Metallurgical and Materials Engineering

Course Structure and Detailed Syllabus of Engineering 2nd Year Semester-II

CODE	SUBJECT	L-T	P	C
MM2201	Mechanical Metallurgy	4	-	4
MM2202	Materials Characterization Techniques	4	-	4
MM2203	Iron Making	4	-	4
MM2204	Non Ferrous Extractive Metallurgy	4	-	4
MM2205	Phase Transformations	4	-	4
MM2801	Mechanical Metallurgy Lab	-	3	2
MM2802	Materials Characterization Lab	-	3	2
MM2803	Non Ferrous Extractive Metallurgy Lab	-	3	2
MM2902	Seminar-II	1	-	1
	TOTAL	**21**	**9**	**27**

MM2201 **MECHANICAL METALLURGY**

Externals: 60Marks **L-T-P-C***
Internals: 40Marks **4-0-0-4**

Objectives:

* Emphasize on the importance of the basic phenomenon and mechanical relationships of materials
* To understand the description of stress and strain
* To analyze the effect of defects on the mechanical properties and flow relations
* To study major mechanical property tests.
* To know the basics of fracture mechanics

Unit 1: Introduction:

Introduction, elastic, plastic, visco-elastic behavior and stress-strain relationships.

Unit 2: Plastic deformation:

Elements of plasticity, flow curve, dependence of flow curve on strain-rate, temperature and strain hardening effect, yield criteria, lattice defects, deformation by slip, critical resolved shear stress for slip, deformation by twinning, stacking faults, deformation bands and kink bands, micro-strain behavior.

Unit 3: Dislocation theory:

Observation of dislocations, burgers vector and dislocation loop, forces on and between dislocations, dislocation climb, intersection of dislocations, dislocation sources and multiplication, strengthening mechanisms.

Unit 4: Mechanical testing:

Hardness - hardness tests like Brinell, Rockwell, Vickers, Meyer, Knoop, Shore-scleroscope, relationships with flow curve.

Tension - evaluation of tensile properties, tensile instability, effect of strain-rate & temperature on flow properties, bend test.

Compression - Comparison with tension, buckling & barreling
Torsion - Stresses for elastic & plastic strain, Torsion Vs. Tension.

Impact - Notched bar impact tests, transition Temperature & metallurgical factors affecting it. Fatigue: S-N curve, low cycle fatigue, structural features, surface effects and metallurgical variables. Creep: Creep, the creep curve, stress rupture test, structural changes, creep mechanisms, DMM (deformation mechanism maps), and superplasticity.

Unit 5: Fracture mechanics:

Fracture, types of fracture, brittle fracture, Griffith theory of brittle fracture of material, ductile fracture, notch effects, and fracture mechanics.

Suggested References:

1. Dieter, G, E., Mechanical metallurgy (SI metric edition), McGraw-Hill book company, 1988.
2. Hertzberg, R, W., Deformation and fracture mechanics of engineering materials (3rd edition), John Wiley & sons, 1997
3. Hull, D and Bacon, D, J., Introduction to dislocations (4th edition), Butterworth-Heinmann, 2001.

*L-T-P-C stands for number of lectures, tutorials, practices and credits

MM2202 MATERIALS CHARACTERIZATION TECHNIQUES

Externals: 60Marks	**L-T-P-C***
Internals: 40Marks	**4-0-0-4**

Objectives:

* To understand the basic concept of different characterization techniques
* To know the working principles of materials characterization techniques.
* To analyze and understand the behavior of materials from characterization techniques.
* To study crystal structure, chemical composition, phase, residual stress and texture of materials.
* To study the microstructure of materials from optical and electron microscopes.
* To understand the spectroscopic, thermal and electrical characterization techniques.

Chapter-I

Introduction, Scope of subject, classification of techniques for characterization, macro & micro-characterization structure of solids

Chapter-II

Diffraction methods: X-ray diffraction (crystal systems and space groups, Bravais lattices, direct and reciprocal lattice, Bragg's law, powder diffraction and phase identification, single crystal diffraction, structure factor, X-ray crystal structure determination).

