

✓ Heat treatment is the controlled heating and cooling of metals for the purpose of altering their properties. In this unit, the theory and the various processes of heat treatment have been presented.

✓ The theory of heat treatment is based on the fact that a change takes place in the internal structure of metal by heating and cooling which induces desired properties in it.

✓ The important heat treatment processes are as follows :

- 1. Annealing
 - (a) Full annealing,
 - (b) Process annealing,
 - (c) Stress relief annealing,
 - (d) Recrystallisation annealing, and
 - (e) Spheroidise annealing.
- 2. Normalising
- 3. Hardening
- 4. Tempering
- 5. Austempering
- 6. Martempering
- 7. Case hardening
 - (a) Carburising,
 - (b) Nitriding,
 - (c) Cyaniding,
 - (d) Carbonitriding,
 - (e) Flame hardening, and
 - (f) Induction hardening.

✓ Annealing is a heat treatment for the general purpose of softening or stress-relieving a material.

✓ Normalising is a heat treatment obtained by austenitising and air cooling to produce a fine pearlite structure. The objective of this heat treatment is to enhance toughness by refining the grain size.

✓ Quenching refers rapid cooling. Some of the quenching medium that are widely used are caustic soda, brine solution, water, oil, and air.

- ✓ **Hardening** refers to the heat treatment which increases the hardness by quenching.
- ✓ **Tempering** is a heat treatment in which martensite is reheated. In this, the ductility and toughness of martensite can be enhanced by reducing the hardness of martensite.
- ✓ The **time-temperature transformation (TTT) diagram**, also known as isothermal transformation (IT) diagram or C-curve, is a plot of temperature versus the logarithm of time for a steel alloy of definite composition. It is used to determine when transformation begins and end for an isothermal (constant temperature) heat treatment of a previously austenitized alloy.
- ✓ The **continuous cooling transformation (CCT) diagram** is a plot of temperature versus the logarithm of time for a steel alloy of definite composition. It is used to indicate when transformations occur as the initially austenitised material is continuously cooled at a specified rate. In addition, using the CCT diagram the final microstructure and mechanical characteristics may be predicted.
- ✓ **Hardenability** refers to the ease with which hardness may be attained. That is it is a measure of ease of forming martensite. The Jominy end-quench test method is widely used to determine the hardenability.
- ✓ **Martempering** is a heat treatment of a steel involving a slow cool through the martensitic transformation range to reduce stresses associated with that crystallographic change.
- ✓ **Austempering** is a heat treatment of a steel involving holding just above the martensitic transformation range large enough to completely form bainite.
- ✓ The **surface heat treatment** is used to achieve (i) the hard outer surface (or case), and (ii) the soft inside (or core), of the components.

- ✓ **Carburising** is a process in which carbon atoms are introduced onto the surface of low carbon steels to produce a hard case of surface, while the interior or core remains soft.
- ✓ **Nitriding** is a process of introducing nitrogen atoms to obtain hard surface of steel components.
- ✓ **Cyaniding** is a process of introducing both nitrogen and carbon to obtain hard surface of the steel components.
- ✓ **Carbonitriding** is a surface-hardening process that involves the diffusion of both nitrogen and carbon into the steel surface.
- ✓ **Selective hardening (or heating) technique** is a technique by which different properties are obtained simply by varying the thermal histories of the various regions.
- ✓ **Flame hardening** is a process of selective hardening with a combustible gas flame as the source of heat for austenitizing.
- ✓ **Induction hardening** is a process of selective hardening using resistance to induced eddy currents as the source of heat.