MATERIALS SCIENCE AND METALLURGICAL ENGINEERING DEPARTMENT

B.TECH. MATERIALS AND METALLURGICAL ENGINEERING

Course of Study & Scheme of Examination
2016-17

Maulana Azad National Institute of Technology
Bhopal

SCHEME

Third Semester

Course Number	Subject	Scheme of Studies Periods per week			Credits
		L	T	P	
MTH 211E	Mathematics III	3	-	-	3
MME 211	Introduction to Profession	3	-	-	3
MME 212	Metallurgical Thermodynamics	3	-	-	3
MME 213	Unit Processes in Metal Extraction	3	-	-	3
MME 214	Principles of Physical Metallurgy	3	-	-	3
MME 215	Nature and Properties of Materials	3	-	-	3
MME 216	Metallography Lab	-		4	2
MME 217	Physical Property Measurement Lab	-	-	4	2
				Total credit	22

Fourth Semester

Course Number	Subject	Scheme of Studies Periods per week			Credits
		L	T	P	
MME 221	Metallurgical Kinetics	3	-	-	3
MME 222	Iron and Steel Making	3	-	-	3
MME 223	Phase Equilibrium and Phase Transformations	3	-	-	3
MME 224	Casting and Solidification Techniques	3	-	-	3
MME 225	Materials Characterization	3	-	-	3
MME 226	Joining Processes	3	-	-	3
MME 227	Materials Processing Lab1 (Casting and Solidification, Joining)	-	-	4	2
MME 228	Materials Characterization Lab 1	-	-	4	2
				Total credit	22

Fifth Semester

Course Number	Subject	Scheme of Studies Periods per week			Credits
		L	T	P	
MME 311	Extractive Metallurgy of Non-Ferrous Metals	3	-	-	3
MME 312	Powder Metallurgical Processing of Metals and Ceramics	3	-	-	3
MME 313	Mechanical Behaviour of Materials	3	-	-	3
MME 314	Process Metallurgy Lab	-	-	4	2
MME 315	Materials Testing Lab	-	-	4	2
DE1	Departmental Elective 1	3	-	-	3
DE2	Departmental Elective 2	3	-	-	3
OE1	Open Elective 1	3	-	-	3
				Total credit	23

Sixth Semester

Course Number	Subject	Scheme of Studies Periods per week			Credits
		L	T	P	
MME 321	Heat Treatment of Ferrous and Non-Ferrous Alloys	3	-	-	3
MME 322	Deformation Processing of Materials	3	-	-	3
MSM 323	Selection and Design of Engineering Materials	3			3
MME 324	Materials Processing Lab 2 – Heat Treatment, Metal Forming, Powder Metallurgy	-	-	2	1
MME 324	Materials Characterization Lab 2	-	-	2	1
MME 327	Minor Project	-	-	4	2
DE3	Departmental Elective 3	3	-	-	3
DE4	Departmental Elective 4	3	-	-	3
OE2	Open Elective 2	3	-	-	3
				Total credit	23

List of Departmental Electives		List of Open Electives	
MME 331	Fuels Furnace and Refractories	MME 351	Composite Materials
MME 332	Secondary Steel Making	*Open Electives of other Departments*	
MME 333	Non-Destructive Testing	MAN 358	Entrepreneurship Development
MSM 334	Polymer Engineering	CHE 352	Environmental Impact and Assessment and Environmental Audit
		CE354	Finite Element Method
		CE355	Theory of Elasticity
		CSE 353	Simulation & Modeling
		ME351	Operation Research
		Any other Elective can be chosen with the approval of DUPC	

Seventh Semester

Course Number	Subject	Scheme of Studies Periods per week			Credits
		L	T	P	
MME 411	Corrosion and Surface Engineering	3	-	-	3
MME 412	Corrosion and Surface Engineering Lab	-	-	2	1
MME 413	Major Project	-	-	2	1
MME 414	Industrial Visit & Training	-	-	-	1
DE5	Departmental Elective 5	3	-	-	3
DE6	Departmental Elective 6	3	-	-	3
OE3	Open Elective 3	3	-	-	3
OE4	Open Elective 4	3	-	-	3
				Total credit	20

Eighth Semester

Course Number	Subject	Scheme of Studies Periods per week			Credits
		L	T	P	
MME 421	Physical Metallurgy of Alloy Steels	3	-	-	3
MME 422	Major Project	-		8	4
MME 423	General Proficiency	-	-	2	1
DE 7	Departmental Elective 7	3	-	-	3
DE 8	Departmental Elective 8	3	-	-	3
OE 5	Open Elective 5	3	-	-	3
OE 6	Open Elective 6	3	-	-	3
				Total credit	20

List of Departmental Electives		**List of Open Electives**	
MME 431	Functional Materials	MME 451	Materials for Automobile and Aerospace Applications
MME 432	Materials for Strategic Applications	MME 452	Advanced Ceramic Materials
MME 433	Comprehensive Examinations and Presentation in Materials Engineering	MME 453	Failure Analysis
		Open Electives of other Departments	
		MAN 453	Project Management
MME 434	High Temperature Materials	CHE 452	Solid Waste Management
MME 435	Professional Communications	ME 458	Finite Element Methods
		ME 459	Experimental Stress Analysis
		ME 461	Advanced Production Engineering
		Any other Elective can be chosen with the approval of DUPC	

SYLLABUS

THIRD SEMESTER

MTH 211E MATHEMATICS 3

Numerical methods: solution of algebraic and trancendal equations, solution of linear simultaneous equations, finite difference, interpolation and extrapolation, inverse interpolation, numerical differentiation and integration, numerical solution of ordinary and partial differential equations, statistics, curve fitting, correlation and regression analysis, probability distribution, sampling and testing of hypothesis.

References:

1. Numerical analysis — Hildebrand
2. Numerical analysis — Scarborough
3. Mathematics statistics — M. Rray
4. Advanced Engineering Mathematics — Erwin Kreyszig,

MME 211 INTRODUCTION TO PROFESSION

Introduction to Materials Science and Metallurgical Engineering, History and Advancement of Materials and Metallurgy, Role of Materials in the Society and its Progress, Relevance and Applications of Different Engineering Materials in Various Industries, Importance Materials and Metallurgical Engineer in the Design and Development of Materials Pertinent to Specific Industries and Applications, Impact of Development of New Materials and Materials related Technologies on the Industrial and Economic Growth, Advanced research areas related with Materials Technology, Necessary Tools and Techniques Relevant to the Development and Assessment of Materials. Some case studies on the effect of development of new materials as well as improvement in the performance of existing materials and technology on the society.

References:

1. An Introduction to Metallurgy: Hodder Arnold; 2nd Revised edition (1975) — Sir Alan Cottrell
2. The Coming of Materials Science — R W Cahn

MME 212 METALLURGICAL THERMODYNAMICS

Introductory concepts and Definitions, First Law of Thermodynamics, Heat Content or Enthalpy, Heat Capacity, Einstein's theory, Debye's Theory, Thermo-chemistry and its Applications in Metallurgy, Experimental Measurements of Enthalpy Changes, Second law of Thermodynamics: Entropy and Free Energy, Entropy and Quantification of Irreversibility, Entropy changes of reversible, irreversible processes, chemical reactions, Criterion of Spontaneity based on Entropy, Criteria for Maximum Work, Free Energy, Criterion of Spontaneity based on Free Energy, Calculation of Free Energy Change, Maxwell's Relations, Third law of thermodynamics.

