Chapter 13
Important Engineering Materials

13.1 Introduction, 13.2 Classification of engineering materials, 13.3 Properties of materials, 13.4 Ferrous materials, 13.5 Non-Ferrous, materials, 13.6 Non-Metallic materials

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13.1 Introduction

The knowledge of engineering materials and their properties is of great significance for all the engineers of different disciplines. A proper understanding of the structure and properties of materials is essential for a proper design of the product and for selecting the best method for its processing. The needs of human beings have also grown with civilization. Several components are required for producing the items which we use in our daily life, from a simple pin to a complicated automobile.

In this chapter, we shall discuss the commonly used engineering materials and their various properties.

13.2 Classification of engineering materials

The engineering materials can be classified as

1. ***Metals and their alloys***, such as iron, steel, aluminium, copper, nickel, etc.
2. ***Non-metals***, such as ceramics, glass, plastic, rubber, etc.

The metals can be further classified as

(i) *Ferrous metals* and (ii) *Non-ferrous metals*

The ***ferrous metals*** are those which have the iron as their main constituent, such as wrought iron, steel, and cast iron.

The ***non-ferrous metals*** are those which has a metal other than iron as their main constituent such as aluminium, copper, tin, zinc, etc.

13.3 Properties of materials **[May '17, June '15]**

Material property is defined as *a qualitative or quantitative measure of response of material to externally imposed conditions like forces and temperatures.* Some of the important properties are given in table 13.1.

Table 13.1

Sr. No	Types of Properties	Name of properties
1.	Physical	Dimensions, density, structure, porosity
2.	Mechanical	Strength, stiffness, hardness, brittleness, toughness, ductility, malleability, elasticity, plasticity, resilience, creep, fatigue
3.	Chemical	Composition, corrosion resistance, etc.
4.	Thermal	Heat capacity, specific heat, thermal conductivity, melting point etc.
5.	Electrical	Conductivity, resistivity, etc.
6.	Magnetic	Permeability, hysteresis, etc.
7.	Optical	Reflectivity, absorptivity, etc.
8.	Technological	Castability, weldability, machinability, solderability, workability, etc.

Since it is not possible within the scope of this book to explain all the above properties. A few number of important properties are explained hereunder.

1. Strength : It is the ability of a material to resist the breaking under the action of external loads. It is expressed as force per unit area of cross section.

The strength of a material depends upon the type of loading such as tensile, compressive and shear. Hence strength is also known as tensile, compressive and shear strength.

2. Stiffness : It is the ability of a material to resist deformation under stress. The modulus of elasticity is the measure of stiffness.

The material which deforms less under load, has high degree of stiffness.

3. Hardness : [Jan. '18, Dec.'14, Dec.'13] It is the ability of a material to resist scratching, wear, penetration, abrasion etc. is known as hardness. It also means the ability of a metal to cut another metal.

Hardness of different material is determined by different methods such as Brinell, Rocknell, and Vickers hardness tests.

4. Ductility : [Jan. '18, Jan. '17, Dec. '15] It is the property of a material to undergo deformation under tension without breaking. It enables material to be drawn into wire with the application of a tensile load. A ductile material must be both strong and plastic.

Ductility can be measured by,

$$\% \text{ Elongation} = \frac{\text{Change in length}}{\text{Original length}} \times 100$$

Examples : mild steel, copper, aluminium, lead, zinc, etc. .

5. Brittlenesss : [Dec. '13, June-July '11] It is the property of material by virtue of which it will fracture without appreciable deformation. Brittle materials have higher brittleness. This property of material is opposite to ductility.

This property is desirable in machine parts which may be subjected to sudden loads. *Examples :* Cast iron, glass, stones etc.

6. Toughness : [Dec. '15, June '11, June '13] It is the property of a material to resist fracture due to high impact loads like hammer blows and absorb a certain amount of energy. It is measured by the amount of energy that a unit volume of the material has absorbed after being stressed upto the point of fracture.

This property is highly desirable property for structural and machine parts which have to withstand shock and impact loads like gears, crane hook etc.

7. Malleability : [June-July '11] It is the ability of a material to withstand deformation under compression without fracture. This property enables a material to be rolled down to very thin sheets. Lead, wrought iron, gold, copper, etc. are the commonly used malleable materials.

