Chapter: 3
HEAT TREATMENT

Heat Treatment

- The heat treatment includes any heating and cooling operation
- It consists of heating to some temperature, holding at this temperature for a definite period and cooling to room temperature.

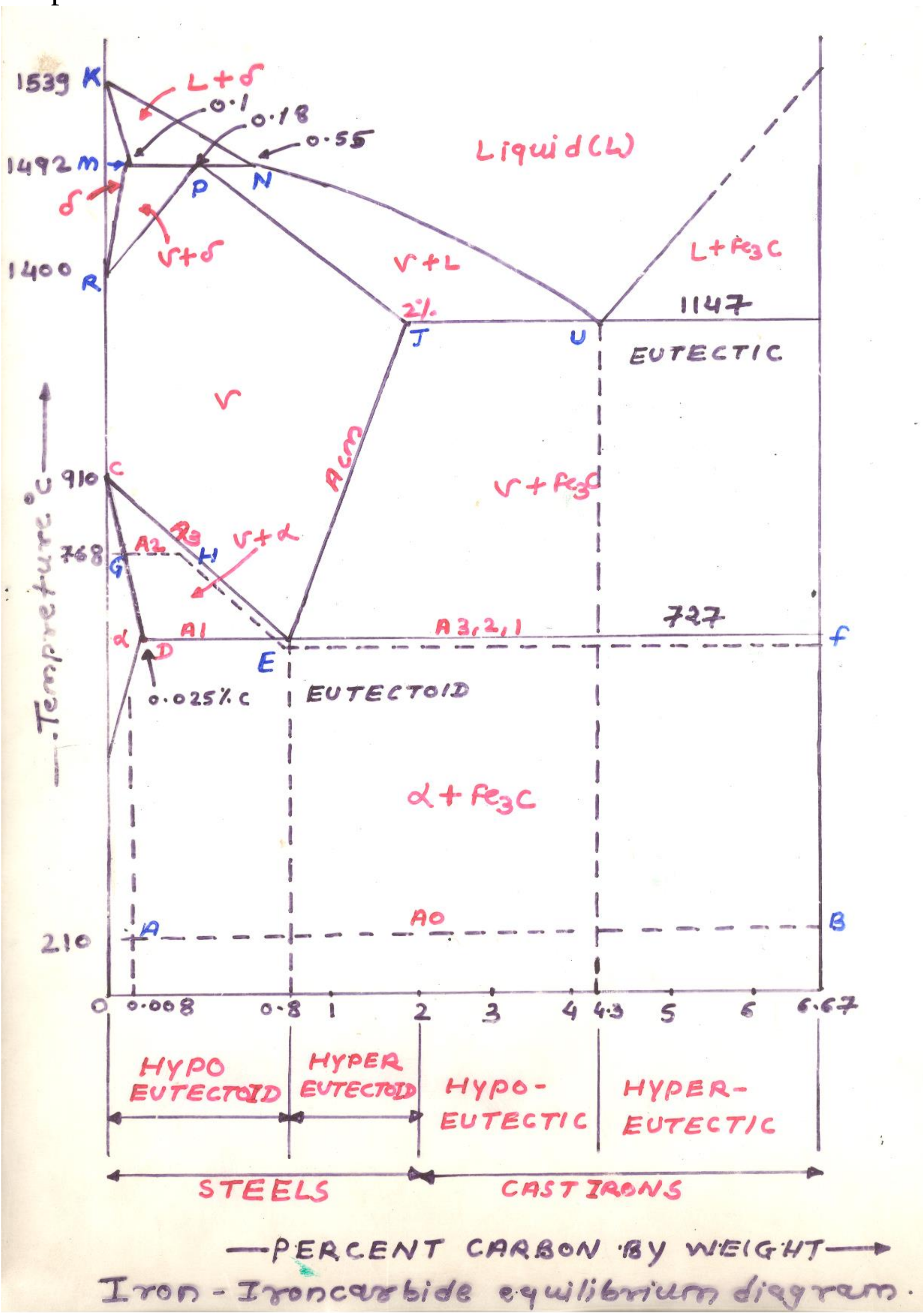

Fig: Iron-Carbide Equilibrium Diagram

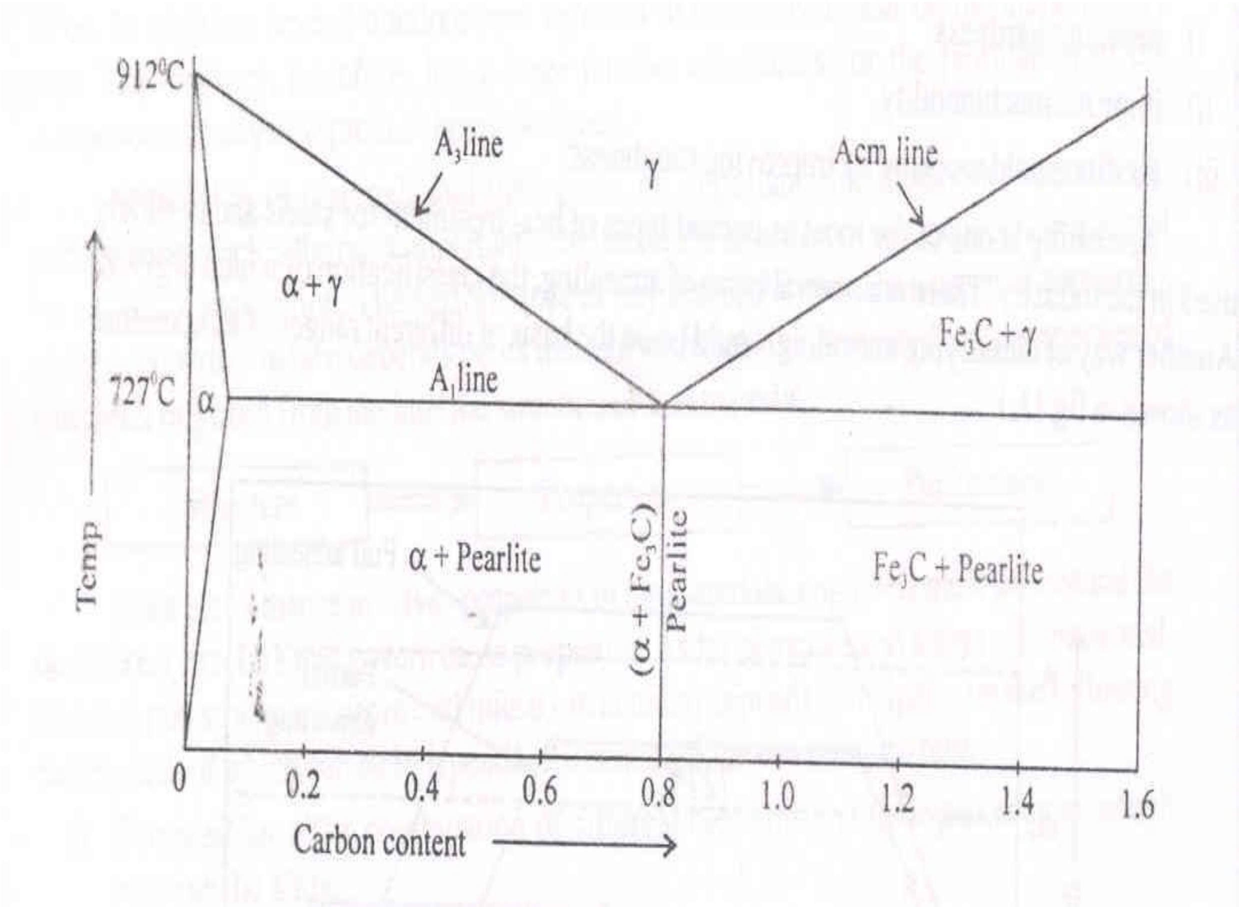

Fig: Eutectoid region of Iron Carbide diagram

Types of Phases:

1. α (Ferrite): It means the pure iron.
It is a relatively soft and ductile phase.
It can be extensively cold worked without cracking.

2. γ(Austenite): It is a soft, ductile, malleable phase.

3. δ(δ- Ferrite): It is similar to α - ferrite except its occurrence at high temperature.

4. Fe_3C (Cementite): It is extremely hard phase.

5. Pearlite: Pearlite is the mixture of ferrite and cementite.

6. Bainite: Bainite is an extremely fine mixture of ferrite and cementite

7. Martensite: The transformation product of austenite at low temperatures is called as martensite.

The purpose of heat treatment processes

1. To increase hardness.
2. To resoften the steel
3. To adjust properties such as Tensile strength, ductility.
4. To reduce internal stresses.
5. To decrease or increase the grain size of steels.
6. To eliminate gases, particularly hydrogen.