The Clausius-Clapeyron Equation and Applications, Trouton's Rule, Fugacity, Activity, Equilibrium Constant, Phase Equilibrium in one component system, Variation of Gibbs Free Energy with Temperature and Pressure, Phase Rule, Graphical Representation of Phase Equilibrium, Ellingham Diagrams, Predominance Area Diagrams. The Behavior of Solutions, Raoult's Law, Hentry's Law, Sievert's Law, Thermodynamic Activity of a Component in a Solution, Gibbs-Duhem Equation, Regular Solutions, Sub-regular Solutions, Interaction Parameter, Free Energy-Composition-Phase diagrams for Isomorphous, Eutectic and Peritectic Systems. Electrochemistry, The relationships between chemical and Electrical Driving Forces, Thermodynamics of Aqueous Solutions, Gibbs Free Energy of Formation of Ions and Std Reduction Potentials, Pourbaix Diagrams, Thermodynamics of Surfaces and Interfaces, Homogeneous Nucleation, Heterogeneous Nucleation, Thermodynamics of Defects in Solids.

References:

1.	Physical Chemistry of Metals	L.S.Darken and R.W. Gurry
2.	Problems in Metallurgical Thermodynamics and Kinetics	G.S.Upadhyaya,R.K.Dubey
3.	Metallurgical Thermodynamics	D.R.Gaskell
4.	Metallurgical Thermodynamics, Kinetics and Numericals	S.K. Dutta, A.B. Lele
5.	Textbook of Materials and Metallurgical Thermodynamics	A. Ghosh

MME 213 UNIT PROCESSES IN METAL EXTRACTION

Introduction: Role of Unit Processes in Metal Extraction; Ore preparation: Principles of Comminution, Crushing and Grinding, Sizing of comminuted particles, Drying, Calcination, Roasting, Sintering; Role of Ellingham diagrams in Extraction of metals; Pyrometallurgical Processes: Reduction and smelting using Blast furnace and Electric arc furnace, Flash smelting, Converting, Principles of metallothermic reduction, Refining processes such as Fire refining, Liquation, Zone Refining, Distillation and Vacuum Refining; Hydrometallurgical Processes: Leaching, Various types of Leaching such as Pressure leaching and Bacterial leaching, leaching methods such as In-situ, Heap, and Percolation leaching, Mechanical and Pneumatic vats, Solution purification methods such as Chemical, Ion exchange and Solvent extraction, Cementation; Electrometallurgical Processes: Faraday's laws, Review of properties of aqueous electrolytes, Ionic mobilities, Transport number and Conductivity in electrolytes, Debye-Huckle limiting law. Mean activity coefficient of ions in electrolytes, Electrode potential, Polarization, Gas and Metal over voltage, E. M. F. of cells, Elementary theory of Electro deposition, Electro winning and Electro refining; Brief idea of metal extraction processes in the Indian context; Calculations of material and heat balances pertaining to some important metal extraction processes.

References:

1.	Principles of Extractive Metallurgy	A. Ghose and H. S. Ray
2.	Principles of Extractive Metallurgy	Terkel Rosenqvist
3.	Unit Processes of Extractive Metallurgy	R. D. Pehike

MME214 PRINCIPLES OF PHYSICAL METALLURGY

Structure of metals and alloys, Miller indices, crystal orientation, stereographic projection. Crystal defects in metals, dislocations, stacking fault, grain boundary Experimental tools and techniques in metallography, Diffusion in solids, Fick's laws, Solidification of pure metal: Surface Energy & under cooling, Nucleation& Growth, homogeneous& heterogeneous nucleation, directional solidification, structure of cast metal, segregation & porosity, Solidification of binary alloys, Fe-C equilibrium diagram, TTT Diagrams, Cu – Zn, Al – Cu systems, ternary diagram, Grain size and Hall-Petch relation, Strengthening mechanisms, micro alloyed steel, ultra high strength steel, super alloy, texture.

References:

1. Fundamentals of Material Science and Engineering — William D. Callister
2. Introduction to Physical Metallurgy — S. H. Avnor
3. Physical Metallurgy (Vol. I & II) — Dr. P. R. Khangaonkar
4. The Science and Engineering of Materials — D.R. Askeland,P.P. Phule

MME 215 NATURE AND PROPERTIES OF MATERIALS

Phase diagrams, Free energy vs composition diagrams, Cu-Ni alloys, Solidification: Nucleation and Growth, solid-liquid interfaces, Theory of Thermally Activated Growth: Interface controlled growth, Diffusion controlled growth, Interface instability and Widmanstatten growth, Rapid solidification, Glass transition, metallic glasses; Precipitation and Particle Coarsening; Stability of regular solution and miscibility gap, intrinsic stability of solution and spinodal decomposition; Zone refining; Order, Disorder transformations, Case studies: Coherent precipitation Ni-Al, Al-Li and Ti-Al, Metastable precipitates: Al- Li and Al-Cu, Cellular precipitation, Precipitate-free zones, Examples from ceramic and polymeric materials, Intermediate phases e.g., lave, sigma, electron compounds; non-equilibrium structures; Ternary phase diagrams -Gibbs triangle, isothermal and vertical sections, polythermal projections, Eutectoid growth, Discontinuous precipitation, Massive transformation; Transformation Kinetics-Johnson-Mehl equation, Avrami model, Transformation kinetics in diffusion-controlled transformations, Kinetics of recrystallization, Martensitic transformation, Bain distortion, Thermoeleastic martensitie; Diffusion equation in spinodal region, Effect elastic strain energy.

References:

1. Introduction to Physical Metallurgy — S. H. Avnor.
2. Physical Metallurgy (Vol. I & II) — P. R.
3. Engineering Metallurgy (Vol. I & II) — R. A. Higgins.
4. The Science and Engineering of Materials — D. R. Askeland

MME 216 METALLOGRAPHY LAB

- Study of Crystal Structures through Ball Models
- Specimen Preparation Techniques for Metallographic Analysis
- Study of Microstructure of Low, Medium, High Carbon Steels
- Study of Microstructure of Grey, SG, White Cast Irons
- Study of Microstructure of Aluminium, Copper and Brass
- Identification of inclusions and Inclusion rating

- ❖ Grain Size Analysis
- ❖ Phase quantification, particle size and Distribution, Coating Thickness Measurements

References:

1. Metallographic Lab. Practices — G. L. Kehl
2. Metallography and Microstructures — ASM Handbook, Vol. 9

MME 217 PHYICAL PROPERTY MEASUREMENT LAB

Physical, Electrical, Electrical and Magnetic Properties of Materials

FOURTH SEMESTER

MME 221 METALLURGICAL KINETICS

Thermodynamics vs. kinetics, homogeneous and heterogeneous reactions; Chemical Reaction Control-rate equation, reaction rate constant, reaction order, non-elementary reactions; Solid State Diffusion - Fick's Law, mechanism of diffusion, uphill diffusion, Kirkendall effect, steady and transient diffusion; External Mass Transfer -fluid flow and its relevance to mass transfer, general mass transport equation, concept of mass transfer coefficient, models of mass transfer - film theory and Higbie's penetration theory; Internal Mass Transfer- Ordinary and Knudsen diffusion, Mass transfer with reaction; Adsorption – physical adsorption vs. chemisorption, adsorption isotherms; Langmuir, BET, adsorption as the rate limiting step; gasification of C by CO2, dissolution of N2 in molten steel, porous solids, specific surface area and pore size distribution; Reactor Design -batch vs. continuous reactors, ideal stirred tank and plug flow reactors, mass balance in ideal reactors, residence time distribution; models of industrial reactors; Electrochemical Kinetics - concept of polarization, activation over potential, Butler-Volmer and Tafel's equation, applications in electro-deposition and corrosion, concentration over-potential, limiting current; electro-winning and corrosion.

