HARDENING

The purposes of hardening are:

(a) to harden the steel to resist wear, and

(b) to enable it to cut other metal.

The metal is heated 30–50°C above the upper critical temperature for hypoeutectoid steel and above the same amount above the lower critical temperature for hypereutectoid steel.

It is left for soaking for considered time. Quenching of high carbon steel heated to 1,100–1,300°C is done in a current of air. Quenching 150–200°C per second in solution 3–10% caustic soda and 5–15% salt is more rapid than the quenching effect in water at 20°C and 32–42°C for oil quenching.

TEMPERING

Tempering is a process of reheating of hardened steel below critical range and cooled at the decreased rate (approximately 4–5 min for each mm of the section). There is partial transformation of martensite to secondary constituent troostite and sorbite. The purposes of tempering are:

(a) to reduce some amount of hardness produced during hardening and increase the ductility, and

(b) to remove strain produced during heating.

TEMPERING

Low Temperature Tempering: Steel is heated to 150–250°C and cooled down. This is used to remove internal stress, reduce hardness, and increase ductility without changing the steel structure.

Medium Temperature Tempering: Steel is heated to 350–450°C and cooled down. Martensite is changed to secondary troostite. It results in reduction in strength and hardness, and increase in ductility.It is used for the part which is to be used in impact loading such as chisel, hammer, spring, and spring plates.

High Temperature Tempering: Steel is heated to 500–600°C and cooled down. Martensite is changed to sorbite. Internal stress is relieved completely. This is used for the part subjected to high impact and stress such as gear wheels, shafts, connecting rod, etc.

Martempering

- Martempering or marquenching permits the transformation of austenite to martensite to take place at the same time throughout the structure of the metal part.
- By using interrupted quench, the cooling is stopped at a point above the martensite transformation region to allow sufficient time for the centre to cool to the same temperature as the surface.
- Then cooling is continued through the martensite region followed by the usual tempering.

CARBURIZING

- Carburizing is a heat treatment process in which iron or steel absorbs carbon liberated when the metal is heated in the presence of a carbon-rich atmosphere, such as charcoal or carbon monoxide, with the intent of making the metal harder.
- Depending on the amount of time and temperature, the affected area can vary in carbon content.
- Longer carburizing times and higher temperatures lead to greater carbon diffusion into the part as well as increased depth of carbon diffusion.
- When the iron or steel is quenched, the higher carbon content on the outer surface becomes hard via the transformation from austenite to martensite, while the core remains soft and tough as a ferritic and/or pearlite microstructure.

CARBURIZING

- It is applied to low-carbon workpieces; workpieces are in contact with a high-carbon gas, liquid, or solid; it produces a hard workpiece surface; workpiece cores largely retain their toughness and ductility; and it produces case hardness depths of up to 6.4 mm.
- **Gas Carburizing:** It is a heat treatment process, which improves the case depth hardness of a component by diffusing carbon into the surface layer to improve wear and fatigue resistance.
- **Pack Carburizing:** It is a heat treatment process in which carbon monoxide derived from a solid compound decomposes at the metal surface into nascent carbon and carbon dioxide.

CYANIDING

- Steel parts may be surface hardened by heating in contact with a cyanide salt, followed by quenching.
- Only a thin case is obtained by this method. Cyaniding is, however, a rapid and economical method of case hardening and may be used in some instances for relatively unimportant parts.
- The work to be hardened is immersed in a bath of molten sodium or potassium cyanide from 30 to 60 min.
- The cyanide bath should be mainlined at temperature of 760–899 oC. Immediately after removal from the bath, the parts are quenched in water. The case obtained in this manner is due principally to the formation of carbides and nitrides on the surface of the steel. The use of a closed pot and ventilating hood are required for cyaniding, as cyanide vapours are extremely poisonous.

NITRIDING

- This method is advantageous due to the fact that a harder case is obtained than by carburizing.
- Many engine parts such as cylinder barrels and gears may be treated in this way. Nitriding is generally applied to certain special steel alloys, one of the essential constituents of which is aluminium.
- The process involves the exposing of the parts to ammonia gas or other nitrogenous materials for 20–100 h at 500–650°C.
- The container in which the work and ammonia gas are brought in contact must be airtight and capable of maintaining good circulation and even temperature throughout. The depth of case obtained by nitriding is about 0.2–0.4 mm if heated for 50 h.
- The nitriding process does not affect the physical state of the core if the preceding tempering temperature was 500oC or over.

INDUCTION HARDENING

- This process involves heating applied rapidly and locally to the steel component followed by quenching.
- High frequency electric fields quickly heat the surface of the component via induction coils, which is then quenched using water.
- This results in a localized hardened layer at the surface.
- Different shaped induction coils are available and can be made to suit.
- Induction hardening offers a cost-effective low-distortion surface hardening treatment to steels, particularly large components where an increase in surface hardness is required whilst maintaining core properties.