8. Elasticity : [Jan. '18, Jan. '17, Dec. '15] It is the ability of a material to regain its original shape after deformation when the external loads are removed. Material possessing this property is known as elastic material. This property is desirable for materials used in tools and machines. It may be noted that steel is more elastic than rubber.

9. Plasticity : [Dec. '14] It is defined as the ability of a material to be permanently deformed without fracture, even after the removal of load. This property of the material is necessary for forging in stamping images on coins and in ornamental work.

10. Resilience : [May '18, Jan. '18] It is the ability of a material to absorb or store energy and to resist shock and impact loads. The material gives off the stored energy on removal of the load. This property is very essential for spring materials.

11. Creep : [May '18, June '13] When a part is subjected to a constant stress at high temperatures for a long period of time, it will undergo a slow and permanent deformation called creep. This property is considered in designing the machine components subjected to high temperatures like I.C. engines, boilers, turbines, etc.

12. Fatigue [Dec. '13] : A material fails at stresses below the yield point stresses when it is subjected to repeated tensile and compressive stresses. This type of failure of a material is known as fatigue. This property is considered in designing shafts, connecting rods, gears, springs, etc.

13. Corrosion resistance : Corrosion is the chemical deterioration of the material which occurs due to its exposure to moisture, acids or other chemicals. A corroded work piece becomes weak, dimensionally inaccurate and externally unattractive. Corrosion resistance is property of a material which resists the corrosion.

14. Thermal conductivity : It is the ability of a material to conduct the amount of heat per unit time through a unit area.

15. Electrical resistivity : It is the property of a material due to which it resists the flow of electricity through it.

16. Electrical conductivity : It is the property of material due to which it allows the flow of electricity through it. It is the reciprocal of electrical resistivity.

17. Castability : It is defined as the ease with which the material can be given various solid shapes from liquid state. Solidification rate, shrinkage, gas porosity etc. are the factors which affect the castability.

18. Weldability : [Dec.08] It is the ability of a material to be welded under the fabrication conditions.

A material has a good weldability if it can be welded easily in order to perform its function satisfactorily in the fabricated structure.

19. Machinability : It is the ease with which a material can be cut or removed by cutting tools in machining operations with satisfactory surface finish.

20. Workability or Formability : It is the ease with which metal can change its shape while in solid state.

13.4 Ferrous materials [Jan. '13]

Ferrous metals and alloys are widely used because they provide a wide range of properties that are not found in other family of materials.

The principle ferrous metals commonly used in engineering practice are

(i) wrought iron, (ii) steels, (iii) alloy steels and (iv) cast iron.

The raw material for all ferrous metal in pig iron. ***Pig iron*** is obtained by smelting the iron in a blast furnace with the help of coke and lime-stone.

1. Wrought iron :

Wrought iron is a highly refined iron with a small amount of slag forged out into fibres. The chemical analysis of the metal shows as much as 99 percent of iron. A representative analysis range of wrought iron is

C = 0.02 – 0.03 %,	Si = 0.02 – 0.10 %
S = 0.008 – 0.02 %,	Mn = 0.00 – 0.02 %
P = 0.05 – 0.25 %,	Slag = 0.05 – 1.50 %

Properties :

The slag fibres in wrought iron improve strength, fatigue resistance and corrosion resistance of iron. It is tough, malleable and ductile.

Applications :

Bolts and nuts, chains, crane hooks, railway couplings, pipe and fittings, sheets and

boiler tubes are the main forms in which wrought iron is used.

2. Steels : [May '18, Jan. '17]

It is an alloy of carbon and iron with carbon content usually ranges from 0.08 to 1.5 percent (with 2 percent as a maximum possible value). These steels are called plain carbon steels or simply carbon steels. Steels generally contain small amounts of sulphur, phosphorous, silicon and manganese in addition to carbon.

The carbon steels can be classified on the basis of their carbon content as

(i) Low carbon steel **(Mild steel)**

(ii) Medium carbon steel, and

(iii) High carbon steel

The properties and applications of these steels are given in table 13.2

Table 13.2

Sr No.	Types of steel and (% of carbon)	Properties	Applications
1	Low carbon steel or Mild steel (0.15 to 0.30 %)	- Ductile and relatively softer - Possess good machinability and weldability	Steel structure for buildings, bridge, ships, plates for boilers, tubes etc.
2	Medium carbon steel (0.30 to 0.60 %)	- Strong and less ductile than mild steels - Strength, toughness, etc can be obtained by heat treatment. - Easily welded and forged.	Connecting rods, crane hooks, crank shafts, axles, gears, shafts, railway wheels, railway tracks, etc
3.	High carbon steel (0.60 to 1.50%)	- good wear resistance, and poor machinability - harder and stronger than medium and low carbon steel - less ductile	Drop hammer, dies, saws, screw drivers, cutting tools piston rings, chisels, spring, etc.

