Course code	Course Name	L-T-P - Credits	Year of Introduction
MT206	METALLURGICAL HEAT TREATMENTS	3-0-0-3	2016

Prerequisite : MT202 Physical metallurgy

Course Objective

- To study the phase changes that occurs during both thermal and thermo mechanical treatments.

Syllabus

Principles of Heat Treatment of Steels: Fe-C phase diagram, Phase Transformation on heating, Heat treatment processes for steels -TTT and CCT Diagrams - Effect of alloying elements on TTT diagram- Applications- Pearlitic Transformation - Effect of alloying elements on transformation - Bainitic transformation - Bainitic structure -Martensitic Transformation -, Retained austenite. Hardenability - Jominy End Quench method- Quenchants - Mechanism of quenching - Heat Treatment Processes -Patenting, Sub-zero treatment- Surface hardening of metals.

Expected Outcome.

Upon completion of the course, the student will be able to:

i. Describe Fe-C phase diagram and the phase transformations on heating and cooling, determine austenite grain size and the heat treatment processes for steels.
ii. Understand the heat treatment of steels using TTT and CCT diagrams
iii. Understand the pearlitic, binitic and martensitic transformation in steels
iv. Determine the heat treatment conditions required to obtain a given microstructure using TTT diagrams
v. Understand the significance of hardenability tests and charecteristics of different quenching media.
vi. Understand the different kinds of industrial heat treatments and surface hardening of steels

References/Textbooks

1. Rajan T. V, Sharma C. P and Ashok Sharma, Heat Treatment: Principles and Techniques, PHI Learning Private Ltd, New Delh
2. Lakhtin, Yu M., Engineering Physical Metallurgy and Heat Treatment, Mir Publishers, Moscow
3. Thelning, K.E., Steel and its Heat Treatment, Butterworths, London.
4. Davies. D.J and Oelmann. L.A, The Structure, Properties and Heat Treatment of Metals,Pitman Books, London
5. Singh, Vijendra, Heat Treatment of Metals, Standard Publishers distributors, Delhi
6. ASM, Metals Hand Book: Heat Treating, Vol. 4, 9th Ed., Metals Parks, Ohio

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	**Principles of Heat Treatment of Steels** 1.1Fe-C phase diagram, Eutectic, Peritectic, Monotetic, Peritectoid, Eutectoid, systems with microstructure development, 1.2 Phase Transformation on heating, Forming of austenite, Kinetics of formation of austenite, Austenitic grain size, Grain growth, 1.3 Heat treatment processes for steels: Annealing, normalizing, hardening, tempering, stress relieving, spheroidizing with reference to Fe-C phase diagram	8	15%
II	**TTT and CCT Diagrams** 2.1 Heating and cooling of steels for heat treatment, homogeneity		15%

	of austenite, 2.2 TTT curves and significance, Method of plotting TTT curves, Types of TTT diagram, Critical cooling rate, 2.3 Effect of alloying elements on TTT diagram, Applications, 2.4 Continuous cooling transformation diagram	7	
FIRST INTERNAL EXAMINATION			
III	**Pearlitic Transformation** 3.1 Mechanism of transformation, Kinetics of transformation, Hull-Mehl model of pearlitic transformation, 3.2 Effect of alloying elements on transformation, Interlameller spacing, 3.3 Bainitic transformation: Characteristics, Mechanism of transformation, Bainitic structure	7	15%
IV	**Martensitic Transformation:** 4.1 Diffusionless transformation, Mechanism of transformation, Kinetics of transformation, Ms - Mf temperatures, 4.2 Bain distortion model / crystallographic theory of martensitic transformation, 4.3 Retained austenite.	5	15%
SECOND INTERNAL EXAMINATION			
V	**Hardenability:** 5.1 Definition, Use / Significance of Hardenability data, 5.2 Factors affecting hardenability, 5.3 Effect of grain size and composition, Residual stresses, Quench cracking. 5.4 Jominy End Quench method, 5.5 Quenchants: Characteristics of quenchants, Different quenching media, Synthetic quenchants, Mechanism of quenching.	7	20%
VI	**Heat Treatment Processes:** 6.1 Annealing – full annealing, partial annealing, bright annealing, diffusion annealing, recrystallization annealing, 6.2 Normalizing, 6.3 Spheroidizing, 6.4 Hardening and Tempering, Hardening of typical steels and cast irons. 6.5 Austempering, Martempering, Ausforming, Patenting, Sub-zero treatment etc., 6.6 Surface hardening of metals**:** Principles involved in induction and flame hardening methods and application of selective hardening, Laser hardening, Case carburizing (solid, liquid and gaseous), Cyaniding, Carbonitriding, Nitriding, Plasma nitriding etc.,	8	20%
END SEMESTER EXAM			

QUESTION PAPER PATTERN:

Maximum Marks : 100 Exam Duration: 3 hours

PART A: 8 Questions from Module 1&2 (4+4). 6 questions to be answered. 6x5=30 Marks
PART B: 8 Questions from Module 3&4 (4+4). 6 questions to be answered. 6x5= 30 Marks
PART C: 6 Questions from Module 5&6 (3+3). 4 questions to be answered. 4x10=40 Marks