## METALS:

Metals are used for various engineering purposes. They are used for making structural members, doors, widows, roofing materials, pipes and many other products. In order to find the suitability of various metals to be used for a specific work it is essential to study their composition and properties.

## Classification of Metals

All the metals used in engineering works can be classified into two categories:-

a- Ferrous Metals: Ferrous metals are those metals in which the chief constituent is iron. Besides, iron, other constituents like carbon, sulpher, manganese and phosphorus, etc…. Also exist in varying proportions. The ferrous metals which find their common use are:
- Cast iron.
- Wrought iron.
- Steel.

b- Non -Ferrous Metals: Non-ferrous metals are those, which do not contain iron and are used widely in building industry. The important non-ferrous metals are copper, lead, tin, zinc and aluminum.

## Ferrous Metals:

### 1- Cast Iron:

Besides iron, cast iron contains carbon, silicon, phosphor and manganese in varying proportions.

Iron:      92 to 95%

Carbon:   2 to 4.5%

Silicon:    1 to 3%

## *Properties of Cast Iron*

Cast iron possesses the following important properties:-

1- It has a fibrous crystalline structure.
2- Brittle and has low resistance to tension and high strength in compression. Tensile and compressive strengths of an average quality of cast iron are ($150 \text{ N/mm}^2$) and ($600 \text{N/mm}^2$) respectively.
3- Its melting point is about ($1200°C$).
4- It cannot withstand sudden – shocks.
5- Because of being brittle it cannot be welded.
6- The specific gravity (7.5).
7- It cannot be magnetized.
8- It is neither malleable, nor ductile.
9- It does not rust easily.

## *Uses of Cast Iron*

1- It is used for the manufacture of steel wrought iron.
2- It is high compressive strength makes it suitable for use in making such parts which are subjected to compressive stress such as supports of heavy machinery.
3- Since it does not rust easily, therefor it is used for parts generally exposed to atmosphere such as damp posts.
4- It is also used for making rail chairs, and carriage wheel.

### *Wrought iron*

It is the purest form of iron. The composition of wrought iron is:-

Iron – about 38%

Carbon content – 0.1 to 0.25%

Slag – 2 to 3%

Sulpher, manganese, phosphor and silicon are present in traces.

### *Properties of Wrought Iron*

1- It has fibrous structure with silky luster.

2- It is melting point is about (1500°C).

3- It can withstand shocks to a certain limit.

4- It is ultimate tensile strength is about ($400N/mm^2$).

5- It is ultimate compressive strength is about ($200N/mm^2$).

6- It is specific gravity is (7.25).

7- The brinell hardness number is (105).

8- It does not form permanent magnetize but can be temporary magnetized.

9- It is malleable and has got high ductility.

10- It can rust more easily than cast iron.

11- It softens at about (100°C) and then it can be hammered to any desired shape.

### *Uses of Wrought Iron:*

1- It is used for making agricultural implements.

2- It is used for making rails, crank hooks and any article capable of withstanding sudden load.

3- It is used for making electro magnets.

4- Because it is extremely easy to weld, it is largely used in ornamental iron work.

5- It is used as a raw material for the manufacture of steel.

### 3-Steel

Steel is the most important material for engineering construction. It contains carbon from 0.15% (very soft steel) to 1.5% (very hard steel). It also contains small amount of other elements.

### Composition of Steel

Iron = 99%

Carbon contents     0.15 to 1.5%

Phosphorus and sulpher less than 0.1%

Manganese up to 0.5%

Silicon up to 0.3%

The higher is the percentage of carbon, the harder is the steel. Depending upon the percentage of carbon contents steel can be classified into different groups as under:-

1- Very low carbon steel: having percentage of carbon below (0.15%).

2- Low carbon steel or mild steel: carbon contents range from (0.15-0.30%).

3- Medium carbon steel: carbon contents range from (0.2-0.5%).

4- High carbon steel having carbon from (0.6-1.5%).

### Low Carbon Steel – Mild Steel

The percentage of carbon in mild steel various from (0.15-0.3%), sulpher, phosphorus, manganese, silicon are present only in minute quantities.

### Properties of Low Carbon Steel

1- It has a bright dark bluish color.

2- It has a fibrous structure.

3- It is melting point is about (1400°C).

4- It can withstand sudden shocks.

5- It is tensile strength is high.

6- It is specific gravity (7.8).

7- It is malleable and ductile and elastic.

8- It can form permanent magnets.

9- It rusts easily and rapidly.

10- It can be easily forged and welded.

## *Uses of Low Carbon Steel*

The chief uses of mild steel are:-

1- It is used for making rolled structural steel sections like girders, angle section, channel section and T-sections, etc…..

2- It is extensively used for making bars and rods which are used as reinforcing material in reinforced concrete structure.

3- It is used for making refrigerators and air conditioners.

4- It is used for making plain and corrugated sheets.

5- Structural mild steel is most commonly used for general construction purposes of buildings, bridges, towers, and industrial buildings.

6- It is also used for making tubes.

## *High Carbon Steel*

These are also termed as hard steels and contain carbon varying from (0.6 to 1.5%). Besides carbon, small percentage of sulpher, phosphors, manganese and silicon are also present.