The hardness and strength of steel increases with the increase of carbon content, and the strength is almost maximum at about 0.8 percent carbon. Thereafter, strength starts decreasing and hardness continues to increase.

3. Alloy steel :

Alloy steels may be defined as steels to which elements other than carbon are added in sufficient amounts to produce improvements in properties. In general, alloy steels can give better strength, ductility, and toughness than plain carbon steels. The commonly added elements include nickel, chromium, silicon, manganese, vanadium, tungsten, molybdenum, copper, cobalt, aluminium, etc. Each of these elements confers certain qualities upon the steels to which it is added.

Main types of alloy steels used in practice are

(i) Stainless steels
(ii) Heat resisting steels
(iii) High sped steels (H.S.S.)
(iv) Spring steels

(i) Stainless steels :

It is defined as that steel which when correctly heat treated and finished, resists oxidation and corrosive attack from most corrosive media.

These steels are alloyed with chromium (4 to 20 %), nickel, molybdenum, and manganese for obtaining the desired properties for particular application. These steels are classified into three broad categories :

(a) Austenitic stainless steel
(b) Ferritic stainless steel
(c) Martensitic stainless steel

Applications : These steels find wide applications in dairy and chemical industries, household utensils, cutlery, and all types of surgical and dental instruments.

(ii) Heat resisting steels :

These steels retain their properties at high temperatures for long periods. They should possess good creep resistance, resistance to scalling and oxidation etc. Alloying elements, such as tungsten, chromium, and nickel are added in order to meet these requirements.

Applications : These steels are used for gas turbines, steam power plants, furnace parts, etc.

(iii) High Speed Steels (HSS) :

High speed steels were so named because they may be operated as cutting tools at much higher cutting speeds than is possible with plain carbon tool steels. They have excellent hardenability and can retain their hardness upto 650° C.

The most common variety of high speed steels is 18–4–1. It contains 18% tungsten, 4% chromium, 1% vanadium and about 0.5 to 0.75 % carbon.

Applications : These steels are used for high speed cutting tools, tools for lathe and shaping machine, drills, and milling cutters.

(iv) Spring steels :

The most suitable material for springs are those which can store up the maximum amount of work or energy in a given weight or volume of spring material, without permanent deformation. These steels should have a high elastic limit as well as high deflection value. The steels most commonly used for making springs are as follows :

(a) Medium and high carbon steels with higher amount of manganese.

(b) Medium carbon alloy steels with manganese and silicon as the main alloying elements.

Applications:

These steels are used for leaf and helical springs, automobile and air craft valve springs etc.

• Effects of the alloying elements on steel

When alloying elements are added to steel, perform different functions depending upon their characteristics, amounts and the subsequent heat treatment. The following are the effects of alloying elements :

1. **Silicon :** It removes the gases and oxides, prevent blow holes and thereby makes the steel tougher and harder. The amount of silicon in steel usually ranges from 0.05 to 0.30%.
2. **Manganese :** It makes the steel ductile and gives it good bending quality. It commonly ranges from 0.30 to 1.00 %.
3. **Sulphur :** It contains in steel either as iron sulphide or manganese sulphide. Sulphur is added to certain steels to give them a free-cutting and good machining quality.
4. **Phosphorus :** It makes the steel brittle and reduces its ductility. It improves the resistance to atmospheric corrosion in low carbon steels. The phosphorus content should not exceed 0.05 % in good quality steels.
5. **Nickel :** It increases the strength and toughness of the steel. It contributes great strength and hardness with high elastic limit, good ductility and good resistance to corrosion.
6. **Chromium :** It is used in steels as an alloying element to combine hardness with high strength and high elastic limit. It also imparts corrosion-resisting properties to steel.
7. **Tungsten :** It forms hard abrasion resistant particles, imparts red hardness, increases hardenability to a great extent. In high speed steel, it is an important alloying element.

4. Cast iron :

Cast iron is primarily an alloy of iron and carbon. The carbon contents in cast iron varies form 2% to 4.3%. In addition to carbon, cast iron contains small amounts of silicon, manganese, phosphorous, and sulphur.

