FIBRE-REINFORCED PLASTIC

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INTRODUCTION

Fibre-reinforced plastic (**FRP**) (also called **fibre-reinforced polymer**, or **fiber-reinforced plastic**) is a composite material made of a polymer matrix reinforced with fibres. The fibres are usually glass (in fibre-glass), carbon, aramid, or basalt. Rarely, other fibres such as paper, wood, or asbestos have been used. The polymer is usually an epoxy, viny-lester, or polyester thermosetting plastic, though phenol formaldehyde resins are still in use.

FRPs are commonly used in the aerospace, automotive, marine, and construction industries. They are commonly found in ballistic armor as well.

PROCESS DEFINATION

A polymer is generally manufactured by step-growth polymerization or addition polymerization. When combined with various agents to enhance or in any way alter the material properties of polymers the result is referred to as a plastic. Composite plastics refer to those types of plastics that result from bonding two or more homogeneous materials with different material properties to derive a final product with certain desired material and mechanical properties. Fibre-reinforced plastics are a category of composite plastics that specifically use fibre materials to mechanically enhance the strength and elasticity of plastics.

The original plastic material without fibre reinforcement is known as the matrix or binding agent. The matrix is a tough but relatively weak plastic that is reinforced by stronger stiffer reinforcing filaments or fibres. The extent that strength and elasticity are enhanced in a fibre-reinforced plastic depends on the mechanical properties of both the fibre and matrix, their volume relative to one another, and the fibre length and orientation within the matrix. Reinforcement of the matrix occurs by definition when the FRP material exhibits increased strength or elasticity relative to the strength and elasticity of the matrix alone

VARIOUS FIBRES AND MATRIX MATERIALS

NATURAL FIBRES:-

- Any hair like raw material directly obtainable from an animal, vegetable or mineral source that can be convertible after spinning into yarns and then into fabric.
- Under them there are various categories:
- (1) plant
- (2) animal
- (3) minerals

Vegetable fibe

they can be further on classified as:

(a)fibre occurring on the seed (raw cotton , java cotton)

(b)phloem fiber (flax, ramie , hemp, jute)

(c)tendon fibre from stem or leaves (manila hemp, sisal hemp etc)

(d)fibre occurring around the trunk (hemp palm)

(e)fibre of fruit/ nut shells (coconut fibre – Coir)

cotton and linen are the most important among them.

ANIMAL FIBRES

- Animal fibers are natural fibers that consist largely of proteins silk, hair/fur, wool and feathers.
- The most commonly used type of animal fiber

MINERAL FIBRE

- Asbestos is the only natural mineral fibre obtained from varieties of rocks.
- **properties**
- It is fibrous form of silicate of magnesium and calcium containing iron and aluminium and other minerals.
- It is acid proof, flame proof and rust proof.
- Its particles are carcinogenic and hence its use is restricted.

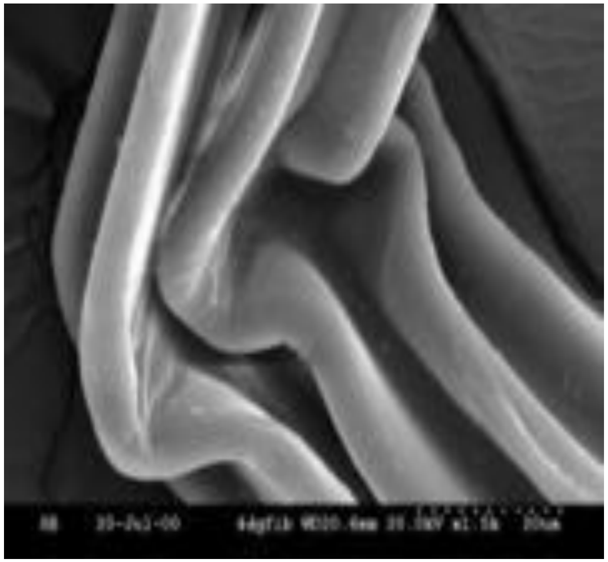
MAN MADE FIBRE

- **Natural man made fibre**

(A) Cellulosic fibres

- Cellulose is one of many polymers found in nature.
- Wood, paper, and cotton all contain cellulose. > Cellulose is an excellent fiber.
- Cellulose is made of repeat units of the monomer glucose.
- The three types of regenerated cellulosic fibres are rayon, acetate and triacetate which are derived from the cell walls of short cotton fibres called linters.
- Paper for instance is almost pure cellulose

SYNTHETIC MAN MADE FIBRE



Polyester is a category of polymers which contain the ester functional group in their main chain.

