UNIT - 4

Heat Treatment for alloys

Heat treatment

"A combination of heating and cooling operations timed and applied to a metal or an alloy in the solid state to produce desired properties" is known as heat treatment

Effect of alloying elements on Fe - Fe_3C system

→ Alloying elements have significant effect on the iron - iron carbide equilibrium dia-gram.

→ The addition of some of these alloy elements will widen the temperature range through which austenite (γ - iron) is stable while other elements will constrict the temperature range.

→ What this means is that some elements like will lower the critical temperature of steel.

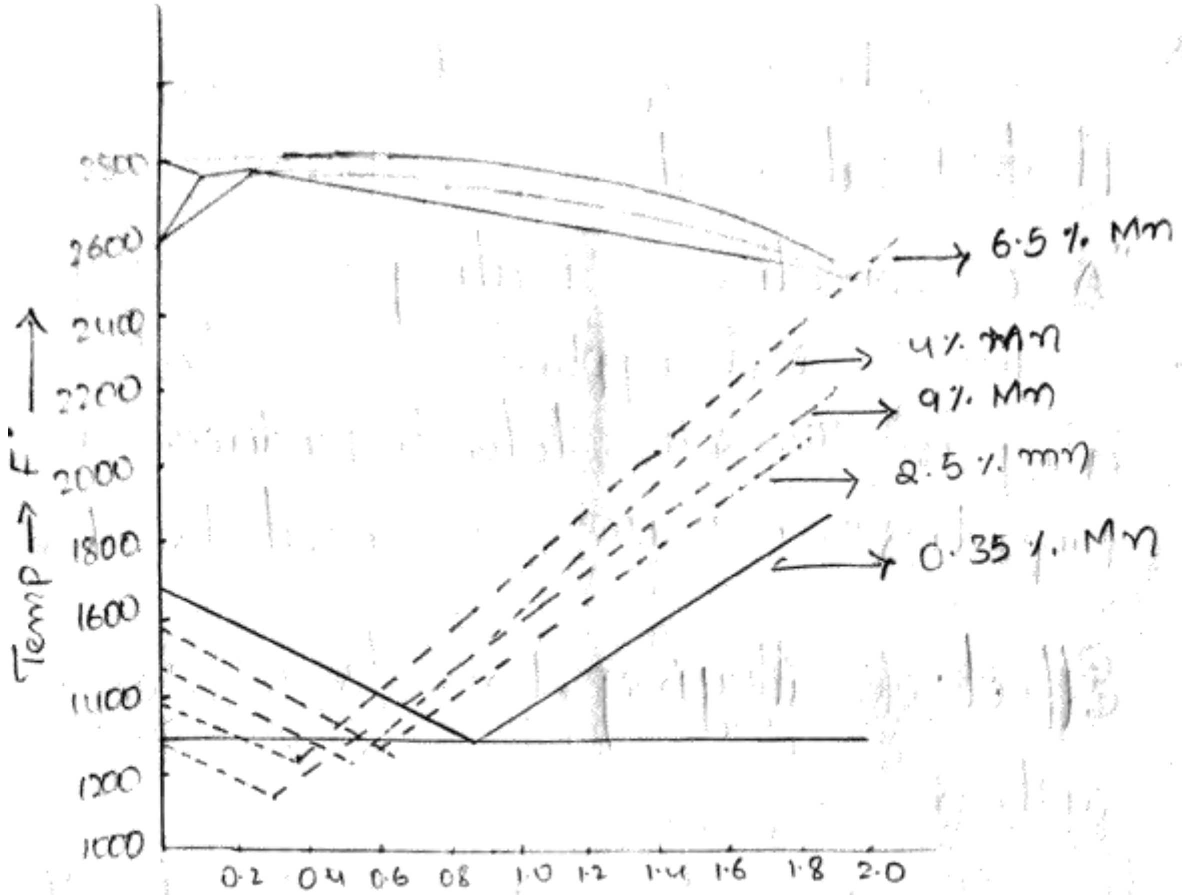


Figure (1)

