NATIONAL INSTITUTE OF TECHNOLOGY JAMSHEDPUR

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

Course Structure of M.Tech.

in

Industrial Metallurgy

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY, JAMSHEDPUR

M. Tech. (Industrial Metallurgy)

CREDIT STRUCTURE

Course Work	**1st Sem**	**2nd Sem**	**3rd Sem**	**4th Sem**	**Total Credits**
Core Course	16	16	-	-	32
Electives	4	4	-	-	08
Project			20	20	40
Total	20	20	20	20	80

M. Tech. (Industrial Metallurgy)

COURSE STRUCTURE

SEMESTER I

S. No.	Course Code	Subject	L-T-P	Credits
1	MM4101	Thermodynamics and Kinetics of Materials	3-0-2	4
2	MM4102	Transport Phenomena in Materials Processes	3-0-2	4
3	MM4126	Metal Melting Technology	3-0-2	4
4	MM4127	Heat Treatment Technology	3-0-2	4
5	MM41XX	Elective I	3-0-2	4
		TOTAL	**15-0-10**	**20**

Elective I

S. No.	Course Code	Subject
1	MM4105	Advanced Processing of Materials
2	MM4106	Environmental Degradation of Materials
3	MM4110	Mathematical Modeling and Computer Application in Materials Processing
4	MM4128	Solidification of Metals and Alloys

SEMESTER II

S. No.	Course Code	Subject	L-T-P	Credits
1	MM4201	Powder Processing and Technology	3-0-2	4
2	MM4202	Characterization of Materials	3-0-2	4
3	MM4229	Inspection, Quality Control and Management	3-0-2	4
4	MM4230	Advanced Foundry Technology	3-0-2	4
5	MM42XX	Elective II	3-0-2	4
		TOTAL	**15-0-10**	**20**

Elective II

S. No.	Course Code	Subject
1	MM4231	Manufacturing Processes
2	MM4232	Structure and Properties of Materials
3	MM4205	MEMS and NEMS
4	MM4233	Joining of Materials
5	MM4234	Geo-Metallurgy

SEMESTER III

S. No.	Course Code	Subject	L-T-P	Credits
1	MM4301	Thesis Part-I Seminar		16 04
		TOTAL		**20**

SEMESTER IV

S. No.	Course Code	Subject	L-T-P	Credits
1	MM4401	Thesis Part--II		20
		TOTAL		**20**

SEMESTER I

MM4101 Thermodynamics and Kinetics of Materials: **4 Credits (3-0-2)**

Introduction and important thermodynamic functions : Laws of thermodynamics - enthalpy, heat capacity, entropy, free energy and their interrelationships; Solutions - chemical potential, Raoults and Henrys law, Gibbs-Duhem equation, activity determination, properties of different solutions, quasichemical theory; Heterogeneous systems -equilibrium constants, Ellingham-Richardson diagrams, predominant area diagrams; Evolution of Phase diagrams-phase rule, free-energy composition diagrams, solidus-liquidus lines, retrograde solidus; Interfaces - energy, shape, segregation at external and internal interfaces; Point imperfections in crystalline solids-elementary and compound crystals.

MM4102 Transport Phenomena in Materials Processes: **4 Credits (3-0-2)**

General equations of heat, mass and momentum balance, laminar, turbulent flow, concept of boundary layer, friction factor, heat and mass transfer coefficients and dimensionless correlations. Laminar and turbulent flow and its application in Metallurgical processes-analysis of metallurgical packed and fluidized bed, fluid-flow in gas-agitated systems. Conductive, convective and radiative heat transfer in metallurgical systems-heat transfer around single bubble/particle, in metallurgical packed and fluidized bed, liquid steel ladles. Mass transfer rates involving diffusion, convection, and its application in homogeneous and heterogeneous systems

MM4126 Metal Melting Technology: **4 Credits (3-0-2)**

Melting furnaces for ferrous and non ferrous foundries. Electric and fuel fired furnaces. Recent developments in energy considerations. Melting practice for carbon steel and alloy steel, stainless steel, Manganese steel, high alloy aircraft, quality steel and super alloys. Secondary refining of melting of cast iron-gray, malleable C.G., S.G., Ni-hard, Ni-resist, high silicon iron.Inoculation methods and materials. Melting practice of non-ferrous alloys of Al, Cu, Mg, Zn and Ni, Refining, Deoxidation, degassing and grain refinement treatments. Heat treatments of castings, Shop floor melt quality tests, Rapid solidification, Near net shape casting.

