less durable but they also have some advantages in certain area to be used particularly in agro-mulching and similar area to where quick consolidation are to take place. For erosion control and rural road considerations, soil protection from natural and seasonal degradation caused by rain, water, monsoon, wind and cold weather are very important parameters. Jute geotextiles, as separator, reinforcing and drainage activities, along with top soil erosion in shouldering and cracking are used quite satisfactorily. Furthermore, after degradation of jute geotextiles, lignomass is formed, which increases the soil organic content, fertility, texture and also enhance vegetative growth with further consolidation and stability of soil.

Synthetic Fibers:

The four main synthetic polymers most widely used as the raw material for geotextiles are – polyester, polyamide, polyethylene and polypropylene. The oldest of these is polyethylene which was discovered in 1931 by ICI. Another group of polymers with a long production history is the polyamide family, the first of which was discovered in 1935. The next oldest of the four main polymer families relevant to geotextile manufacture is polyester, which was announced in 1941. The most recent polymer family relevant to geotextiles to be developed was polypropylene, which was discovered in 1954.

- **Polyamides (PA):** There are two most important types of polyamides, namely Nylon 6 and Nylon 6,6 but they are used very little in geotextiles. The first one an aliphatic polyamide obtained by the polymerization of petroleum derivative ε-caprolactam. The second type is also an aliphatic polyamide obtained by the polymerization of a salt of adipic acid and hexamethylene diamine. These are manufactured in the form of threads which are cut into granules. They have more strength but less moduli than polypropylene and polyester. They are also readily prone to hydrolysis.
- **Polyesters (PET):** Polyester is synthesised by polymerizing ethylene glycol with dimethyle terephthalate or with terephthalic acid. The fiber has high strength modulus, creep resistance and general chemical inertness due to which it is more suitable for geotextiles. It is attacked by polar solvent like benzyl alcohol, phenol, and meta-cresol. At pH range of 7 to 10, its life span is about 50 years. It possesses high resistance to ultraviolet radiations. However, the installation should be undertaken with care to avoid unnecessary exposure to light.
- **Polyethylene (PE):** Polyethylene can be produced in a highly crystalline form, which is an extremely important characteristic in fiber forming polymer. Three main groups of polyethylene are – Low density polyethylene (LDPE, density 9.2-9.3 g/cc), Linear low density polyethylene (LLDPE, density 9.20-9.45 g/cc) and High density polyethylene (HDPE, density 9.40- 9.6 g/cc).

- **Polypropylene (PP):** Polypropylene is a crystalline thermoplastic produced by polymerizing propylene monomers in the presence of stereo-specific Zeigler- Natta catalytic system. Homo-polymers and copolymers are two types of polypropylene. Homo polymers are used for fiber and yarn applications whereas co-polymers are used for varied industrial applications. Propylene is mainly available in granular form. Both polyethylene and polypropylene fibers are creep prone due to their low glass transition temperature. These polymers are purely hydrocarbons and are chemically inert. They swell by organic solvent and have excellent resistance to diesel and lubricating oils. Soil burial studies have shown that except for low molecular weight component present, neither HDPE nor polyethylene is attacked by micro-organisms.
- **Polyvinyl chloride (PVC):** Polyvinyl chloride is mainly used in geo membranes and as a thermo plastic coating materials. The basic raw materials utilized for production of PVC is vinyl chloride. PVC is available in free- flowing powder form.
- **Ethylene copolymer Bitumen (ECB):** Ethylene copolymer bitumen membrane has been used in civil engineering works as sealing materials. For ECB production, the raw materials used are ethylene and butyl acrylate (together forming 50-60%) and special bitumen (40-50%).
- **Chlorinated Polyethylene (CPE):** Sealing membranes based on chlorinated poly ethylene are generally manufactured from CPE mixed with PVC or sometimes PE. The properties of CPE depend on quality of PE and degree of chlorination.

TYPES OF GEOTEXTILES FABRICS

Geotextiles are a permeable synthetic material made of textile materials. They are usually made from polymers such as polyester or polypropylene. The geotextiles are further prepared in three different categories – woven fabrics, non-woven fabrics and knitted fabrics

- **Woven fabrics:** Large numbers of geosynthetics are of woven type, which can be sub-divided into several categories based upon their method of manufacture. These were the first to be developed from the synthetic fibers. As their name implies, they are manufactured by adopting techniques which are similar to weaving usual clothing textiles. This type has the characteristic appearance of two sets of parallel threads or yarns. The yarn running along the length is called warp and the one perpendicular is called weft. The majority of low to medium strength woven geo synthetics are manufactured from polypropylene which can be in the form of extruded tape, silt film, monofilament or multifilament. Often a combination of yarn types is used in the warp and weft directions to optimize the performance/cost. Higher permeability is obtained with monofilament and multifilament than with flat construction only.

- **Non-woven:** Non woven geo-synthetics can be manufactured from either short staple fiber or continuous filament yarn. The fibers can be bonded together by adopting thermal, chemical or mechanical techniques or a combination of techniques. The type of fiber (staple or continuous) used has very little effect on the properties of the non – woven geo synthetics. Non-woven geotextiles are manufactured through a process of mechanical interlocking or chemical or thermal bonding of fibers/filaments. Thermally bonded non-wovens contain wide range of opening sizes and a typical thickness of about 0.5-1 mm while chemically bonded non-wovens are comparatively thick usually in the order of 3 mm. On the other hand mechanically bonded non-wovens have a typical thickness in the range of 2-5 mm and also tend to be comparatively heavy because a large quantity of polymer filament is required to provide sufficient number of entangled filament cross wires for adequate bonding.
- **Knitted fabrics:** Knitted geosynthetics are manufactured using another process which is adopted from the clothing textiles industry, namely that of knitting. In this process interlocking a series of loops of yarn together is made. An example of a knitted fabric is illustrated in figure. Only a very few knitted types are produced. All of the knitted geosynthetics are formed by using the knitting technique in conjunction with some other method of geosynthetics manufacture, such as weaving. Apart from these three main types of geotextiles, other geosynthetics used are geonets, geogrids, geo-cells, geo membranes, geo composites, etc. each having its own distinct features and used for special applications.

IMPORTANT CHARACTERISTICS OF GEOTEXTILES

The characteristics of geotextiles are broadly classified as:

1. Physical properties:

a) Specific gravity b) weight c) thickness d) stiffness e) density

2. Mechanical properties:

a) Tenacity b) Tensile strength c) Bursting strength d) Drapability e) Compatibility

f) Flexibility g) Tearing strength h) Frictional resistance

3. Hydraulic properties:

a) Porosity, b) Permeability c) Permittivity d) Transitivity e) Turbidity /soil retention f) Filtration length etc.

4. Degradation properties:

a) Biodegradation b) Hydrolytic degradation c) Photo degradation d) Chemical degradation

e) Mechanical degradation other degradation occurring due to attack of rodent, termite etc.

5. Endurance properties:

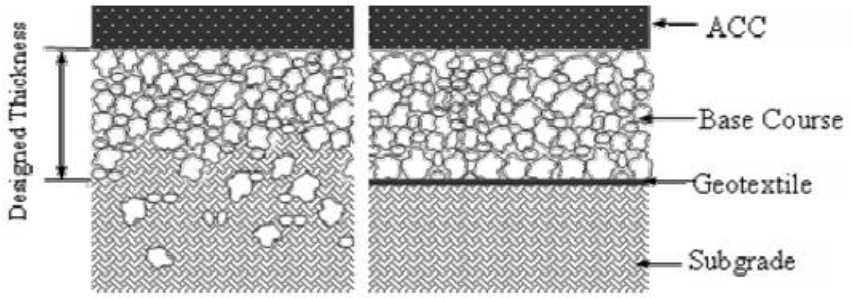
a) Elongation b) Abrasion resistance c) Clogging length and flow etc.