HEATING MEDIA

1. Air: Air heating is non-uniform and slow.
Above 850°C, appreciable oxidation and decarburization occurs.

2. Oil: Oils give uniform and rapid heating but they cannot be used above 200°C. Some oils like silicon oil can be used up to about 275°C.

3. Salt baths: Salt baths can be used for temperatures above 200°C. They not only provide uniform and fast heating but also reduce decarburization and oxidation of components.

COOLING MEDIA

(i) Brine (cold water + 5 to 10% salt) - The salt may be sodium chloride, sodium hydroxide or calcium chloride.
(ii) Cold water
(ii)Water + soluble oil
(iv) Oil
(v) Fused salts
(vi) Air

They are arranged in order of decreasing cooling rates.

HEAT TREATMENT PROCESSES

A) Full Heat Treatment Processes

1. Annealing

Purpose:

1. To relieve the internal stresses induced due to cold working, welding etc.
2. To reduce hardness and to increase ductility.
3. To refine the grain size.
4. Increase machinability.

Process:

The process consists of heating hypoeutectoid steels above A3 temperature and hypereutectoid steels above A_l temperature by 30 to 50°C, holding at this temperature for a definite period and slowly cooling to room temperature in furnace.

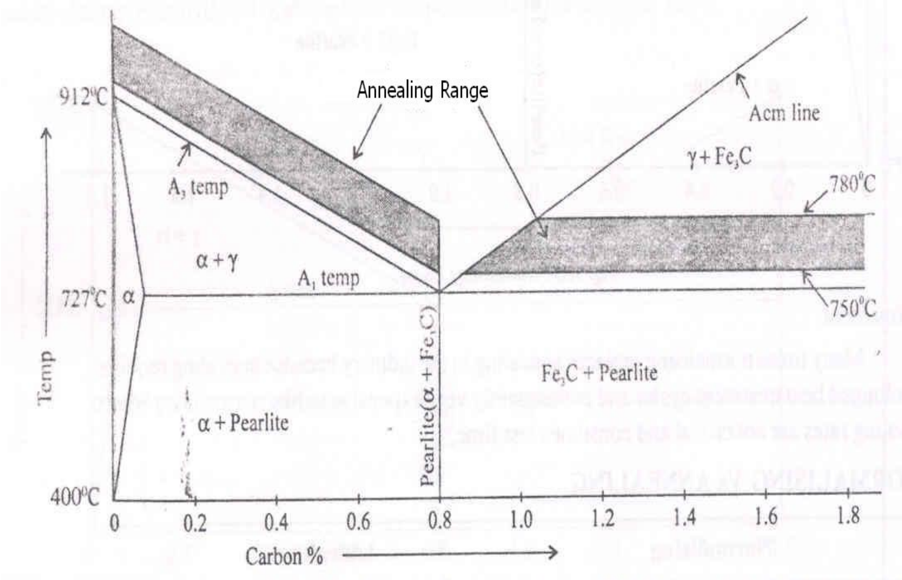

Fig. Annealing Temperature Range

2. NORMALISING

Purpose:

The purpose of the process is the same as that of annealing.

Process:

The process consists of heating hypoeutectoid steels above A3 temperature and hypereutectoid steels between A_l and A_{cm} temperature by 30 to 50°C and cooling to room temperature in air.

