

ME – INDUSTRIAL METALLURGY

ME Industrial Metallurgy (IM) 2007-08

I Semester

S No	Code	Subject	Marks		Total	Credits
			Internal	External		
1.	IM11	Material Science	30	70	100	4
2.	IM12	Advances in Casting	30	70	100	4
3.	IM13	Advances in Forming	30	70	100	4
4.	IM14	Engineering Materials	30	70	100	4
5.	IM15	Advances in Welding	30	70	100	4
6.	IM16P	Casting Lab	50	50	100	2
7.	IM17P	Materials Testing Lab	50	50	100	2
Total			250	450	700	24

II Semester

S No	Code	Subject	Marks		Total	Credits
			Internal	External		
1.	IM21	Failure Analysis	30	70	100	4
2.	IM22	Strengthening Mechanisms	30	70	100	4
3.	IM23	Industrial Heat Treatment	30	70	100	4
4.	IM24	Powder Metallurgy	30	70	100	4
5.	IM25	Non-Destructive Testing	30	70	100	4
6.	IM26P	Forming Lab	50	50	100	2
7.	IM27P	Welding Lab	50	50	100	2
Total			250	450	700	24

III Semester

S No	Code	Subject	Marks		Total	Credits
			Internal	External		
1.	IM31	Advances in Iron & Steel Making (Seminar Course)	50	--	50	3
2.	IM32	Corrosion Engineering (Seminar Course)	50	--	50	3
3.	IM33	Minor Project	50	--	50	4
Total					150	10

IV Semester

S No	Code	Subject	Marks		Total	Credits
			Internal	External		
1.	IM41	Dissertation	100	--	100	6

ME – INDUSTRIAL METALLURGY

(with effect from 2007-08)

I - SEMESTER

IM11 - MATERIALS SCIENCE

Periods / week: 4

Credits: 4

Sessionals: 30

Exam: 70

Introduction, classification of materials, dislocations, types, Burgers' Vector, Dislocation movement by climb and cross slip. Dislocation sources, Dislocation point defect interaction and pileups.

Plastic deformation of single crystals. Deformation by slip, CRSS for slip. Deformation of single crystal. Deformation by twinning. Stacking faults, hot working, cold working. Recovery, recrystallization and grain growth. Grain size, Hall-Petch equation.

Mechanical properties. Tensile stress-strain diagrams, proof stress, yield stress diagrams, modulus of elasticity. Hardness Testing: -Rockwell, Brinell and Vickers.

Impact toughness, Charpy V-Notch, fracture, ductile, brittle, Griffith criteria for brittle failure, creep, creep mechanisms, fatigue-mechanism-factors to improve fatigue resistance.

Electrical and Electronic properties of materials, Electronic conductivity, free electron theory and band theory of solids. Intrinsic semi-conductors. Super conductivity. Magnetic properties, Dia, para, ferro, ferri magnetism. Soft and hard magnetic materials.

Optical properties of materials. Refractive index, absorption emission of light, optical fibers. Opto-electronic materials. Polymerization, cross linking, glass transition, classification of polymers. Uses of polymers.

Text books: 1. An introduction to material Science – V Raghavan.

2. Mechanical Metallurgy – GE Dieter.

3. Material Science – Callister.

References: 1. Material Science for Engineers – Vanvlack.

2. Material Science for Engineers – Schackelford.

IM12 - ADVANCES IN METAL CASTING

Periods / week: 4

Credits: 4

Sessionals: 30

Exam: 70

New and emerging casting techniques:

Counter gravity low pressure casting, squeeze casting, semi solid metal casting and forging, plaster molding, ceramic molding, replicast process

Design Considerations:

Risers, gating, casting, dimensional tolerances and allowances.

Computer applications in metal casting:

Modeling of solidification heat transfer, fluid flow, combined fluid flow and heat / mass transfer, microstructural evolution.

- References:*
- 1. Principles of Metal Casting - Rosenthal*
 - 2. Foundry Technology – Beely*
 - 3. Metals Hand Book - Casting*

IM13 – ADVANCES IN FORMING

Periods / week: 4

Credits: 4

Sessionals: 30

Exam: 70

Mechanical Testing:

Hardness Testing, tensile properties, Fatigue and Creep Properties of metals.

Fundamentals of metal working:

Classification of forming processes, mechanics of metal forming, temperature of metal working, hot working, cold working, friction and lubrication.

Forging:

Classification of forging processes, forging of plate, forging of circular disc, open-die and close-die forging, forging defects and powder metallurgy forging.

Rolling of metals:

Rolling processes, forces and geometrical relationship in rolling, simplified analysis of rolling load, rolling variables, theories of cold rolling and hot rolling, problems and defects in rolled variables, torque and horsepower.

Extrusion: Classification of extrusion processes, hot extrusion, analysis of extrusion processes, defects in extrusion, extrusion of tubing, production of seamless pipe.

Drawing of tubes, rods and wires:

Introduction, wire drawing dies, tube drawing processes, analysis of wire and tube drawing.

Sheet metal forming:

Forming methods, bending, stretch forming, deep drawing, forming limit criteria, defects in formed parts.

Advanced metal forming process:

High Energy rate forming operation, electromagnetic forming.

TEXT BOOKS:

- 1. Mechanical Metallurgy-G.E.DIETERR*
- 2. Principles of Metal working-SURENDER KUMAR*
- 3. Principles of Metal working- G.W.ROWE*

REFERNCE: ASM Metal hand book

IM14 – ENGINEERING MATERIALS

Periods / week: 4

Credits: 4

Sessionals: 30

Exam: 70

Engineering Alloys:

Low carbon steels, Mild steels, Medium carbon steels, High strength structural steels, Tool steels, Stainless steels, High temperature alloys, Cast irons, The light alloys, Copper and its alloys, Bearing alloys

Composites:

Introduction, Matrix materials, Reinforcements, Mechanical behaviour of composites, Metal matrix composites, Polymer matrix composites, Ceramic matrix composites, Carbon fiber composites

Ceramics:

Silicate ceramics, Imperfections in ceramics, Diffusion in ionic materials, Brittle fracture, Stress - Strain behavior, Fabrication and processing of ceramics, Powder pressing, Refractories, Abrasives and Advanced ceramics

Smart Materials:

Introduction to sensors and actuators, Piezo-electrics, shape memory alloys, Basics of MEMS

Text Books:

1. Introduction to Physical Metallurgy - SH Avner
2. Materials Science and Engineering: An Introduction - William D Callister Jr
3. Composite Materials - Krishna K Chawla

Reference Books:

1. Introduction to Ceramics - Kingery, Bowen and Uhlmann
2. ASM Handbook Volume 21: Composites

IM15 – ADVANCES IN WELDING

Periods / week: 4

Credits: 4

Sessionals: 30

Exam: 70

Flux assisted GTAW process

Lead Free Soldering

Friction welding processes, Friction stir welding and Friction surfacing

Micro Joining, Microwave Joining and Hybrid Welding.

Heat flow and temperature distribution in and around weld metal.

Calculation of heat input and heat affected zone width.

Problems during welding of carbon steels,

Welding of Stainless steels. Schaffler diagram.

Welding of Aluminum alloys a

Welding of Titanium alloys and Nickel base alloys.

Welding of Dissimilar metals.

Corrosion of welds.

REFERNCE: ASM Metal hand book

IM16P – CASTING LAB

Periods/week: 3P

Credits: 2

Sessionals: 50

Exam:50

List of Experiments:

A laboratory project on any one of these topics.

1. CO₂ Molding
2. Shell Molding
3. Vacuum Molding
4. NDT of Castings
4. Design of Gating systems
6. Sand Testing

IM17P – MATERIALS TESTING LAB

Periods/week: 3P

Credits: 2

Sessionals: 50

Exam:50

1. Annealing and normalizing
2. Hardening and tempering
3. Hardenability- Jominy End Quench Test
4. ASTM grain size determination
4. Microstructural studies of plain carbon steels
6. Microstructural studies of cast irons
7. Microstructural studies of alloy steels
8. Microstructural studies of stainless steels
9. Microstructural studies of Al alloys
10. Microstructural studies of Ti alloys
11. Microstructural studies of Mg alloys
12. Microstructural studies of Superalloys

REFERENCES:

1. *Elements of Heat Treatment-ZAKHAROV*
2. *Physical Metallurgy for Engineers-D.S.CLARK& W.R.VARNEY*
3. *Introduction to Physical Metallurgy-S.H.AVNER*

II - SEMESTER

IM21 – FAILURE ANALYSIS

Periods / week: 4

Credits: 4

Sessionals: 30

Exam: 70

Sources of Failures, Steps in Failure Analysis, Characteristics of ductile and brittle fracture, ductile to brittle transition. High Temperature failures, fatigue failures, corrosion failures and their identification, failures of industrial components like casting and welding. Some case studies in failure analysis.