MM4127 Heat Treatment Technology: **4 Credits (3-0-2)**

Time-temperature parameters of a heat treatment process; classification of heat treatment processes; heat treatment as applied to the products of steel-making industry, machine building and automobile industry, tool making industry, etc.; heat treatment defects and their rectification, modernization of heat treatment processes for near net shape applications and surface treatments; energy efficiency in heat treatments; furnace atmospheres and their production, heating and cooling media and their characteristics; calculations on heating and cooling of charges; equipment of heat treatment shops and their selection; mechanization, automation, design and layout of heat treatment shops.

Elective I

MM4105 Advanced Processing of Materials: **4 Credits (3-0-2)**

Rapid solidification, Powder processing, Preparation and consolidation of nanopowders, Sintering, Spark Plasma and Microwave sintering, Shock compaction, Severe plastic deformation, Mechanical Alloying, near-net-shape forming, self-sustaining high temperature synthesis, sol-gel processing, zone refining, molecular beam epitaxy, laser processing, EDM, etching, glass-ceramic seals, solid oxide fuel cells, armor ceramics, Processing and manufacturing technologies for non-oxide and oxide based structural ceramics, composites, multifunctional materials; Stereolithography (SLA), selective laser sintering (SLS), direct metal laser sintering; (DMLS) and laser engineered net shaping (LENS), Spray formed tooling for rapid manufacture, Plasma spray coating; Preparation of single crystals, doping, sputter coating, CVD and EVD process.

MM4106 Environmental degradation of materials: **4 Credits (3-0-2)**

Degradation of materials: Oxidation, corrosion and wear. Basics of thermodynamics and kinetics of oxidation and corrosion.Pourbaix diagram, Polarization, Mixed potential theory. Passivity, Characteristics of passivation, Degradation of composites; Corrosion: Fundamentals of corrosion studies. Different types of corrosion. Atmospheric, galvanic, pitting, crevice corrosion, intergranular and de-alloying. Stress corrosion cracking, season cracking, Hydrogen damage and radiation damage. Hydrogen embrittlement.Corrosion rate measurement. Weld-decay and knife line attack. Tafel's extrapolation.Oxidation and hot corrosion of materials at high temperature.Kinetics of oxidation.Pilling-Bedworth ratio. ; Prevention of degradation: Alloying environment, environmental conditioning, design modification, cathodic and anodic protection, organic and inorganic coating, inhibitors and passivators, Wear resistant coating.

MM4110 Mathematical Modeling and Computer application in Materials Processing:

4 Credits (3-0-2)

Mathematical modeling: Basic equations of diffusive, convective heat, mass, momentum transfer, turbulent system and concept of friction factor, heat & mass transfer coefficients and correlations. Formulation of mathematical model. Case studies. Numerical solution of partial differential equations.

Physical Simulation: Experimental design based on dimensional analysis, similarity criteria, case studies.

Reactor Design: Ideal reactors (PFR, CSTR), real reactors, characterization of these reactors, chemical performance of reactors, Modeling/design of reactors.

Thermodynamic modeling: Phase prediction using first principles and CALPHAD approach; Structure-property relationship using molecular dynamic simulation; Processing – microstructure correlation using finite element and phase field simulation methods.

MM4128 Solidification of Metals and Alloys: **4 Credits (3-0-2)**

Thermodynamic conditions for solidification, Solidification as atomic process Nucleation and heat flow. Stability of nuclei and conditions for growth- Growth rate and heat flow relationships-Controlling factors. Structure of cast metals and alloys. Distribution of solutes during solidification, and seggregations. Solidification in continuous casting. Centrifugal casting.Chilled castings-effect of pressure and other variables. Unidirectional solidification of castings and effect on properties.

SEMESTER II

MM4201 Powder Processing and Technology: **4 Credits (3-0-2)**

Different methods of Powder Production, Characterization of Powders, Compaction of metal powder, die compaction, Isostatic compaction, Injection molding, Pressureless Sintering: Mechanism and Method, Laser Sintering, Spark Plasma Sintering, Microwave Sintering, Hot pressing/ Isostatic Pressing, Dynamic Consolidation/Explosive Compaction, Powder forging/ rolling/ extrusion, Post Sintering process, Application of Powder Metallurgy: Nanostructured Materials, Heterogeneous Microstructures.