Chapter-III

Metallographic techniques: Optical metallography, image analysis, quantitative phase estimation. Electron optical methods: Scanning electron microscopy and image formation in the SEM, Transmission electron microscopy (TEM), Scanning tunneling microscopy (STM), Atomic force microscopy (AFM) and scanning transmission electron microscopy (STEM).

Chapter-IV

Optical & X-ray spectroscopy: Atomic absorption spectroscopy, X-ray spectrometry, infrared spectroscopy, Raman spectroscopy, EDS and WDS.

Chapter-V

Bulk averaging techniques: Thermal analysis, DTA, DSC, TGA, TMA, dilatometry, resistivity/conductivity.

Suggested References:

1) Spencer, Michael, Fundamentals of Light Microscopy, Cambridge University Press,1982.
2) David B. Williams, C. Barry Carter, " Transmission Electron Microscopy: A Textbook for Materials Science", Springer, pub. 2009.
3) Joseph I Goldstein, Dale E Newbury, Patrick Echlin and David C Joy, "Scanning Electron Microscopy and X-Ray Microanalysis", 3rd Edition, 2005.
4) B.D.Cullity and S.R.Stock, "Elements of X-Ray Diffraction" Third edition, Prentice Hall, NJ, 2001.

5) G.W.H. Hohne, W.F. Hemminger, H.-J. Flammersheim , "Differential Scanning Calorimetry", Springer, 2nd rev. a. enlarged ed., 2003.
6) 'Fundamentals of light microscopy and electronic imaging' Douglas B. Murphy, 2001, Wiley-Liss, Inc. USA
7) Electron optical applications in materials science (McGraw-Hill series in materials science and engineering) by Lawrence Eugene Murr.

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MM2203 **IRON MAKING**

Externals: 60Marks **L-T-P-C***

Internals: 40Marks **4-0-0-4**

Objectives:

* To study history of iron production and methods of producing iron from its ores.
* To study and understand iron production by blast furnace
* To study the physical chemistry during iron production from its ores at higher temperatures
* To understand the difficulties of iron production by blast furnace and sponge iron making methods.
* To study and understand iron production by sponge iron making process.

UNIT-I

Introduction to pig iron production in India and the world, Occurrence and distribution of iron ore , limestone and coke in India. Preparation of iron ores; Agglomirtion of Iron ore fines, Sintering, Pelletising, Coke properties and its production.

UNIT-II

B.F profile and design considerations. Furnace lining. Furnace cooling system. Hoisting equipment.B.F. Stoves. BF gas cleaning system and gas uses,Coal injection, reduction and gas utilization- Rist diagram, thermal reserve zone, chemically inactive zone.

UNIT-III

Physical chemistry of Iron making; Blast furnace reactions; Physical and chemical factors affecting reduction of ores; Relevant CO/CO2 and H2/H2O diagram. Controls of C, Si, S, P in metals and slags,effect of alkali materials, types of Pig Irons & Blast furnace Slags,Furnace: combustion zone, RAFT, deadman's zone, cohesive zone- size and shape.

UNIT-IV

Blast furnace operations and difficulties; Modern Trends in Blast furnace; Burden calculation; Limitations of Blast furnace Iron production; Alternate Routes of Iron Making.

UNIT-V

Principles of Sponge Iron Making, Degree of Metallization, Percentage Reduction, Classification of Sponge Iron making methods.Sponge Iron Production 1. Using gases reducing agent a. Midrex process b. HYL, c. Kiln Krupp-Renn; 2. Using solid reducing agent process such as SL/RN process, Smelt Reduction Methods; COREX, INRED, ELRED, Plasma Smelting; Iron making in India

TEXT BOOKS:

1. Principles of Blast furnace Iron making – A.K Biswas.

2. Modern Iron Making – Dr. R. Tupkary

3. Iron making and Steel making – Ahindra Ghosh & Amit Chaterjee REFERENCES:

1. Beyond Blast furnace – Amit Chaterjee – CRC Press.

2.Hand Book of Extractive Metallurgy – Fathi Habhashi Vol. 1 Metals Industry Ferrous Metals

