MM 15 019 - INTRODUCTION TO PHYSICAL METALLURGY *(Third Semester)*

Module I (10 Hours)

Introduction, Atomic structure of materials, Symmetry aspects in crystals, Crystal systems, crystal planes and directions, atomic packing efficiency, voids in common crystal systems, Solidification of pure metal, Homogeneous and heterogeneous nucleation processes, cooling curve, concept of supercooling, microstructures of pure metals, solidification of metal in ingot mould. Crystal imperfections,

Module II (10 Hours)

Mechanical properties of metals, concept of plastic deformation of metals, CRSS, Slip and twinning Concept of cold working: Recovery; Recrystallization and grain growth; Hot working. Concept of equilibrium, Concept of alloy formation, types of alloys, solid solutions, factors governing solid solubility; **U**nary phase diagram, phase rule, binary phase diagrams: Isomorphous, Eutectic, Peritectic, Eutectoid, Peritectoid, Monotectic and Monotectoid system.

Module III (10 Hours)

Lever rule and its application, interpretation of solidification behavior and microstructure of different alloys belonging to those systems, effect of non equilibrium cooling, coring and homogenization. Allotropic transformations, order disorder transformations, Iron cementite and iron- graphite phase diagrams, microstructure and properties of different alloys (both steels and cast irons),

Module IV (10 Hours)

Concept of heat treatment of steels i.e., annealing, normalizing, hardening and tempering; Microstructural effects brought about by these processes and their influences on mechanical properties. Effect of common alloying elements on the Fe-Fe_3C and Fe-C diagrams, concept to hardenability, factors affecting hardenability. Alloy steels- Stainless steels. Physical metallurgy of non-ferrous alloys Cu-Al, Bronze, Brass.

Text Books:

1. Introduction to physical metallurgy – Sydney Avner
2. Fundamentals of materials science and engineering W. Callister

MM 15 013 - FUEL, FURNACE AND REFRACTORIES *(Third Semester)*

Module I (10 Hours)

Introduction of fossil fuels and their world wide reserves; Primary and secondary fuels, Coking and non-coking coals, Characterization of coal properties (caking and swelling indices, calorific value, proximate and ultimate analyses, etc.); Coal carbonization and effects of different parameters; Properties of coke, char and graphite. Selection of coal for sponge iron making and thermal power plants. Alternative sources of energy (viz. ferro-coke, formed coke, charcoal, solar, wind, tidal, etc.) and their suitability for metallurgical and power industries.

Module II (10 Hours)

Classification of refractories, raw materials, manufacture, testing and properties of heavy and special refractories, silica, silicousaluminosilicate, high alumina, magnetisite, chrome, chrome-magnesite, dolomite, forsterite, chemically bonded basic, carbon and insulating refractories and special purpose oxides, carbide nitride refratories. Binary phase diagrams of Al_2O_3-SiO_2, CaO - MgO,Cr_2O_3-MgO and MgO - SiO_2 systems. Refractory mortars and cements, Refractory castables, selection of refractories for coke oven ,ironblast furnace, copper convertor ,soaking reheating furnaces and heat treatment furnaces, electric arc furnaces.

Module III (7 Hours)

Classification of furnaces: basis and uses. Mechanism of combustion, ignition temperature. Flames: Flame propagation, flame speed and inflammability limits, types of flames; premixed and diffusion flames and their characteristics.

Module IV (13 Hours)

Combustion control; variables of control, viz.: temperature, pressure and gas ratio control, modes or combustion control. Theoretical, adiabatic & true flame temperature.Available heat and factors affecting it. Heat losses in furnaces: Heat balance and furnace efficiency. Liquid and gaseous fuel burners: methods of atomization, types of liquid fuel burners and principle of design. Low pressure, high pressure and injection type gaseous fuel burners and principles of their design.

Text Books:

1. Fuels,Furnaces and Refractories by J.D. Gilchrist.
2. Fuels,Furnaces and Refractories by O. P. Gupta.

MM 15 029 - METALLURGICAL THERMODYNAMICS & KINETICS *(Third Semester)*

Module I (10 Hours)

Importance of Thermodynamics, Definition of Thermodynamics ; concept of state and path functions, Equation of states, thermodynamic processes, first law of thermodynamics, Phase diagram of a single component system, Internal energy, heat capacity, enthalpy. Second law of thermodynamics, entropy, and entropy changes for various processes.

Module II (10 Hours)

Free energy and its significance, free energy change as a function of temperature, reversible and irreversible process, criteria of equilibrium, auxiliary functions, combined statements, Maxwell's relations, transformation formula, Gibbs-Helmoltz equation, Concept of standard state.

Module III (10 Hours)

Fugacity, activity, equilibrium constant, Concept of Third law of thermodynamics, temperature dependence of entropy, statistical interpretation of entropy, relation between C_p and $C_{v,}$ consequences of third law, Ellingham – Richardson diagrams. Solutions: partial molal quantities, ideal and non-ideal solutions, Roult's law; Henry's law, Gibbs – Duhem equation, regular solution, Chemical potential.

Module IV (10 Hours)

Free energy – composition diagrams for binary alloy systems, determination of liquidus, solidus and solvus lines, Thermodynamics of electrochemical cells, solid electrolytes.

Introduction of metallurgical kinetics: heterogeneous reaction kinetics: gas-solid, solid-liquid, liquid-liquid and solid-solid systems. Concept of Johnson-Mehl equation, thermal analysis.

Text Books:

1. Introduction to the Thermodynamics of Materials by D.R.Gaskell; Taylor and Francis.
2. Textbook of Materials and Metallurgical Thermodynamics by A. Ghosh; Prentice Hall of India Pvt. Ltd.

MM 15 050 - TRANSPORT PHENOMENA *(Fourth Semester)*

Module I (10 Hours)

Fluid Flow: Classification of fluids, Energy balance, Laminar and Turbulent flows. Flow through pipes and ducts. Flow measurement, Application of dimensional analysis of fluid flow. Concept of boundary layer. molecular of Knudsen flow, etc. as in problems and exercises.

Module II (10 Hours)

Heat Transfer I: Steady state and Transient conduction in solids. One dimensional steady state problems of heat flow through composite walls, Cylinder and Spheres. Unsteady conduction in one dimensional system.Use of Heisler charts and applications. Convective heat transfer, equation of energy, free and forced convections.

Module III (10 Hours)

Heat Transfer II: Radiation, Nature of thermal radiation, Black and Grey bodies, Stefan and Boltzmann law, Kirchhoff's laws, Intensity of radiation, lamberts law, View factor. Heat transfer between two black walls in an enclosure. Combined effect of convection, conduction and radiation. Overall heat transfer coefficient. Example problems and exercises on systems of steady heat flow important in Metallurgy.