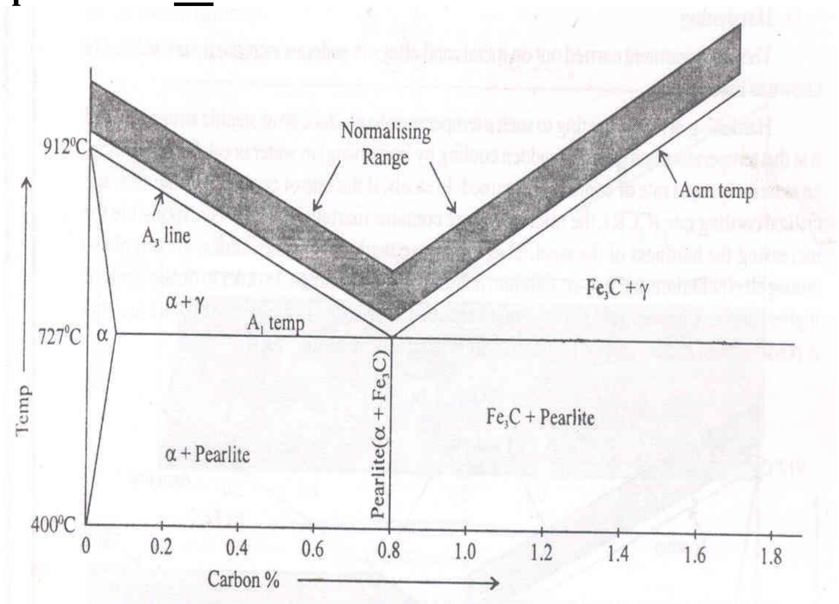

Fig. Normalizing Temperature Range

3. HARDENING

Purpose:
To increase hardness of the steel.

Process
The process consists of heating hypoeutectoid steels above A3 temperature and hypereutectoid steels between A_l and A_{cm} temperature by 30 to 50°C and <u>rapidly cooling</u> to room temperature

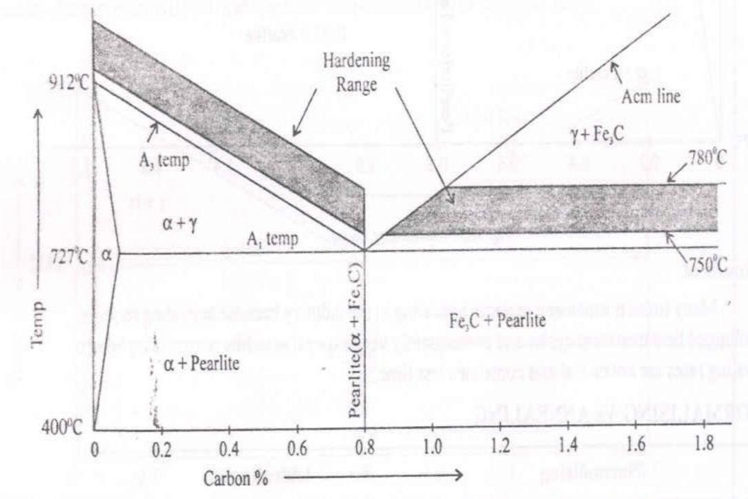

Fig. Hardening Temperature Rang

4. <u>TEMPERING</u>

Purpose
1. To relieve the internal stresses developed due to rapid cooling of steels.

2. To reduce hardness, to increase ductility and toughness.

Process
The process consists of heating the hardened components to a temperature between 100° and 700°C (below $A_{1)}$, holding at this temperature for specific period (1-2 hours) and cooling to room temperature, usually in air.

Types
1. Low temperature tempering (100-200^{0}C)

2. Medium temperature tempering (200-500^{0}C)

3. High temperature tempering (500-700^{o}C)

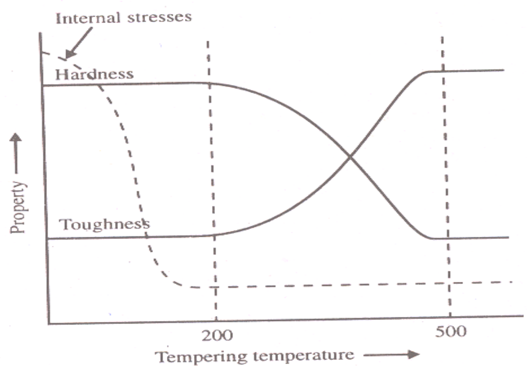

Fig. Property Variation with Tempering Temperature

B) SURFACE HEAT TREATMENT

I) Case Hardening

1. Carburizing

DEFINITION

It is the method of increasing the carbon on the surface of steel.

PROCESS

The process consists of heating the steel in the austenitic region in contact with carburizing media, holding at this temperature for sufficient time and cooling to room temperature.

Immediately after carburising hardening treatment is necessary to bring the carbon in the martensitic form.

Types

1. Solid Carburising- Case depth of 1 mm to 2.5 mm can be obtained.
2. Liquid Carburising- Case depth of 0.2 mm to 0.5 mm can be obtained.
3. Gas Carburising-Case depth of 0.1 mm to 0.5 mm can be obtained.