References:

1. A Textbook of Metallurgical Kinetics — A Gosh, S Gosh
2. Kinetics of Metallurgical Reactions — H S Ray
3. Extractive Metallurgy 1: Basic Thermodynamics and Kinetics — Alain Vignes
4. Rate Processes in Metallurgy — A. K. Mohanty

MME 222 IRON AND STEEL MAKING

Blast Furnace: Introduction, Blast Furnace Route for Iron Making; The Blast Furnace and its accessories, The burden and its preparation, Physical – Thermal and Chemical process in a Blast Furnace, Blast Furnace slag and its control, Control of hot metal composition, Blast Furnace plant and accessories, Modern trends in Blast Furnace practice, Control of irregularities in the blast furnace, Performance of Blast Furnace over the years.

Alternative Methods: Need for alternative Methods, Sponge Iron production by using solid and gaseous reductants, Smelting Reduction Processes.

Modern Steel Making: Different routes of steelmaking; Oxygen Steelmaking; Top and Bottom blown converter processes, Hybrid processes. Electric Steel making; Electric Arc furnaces, Induction furnaces. Secondary Steelmaking. Casting of liquid steel: Ingot Casting of Steel, Continuous Casting of Steel. Iron and Steel Scenario in India in the last decade.

References:

1. Modern Iron making — R. H.Tupkary.
2. Manufacture of Iron &Steel, Volume I — R.W. Bashforth
3. Physical Chemistry of Iron&Steel — R.G. Word
4. Principals of Blast furnace Ironmaking — A.K. Biswas
5. Modern Steel making — R.H. Tupkary.

MME 223 PHASE EQUILIBRIUM AND PHASE TRANSFORMATIONS

Application of Physical metallurgy: Strengthening mechanism, strength vs. toughness (ductility), thermo mechanical processing, micro alloyed steel, ultra high strength steel, superalloy, control of texture

Thermodynamics order of transformations, Theory of nucleation-Kinetics of homogeneous, transient and heterogeneous nucleation, Theory of thermally activated growth, Interface controlled growth, Diffusion controlled growth, Interface instability and Widmanstatten growth, Eutectoid growth, Discontinuous precipitation, Massive transformation, Transformation Kinetics- Johnson-Mehl equation, Avrami model, Transformation kinetics in diffusion-controlled transformations, Isothermal and continuous cooling transformation diagrams, Precipitation and particle coarsening, Kinetics of recrystallization, Theory of grain growth, Effect of second phase particles, Martiensitic transformations- nature of martensitic transformations, Bain distortion, Nucleation and growth of martensite, Athermal, isothermal and burst transformations, Thermoelestic transformations, Spinodal Decomposition- diffusion equation in spinodal region, Effect of gradient energy and elastic strain energy, Solidification-Nature and growth of solid-liquid interfaces, Rapid solidification, Glass transition, metallic glasses, Heat treatment – IT and ICT diagrams in steels, quench hardening and tempering of martensity, hardenablity of steels, surface hardening processes, tool steels and their heat treatments, heat treatment of cast irons, heat treatment of Ni-base superalloys and Ti alloys, Thermo-mechanical treatments

References:

1. Physical Metallurgy Principles — Robert E Reed-Hill and Reza
2. Phase Transformation in Metals & Alloys — D A Porter & K Easterling
3. Fundamentals of Physical Metallurgy — John D Verhoeven
4. Theory of Structural Transformations in Solids — G. Khachaturyan

MME 224 CASTING AND SOLIDIFICATION TECHNIQUES

Introduction**:** Casting as a process of Manufacturing. Moulding Processes, Equipments and Mechanization**:** Different types of Moulds, Moulding Materials and Moulding processes, Pattern and other mould making equipments, forces acting on moulds, Mould factors in metal flow, Moulding factors in casting design. Different types of binders and their uses in mould and core-makings. Melting of Metals and Alloys for casting: Brief mention of various melting units, melting and post melting treatments, melting practices as adopted for a few metals and alloys such as CI, Al, Cu, steels, cast irons. Solidification of Metals and Alloys: Nucleation, Growth, Role of alloy constitution, Thermal conditions and inherent nucleation and growth conditions in the liquid melt, Significance and practical control of cast structure

Principles of Gating and Risering: Feeding characteristics of alloys, Types of Gates and Risers, Time of solidification and Chowrinov rule, Wlodawer system for feeder head calculations, gating ratio, concept of directionality in solidification, Yield of casting and prescription for its augmentation. Special casting Methods: Investment casting, Die casting, Centrifugal casting, Full mould casting, Vacuum sealed casting. Casting Defects: A detailed analysis of casting defects. Their causes and prescription of remedial measures.

References:

1. Fundamentals of Metal casting Technology P. C. Mukherjee,
2. Principles of Metal casting R. W. Hein, C. R. Loper, P. C. Rosenthal

MME 225 MATERIALS CHARACTERIZATION

Advance microscopic techniques: Phase contrast, interference and polarized light microscopy, and High temperature microscopy, X Ray diffraction: working principle, counters, filters and cameras, Calculations for SC, BCC, FCC and HCP structures,. Indexing patterns, Precise lattice parameter determination Chemical analysis, Particle size and strain, Electron microscopes: Construction and working principles of TEM, Image formation, resolving power, magnification, depth of focus, elementary treatment of image contrasts, important lens defects and their correction, Bright field and dark field images, Stereographic projection, Formation of SAD patterns, reciprocal lattice and Ewald sphere construction, indexing of diffraction patterns, sample preparation techniques, Scanning electron microscope; construction, interaction of electrons with matter, modes of operation, Chemical analysis using EDX, EPMA Atomic force microscopy, working principles of XRF,, Augur spectroscopy, TG-DTA and DSC.

References:

1. Elements of X Ray Diffraction B. D. Cullity
2. Materials Characterization: Introduction to Microscopic and Spectroscopic Methods Yang Leng
3. A Guide to Materials Characterization and Chemical Analysis Y John P. Sibilia
4. Experimental Techniques in Materials and Mechanics C. Suryanarayana

MME 226 JOINING PROCESSES

Fusion welding processes**:** OAW, SMAW, GTAW, PAW, GMAW, FCAW, SAW, ESW, EBW, LBW, Analysis of Heat flow in welding, Gas-metal reactions, Slag-metal reactions, Residual stresses, distortion and fatigue.