Module IV (10 Hours)

Mass Transfer and Kinetics: Importance in Heterogeneous metallurgical systems of reactions. Steady state one dimensional mass diffusion of component through stationary media. Convective mass transfer in fluids, concept of concentration boundary layer, Mass transfer coefficient.Heterogeneous reactions of metallurgical importance, their rate controlling steps. Discussion of the following examples from metallurgical systems: Nucleation and growth and bubble formation phenomenon, Interfacial reaction, Carbon gasification by CO_2, slag-metal reaction at the interface, Topo-chemical model of gas-solid reaction

Text Books:

1. F.P. Incropera, D. P. Dewitt, T. L. Bergman and A. S. Lavine, Fundamentals of Heat and Mass Transfer, Wiley.
2. H.S. Ray, Kinetics of Metallurgical Reactions.

MM 15 030 - MINERAL PROCESSING *(Fourth Semester)*

Module I (10 Hours)

Introduction to mineral beneficiation, sampling, liberation studies and its importance. Comminution: Fundamentals of comminution, crushing: construction and operational features of jaw, gyratory, cone and roll crushers. Grinding: Theory of ball mill, rod mill, critical speed of the mill, open circuit and closed circuit, circulating load.

Module II (10 Hours)

Size separation: Sieving and screening, laboratory sizing and its importance, representation and interpretation of size analysis data, industrial screening. Classification: Movement of solids in fluids, free setting and hindered settling of particles, different types of classifiers, e.g. sizing and sorting classifiers used in mineral industry.

Module III (10 Hours)

Concentration: Gravity separation, concentration criteria, jigging, flowing film concentration and tabling, dense media separation. Froth flotation: Theory, reagents used in floatation processes, machines and practice. Magnetic and electrostatic separation: Theory and application of magnetic and electrostatic separation techniques in mineral industry. Dewatering and drying: Theory and practice of thickening; filtration and drying.

Module IV (10 Hours)

Agglomeration techniques: Sintering, palletizing, briquetting and their applications in ferrous and non-ferrous metal industries, testing of agglomerates. Important mineral deposits in India.

Text Books:

1. Principle of Mineral Dressing by A. M. Gaudin
2. Mineral Processing Technology by Berry A. Willis

MM 15 052 - UNIT PROCESS OF EXTRACTION *(Fourth Semester)*

Module I (10 hours)

Overview of Extractive Metallurgy processes; Pyro-metallurgy, Hydrometallurgy and Electrometallurgy; Thermodynamic and Kinetic Principles of metal extraction; Ellingham diagrams, Calcinations; Roasting; Predominance Area Diagram, Roasting Practices, Smelting, Formation and function of slag and their calculations ,Metallo-thremic reduction of oxides, Smelting Furnaces, Matte Smelting, Pyro metallurgical processes using vacuum

Module II (12 hours)

Hydrometallurgy: Leaching; Theory of Leaching; Role of oxygen in leaching operation; Bacterial and microbial leaching; Contact reduction of metals in aqueous solutions; Gaseous reduction of metals in aqueous solutions; Ion exchange, Solvent Extraction and Electrolysis

Module III (8 hours)

Electrometallurgy: laws of electrolysis, electrolyte Structure of solvent media; Electrolysis of aqueous solution; Electrolysis of fused salts; Cell design; Electro-plating.

Module IV (10 hours)

Halide Metallurgy and Halogenisation.,Basic approaches of refining, preparation of pure compounds; Purification of crude metals produced in bulk; Numerical problems relevant to Pyro, Hydro and Electrometallurgical processes

Text Books:

1. Principles of Extractive Metallurgy: A. Ghosh & H.S. Ray, IIN Publications, Kolkata 1984.
2. Principles of Extractive Metallurgy: Rosenquist, T., McGrawhill-Kogakusha International – 1983

MM 15 020 - IRON MAKING *(Fifth Semester)*

Module I (8 Hours)

History of Iron making in India, Indian and other resources of raw materials required for iron making. coke making. Blast furnace plant and -Modern blast furnace, plant layout, Details of construction of blast furnace and its main accessories; gas cleaning system, hot blast generation. Blast furnace refractories and blast furnace cooling system

Module II (10 Hours)

Agglomeration of iron ore fines, sintering and pelletision, evaluation of properties of blast furnace, burden materials and application to blast furnace performance. Blast furnace plant operation, blowing in, blowing out and banking of blast furnace, role of burden charging and distribution in iron extraction, irregularities in Blast furnace operation and their remedies. Blast furnace products their quality control and disposal, coke rate and fuel efficiency of B.F. operations.

Module III (12 Hours)

Modern trends in Blast furnace practice-Production of super flux sinter, pellets, super flux and cold bonded pellets. Auxiliary fuel injection in the blast furnace. High temp.blast, humidified and oxy generated blast, high top pressure, Desulphurization of hot metal. Chemical processes in Blast Furnace, Reactions in Tuyere, hearth and bosh zone. Reduction and coke gasification, Reactions in stack and exit gases. Thermodynamics of Blast furnace process requirement in Blast furnace, temp. profile in the furnace. Free energy and equilibrium consideration in Blast furnace a brief discussion on blast furnace stoichiometry and enthalpy balance

Module IV (10 Hours)

Alternate route for iron making charcoal blast furnace, low shaft furnace and electro thermal processes of iron making. Direct reduction processes, their classification, choice of DR process. Introduction to Production of Ferro-alloys. Production of various ferro-alloys Fe-Mn, Fe-V, Fe-Cr etc. uses of ferro-alloys in iron and steel industry

Text Books:

1. Modern Iron Making - Dr. R.H. Tupkary
2. Principles of Blast Furnace iron making - Dr. A K Biswas

MM 15 036 - PHASE TRANSFORMATIONS *(Fifth Semester)*

Module I (12 Hours)

Classification of phase transformations. Thermodynamics and Kinetics: Introduction, Equilibrium, Gibbs free energy change with single component system, Thermodynamic parameters in binary system, Binary phase diagrams, Free energy Vs Composition phase diagrams.

Diffusion: Driving force for diffusion, atomic mechanisms of diffusion, interstitial diffusion: steady state diffusion, Non-steady state diffusion, Solutions to the diffusion equation substitutional diffusion, High diffusivity paths.