Cast iron is the most important and widely used metal. It is very brittle, less ductile material. The various types of cast iron in use are as follows :

(i) Grey cast iron (ii) White cast iron (iii) Malleable cast iron

(i) Grey cast iron

When carbon is present in the form of graphite flakes, the cast iron is called grey, because it shows grey surface on fracture. Ordinary commercial iron having the following compositions :

Carbon = 3 to 3.5 %, Silicon = 1 to 2.75 %,
Manganese = 0.40 to 1.0 %, Phosphorous = 0.15 to 1.0 %,
Sulphur = 0.02 to 0.15 %, and the remaining is iron.

Properties : It has a low tensile strength, high compressive strength and no ductility. It can be easily machined. It is hard and brittle and may easily be broken if a heavy hammer is used. A very good property of grey cast iron is that the free graphite in its structure acts as a lubricant.

Applications : The fluidity of this iron enables it to be used widely for making casting of parts having complicate shape. This iron castings are widely used for machine tool bodies, automotive cylinder blocks, fly-wheels, pipes, and pipe fittings, etc.

(ii) White cast iron :-

White cast iron contains carbon in the form of cementite (iron carbide, Fe_3C). It shows white fractured surface due to fact that it has no graphite. It's composition is :

Carbon = 1.75 to 2.3 %, Silicon = 0.85 to 1.2 %,
Manganese = less than 0.4 %, Phosphorus = less than 0.2%,
Sulphur = less than 0.12 %, and the remaining is iron.

Properties : It is extremely hard and brittle. Its fractured surface has a silvery metallic appearance. It has excellent resistance to wear but has poor machinability.

Applications : It is cast as the intermediate material for making malleable cast iron. Other typical applications of white cast iron include weraring plates, mill liners, pump liners, grinding balls etc.

(iii) Malleable cast iron

Malleable cast iron is produced by giving long heat treatment (annealing) to white cast iron at sufficiently high temperature (900^{o} C to 950^{o} C) and then allowed to cool slowly. The combined carbon of the white cast iron is separated into nodules of graphite.

Properties : It is ductile and may be bent without breaking or fracturing the section. The tensile strength is usually higher than that of grey cast iron and has excellent machining qualities.

Applications : These castings are widely used in automotive industry. They are also used for hubs of wagon wheels, small fittings for railway rolling stock, brake supports, parts for agricultural machinery, door hinges etc.

• Effect of various alloy materials on cast iron

1. Silicon : It helps the formation of free graphite which makes the iron soft and easily

machinable. It also helps to produce, sound castings free from blow-holes. It may be present in cast iron upto 4%.

2. Sulphur : It makes the cast iron hard and brittle. It should be kept well below 0.1 % for most foundry purposes because too much sulphur gives unsound casting.

3. Manganese : It may be present in cast iron upto 0.75%. It makes the cast iron white and hard. It helps to exert a controlling influence over the harmful effect of sulphur.

4. Phosphorus : It's content in cast iron varies between 0.05 to 1.00 %. Phosphorus increases the fluidity of the cast iron. It lowers the melting point and reduces shrinkage.

5. Carbon : If carbon is present in combined form, it makes the iron hard and strong. If it is present in free state, then it makes the iron weak and brittle. It varies from 2 to 4.3%.

13.5 Nonferrous materials [Jan. '13]

The non-ferrous metals are those which contain a metal other than iron as their chief constituent. They are usually used in industry due to the following characteristics.
(i) Ease of manufacturing, (ii) Resistance to corrosion (iii) Electrical and thermal conductivity, and (iv) Weight

Important non-ferrous metals are aluminium, copper, lead, tin, nickel, zinc, and titanium.

1. Aluminium and its alloys

Aluminium is silvery-white and lighter in weight than steel and copper. It has high electrical and thermal conductivity. It has high corrosion resistance. Aluminium has good machinability, formability and castability. The main drawback of aluminium is its low hardness and poor strength.

Duralumin and Y-alloy are the important aluminium alloys.

Applications : Aluminium and its alloys are widely used in air craft and automobile industry, for overhead cables and electrical wiring, cooking utensils.

2. Copper and its alloys

Copper is one of the most widely used non-ferrous metals in industry. It is a soft, malleable and ductile material with a reddish-brown appearance. It is a good conductor of electricity. It has higher resistance to corrosion.

