INTRODUCTION TO CERAMICS, GLASS AND REFRACTORIES

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9) COMPOSITES
Composite material is a material composed of two or more distinct phases (matrix phase and dispersed phase) and having bulk properties significantly different from those of any of the constituents.

Composites are combinations of two or more materials in which one of the materials, called the reinforcing phase, is in the form of fibers, sheets, or particles, and is embedded in the other materials called the matrix phase. The reinforcing material and the matrix material can be metal, ceramic, or polymer. The dispersed phase is usually stronger than the matrix, therefore it is called reinforcing phase.

Examples of some current application of composites include the diesel piston, brake-shoes and pads, tires and aircraft in which 100% of the structural components are composites.
Classification of Composites

Based on Matrix Material

Metal Matrix Composites MMC are composed of a metallic matrix (aluminium, magnesium, iron, cobalt, copper) and a dispersed ceramic (oxides, carbides) or metallic (lead, tungsten, molybdenum) phase.

Ceramic Matrix Composites CMC are composed of a ceramic matrix and embedded fibers or Whiskers of other ceramic material (dispersed phase).

Polymer Matrix Composites PMC are composed of a matrix from thermoset (Unsaturated Polyester (UP), Epoxiy (EP)) or thermoplastic (Polycarbonate (PC), Polyvinylchloride, Nylon Polysterene) and embedded glass, carbon, steel or Kevlar fibers (dispersed phase).

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Based on Reinforcing Material

1. **Short-fiber or Whiskers reinforced composites.** consist of a matrix reinforced by a dispersed phase in form of discontinuous fibers (length < 100*diameter) or Whiskers (Length less than 15µ and diameter of less than 1µ)
   A. Composites with random orientation of fibers.
   B. Composites with preferred orientation of fibers.

2. **Long-fiber reinforced composites.** Long-fiber reinforced composites consist of a matrix reinforced by a dispersed phase in form of continuous fibers.
   A. Unidirectional orientation of fibers.
   B. Bidirectional orientation of fibers (woven).

**Particulate Composites**

Particulate Composites consist of a matrix reinforced by a dispersed phase in form of particles.

1. **Composites with random orientation of particles.**
2. **Composites with preferred orientation of particles.**

   Dispersed phase of these materials consists of two-dimensional flat platelets (flakes), laid parallel to each other.

**Laminate Composites**

When a fiber reinforced composite consists of several layers with different fiber orientations, it is called **multilayer (angle-ply) composite.**
Design with composites

Specification and Properties required

Matrix

Dispersed phase

Composite Material

Possible Advantages

Light weight
High strength
High Hardness
High Toughness
High corrosion resistance
High impact resistance
Durability