- The term "polyester" is most commonly refered as polyethylene terephthalate (PET).
- it has a high melting temperature
- it can be dyed with only disperse dyes
- they are thermoplastic, have good strength and are hydrophobic
- the fibre has a rod like shape with a smooth surface.
- it is lustrous and its hand is crisp.
- it has excellent resiliency and so it the best wash and wear fabric.
- there are problems of static and pilling in it.

NYLON

- NYLON is one of the most common polymers used as a fiber.
- There are several forms of nylon depending upon chemical synthesis such as nylon 4, 6, 6.6, 6.10, 6.12, 8,10 and 11.

Nylon is found in clothing all the time, but also in other places, in the form of a thermoplastic material.

- Nylons are also called polyamides, because of the characteristic amide groups in the backbone chain.
- These amide groups are very polar and are linked with each other with hydrogen bonds.
- nylon is a regular and symmetrical fibre with crystalline regions and make very st fibers.
- the fibre has a smooth rod like shape with a smooth surface

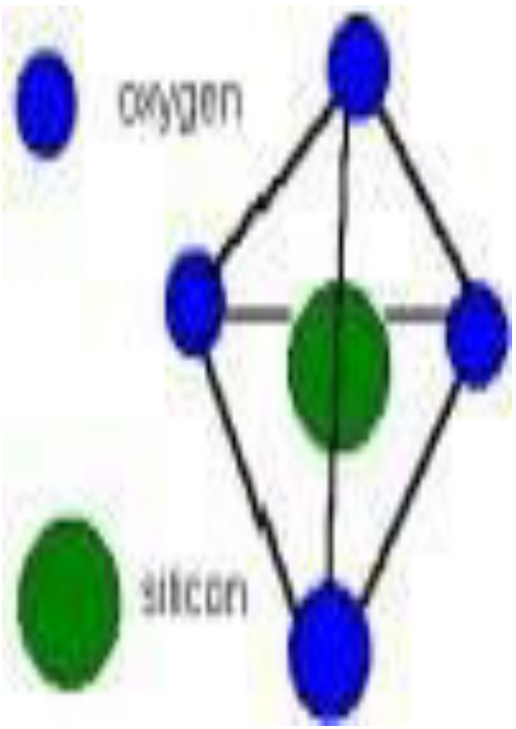
RUBBER FIBRE

- Rubber is an elastic hydrocarbon polymer that naturally occurs as a colloidal suspension, or latex, in the sap of some plants
- The manufacturing process consists of extruding the natural rubber latex into a coagulating bath to form filament.the material is cross linked to obtain fibres which exhibit high stretch
- It can be synthesized.

- natural rubber is essentially a polymer of isoprene units, a hydrocarbon diene monomer.
- Synthetic rubber can be made as a polymer of
- oprene or various other monomers
- The material properties of natural rubber make it an elastomer .
- Rubber exhibits unique physical and chemical properties.
- Rubber's stress-strain behavior exhibits the Mullins effect, the Payne effect and is often modeled as hyperelastic.
- Rubber strain crystallizes.

GLASS FIBRE

- It is also known as Fiberglass that is a material made from extremely fine fibers of glass. .Glass fiber is formed when thin strands of silica-based or other formulation glass is extruded into many fibers with small diameters suitable for textile processing
- it has a high degree of viscosity
- The basis of textile grade glass fibers is silica, SiO_2. In its pure form it exists as a polymer, $(SiO_2)_n$.
- In order to induce crystallization, it must be heated to temperatures above 1200°C for long periods of time.



