SEMESTER I

18YN01 STATISTICAL QUALITY CONTROL AND DESIGN OF EXPERIMENTS 2 2 0 3

STATISTICAL QUALITY CONTROL: Methods and philosophy of statistical process control – chance and assignable causes of variation, statistical basis of control charts - control charts for variables - \( \bar{X} \), R, and s charts - control charts for attributes – p, np, c and u charts.

ACCEPTANCE SAMPLING: Lot-by-Lot acceptance sampling for attributes – single sampling plans for attributes, double, multiple and sequential sampling plans, acceptance sampling by variables - chain sampling, continuous sampling, skip-lot sampling plans.

DESIGN OF EXPERIMENTS: Fundamentals of experimental design, guidelines for designing experiments, analysis of variance, experiments with one factor, completely randomized design, randomized block design, factorial experiments, Latin square design.

RESPONSE SURFACE METHODOLOGY: Empirical models – linear regression models, estimation of parameters in linear regression models, confidence interval and hypothesis testing in multiple regression, 2^k factorial design – 2^3 design, general 2^k design, single replication of 2^k design, design for fitting second order models – class of central composite design.

REFERENCES:

18YN02 PHASE TRANSFORMATIONS 3 2 0 4


FUNDAMENTALS OF PHASE TRANSFORMATIONS: Time Scale for phase transformations, types of transformations-spinoidal, nucleation & growth, theory of transformation kinetics- kinetics of solid state reactions occurring at elevated temperatures, liquid, solid state and dissociation reactions, nucleation and growth-nucleation kinetics, homogeneous nucleation, heterogeneous nucleation, growth and overall transformation kinetic - Sintering & crystallization in ceramics and glass forming systems.

SOLID STATE DIFFUSIVE TRANSFORMATION: Classification, Nucleation and growth - homogeneous and heterogeneous mechanism, Precipitate growth under different conditions, Age hardening, Spinoidal decomposition, Precipitate coarsening, Transformation with start range diffusion, Moving boundary transformations recrystallization, grain growth, eutectoid transformation, discontinuous reactions


REFERENCES:

18YN03 MECHANICAL METALLURGY 2 2 0 3

PLASTIC DEFORMATION OF MATERIALS: Theoretical Cohesive strength and practically measured strength, Dislocations, Burger's Vector, Stress fields and Energies of dislocations, Deformation by slip – Critical resolved shear stress, Deformation by twinning, Perfect and imperfect dislocations, Forces between dislocations, Intersection and cutting of dislocations, Dislocation multiplication – Frank-Read sources, Dislocation pile-up’s.

REFERENCES:
59th ACM

STRENGTHENING MECHANISMS - Grain size strengthening-solid solution strengthening-factors affecting solid solution strengthening, martensitic strengthening, precipitation hardening-conditions for precipitation hardening-aging-formation of precipitates-coarsening of precipitates, mechanism of strengthening-dispersion strengthening.


REFERENCES:

18YN04 CHARACTERIZATION TECHNIQUES

LIGHT MICROSCOPY: Macro examination, principle and working of optical microscope, specimen preparation, optical principles - numerical aperture, resolving power, depth of focus, depth of field, aberrations in optical microscopes and their remedial measures, different microscopic techniques-dark field microscopy, phase-contrast microscopy, polarized light microscopy, interference microscopy, high temperature microscopy; quantitative metallography.

X-RAY DIFFRACTION: X-Ray Radiation–Properties, Generation of X-rays, X-ray absorption, Diffraction-Bragg's law, Reciprocal Lattice, Laue's, rotating crystal and powder diffraction methods, X-ray diffractometer - principle, equipment and applications, X-ray filters and counters, Applications- Determination of crystal structure, lattice parameter, Crystallite Size calculation, Residual stress measurements.

TECHNIQUES OF ELECTRON MICROSCOPY: Electron specimen interactions, electron optical instruments, transmission electron microscopy - specimen preparation, imaging modes, applications, selected area diffraction, scanning electron microscopy - operating modes and applications, electron probe microanalyser-qualitative and quantitative analysis, vacuum systems for electron microscopy.


REFERENCES:

18YN05 CASTING TECHNOLOGY

INTRODUCTION, PATTERNS, FOUNDRY SANDS: Types and foundries, various operations involved in foundries, Comparison of Solidification route with other manufacturing routes. Patterns - Types, design of patterns, Allowances, material selection and manufacture of patterns. Foundry Sand: Functional requirements moulding sand, types of moulding sand, preparation of mould sands, testing of moulding sand, Cores – types, core sand preparation, core supports.

