

MSE-476 Heat Treatment and Phase Transformations

Credit Hours: 3-0

Pre-requisites: Nil

Course Description

The course presents the principles of thermodynamics and kinetics of phase transformation. These principles are used to understand various types of transformations during different heat treatments. Additionally, the effect of different heat treatment processes on the mechanical properties of the alloys will be presented. The role of composition, time, and temperature of transformation on the evolution of different microstructures will be taught.

Course Contents

- Thermodynamics of Phase Transformation, Gibbs free energy, and phase equilibrium.
- Free-energy changes in the single-component system, Clausius Clapeyron equation, Gibbs free energy changes in binary alloys
- Free energy of mixing, Ideal and real solutions, Ordered-disordered phases, Gibbs phase rule
- G vs X curves and phase diagrams, Time-temperature transformation diagrams
- Bulk Heat Treatment processes: Annealing, Normalizing
- Hardening and Tempering processes, Hardenability measurement techniques.
- Case hardening methods, Surface hardening methods
- Heat treatment of cast-irons, die and tool steels, Thermo-mechanical treatment of steels

Weekly Plan

Week	Topics
1	Thermodynamics of Phase Transformation
2	Gibbs free energy, and phase equilibrium
3	Free-energy changes in the single-component system, Clausius Clapeyron
4	Gibbs free energy changes in binary alloys
5	Free energy of mixing, Ideal and real solutions
6	Ordered-disordered phases, Gibbs phase rule
7	G vs X curves and phase diagrams
8	Time-temperature transformation diagrams
9	Mid-Semester Exams
10	Annealing, Normalizing
11	Hardening and Tempering processes
12	Hardenability measurement techniques

13	Case hardening methods
14	Surface hardening methods
15	Heat treatment of cast-irons,
16	Thermo-mechanical treatment of steels
17-18	End Semester Exams

Course Outcome

At the end of the course, the students are expected to have learned the following:

- Phase transformations and associated thermodynamics, including Gibbs free energy, phase equilibria, phase diagrams, and the factors governing phase stability in single-component and binary systems
- The principles and applications of heat treatment processes, including bulk, surface, and thermo-mechanical methods, to optimize microstructures and tailor material properties.

Suggested Books

- Phase Transformation in Metals and Alloys by D. A. Porter, K. E. Easterling and M. Y. Sherif. 3rd ed., CRC press (2009)
- Physical Metallurgy: Metals, Alloys, Phase Transformations by V. M. Schastlivtsev, V. I. Zel'dovich. De Gruyter GmbH (2022)
- Phase Equilibria, Phase Diagrams and Phase Transformation: Their Thermodynamic Basis by M. Hillert. 2nd ed. Cambridge University Press (2012).
- Steel Heat Treatment, Metallurgy and Technologies edited by G. E. Totten. 1st ed. CRC Press (2006)
- Heat Treatment: Principles and Techniques by T.V. Rajan, C.P Sharma, Ashok Sharma. 2nd ed. Prantice Hall, India, (2011)
- Heat Treatment of Metals by Vijendra Singh (2017)