FUNCTIONS OF GEOTEXTILES

Every textile product applied under the soil is a geotextile. The products are used for reinforcement of streets, embankments, ponds, pipelines, and similar applications. Depending on the required function, they are used in open-mesh versions, such as a woven or, rarely, warp-knitted structure, or with a closed fabric surface, such as a non-woven. The mode of operation of a geotextile in any application is defined by six discrete functions: separation, filtration, drainage, reinforcement, sealing and protection. Depending on the application the geotextile performs one or more of these functions simultaneously.

Separation:

Separation is defined as, "*The introduction of a flexible porous textile placed between dissimilar materials so that the integrity and the functioning of both the materials can remain intact or be improved*". In transportation applications separation refers to the geotextile's role in preventing the intermixing of two adjacent soils. For example, by separating fine subgrade soil from the aggregates of the base course, the geotextile preserves the drainage and the strength characteristics of the aggregate material. The effect of separation is illustrated in figure 5.



Concept of Separation function

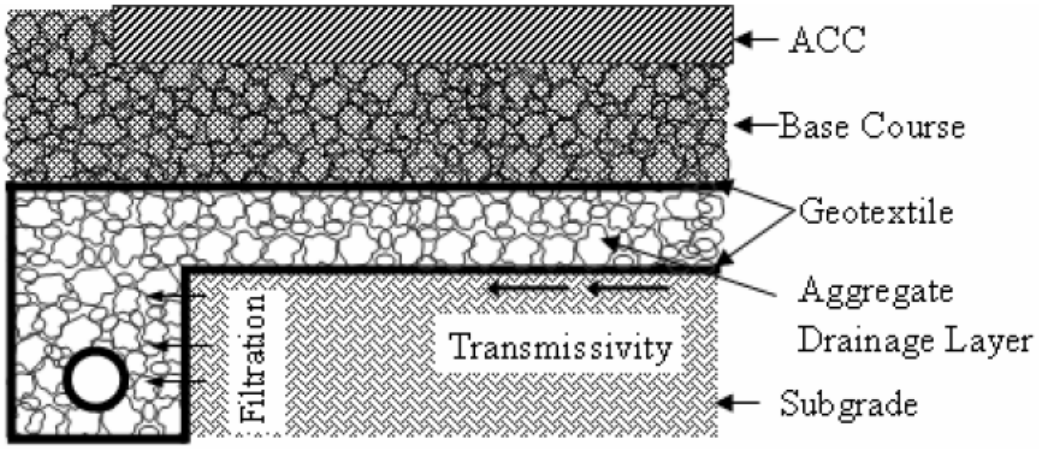
They are used in all classes of roads and similar civil foundation as the base of construction on contaminated layer is the single most cause of premature failure. The use of separator prevents pumping effect created by dynamic load and also helps the passage of water while retaining soil particles. In these types of geotextiles, thickness and permeability are most important characteristic properties. Some of the applications areas are:

- Between subgrade and stone base in unpaved and paved roads and airfields
- Between subgrade in railroads
- Between landfills and stone base courses
- Between geomembranes and sand drainage layers
- Beneath sidewalks slabs
- Beneath curb areas
- Beneath parking lots
- Beneath sport and athletic fields

Filtration:

It is defined as "*the equilibrium geotextile-to-soil system that allows for adequate liquid flow with limited soil loss across the plane of the geotextile over a service lifetime compatible with the application under consideration*". In filtration, fabrics can be either woven or non-woven, to permit the passage of water while retaining soil particles. Porosity and permeability are the major properties of geotextiles which involves infiltration action. Application helps the replacement of graded aggregate filters by a geotextiles warping. These applications are also suitable for both horizontal and vertical drains. A common application illustrating the filtration function is the use of a geotextile in a pavement edge drain, as shown in figure.

Filtration and Transmissivity functions



Drainage (Transmissivity):

This refers to the ability of thick nonwoven geotextile whose three-dimensional structure provides an avenue for flow of water through the plane of the geotextile. Also illustrates the transmissivity function of geotextile. Here the geotextile promotes a lateral flow thereby dissipating the kinetic energy of the capillary rise of ground water.

Reinforcement:

This is the synergistic improvement in the total system strength created by the introduction of a geotextile into a soil and developed primarily through the following three mechanisms:

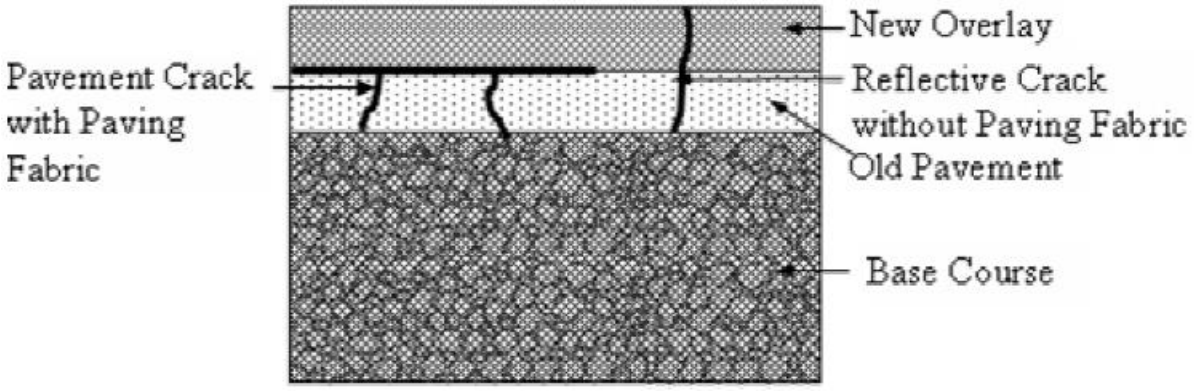
- lateral restraint through interfacial friction between geotextile and soil/aggregate
- forcing the potential bearing surface failure plane to develop at alternate higher shear strength surface
- membrane type of support of the wheel loads.

In this method, the structural stability of the soil is greatly improved by the tensile strength of the geosynthetic material. This concept is similar to that of reinforcing concrete with steel. Since concrete is weak in tension, reinforcing steel is used to strengthen it. Geosynthetic materials function in a similar manner as the reinforcing steel by providing strength that helps to hold the soil in place. Reinforcement provided by geotextiles or geogrids allow embankments and roads to be built over very weak soils and allows for steeper embankments to be built.

Sealing Function:

A non-woven geotextile performs this function when impregnated with asphalt or other polymeric mixes rendering it relatively impermeable to both cross-plane and in-plane flow. The classic application of a geotextile as a liquid barrier is paved road rehabilitation, as shown in Figure 7. Here the non-woven geotextile is placed on the existing pavement surface following the application of an asphalt tack coat. The geotextile absorbs asphalt to become a waterproofing membrane minimizing vertical flow of water into the pavement structure.

