UNIT – 1

INTRODUCTION OF MATERIALS TESTING

SYLLABUS

Overview of materials, classification of material testing, purpose of testing, selection of material, development of testing, testing organizations and its committee, testing standards, result analysis, advantages of testing.

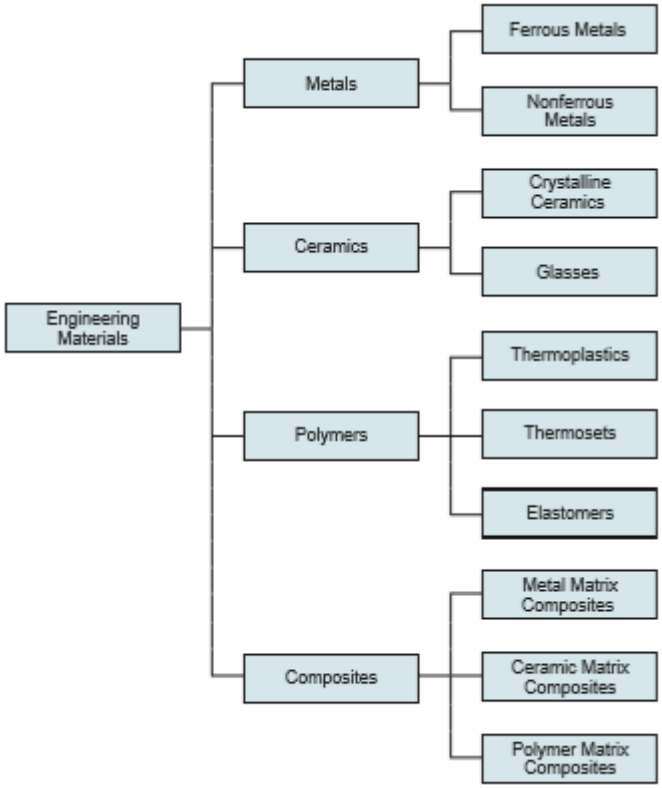
1.1 Overview of Materials

Every **material** in nature has certain properties. These properties define the behavior of the materials. **Material** is a substance or mixture of substances that constitutes an object. Materials can be pure or impure, living or non-living matter. Materials can be classified on the basis of their physical and chemical properties, or on their geological origin or biological function. Materials science is the study of materials, their properties and their applications. Raw materials can be processed in different ways to influence their properties, by purification, shaping or the introduction of other materials. New materials can be produced from raw materials by synthesis.

1.1.1Classification of Materials

There are thousands of materials available for use in engineering applications. Most materials fall into one of three classes that are based on the atomic bonding forces of a particular material. These three classifications are metallic, ceramic and polymeric. Additionally, different materials can be combined to create a composite material. Within each of these classifications, materials are often further organized into groups based on their chemical composition or certain physical or mechanical properties. Composite materials are often grouped by the types of materials combined or the way the materials are arranged together. Below is a list of some of

the commonly classification of materials within these four general groups of materials.



Metals

Metals account for about two thirds of all the elements and about 24% of the mass of the planet. Metals have useful properties including strength, ductility, high melting points, thermal and electrical conductivity, and toughness. From the periodic table, it can be seen that a large number of the elements are classified as being a metal. A few of the common metals and their typical uses are presented below.

Common Metallic Materials

- Iron/Steel - Steel alloys are used for strength critical applications
- Aluminum - Aluminum and its alloys are used because they are easy to form, readily available, inexpensive, and recyclable.

- Copper - Copper and copper alloys have a number of properties that make them useful, including high electrical and thermal conductivity, high ductility, and good corrosion resistance.
- Titanium - Titanium alloys are used for strength in higher temperature (~1000° F) application, when component weight is a concern, or when good corrosion resistance is required.
- Nickel - Nickel alloys are used for still higher temperatures (~1500-2000° F) applications or when good corrosion resistance is required.
- Refractory materials are used for the highest temperature (> 2000° F) applications.

Ceramics

A ceramic has traditionally been defined as “an inorganic, nonmetallic solid that is prepared from powdered materials, is fabricated into products through the application of heat, and displays such characteristic properties as hardness, strength, low electrical conductivity, and brittleness." The word ceramic comes the from Greek word "keramikos", which means "pottery." They are typically crystalline in nature and are compounds formed between metallic and nonmetallic elements such as aluminum and oxygen (alumina-Al2O3), calcium and oxygen (calcia - CaO), and silicon and nitrogen (silicon nitride-Si3N4).