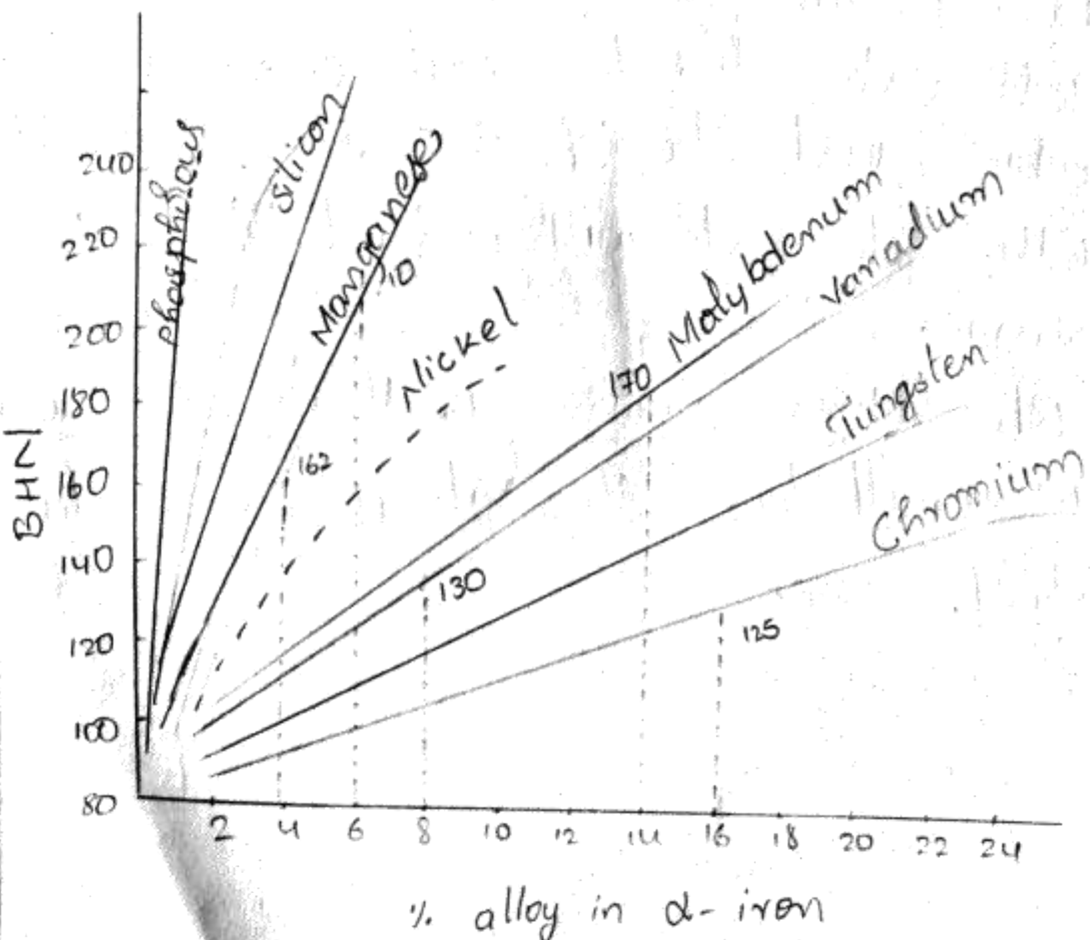


Figure (2)