Sealing Function



APPLICATIONS OF GEOTEXTILES

Civil engineering works where geotextiles are employed can be classified into the following categories –

a) Road Works:

The basic principles of incorporating geotextiles into a soil mass are the same as those utilized in the design of reinforced concrete by incorporating steel bars. The fabrics are used to provide tensile strength in the earth mass in locations where shear stress would be generated. Moreover, to allow rapid dewatering of the roadbed, the geotextiles need to preserve its permeability without losing its separating functions. Its filtration characteristics must not be significantly altered by the mechanical loading.

b) Railway Works:

The development of the railway networks is being greatly boosted by the present state of economy because of their profitability in view of increasing cost of energy and their reliability as a result of the punctuality of trains even in the adverse weather conditions. The woven fabrics or non-wovens are used to separate the soil from the sub-soil without impeding the ground water circulation where ground is unstable. Enveloping individual layers with fabric prevents the material wandering off sideways due to shocks and vibrations from running trains.

c) River Canals and Coastal Works:

Geotextiles protect river banks from erosion due to currents or lapping. When used in conjunction with natural or artificial enrockments, they act as a filter. For erosion prevention, geotextile used can be either woven or nonwoven. The woven fabrics are recommended in soils of larger particle size as they usually have larger pore size. Nonwovens are used where soils such as clay silt are formed. Where hydrostatic uplift is expected, these fabrics must be of sufficiently high permeability.

d) Drainage:

In civil engineering, the need for drainage has long been recognized and has created the need for filters to prevent in-situ soil from being washed into the drainage system. Such wash in soil causes clogging of the drains and potential surface instability of land adjacent to the drains. The use of geotextiles to filter the soil and a more or less single size granular material to transport water is increasingly seen as a technically and commercially viable alternative to the conventional systems. Geotextiles perform the filter mechanism for drainages in earth dams, in roads and highways, in reservoirs, behind retaining walls, deep drainage trenches and agriculture.

e) Sports field construction:

Geotextiles are widely used in the construction of Caselon playing fields and Astro turf. Caselon playing fields are synthetic grass surfaces constructed of light resistance polypropylene material with porous or nonporous carboxylated latex backing pile as high as 2.0 to 2.5 cm. Astro Turf is a synthetic turf sport surface made of nylon 6,6 pile fiber knitted into a backing of polyester yarn which provides high strength and dimensional stability. The nylon ribbon used for this is of 55 Tex. It is claimed that the surface can be used for 10 hr/day for about 10 years or more. Modern Astro Turf contains polypropylene as the base material.

f) Agriculture

It is used for mud control. For the improvement of muddy paths and trails those used by cattle or light traffic, nonwoven fabrics are used and are folded by overlapping to include the pipe or a mass of grit.

ROLE OF GEOTEXTILES IN ENVIRONMENT

Environment and ecological sustainability become one of the prime issues in the modern developmental strategy. Without positive ecological sustainability the technology/product becomes obsolute. Utilization of geotextile in civil engineering is not a new technology. But their modern uses have started with the advancement of synthetic and polymeric products and their ever increasing application in different forms and areas of civil engineering was initiated only a few decades ago. Again uses of natural fibrous materials in the field of bioengineering, erosion control and agro-mulching are also recent practices.

In geotechnical uses like fiber drain, separator, filter and reinforcing materials are mostly synthetic and non biodegradable with longer span of life. Woven, nonwoven, composite geosynthetics are used in the construction of roads-highways, railways, water-bodies, river banks erosion controls and other areas. On the other hand in soil bioengineering, permanent and self propagating vegetation is required with environmentally desirable and aesthetically pleasing appeal besides being economical and self sustainable.

The roots bind the soil and counteract surface erosion for which natural geotextiles are more acceptable due to their better performance. Synthetic geotextiles are made of polymers and plastics. Hydro-carbon, petrochemicals, fossils are the basic raw materials for their production. Thus, all green house gases and effects are somehow related with their manufacturing. Moreover, non-destructible nature of these synthetic geotextiles has direct effect on soil, water air and other biotic and a biotic system. These geotextiles may often come in contact with life cycles of animals, fishes, insects, and pests along with

various micro organisms and create imbalance in the ecosystem. Thus, synthetic geotextiles may have direct negative impact on climate and ecology as a whole for which extensive research is essential in this area.

FUTURE OF GEOTEXTILES

When looking to future generations of geotextiles, an examination of the role of nanotechnology in the functional enhancement of geotextiles is in order. By reducing fiber diameter down to the nanoscale, an enormous increase in specific surface area to the level of 1000 m2/g is possible. This reduction in dimension and increase in surface area greatly affects the chemical/biological reactivity and electroactivity of polymeric fibers. Because of the extreme fineness of the fibers, there is an overall impact on the geometric and thus the performance properties of the fabric. There is an explosive growth in worldwide research efforts recognizing the potential nanoeffect that will be created when fibers are reduced to nanoscale.

Unit - IV

Automobile Textiles

What are Automobile Textiles?

Automobile textiles, which are non apparel textiles, are widely used in vehicles like cars, trains, buses, aircrafts and marine vehicles. Hence, the term automobile textile means all type of textile components. e.g. fibers, filaments, yarns and the fabric used in automobiles.

Role of Automobile Industry

Nearly two third of the automobile textiles are for interior trim, i.e. seat cover, carpets and roof and door liners. The rest is utilized to reinforce tyres, hoses, safety belts, air bags etc. Automotive industry is getting eco-friendly and more conscious about the environment day by day. Natural fibers have made a significant place for themselves in the recent past. Recent innovations depict that industry is shifting its focus on different types of natural raw materials for the production of auto parts.

I. SUITABLE FIBERS FOR AUTO MOBILE INDUSTRY

1. Characteristics of Natural Fibers in Auto Mobile Industry

Natural fibers with features like high strength, low-cost and light weight are largely used for making different auto accessories. In recent inventions, different types of natural fibers like hemp, flax, jute, kenaf etc., are being used in the production process for making door accessories, package trays and other automotive covers and mats.

a) Coconut Fibers

Auto parts like floorboards, trunk liners or other automotive parts being made from natural fibers. These fibers used for making varied auto parts are made from coconuts' outer husks. Coconut husk is also being used for manufacturing auto accessories like car door interior covers. The focus on natural fibers has replaced synthetic polyester fibers thus reducing the affect on environment hazard. This recent innovation is receiving warm response across the automotive sector. Coconut husk is an easy resource that can be used as raw material for auto parts. Countries like India, Philippines, Indonesia, etc. are abundant source for coconut. Over the years, car makers across Europe have used such composites of natural fibers in their manufacturing process.

Advantages of Natural Fibers

The biggest advantage that this fiber offers is that is they are environment friendly. Amongst the other benefits of these fibers include ability to provide stiffness. These fibers also dampen sound at lower density and low cost as compared to glass fibers. The varied automotive components or parts that are manufactured using these natural fiber composites are dashboards, automotive seat backs, door panels, headliners, truck liners, package trays.

- Renewable resource, Reduction in potential harmful effects related to materials processing, Easy disposal of materials, Natural plant fibers cost less than glass fibers, Low density, High strength, Stiffness, Enhanced energy recovery, Carbon dioxide sequestration, Biodegradable, Reduces dependency on synthetic fibers and Petroleum.

Technically speaking, the use of natural fibers in automotive applications involves primarily press-molded composites, produced by the pressing of the nonwoven mat with a binder. Typical uses are in door panels, hat racks, and trunk liners.

a) a blend of natural and polypropylene fibers is processed into a nonwoven mat and pressed into desired shape under heat ("thermoplastic matrix")
b) Nonwoven mats are coated with thermosets, such as epoxy resin or polyurethane and molded the ultimate material is generated by polymerization and hardening of the resin ("duromeric matrix")

The main reasons for the use of natural fibers are :

- Weight reduction of 10 to 30 %
- Good mechanical and manufacturing properties
- Possibility to manufacture complex structural elements from one material in a single pass
- Good performance in accidents (high stability, no splintering)
- Superior environmental balance during material and energetic use, confirmed by several studies
- Occupational health advantages compared to glass fibers
- No emissions of toxic substances
- Overall cost advantage compared to conventional construction

b) Natural Fibers Blends

Blends of natural fibers (e.g., flax and jute or flax and hemp) are particularly interesting. The finer flax fibers impart high stability, but because they impede complete soaking with thermosetting binders, fractures may develop. Only the mixture with coarser sisal or hemp fibers achieves an optimum balance between stability and complete saturation with the binder.