Ceramics have many daily applications like dishes and wall tiles depending on their method of formation, ceramics can be dense or lightweight. Typically, they will demonstrate excellent strength and hardness properties; however, they are often brittle in nature. Ceramics can also be formed to serve as electrically conductive materials or insulators. Some ceramics, like superconductors, also display magnetic properties. They are also more resistant to high temperatures and harsh environments than metals and polymers. Due to ceramic materials wide range of properties, they are used for a multitude of applications.

The broad categories or segments that make up the ceramic industry can be classified as:

- ✓ Structural clay products (brick, sewer pipe, roofing and wall tile, flue linings, etc.)
- ✓ White wares (dinnerware, floor and wall tile, electrical porcelain, etc.)
- ✓ Refractories (brick and monolithic products used in metal, glass, cements, ceramics, energy conversion, petroleum, and chemicals industries)
- ✓ Glasses (flat glass (windows), container glass (bottles), pressed and blown glass (dinnerware), glass fibers (home insulation), and advanced/specialty glass (optical fibers))
- ✓ Abrasives (natural (garnet, diamond, etc.) and synthetic (silicon carbide, diamond, fused alumina, etc.) abrasives are used for grinding, cutting, polishing, lapping, or pressure blasting of materials)
- ✓ Cements (for roads, bridges, buildings, dams, and etc.)

<u>Advanced ceramics</u>

- Structural (wear parts, bio ceramics, cutting tools, and engine components)
- Electrical (capacitors, insulators, substrates, integrated circuit packages, piezoelectric, magnets and superconductors)
- Coatings (engine components, cutting tools, and industrial wear parts)
- Chemical and environmental (filters, membranes, catalysts, and catalyst supports)

The atoms in ceramic materials are held together by a chemical bond which will be discussed a bit later. Briefly though, the two most common chemical bonds for ceramic materials are covalent and ionic. Covalent and ionic bonds are much stronger than in metallic bonds and, generally speaking, this is why ceramics are brittle and metals are ductile.

Polymers

A polymeric solid can be thought of as a material that contains many chemically bonded parts or units which themselves are bonded together to form a solid. The word polymer literally means "many parts." Two industrially important polymeric materials are plastics and elastomers. Plastics are a large and varied group of synthetic materials which are processed by forming or molding into shape. Just as there are many types of metals such as aluminum and copper, there are many types of plastics, such as polyethylene and nylon. Elastomers or rubbers can be elastically deformed a large amount when a force is applied to them and can return to their original shape (or almost) when the force is released.

Polymers have many properties that make them attractive to use in certain conditions. Many polymers:

- ✓ are less dense than metals or ceramics,
- ✓ resist atmospheric and other forms of corrosion,

- ✓ offer good compatibility with human tissue, or
- ✓ exhibit excellent resistance to the conduction of electrical current.

Polymers are used for many things like gloves and wire casings.

The polymer plastics can be divided into two classes, depending on how they are structurally and chemically bonded.

- thermoplastics and
- thermosetting plastics,

Thermoplastic polymers comprise the four most important commodity materials polyethylene, polypropylene, polystyrene and polyvinyl chloride.

There are also a number of specialized engineering polymers. The term ‘thermoplastic’ indicates that these materials melt on heating and may be processed by a variety of molding and extrusion techniques. Alternately, ‘thermosetting’ polymers can not be melted or remelted. Thermosetting polymers include alkyds, amino and phenolic resins, epoxies, polyurethanes, and unsaturated polyesters.

Rubber is a natural occurring polymer. However, most polymers are created by engineering the combination of hydrogen and carbon atoms and the arrangement of the chains they form. The polymer molecule is a long chain of covalent-bonded

atoms and secondary bonds then hold groups of polymer chains together to form the polymeric material. Polymers are primarily produced from petroleum or natural gas raw products but the use of organic substances is growing. The super-material known as Kevlar is a man-made polymer. Kevlar is used in bullet-proof vests, strong/lightweight frames, and underwater cables that are 20 times stronger than steel.

Composites

A composite material is a material in which one or more mutually insoluble materials are mixed or bonded together. The primary classes of composites are particulate composites, fibrous composites, and laminated composites.

Particulate Composites

Particulate composites are created by adding particles of one material to a matrix (the filler material). The particles will typically account for less than 15% of the total material volume. The particles are added to improve upon some shortcoming of the matrix material.

Fibrous Composites

A fibrous composite is a material in which fibers of one material are embedded within a matrix. The fibers carry most of the stress, and the matrix serves to hold the fibers in place and to transmit stress between the fibers. The fibers can be short and randomly oriented, or they can be long and continuous.

Laminated Composites

Laminated composites are created by combining layers of composite materials. The layers will typically differ in the orientation of the fibers, or they will differ in the material itself. *Sandwich* materials are common, in which a lightweight material (such as foam or a honeycomb) will be placed in between layers of a strong, stiff material.