

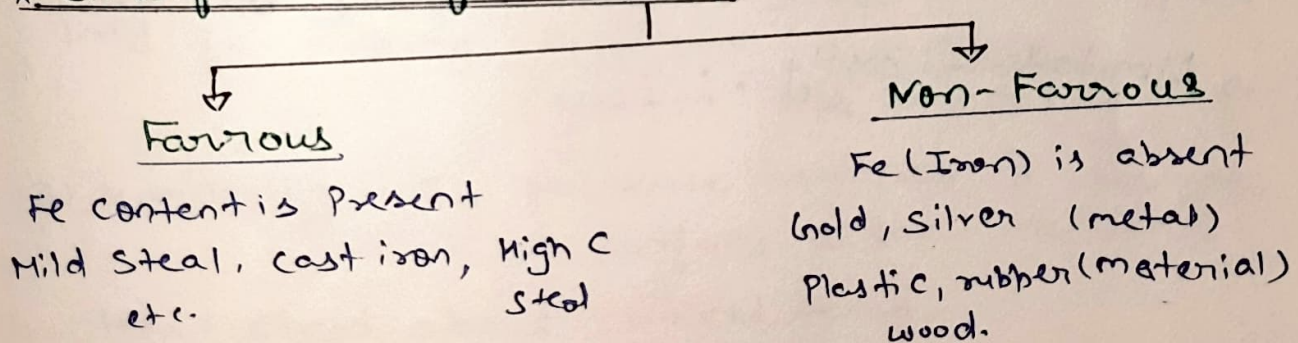
Engineering Materials

Heat Treatment of Steel

* Properties of material -

- (1) Hardness - which resists penetration.
- (2) Strength - which resists external load without breaking
- (3) Elasticity - material can regain its original shape & size after removal of load. (Rubber band)
- (4) Plasticity - It can not regain its original shape & size after removal of load. (deform permanently)
- (5) Malleability - It can be converted into a thin sheet metal without any failure (Pypture)
- (6) Ductility - It can be drawn into a thin wire without any rupture (Copper,
- (7) Brittleness - without any deformation, it breaks
- (8) Toughness - It can bent, twist & stretched without
- (9) Creep - Plastic deformation due to constant ^{failure} load applied for long time.
- (10) Fatigue -
- Stiffness - It is difficult to bend the material. (wood, silicon carbide.

* Classification of material -



(1) Metal And Alloys - all ferrous & non ferrous material are metal

→ mixing two or more metal known as Alloys.

(2) Ceramics - Are made of clay & permanently hardened by heat.

Ex Tiles, cement etc

(4) Organic Polymers - Having carbon content as a backbone⁽¹⁸⁾.
ex PVC (Poly vinyl chloride)

(5) Composites - made of more than one metal.
ex, fiberglass etc.

(6) Semiconductors - Are those whose conductivity is present between conductor and insulator.

ex, Si, Ge.
(7) Biomaterials - made from glass, ceramics, living cells & tissues.

* Mild Steel - C \rightarrow 0.15 to 0.25%, strong, good weldability.
Production cost low.

Medium carbon steel - C \rightarrow 0.3 to 0.6%, good strength.
less weldability.

High carbon steel - C \rightarrow 0.65 to 1.5%, hard & tough by heat
poor weldability.

Cast iron - C \rightarrow 2 to 4%, Production cost is less.
used to create railway track.

Titanium alloy - low density, high strength, high melting point,

\rightarrow Application - space vehicles, Airplane structure.

\rightarrow Limitation - costly.

* Heating treatment of Steel-

Heating and cooling metals in a controlled way to change their mechanical properties.

- Objective
- Improve hardness or softness
 - Increase strength or ductility
 - Relieve internal stresses
 - Refine grain structure
 - Improve wear & corrosion resistance.

Furnace — Muffle furnace, Conveyor furnace, Bath furnace, induction heating furnace.

Process

- (1) Annealing — To soften steel, improve ductility & machinability, Relieve internal stresses.

Heat the sheet above its Critical temp (723°C)
Hold it at that temp for a certain time. (Soaking)
Cool it very slowly, usually in a furnace.

- (2) Normalizing — To Refine grain structure, improve strength & toughness. (Stronger)

Heat steel above critical temp.
Hold for soaking. then cool it in open air
(faster than annealing)

- (3) Hardening — To increase hardness & strength.
Make surface wear-resistance.

Heat steel above critical temp.
then Rapidly cool (quenching) in water, oil, air.

- (4) Tempering — To reduce brittleness of hardened steel.
Improve toughness & flexibility.

→ Reheat hardened steel to a lower temp ($150-650^{\circ}\text{C}$)
Hold for some time
Cool it in Air

Case hardening -

- To make outer surface hard but core soft.
Ideal for parts needing wear resistance on the outside. (gear, camshaft) without cracking.
- ⇒ Heat steel in a carbon rich atm.
Carbon atom diffuse into surface.
Then harden the surface by quenching