MOULDING AND CASTING PROCESSES: Classification of moulding processes, mould materials, bonds formed in moulding aggregates, green sand moulds, dry sand moulding, loam moulding, CO₂ moulds, shell moulding, Resin binder processes, plaster moulding processes, ceramic moulding processes, investment casting processes, graphite moulding processes, permanent mould casting processes, die casting processes, centrifugal casting processes, continuous casting processes, Squeeze casting, semi solid metal casting, directional solidification processes, CLA process, Thixocasting and Rheocasting processes.
MELTING FURNACES AND ENERGY CALCULATIONS: Types of furnaces, Construction and operation of electric arc furnace (Direct and Indirect Arc). Core and core less induction furnace, cupola, rotary and crucible furnaces-Furnace design- cupola, crucible, Induction furnace - Energy audit, energy calculations, metal utilization, energy utilization-simple problems.

DESIGN CONSIDERATIONS AND CASTING DEFECTS: Casting design, methoding, Gating and Risering calculations, improvement of yield and efficiency, simple problems in gating and risering for steels and cast irons. Casting defects - Identification, analysis and Remedies. Fish bone diagram, FMEA and Y - Y analysis.

REFERENCES:

18YN51 MICROSTRUCTURAL ANALYSIS LABORATORY

LIST OF EXPERIMENTS:
1. Macro and Micro Examination of Castings and Welds.
2. Inclusion rating of Steels and Grain size measurement in Ferritic and Austenitic Steels.
3. Assessment of morphology and characteristics of graphite in various cast irons.
4. Identification of plain carbon and alloy steels from their microstructures.
5. Determination of mechanical working and heat treatment condition of steels.
6. Evaluation of ferrite and austenite content in different types of stainless steels.
8. Microstructural examination of Al – Si Cast Alloys, Brasses and Bronzes.
10. Investigations on surface modified and hardened steels and tool steels.

REFERENCES:
1. Laboratory manual prepared by the Department of Metallurgical Engineering.

SEMESTER II

18YN06 THERMODYNAMICS AND KINETICS OF MATERIALS

INTRODUCTION FIRST LAW OF THERMODYNAMICS: System and surrounding, classification of systems, path and state properties, thermodynamic processes - First law of thermodynamics thermodynamic equilibrium, reversible and irreversible processes, intensive and extensive properties, Heat and work, internal energy, heat capacity of materials, enthalpy, thermodynamic processes.


REFERENCES:
18YN07 JOINING OF MATERIALS

INTRODUCTION: Joining techniques, welding processes and grouping, welding terms, AWS specifications for classification

ARC PHYSICS: Plasma, electron emission and ionization potential, arc temperature, influence of magnetic fields on arcs, arc blow, metal transfer, effect of polarity, effect of shielding gases. POWER SOURCES: Static and dynamic characteristics, CC and CV power source designs, current and voltage relationships, solid state power sources, waveform controlled power sources. (11)

HEAT FLOW IN WELDING: Heat transfer in weldments, dissipation of welding heat, cooling rates, weld metal cooling curves, peak temperature, calculating width of heat affected zones, solidification rate and effects of heat input.

PROCESSES: Shielded metal arc welding, gas metal arc welding, flux cored arc welding, gas tungsten arc welding: process equipment, control of parameters, consumable specifications for electrodes and filler metals and applications. (12)

PROCESSES: plasma arc welding, submerged arc welding, stud arc welding, process equipment, control of parameters, consumable specifications for electrodes and filler metals and applications. (12)


WELDING DEFECTS: Causes and remedial methods, Residual Stresses and Distortion, Safety in Welding Introduction to Welding Metallurgy (11)

REFERENCES:

18YN08 PHYSICAL METALLURGY OF ALLOYS

ALLOY STEELS: Introduction to plain carbon steels, effect of alloying elements in Fe-Fe-C diagram - Physical metallurgy, composition, structure, property, effect of alloy elements, heat treatment and applications of maraging steels, HSLA and microalloyed steels, armour steels, DP steels, IF steels, TRIP steels, bainitic steels, silicon steels, high manganese steels, tool steels and steels for high temperature application. (12)

STAINLESS STEELS: Physical metallurgy, composition, structure, property, effect of alloy elements, heat treatment and applications of ferritic, martensitic, austenitic, precipitation hardening, duplex, Nickel free stainless steels, high nitrogen stainless steels (HNS) - Sensitization - causes and remedial measures for stainless steels - classifications by AISI system. (10)

ALUMINUM, COPPER AND MAGNESIUM ALLOYS: Classification, designation, composition, heat treatment, microstructure, properties physical metallurgy and composition of pure aluminium and its alloys strengthening mechanisms in non-heat treatable alloys and heat treatable alloys; introduction to Al-Li alloys - Classification, designation, physical metallurgy, composition, heat treatment, microstructure, properties and composition of pure copper and its alloys. - Properties and applications of magnesium and magnesium alloys; influence of alloying elements-Al, Mn, Zn, Si, Ag, Th, Zr; classification-cast alloys and wrought alloys. (13)