It is projected that nearly 45 square meters of textile material is utilized in a car for interior trim. (seating area, headlines, side panel, carpet and trunk). Industrial textiles are largely utilized in vehicles and systems including cars, buses, trains, air craft's and marine vehicles. In automobile textile industry, four types of fabrics are used, namely;

a) Air bag fabrics
b) Fabric used as a basis for reduction in weight of body parts
c) Tyre cord fabrics
d) Automotive upholstery and other textile fabrics used inside the vehicle

II. SAFETY DEVICES

Airbags – Introduction

Airbags were first introduced in the late 1960s, that their use increased amazingly and it is set to grow further. This validates the research and development still being made on design, deployment and base fabric material. The prospects for the textile and making up industries are huge in the area of airbag production.

What is airbag?

An air bag is an inflatable cushion designed to protect automobile occupants from serious injury in the case of a collision. The air bag is part of an inflatable restraint system, also known as an air cushion restraint system (ACRS) or an air bag supplemental restraint system (SRS), because the air bag is designed to supplement the protection offered by seat belts.

Airbag system and their Manufacturing Process

An air bag system consists of an airbag module, crash sensors, a diagnostic monitoring unit, a steering wheel, connecting coil, and an indicator lamp.

An airbag module has three main parts : a) the air bag, b) the inflator, c) the propellant.

a) The air bag is sewn from a woven nylon fabric and can come in different shapes and sizes depending on specific vehicle requirements. The driver's side air bag material is manufactured with a heat shield coating to protect the fabric from scorching, especially heat the inflator assembly, during deployment. Talcum powder or corn starch is also used to coat the air bag; either substance prevents the fabric from sticking together and makes it easier to assemble. Newer silicone and urethane coated air bag materials require little or no heat shield coating, although talcum powder or corn starch will probably still be used as a processing aid.

b) The inflator canister or body is made from either stamped stainless steel or cast aluminum. Inside the inflator canister is a filter assembly consisting of a stainless steel wire mesh with ceramic material sandwiched in between. When the inflator is assembled, the filter assembly is surrounded by metal foil to maintain a seal that prevents propellant contamination.

c) The propellant, in the form of black pellets, is primarily sodium azide combined with an oxidizer and is typically located inside the inflator canister between the filter assembly and the initiator.

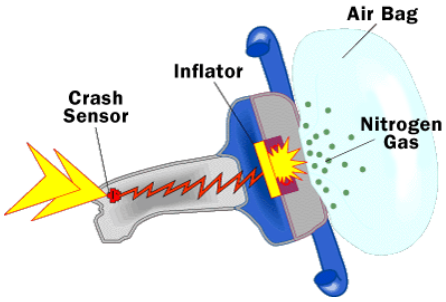
Propellant :-

1. The propellant consists of sodium azide mixed together with an oxidizer, a substance that helps the sodium azide to burn when ignited.
2. Form storage, the sodium azide and the oxidizer are then carefully blended under sophisticated computerized process control.

3. After blending the propellant mixture is sent to storage. Presses are then used to compress the propellant mixture into disk or pellet form.

Inflator assembly

1. The inflator components, such as the metal canister, the filter assembly stainless steel wire mesh with ceramic material inside and initiator (or igniter) are received from outside vendors and inspected. The components are then assembled on a highly automated production line.



Finishing procedure for airbag:-

After weaving, the airbag fabric will undergo scouring to reduce size. To gain accurate air permeability, the airbag fabric can be calendared. Apart from influencing the air permeability by weaving and finishing, accurate permeability control can be achieved by coating when the airbag material has been finished, it is sewn together, the best practice is by using it with a laser.

Airbag are sewn with Nylon 6, 6 polyester, and Kevlar aramid yarns, the sewing patterns and densities being selected to maximize performance. When a bag is sewn it is folded inside its cover. Packing should permit for tethers connected to the bag to manage operation. Finally, a cover can be set up over the bag to safeguard it from abrasion.

General Properties of airbags :

Generally, the bag is woven by nylon 6, 6 filament yarns, which are in demand in huge quantities because of their high strength to weight ratio, favorable elongation, adequate thermal properties and relatively low cost of production. Other properties required are high tear strength, high anti-seam slippage, controlled air permeability and be capable for being folded into confined places for over ten years without deterioration.

Functions :-

A triggering device sets off explosive chemicals when it senses an accident above 35 km/h is about to occur. These chemicals hold back and cushion the car occupant from collision with harder objects. The fabric from which the bag is made must be competent for withstanding the strength of the propellant chemicals. Moreover, the hot gases must not penetrate the fabric and burn the skin of the car occupant.

For airbags to perform their protective function, each function in the system must work with reliability and predictability. In frontal airbag initiation, the cushion begins to deploy within 20 ms after collision and is fully set up in 50 ms. Within this period of time, the bag has to spread through the plastic cover, blown up and fill the space between the dashboard and occupant.

The air bag parts are die cut out of woven nylon, sewn together. The bag is then carefully folded so that it will fit inside the plastic module cover.

The role of airbag

The airbag and seat belts used as safety measures are one of the latest types of textiles in automobiles and have a potential market for technical textiles that has a considerable scope for growth and development.

Airbags or inflatable restraints have received noteworthy significance as a safeguard for the driver and the passengers in case of an accident. Initially, the bags were made for head on collision, but now, there are many other safety devices like side impact bags, knee bolsters, side curtain etc. available for safety in any type of crash. Because frontal collisions are a main reason of accidental deaths, airbags are being presented as a standard product in vehicles by legislation, which has given the quick increment of airbags business in the last decade.

New Applications of Airbags

As new applications are developing for airbags, including rear seat bags, inflatable seat belts and an outside airbag system for pedestrians, new fabrics and combinations are being applied. The front and passenger bags have different requirements because of the distance from the occupant, but they both have rapid increment and deflation in a very short time span.

Rollover bags must remain inflated for five seconds. In addition to new uses, expected trends include lighter fabric for use with newer “cold inflators”, blended with materials like fabric and film, new coating polymers.

Growth of safety devices in the car interior :-

Increasing electronics and safety devices require more space in the interior together with new concepts for arrangement. **A fabric cushion** is included as a part of textile ingredient for an airbag, which is folded into the center of the steering wheel (for the driver) or in the glove compartment (for the front seat passenger).

Material Applications and its Characteristics :-

Airbags are generally made from high tenacity multifilament nylon 6, 6 in yarn quality fitness from 210, 420 to 840 denier. As Nylon 6 is softer, it is used to lessen skin abrasion. Airbag fabric is not dyed, but has to be scoured to eliminate impure substances, which could encourage mildew or other problems. Airbags are created in compact size, plain woven fabrics.

The amount of fabric required to make an airbag depends on its location in the car and the market it serves. Most drivers' side airbags are coated by using lower denier yarns that give strong and light weight fabrics. The looser weave has been permitted by stronger nylon 6,6 yarns that create fabrics with lighter weight, less stiffness and better packagability.

The fabric which is used to produce passenger airbags is generally uncoated. These kinds of passenger bags are larger so they create lower gas pressures, have longer inflation times, and possess gas which is cooler. The constituent yarns are of relatively heavy denier. Normally, airbag fabrics are made by rapier weaving machines or air jet looms with electronic dobbies.

Airbag sizes:-

Airbags are available in various sizes and configurations depending on the type of car and steering.

Airbag fabrics varieties :-

The majority of the fabrics are coated with an elastomeric material such as neoprene or silicone. The long lasting popularity of coated materials for airbags has been seen because of its capability to work as a heat shield and the comparative ease that design engineers to expect wider performance in their use.

Though, there are some intrinsic problems with coated airbags, which cover their large thickness, incapability to be folded into small spaces and inclination of decay over time. Coated fabrics are simple to cut and sew and the air porosity can be well managed.

