MODULE -III

PHASE RULE AND COMPOSITES

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3.7 Composites

All the Engineering materials (high polymers, metals and ceramics) possess their outstanding characteristics as well as limitations. None of these can be properly used where very stringent and specific requirements are required. High temperature reactors, supersonic aircrafts, missiles etc., In order to meet such a stringent and specific requirement, scientists and technologists have developed a new class of materials called composites

Definition:

A composite material may be defined as a material system consisting a mixture of two or more micro constituents, which are mutually insoluble, differing in form or composition and forming distinct phases.

Need of composites

Composites possesses a peculiar property.

- They possess higher specific strength and lower specific gravity.
- They possess lower electrical conductivity and thermal expansion.
- They possess better creep, fatigue, strength, corrosion and oxidation resistance.
- They maintain very good strength even up to high temperatures.
- Due to its lower weight reduces, fuel consumption and emission.

3.8 Constituents of composites

Composites consist of two important constituents

a) Matrix phase (or) Matrix resin

b) Dispersed phase (or) Reinforcement

3.8.1 a)Matrix phase (or) Matrix resin

Matrix phase is the continuous body constituent, which encloses the composite.

Matrix phase may be Metals, ceramics, polymers.

Based on the type of matrix phase, composites are classified into three types

i) Polymer matrix composites (PMC)

ii) Metal matrix composites (MMC)

iii) Ceramic matrix composites(CMC)

The matrix phase has several important functions.

- 1.It binds the fibres together by virtue of its cohesive and adhesive characteristics.
- It acts as a medium by which an externally applied load is transmitted and distributed to the dispersed phase.
- It protects the individual fibres from chemical reaction with the environment and from surface damage due to mechanical abrasion.

3.8.2 Dispersed phase

Dispersed phase is the structural constituent, which determines the internal structure of composites

Eg:Fibres, particulates, flakes, whiskers.

3.8.1.1 Properties and applications of Metal matrix composite (MMC)

A metal matrix composite (MMC) is a composite material with at least two constituent parts, one being a metal necessarily, the other material may be a different metal or another material, such as a ceramic or organic compound.

The most important MMC systems are:

- Aluminum matrix. Continuous fibers: boron, silicon carbide, alumina, graphite. ...
- Magnesium matrix. Continuous fibers: graphite, alumina. ...
- Titanium matrix. Continuous fibers: silicon carbide, coated boron. ...
- Copper matrix. Continuous fibers: graphite, silicon carbide. ...
- Superalloy matrices.

Properties

Metal matrix composites (MMCs), by virtue of their low density, **high strength-to-weight ratio**, high temperature strength retention, sustainability, **increased specific strength/stiffness**, enhanced elevated temperature strength, improved wear, or corrosion resistance.

Applications

The following are some of the most common application areas of composite metal matrix materials:

Lightweight high-strength metal matrix nano-composites (MMNCs) can be used in a wide variety of applications, e.g., aerospace, automotive, and biomedical engineering.

- Pushrods for racing engines.
- Carbide drills.
- Tank armors.
- Automotive industry - disc brakes, driveshaft, engines.
- Aircraft components - structural component of the jet's landing gear.
- Bicycle frames.
- Space systems

3.8.1.2 Properties and applications of Ceramic matrix composites

Ceramic matrix composites are a subgroup of composite materials and a subgroup of ceramics. They consist of ceramic fibers embedded in a ceramic matrix. The fibers and the matrix both can consist of any ceramic material, whereby carbon and carbon fibers can also be regarded as a ceramic material.

Properties

- High thermal shock and creep resistance.
- High temperature resistance.
- Excellent resistance to corrosion and wear.

- Inertness to aggressive chemicals.
- High tensile and compressive strength, thus no sudden failure as compared to conventional ceramics.

Applications:

Ceramic matrix composites (CMCs) are widely used in

- Aerospace sector (gas turbines, structural re-entry thermal protection)
- Energy sector (heat exchangers, fusion reactor walls).

Advantages

Ceramic matrix composites **can withstand higher temperatures than other material composites**, making them appropriate for projects that other materials can't handle. They're also more resistant to everyday wear and tear than other composite materials, which means that they can last longer than those materials.

