

# Chapter 2

## Steel

### CHAPTER HIGHLIGHTS

- Introduction
- Uses of steel
- Properties: Mild steel vs hard steel
- Defects in steel
- Steel manufacturing processes
- Mechanical treatment of steel
- Market form of steel

### INTRODUCTION

As far as the carbon content is concerned, steel forms an intermediate stage between cast iron and wrought-iron. In cast iron, carbon content varies between 2–4%. In wrought-iron, carbon content does not exceed 0.15%

- In steel, carbon content varies between 0.25–1.5%.
- If carbon content exceeds 1.5%, it does not combine with iron. It remains as free graphite.
- If there is no free graphite in the composition of material, it is said to be steel. If there is presence of free graphite, then it indicates cast-iron.

Depending upon carbon content, steels can be classified as mild steel, or medium carbon steel, or high carbon steel.

- The carbon content in mild steel varies between 0.10–0.25%. When carbon content is less than 0.10%, it is known as dead steel or very low carbon steel.
- The carbon content in medium carbon steel varies between 0.25–0.60%.
- In high carbon steel, also known as hard steel, carbon content varies between 0.60–1.10%

### USES OF STEEL

Name of Steel	Carbon Content	Uses
Mild steel	Up to 0.10%	Motor body, sheet metal, tin plate, etc.
	Up to 0.25%	Boiler plates, structural steel, etc.
Medium carbon steel	Up to 0.45%	Rails, tyres, etc.
	Up to 0.60%	Hammers, large stamping and pressing dies, etc.
High carbon steel or hard steel	Up to 0.75%	Sledge hammers, springs, stamping dies, etc.
	Up to 0.90%	Miner's drills, smith's tools, stone mason's tools, etc.
	Up to 1.00%	Chisels, hammers, saws, wood working tools, etc.
	Up to 1.10%	Axes, cutlery, drills, knives, picks, punches, etc.

## PROPERTIES: MILD STEEL Vs HARD STEEL

Mild Steel	Hard Steel
It has fibrous structure.	It has granular structure.
It cannot be easily hardened and tempered.	It can be easily hardened and tempered.
It can be readily forged and welded.	It cannot be readily forged and welded.
It can be permanently magnetised.	It can be permanently magnetised.
Melting point of mild steel is about 1400°C.	Melting point hard steel is about 1300°C.
Its specific gravity is 7.80.	Its specific gravity is 7.90.
Its ultimate compressive strength is 20 kN/cm <sup>2</sup> .	Its ultimate compressive strength is 140–200 kN/cm <sup>2</sup> .
Its ultimate tensile and shear strengths are about 60–80 kN/cm <sup>2</sup> .	Its ultimate tensile strength is about 80–110 kN/cm <sup>2</sup> and ultimate shear strength is about 110 kN/cm <sup>2</sup> .
It is tougher and more elastic than wrought-iron.	It is tougher and more elastic than mild steel.
Used for all types of structural work.	Used for manufacturing cutlery, edge tools, parts exposed to shocks and vibrations.

## DEFECTS IN STEEL

The following four types of defects are found in steel.

- 1. Cavities/blow-holes:** Cavities or blow-holes are formed when gas is confined in the molten mass of metal. This confined gas produces bubbles or blow-holes on solidification of metal.
- 2. Cold shortness:** Steel with this type of defect cracks when worked in cold state. This defect imparts due to presence of excess amount of phosphorus in the steel.
- 3. Red shortness:** Steel having this defect cracks when worked in hot state. This defect happens due to presence of excess amount of sulphur in the steel.
- 4. Segregation:** Some constituents of steel solidify at an early stage. Those are separated out from the main mass. This process is known as segregation.

## STEEL MANUFACTURING PROCESSES

The following processes are used in manufacturing of steel.

1. Bessemer process
2. Cementation process
3. Crucible steel process
4. Duplex process
5. Electric process

6. LD Process (Linz-Donawitz process)

7. Open-hearth process

## MECHANICAL TREATMENT OF STEEL

- The purpose of giving mechanical treatment to steel is to give desired shape to the ingots to make steel available in marketable forms.
- Mechanical treatment of steel requires the following types operations.

### Drawing

- This operation is carried out to reduce the cross-section and to increase the length proportionately.
- This process is used to prepare wires and rods.

### Forging

- This operation is carried out by giving repeated blows under a power hammer or press.
- This increases the density and improves grain size of metal.
- Forging is used for manufacture of bolts, cramps and in riveting, etc.

### Pressing

- It is a slow process, carried out using in equipment known as press.
- The main advantage of this process is it does not involve any shock. Pressing is useful in manufacturing large number of uniform type engineering products.

### Rolling

- It is carried out in specially prepared rolling mills.
- Using rolling process, various shapes, such as angles, channels, flats, joists, rails, etc., are manufactured.

The physical properties of steel, such as ductility, elasticity, strength, etc., are greatly influenced by the following three factors.

- 1. Carbon content:** Carbon assists in increasing the hardness and strength of steel, but decreases the ductility of steel.
  - Mild steel with carbon content of about 0.10–0.25% is widely used in structural work.
- 2. Presence of impurities:** Silicon, phosphorus and manganese are the common impurities in found in steel.
  - If silicon content is raised about 0.3–0.4%, elasticity and strength of steel are considerably increased without serious reduction in its ductility.
  - Excess amount of sulphur decreases strength, ductility, malleability and weldability of hot metal.
  - Presence of excess phosphorus reduces shock resistance, ductility and strength of steel.
  - When manganese content exceeds about 1.5%, steel becomes very brittle, and hence loses its structural value.

**Common Impurities and Desirable Limits**

Impurities	Desirable Limits
Silicon content	<0.20%
Sulphur content	0.02–0.10%
Phosphorus	<0.12%
Manganese	0.30–1%

**3. Heat treatment processes:**

- The properties of steel can be altered by heating and cooling under controlled conditions.
- The term 'heat treatment' is used to indicate the process in which the heating and cooling of solid steel is involved in changing the structural or physical properties of steel.
- Heat treatment is used for the following purposes:
  - (a) To alter magnetic and electrical properties of steel.
  - (b) To change the structure of steel
  - (c) To increase resistance against heat and corrosion.
  - (d) To increase surface hardness.
  - (e) To make the steel easily workable.
  - (f) To vary the strength and hardness.
- The principal process involved in heat treatment of steel are:
  - (a) Annealing
  - (b) Case hardening

- (c) Cementing
- (d) Cyaniding
- (e) Hardening
- (f) Nitriding
- (g) Normalizing
- (h) Tempering

**MARKET FORM OF STEEL**

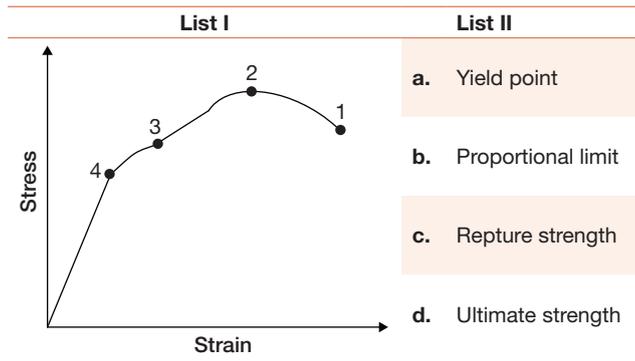
Various forms of steel available in the market are:

1. Angle sections
2. Channel sections
3. Corrugated sheets
4. Expanded metal
5. T-sections
6. I-sections
7. Plates
8. Ribbed (HYSD) bars
9. Round bars
10. Square bars
11. Flat bars
12. Ribbed mild steel bars
13. Thermo-mechanically treated (TMT) bars
14. Cold twisted deformed (CTD) bars
15. Welded wire fabrics (WWF)

**EXERCISES**

1. Wrought iron contains carbon upto \_\_\_\_\_.
  - (A) 0.15%
  - (B) 1.0%
  - (C) 1.5%
  - (D) 2%
2. Red short iron cracks, are due to presence of \_\_\_\_\_.
  - (A) sulphur
  - (B) carbon
  - (C) phosphorus
  - (D) silicon
3. Bessemer process is used for the manufacture of \_\_\_\_\_.
  - (A) pig iron
  - (B) cast iron
  - (C) wrought iron
  - (D) steel
4. The steel used in RCC work is \_\_\_\_\_.
  - (A) stainless steel
  - (B) mild steel
  - (C) high carbon steel
  - (D) wrong iron
5. The steel used for manufacture of rails is \_\_\_\_\_.
  - (A) medium carbon
  - (B) mild steel
  - (C) high carbon steel
  - (D) stainless steel
6. The type of steel used for wood working tools, is \_\_\_\_\_.
  - (A) mild steel
  - (B) high carbon steel
  - (C) invar steel
  - (D) stainless steel
7. Steel contains carbon approximately \_\_\_\_\_.
  - (A) 1.5% to 5.6%
  - (B) 0.05% to 1.5%
  - (C) 0.25% to 0.5%
  - (D) 0.5% to 3%
8. Galvanising means covering iron with thin coat of \_\_\_\_\_.
  - (A) zinc
  - (B) glaze
  - (C) tin
  - (D) tar
9. For the manufacture of stainless steel, steel is mixed with \_\_\_\_\_.
  - (A) chromium
  - (B) nickel
  - (C) tungsten
  - (D) None of these
10. The yield strength and tensile strength of low carbon steel may be improved by the addition of \_\_\_\_\_.
  - (A) manganese
  - (B) chromium
  - (C) nickel
  - (D) vanadium
11. Cast iron is used for \_\_\_\_\_.
  - (A) structural works in beams
  - (B) small sized water pipes
  - (C) columns and struts
  - (D) None of these

12. Match the List I with List II



Codes:

- (A) 1 - c, 2 - d, 3 - a, 4 - b  
 (B) 1 - c, 2 - d, 3 - b, 4 - a  
 (C) 1 - d, 2 - c, 3 - a, 4 - b  
 (D) 1 - d, 2 - c, 3 - b, 4 - a

## ANSWER KEYS

### Exercises

1. A    2. A    3. D    4. B    5. A    6. B    7. B    8. A    9. A    10. D  
 11. C    12. A