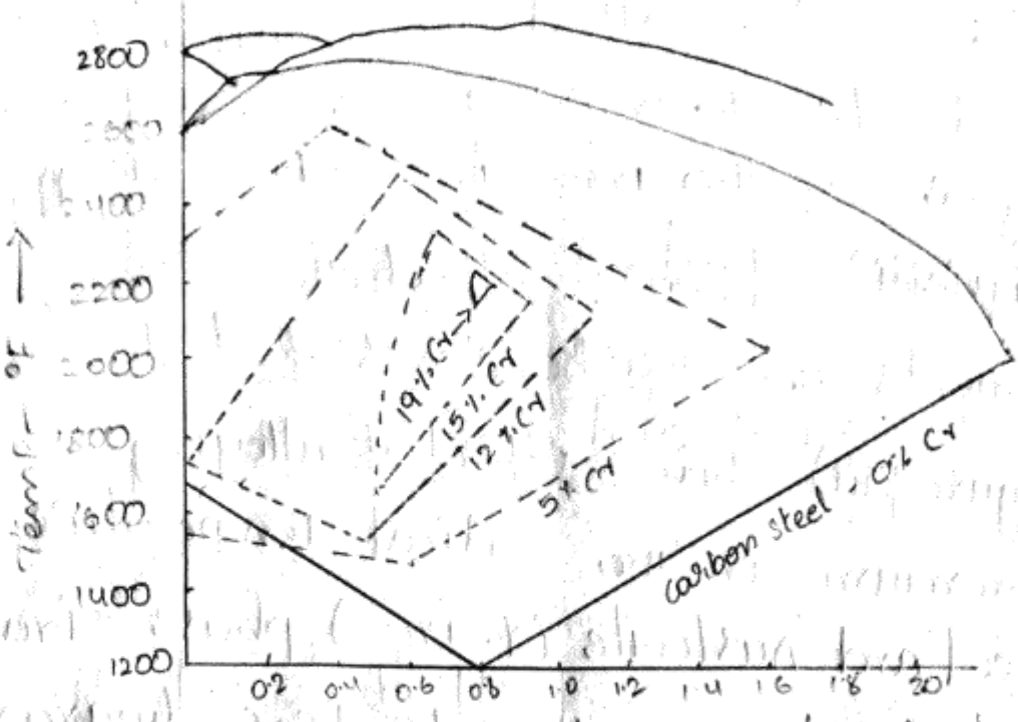


Figure (5)