- The ceramic composites have very high temperature range of above 2000 .
- High elastic modulus and low density.

Disadvantages:

- Susceptible to oxidation at elevated temperatures.
- High material and production cost.
- Low shear strength.

3.8.1.3 Properties and applications of polymer matrix composites (or) fibre Reinforce polymer composites(FRP).

The fibre reinforced polymer composites constitute more than 90%(by weight) of the total composites used in various industries. The advantages of using polymer in structural composites is the ease of fabrication of complex structural shapes. It can be easily manufactured.

Properties of FRP

(1) It possess superior properties like higher yield strength fracture strength and fatigue life.

(2) Since fibre prevents slip and crack propagation, the mechanical properties of FRP gets increased.

(3) It possess high corrosion resistance and heat resistance property.

The property of FRP mainly depends on the nature of resin matrix.

Resin	**Properties**
Polyester resin	Gives very good strength and mechanical
Epoxy resin	Gives good mechanical properties
Silicon resin	Gives excellent thermal & electrical properties
Phenolic resin	Withstand at high temperatures
Thermo plastics	has repairability character

Types of FRP composites

1. Glass FRP
2. Boron FRP
3. Carbon FRP
4. Aramid FRP
5. Alumina FRP

Applications of fibre Reinforced polymer composites

- Glass-FRP used in automobile parts, storage tanks plastic pipes, flourings transportation industries.
- Boron-FRP used in horizontal & vertical tail in aeroplane. Stiffening spares, ribs.

- Carbon-FRP used in making of structural components of air craft and helicopters, recreational equipments sports materials, antenna disc, solar panel.
- Aramid-FRP used in structural component in aircraft helicopter parts.
- Alumina-FRP used in components of engine parts in automobile industry and components of turbine engine parts manufacturing fields.

3.8.2.1 Fibres

Any polymer, metal or ceramic that has been drawn into long and thin filament, is termed as fibre. It is characterized by high aspect ratio (length to diameter ratio) and near crystal sized diameter.

Properties

- They have high tensile strength and stiffness.
- Orientation of fibres determine the property of fibrous composites.
- It lowers overall density of composites.

Classification of fibres

- Natural fibre – Cotton,wool,silk,coir
- Semi synthetic fibre- Rayon,cellulosic
- Synthetic fibre- glass fibres, carbon fibres, aramide fibres, boron fibres and ceramic fibres.

3.8.2.2 Particulates

Particulates are small pieces of hard solid materials. These particles can be metallic (or) non-metallic. Properties of matrix materials which are modified by adding particulate fillers are

- Improved performance at elevated temp.
- Improved users and abrasion resistance.
- Increase surface hardness.
- Reduction in cast.
- Modification in thermal and electrical conductivities.

3.8.2.3 Flakes

Flakes are very thin slid lie materials.Thin flakes have a two dimentional geometry. It gives equal strength in all directions.

Flakes can be packed more efficiently then fibres (or) spherical particles.

(Ex) Mica flakes are used in electrical and heat insulting applications.

3.8.2.4 Whiskers

Whiskers are very thin, single crystals with a high degree of crystalline perfection. It posses high strength.

(Ex) Graphite, Aluminium oxide, Silicon carbide and Silicon nitride.

1.Perfect whiskers possess high strength.

2.Possess high elastic modules and high degree of crystallinity.

3.8.3 Hybrid composites

Hybrid composites are obtained by using two (or) more different types of fibres in a single matrix.

Properties:

- Hybrid composites possess very good properties compared to their single fibre composites.
- They possess strong ,tough and higher impact resistance.
- When hybrid composites are stressed in tension, failure does not occur suddenly.
- They possess balanced strength and stiffness
- They exhibit superior mechanical and tribological properties than other composites.

Uses

- It is used in light weight transport structural components(land ,water)
- Used in light weight orthopedic components and sporting goods.
- Used to make furniture like chair, table and bath tubs.
- Used in railway coach interioors.

- Auto mobile industry utilizes hybrid composites in many of the interior and exterior applications.