The drawbacks linked with coated airbags and their subsequent substitution with uncoated materials has warranted significant developments from two sectors of the industry. The uncoated airbags can be recycled in a simple manner. The first development has come from the yarn and fabric producers, who have concurrently developed the performance of the fabrics.

Their gas permeability has fallen under specific scrutiny since the way an uncoated fabric discharges gas and establishes the capability of an airbag to resist impact. The second development has gained from the inflator producers, who have started to substitute the original inflators, which release air, with devices that emit air like argon and helium. This is greatly helpful because these gases are equally as effective at lower temperatures and discharge less hot particles.

Quality Control :

The quality control aspect of air bag production is, obviously, very important because many lives depend on the safety feature. Two major areas where quality control is critical are the pyrotechnic or propellant tests and the air bag and inflator static and dynamic tests.

The Future :-

The future for air bags looks extremely promising because there are many different applications possible, ranging from aircraft seating to motor cycle helmets.

2. Seat belts

The seat belt is an energy absorbing device that is designed to keep the load imposed on a victim's body during a crash down to survivable limits. It is designed to offer non recoverable extension to decrease the deceleration forces that the body comes across in a crash. The automatic belt has a locking device known as inertia reel. An efficient seat belt will only permit its wearer to move forward a maximum of about 30 cm to avoid contact with any fixed parts of the car.

It is believed that the seat belts were invented concurrently in America as well as Sweden. The only difference was that the American belt was a strap to encircle the waist and the Swedish belt was diagonal band made to defend the upper body. Now, a blend of the two designs is a most prevalent arrangement and is called the 3-point belt, which is secured by two fittings on the floor and a third on the sidewall or pillar. Racing drivers wear other patterns, particularly two shoulder straps and a lap belt. The earliest automotive seat belts were set up and were adjustable so that they could fit the wearer manually. The automatic belt superseded this pattern by providing the wearer more space to move

Types of Seat belt

Depending on the type of motor vehicle and its purpose, the vehicle may include any of several different seat belt types. Some of the most common types of seat belts include lap belts, sash belts, automatic seat belts, three-point belts, belt-in-seat (BIS), five-point harnesses, and six-point harnesses. However, not all seat belts offer the same level of protection.

- **Lap Belts**

Lap belts are the oldest type of seat belt. A lap belt uses an adjustable strap that only goes across the waist. However, the lap belt design fails to restrain your torso, shoulders, head, or neck during a collision. Lap belts are rare in newer cars, although you'll sometimes see a lap belt in the middle rear seat.

- **Sashes or Shoulder Belts**

A sash or shoulder belt is an adjustable strap that only goes over the shoulder of an occupant. These belts do a poor job of providing restraint during a crash, and they've been almost entirely phased out of existence in newer cars. During a collision, vehicle occupants can easily slide out of a shoulder belt and suffer catastrophic injuries.

- **Three-Point Belts**

Most modern vehicles contain three-point seat belts. A single piece of nylon (or other material) stretches from the occupant's shoulder, runs across the chest, and ends in a lap belt. When an impact occurs, these belts help spread out the energy of the moving body across the chest, pelvis, and shoulders.

- **Automatic Seat Belts**

Some vehicles have shoulder belts that automatically move in place to secure the passenger when the vehicle starts. A separate lap belt is usually included, and the lap belt must be fastened manually. Once popular among automakers, automatic seat belts have fallen out of favor somewhat in newer cars.

- **Belt-in-Seat (BIS)**

The BIS is a three-point harness in which the shoulder belt is attached to the backrest. Some studies have shown that this type of belt may provide additional protection during rollover accidents, particularly when a BIS is used to restrain a child between four and eight years old.

- **Five-Point Harness**

A five-point harness is safer than other seat belts but also restricts movement more. This type of seat belt is usually used in child safety seats or in cars used for competitive racing. Some vehicle owners also install five-point harness belts as an aftermarket modification.

- **Six-Point Harness**

A six-point harness is like a five-point harness, but it has an additional belt that goes between the legs. These belts are mostly used in racing and began to gain popularity after the tragic death of race car driver Dale Earnhardt, who was wearing a five-point harness at the time of his fatal crash.

Fabric used in Seat Belt

Seat belts are available in multiple layers and are woven in narrow fabrics in twill or satin fabrication from high tenacity polyester yarns, generally 320 ends of 1100 dtex. These structures permit highest yarn packing within a given area for highest strength and the trend is to utilize coarser yarns for good abrasion resistance. Nylon was utilized in some early seat belts, but due to of its higher UV degradation resistance polyester is now widely used worldwide. The seat belt must be long lasting without any significant deterioration.

Unit – V

PROTECTIVE CLOTHING

Introduction

The garment worn for safety between the wearer and the source of journey and the emphasis given on the preservation of human life from hazards is called protective clothing or safety textile

The types of protective garments are

Tents, helmets, gloves, sleeping bag, survival bag and suits, fire protective clothing, heat resisting garment

- Ballistic – resistant vests
- Biological and chemical protective clothing
- Blast proof – vest
- Military protective garment
- Submarine survival suits
- Immersion and dive suits
- Diapers, ropes

Types of occupation that need protective garments are

The types of occupation for clothing the protective garments used are police, security, mountaineering, caving, climbing, aircrew, soldiers, submarine, foundry and glass workers, fire fighters, water sports, commercial fishing and diving, off shore oil and gas rie workers, health care, racing drivers, astronauts, coal mining, cold storage workers

Protection against hazards can be divided in to two categories

1. Accidents – Short term

   Fire, smoke, toxic fumes, attack by weapon – Chemical, Nuclear, Ballistic

2. Long term
   a) Weather – Extreme, Cold and heat, Rain, Wind
   b) Chemical, Nuclear reagents, Molten metal, Microbes and Dust

Ballistic protection

Source of injury

- The main threat is from grenades, mines, explosion used by terrorists
- Another causes to civilians has been from bullets like hand guns, revolvers, pistols. These are of low velocity
- High velocity weapons are rifles, machine guns

Textile material for ballistic protection

- This requires the use of high modulus textiles fibers, those having very high strength and low elasticity. This protects them from trauma
- Woven textiles are commonly used
- Non woven like felts are also used (eg) woven silk – provide protection
- High modulus fibers made of aliphatic nylon 6-6 are used in body armour protection and in helmets
- A range of ultra high modular polyethylene has been developed for protective clothing
- Para – aramids and polyethylene fibers have given vast improvements in performance

Fiber types and composition suitable for Ballistic protective

1. Majority of the ballistic fabrics of a coarse loose plain woven coust
2. Continuous multifilament yarns with the minimum of twist tent to give best results
3. The loose woven construction produces a light flexible fabric ideal for shaped clothes
    - No.of layers are used between 5-20 to produce ballistic pack and each layer is allowed to move independently by stitching quality lines
    - Seal the ballistic garment inside the light tight cover and water proof

Other types of inherently flame retardant fabrics

4. (a) Such as – aramids, modacrylic, poly benziunmidazole (PBI), semicarbon, phenolic
   (b) Chemically modified fibers and fabrics flame retardant cotton, wool and synthetic
    - PBI offer improved thermal and flame resistance, durability, chemical resist, dimensional stability and comfort compared with high performance fiber
    - Although PBI expensive, the chemical resistance and comfort make it ideal for protecting clothing where a high degree of protection is required (eg) fire fighty suit, suit for astronoats, air craft fabric
    - PBI is easily processed on all conventeral textile equipments and can be readily formed in to woven, knit and non woven fabrics

5. Oxidized acrylic fibers have excellent heat resistant and heat stability
    - They do not burn or melt in air and have excellent resistance to molten metal splashes
    - They are resist to common acrylic alternative
    - Very durable and comfort table to wear (eg) police and paramilitary suits. They are designed to provide protection against both flame and acid and provide maximum movement to body.