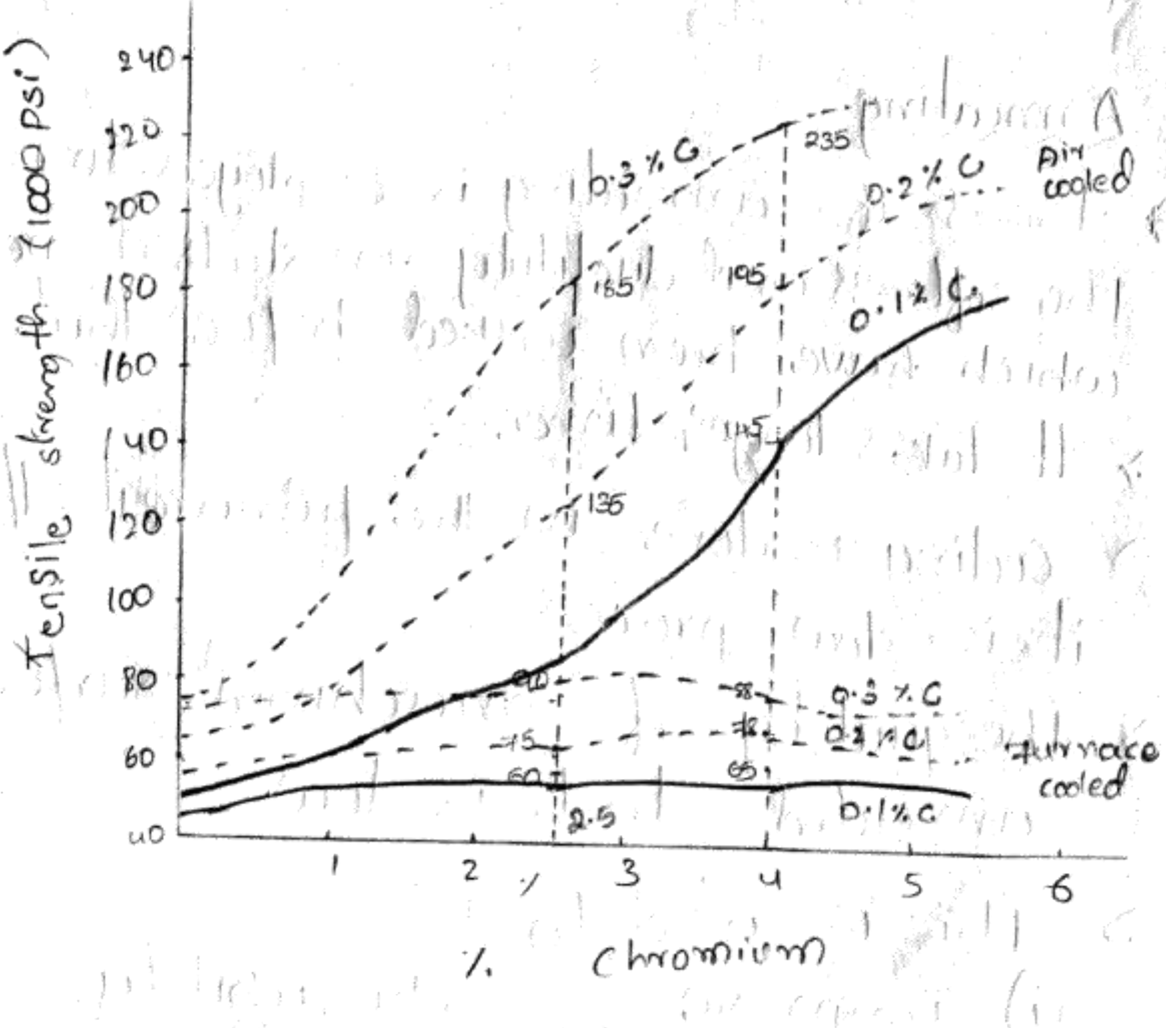


Figure (4)

→ Figure(i) shows the effect of alloying with Manganes on the critical Temperature of steel and Austenite (γ - iron) phase Transformation zone on the iron - iron carbide diagram.

→ Figure(ii) shows effect of various alloying elements on the hardness of steel.

→ Figure (iii) shows effect of alloying with chromium on the critical Temperature of steel and Austenite (γ - iron) phase Transformation zone on the $Fe - Fe_3C$ diagram.

→ Figure (iv) shows effect of different % of carbon on the tensile strength of steel in the Presence of chromium.

Annealing

→ Process of annealing is employed to improve the softness and ductility on steels & metals which have been worked before that.

→ It takes longer time.

→ Cooling is done in the furnace itself, so it is slow process

→ The quality of machined surface of annealed steels is low.

→ This is used to

(i) Improve machinability

(ii) Relieve internal stress caused by a heat treatment is more expensive than

→ Grain structure is coarse.

→ Annealing treatment is more expensive than normalising.

→ Annealed steels are less harder than the normalized ones

→ Improves machinability of medium carbon steels.

Normalizing

→ Process of normalizing is employed to refine the grain structure of steels which has undergone cold or hot working.

→ It does not take much time.

→ Cooling is done in still air.

→ The quality of machined surface of normalized steel is high.

→ This is used to
  (i) Improve machinability.
  (ii) Release internal stresses caused by the previous phase cold working in the previous phase

→ Grain structure is finer

→ Compared to annealing it is a less expensive method of heat treatment.

→ Normalized steels are harder than the annealed steels.

→ Improves Machinability of low carbon steels.

Hardening

Hardening is divided into following types

Flame Hardening

1. In this method, the surface of the steel is heated by an oxyacetylene flame and then quenching it immediately in cold water.
2. Selective heating can be possible by this method.
3. Coast of the equipment is less
4. Requires skilled labour.
5. Maintenance cost is less.
6. Production of hardended zone less than 1/16 inch depth is difficult.
7. Possibility of overheating and damaging the part is more.