TITANIUM AND NICKEL: Classification, effect of alloying elements, heat treatment, microstructure, physical metallurgy, properties and applications of Titanium and its alloys -Alpha stabilisers; beta stabilisers; Metallurgy of nickel base alloys-Alloying elements and their effects-Nickel base super alloys, types, composition, physical metallurgy, properties and applications. Other nonferrous alloys zinc, tin, lead, refractory materials, zirconium alloys, rare earth metals. (10)

REFERENCES:

18YN09 FORMING AND PARTICULATE TECHNOLOGY


POWDER METALLURGY: Introduction – brief description on stages in P/M processing – production - consolidation: compaction and sintering, plastic forming-rolling, extrusion and forging, secondary and finishing operations, applications

REFERENCES:

18YN52 MATERIALS TESTING AND CHARACTERIZATION LABORATORY

LIST OF EXPERIMENTS:
1. Hardness test, Impact test and Tension Test.
2. Wear Test
3. Non Destructive Testing
4. Corrosion Test
5. Quantitative Metallography and Optical emission spectroscopy
6. Determination of crystal structure, lattice parameter using XRD
7. Determination of crystallite size and lattice strain using XRD
8. Scanning Electron Microscopy imaging and EDS
9. Failure analysis using Scanning Electron Microscopy

18YN61 INDUSTRY VISIT & TECHNICAL SEMINAR

VISIT TO INDUSTRIES: Study tour/Industry visit. Reports are to represent the observations of the students after the visits with their personal comments/suggestions.

TECHNICAL SEMINAR : Lectures by experts preferably from industries to highlight the recent technical and soft skill trends.

SEMESTER III

18YN53 COMPUTATIONAL MATERIALS LAB

LIST OF EXPERIMENTS
1. Introduction to CALPHAD approach and Thermo Calc software, Free energy calculation.
2. Construction of binary and ternary phase diagrams and label primary phases using Thermo Calc software. (Fe-Fe3C system, Fe- Cr system, Al-Si system, Fe-Cr-Ni system and etc)
3. Construction of the property diagram and calculation of amount of phases for multi component alloy systems using Thermo Calc software. (Alloy steels and nonferrous alloys)
4. Construction of isothermal and non- isothermal cooling curves for various ferrous alloys using TC-PRISMA.
5. Study of precipitation kinetics in alloy steels using TC- PRISMA.
6. Study of precipitation kinetics in non ferrous alloys using TC- PRISMA.
7. Simulation of Scheil Solidification of ferrous and non ferrous alloys using Thermo Calc software.
8. Study of diffusion behavior of carbon in steels using DICTRA.
9. Study of homogenization of a binary Fe-Ni alloy using DICTRA.
10. Study of diffusion behavior of dissimilar weldments using DICTRA.

18YN71 PROJECT WORK - I

COURSE CONTENT:
1. Identification of a real life problem in thrust areas of metallurgy and materials.
2. Developing a suitable methodology for solving the above problem.
SEMESTER IV

18YN72 PROJECT WORK – II

Identification of a real life problem in thrust areas, literature survey, experimental work, results and discussion, paper writing, thesis writing.

ELECTIVES

WELDING

18YN10 WELDING METALLURGY

3 0 0 3

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

WELDABILITY AND WELDABILITY TESTING: Factors affecting weldability, cold cracking tests, hot cracking tests, Glebe test, Mechanical tests (emphasis on tension and bend tests) (11)

WELDING OF CARBON STEELS AND LOW ALLOY STEELS: Phase transformation, Hydrogen induced cracking, carbon equivalent, preheating and post heating, solidification cracking, lamellar cracking, reheat cracking.

WELDING OF CAST IRONS: Weld metal and HAZ microstructures, Defects and remedies, Filler metal selection. (11)


WELDING OF ALUMINIUM ALLOYS: Oxide formation, Hydrogen solubility, Difficulties due to electrical and thermal characteristics, sensitivity to weld cracking. Filler metal selection. Weldability of heat treatable and non-heat treatable aluminium alloys. (12)


Total L: 45

REFERENCES:

18YN11 WELDING PROCESSES AND QUALIFICATIONS

3 0 0 3

PROCESSES & WELDING METALLURGY:

CODE PRACTICE
Familiarization of codes: Section IIC, Section IX of ASME B&PV Essential variables, non-essential variables, Supplementary essential variables WPS formats, PQR formats and WPQ formats Test requirements: Range qualified for varying values of essential values (12)

WELDING PROCEDURE SPECIFICATIONS (WPS) – FERRITIC STEELS
Preparation of WPS’s for metal joining for Process variation: SMAW, GTAW, GTAW+SMAW, GMAW, SAW, SAW+SMAW, GTAW+SMAW Material variation: Carbon steels, Low Alloy Steels, Cr-Mo Steels Post Weld Heat Treatment: No PWHT, Stress Relieving, Other Heat Treatments Thickness: 2 to 200 mm. Model WPSs of all the above categories and combinations to be prepared. (11)