Module II (8 Hours)

Crystal interfaces: Interfacial free energy, Boundaries in single phase solids, Bond breaking model, Interphase interfaces in solids: interface coherency, interfacial energy effects, misfit strain effects.

Nucleation and growth: Homogeneous nucleation, homogeneous nucleation rate, Heterogeneous nucleation, Heterogeneous nucleation rate, Growth of a pure solid,

Module III (15 Hours)

Diffusional transformations in solids: Overall transformation kinetics: TTT diagrams, Precipitation in age hardening alloys, Particle coarsening, Spinodal decomposition, Ferrite: nucleation and growth, Pearlitic transformation: mechanism, nucleation and growth, Bainitic transformation: mechanism, nucleation and growth, Effect of alloying elements on hardenability, CCT diagrams, massive transformations, ordering transformations

Module IV (5 Hours)

Diffusionless transformations: Martensitic transformations: characteristics, crystallography, theories of Martensitic nucleation, martensite growth. Recovery, Recrystallization and grain growth.

Text Books:

1. Phase transformations in metals and alloys by D.A.Porter, K.E.Easterling and Sharif, CRC press
2. Phase transformation in materials by Romesh C Sharma, CBS publishers & Distributors

MM 15 008 - DEFORMATION THEORY OF METALS *(Fifth Semester)*

Module I (10 Hours)

Introduction: Scope of the subject, elastic, plastic and visco-elastic deformation. Deformation behavior: Tensile and compression testing, effect of temperature and strain rate Continuum mechanics: Concepts of stress and strain in 3D stress and strain tensor, principal stresses and strains and principal axes, mean stress, stress deviator, maximum shear, equilibrium of stresses, equations of compatibility.

Module II (10 Hours)

Elastic behavior of materials: Constitutive equations in elasticity for isotropic and anisotropic materials, strain energy, elastic stiffness and compliance tensor, effect of crystal structure on elastic constants. Plastic response of materials-a continuum approach: classification of stress-strain curves, yield criteria.

Module III (10 Hours)

Microscopic basis of plastic deformation: Elements of dislocation theory, movement of dislocation, elastic properties of dislocation, intersection of dislocation, dislocation reactions in different crystal structures, origin and multiplication of dislocations. Plastic deformation of single crystals: Critical resolved shear stress, deformation by twinning, deformation band and kink band, strain hardening of single crystal; stress-strain curves of fcc, bcc and hcp materials

Module IV (10 Hours)

Plastic deformation of polycrystalline materials: Role of grain boundaries in deformation, strengthening by grain boundaries, yield point phenomenon, strain ageing, strengthening by solutes, precipitates, dispersoids and fibres. Deformation in non-metallic materials: structure and deformation of polymers, concept Super lattice dislocations in inter metallics, and concept of charge associated with dislocations in ceramics.

Text Books:

1. Mechanical Metallurgy, 3rd Ed., McGraw Hill Book Company, New Delhi, 1986 - G.E. Dieter
2. Mechanical Behavior of Materials, McGraw Hill Book Company, New Delhi, 1990 - T.H. Courtney

MM 15 025 - MATERIALS TESTING *(Fifth Semester)*

Module I (10 Hours)

Engineering materials and their applications, testing of materials: Types of testing systems, significance of measurement of properties and test conditions, interpretation of test results, Tensile Testing: significance of measured parameters, necking, stress distribution, ductility measurement,

Module II (10 Hours)

Effect of gauge length, effect of strain rate and temperature on flow properties, Machine stiffness in tensile testing system, measuring instrument computerization, Torsion Test: Mechanical properties in torsion. torsion vs tension test.

Module III (10 Hours)

Hardness Test: Rockwell, Brinell, Vickers and micro-hardness, elastic and plastic behavior during hardness testing, Special hardness tests: superficial, micro and shore. Fracture Mechanics: Introduction, Strain-Energy Release Rate, Stress Intensity Factor, Fracture Toughness and Design, KI_c Plane-Strain Toughness Testing Ductile, brittle fracture, Griffith theory, Ductile to brittle transition, Notch effect in fracture,

Module IV (10 Hours)

Fatigue Tests: Stress cycles, SN curve, effect of stress concentration, size and surface conditions on fatigue, Creep, Stress rupture tests, Creep curve and its analysis, Non-destructive Testing: Visual, magnetic, radiographic, ultrasonic, electromagnetic, penetrant tests, their applications in quality control and inspection.

Text Books:

1. Mechanical Metallurgy George E. Dieter
2. Materials Testing by S. Bhargava

MM 15 007 - CORROSION AND DEGRADATION OF MATERIALS *(Fifth Semester)*

Module I (10 Hours)

Introduction, importance of corrosion study, corrosion as non equilibrium process, corrosion rate expressions, electrochemical principles of corrosion-cell analogy, concept of single electrode potential, reference electrodes, e.m.f. and galvanic series-their uses in corrosion studies, polarization, passivity.

Module II (10 Hours)

Different forms of corrosion-uniform attack, galvanic, crevice, pitting, intergranular, stress corrosion cracking - their characteristic features, causes and remedial measures. Principles of corrosion prevention-material selection control of environment including inhibitors

Module III (10 Hours)

Cathodic and anodic protection, coatings and design considerations. Corrosion testing methods. Introduction to high temperature corrosion, Pilling- Bedworth ratio, oxidation kinetics, oxide defect structures.

Module IV (10 Hours)

Considerations in high temperature alloy design, prevention of high temperature corrosion -use of coatings. Hydrogen Damage-Sources, Types of damage, Mechanisms and preventive methods, Liquid metal attack - liquid metal embrittlement, preventive measures.

Text Books:

1. M. G. Fontana : Corrosion Engineering , 3rd edition, Mc Graw Hill International, 1987.
2. U. K. Chatterjee, S. K. Bose and S. K. Roy: Environmental Degradation of Metals, Marcel Dekker, 2001

MM 15 044 - STEEL MAKING *(Sixth Semester)*

Module I (10 Hours)

Introduction: Principles of steel making reactions, Viz. Decarburisation, dephosphorisation, desulphurisation, silicon and manganese reaction. Slag Theories: Molecular and Ionic theories; Interpretation of the above reactions in terms of ionic theory of slag, LD Process: Design of converter & lance, Quality of raw materials charged, Operation of the converter and control of bath and slag composition,Some characteristics of L. D. blow Viz. Emulsion formation, lance height for dephosphorisation and decarbonisation

Module II (10 Hours)