Induction hardening

1. In this method, steel component is placed in a coil and a high frequency current is passed through the coil, which induces eddy current in the

the surface layer, thus heating it to austenite state.

- Selective heating is not possible.
- Cost of the equiment is more
- High maintenance cost.
- Hardened zone less than 1/16 inch depth can be easily produced.
- As the process is carried out automatically there is no chance of overheating and damaging of the parts.

Quench Hardening

- It is a heat treatment process in which steel is heat to austenite phase followed by rapid cooling in a liquid medium such as oil or water.
- It improves the hardness and wear resistance of the steel.
- Metal in heat 30-50°C above upper critical temperature for hypo eutectoid steels 30-50°C above lower critical temperature for hyper eutectoid.

Precipitation Hardening

1. It is a heat treatment process for non-ferrous alloys consisting of two stages i.e., solid solution treatment and aging.

2. It improves the hardness and strength of the alloys.

3. This process is carried out ~~at~~ to temperature where pecipitation rate is slow due to which ductility of alloys increases.

Tempering

→ Tempering is a heat treatment process that is carried out for hardened steels.

→ It is immediately ~~process that is carried out for hardened steels.~~ done after hardening so that the high internal stresses produced due to hardening are relieved.

→ It increases ductility of the steel and reduces hardness.

Tempering is classified into the following types depending on the transformation behaviour:

(a) Low temperature tempering (100 - 200°C)

(b) Medium temperature tempering (200 - 500°C)

(c) High temperature tempering (500 - 700°C)

Tempering is required to meet the following objectives (5)

(i) To relieve the metal from internal stresses produced during hardening.

(ii) To ensure stable structure of the metal.

(iii) To increase the ductility of the metal and reduce hardness.

(iv) To increase toughness and shock-resistance of metal.

Hardenability

It is defined as ability of steel to develop its maximum hardness when subjected to normal hardening and quenching.

Jominy end Quench Hardenability test

-> The steel bar to be tested in first normalized at about 85°C above upper critical temperature.

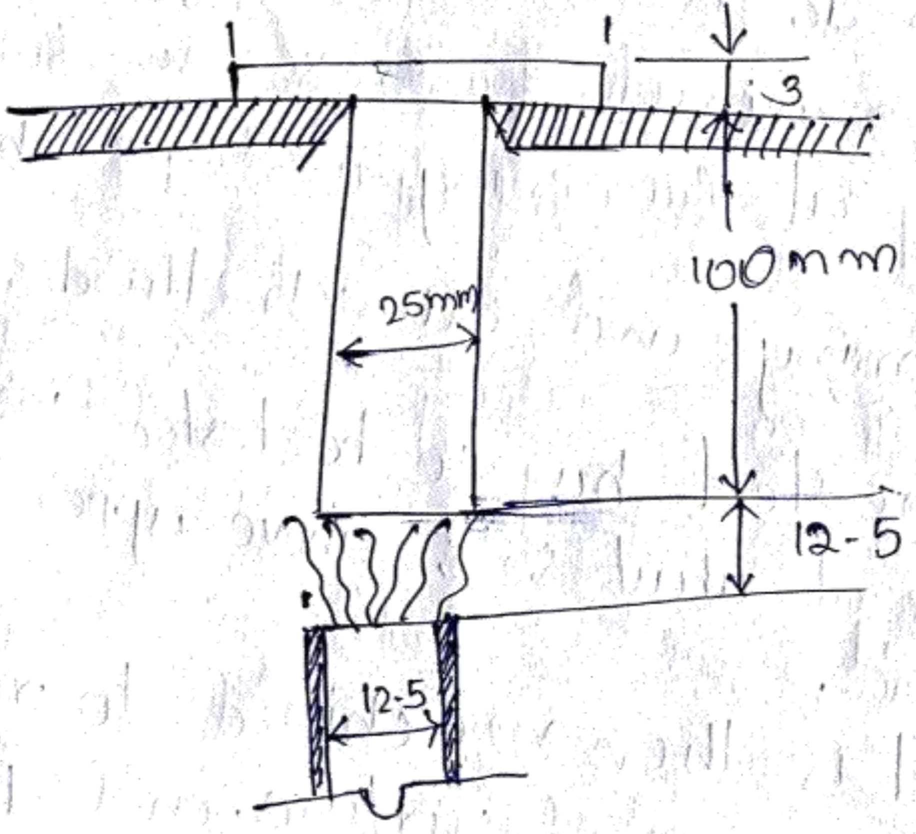
-> It is then machined to remove the decarburized surface and to bring it to exactly 25 mm in diameter, then it is heated in non-oxidising atmosphere 40°C above the upper critical temp.