Following are the main alloys of copper,

(i) Brass (ii) Bronze

Applications : Copper is largely used in making electric cables and wires for electric machinery and appliances, automobile radiator and heat exchangers, refrigerators, pressure vessels, etc.
Following are the main alloys of copper

(i) Brass (ii) Bronze

(i) Brasses : Brass is fundamentally copper and zinc alloy. By adding zinc in copper, improves colour, machinability and strength.

Applications : Brasses are used in hydraulic fittings, pump lining, utensils, bearings, etc.

(ii) Bronzes : The alloys of copper and tin are usually termed as bronzes. The useful range of composition is 75 to 95% of copper and 5 to 25% of tin. Bronze is harder and stronger than brass. It resists surface wear and can be cast into shape or rolled into wire, rods and sheets very easily.

Applications : It is used in pump lining, bearings, bushes, gears, springs, utensils etc.

3. Lead and its alloys

Lead is the heaviest and softest among all common metals. It is a very soft, malleable, and ductile metal and can be rolled easily. It is corrosion resistant and having good lubricating properties. It has high radiation absorbing power for X-rays and γ-rays.

Applications : It is extensively used for making solders, as a lining for acid tanks, water pipes,, batteries, bearings, etc.

4. Tin

Tin is brightly shining white, soft and malleable metal. It can be rolled into very thin sheets.

Applications **:** It is used for making fine solder, as a protective coating for iron and steel sheets, for making tin foil used as moisture proof packing, etc.

5. Nickel and its alloys

Nickel is an important alloying element and widely used in engineering industry on account of their high mechanical strength properties, corrosion resistance, etc.

Applications : A large percentage of nickel is used for production of stainless steel. Alloy of nickel and copper (called monel metal) is used for making propellers, condenser tubes etc. Pure nickel is used as a catalyst in chemical reaction.

13.6 Non-Metallic Materials [Jan. '10]

Various non-metallic materials are used in engineering applications due to their low cost, low density, resistant to heat and electricity and flexibility. These include timber, abrasive material, silica, ceramics, glass, graphite etc. These are either natural materials like rubber, wood, ceramics, asbestos or synthetic materials like plastics, polymers, etc.

Some of the important non-metallic materials are being discussed following in brief :

1. Timber

Timber is the wood which made suitable for engineering practice. Wood is natural polymer composite. The principle polymeric molecules are those of cellulose. Timber is obtained by cutting trees after their full growth.

Structure of timber

The structure of timber is shown in Fig. 13.1.

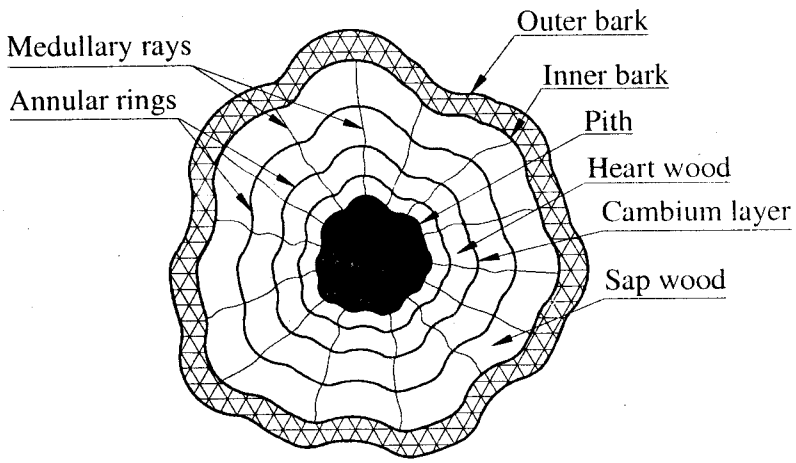

Fig. 13.1 Structure of Timber

The innermost part or core is known as the pith. Heart wood which consists of innermost annular rings is around the pith. The thin layer below the bark is called the cambium layer. The thin fibers, which extend from pith outwards and hold the annular rings together are called medullary rays. The heart wood and sap wood form the main part of timer for suitable applications.

Applications : It is widely used for making door-window, roof members, furniture, sound-proof construction, tool-handles, railway sleepers, sports goods, packing cases, etc.

Advantages : It has high strength to weight ratio.
- Easily desired shape can be given.
- Attractive appearances and good toughness.

Disadvantages : Properties of timber are being changed with season.
- It is inflammable and strength is very along the length and across the length

2. Abrasive material

An abrasive is a hard material used to wear away a softer material. Abrasives are used for operation such as grinding, cutting, scratching, rubbing, and polishing. Abrasive materials are used in the form of powder, emery paper, emery cloth, solid discs, wheels or bars of various shapes and sizes.

Silicon carbide, aluminium oxide, emery, diamond, etc. are the various abrasive materials.

3. Silica

Silica (SiO_2) is basically a refractory material which can withstand high temperatures.

It is the most simple silicate material found on earth. The tetrahedron structure of silica is electrically neutral. Silica has three primary polymorphic crystalline forms which are known as quartz, cristobalite and tridymite.

Silica is used for blast furnaces, chemical reactor lining, lining of aluminium melting furnaces, rotary kilns, etc.

4. Ceramics

Ceramic materials are defined as those consisting of compounds of metallic and nonmetallic elements. The compounds are usually oxides, nitrides, carbides etc. The very commonly used ceramic materials include clay, cement and glass.

Ceramic materials have greater stability at high temperatures. Those are very hard, strong and dense materials. Ceramics are very brittle and less ductile. Generally ceramics are chemically inert so they are not affected by chemical actions and remain stable under severe environmental conditions.

Applications : The ceramics are used in the field of heat engines, electronic packaging, gas turbines, chemical reactor lining, electrical resistance heating elements, etc.

5. Glass

Glass is a transparent silica product which may be amorphous or crystalline, depending on heat treatment. Glass refers to material which is made by the fusion of mixture of silica, basic oxides and a few other compounds that react either with silica or with the basic oxides.

It is used for glass equipments for various use due to its better optical properties, chemical stability, non corrosive nature and high temperature resistance.

6. Graphite

Graphite is an allotrope of carbon. It is conductor of electricity. It is used as electrodes of an arc lamp and arc welding. It is a very stable material and withstand high temperatures. Graphite has been used in bronze bearings as a lubricant. It is also used for making graphite crucibles in steel making, brake lining, foundry facings, zinc-carbon batteries, electric motor/ generator brushes and pencils for drawing and writing.

7. Diamond [Dec. 2010]

It is an allotrope of carbon and the hardest known material. Diamonds are naturally available material. Now a days artificial diamonds are also available. Artificial diamonds are manufactured by high pressure, high temperature process. It is yellow in colour due to nitrogen as impurity.

Diamond is the hardest and tough and has the characteristic of high dispersion of light due to which it is used in many industrial applications and jewelry. Diamonds make superlative abrasive due to this it is used in engraving tools.

Diamonds are widely used in drilling and other finishing operations like lapping, honing and super finishing.

8. Plastics

The plastics are synthetic materials which are moulded into shape under pressure with or without the application of heat. These can also be cast, rolled, extruded, laminated and machined. Plastics are usually divided into two groups, ***thermoplastic*** and ***thermosetting plastics***.

Plastics have been increasingly accepted as engineering materials due to the fact that plastics are attractive materials and offer advantages in weight, cost, moisture and chemical resistance, toughness, abrasive resistance, strength, appearance, insulation, formability, and machinability. They are mostly used in the manufacture of aeroplane and automobile parts. They are also used for making safety glasses, laminated gears, self-lubricating bearings etc.

9. Polymer

The basic structural units of polymers are referred to as monomers. A polymer is therefore, made up of thousands of monomers joined together to form a large molecule of colloidal dimension, called macromolecules. The process by which polymers are formed is a chemical reaction known as polymerization. There may be naturally occurring polymers or synthetic polymers. Polyethylene, polytyrene, nylon, terylene, dacron, etc are the synthetic polymers.

Low density, good corrosion resistance, excellent surface finish, good insulator (electrical and thermal) etc are some of the characteristics of polymer.

Applications : Polymers are used for making high structure fibres like silk and wool. They are also used in optical industries, reflectors, packaging and coating material etc.

10. Composite materials **[June '09, Dec. '10]**

A composite material is defined as *a combination of more than one materials which are used in combination to rectify a weakness in one material by a strength in another.* This combination of two or more materials offers properties distinctly different from those of the individual materials used to make the composite.

Composites may be man-made or natural. Wood material obtained from trees is also a composite which is formed naturally.