Recovery of waste heat, OBM/Q-BOP, Process, Concept and operation of the process, Mixed/Combined blowing Processes, Oxygen top blowing with inert gas purging at bottom, Oxygen top blowing with inert and oxidizing gases at bottom, Oxygen top and bottom blowing. Open Hearth Furnace: Its modification into Twin Hearth, Operational principle, Advantages. Electric Arc Furnace: Advantages; Charging, Melting and refining practices for plain carbon and alloy steels, Use of DRI in arc furnace and its effect on performance,

Module III (8 Hours)

Duplex processes of stainless steel making using VOD, AOD. Induction Furnace: Advantages, principle of induction melting, Its use in steel industry. Deoxidation of liquid steel: Requirements of deoxidisers, deoxidationpractice,Use of complex deoxidisers, Inclusions and their influence on quality of steel, Killed, Semi-killed and Rimming steel

Module IV (12 Hours)

Secondary refining of steel: Objectives, Principle of degassing, Different industrial processes such as DH, RH, VAD, SD. LF, and ESR, Limitations and specific applications. Continuous Casting of Steel: Advantages, types of machines, Mould lubrication and reciprocation, Developments in technology with respect to productivity, quality and energy conservation, Near-net-shape casting, Strip casting

Text Books:

1. Iron and steel making theory and practiced - Ahindra Ghosh, Amit Chatterjee
2. Introduction to Modern Steel Making, Khanna Publishers, Delhi - R.H. Tupkary

MM 15 022 - MATERIALS CHARACTERIZATION *(Sixth Semester)*

Module I (10 Hours)

Introduction to materials characterization & its importance, Fundamentals of Crystallography, levels of characterization (macro, meso and micro), Resolution, depth of field/focus, aberrations (spherical, chromatic and astigmatism) and its remedial measures. Optical microscopy (OM) – Microscope construction and working, reflected/transmitted light microscope, theoretical and practical resolution of optical microscope, numerical aperture, principle of image formation, , effective/empty magnification, Types of illumination - bright field, dark field, polarized light and phase contrast, applications of each type of illumination. Sample preparation for optical microscopy, features of an image

Module II (12 Hours)

Introduction to scanning electron microscope (SEM), working and construction, advantages/disadvantages as compared to OM, types of electron gun and comparison between them. Electron - specimen interaction, imaging modes (secondary and backscattered), effect of spot size, apertures, accelerating voltage on SEM image, Everhart-Thornley detector, Robinson detector, solid state segmented detector, atomic number and topological contrast. Chemical analysis using SEM, EDS/WDS working principle, construction, resolution of EDS/WDS detector, advantages/disadvantages.

Module III (8 Hours)

X-ray diffraction: Generation of X-rays, characteristic X-ray spectrum, Bragg's Law, Diffraction methods: Laue method, rotating crystal method, powder method, structural factor, applications of X-ray diffraction in materials characterization: determination of crystal structure, lattice parameter.

Module IV (10 Hours)

Thermal analysis techniques & its Importance, principles and applications of differential thermal analysis (DSC), differential scanning calorimetry (DSC) and thermogravimetric analysis (TGA). Brief idea of TEM: principle of operation, application. Introduction to advanced microscopic techniques.

Text Books:

1. Elements of X-Ray Diffraction, B.D. Cullity, Prentice Hall (2001)
2. Electron Microscopy and Microanalysis, Goodhew, Humphreys and Beanland, Taylor and Francis, New York, 2001

MM 15 015 - HEAT TREATMENT *(Sixth Semester)*

Module I (10 Hours)

Objective and variables of heat treatments, Classification of steels, Heat treatment of steel, Phase transformation mechanisms, Fe-Fe_3C , Fe-C phase diagrams, TTT, CCT diagrams, Microstructure evolution during austenite decomposition, Microstructure evolution during reheating, Strengthening mechanisms in steel.

Module II (10 Hours)

Effects of Alloying Elements on Heat Treatment Processing of Iron–Carbon Alloys, Effect of Alloying Elements on Austenite Transformations, Definition of Hardenability, Factors Influencing Depth of Hardening, Determination of Hardenability, Grossmann's Hardenability Concept, Jominy End-Quench Hardenability Test, Hardenability Bands, Application of Hardenability Concept for Prediction of Hardness after Quenching, Hardenability in Heat Treatment Practice

Module III (10 Hours)

Heat Treatment with Gaseous Atmospheres: Carburizing, Reactions with Hydrogen and with Oxygen, Nitriding and Nitrocarburizing, Quenching: Metallurgical Transformation Behavior during Quenching, Quenching Processes, Determination of Cooling Characteristics, Quenching as a Heat Transfer Problem, Process Variables Affecting Cooling Behavior and Heat Transfer: Distortion of Heat-Treated Components: Basic Distortion Mechanisms, Residual Stresses, Distortion during Post Quench Processing

Module IV (10 Hours)

Heat treatments of general engineering steels: Spring, Bearing steels, Tool steels, HSLA steel and Maraging steels, Dual phase steels and Stainless steels, Heat treatment cast irons, Heat Treatments of Non ferrous alloys : Al-alloys, Brass, Bronze, and Ti-alloys, Superalloys

Text Books:

1. R.C. Sharma, Principle of Heat Treatment of Steel, New Age Publishers
2. V. Singh, Heat Treatment of Metals, Standard Publishers

MM 15 035 - NON-FERROUS EXTRACTIVE METALLURGY *(Sixth Semester)*

Module I (10 Hours)

General principles of extraction of metals from oxides and sulphides; Mineral resources of non – ferrous metals in India; their production, consumption and demand; Future of non – ferrous metal industries in India; Thermodynamic considerations and process selection in pyro-metallurgical extraction of metals. Aluminium: Bayer's process and factors affecting its operation; Hall – Heroult process: principle & practices, use of electrodes, anode effect; Refining of Aluminium; Alternative methods of Alumina and Aluminium production.

Module II (12 Hours)

extraction of metals from Sulphide ores (Cu, Ni, Pb and Zn) Matte smelting; Converting; Refining; by-products recovery; recent developments; Continues copper production processes, hydrometallurgy of copper.

Module III (8 Hours)

Extraction of metals from oxide ores (Sn, Mg), and extraction of metals through halide route (Ti and Zr).

Extraction of metals like (U,Nb, etc)

Module IV (10 Hours)

Electro winning and Electro refining of metals:

a) From aqueous salts (Cu, Ni, Au, and Ag)

b) From fused salts (Al and Mg)

Environmental pollution and its address related to various metal extraction processes in general.