Weld Solidification and Transformation In Weldments**:** Weld solidification, Absorption of gases, liquid metal reactions, solid state transformations in weldments, strengthening mechanisms in weld metals, heat affected zones,Welding Defects**:** Causes and remedial methods

Welding of Carbon Steels and Low Alloy Steels, Stainless Steels, Cast Irons, Aluminium Alloys, Special Alloys.
Weldability and Weldability Testing: Factors affecting weldability, cold cracking tests, hot cracking tests, Gleeble test, Mechanical tests (emphasis on tension and bend tests)

Welding Qualifications: Welding Procedure Specification, Procedure qualification and welder qualification.

Brazing , Soldering, Threaded joints, Resistance Welding, Frictional Welding, Riveting, Modern Joining Processes,

References:

1. Metallurgy of Welding — Lancaster J
2. Welding, Brazing and Soldering — ASM Metals Hand Book, Vol. 6
3. Welding Metallurgy — Linnert G E
4. AWS Welding Handbook: Materials and Applications - Part 1 — Vol.3:, AWS
5. Welding Metallurgy — Sindo Kou

MME 227 MATERIALS PROCESSING LAB 1 (CASTING AND SOLIDIFICATION, JOINING)

- Casting Design
- Casting of Aluminum Alloys
- Casting Defects and Microstructure Control
- Sand Testing
- Arc striking practice, Bead On plate welding, Effect of welding parameters on weld bead, GTA welding (Demonstration)
- Microstructural observation of weldments, Carbon steel, Stainless steel, Aluminium alloy, Titanium alloy, Dissimilar joints
- Welding Defects and Microstructure Control

MME 228 MATERIALS CHARACTERIZATION LAB 1

- Optical Microscopy
- XRD
- SEM
- EDX
- OES

FIFTH SEMESTER

MME 311 EXTRACTIVE METALLURGY 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 nonferrous metals (Sources in land and sea, exploration methods, methods of beneficiation, nonferrous metals wealth in India) ,Principles of metals extraction, (Thermodynamic principles, homogeneous and heterogeneous reactions, Ellingham diagrams, kinetic principles, principles of electro-chemistry) ,General methods of extraction,(Pyrometallurgy – 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),Extraction of metals from oxide sources, (Basic approaches and special features of specific extraction processes, extraction of metals such as magnesium, aluminum, tin and ferro-alloying elements, production of ferro alloys. Extraction of metals from sulphide ores, (Pyro-metallurgy and hydro-metallurgy of sulphides, production of metals such as copper, lead, zinc, nickel etc.), 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.), Production of precious metals (Methods applied for gold, silver and pt. group of metals), Secondary metals and utilization of wastes, Energy and environmental issues in nonferrous metals extraction.

References

1. Extraction of Non-ferrous Metals — H. S. Ray, R. Sridhar, K. P. Abraham
2. Principals of Extractive Metallurgy — A. Ghosh & H. S. Ray
3. Principals of Extractive Metallurgy — T. Rosenquist,
4. Unit Processes of Extractive Metallurgy — R. D. Pehike,

MME 312 POWDER METALLUGICAL PROCESSING OF METALS AND CERAMICS

Introduction: Development of powder metallurgy-scope of powder metallurgy, characterization of metal powders, physical properties-particle size and shape determination, technological properties-apparent density, flow rate etc. and chemical properties,

Powder manufacture: Reduction from oxide, electrolysis, and atomization processes, Machining, milling, electrodeposition, carbonyl process, production of alloy powders, new development

Powder characterization Powder conditioning, fundamentals of powder compaction, density distribution in green compacts, types of compaction presses, compaction tooling and role of lubricants, Single and double die compaction, isostatic pressing, hot pressing.

References:

1. Powder Metallurgy: Science, Technology and Applications — P. C. Angelo, R. Subramanian
2. Powder Metallurgy Technology — G. S. Upadhyaya
3. Powder Metallurgy — P. Ramakrishanan
4. Powder Metallurgy: An Advanced Technique of Processing — B. K. Datta
5. Powder Metallurgy — S. A. Tsukerman

MME 313 MECHANICAL BEHAVIOUR OF MATERIALS

Introduction to deformation behaviour: Concepts of stresses and strains, types of loading, stress - strain response for metal, ceramic and polymer, elastic region, yield point, plastic deformation, necking and fracture, Bonding and Material Behaviour, theoretical strength in metals and ceramics, Elasticity Theory: The State of Stress and strain, stress and strain tensor, transformation, principal stress and strain, elastic stress-strain relation, anisotropy, Yielding and Plastic, Deformation: Hydrostatic and Deviatoric stress, Octahedral stress, yield criteria and yield surface, texture and distortion of yield surface, true stress and true strain, flow rules, strain hardening, Ramberg-Osgood equation, stress - strain relation in plasticity dislocations, slip and glide, dislocation generation - Frank Read and grain boundary sources, stress and strain field around dislocations, force on dislocation - self-stress, dislocation interactions, partial dislocations, twinning, dislocation movement and strain rate, deformation behavior of single crystal, critical resolved shear stress (CRSS), deformation of poly-crystals - Hall-Petch and other hardening mechanisms, grain size effect, Fracture: types of fractures, KIC, elasto-plastic fracture mechanics, JIC, Measurement and ASTM standards, Fatigue: S-N curves, Low and high cycle fatigue, Life cycle prediction, Deformation at High temperature: different stages of creep, creep and stress rupture, creep mechanisms and creep resistant alloys.

References:

1. Mechanical Metallurgy — George E. Dieter
2. Mechanical Behavior of Materials — William F. Hosford
3. Mechanical Metallurgy: Principles and Applications — Marc A. Meyers, K K Chawla
4. Dislocations and Mechanical Behaviour of Materials — M. N. Shetty
5. Mechanical Behavior of Materials: Engineering Methods — Norman E. Dowling

MME 314 PROCESS METALLURGY LAB

- Identification of Minerals
- Blast Furnace -Simulation

- Basic Oxygen Steel Making- Simulation
- Electric Arc Furnace – Simulation
- Secondary Steel Making - Simulation
- High Temperature Measurements
- Chemical Analysis of Liquid Metals
- Production of Direct Reduced Iron
- Refining of Metals

MME 315 MATERIAL TESTING LAB

- Tensile Testing
- Compression Testing
- Bending Test
- Shear Test
- Impact Test (Charpy & Izod)
- Hardness Test (Macro & Micro)
- Sliding and Abrasive Wear Testing
- Ultrasonic Testing
- Eddy Current Test
- Creep Test
- Fatigue Test.

SIXTH SEMSTER

MME 321 HEAT TREATMENT OF FERROUS AND NON-FERROUS ALLOYS

Role of heat treatment on structure and properties, Recapitulation of Fe-C equilibrium diagram, effect of alloying elements on phase diagram, formations of austenite on heating, decomposition of austenite, Time-Temperature-Transformation (TTT) diagrams, effect of alloying elements on TTT diagram, Continuous cooling transformations (CCT), Pearlitic and bainitic transformations, Martensitic transformation: Mechanism, effect of applied stress, Athermal and Isothermal martensite, Habit planes, Bain distortion, Heat treatment processes of steels: Recovery, Recrystallization and Grain Growth, Annealing, spheroidizing, Normalizing, hardening, tempering, precipitation hardening, Quenching media and their evaluation, Sub-zero treatment, Temper embitterment, Austempering, Martempering, Patenting, Hardenability: Grossman's critical diameter, Jominy end quench test, Fracture Test, Surface hardening treatments: Carburizing, Nitriding, Cyaniding, Boronizing, Flame and Induction Hardening, Chromizing, Defects in heat treatment and remedies, Heat treatment of non-ferrous metals.