WELDING PROCEDURE SPECIFICATIONS (WPS) – STAINLESS STEELS AND NON-FERROUS ALLOYS
Preparation of WPS’s for metal joining for Process variation: SMAW, GTAW, GTAW+SMAW, GMAW, SAW, SAW+SMAW, GTAW+SMAW Material variation: Stainless steels, Nickel alloys, Copper alloys, Titanium alloys, Al Alloys. Preparation of WPS’s for dissimilar metal joining for Process variation. SMAW, GTAW+SMAW Material combination: Carbon steel to low alloy steels, Stainless steels to carbon steels, Copper alloys to carbon steels, Low alloy steels to another low alloy steel. Preparation of WPS’s for weld overlaying of Stainless steels over carbon steel, Nickel alloys over carbon steels, Cu alloys over carbon steels, Stellite over carbon steels / stainless steels Model WPS of all the above categories and combinations to be prepared. (11)
Preparation of PQRs for selected WPSs for butt welding, fillet welding and weld overlay. Model PQRs to be prepared for WPSs for butt welding, fillet welding and weld overlay.

REFERENCES:

18YN12 WELDING CODES AND STANDARDS


MATERIALS AND CONSUMABLES: Classification of materials: Ferrous and Non Ferrous, Compositions, mechanical properties, for various shapes – plates, forgings, castings, wires, rods and pipes. As per ASTM, ASME B&PV II A and II B Classification of welding electrodes and filler metals for various processes like SMAW, GMAW, GTAW, SAW and for materials like carbon steels, low alloy steels, stainless steels, cast irons, hard facing alloys, nickel alloys, copper alloys, aluminium alloys and titanium alloys. Compositional features, mechanical properties and other tests. Consumable qualifications. As per AWS Specs / ASME B&PV I IC

STRUCTURAL WELDING CODES: General requirements of structural fabrications, welding symbols, Welded connections, nontubular and tubular members, static loading, cyclic loading, Joint configurations, Groove welds, Fillet welds, plug and slot welds, Built up members, calculation of stresses, stress ranges, Prequalification of WPS, Temperature requirements, Minimum preheat and interpass temperatures, PWHT, Welding personnel qualifications, Weld types, preparation of WPSs. Testing and acceptance criteria for SPS qualifications, welding consumable and electrode testing, distortion control, Inspection, NDT. As per AWS D1.1


PRESSURE VESSEL FABRICATION: Pressure vessel materials, Design, Openings and Reinforcements, Braced and Stayed Surfaces, Fabrication, Inspection and Tests, Marking and Reports, Overpressure Protection, Design requirements fabrication methods, joint categories, welding and inspection, post weld heat treatment and hydrotesting. As per ASME B&PV VIII-1.

REFERENCES:
2. ASME B&PV Code Section IX and Sections I, IIC, VIII Div 1, IX, 2015
3. API Code 1104: Welding of pipelines and related facilities.
4. AWS code D1.1 Structural welding – steel.

18YN13 WELDING CONSUMABLES

FLUX COATED ELECTRODES: SMAW electrodes for carbon steels, low alloy steels, stainless steels, Al alloys, Cu alloys, Ni alloys – Classification as per AWS, Requirements of mechanical properties, chemical composition, testing requirements, intended use of important electrodes Problems based on selection of flux coated electrodes based on flux characteristics, material to be welded, properties required / applications. Filler metal qualification as per Section IIC.

BARE WELDING ELECTRODES AND RODS: Bare welding electrodes and rods for carbon steels, low alloy steels, stainless steels, Al alloys, Cu alloys, Ti alloys– Classification as per AWS, Requirements of mechanical properties, chemical composition, testing requirements, intended use of important electrodes. Problems based on selection of bare welding electrodes and rods based on material to be welded, properties required / applications. Filler metal qualification as per Section IIC.

ELECTRODES AND FLUXES FOR SAW AND FLUX CORED ELECTRODES: SAW electrodes for carbon steels, low alloy steels, Fluxes, manufacturing methods, chemical nature; FCAW electrodes for Carbon steels, Low alloy steels, Stainless steels, Ni alloys. Classification as per AWS, Requirements of mechanical properties, chemical composition, testing requirements, intended use of important electrodes. Problems based on selection of electrodes and fluxes based on flux characteristics, material to be welded, properties required / applications. Filler metal qualification as per Section IIC.
SURFACING ELECTRODES, CAST IRON ELECTRODES AND RODS: Classification as per AWS, Requirements of mechanical properties, chemical composition, testing requirements, intended use of important electrodes. Problems based on selection of electrodes / rods based on material to be welded, properties required / applications. