

PMT4I101 PHASE TRANSFORMATIONS AND HEAT TREATMENT

Module I (14 Hours)

Introduction: Thermodynamics of phase equilibrium and phase changes; Definition, utility, order and classification of phase transformations.

Diffusion: Definition of Fick's law on steady and non-steady state diffusion and their solutions; Mechanism of diffusion in solids; Chemical diffusion and Darken's equation; Kirkendall effect; Effect of pressure and temperature on diffusivity.

Nucleation and growth: Formation of nucleus; Homogeneous and Heterogeneous nucleation; Mechanism and kinetics of thermally activated growth; Interface and diffusion control growth regimes.

Phase equilibrium and phase diagrams: Important phase changes in unary and binary systems; Types and interpretation of phase diagram; Utility of phase diagrams, Lever rule; Important phase diagrams in metallic and ceramic systems; Free energy Composition diagrams; Ternary phase diagrams; Isomorphous and eutectic Systems.

Module II (12 Hours)

Liquid-solid transformation: Solidification, nucleation and growth mechanisms and kinetics; Alloy solidification – cellular and dendritic morphology; Eutectic and peritectic solidification. Application of solidification.

Solid state diffusive transformation: Classification of solid-solid transformations; Nucleation in solids; Precipitate growth; Age hardening; Spinodal decomposition; Precipitate coarsening. Order-disorder change, polymorphic change. Recrystallization, grain growth. Eutectoid transformation. Application of solid state precipitation. Pearlitic and bainitic transformations in steel; Martensite and martensitic changes in ferrous materials.

Module III (12 Hours)

Review of Iron-carbon alloy system: Iron-cementite and iron-graphite phase diagrams, cooling of hypo-eutectoid, eutectoid and hyper-eutectoid steels, hypo-eutectic, eutectic and hyper-eutectic cast irons, nucleation and growth of pearlite.

Heat treatment of steels: TTT and CCT diagrams, conventional heat treatment processes – annealing, normalizing, hardening and tempering. Hardenability, role of alloying elements in steels. Surface hardening and chemical treatment in steels. Thermo-mechanical treatment of steels; High temperature and low temperature Thermo-Mechanical treatment. Heat treatment of some Cu, Al and Ti based alloys.

Books for reference

1. *Phase Transformations in Metals and Alloys* by D. A. Porter and K. E. Easterling, CRC Press.
2. *Phase Transformations in Materials* by R. C. Sharma
3. *Solid State Phase Transformations* by Raghavan, PHI.
4. *Steel and its Heat treatment* by K E Thelning, Butterworth.
5. *Heat Treatment* by Rajan and Sharma, PHI.
6. *Principles of Heat Treatment of Steels*, ASM
7. *Physical Metallurgy Principles* by R. E. Reed-Hill, East West Press.
8. *Theory of Transformations in Metals and Alloys* by J.W.Christian, Pergamon Press.
9. *W C Leslie, The Physical Metallurgy of Steels* , McGraw-Hill International.

(Practical)

Suggested experiments:

1. *Annealing treatment of a cold worked steel and comparison of the annealed microstructure with the cold worked structure.*
2. *Normalizing treatment of steel and comparison of the microstructure with annealed structure.*
3. *To study the quenched structures of steel – quenched in oil, water and brine solution.*
4. *To study the quenched and tempered structures of steel –*
 1. *(i) low temperature tempering.*
 2. *(ii) medium temperature tempering.*
 3. *(iii) high temperature tempering.*
4. *To study the recrystallisation behaviour of pure metal (iron / copper).*
5. *To study the effect of time and temperature on grain size of a metal (grain growth) (iron/ copper).*
6. *To study the nucleation rate and growth rate of pearlite in eutectoid steel.*
7. *To study the susceptibility of a steel to harden by quenching (hardenability) by Jominy test.*
8. *Pack carburizing of 0.2% carbon steel and to measure the diffusion coefficient of carbon in steel.*
9. *To study the microstructure of tool steels, stainless steels and other high alloy steels.*
10. *Austempering of steels and S G cast irons.*
11. *To carry out age hardening of non ferrous alloys.*
12. *Determination of hardenability of steels.*