References:

1. Heat Treatment : Principles and Techniques — T. V. Rajan, C. P. Sharma, Ashok
2. Principles of heat treatment of steels — Romesh C. Sharma
3 Steel Heat Treatment Handbook — George E. Totten, Maurice A.H.
4. Physical Metallurgy for Engineers — D. S. Clark & W. R. Varney
5. Handbook of Heat Treatment of Steels — K. H. Prabhudeva

MME 322 DEFORMATIONS PROCESSING OF MATERIALS

Elementary stress analysis, Principal stresses, Yield criteria, Overview of metal forming processes, classification, Formability limits, Non-uniformity and segregation in materials, Hot, Cold and Warm working of materials, Strain rates in metal forming, Development of metallurgical structure during deformation, Flow curves, Rolling, Forging, Extrusion, Wire drawing, Deep drawing, Other sheet metal working processes, Defects in metal forming and remedies, methods of estimating formability,

References:

1.	Mechanical Metallurgy	Dieter
2.	Principal of industrial Metal Working	G.W. Rowe
3.	Metal Forming Mechanics and Metallurgy	Hosford and Caddell
4.	Hot Rolling and Steels	Roberts.

MME 323 SELECTIONS AND DESIGN OF ENGNEERING MATERIALS

Introduction: Need Identification and Problem Definition, Concept Generation and Evaluation, Selection of Materials and Shapes, Properties of Engineering Materials, Co-selection of Materials and Shapes, Materials and Design ,Evolution of Engineering Materials, Evolution of Engineering Materials, Material Resource in Indian Context, Case Study: Materials Selection for Vehicle Body.

Selection of Manufacturing Processes Review of Manufacturing Processes, Design for Sheet Metal Forming Processes, casting and heat treatment process.

Design for Reliability and Quality Failure Mode and Effect Analysis, Design for Quality, Design for Reliability, Approach to Robust Design, Design for Optimization.

The Role of Shape Factors in Material Selection
Material Selection using Ashby Method,Material Selection using Ashby Method,Case Study,M ultiple Constraints in material selection,Multiple Objectives,Role of Materials in Shaping the Pr oduct Character.

References

1.	Materials and Design - the art and science of material	M F Ashby and K Johnson
2.	Engineering Design - a materials and processing approach	G Dieter
3	Material Selection in Mechanical Design	M F Ashby
4.	Mechanical Behavior of Materials	T H Courtney

MME 324 MATERIAL PROCESSING LAB 2- HEAT TREATMENT, METAL FORMING, POWDER METALLURGY

Metal Forming

- Rolling, Forging, Extrusion, Wire drawing, Deep drawing, Other sheet metal working processes.

Powder Metallurgy

- Powder synthesis and Characterization
- Compaction, Sintering and Heat Treatment
- Property Evaluation of Sintered Products

Heat treatment

- Annealing, Normalizing
- Hardening: Water quenching, Oil quenching, Air Quenchinng
- Tempering
- Surface Hardening
- Jominey End Quench Test
- Characteristics of Quenching Media

MME 325 MATERIAL CHARACTERIZATION LAB 2

- Microscopy and Image Processing
- XRD – Indexing, crystal size, strain analysis
- SEM – Practical aspects, Sample Preparation Techniques, Working with SE/BEI/X-Ray mode , Effect of WD, Accelerating Voltage, Beam Dia etc.
- EDX Analysis
- Optical Emission Spectroscopy – Analysis and Calibration Techniques
- Raman Spectroscopy, DSC/DTA AFM, TEM Indexing.

MME 325 MINOR PROJECT

The student has to select a project work based on topic of interest. Periodically the implementation will be evaluated by the project guide. The end of each semester student will be evaluated by departmental committee formed by HOD**.**

LIST OF DEPARTMENTAL ELECTIVES

MME 331 FUEL FURNACE AND REFRACTORIES

Fuels characterization and energy balance**:** Energy Resources and Environment, Characterization of Fuels, Production of Secondary Fuels: Carbonization, Materials Balance in Coke-making, Heat Balance and Clean Development Mechanism, Gasification, Materials and Heat Balance in Gasification, Combustion and heat utilization: Principles of combustion, Materials balance in combustion, Flame Temperature, Refractory in Furnaces: Properties, Applications, Types and Classification, Heat Utilization in furnaces, Energy flow diagrams,

Heat Recovery, Transport phenomena in furnaces: Fluid Flow, Macroscopic Energy Balance, Design of flow measuring devices, Principles of Burner Design, Types of flame, Heat transfer-Conduction, Convection and Radiation, Role of refractory surfaces, Refractory Design, Heat transfer calculations, miscellaneous topics and carbon credit: Steady Heat flows in Furnace and Heat Exchanger, Atmosphere in Furnaces, Temperature measurements, Pyrometry, Electric Resistance Heating, Furnace efficiency, Fuel Saving, Carbon Offset: Concepts and Exercises

References:

1. Met. Engg. Principles. R.Schumann
2. Industrial and Process furnaces P.Mullinger and B. Jenkins:
3. Met.Engg. Problems Butts

MME 332 SECONDARY STEEL MAKING

Basic Oxygen furnace: Design and Operation, Fundamentals of Converter steelmaking technology, Feed materials and practice, Combined blown steelmaking, Modern trends in BOF Technology, Steelmaking in electric arc furnace; design and operation, Development in Electric Furnace steelmaking, DRI in electric steelmaking, Alloy Steelmaking, Novel steelmaking technologies: CONARC and EOF, Process control and automation, Ladle Metallurgy: Evolution of ladle treatments and requirements, Synthetic slag practice, deoxidation, degassing, Clean steel : Impact of inclusions on steel properties, Sources of inclusions in steel and their control, Inclusion engineering, Numerical problems and exercises, Solidification and casting and finishing operations: Principles of solidification of steel, Ingot casting, Continuous casting, Developments in Continuous casting technology, Final finishing operation: Surface treatments, Heat treatment, Deformation processing, Few case studies and discussions, Future of steelmaking in India.

References:

1. Modern Steel making R.H. Tupkary.
2. Fundamentals of steel making E.T. Tukdogan
3. Secondary processing and casting of liquid A. Ghosh
4. Steelmaking Kurdin.