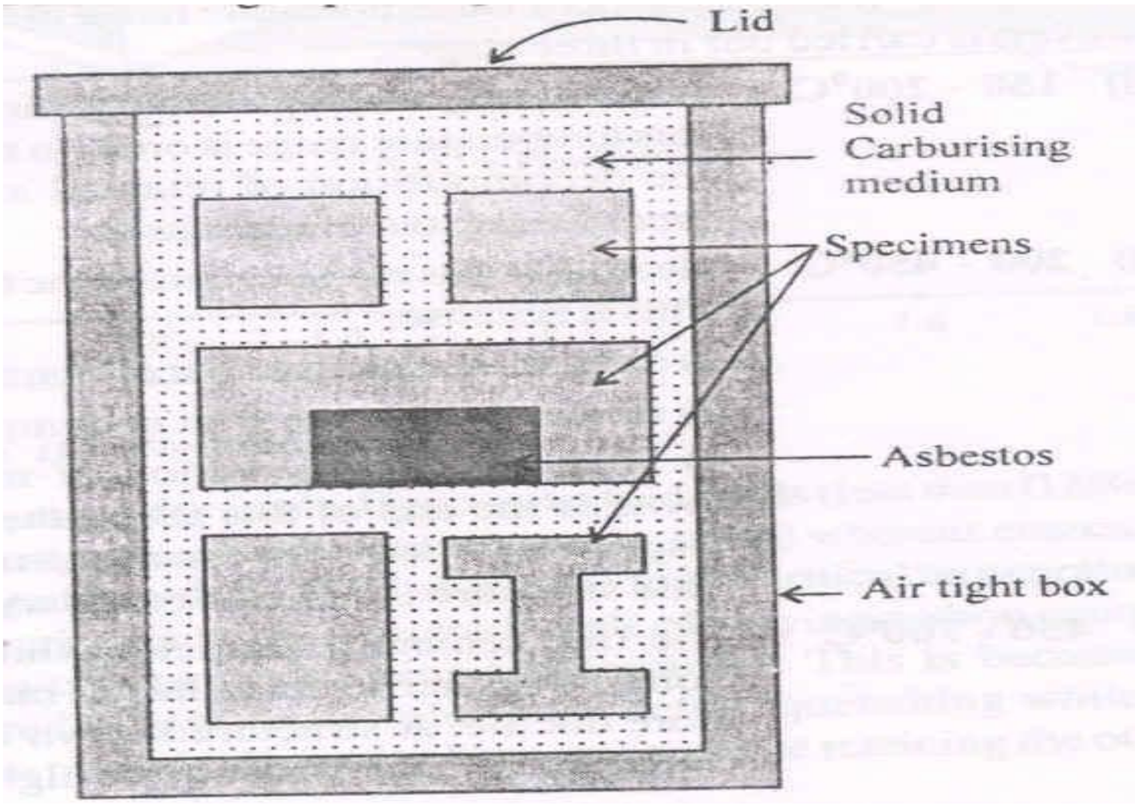

Fig. Solid Carburising

2. Nitriding

Process

The process consists of heating the steel in contact with source of atomic nitrogen at a temperature of about 550°C.

This atomic nitrogen diffuses into the steel and combines with iron and certain alloying elements present in steel and forms respective nitrides.

Types

1. Liquid Nitriding
2. Solid Nitriding

(Case depth of 0.25 to 0.5 mm can be obtained)

3. Cyaniding

Process

In this process steel surfaces can be hardened by adding both carbon and nitrogen.
The component to be hardened is placed in a liquid bath containing sodium cyanide and heated to tempreture range of 800 to 960°C

4. Carbo-Nitriding

Carbonitriding is similar to cyaniding except that steels are heated in a gaseous environment.

II) Surface Hardening

1. Flame Hardening

It involves heating the steel specimen by means of oxy-acetylene flame to the austenitic region followed by quenching.
Case depth upto 5 mm can be obtained.