6. Modacrylic fibers have improved thermal stability can be used alone (or) blends for protective clothing. (eg) In defence wear – reduce the cost, maintenance and improve the wear life performance of flame – retardant sweaters

7. Wool is advantageous because it has a high ignition temperature, high limiting 02 index, low flame temperature and material does not drip. (eg) for foundry workers who are at risk of being splashed by molten metal like steel, iron, copper, zinc, aluminum, lead showed that wool finished with zipro flame retardant offered best protection.

8. Aramid fibers soften the melt or melt around 316^0C

9. Untreated cotton offers good protection against molten aluminum

Use of fiber blends in protective clothing

Fabric blend known as Normex III has been developed with names and 5% Kevlar. (eg)

- Aramid is a blend with flame retardant viscose and flame retardant wool
- Normex is used for fire fighters
- Now for military and civilian
- Kermet with fire reinforce viscose is used for resistance to UV radiation.

Different types of protection

a) A biological chemical hazard is a constant threat. The toxic agents used are relatively easy to produce and their effects are horrific to human population

The chemical affect the skin, tissues and the respiratory system causing severe bilistery, swelling and burns. (eg) bis – 2 – chloroethyl sulphide

There are also argeno phosphorus compound

- Phospho no fluoridates
- Phosphoryl cyanides Which when absorbed affect the skin and respiratory system

The device used to protect are :

a) Orinasal (or) full face respirators which are designed to filter out the toxin
b) Also the pressure point such as finger, knees, elbows need full body protective clothing
c) Activated carbon on a textile material to absorb the vapour and it can be used as a powder form, bead form or in carbon fiber and fabric form

- Because it has highly developed pore structure and a high surface area, enabling the adsorption of toxic gases
- Charcoal layer can be used as a laminating (or) on a foam backed textile, consisting of two textile fabrics sand weighing a char coal layer
- The fabrics is treated with an H_2O repellent soil finish
- Protective clothing is now worn over the existing combat clothing. Efforts are taken to reduce the number of bulk layers

b) Protectors from extreme whether

- Protection from wind, snow and military personnel and other hazards are very important
- Persons working in drill for oil under ice caps face breathy problem which attracts the attention among the various sectors of textiles and apparel industries
- Design the garment that is effective and comfortable for submarine suits and survival suits to maintain the body temperature

c) Protection from pesticide

- Farm workers and pesticide mixers face the risk of contamination by pesticides
- Non woven fabrics perform better than woven fabrics
- Fabric weight and thickness is a very important factor for protection
- Fabrics made from synthetic show more willing of pesticide on to a skin than cotton
- Fluorocarbon soil repellent finish found to be excellent finish against pesticides
- Olefin garment worn during mixing, handling and application of pesticides helps in protection

d) Protection from radiators

- Protection against airborne radioactive particles is a problem in nuclear industry
- The spum bonded polyolefin fabrics is super or to other fabrics in the nuclear industry

Factors considered in selection of protective clothing

- Cost, style availability, mode of use construction or designing is very important
- Time of contact (eg) exposure period
- Penetration of the protective garments
- Characters lies of the contact
- Effect of exposure – ingestion or inhalations
- Physical properties such as – flexibility, puncture, abrasion, resistance, thermal protection

The level of protection used should be based on the following :

Effect of skin contact with the chemicals (eg) toxicity, allergic rectus.

THE ROLE OF TEXTILE FIBERS AND THEIR PROPERTIES

The development of technical textile is closely associated to advancements in fiber production. The creation of polyamide fiber (Carothers, 1930) gave a direction for development technology, followed by the invention of polyester, polyethylene and carbon fibers. In recent time, high performance fibers as Aramid, UHMW polyamide, HP-Polyethylene, that had an extraordinary significant influence for development of technical textile were obtained.

Natural fibers

In the beginning, of manufacturing of technical textile (early in the 20th century) natural fibers like cotton, flex, just and sisal was utilized. The most common products had been lines, rubbers, and thread. It is typical that those were heavy weight products with limited resistance to moisture, microbes, fungus and low flame resistance. Natural animal fibers as wool and silk had limited application. The wool fibers were used in some cases for insulation properties and flame resistance. Silk fiber had limited and very narrows application in manufacturing of sutures in medicine

Viscose fiber

Viscose is the first commercial "manmade" fiber (1910) used as reinforcing material for tires and other rubber products like safety belts, conveyor belts and hoses. The fiber has relatively high uniformity, (16-30 cN/tex) and modulus, especially if impregnated with rubber. Its moisture contained is about 3% and 16-22% extension at brake. The viscose fiber obtained by a special process of spinning has tenacity up to cN/tex and elongation this fiber has been proven ideal for the automotive industry, which at the time viscose fiber was discovered, announced rapid expansion. Much later, as a result of high moisture of hygienic and sanitary products via nonwoven technology.

Polyamide fiber

Polyamide fiber (first introduced in 1930) is characterized by high tenacity (35-90 cN/tex), elasticity (15-60%), resistance to abrasion and moisture (3-5%). Capability of energy resilience is a condition for an application in manufacturing climbing ropes and linen for parachutes and sail fabrics. The typical application of polyamide is for reinforcing tires for use at low quality roads vehicles. The tries designed for due to better thermal resistance.

Polyester fiber

Production of polyester (commercialized during 1950's) made possible to compared to PA and viscose fiber. Great world producers of PET fiber are Japan, developed Asian countries and China, were polyester is applications, like geo textile and floor coverings, i.e. in cases where more usual polyolefin would be employed. The need for light and soft ware repellent fabric without water proof coating and improved manufacturing processes, lead to development of ultra fine or microfibers. Microfibers are usually made of PET and PA but other polymers have been introduced in recent time. The small fiber diameter allows producing weaving fabrics of densities up to 30000 filaments per cm^2 . Such fabrics are practically waterproof while allowing at time water and air transportation weaving fabrics for bacterial protection in medicine.

Polyolefin fibers

Polyethylene and particularly polypropylene fiber (commercial production 1940-50's) represented a substantial contribution to the development of technical textile. Advantages of the polyolefin fibers are low price, low specific gravity (0.90-0.96 X cm^{-3}), good abrasion resistance, and low moister content (0%). Such properties have determined their use in a range of technical application. Packing equipment, ropes, base fabric for floor coverings, linings for upholstery, technical nets etc in the beginning, natural fibers such application, but with the time, polyolefin fibers overtook the market. Every day new opportunities for applications emerge such as base fabrics for sport courts.

Low melting temperature of polyolefin's is a advantage for application in manufacturing of nonwoven by thermal bonding, high water repellency of PP finds application in manufacturing of diapers and special thermo physiological clothing were two employed layers are : hydrophobic and hydrophilic, and the wicks made of pp enable transport capacities for polypropylene are mainly concentrated in Europe and North America, but with the increase of the demand investments in new geographic regions have been made.

The fibers discussed so far, natural or synthetic represent 95% of the employed organic fibers in the production of technical textile. Due to the market demand some of these fibers have been modified for special purposes, which lead to production of high performance or high tech fibers.

FIRE RETARDING FABRICS

Although many range of FRF are available, their end use in less. The impact of FRF and its applications are :

1. **Proban**

   Treated cotton, which is a tetrak is hydoxymethy phosphonium hydroxide product, bound in fiber and cured with ammonia.