- The first type of glass used for fiber was soda-lime glass or A glass which was not very resistant to alkali. A new type, E- glass was Glass fibers are useful because of their high ratio of surface area to weight. However, the increased surface area makes them much more susceptible to chemical attack.
- By trapping air within them, blocks of glass fiber make is used as a reinforcing agent for many polymer products.
- it has a good thermal insulation, with a thermal conductivity of 0.05 W/m-K.

- Because glass has an amorphous structure, its properties are the same along the fiber and across the fiber.
- Humidity is an important factor in the tensile strength. Moisture is easily adsorbed, and can worsen microscopic cracks and surface defects, and lessen tenacity.
- it has no effect on exposure to sunlight even after extended periods.
- It is completely hydrophobic

METALLIC FIBRES

- Metallic fibers are manufactured fibers composed of metal, plastic-coated metal, metal-coated plastic, or a core completely covered by metal. Gold and silver have been used since ancient times as yarns for fabric decoration. More recently, aluminum yarns, aluminized plastic yarns, and aluminized nylon yarns have replaced gold and silver.

- they are made through laminating process. Coated metallic filaments help to minimize tarnishing.

- When suitable adhesives and films are used, they are not affected by salt water, chlorinated water in swimming pools or climatic conditions.
- If possible anything made with metallic fibers should be dry-cleaned.
- Ironing can be problematic because the heat from the iron, especially at high tempatures, can melt the fibers.
- they are used mainly for decorative purposes.

MATRIX MATERIAL

While the principal strength and stiffness of the composite is provided by the fibres, the matrix material also has a large part to play in the overall mechanical properties. The matrix is not designed to bear much of the load. Instead, the matrix binds the fibres together and distributes the load. It also provides ductility and protects the fibres from surface damage. It separates the fibres and prevents propagation of cracks from one fibre to the next. Also, unless the matrix chosen is a particularly flexible one then it will assist in prevention of the fibres buckling under compression.

The requirements of a good matrix material are that it can infiltrate between the fibres and form a strong interfacial bond. It is also essential that there is no chance of chemical reaction between the matrix material and fibres and that the matrix material does not cause damage to the fibres.

There are three main types of composites based on the type of matrix they employ –

1. polymer matrix composites (PMC)
2. ceramic matrix composites (CMC) and
3. metal matrix composites (MMC).

The most common type are polymer matrix composites. They are produced in the largest quantities, due to their good room temperature properties, ease of manufacture and low cost.

There are two main types of polymer composite matrix materials, thermoplastics and thermosetting resins.

- Fibers and whiskers in composites are held together by a binder known as *matrix*. This is required since fibers by themselves:
  - Given their small cross-sectional area, cannot be directly loaded.
  - Further, they cannot transmit load between themselves.

- This limitation is addressed by embedding fibers in a matrix material.

- Matrix material serves several functions, the important ones being:
  - Binds fibers together.
  - Transfers loads and stresses within the composite structure.
  - Support the overall structure
  - Protects the composite from incursion of external agents such as humidity, chemicals, etc.
  - Protects fibers from damage due to handling.

Matrix material strongly influences composite’s overall transverse
modulus, shear properties, and odu us, s ea p ope t es, a d compression properties.

• Matrix material also significantly limits a composite’s maximum permissible operating temperature.

• Most of the matrix materials are relatively lighter, more compliant, and weaker vis-à-vis fibers and whiskers.

• However, the combination of fibers/whiskers and matrix can be very stiff, very strong, and yet very light.

– Thus most of modern composites have very high specific strengths, i.e. very high strength/density ratios.

– This makes them very useful in aerospace applications, where weight minimization is a key design consideration.

POLYMERS AS MATRIX MATERIALS

Polymers: Most widely used matrix materials

– Common examples: Polyesters, vinylesters, PEEK, PPS, nylon, polycarbonate, polyacetals, polyamides, polyether imides, polystyrene, epoxies, ureas, melamines, silicones.

- Advantages:

– Low cost

– Easy to process

– Low density

– Superior chemical resistance

- Limitations:

– Low strength

– Low modulus

– Limited range for operating temperature

– Sensitivity to UV radiation, specific solvents, and occasionally humidity

THANK YOU