MM4202 Characterization of Materials: **4 Credits (3-0-2)**

Optical Metallography techniques like polarized light microscopy, DIC, fluorescence, etc.; Diffraction Methods like texture measurement, residual stress analysis, EXAFS, neutron diffraction, etc.; Electron Optical and related techniques like TEM, SEM, EDS, WDS/EPMA, CBED, HREM, EELS, etc.; Surface Analysis and related techniques like Auger, XPS, SIMS, RBS, STM, AFM, etc.; Thermal Analysis like DTA, DSC, TGA, TMA, etc.; Spectroscopy Techniques like optical emission spectroscopy, atomic absorption spectrometry, x-ray spectrometry, infrared spectroscopy, Raman spectroscopy, electron spin resonance, nuclear magnetic resonance, Mossbauer spectroscopy, etc.; Electrical Resistivity measurement.

MM4229 Inspection, Quality Control and Management: **4 Credits (3-0-2)**

Analytical instruments used for inspection in industries: Ultrasonic testing, magnetic particle testing, eddy current testing, radiography, acoustic emission, thermal imaging method. Comparision and selection of NDT methods.

Aims and objectives of quality control: Quality -philosophy, cost of quality; overview of the works of Juran, Deming, Crosby, Taguchi; quality loss function; PDCA cycle. quality control; quality assurance; quality audit; vendor quality assurance.

Quality control: Control charts, Control using mathematical model. Linear programming CPM & PERT, multiple linear regression analysis. Application of computer for complete automation in industries.

Statistical quality control: Review of some calculation procedures involving statistics and probability; exposure to some applications of statistics and probability; distribution functions; normal distribution curve. Variations; analysis of variance – statistical tools – statistical quality control; control charts; process capability analysis; statistical process control; introduction to six sigma Inspection; inspection by sampling; acceptance sampling; statistical approaches; single, double and multiple sampling plans; statistical design of experiments.

Quality organization; quality management; quality system; total quality management; quality awards; quality certification; typical procedure for ISO 9000, ISO 14000, QS 9000.

MM4230 Advanced Foundry Technology: **4 Credits (3-0-2)**

Recent developments in design, materials and methods of manufacture of patterns. Modification in casting design with reference to foundry and metallurgical principles.Principles design and methods involved in gating and risering of ferrous and non-ferrous castings. Recent developments in materials and methods of mould and core making such as high pressure moulding. V- process, magnetic moulding, Sodium silicate based processes, shell process, Hot box, cold box, full moulding etc. Moulding and sand conditioning equipments. Sand reclamation, principles, technology and scope of sand casting processes, Non-metallic mould etc. Precision casting processes. Principles, technology and scope of Die casting. Continuous casting, investment casting. Slush casting. Casting defects, metal-mould reactions, metal penetration and burn-out etc. general principles and objectives of foundry mechanization and lay out. Special casting processes: Investment casting, Die casting, centrifugal casting, full mould casting, vacuum shield casting etc. Industrial melting practices: Aim of melting and melting practices as adopted in case of Cast Irons, Steel, Cu, Al and its alloys.

Elective II

MM4231 Manufacturing Processes: **4 Credits (3-0-2)**

General structure and properties of engineering materials, classification of common materials, their unique properties and applications; metals and alloys, glass and ceramics, polymeric materials and composites, behavior, testing and manufacturing properties of these materials. Concepts of manufacturing, basic principles of engineering manufacturing; shaping, joining, removal and regenerative processes, methods of applications of common manufacturing processes; performing by casting, forging, rolling, melting, injection and compression moulding, extrusion and drawing, press tool work, powder processing etc., finishing by machining, grinding and superfinishing, Non-traditional manufacturing by chemical. Electro-chemical, electrophysical and mechanical processes