Reference: Analysis of Metallurgical failures - VJ Collangelo and PA Heiser.

IM22 - STRENGTHENING MECHANISMS

Periods / week: 4

Credits: 4

Sessionals: 30

Exam: 70

Strengthening from grain boundaries, Hall-Petch relation, ASTM grain size measurement, yield-point phenomenon, strain aging, strengthening due to point defects.

Solid solution strengthening: Elastic interaction, modulus interaction, stacking fault interaction, electrical interaction, short range order interaction, long range order interaction.

Cold working, Strain hardening of single crystals, annealing of cold worked metal, recovery, recrystallization and grain growth.

Strengthening from fine particles, Principle, mechanisms and examples of Precipitation hardening (age hardening), Dispersion hardening. Fiber strengthening, strength and moduli of composites (Iso-strain and Iso-stress condition), influence of fiber length, orientation and concentration

Strengthening by phase transformations, annealing, normalizing and hardening. martensite strengthening.

Text Books:

1. *Mechanical Metallurgy - George E Dieter*
2. *Mechanical Behaviour of Materials - Thomas H Courtney*
3. *Materials Science and Engineering an Introduction - William D Callister Jr*
4. *Materials Science and Engineering – V Raghavan*

IM23 – INDUSTRIAL HEAT TREATMENT

Periods / week: 4

Credits: 4

Sessionals: 30

Exam: 70

Heat Treatment Equipment:

Furnaces, salt bath equipment, fluidized bed equipment, vacuum furnaces and auxiliary equipment, energy efficient furnace design and operation.

Process and quality control considerations:

Temperature control, furnace atmosphere control, control of surface carbon, evaluation of C control in processed parts, furnace safety

Heat treatment of Cast iron, tool steels, stainless steel and heat resistant alloys, non-ferrous alloys: Al, Cu, Mg, Ti. Annealing of precious metals.

Thermo mechanical processing of steels

References:

- 1. Nanomaterials – AK Bandyopadhyay, Newage International (p) limited publishers.*
- 2. Nanomaterials- J Dutta and H Hofmann*
- 3. Nanostructured materials processing, properties and applications- Carl C Koch, Jaico publishing house.*
- 4. Nanotechnology- William Illsey Atkinson, Jaico publishing house.*

IM24 – POWDER METALLURGY

Periods / week: 4

Credits: 4

Sessionals: 30

Exam: 70

Advantages and limitations of powder metallurgy.

Powder production methods:

Mechanical, Chemical, Electrolytic and atomization Methods. Commercial production of metallic powders.

Powder characteristics:

Composition and structure, particle size, shape, specific surface, surface topography, flow rate, apparent and tap density, pressing properties.

Shaping of metal powders:

Dies and die design. Die compaction. Powder forging and Extrusion. Isostatic pressing. Explosive forming, HIP. Pressureless compaction techniques. Behavior of powder during compaction. Properties of green compacts.

Principles and practice of sintering:

Sintering mechanisms, stages of sintering. Driving forces for sintering. Effect of material and process variables. Liquid phase sintering.

Applications of powder metallurgy. Cermets, bearing materials, friction parts, magnets, dispersion strengthened materials and other miscellaneous applications.

REFERENCES:

1. *Powder Metallurgy – J.S. HIRSCHHORN*
2. *Treatise on Powder Metallurgy – C. GOETZEL, vol. 1&2.*
3. *Powder Metallurgy Practice and Applications – R.L. SANDS & C.R. SHAKESPEARE.*
4. *Handbook of Powder Metallurgy – H. H. HAUSNER & M.MAL- 2nd Ed.*

IM25 – NON-DESTRUCTIVE TESTING

Periods / week: 4

Credits: 4

Sessionals: 30

Exam: 70

Visual Examination. Leakage Testing:

Penetrant methods:

Principles, equipment, applications and limitations.

Magnetic methods:

Principles of magnetism and magnetization. Principles of magnetic particle inspection. The magnaflux machine. The process. The magnetic bath. Methods for the application of magnetic bath. Demagnetization. Application of the method. Salient features of the process.

Ultrasonic testing:

Types of ultrasonic waves. Flow detection and ultrasonic energy. Interpretation of results and limitations.

X-ray radiography:

Production of X-rays. X-ray tube. The Radiograph. Optical factors which effect the radiograph. X-ray films. Filters and screens. Sensitivity of a radiograph.

Gamma ray radiography:

Production of gamma-rays, interpretation of the radiograph. Safety precautions.