-> It is then transferred immediately to a standarded critical temperature.

→ And it is quenched in such a manner that only one end of 100mm long specimen comes in contact with a stream of water from a 12.5 mm diameter.

→ The specimen cooles rapidly at quenched end and progessively less rapidly towards the opposite end.

→ Hardness determination are made on ground surfaces at intervals of 1.5mm from the quenched end.



Jominy and Quench Test

Surface - Hardening Methods

Surfac Hardening

- carburizing
  - → Gas carburizing
  - → Liquid carburizing
  - → Pack carburizing.
- carbon nitriding
- cyaniding
- Boronizing
- Hardening
  - ↳ Flame hardening
  - ↳ Induction hardening.

Carburizing

→ Carburizing is a process by which the surface of low carbon steels is hardened by the addition of carbon.

→ Both solid carburizing & gas carburizing can be employed for carburizing process

→ Gas carburizing is mostly used now-a-days which the low carbon steels are heated to a proper temp. about 900°C in an oven. The oven contain gases which are rich in hydrocarbons like methane, ethanes and coal gas. The carbon's in these gases combine with the surface of the metal and make it hard.

→ Case depth is about 1.27 mm

Nitriding

→ Nitriding is process by which the surface of the steel is hardened by the addition of nitrogen gas.

→ Only gas nitriding is the process for employing the nitriding process.

→ Alloy steels containing chromium aluminium molybdenum and manganese are used in this process, which is done in an electrical furnace at a temperature of 500°C. The process is carried out in the presence of ammonia gas. The gas separates as nacent nitrogen and reacts with steels surface to form nitrides which are very hard. (7)

4. case depth is about 0.381 mm.

Age hardening Treatment

→ Age-hardening is the process of ~~har~~ increasing strength and hardness of some metal alloys. This process has significant role amoung heat treatment processes employed for non ferrous alloys. It is also known as precipitation hardening. ~~I~~

→ The particles of the precipitat act as obstacles of dislocation movement for strengthening the heat-treated alloys.

→ Age hardening occurs only in alloys where decrease in solid solubility with decrease in temperature.

Cryogenic Treatement of alloys

→ In cryogenic treatment of the alloy is subjected to deep freezing temperature as low as -185°C (-301°F) but usually -75°C is sufficient.

→ It is done to eliminate retained austenite during quenching.

→ At hardening temperature, the steel has a solid solution of carbon and iron.

→ During quenching, the amount of martensite formed depends on the lowest temperature encountered. At any given temperature of quenching, there is a certain amount of martensite and the balance is untransformed austenite.

→ This untransformed austenite is very brittle and can causes loss of strength, hardness, dimensional instability, cracking etc.

→ Most of the low carbon and medium carbon steel during quenching to room temperature transforms to 100% martensite.

→ But the high carbon and high alloys steels consists of retained austenite at room temperature.

→ In order to eliminate the retained austenite cryogenic treatment is carried out.