Advantage

Low cost, has high finish resistance to washing, give good protection with low thermal shrinkage in a fire. Readily available

Used

The proban fiber is used in naval dress blended with 25% of polyester which improves the appearance and durability. The proban treated with white knitted is used for head cover and gloves during high alert action

Disadvantage

It liberates fumes and smoke when activated and the treatment weaken the fabrics or spoils

2. **Meta aramid fibers**

   It has good physical durability, low toxicity and low smoke evolution properties, but expensive fiber. It is used by tank crew cover, air crew cover, bomb disposal unit, sub marine clothing

3. **Zirpro wool**

   Wool is treated with colourless hexafluor-titanium for heavy fire fighters

   These are heavy felted fabrics which provide good thermal insulation properties for high risk duties. The cost is medium (eg) It is used by Navy fire fighters, foundry workers, biological and chemical clothing.

4. **Modacrylic**

   A woven twill with a nylon warp and modacycrlie wesf is used as two layer over-suits with boots and gloves to protect from neuclear bio, chemi ware fare threats. This modacrylic ie component provides limited degree of flame and flash protection.

5. **Polyester**

   Cotton core spun fabric is coated with mixture of PVC and PVDC resins with antimony oxide as a flame inhibitor. Used as a roofing agent.

6. There are currently a range of neoprene and hypalon rubber coated nylon and polyester fabries are used for flame retardant covers and shelters.

HIGH TEMPERATURE FABRICS

1. **Oxidized acrylic**

   Oxidized fibers have excellent heat resistance and heat stability. They do not burn in air or melt. They are flexible, resistance to acid, alkalis, durable and comfortable to wear

   An anti-riot suit is made from oxidized acrylic fabrics specially designed for paramilitary and police personal, This suit provide protection against heat, flame, acid and permit maximum of freedom to body movements.

2. **Modacrylic**

   For lower specification of protective clothing, modacrylic is used successfully. It has improved thermal stability up to 1900C. This can be used alone or as blends. Modacrylic and wool reduce cost and maintenance and improve the wear life and performance

3. **Wool**

   It is advantageous because it has high ignition temperature and high limiting oxygen index, low heat and flame and does not drip

   Properties of high temperature fabrics

- Maintain a barrier to prevent direct exposure to heat
- Good thermal isolate that is it reduces heat transfer and give adequate time for escape before burn
- Low shrinkage and maintain air
- Comfortable to the wearer and light weight
- Easily clearable
- For high temperature specially when exposed to direct flame, light weight tightly woven construction such as flame retardant cotton sateen of 150 – 250 m-2 is suitable.
- For firefighting cotton drill is used 250-320 m-2
- When garment is exposed to a continuous shower of sparkers and heat heavier fabric, raised twill about 320 – 400 gm-2 of cotton is required
- When heat is of longer duration, protection is needed so fabric thickness and density are the major considerations.

For short duration, when increase in the fabric weight and it increases the protection

- In case of protection against radiant heat, aluminized fabrics are essential
- Clean reflective surfaces are very effective for high temperature
- Non woven fabrics could be considered as a backing or thermal liner for protective apparel.
- Design suitable garment to enable the body heat to be dissipated. (Eg) Nomex III, Goretex, Modacrylic, Aramid Kevlar, in both woven and non woven fabrics are suitable for high temperate other hazards
- High temperature fabrics should not continue to burn, garment remain intact, and teard heat transfer to provide time for the wearer to take action. It should have liquid repellency (avoid the penetrations of oil, H2O solvents and chemicals.

HIGH VISIBILITY FABRIC

High-visibility clothing, sometimes known as "hi-viz", is any clothing worn that is highly luminescence in its natural matt property, or a colour that is easily discernible from any background. Most commonly worn on the torso and arm area of the body. Most industrial employers require it as a type of personal protective equipment (PPE). Traditionally yellow waistcoats worn by emergency services are a common example, but in more recent times any type of clothing in the "Hi Viz" colour spectrum is now deemed acceptable.

Accepted colours are usually light green/ yellow, orange, and pink from a magenta derivative. Contrasting colours such as dark blue, black and white are often incorporated in the design of "Hi Viz" clothing. Occupational wearers of clothing with high-visibility features include railway and highway workers, airport workers, or other places where workers are near moving vehicles or in dark areas. Some cyclists wear high-visibility clothing when riding amongst motor vehicles. Hunters may be required to wear designated high-visibility clothing to prevent accidental shooting.

Reflective tape originally developed by 3M may also be used to enhance "Hi Viz" clothing in low light conditions. However some reflective tapes can reflect as much as 82% of the source light causing retinal damage. It is therefore recommended that aircraft pilots, professional truck/ bus drivers and operators of heavy plant (encased in mainly glass ROPS) refrain from wearing highly reflective clothing while conducting their duties.

HIGH PERFORMANCE FIBERS

Aramid fibers

Since then the industrial application of aramid fiber into the products where high strength and modulus are required, like in ballistic for life safe waists, in the automotive industry for lorry tires and in protection clothing industry for cutting resistant gloves started. Aramid fiber used in ballistic is known under the trade name Kevlar and Twaron. The characteristic property of aramid fiber is a high melding temperature of 370^0 C (compared to 248^0C at conventional polyamide. Due to such a property the use of aramid fiber is extended to high temperature applications. For example, the seats in aircraft having polyurethane foam as wadding use lining of aramid fibers, due to its fire retardant properties. The other use of aramid is as asbestos substitution in automotive breaks. The aramid finer intended for a high temperature application is known under trade name Nomex. For example, the special clothing for formula 1 pilot is made of woven fabrics and thread made of this fiber.

UHMW polyethylene fiber

Polyethylene processed by extended highly orientated chain structure has got much higher longitudinal orientation is a precondition for accomplishing high mechanical properties. The result of this treatment is production of high performance polyethylene fiber (HPPE), so far highest strength of 400 cN/tex, i.e. two times higher than aramid fiber. The advantages of HPPE are low specific gravity (0.396 g/cm^3), almost about the half less than a high modulus carbon fiber and about one third less than the aramid fiber. This is the reason why HPPE has much higher specific gravity than the other high performance fibers. The fiber has low melting temperature (-150^{0}C), which restricts the possibility for the high temperature application. Chemical inertia is also a disadvantage and can be handicap for composite production because it lowers adhesion between fiber and matrix.

Carbon fiber

Carbon fiber is a good example of renewed actualization of older technology, which did not find its place after its appearance on the marked. The demand for carbon fiber was under stagnation almost for 80 years, when the development of the space program demanded the materials of excellent thermal resistance, high modules, acceptable textile process ability and excellent ablative properties. Carbon fiber can be manufactured from several precursors, of which rayon and acrylic are the most usually employed. Today, the field of application of carbon fiber is spread on to the civil aviation, special sport and industrial goods, such as turbine parts for generators and reinforced fuel tanks.

The classification of carbon fiber is based on a) magnitude of final head treatment (HTT) and carbon content of final product and b) b on the mechanical characteristic of the fibers. Regarding the first classification carbon fibers may be subdivided in to three classes : partially carbonized fibers (HTT 500^{0}C, carbon content up to 90 wt %); carbonized fibers (HTT 500-1500^{0}C, carbon content 93-99 wt %) and graphitized fibers. The high quality PAN based fibers are classified into a) high strength carbon b) high modulus graphite and c) carbon fibers with enhanced strength and elasticity.

Glass fibers

Glass fiber represents the first “synthetic” fiber product of the human intelligence. Soon after discovering the art of glass, ancient Egyptians discovered the value of glass fiber, which had strength for reinforcing the vases and amphorae found in the tombs of pharaohs.