Text Books:

1. Extraction of Non Ferrous Metals by H.S.Ray, R.Sridhar&K.P.Abraham, Affiliated EastWest Press, New Delhi
2. Principles of Extractive Metallurgy, by T. Rosenquist, McGraw hill, 1974

MM 15 040 - POWDER METALLURGY AND COMPOSITE MATERIALS *(Seventh Semester)*

Module I (10 Hours)

Introduction to powder metallurgy, Metal and alloy powder production, chemical, physical and mechanical methods of production, metal powder characterization introduction, chemical composition, particle size, surface area, densit , compressibility, strength .

Module II (8 Hours)

Powder compaction, Sintering introduction, Introduction to Composites: Matrices, Reinforcements: galss fibre, carbon fibre, whiskers, Fundamental concept of reinforcement, review of current developments; Basic mechanics of reinforcement, stiffness of parallel arrays of fibers in a matrix,

Module III (12 Hours)

Polymer Matrix Composites (PMCs): processing of thermoplastic and thermoset matrix composite, structural defect and mechanical properties, application .Metal Matrix Composites (MMCs):Aluminum alloy, copper alloy, titanium alloys, solid state processing, in situ processing, high temperature properties and strength, applications .

Module IV (10 Hours)

Ceramic Matrix Composites (CMCs):cold pressing and sintering, hot pressing, self propagating high temperature synthesis, thermal shock resistance properties, crack deflection and toughness. Nano composites: polymer clay nano composite, self healing and self reinforced composite, bio composite, hybrid composite.

Text Books:

1 Powder metallurgy technology by G. S. Upadhyaya

2 Composite materials science and engineering by K. Chawla

MM 15 028 - MECHANICAL WORKING OF METALLIC MATERIALS *(Seventh Semester)*

Module I (10 Hours)

Fundamentals of Metal Working: Classification of forming processes; Temperature in Metal– working, Hot working, Cold working and Warm working of metals, Heating of metals and alloys for hot working, Friction in Metal working, Lubrication, concept of yield criteria.

Module II (10 Hours)

Rolling of Metals: Classification of Rolled products, Types of rolling mills, terminology used in rolling; Forces and Geometrical relationships in rolling, Rolling variables, Theories of rolling, Rolling Torque and HP calculations. Roll-pass Design: Fundamentals of Roll-pass-design; Mill type, Layout and rolling practice adopted for some common products such as Slabs, Blooms, Billets, Plates, Sheets etc. Rolling defects and their control

Module III (10 Hours)

Forging of Metals: Forging principles, types of forging and equipments needed, calculation of forging load under sticking and slipping friction conditions, Forging defects and their control, Manufacture of rail wheels and tyres. Extrusion: Types, Principles and Equipments. Variables in extrusion, deformations in extrusion, calculation of extrusion pressure under plane strain conditions; extrusion defects; production of tubes and seamless pipes.

Module IV (10 Hours)

Wire Drawing**:** Drawing of Rods, Wires and Tubes, calculation of drawing load; drawing defects. Sheet Metal Forming**:** Forming methods such as bending stretch forming, shearing and blanking, deep drawing, and redrawing. Defects in formed products, Special forming methods such as explosive forming (elementary ideas excluding mathematical treatment)

Text Books:

1. G. W. Rowe, Principles of Industrial Metal Working processes, Crane Russak, 1977.
2. Amitabh Ghosh, Asok Kumar Mallick, Manufacturing sciences, East-west press private ltd; latest reprint-1991.

MM 15 004 - CASTING & SOLIDIFICATION OF MATERIALS *(Seventh Semester)*

Module I (10 Hours)

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, Different types of binders and their uses in mould and core makings

Module II (10Hours)

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.

Module III (10Hours)

Solidification of Metals and Alloys: Nucleation, Growth, Role of alloy constitution, Thermal conditions and inherent nucleation and growth conditions in the liquid melt, Time of solidification and Chowrinov rule, concept of directionality in solidification Significance and practical control of cast structure Principles of Gating and Risering: Feeding characteristics of alloys, Types of Gates and Risers, gating ratio.

Module IV (10Hours)

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

Text Books:

1. P. R. Beeley, Foundry Technology, Newnes-Buttterworths, 2001

2. P. D. Webster, Fundamentals of Foundry Technology, Portwillis press, Red hill, 1980.

MM 15 010 - ENGINEERING MATERIALS *(Eighth Semester)*

Module I (10 Hours)

Introduction, Metals: the generic metals and alloys; iron-based, copper-based, nickel-based, aluminium-based and titanium-based alloys. Metal structures the range of metal structures that can be altered to get different properties:

crystal and glass structure, structures of solutions and compounds, grain and phase boundaries, equilibrium shapes of grains and phases;

Module II (10 Hours)

The light alloys where they score over steels; how they can be made stronger: solution, age and work hardening; thermal stability; *Alloy steels* adding other elements gives hardenability (ease of martensite formation), solution strengthening, precipitation strengthening, corrosion resistance, and austenitic (f.c.c.) steels; Introduction: Ceramics and glasses: the generic ceramics and glasses: glasses, vitreous ceramics, high-technology ceramics,

Module III (10 Hours)

cements and concretes, natural ceramics (rocks and ice), ceramic composites; Structure of ceramics,crystalline ceramics; glassy ceramics; ceramic alloys; ceramic micro-structures: pure, vitreous and composite; The mechanical properties of ceramics high stiffness and hardness; poor toughness and thermal shock resistance; the excellent creep resistance of refractory ceramics.

Module IV (10 Hours)

Introduction: Polymers and composites Polymers the generic polymers: thermoplastics, thermosets, elastomers, natural polymers; The structure of polymers giant molecules and their architecture; molecular packing: amorphous orcrystalline?; Mechanical behaviour of polymers how the modulus and strength depend on temperature and time;making giant molecules by polymerisation; polymer “alloys”; Composites: fibrous, particulate and foamed how adding fibres or particles to polymers can improve their stiffness, strength and toughness; why foams are good for absorbing energy.

Text Books:

1. Engineering Materials 1 by Michael F Ashby & David R H Jones
2. Engineering Materials 2 by Michael F Ashby & David R H Jones

MM 15 046 - SURFACE ENGINEERING *(Eighth Semester)*

***Module I* (10 Hours)**

Introduction, Surface dependent engineering properties, viz., Friction and wear, corrosion, fatigue, etc.; common surface initiated engineering failures; mechanism of surface degradation; importance and necessity of surface

engineering; classification and scope of surface engineering in metals, ceramics, polymers and composites, tailoring of surfaces of advanced materials.

***Module II* (10 Hours)**

Surface protection (Physical); surface modification (Chemical) techniques: classification, principles, methods, and technology. Conventional surface engineering methods: carburising, nitriding, cyaniding, diffusion coating, hot dipping, galvanizing etc.

***Module III* (8 Hours)**

Electrochemistry and electro-deposition; scope and application of conventional surface engineering techniques in engineering materials; advantages and limitations of conventional processes

***Module IV* (12 Hours)**

Recent trend in surface engineering: physical/chemical vapor deposition; plasma spray coating; plasma assisted ion implantation. Surface modification by directed energy beams like ion, electron and laser beams; energy transfer, novelty of the directed energy beams assisted surface modification techniques.

Text Books:

1. K. G. Budinski (Ed.): Surface Engineering for Wear Resistance, Prentice Hall, New Jersey 1988.
2. J. R. Davis (Ed.): Surface Engineering for Corrosion and Wear Resistance, ASM International, Materials Park, Ohio, 2001.

MM 15 053 – WELDING TECHNOLOGY ***(Core Elective - I) (Sixth Semester)***

Module I (10 Hours)

Introduction: Principle, Theory and Classification of welding and other joining processes. Manual metal arc (MMA): Equipment requirement, electrodes for welding of structural steels, coating constituents and their functions, types of coatings, current and voltage selection for electrodes,

Module II (10 Hours)

Arc welding power sources; Conventional welding transformers, rectifiers and current and voltage. The influence of these power sources on welding, metal transfer. Submerged arc welding (SAW): Process details, consumables such as fluxes and wires for welding mild steel, Variations in submerged arc welding process. Gas metal arc welding (GMAW) or MIG/ MAG welding: Process details, shielding gases, electrode wires, their sizes, and welding current ranges.

Module III (10 Hours)

TIG welding: Process details, power sources requirements, electrode sizes and materials, current carrying capacities of different electrodes, shielding gases, application of process. Resistance welding: General principle of heat generation in resistance welding, application of resistance welding processes. Process details and working principle of spot, seam, and. projection welding, electrode materials, shapes of electrodes, electrode cooling, selection of welding currents, voltages.

Module IV (10 Hours)

Welding metallurgy of carbon and alloy steels, Cast irons, Stainless steels, Al- and Cu-based alloys. Weldability and Heat affected zones (HAZ). Welding defects and detection techniques. Soldering and brazing: Difference between both the processes, consumables used, methods of brazing, fluxes used, their purposes and flux residue treatment.

Text Books:

1. J F Lancaster, Allen and Unwin, Metallurgy of Welding.
2. R L Little, Welding and Welding Technology, TMH.

MM 15 002 - ALTERNATIVE ROUTES OF IRON MAKING ***(Core Elective - I) (Sixth Semester)***

Module I (12 Hours)

Introduction: Present and future of sponge iron industries in India; Classification of DR processes; Characteristics of raw materials and their preparation. Thermodynamics and Kinetics aspects. Direct Reduction Processes: Reduction of Iron bearing materials in shaft furnace, rotary kiln.

Module II (8 Hours)

Retort and fluidized bed with special reference to reductant, energy consumption and operational problems. Salient features of coal- based (rotary kilns) DR processes; Salient features of gas-based DR processes.

Module III (10 Hours)

Commercially available processes like SL/RN, ACCAR, Krup-CODIR, Kinglon Meter, MIDREX, HyL, Purofer, Iron Carbide, etc. Uses of DRI in steel making, iron making and foundries; effect on DRI on EAF performance and product characteristics.

Module IV (10 Hours)

Smelting Reduction Processes: COREX, ROMELT, Fluidized bed reactors, Hismelt etc. Strengths and weaknesses of different DR processes particularly in context to India; Properties and usage of DRI; Pollution issues in the Indian DR industries. Present status of alternative methods of iron making in India.

Text Books:

1. Alternative Routes of Iron Making by Amit Chatterjee, PHI
2. Beyond the Blast Furnace by Amit Chatterjee

MM 15 043 - SINTERING THEORY AND PRACTICE ***(Core Elective - I) (Sixth Semester)***

Module I (10 Hours)

Introduction to sintering over view, brief history, the sintering process, overview of sintering technique, goals in sintering, related problems

Module II (12 Hours)

Fundamental of solid state sintering coarsening and densification ,sintering stress, mass transfer , stages of sintering rearrangement mechanism , coarsening and densification., sintering diagrams. Microstructure and processing

Module III (8 Hours)

Liquid phase sintering over view, rearrangement mechanism, grain growth mechanism

Module IV (10 Hours)

Mixed power sintering novel sintering .sintering atmosphere, sintering practices, post sintering process overview

Text Books:

1. Sintering Theory and Practice Hardcover – January 19, 1996 - Randall M. German
2. Powder metallurgy technology by G. S. Upadhyaya

MM 15 017 - HYDRO AND ELECTRO METALLURGY ***(Core Elective - I) (Sixth Semester)***

Module I (10 Hours)

Introduction**:** Justification of Hydrometallurgical selection of solvent processing, Eh-Pt diagrams Principles underlying hydrometallurgical processes, various commercial hydrometallurgical processes. Criteria for selection of solvents, Types of Solvents.

Module II (10 Hours)

Thermodynamics & kinetics of hydrometallurgical processes, Unit operations in hydrometallurgical processing, Thickness & filters, counter current decantation. Applications of hydrometallurgy to Copper, Zinc, Precious metals etc.

Module III (10 Hours)

Solvent Extraction & Ion Exchange, Purification methods of leach solutions, Recovery of metal values from solution, Precipitation methods Thermodynamics & Kinetics of concentration.

Module IV (10 Hours)

Electrolytic Recovery: Electrowining of methods from Aq. Solutions Electro Refining, Fused Salt Electrolysis – Extraction of Aluminum& Magnesium from their ores, Mass balance calculations.

Text Books:

1. H. S. Ray, K. P. Abraham and R. Sridhar, Extraction of Non-Ferrous Metals, Affliated East- West Press.
2. E. Jackson, Hydrometallurgical Processing & Reclaimation, John Wicky & Sons.

MM 15 049 - THEORY OF ALLOYS ***(Core Elective - II) (Seventh Semester)***

Module I (10 Hours)

Structure and physical properties of elements: Alloys formation: primary solid solution, intermetallic compounds, concept of atomic size factor, normal valance compounds, electron compounds in noble metals and transition metal systems, size compounds, borides, carbides and silicides of metals:

Module II (10 Hours)

Experimental methods for the study of alloying behaviour of metals Aluminium alloys. Phase diagrams. Alloys and tempers. Alloy characteristics. Review of preciptation hardening, oxidation, corrosion resistance and fatigue. Titanium alloys. Pure Ti. Alloying Ti. Specific alloys: α, $\alpha + \beta$, and β. Superplasticity.