MME 333 NON-DESTRACTIVE TESTING

Introduction to NDT, Visual Optical methods, Dye penetrant testing, Basic principle, Types of dye and methods of application, Developer application and Inspection, Magnetic particle testing, Basic theory of magnetism, Magnetization methods,Field indicators, Particle application,Inspection. Eddy current testing, Basic principle; Faraday's law, Inductance, Lenz's law,Self and Mutual Inductance, Impedance plane, Inspection system and probes,System,calibration. Ultrasonic testing: Basics of ultrasonic waves, Pulse and beam

shapes,Ultrasonic,transducers. Test method, Distance and Area calibration,Weld inspection by UT , Acoustic emission testing: Basic principle, Sources of acoustic emission, Source parameters, Kaiser-Felicity theory, Equipment and Data display, Source location schemes. Radiography: X-rays and their properties, X-ray generation, X-ray absorption and atomic scattering, Image formation, Image quality, Digital Radiography, Image interpretation,Radiation Shielding. Comparison and selection of NDT methods, concluding remarks.

References:

1. Nondestructive Testing, Louis Cartz, ASM International
2. Nondestructive Evaluation and Quality Control, ASM Handbook, Vol. 17.
3. Non-Destructive Examination K.G. Bowing
4. Non-Destructive Testing R. Halmshaw

MME 334 POLYMER ENGINEERING

Basic concepts on polymers, Classification of polymers; Polymer structure: Copolymers, Tacticity, Geometric Isomerism, Nomenclature. Polymerization principles and processes Structure and properties of polymers: Amorphous state, crystalline state, Thermal transitions; Glass transition; Crystalline melting temperature; Structure property relationships, Effect of weight, composition and pressure on Tg, Mechanical properties of polymers, Viscoelastic properties of polymer solutions and melts; Dielectric analysis; Dynamic calorimetry, Additives, Blends and Composites: Plasticizers, Fillers and reinforcements, polymer blends; Polymer processing: Extrusion, Molding; Calendering; Coating, Polymer Rheology, Biopolymers, Natural polymers; Fibres; Engineering and Specialty polymers: Polyamides; Polycarbonates; Engineering polyesters etc; Ionic polymers; Liquid crystal polymers; Conductive polymers; High performance fibres; Dendritic polymers, environmental Problems with polymers.

References:

1. Polymer Science W.Billmerycr
2. Structure & Properties of Polymeic materials D.W. Clegg & A. A. Collyer
3. Engineering Materials Vol. I and II Jones
4. Polymer Science & Technology J.R.Fried

LIST OF OPEN ELECTIVES

MME 351 COMPOSITE MATERIALS

Types of Composites, Reinforcements, Whiskers, Laminar composites, Flake composites, Filled composites, Particulate reinforced composites, Cremates, Micro-spheres, Solidification of composites. Economics of Composites and Reinforcements, Design of Composite Materials, Mechanics of composites, Applications of Composites. Stress – strain relations for arthotropic,

anisotropic materials, Plane stress problems, strength theories, mechanics of laminates, symmetric and non symmetric laminates. Unidirectional fiber composites, Critical volume fraction, Discontinuous fiber composites, Rule-of mixtures equation, Critical angle, Analysis of composite plates and shells. Interfacial bonds, interfacial strength, Laminated metal composites, Ceramic materials, Ceramic-metal systems, Ceramic glass system, Geometric relationships, Ceramic-ceramic systems, Thermal conductivity, Thermal expansion. Metal Matrix Composites, Reinforcement, Reinforcement selection, Matrix selection, effects of reinforcements, Properties, Fabrication, Whisker reinforcement, Whisker composite properties. Al-composite foam, functionally gradient composite materials. Composite material for automobile, aerospace and general Engineering applications. Ceramic Matrix Composites: Particulate reinforced composites, Continuous fiber reinforced composites, Chopped fiber and whisker reinforced composites, Fabrication processes, Properties.

References

1. Composite Materials — Lawrence J. Broutman
2. Composite Materials — R.M. Jones

SEVENTH SEMSTER

MME 411 CORROSION AND SURFACE ENGINEERING

Electrochemical and thermodynamic principles, Nernst equation and electrode potentials of metals, EMF and galvanic series, merits and demerits; origin of Pourbaix diagram and its importance to iron, aluminium and magnesium metals. Exchange current density, polarization - concentration, activation and resistance, Tafel equation; passivity, electrochemical behaviour of active/passive metals, Flade potential, theories of passivity. Atmospheric, pitting, dealloying, stress corrosion cracking, intergranular corrosion, corrosion fatigue, fretting corrosion and high temperature oxidation; causes and remedial measures. Purpose of testing, laboratory, semi-plant and field tests, susceptibility tests for IGC, stress corrosion cracking and pitting, sequential procedure for laboratory and on-site corrosion investigations, corrosion auditing and corrosion map of India. Corrosion prevention by design improvements, anodic and cathodic protection, metallic, non-metallic and inorganic coatings, mechanical and chemical methods and various corrosion inhibitors.

Fundamentals of surface engineering: surface dependent properties and failures, Surface and surface energy, Structure and types of interfaces, surface energy and related equations, Conventional surface engineering practices: Cleaning, pickling, etching, grinding, polishing, buffing / puffing, hot dipping, Electro-deposition / plating, carburizing, Aluminizing, calorizing, diffusional coatings, Surface Cyaniding, Nitriding, carbonitriding, Advanced surface engineering practices: Laser assisted microstructural modification – surface melting, hardening, shocking and similar processes, surface alloying of steel and non-ferrous metals and alloys., cladding, composite surfacing and similar techniques, Electron beam assisted modification and joining, Ion beam assisted microstructure and compositional modification, Flame spray, Plasma

coating, HVOF, Evaporation - Thermal / Electron beam, Sputter deposition of thin films & coatings – DC & RF, Sputter deposition of thin films & coatings – Magnetron & Ion Beam, Hybrid / Modified PVD, CVD, analysis.

References:

1. An Introduction to Metallic Corrosion and its Prevention — Raj Narayan
2. Corrosion Engineering — Fontana M. G., Greene N. D
3. Principles and Prevention of Corrosion — Denny Jones
4. Surface Engineering for Wear Resistances — K.G. Budinski
5. The Materials Science of Thin Films — M. Ohring,
6. Surface Engineering & Heat Treatment — P.H Morton

MME 412 CORROSION AND SURFACE ENGINEERING LAB

- Corrosion Rate Determination by Weight Loss Method (with and without inhibitor), Electrical Resistance Method, Potentiostatic/dynamic polarization experiment
  (a) Tafel method and (b) LPR method
- Atmospheric/Environmental corrosion (using colour indicator method)
- Galvanic corrosion, Pitting corrosion, Stress corrosion cracking, IGC Susceptibility Tests for Stainless Steels, Salt Spray Test, High Temperature Corrosion
- Acid pickling, Hot Dip Galvanizing, Electroplating, Electroless Plating, Anodizing
- Cathodic protection,.Study of Ceramic/Polymer/Metallic coating
- PVD, CVD
- Wear Testing

MME 413 MAJOR PROJECT

The student has to select a project work based on topic of interest. Periodically the implementation will be evaluated by the project guide. The work starts in seventh semester and continues through eighth semester. The end of each semester student will be evaluated by departmental committee formed by HOD**.**

MME 414 INDUSTRIAL VISIT & TRAINING

Students have to undergo a short or long tour and visit the industry of their interest, prepare a write up and present with suitable demonstration. Evaluation will be based on relevant topic student has studied, communication skill and reporting/documenting procedure.

