INTRODUCTION /

Basic Classifications of Materials:

The basic factors for classifications of materials in material science and engineering are:

(i) The chemical composition of the material,
(ii) The mode of the occurrence of the material in the nature,
(iii) The refining and the manufacturing process to which the material is subjected prior it acquires the required properties,
(iv) The atomic and crystalline structure of material.
(v) The industrial and technical use of the material.

Generally, materials engineering may be classified into the following categories:

1) Metals and alloys.
2) Ceramics.
3) Polymers.
4) Composites.
5) Advanced materials: such as semiconductors, biomaterials, smart materials, and nanoengineered materials.

1.) Metals and alloys:

Metals are elements which have free valence electrons which are responsible for their good thermal and electrical conductivity. Metals readily lose their electrons to form positive ions. The metallic bond is held by electrostatic force between delocalized electrons and positive ions. Atoms in metals and their alloys are arranged in a very orderly manner.

Note : Engineering metals are generally Alloys.

General properties:

- High electrical conductivity.
- High thermal conductivity.
- Ductile and relatively high stiffness.
- Toughness and strength.
- They are ready to machining, casting, forming, stamping and welding.

Nevertheless, they are susceptible to corrosion.

Applications:

♣ Structures: buildings, bridges, etc.
♣ Automobiles: body, springs, engine block, etc.
♣ Airplanes: engine components, fuselage, landing gear assembly, etc.
♣ Trains: rails, engine components, body, wheels
♣ Machine tools: drill bits, hammers, screwdrivers, saw blades, etc.
♣ Electrical wiring.
♣ Magnets

2.) Ceramics:

Inorganic, non-metallic crystalline compounds, usually oxides (SiO2, Al2O3, MgO, TiO2, BaO), Carbides (SiC), Nitrides (Si3N4), Borides (TiB2), Silicides (WSi2, MoSi2). Some literature includes glasses in the same category, however; glasses are amorphous (noncrystalline) compounds i.e. they possess "short range" order of atoms.

Classification:

There are various classification systems of ceramic materials, which may be attributed to one of two principal categories: application base system or composition base system

i. Traditional Ceramics: Includes pottery, china, porcelain products…etc, these products utilizes natural ceramic ores.

ii. Advanced Ceramics: Alumina, magnesia, Carbides, Nitrides, Borides, Silicides …etc, they are synthetic materials, usually of better mechanical properties. Electronic ceramics falls in the same category.

General properties:

- Light weight.
- Hard.
- High strength.
- Stronger in compression than tension.
- Tend to be brittle.
- Low electrical conductivity,
- High temperature resistance.
- Corrosion resistance

Applications:

- ♣ Electrical insulators
- ♣ Thermal insulation and coatings
- ♣ Windows, television screens, optical fibers (glass)
- ♣ Corrosion resistant applications
- ♣ Electrical devices: capacitors, varistors, transducers, etc.
- ♣ Highways and roads (concrete).
- ♣ Building blocks (bricks).
- ♣ Building binders (cement, gypsum).
- ♣ Biocompatible coatings (fusion to bone)
- ♣ Magnetic materials (audio/video tapes, hard disks, etc.)

3) Polymers:

A polymer (the name means "many parts") is long chain molecule made up many repeating units, called monomers. Polymers can be natural (organic) or synthetic. The properties of polymers are linked directly to their structure, which is dictated mostly by intermolecular bonds.

INTRODUCTION /

Examples:

Polymers are everywhere: in plastics (bottles, toys, packaging), cosmetics, shampoos and other hair care products, contact lenses, nature (crab shells, amber), food (proteins, starches, gelatin, gum, gluten), fabric, balls, sneakers, and even in your DNA!.

General properties: Compared with metals:

- ♣ Polymers have lower density, lower stiffness and tend to creep.
- ♣ High thermal expansion and corrosion resistance.
- ♣ Low electrical and thermal conductivities.
- ♣ The prime weakness is that polymers do not withstand high temperatures.

Classification: according to their properties:

i.) Plastics: (Hard), they can be semi-crystalline or amorphous (glassy).

1. Thermoplastics: such as Polyethylene (PE) and Polymethylmethacrylate (Acrylic and PMMA) are composed of "linear" polymer chains. They flow under shear when heated. They can be compression- or injection- molded.

2. Thermosets: such as Polystyrene (PS) and Polyvinylchloride (PVC) are composed of "branched" polymer chains. They not flow when heated. The monomers are 'cured' in a mold.

ii.) Elastomers: (Soft) Rubbery cross-linked solids that will deform elastically under stress, e.g. natural rubber

iii.) Solutions: Viscosity modifiers, lubricants.

Applications & Examples :

- Adhesives and glues
- Containers • Moldable products (computer casings, telephone handsets, disposable razors)
- Clothing and upholstery material (vinyls, polyesters, nylon)
- Water-resistant coatings (latex)
- Biomaterials (organic/inorganic interfaces)
- Liquid crystals
- Low-friction materials (Teflon)
- Synthetic oils and greases
- Soaps and surfactants