3. Hot metal Production by Smelting Reduction of Iron Oxides – Amit chaterjee,

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MM2204 NONFERROUS EXTRACTIVE METALLURGY

Externals: 60Marks **L-T-P-C***

Internals: 40Marks **4-0-0-4**

Objectives:

* To understand the methods of metal extraction and sources of non ferrous metals
* To study the thermodynamics principles involved in metal extraction
* To study the methods of extracting non ferrous metals from their sources
* To study various methods of refining the extracted metals.

UNIT-I

History of Non ferrous Metals: Early developments in metal extraction (Introduction, discovery of metals and their importance, important landmarks, nonferrous metals in Indian history, uses of nonferrous metals), Sources of None ferrous metals(Sources in land and sea, exploration methods, methods of beneficiation, nonferrous metals wealth in India).

UNIT-II

Principles of metals extraction, (Thermodynamic principles, homogeneous and heterogeneous reactions, Ellingham diagrams, kinetic principles, principles of electro-chemistry), General methods of extraction, (Pyro-metallurgy – calcinations, roasting and smelting, Hydrometallurgy – leaching, solvent extraction, ion exchange, precipitation, and electrometallurgy – electrolysis and electro-refining),General methods of refining, (Basic approaches, preparation of pure compounds, purification of crude metal produced in bulk).

UNIT-III

Extraction of metals from oxide sources: Extraction of metals such as magnesium, aluminum, tin and ferro-alloying elements, production of ferro alloys.

UNIT-IV

Extraction of metals from sulphide ores: Pyro-metallurgy and hydro-metallurgy of sulphides, production of metals such as copper, lead, zinc, nickel etc.)

UNIT-V

Extraction of metals from halides, (Production of halides and refining methods, production of reactive and reactor metals. Methods of extraction of metals such as titanium, rare earths, uranium, thorium, plutonium, beryllium, zirconium etc.)

TEXT BOOKS:

1. Extraction of Non-Ferrous Metals - HS Ray, KP Abraham and R. Sridhar. .

2. Non Ferrous Extractive Metallurgy – G B Gill John Wiley & Sons.

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MM2205 PHASE TRANSFORMATIONS

Externals: 60Marks **L-T-P-C***
Internals: 40Marks **4-0-0-4**

Objectives:

* To revise the basics of thermodynamics and stability concept of phase transformations
* To understand the principles of solidification
* To analyze the mechanisms and phenomenon associated with diffusion
* To study pearlitic and bainitic transformation
* To know the diffusionless transformation

Unit 1: Introduction

Phase equilibrium: Introduction, Thermodynamics and stability of phases, classification of phase transformations, order of transformation, Gibbs rule and application, phase diagrams, construction and interpretation.

Unit 2: Liquid-solid transformation:

Nucleation: homogeneous and heterogeneous, Growth: continuous and lateral, interface stability; alloy solidification: cellular and dendritic, eutectic, off-eutectic, peritectic solidification, welding, casting and rapid solidification.

Unit 3: Diffusion:

Atomic mechanism, interstitial and substitutional diffusion, atomic mobility, tracer diffusion in binary alloys and diffusion in multiphase binary systems.

Solid state diffusive transformation:

Classification, nucleation and growth - homogeneous and heterogeneous mechanism, precipitate growth under different conditions, age hardening, spinodal decomposition, precipitate coarsening, transformation with start range diffusion, recrystallization, grain growth, eutectoid transformation, discontinuous reactions.

Unit 4: Pearlitic and bainitic transformation:

Factors influencing pearlitic transformation, mechanism of transformation, nucleation and growth, orientation relationship, degenerate pearlite.

Bainite: mechanism of transformation, nucleation and growth, orientation relationships, surface relief, classical and non-classical morphology, effect of alloying elements.