EIGHTH SEMSTER

MME 421 PHYSICAL METALLURGY OF ALLOY STEELS

Advantages of alloy steels over plain carbon steels, classification of alloy steels, common alloying elements and their influence on properties of steel. Strengthening mechanisms in steels. Heat treatment of alloy steels. Thermo-mechanical treatment of steels, Microstructure–property correlation in steels, Effect of non-metallic inclusions and residual elements on properties of steels. Composition, properties and applications of some low alloy steels. Composition, properties and applications of some high alloy steels. Composition, properties and applications of some alloy cast irons.

References

1. Physical Metallurgy of Steels — Laslie, W.C.
2. Alloying Elements in Steels — Bain, E.C. and Paxton, H.W.
3. Introduction to Physical Metallurgy — Avner, Sidney H.
4. Engineering Physical Metallurgy and Heat Treatment — Lakhtin, Yu, M.
5. Physical Metallurgy and The Design of Steels — Pickering, F.B.
6. Cast Iron – Physical and Engineering Properties — Angus, H.T.

MME 422 MAJOR PROJECT

The student has to select a project work based on topic of interest. Periodically the implementation will be evaluated by the project guide. The work starts in seventh semester and continues through eighth semester. The end of each semester student will be evaluated by departmental committee formed by HOD**.**

MME 423 GENERAL PROFICIENCY

General proficiency is meant for developing participation in core/ curricular activities in individual students like sports, NCC, student activities, etc

Students have to undergo a short or long tour and visit the industry of their interest, prepare a write up and present with suitable demonstration. Evaluation will be based on relevant topic student has studied, communication skill and reporting/documenting procedure.

DEPARTMENTAL ELECTIVES

MME 431 FUNCTIONAL MATERIALS

Basic concept of functional materials , shape memory effect, response to thermal, magnetic, electrical, piezoelectric, and others effects, creation of functional and smart materials with preset properties, generation of shape memory effect, structure, phase transformation and properties, specific property characterization, interpretation of information, smart materials (shape memory alloys and polymers, piezoelectric, magnetostrictive, pH-sensitive, halochromic, chromogenic, surface active & biomimitic materials, ferrofluids, electro and magneto rheological material, Biomaterials etc.), material development, application potential (energy

sector, information technology, health, lab-on-a-chip etc.), principles of ferrofluids, synthesis, characterization, properties and applications.

References:

1. Functional Materials: Preparation, Processing and — S. Banerjee, A. K. Tyagi
2. Functional Materials: Electrical, Dielectric, Electromagnetic, — Deborah D. L. Chung
3. Advanced Functional Materials — Hee-Gweon Woo, Hong Li
4. Advanced Functional Materials — Ashutosh Tiwari and Lokman Uzun

MME 432 MATERIALS FOR STRATEGIC APPLICATIONS

Types and Nature of Materials: Crystal Structure, Crystalline and Amorphous Structures, Metals, Alloys, Intermetallics, Ceramics, Electrical Conductivity, Conductors, Semiconductors, Ferroelectric, Piezoelectric, Pyroelectric, Defects in Crystalline Solids, Magnetism, Optical Properties, Shape Memory Effect and Superelasticity, Mechanical Properties of Materials.
Functional and Multifunctional Materials. Key Applications of Functional Materials for Defense (Warheads, Missiles, Tanks, etc.), Aerospace, and Nuclear Applications, with examples and elaborations. Introduction to Key Energy Materials, Design and Application of Energy Storage Materials including Fuel Cells and Hydrogen Storage Materials. Case Studies related with issues and application.
Important Structural Materials for Aerospace, Defense (Warheads, Missiles, Tanks, etc.), and Nuclear Applications, including Metallic Materials, Intermetallics, Ceramics, and Composites. High Temperature Structural Materials and their relevance to Strategic Applications. Cryogenic Technology and Materials. Case Studies related with issues and application.
References:

1. Fundamentals of Material Science and Engineering William D. Callister.
2. Introduction to Physical Metallurgy S. H. Avnor.
3. Sir Alan Cottrell, An Introduction to Metallurgy: Hodder Arnold; 2nd Revised edition (1975).
4. ASM Handbook.
5. Journal of Materials at High Temperatures: Taylor and Francis.
6. Yoseph Bar-Cohen, High Temperature Materials and Mechanisms: CRC Press.
7. Ashutosh Tiwari and Lokman Uzun: Advanced Functional Materials: Wiley.

MME 433 COMPREHENSIVE EXAMINATIONS AND PRESENTATION IN MATERIALS ENGINEERING

Thermodynamics and Rate Processes
Laws of thermodynamics, activity, equilibrium constant, applications to metallurgical systems, solutions, phase equilibria, Ellingham and phase stability diagrams, thermodynamics of surfaces, interfaces and defects, adsorption and segregation; basic kinetic laws, order of

reactions, rate constants and rate limiting steps; principles of electro chemistry- single electrode potential, electrochemical cells and polarizations, aqueous corrosion and protection of metals, galvanic corrosion, crevice corrosion, pitting corrosion, intergranular corrosion, selective leaching, oxidation and high temperature corrosion – characterization and control; heat transfer – conduction, convection and heat transfer coefficient relations, radiation, mass transfer – diffusion and Fick's laws, mass transfer coefficients; momentum transfer – concepts of viscosity, shell balances, Bernoulli's equation, friction factors.

Extractive Metallurgy

Minerals of economic importance, comminution techniques, size classification, flotation, gravity and other methods of mineral processing; agglomeration, pyro-, hydro-, and electro-metallurgical processes; material and energy balances; principles and processes for the extraction of non-ferrous metals – aluminium, copper, zinc, lead, magnesium, nickel, titanium and other rare metals; iron and steel making – principles, role structure and properties of slags, metallurgical coke, blast furnace, direct reduction processes, primary and secondary steel making, ladle metallurgy operations including deoxidation, desulphurization, sulphide shape control, inert gas rinsing and vacuum reactors; secondary refining processes including AOD, VAD, VOD, VAR and ESR; ingot and continuous casting; stainless steel making, furnaces and refractories.

Physical Metallurgy

Crystal structure and bonding characteristics of metals, alloys, ceramics and polymers, structure of surfaces and interfaces, nano-crystalline and amorphous structures; solid solutions; solidification; phase transformation and binary phase diagrams; principles of heat treatment of steels, cast iron and aluminium alloys; surface treatments; recovery, recrystallization and grain growth; structure and properties of industrially important ferrous and non-ferrous alloys; elements of X-ray and electron diffraction; principles of optical, scanning and transmission electron microscopy; industrial ceramics, polymers and composites; introduction to electronic basis of thermal, optical, electrical and magnetic properties of materials; introduction to electronic and opto-electronic materials.

Mechanical Metallurgy

Elasticity, yield criteria and plasticity; defects in crystals; elements of dislocation theory – types of dislocations, slip and twinning, source and multiplication of dislocations, stress fields around dislocations, partial dislocations, dislocation interactions and reactions; strengthening mechanisms; tensile, fatigue and creep behaviour; superplasticity; fracture – Griffith theory, basic concepts of linear elastic and elastoplastic fracture mechanics, ductile to brittle transition, fracture toughness; failure analysis; mechanical testing – tension, compression, torsion, hardness, impact, creep, fatigue, fracture toughness and formability.