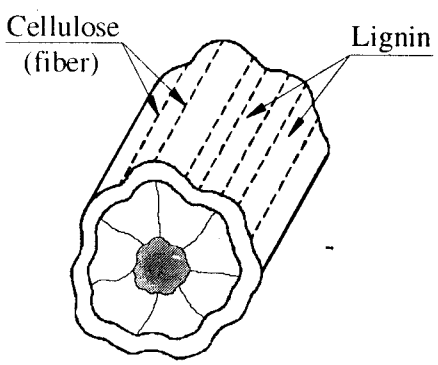

Fig. 13.2 Composite material

Wood consists of strong and flexible cellulose fibres surrounded by a stiff material called lignin as shown in Fig. 13.2.

Exercise

13.1 Define Ductility, Elasticity, Plasticity and Weldability. **[Dec. 08]**

13.2 Define the following mechanical properties

(i) strength (ii) hardness (iii) ductility

(iv) toughness (v) malleability (vi) elasticity

(vii) resilience (vii) creep

13.3 Define the following technological properties

(i) castability (ii) Machinability (iii) workability

13.4 Give only the name of magnetic and optical properties of material.

13.5 Give classification of engineering materials.

13.6 Define ferrous and non-ferrous materials.

13.7 Differentiate between cast iron and steel.

13.8 Classify plain carbon steels.

13.9 Give advantages of alloy steel.

13.10 What is stainless steel ? Give types and advantages of stainless steel.

13.11 Write the effects of following alloying elements on steel

(i) silicon (ii) manganese (iii) sulphur

(iv) nickel (v) chromium (vi) tungsten

13.12 Define cast iron.

13.13 Give applications of following

(i) Grey cast iron (ii) white cast iron (iii) Malleable cast iron

13.14 What do you mean by non-ferrous metals ? Name any five and state their application.

13.15 Write the properties and applications of following materials

(i) Timber (ii) Abrasive material (iii) Ceramics

(iv) Graphite (v) Diamond (vi) Plastic

13.16 Enlist physical properties of Engineering materials. **[June '09, 4 marks]**

13.17 Write short note on composite materials. **[June '09, 3 marks]**

13.18 What do you understand by non-metallic materials? Name any six and state their practical importance. **[Jan. '10, 4 marks]**

Objective Type Questions

1. Following is non metallic material
   (a) steel (b) copper (c) nickel (d) ceramics
2. _____ is the ability of a material to resist deformation under stress. **[Dec. '14]**
   (a) strength (b) stiffness (c) hardness (d) brittleness
3. _____ is the property of a material to resist fracture due to high impact loads.
   (a) strength (b) stiffness (c) toughness (d) hardness **[June '14]**
4. Malleability is the ability of a material to withstand fracture under _____
   (a) tension (b) compression (c) shear (d) all of the above
5. _____ is a malleable material.
   (a) gold (b) cast iron (c) spring steel (d) HSS
6. Corrosion resistance is _____ property.
   (a) chemical (b) mechanical (c) electrical (d) thermal
7. _____ is not a ferrous material
   (a) wrought iron (b) cast iron (c) steel (d) tin
8. _____ is commonly used material for machine tool bad.
   (a) tin (b) low carbon steel (c) cast iron (d) wrought iron
9. Cast iron contains _____ % of carbon.
   (a) 1 to 2 (b) 2 to 4.3 (c) 0.5 to 1 (d) 0.5 to 1.5
10. _____ is characteristic of cast iron. **[Dec. '15]**
    (a) very brittle (b) malleable (c) ductile (d) all of the above
11. _____ is the lightest engineering material from the following.
    (a) copper (b) steel (c) aluminium (d) nickel
12. _____ is the hardest known material.
    (a) gold (b) platinum (c) ceramic (d) diamond
13. The sealing ring for pressure cooker is made from **[June '16]**
    (a) Leather (b) Rubber (c) Plastic (d) Huminum
14. Brass is fundamentally alloy of **[May '18]**
    (a) Copper and zinc (b) Copper and nickel
    (c) Copper and tin (d) Copper, Zinc and molyblender

15. Mild steel contain _____ % of carbon **[Jan. '18]**

(a) 0 to 0.5 (b) 0.5 to 1

(c) 1 to 2 (d) 2 to 4

Answer

(1) d (2) b (3) c (4) b (5) a (6) a (7) d (8) c (9) b (10) a
(11) c (12) d (13) b (14) a (15) a