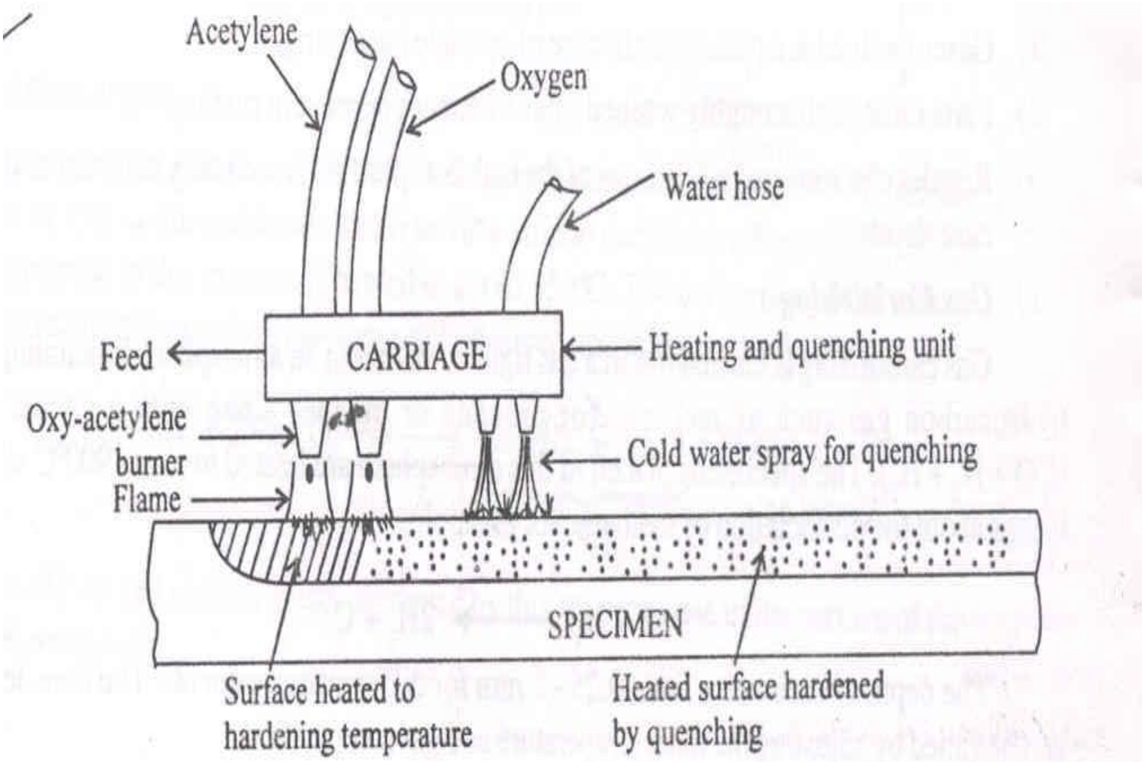

Fig. Flame Hardening

2. Induction Hardening

It consist of heating the surface with high frequency alternating current through induction coils followed by water cooling.

Case depth from 0.5 to 6 mm can be obtained.

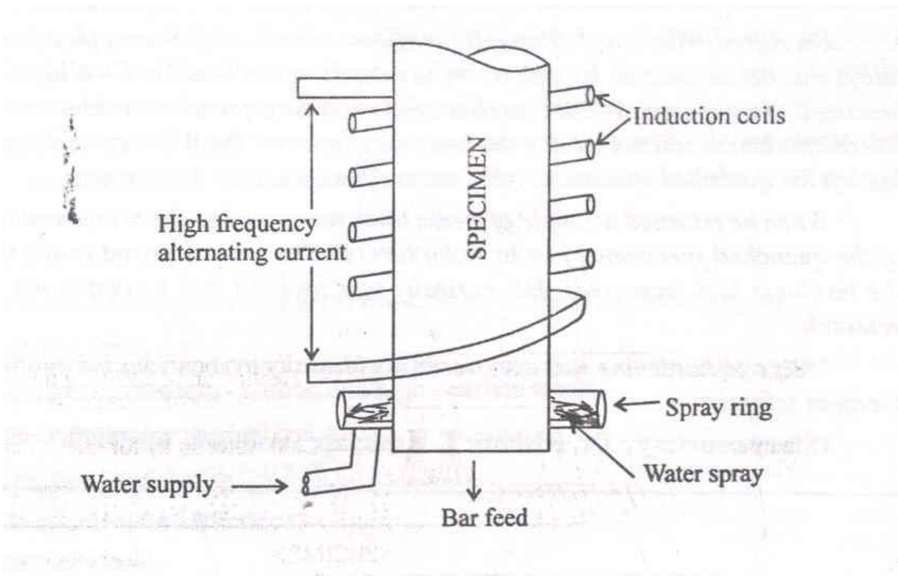

Fig. Induction Hardening