Materials in Product design

Description

A **material** is a substance or mixture of substances that constitutes an object. Materials can be pure or impure, living or non-living matter.

Classifications of Materials

1. Metals - Both ferrous,Non-ferrous and alloys (ferrous means containing iron)
2. Plastics- Polymers containing long chains of carbon and hydrogen
3. Ceramics- non-metal inorganic solids
4. Composites- combinations of multiple materials

Materials Properties

Materials are used/selected for a specific application based on the properties they have, the properties are based on how the materials respond to forces applied to them.

These properties are as follows ;

- **Stiffness** - the extent to which an object resists changing its shape in response to an applied force (e.g a metal is stiffer than rubber).
- **Strength** - the ability for a material to withstand an applied force before it fails or breaks.(e.g stainless steel has more strength than copper)
- **Toughness** - the ability of a material to absorb energy and plastically deform (change shape) without fracturing.
- **Hardness** - Measure of a material to resist indentation or abrasion.
- **Thermal conductivity** - measure of a material's ability to conduct heat.
- **Heat capacity** - Amount of heat required to change the temperature of a

Metals

- Metals are the most important material in use today.
- They have properties that satisfy a wide variety of design requirements
- The manufacturing processes by which they are shaped into products have been developed and refined over many years.

Why Metals Are Important

- High stiffness and strength - can be alloyed for high rigidity, strength, and hardness •
- Toughness - capacity to absorb energy better than other classes of materials
- Good electrical conductivity - Metals are conductors
- Good thermal conductivity - conduct heat better than ceramics or polymers
- Cost –the price of steel is very competitive with other engineering materials

Classifications of Metals

1. **Ferrous** - those based on iron Steels Cast irons.
2. **Non-ferrous** - all other metals Aluminum, magnesium, copper, nickel, titanium, zinc, lead, tin, molybdenum, tungsten, gold, silver, platinum, and others.
3. **Superalloys-** when different metals are mixed to achieve certain properties.

Plastics

Plastics give us the possibility of manufacturing well-designed, beautiful products from the very many different types of plastics materials that are commonly available today.

The word plastic itself comes from the Greek word plasticos, which means to be able to be shaped or moulded by heat. As we will see, shaping plastics by using heat is a basic part of nearly all plastics manufacturing processes.

'Polymers' is a general term for all plastic materials and means that they are organic, carbon based compounds whose molecules are linked together in long chain patterns.

Classifications of Plastics

1. **Natural plastics** - these are naturally occurring materials that can be said to be plastics because they can be shaped and moulded by heat. An example of this is amber, which is a form of fossilised pine tree resin and is often used in jewellery manufacture.

2. **Semi synthetic plastics** - these are made from naturally occurring materials that have been modified or changed but mixing other materials with them. An example of this is cellulose acetate, which is a reaction of cellulose fibre and acetic acid and is used to make cinema film.
3. **Synthetic plastics** - these are materials that are derived from breaking down, or 'cracking' carbon based materials, usually crude oil, coal or gas, so that their molecular structure changes. This is generally done in petrochemical refineries under heat and pressure, and is the first of the manufacturing processes that is required to produce most of our present day, commonly occurring plastics. Synthetic and semi synthetic plastics can be further divided into two other categories. These two categories are defined by the ways in which different plastics react when heated.

    - **Thermoplastics** - these are plastics that can be softened and formed using heat, and when cool, will take up the shape that they have been formed into. But if heat is reapplied they will soften again. Examples of thermoplastics are acrylic and styrene, probably the most common plastics found in school workshops.
    - **Thermosetting plastics** - these are plastics that soften when heated, and can be moulded when soft, and when cool they will set into the moulded shape. But if heat is reapplied they will not soften again, they are permanently in the shape that they have been moulded into. Why this happens we will look at later. Examples of thermosetting plastics are polyester resins used in glass reinforced plastics work, and melamine formaldehyde used in the manufacture of Formica for kitchen work surfaces.

Ceramics

Ceramics are defined as products made from inorganic materials having non-metallic properties, usually processed at a high temperature at some time during their manufacture.

The word "ceramics" comes from the Greek word "Keramos" meaning "Pottery," "Potter's Clay," or "a Potter." This Greek word is related to an old Sanskrit root meaning "to burn" but was primarily used to mean "burnt stuff."

The technical definition of ceramics involves a much greater variety of products than is normally realized. To most people, the word ceramics means dinnerware,

figurines, vases, and other objects of ceramic art. The majority of ceramic products are not generally recognized. Examples are :

- bathtubs,
- washbowls,
- sinks,
- electrical insulating devices,
- water and sewerage pipes,
- bricks,
- hollow tile,
- glazed building tile,
- floor and wall tile,
- earthenware,
- porcelain enamel and glass. •

Ceramic products have a number of outstanding properties which determine their usefulness. One of the most unusual of these is their great durability. This durability can be divided into three types:

1. **Chemical,**
2. **Mechanical**
3. **Thermal.**

Chemical

- The high chemical durability of the great majority of ceramic products makes them resistant to almost all acids, alkalis, and organic solvents. - Of further importance is the fact that ceramic materials are not affected by oxygen.

- The materials generally contained in the ceramic products have already combined with all of the oxygen for which they have an affinity, and therefore, are not affected further by the presence of oxygen in their environment.

Mechanical

- The mechanical durability of ceramics is evidenced by their strength and hardness. The compressive strengths of ceramic materials are extremely high,

- The hardness makes ceramic materials very resistant to abrasion. It is this property which makes them useful for floors, and for the grinding of metals and other materials.

Thermal

- Most ceramics have the ability to withstand high temperatures.
- This is why they are useful in the production of all types of heat-containing equipment such as kilns for the ceramic industry, and such products as the inner linings of fireplaces and home heating furnaces.

Composites

Many of our modern technologies require materials with unusual combinations of properties that cannot be met by the conventional metal alloys,ceramics,and polymeric materials.

Material property combinations and ranges have been, and are yet being, extended by the development of composite materials

Generally speaking, a composite is considered to be any multiphase material that exhibits a significant proportion of the properties of both constituent materials such that a better combination of properties is realized.

Examples of composite materials include:

1. **Concrete** - a combination of cement which is a ceramic and steel which is a metal, the cement has high compression resistance while the steel has high tensile resistance making concrete have both good compressive and tensile strength.
2. **Fiberglass** - a combination of glass fibre threads and polyurethane resin, in this case the fibre threads have high tensile strength while the resin has high compressive strength when cured by UV light.

Assignment

1. Identify 3 products from your surrounding, take a picture and list down all the materials used in that product and explain the reasons why you think those materials were used.

(Submit the image together with the text before next class and make sure the product has multiple materials)