Unit 5: Non-diffusive transformation:

Characteristics of transformation, thermodynamics and kinetics, nucleation and growth, morphology, crystallography, stabilization, strengthening, mechanisms, non-ferrous martensite, shape memory effect/alloys and glass transition concept.

Suggested References:

1. Porter, D, A and Easterling, K. E., Phase transformations in metals and alloys (2^{nd} edition), CRC press, 1992.
2. Reed-Hill, R, E and Abbaschian, R., Physical Metallurgy Principles (3rd edition), PWS-Kent publishing company, 1994.

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MM2801 MECHANICAL METALLURGY LAB

Externals: 60Marks **L-T-P-C ***
Internals: 40Marks **0-0-3-2**

Objectives:

* To provide hands on experience of different mechanical testing procedures
* To understand the mechanisms of deformation
* To analyze results and draw conclusions from the results of the tests

List of Experiments:

1. Hardness Test: to determine the Brinell Hardness Values of values of ferrous and non-ferrous samples.

2. Tension Test: - To determine the elastic modulus, ultimate tensile strength, breaking stress, Ercentage elongationed percentage reduction in area of the given specimen. - To determine the strain distribution along the gauge length.

3. To Conduct Erichson cupping test.

5. Impact Testing: - To determine the charpy and Izod (V & U Groove notch) values of a given material at room temperature. - To establish the ductile - brittle transition temperature of the material.

6. To determine the Rockwell hardness values of heat treated steels.

7. To find the microhardness of phases by using vickers hardness tester.

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Suggested References:

1. Dieter, G, E., Mechanical metallurgy (SI metric edition), McGraw-Hill book company, 1988.
2. Hertzberg, R, W., Deformation and fracture mechanics of engineering materials (3rd edition), John Wiley & sons, 1997

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MM2802 MATERIALS CHARACTERISATION LAB

Externals: 60Marks **L-T-P-C ***
Internals: 40Marks **0-0-3-2**

Objectives:

* To provide hands on experience of XRD, FESEM, and EDX
* To study and analyse the peaks of XRD of materials
* To analyse quantitatively the chemical composition of materials
* To analyse the microscopic images of materials produced by FESEM

List of experiments

1) Index and calculate the lattice parameter of cubic systems by analytical method.
2) Index and calculate the lattice parameter of cubic systems by mathematical method.
3) Calculate the precise lattice parameter by mathematical method.
4) Calculate the precise lattice parameter by graphical method.
5) Calculate the crystalline size from given XRD data.
6) Calculate the residual strain from given XRD data.
7) Calculate the residual stress from given XRD data.
8) Phase identification from given XRD data.
9) Demonstration on FESEM image formation.
10) Demonstration on EDX.
11) Demonstration on powder XRD.
12) Demonstration on thin film XRD.

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MM2804 NON FERROUS EXTRACTIVE METALLURGY LAB

Externals: 60Marks **L-T-P-C ***
Internals: 40Marks **0-0-3 -2**

Objectives:

* To understand the methods of ferrous metal extraction and non ferrous metals.

List of Experiments:

1. Preparation of lead by reaction of lead (II) oxide with carbon.
2. Preparation of iron by reaction of iron (III) oxide with aluminum (Thermite reaction)
3. Roasting of a sulphide concentrate (FeS , FeS2,ZnS)
4. Formation of aluminum trihydrate and its calcinations to Al2O3.
5. Leaching of Al2O3 from A mixture SiC and Al2O3
6. Electroforming of copper on an aluminum mandrel.
7. Electrolytic dissolution study of a precipitation harden nonferrous alloy.
8. Making of copper metal from its dissolved copper compounds.
9. Electro-less plating of copper on a low carbon steel
10. Oxidation studies of nonferrous metal like copper and ferrous metal like high carbon steel.
11. Determination of Iron ore or any non-ferrous ore.
12. Extraction of Hf/Zr.

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MM2902 SEMINAR-II

Externals: 60 Marks **L-T-P-C**
Internals: 40 Marks **0-0-2-1**

Objectives:
• To improve the presentation skills
• To prepare PPT more effectively

Student has to choose a general topic to give a power point presentation