Module III (10 Hours)

Magnesium alloys. Mg alloys. Heat treatment of Mg alloys. Nickel alloys: overview and superalloys : Ni-base, Fe-base and Co-base superalloys and their properties.

Module IV (10 Hours)

Steels. Review of plain C, alloy steels and cast irons. Commercial steels: high-strength, lowalloy (HSLA), bainitic, dual-phase, transformation induced plasticity (TRIP), TWIP Steels, IF steels and Stainless steels.

Text Books:

1. The structure of metal and alloys - William Hume Rothery
2. Physical metallurgy Principles - Reza Abbaschian and Robert E.Reed Hill

MM 15 033 - MODELING OF MATERIALS PROCESSES ***(Core Elective - II) (Seventh Semester)***

Module I (10 Hours)

Solution of linear, non-linear algebraic equations, ordinary differential equations and related metallurgical problems, transport phenomena based Modeling:

Module II (10 Hours)

Model formulation based on heat, mass and momentum transfer, governing equations and boundary conditions.

Module III (10 Hours)

Numerical solution of differential equations, process related numerical problems. Stress Analysis. Mesoscopic Modeling: CA based modeling, Monte Carlo Simulation, application to metallurgical processes.

Module IV (10 Hours)

Classical Molecular Dynamics Modeling and its applications in materials, Optimization and control, Elements of modern artificial intelligence (AI) related techniques. Introduction to Genetic Algorithm and Artificial Neural Networks

Text Books:

1. Handbook of Materials Modeling, Springer, 2005 - S. Yip (Ed)
2. Numerical Methods for Engineers, New Age International (P) Limited, New Delhi, 1998 - Santosh K. Gupta

MM 15 012 - FAILURE ANALYSIS ***(Core Elective - II) (Seventh Semester)***

Module I (10 Hours)

Causes & Sources of Failures, Methodology, Art of Questioning, Fractography: ductile versus brittle, Fractography: Fatigue, Creep, Stress Calculations, Fatigue Design Fractography: overload Calculations. Case studies related this topic.

Module II (10 Hours)

Fracture Toughness, Creep, Wear, Rolling Contact Fatigue, Advanced Fractography, Case studies related this topic.

Module III (10 Hours)

Non Destructive Evaluation (NDE) Metallography, Introduction to Corrosion, Forms of Corrosion, Galvanic, Pitting, crevice corrosion etc. Polymer Failures Ceramics and Glass Liquid Metal Embrittlement, Case studies related this topic.

Module 1V (10 Hours)

Failures releted to Casting, Welding, Metal working, Fasteners (screws bolts, rivets), Shafts and Gears, Sequencing, Case studies related this topic.

Text Books:

1. ASM Handbook, Vol. 11, Failure Analysis and Prevention," edited by R.J. Shipley and W.T. Becker,
2. Mechanical Metallurgy, 3rd Ed., McGraw Hill Book Company, New Delhi, 1986 - G.E. Dieter

MM 003 - BIOMATERIALS ***(Core Elective - II) (Seventh Semester)***

Module I (10 Hours)

Introduction: Biomaterials, bio-inert, bioactive, property requirement of biomaterials. Biocompatibility: tissue response to biomaterials; corrosion. Assessment of biocompatibility of biomaterials: in vitro and in vivo testing of biomaterials.

Module II (10 Hours)

Metallic materials in medical application: Stainless steel, cobalt based alloys, titanium based alloys (including shape memory alloys).

Module III (10 Hours)

Ceramics and polymer based implant material. Processing and properties of different bio-ceramics materials

Module IV (10 Hours)

Surface modification of implant material, mechanical, Physical, chemical and high energy based surface modification. Design concept of developing new materials for bio-implant application.

Text Books:

1. J.B. ParkandJ. D. Boonzino, Biomaterials: Principles and Application, CRC Press, 2002.
2. R E Smallman, A. H. W., Butterworth-Heinemann, Physical Metallurgy and Advanced Materials, Seventh Edition, 2007, ISBN: 0750669063.

MM 15 001 - ADVANCED MATERIALS (*Open Elective*)

Module I (10 Hours)

Electronic Polymers, Organic electronics, Melanin, Organic semiconductor, Printed electronics, Organic LED. Nanostructures, Nanomaterials, Nanocomposites. Biomaterials: Metallic biomaterials like 316L stainless steel, Co-Cr Alloys, Titanium Ti6Al4V,.

Module II (10 Hours)

Ceramic biomaterials like Alumina, Zirconia, Carbon Hydroxy-apatite, Polymeric biomaterials like Ultra high molecular weight polyethylene, Polyurethane Smart Materials: Piezoelectric materials, Shape memory alloys and shape memory polymers.

Module III (10 Hours)

High Performance Alloys: Nickel super alloys, Ti alloys, Al-Li alloys, Hastelloy, Inconel, Monel, Nitronic, Cobalt based alloys and commercially available pure nickel alloys. Functional and Engineering Ceramics: diverse applications as cutting tools, mobile phone microwave devices, polycrystalline diamond and fuel cells.

Module IV (10 Hours)

Hybrid Materials: Design, Synthesis and Properties of hybrid materials created by blending disparate materials such as plastics with metals. Processing of Advanced Materials: Superplastic, spray forming, rapid solidification. Materials selection and design.

Text Books:

1. Mark J. Hampden-Smith Wiley-VCH, Chemistry of Advanced Materials: An Overview Leonard V. Interrante, 1st edition (1997) ISBN-10: 0471185906 ISBN-13: 978-0471185901.
2. R E Smallman, A. H. W., Butterworth-Heinemann, Physical Metallurgy and Advanced Materials, Seventh Edition, 2007, ISBN: 0750669063

MM 15 018 - INTRODUCTION TO NANO SCIENCE AND NANO TECHNOLOGY ***(Open Elective)***

Module I (12 Hours)

Introduction to nano science and nanotechnology, Definition, Background and Development of nanotechnology, Basic ideas about Atoms, Molecules and structure.Length scale and properties of matter. Techniques for Synthesis and preparation of Nanostructured materials, Concept of Bottom Up and top down approach of nanotechnologies: nanolithography, mask and resist technology, electron beam lithography, dip penlithography, mechanical milling,, Self-assembly, Sol – Gel method, Chemical Vapor deposition (CVD)/PECVD etc.