For years the glass fiber has been used as cheap insulation material and reinforcement for plastic of average properties. Today, the application of glass fiber is remarkably increased because of the knowledge of a glass fiber as superior engineering material with excellent thermal resistance. The glass fiber is at great extent accepted in the production of high performance composite a material, including

protective materials, varies filters, protective clothing and packing. The greatest opportunity for application of glass fiber is in the field of automotive industry for large scale production of fiber reinforced car parts because of great weight savings. The glass fiber is manufactured in several types : E, R, D, AR, and S. E-glass fiber is most often used particularly for textile industry and composite production where it is used as reinforcement in 92% of cases. R glass fiber is used for special applications, such as, aviation, space program and defense due to its special performances regarding fatigue, temperature and moisture. AR type is used for cement reinforcement, with high content of zirconium oxide, which gives excellent resistance to alkaline compounds generated during drying. The cement reinforced with AR glass fiber has improved modulus and good durability. S type has stiffness and finds its application where high mechanical properties are required.

The fiber intended for resin reinforcement receive plastic sizing which contains : film forming binding products, antistatic products, plasticizers and coupling agents, which enable a good performance during mauling and provide a high degree of compatibility between glass and resin.

The fibers intended for purely textile processing (weaving, knitting, braiding etc) obtain textile sizing consisting of softening agents, bonding agents and lubricants, which provide the necessary lubricity and abrasion resistance, essential for further textile processing.

Development of the high performance fibers

After the appearance, the high performance fibers accomplished remarkable penetration on the market and opened new opportunities for the products of technical textile.

High temperature resistant meta aramid and the high strength and modulus para aramid made the first and most important effect. Numerous multifunctional fibers are nowadays available on the market, offering a diversity of improved functional properties. In addition to thermally adaptable fibers. A new generation of fibers based on a multi properly holistic concept is developed for the use of automotive interiors, battery warmer, and outdoor architectural structures, protective clothing for bullet proof vests, geo textile, agricultural etc.,

APPLICATIONS OF SMART AND INTELLIGENCE TEXTILES

1. **Shape memory materials :**
   - These materials are stable at different temperature
   - They assume different shapes when their transformation temperature is reached
   - Another type of shape memory materials which are composed of electro active polymer (EAPs) – They change into thin shape, in response to electrical control.

- Shape changing fiber, yarn and fabric are produced with the help of suitable sensitive copolymers.
- They respond to quickly to small changes in temperature and pH (Reciprocal of hydrogen ion concentrated)
- These material provide sensing functions
- Yarns are made from shape memory polymers used to make fabrics with different properties

They are two types of Shape Memory Materials

- 1st class materials are stable at different temperature states.
- Another types are electro active polymers which can change their shape in response to electrical stimuli

2. Chromic materials :

- This type of Intelligent Textiles change their color reversibly according to external environmental conditions.
- They are called chameleon fibers which Radiate color, or erase the color
- They are different types of chromic materials
  - Photo chromic – stimulus to light
  - Thermo chromic – Stimulus to heat
  - Electro chromic – Stimulus to electricity
  - Piezoro chromic – Stimulus to pressure
  - Solvate chromic – Stimulus liquid or gas

3. The Sensory baby vest :

- Equipped with sensor – This constantly monitor the vital function of the heart, lungs, skin and body temperature
- The above is used to detect and monitor heart and circulatory illness
- Prevent the clotting of blood, death and other life threatening situation in babies
- The sensor do not disturb the baby whiles sleeping

4. Reflective Tech :

- This reflect the incoming light the figure of a person (eg) automobile head light, bicycle or other object light
- The size is finer than of grain of sand or human hair
- They can be attached or imbedded in to the weave of any fabric
- The fabric is soft
- You can distinguish to treated with untreated.

5. Thermal performance enhancing fabric :

- Hydro-weave provide extra ordinary protection against heat
- Maintain body temperature
- It has 3 layer designers
  - Hydrophilic
  - Hydrophobic
- The 3rd layer is kept between the shell fabric
- It is thermally conductive, has inner lining

6. Flash dried fabrics :

- 3 X-DRY finishing was developed to provide treatment that retain H_2O on the face the fabric
- This finishing increases wick ability
- The hydrophilic finish take away the perspiration from the body
- The hydrophobic finish repels H_2O and dirt
- This fabric dries faster
- This treatment can be given to control odor

7. Protective flex :

- Smart response fiber provide safety for the passenger
- It combines polyethylene Terephtdalate (PET) and polycaprolactone (PCL) and provide flexibility and cautioning

8. Thermal sensitivity :

- Smart skin hydrogel is a new technology that absorbs cold H_2O into the suit and expands at hands, feet and neck.
- This also prevent H_2O from entering
- This H_2O inside the suit heat up body contact

9. Phase change materials – PCM :

- Outlast temperature regulating tech – recycles the body heat
- It is first used in astronaut uniforms
- Also to protect the severe temperature changes in out space
- It is a paraffin wax compound converted into impenetrable, hard shells
- This recycle body heat by
  - Absorbing

- Storing
- Distributing
- Releasing

- This keep the skin temperature in comfortable range

10. Wearable Tech

- The clothing now is capable of displaying date, recording, analyzing, storing, sending
- This also provide useful information
- Display helpful data – information
- Monitor health parameters – medicine
- Detect danger, call for help (security)

11. Bio-mimics :

- The fibers developed will change them color hue, depth of shade by the application of an electrical or magnetic field
- The change in color is due to the absence of specific weave of the light

12. Tissue engineering :

- This uses the living cell and components with textile based biomaterial to develop biological tissue for human body repair
- The biomaterial provide support for cellular attachment
- This will solve shortage of problem associated with organ transplants
- The nonwoven specially biodegradable materials are used

13. Detection of vital signals :

- Sensatex is is developing "Smart shirt" to protect the public safety personnel (eg) fire fighters, police officers and other rescue teams
- The smart shirt monitor the health and safety of the public
- The victims of building. It is able to detect the location of victims
- This also detect the falls, hazardous due to gas and offer communication to voices

14. Global positioning system (GPS)

- This can detect the user its location and weather
- Electronic textiles with integrated GPS enhance safety
- It is wireless hand free communication

- Electronic devices enhances digital information, power control the signals within the user personal space.

15. Cooling / warming system

- A high tech vest help to keep the soldiers / fire fighters to be active / alive in the high or low temperature in desert, mines and major fires
- Cooling system has heat pipe technology which warm up the body
- This also can be used by people in armor, nuclear, biological and chemical

16. Warning signals :

- A combination of sensors and small flexible light emitting display can receive and respond to reaction of the body, enabling a warning signal to be sent / displayed

17. Self cleaning fabrics

- Nano size particles like Titanium Dioxide, Zinc Oxide posses photo catalytic and oxidizing ability which is used as self cleaning fabrics
- When Titanium Dioxide is exposed to light the electron is able to break down the dirt, microorganism into substances like CO_2 and H_2O

18. Electrical conductive fabrics

- Electrical conductive fabrics are manufactured by using metals and polymers
- Fabrics are manufactured by direct use of conductive yarns in order to provide a versatile combination of physical and electrical properties for a variety of demanding applications.
- These conductive fabrics satisfy very well all the important properties that a garment should have. They are lightweight, durable, flexible

19. Smart Bra

- One of the best examples of conductive polymer coated fabric for improving comfort properties of women is the Smart Bra
- This bra will provide better support to active women when they are in action
- The fabrics can alter their elasticity in response to information about how much strain they are under.
- The smart bra will be capable of instantly tightening and loosening its straps or stiffening cups when it detects excessive movement

- Another main applications of conductive textile materials are their uses for the power supply of electronic devices used in the garments called “SMART SHIRT” which is manufactured for use in combat conditions, for fire fighters where the sensor that monitors oxygen or hazardous gas levels and other sensors monitor respiration rate and body temperature.

20. Smart textiles from Electronics

- An interconnect and packaging technology is demonstrated using a polyester narrow fabric with several warp threads replaced by copper wires which are coated with silver and polyester.
- For the electrical connections, the coating of the wires and the surrounding textile material is removed by laser treatment forming holes.