## *Properties of High Carbon Steel*

1- It has a granular structure.

2- It is very hard.

3- It is specific gravity (7.9).

4- It cannot be easily forged or welded.

5- It can absorb shocks and vibrations in a better way.

6- It is tougher and more elastic than mild steel.

7- It is brittle and less ductile than mild steel.

8- It rusts easily.

9- It is melting point is (1300°C).

10- It can form permanent magnets.

## *Uses of High Carbon Steel*

1- It is used for parts of structures and machinery where hard, elastic, shock proof and durable material is required.

2- It is used in pre stressed concrete.

3- It is used for making knives, needle bolts and surgical instruments.

## *The Factors Affecting Properties of Steel*

**1- Carbon Content**

a- The strength and hardness of steel increases a percentage of carbon increases and up to (1.5%).

b- The elongation decreases as the carbon content increases and the metal becomes less resistance to impact.

c- The elastic range remains nearly on the same linearity, indicating that the modulus of elasticity is nearly the same and can be considered constant for various types of steel as shown in figure below.
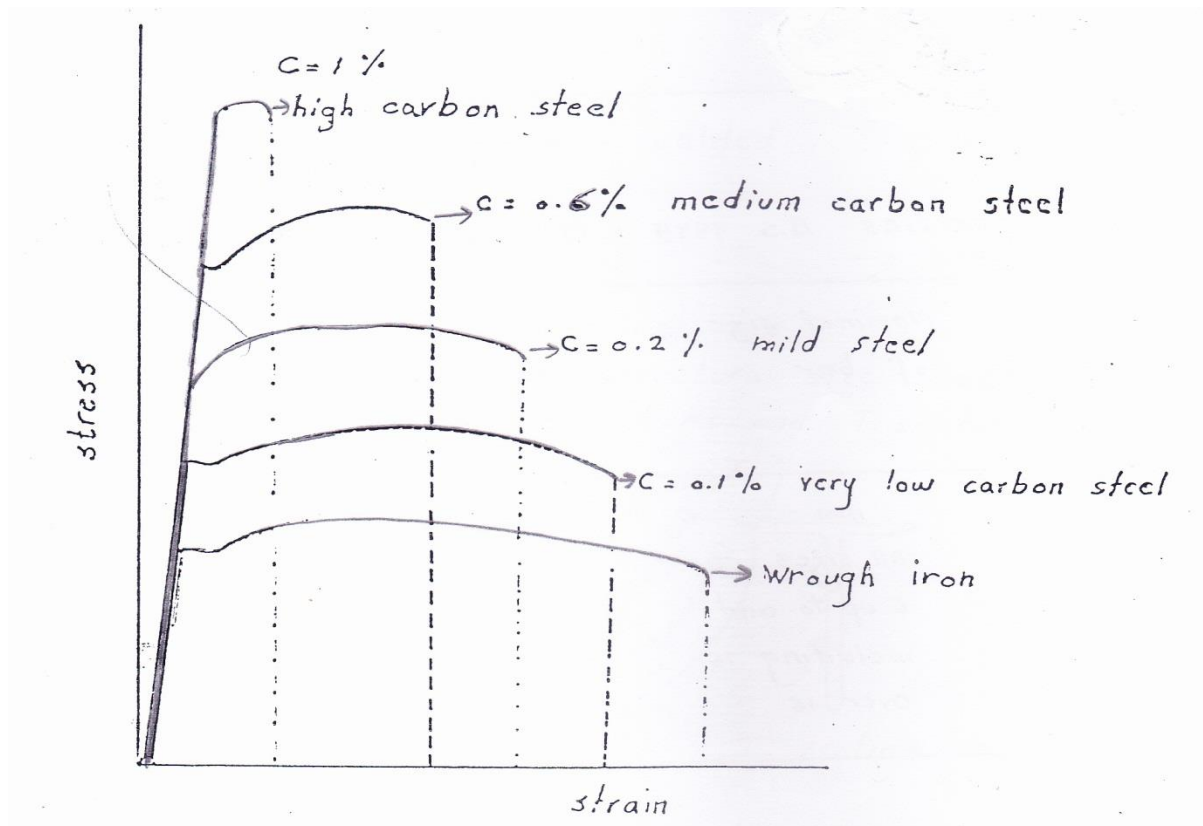
## 2- Chemical Composition

The presence of carbon in steel gives high degree of hardness and strength. The addition of carbon to iron decreases the malleability and ductility of the metal, and reduces its permeability to magnetic forces. The final product always contains small percentages of the metallic impurities like silicon, manganese, sulphur, and phosphorus besides iron and carbon.

## 3- Heat Treatment

The object of heat treatment is to develop desired properties in steel. The properties of steel can be controlled and changed as well by various heat treatments. The heat treatment process consists in subjecting, a metal to definite temperature–time course.

## 4- Mechanical Work.

Steel products are made by casting molten refined steel of suitable composition into the desired form or by mechanically working steel form the ingot through many intermediate forms to the desired product. Mechanical work may be hot or cold. Mechanical working involves many stages of hot working and may or may not include eventual cold working.