Module II (12 Hours)

Measurement and Characterization of Nanocrystalline Materials: *Structure* (Atomic structure, Particles size determination, surface structure), Microscopy scanning probe microscopy, principle of working of STM and AFM, Electron microscopy, resolution vs. magnification issue, SEM, Field Ion, high resolution TEM.

Module III (8 Hours)

Carbon nanostructure: Introduction to Carbon Molecules, Carbon Clusters (C60, Bucky ball), Carbon Nanotube –Type of Carbon Nanotube, Formation of Carbon Nanotube and properties and Application of Carbon Nanotube.

Module IV (8 Hours)

Cutting age areas of application of Nanotechnology; state of art of the nano technology, current areas of research, scope and opportunity of the technology, some special topics on application of nanomaterials.

Text Books:

1. Introduction to Nanotechnology. Charles P Pool. Frank J Owens, JhonWiely and Son Publication, New Jersey, 2003
2. Introduction to Nanoscience and Nanotechnology , K KChattopadhyay and A. N Banerajee, PHI, Learning Privet Limited, New Dehli, 2010

MM 15 048 - THERMO-MECHANICAL PROCESSING OF MATERIALS (*Open Elective*)

Module I (10 Hours)

General introduction, Microstructure and Properties, Plasticity, Work hardening Mechanisms and theories, Softening mechanisms, Alternative deformation mechanisms,

Module II (10 Hours)

Phase transformations during thermo-mechanical processing, Textural developments during thermo-mechanical processing, Residual stress modeling of texture and microstructural evolution

Module III (10 Hours)

Forming Techniques, Defects in TMP, Physical Simulation of Properties

Module IV (10 Hours)

Case studies: Thermo mechanical processing of steel, aluminum, magnesium, titanium and other advanced alloy systems, recent trends in thermo mechanical processing, new Technologies

Text Books:

1. Recrystallization and related phenomena - F.J. Humpherys and M. Hatherly
2. Thermo-mechanical Processing of Metallic Materials - Bert Verlinden, Julian Driver, Indradev Samajdar, Roger D. Doherty

MM 15 054 - X-RAY DIFFRACTION ***(Open Elective)***

Module I (10 Hours)

Introduction to crystallography, Symmetry - point group and space group, X-ray diffraction and analysis: Production and properties of X-rays, X-ray diffraction, Structure factor and intensity calculations. Continuous and characteristics spectrum, absorption. Filter and detectors, Bragg's law, scattering by atom, electron, unit cell, and structure factor calculation.

Module II (10 Hours)

Diffraction Methods: Laue's method, rotating crystal, Debye scherrer – Specimen preparation, film loading, powder method, Determination of crystal structure, determination of precision lattice parameter, sources of error in measurements. Determination of particle size, grain size, residual stresses, determination of phase diagrams, order-disorder transformation, texture, importance of texture, measurement of texture, pole figures (stereographic projections), orientation distribution function, sample symmetry.

Module III (10 Hours)

Electron optical methods –I: Scanning electron microscopy and X-ray microanalysis including electron probe microanalysis, electron optics, electron beam specimen interaction, image formation in the SEM. X-ray spectral measurements: WDS and EDS, quantitative X-ray analysis.

Module IV (10 Hours)

Electron optical methods –II: Analytical transmission electron microscopy: Electron diffraction, reciprocal lattice, analysis of SAD patterns; different electron diffraction techniques, atomic resolution microscopy, analytical devices with TEM, field ion microscopy, and scanning tunneling microscopy, advanced techniques.

Text Books:

1. Elements of X-Ray Diffraction by B. D. Cullity, Adison-Wesley.
2. Materials Characterization, Metals Handbook, Vol. 10, ASM

MM 15 011 - FABRICATION OF MATERIALS *(Open Elective)*

Module I (10 Hours)

Foundry : Introduction to patterns and foundry process, Sand binders and different additives, Sand testing and melting furnaces for ferrous and non-ferrous metals such as cupola, Induction furnace, Arc furnace & Resistance furnace. Solid fiction of castings, Continuous casting process: Precision investment casting, centrifugal casting, Die casting, Casting defects.

Module II (10 Hours)

Continuous casting process: Precision investment casting, centrifugal casting, Die casting, Casting defects. Solid fiction of castings, Continuous casting process: Precision investment casting, centrifugal casting, Die casting, Casting defects. Principles of Gating and Risering: Feeding characteristics of alloys, Types of Gates and Risers.

Module III (10 Hours)

Welding and cutting: Introduction to gas welding, cutting, Arc welding and equipment's. TIG (GTAW) and MIG (GMAW) welding, resistance welding and thermit welding. Weldability, Newer Welding methods like plasma Arc, Laser Beam, Electron Beam, Ultrasonic, Explosive and friction welding. Brazing and soldering, welding defects. Destructive and non-destructive testing of castings and weldings

Module IV (10 Hours)

Brief introduction to powder metallurgy processes.; Plastic deformation of metals: Variables in metal forming and their optimization. Dependence of stress strain diagram on Strain rate and temperature. Hot and cold working of metals.; Rolling: Pressure and Forces in rolling, types of rolling mills, Rolling defects.

Text Books:

1. P. D. Webster, Fundamentals of Foundry Technology, Portwillis press, Red hill, 1980.
2. Kalpakjian, S., & Schmid, S. R. 2008. Manufacturing processes for engineering materials: Pearson Education.

MM 15 045 - STEEL TECHNOLOGY *(Open Elective)*

Module I (8 Hours)

Introduction to steel: classification of steels over view:, carbon steels , alloy steel, effect of alloying elements on steel properties , difference between steel and cast iron, steel vs other non ferrous alloys , important application in automotive , construction and power sectors , strengthening mechanism in steels , phases in steels over view

Module II (12 Hours)

Steel making practice over view: history of steel making practices ,general layout of steel making plant Ld, electric arc , bop ,obm , hybrid process , Slag basicity and fluidity, refractory linings , and secondary steel making process like steel degassing , and steel cleaning .deoxidation practice , inclusions in steel .

Module III (8 Hours)

Advance casting process over view: Thin slab casting, near net shape casting continuous casting vs conventional casting , heat treatment over view:, normalising, annealing, hardening , tempering ,

Module IV (12 Hours)

Destructive testing over view like tensile test, charpy impact test, fatigue test , creep test, wear test , problems face by steel industries , further developments in steel industries ,surface treatment over view, anodising, galvanisation ,aluminising.

Text Books:

1. Iron and steel making theory and practice book by Ahindra Gosh and Amit Chatterjee
2. Physical Metallurgy Principles by Reza Abbaschain, Lara Abbaschain, RoberE. Red Hill