Manufacturing Processes

Metal casting – patterns and moulds including mould design involving feeding, gating and risering, melting, casting practices in sand casting, permanent mould casting, investment casting and shell moulding, casting defects and repair; Hot, warm and cold working of metals; Metal forming – fundamentals of metal forming processes of rolling, forging, extrusion, wire drawing and sheet metal forming, defects in forming; Metal joining – soldering, brazing and welding, common welding processes of shielded metal arc welding, gas metal arc welding, gas tungsten arc welding and submerged arc welding; Welding metallurgy, problems associated with welding of steels and aluminium alloys, defects in welded joints; Powder metallurgy – production of powders, compaction and sintering; NDT using dyepenetrant, ultrasonic, radiography, eddy current, acoustic emission and magnetic particle methods.

MME 434 HIGH TEMPERATURE MATERIALS

Introduction and Elevated temperature characteristics of engineering materials, Corrosion at elevated temperatures, High temperature creep, thermal and thermo-mechanical fatigue of structural alloys, Elevated temperature crack growth and creep-fatigue interaction, Elevated temperature mechanical characteristics of carbon alloy steels and Stainless steels, Elevated temperature corrosion properties of carbon alloy steels and Stainless steels, Elevated temperature mechanical and corrosion properties of high alloy cast steels, Super-alloys: their processing, high temperature mechanical properties, corrosion behavior, micro-structural degradation behavior of super alloys, Titanium and titanium alloys, Nickel alloys, Refractory metals, alloys and Structural inter-metallic, Ceramics for applications in refractory technology, Oxidation resistant coatings, Thermal barrier coatings, High temperature polymers, Carbon - carbon composites, Ceramic Matrix composites for refractory applications, Thermal barriers in space vehicles and satellites, Materials for in extreme environments: Case studies for applications in industry, defense and nuclear applications.

References

1. Ceramic Processing and Sintering M N Rahman and Mercel Dekker
2. Handbook of Advanced Ceramics S Smoiya
3. Introduction to High Temperature Oxidation of Metals Meil Briks, Gerald.H.Meier
4. The Super Alloys: Fundamentals and Applications Roger C. Reed

MME 435 PROFESSIONAL COMMUNICATIONS

The Seven C's of the Effective Communication:- Completeness, Conciseness, Consideration, Concreteness, Clarity, Courtesy, Correctness, **Communication: Its interpretation** :- Basics, Nonverbal Communication, Barriers to Communication, **Business Communication at Work Place:-** Letter Components and Layouts, Planning a letter, Process of Letter writing, Email Communication, Memo and Memo Reports , Employment Communication, Notice Agenda and Minutes of Meeting, Brochures, **Report Writing:-** Effective Writing, Types of Business Reports, Structure of Reports, Gathering Information, Organization of the Material, Writing Abstracts and Summaries , Writing Definitions, Visual Aids, User Instruction Manual, **Required Skills**:- Reading Skills, Note-making, Precise Writing, Audio Visual Aids, Oral Communication, **Mechanics of Writing:-** Transitions, Spelling Rules, Hyphenation, Transcribing Numbers, Abbreviating Technical and Non Technical Terms

References:-

1. Professional Communication McGraw Hill Koneru Aruna
2. Effective Business Communication, 1997, McGraw Hill Murphy Herta, Herbert W Hidderbrandt, Jane P Thomas
3. Willey, Communication Skills Handbook, Summers Willey Pub. India.

OPEN ELECTIVES

MME 451 MATERIALS FOR AUTOMOBILE AND AEROSPACE APPLICATIONS

Introduction, Materials and Materials Requirements for Aerospace and Automobile Applications, Advance Materials and Process Technologies for Aerospace Applications, Materials for Civil Transport Aircraft, Al-Li alloys, Mg Alloys, Polymers and Ploymer Matrix Composites, Metal Matrix Composites: Al based, Titanium based, Ceramic Matrix Composites: C/C, C/SiC, Titanium alloys and Aluminides, Super Alloys, Shape Memory Alloys, Oxidation and Coatings, Steels for Automobile and Aerospace Applications, Selection of Aerospace and Automobile Materials

References:

1.Aerospace Materials, Brian Cantor, H Assender, P. Grant
2.Introduction to Aerospace Materials, Adrian P Mouritz
3.Advanced Materials in Automotive Engineering, Jason Rowe

MME 452 ADVANCED CERAMIC MATERIALS

Introduction: oxide and non-oxide ceramics, their chemical formulae, crystal and defect structures, nonstoichiometry and typical properties. Powder Preparation: Physical methods (different techniques of grinding), chemical routes - coprecipitation, sol-gel, hydrothermal, combustion synthesis, high temperature reaction (solid state reaction).Basic principles and techniques of consolidation and shaping of ceramics: powder pressing- uniaxial, biaxial and cold isostatic and hot isostatic, injection moulding, slip casting, tape-casting, calendaring, multilayering. Sintering: different mechanisms and development of microstructure (including microwave sintering),Preparation of single crystal, thick and thin film ceramics Mechanical behaviour: fracture mechanics and tribology ,Engineering applications: at room and high temperatures (including armour application) ,Electrical behaviour: insulating (dielectric, ferroelectric, piezoelectric, pyroelectric) semiconducting, conducting, superconducting and ionically conducting, specific materials and their applications. Magnetic behaviour: basic principles, materials and their applications. Transparent ceramics, coatings and films: preparation and applications Porous ceramics and ceramic membrane: fabrication techniques and applications in separation technology. Bio-medical applications of ceramic materials Ceramics for energy and environment technologies (fuel cell, lithium battery, gas sensor and catalytic support), Ceramics matrix composites: different types, their preparation and properties (including nanocomposites) Exotic ceramics: functionally graded, smart/ Intelligent, bio-mimetic and nano- ceramics - basic principles, preparation and applications

References

1. Fundamental of Ceramics — Michel W. Barsoum
2. Modern Ceramic Engineering — David. W. Richerson, Mercel Dekker
3. Ceramic Processing and Sintering — M. N. Rahman, Mercel Dekker

MME 453 FAILURE ANALYSIS

Introduction: Engineering aspects of failure & failure analysis Defects: Types and characteristics, Effects of defects on service properties General Procedures for Failure Analysis Basic Failure Mechanisms: Distortion Failures, Overload Failures, Fatigue Failures, Wear Failures, Corrosion Failures, Elevated Temperature Failures, Fractures. Failure Analysis Techniques and Preventive Measures: Non Destructive Testing Techniques and Metallographic Techniques. Component Failures: Bearings, Chain and Belt Drives, Gears, Lifting Equipments, Mechanical Fasteners, Pressure Vessel, Seals, Shafts, Springs Failure Modes and Effect Analysis: Failure Modes, Categories of Failure Modes, Failure Effects, Sources of Information about modes and effects, failure consequences, Case Studies on failure Analysis

References

1. Failure Analysis and Prevention Metals Hand Book 9th Edition, Vol. 11
2. Failure of materials in Mechanical Design: Analysis, Prediction and Prevention Jacks A Collins
3. Metallurgy of Failure Analysis. A.K. Das.
4. CRC Hand book of lubrication Vol. I Application and maintenance. E.R.Boosy