Electrical methods:

Thermoelectric methods. Eddy Current methods. Detection of the eddy currents. Eddy current instruments. Continuous inspection and testing.

Thickness measurements:

Surface and thickness measurements: Surface roughness and its measurements. Thickness measurement. Contact gauging, ultrasonic gauges. Magnetic induction gauges, Magnetic attraction gauges, Magnetic reluctance gauging.

Non contact gauging:

Measurements by radiation absorption.

REFERENCES:

- 1. Metals Hand Book Vol.11 (Non-Destructive Testing)*
- 2. Non-Destructive Testing-W.J.Mc GONNANGLE*

IM26P – FORMING LAB

Periods/week: 3P

Credits: 2

Sessionals: 50

Exam:50

1. Rolling of Copper, brass, stainless steel and plain carbon steel using laboratory rolling mills
2. Determination of tensile properties, n & k
3. Study on mechanical properties and microstructural change of cold worked copper, brass and stainless steel.
4. Study on mechanical properties and microstructural change of cold worked and annealed brass and stainless steel.
4. Ericksen ductility test
6. Determination of minimum bend radii.
7. Study on heat affected zone (HAZ) of steels joined by MMAW
8. Study on stress corrosion cracking of brass.

IM27P – WELDING LAB

Periods/week: 3P

Credits: 2

Sessionals: 50

Exam:50

About 6 experiments on welding methods and parameters.

III - SEMESTER

IM31 – ADVANCES IN IRON AND STEEL MAKING (Seminar course)

Periods / week: 4

Credits: 3

Sessionals: 50

Iron making:

Modern trends in Blast Furnace Operation, alternative routes of Iron Production (COREX, MBF), direct reduction process: HYL, SL/RN processes, Midrex, fluidized bed.

Steel making:

Review of electric and L.D. Steel making processes, Hybrid steel making processes, Ajax, Twin hearth, Tandem, SIP, OBM, high tension electric steel making, plasma arc steelmaking processes.

Continuous Steel making processes: WORCRA, IRSID, Spray steel making, INRED, ELRED processes.

Production of High purity steel: Nonmetallic inclusions and their effect on properties of steel.

Refining techniques, ESR, VAR, and Vacuum Degassing of liquid steel.

Alloy steel making, Tool steels and stainless steel making practice.

Review of Iron and steel Industry in India.

REFERENCES:

1. *Reduction of Iron Ores – VAN BOGDANDY.*
2. *Aspects of Modern ferrous Metallurgy – J.S.KIRKALDY & G.WARD.*
3. *IIM-Silver Jubilee Symposium on Recent Developments in Materials Science and Technology.*
4. *Making, Shaping Treating of Steel published by United States Steel Corporation.*
4. *Introduction of Modern Iron Making – R.H.TUPKARY.*
6. *Introduction of Steel making – R.H.TUPKARY*

IM32 – CORROSION ENGINEERING

(Seminar course)

Periods / week: **4**

Credits: **3**

Sessionals: **50**

Corrosion – Practical aspects .Importance. Direct and indirect losses. Types and Forms of Corrosion. Uniform Corrosion, Pitting Corrosion, Galvanic Corrosion, and Intergranular Corrosion, Stress Corrosion cracking. Cavitation Erosion, Erosion Corrosion. Corrosion Fatigue. Differential aeration corrosion.

Corrosion prevention, 1) Design aspects 2) Alteration of Environment inhibitors 3) Alteration of the material . pure metals alloys, Non-metallic as structural materials – Reinforcement of the material for reducing. Corrosion rates. 4) Surface protection. Electroplating , Principles – Throwing power and its evaluation. Commercial plating of Cu, Ni, Cr, Cd, Zn, Ag, Au. Electro-deposition of alloys plating structure of Electro deposits and testing of deposits. 4) Anodic oxidation of Aluminum and its alloys. Commercial anodizing process. Faults in the anodic coating and the remedies. Treatment after anodizing. 6) Cathodic and Anodic protection.

Text books:

- 1. An introduction to Electrometallurgy, Sharan and Narain, Standard Publishers*
- 2. Corrosion Engineering, MG Fountana, Mc-Graw Hill book company*

IM33 – MINOR PROJECT

Periods / week: **12**

Credits: **4**

Sessionals: **50**

A technical / research problem to be handled by the candidate and submit a report.

IV – SEMESTER

Periods / week: **Semester**

Credits: **6**

Sessionals: **100**

The student has to submit a comprehensive Design/Experimental project report on a selected topic.