MM4232 Structure & Properties of Materials: **4 Credits (3-0-2)**

Materials in Engineering Design- Metals, Polymers, Ceramics, Composites, Properties of engineering materials relevant to failure Atomic Structure of Metals-Crystalline solids, Polycrystalline solids, grains and grain boundaries Metals and Alloys: microstructures, their effect on mechanical properties and their control -Plastic deformations in metals, Elements of fracture mechanics, High temperature creep, Corrosion Microstructure control in metal alloys-Solidification, Solid state diffusional transformation, Precipitation, nucleation and growth, dispersion strengthened alloys Case studies-Light alloys (Al & Ti), Steels and Ni superalloys Molecular Structure of Polymers-Polymerisation, Molecular architecture, Co-polymerisation Thermoplastics and thermosets Mechanical Properties and Testing-Elastomers, Brittle Materials, Semicrystalline Polymers Ageing and Failure Blends and Composites, Case Studies-Thermoplastics, Composites Material Characterization-Mechanical Properties, Structural Characterization

MM4205 MEMS and NEMS: **4 Credits (3-0-2)**

Micro and nano mechanics – principles, methods and strain analysis, an introduction to micro sensors and MEMS, Evolution of Microsensors& MEMS, Microsensors& MEMS applications, Microelectronic technologies for MEMS, Micromachining Technology – Surface and Bulk Micromachining, MicromachinedMicrosensors, Mechanical, Inertial, Biological, Chemical,Acoustic, Microsystems Technology, Integrated Smart Sensors and MEMS, Interface Electronics for MEMS, MEMS Simulators, MEMS for RF Applications, Bonding & Packaging of MEMS, Conclusions & Future Trends. Nanoelectromechanical systems (NEMS) – a journey from MEMS to NEMS, MEMS vs. NEMS, MEMS based nanotechnology – fabrication, film formation and micromachining, NEMS physics – manifestation of charge discreteness, quantum electrodynamical (QED) forces, quantum entanglement and teleportation, quantum interference, quantum resonant tunneling and quantum transport, Wave phenomena in periodic and aperiodic media – electronic and photonic band gap crystals and their applications, NEMS architecture, Surface Plasmon effects and NEMS fabrication for nanophotonics and nanoelectronics, Surface Plasmon detection – NSOM/SNOM

MM4233 Joining of Materials: **4 Credits (3-0-2)**

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, 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. 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; 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 the processes, consumables used, methods of brazing, fluxes used, their purposes and flux residue treatment.

MM4234 Geo-Metallurgy:

UNIT-I:

Natural resources: Ore minerals, refractories and fluxes required for extraction of metals, Geological and geographical occurrences of minerals, Classifications of minerals, Basic idea about Rock types, origin of minerals and types of mineral deposits,

UNIT-II:
Quality Control in Raw material handling plant in industries: Properties of ore minerals or flux required for extraction of a metals, Characterisation of minerals, Knowledge of BIS and other codes for methods of characterisation,

UNIT-III:
Mineral Beneficiation: Equipments, Processes and Steps involved in mineral beneficiation-Liberation, Comminution, Principles of crushing, grinding and Grindability. Evaluation of particle size, Size distribution curves and their significance. Mechanism of breakage of material, Industrial screening, classification. Dry and wet classifiers. Free and hindered settling, Thickeners, hydrocyclones, filtration, agitation and mixing, tabling, jigging, magnetic and electrostatic separation. Surface behavior and flotation principles. Flotation machines. Elements of hydrometallurgy, microbial leaching etc.

UNIT-IV:
Case studies: Beneficiation flow sheets of Ores of Iron, copper, lead, zinc, coal etc.
Application of Beneficiation processes: Effective utilisation of industrial waste like coal ash, tailing deposits, slimes etc for converting waste to wealth.

UNIT-V:
Basic Idea about Rules, Regulations, Safety and environmental issues related to Mineral Based Industries: Legislation and code of practice in regard to pollution and pollution control, Environmental Protection act, Knowledge of mineral legislations e.g. MMRD, MCR, FRA etc.

Text Book:
1. Principles of Mineral Dressing by A. M. Gaudi
2. Will, B. & Napier-Munn, T., 2006. Wills' Mineral Processing Technology, Elsevier Science & Technology Books, ISBN: 0750644508.

Reference Book:
1. Principles of Floatation by K. L. Sutherland and I. W. Wark
2. Mixing Theory and Practice by C. W. Clump and V. W. Uhl.
3. Handbook of Mineral Dressing : Ores and Industrial Minerals by A. F. Taggart.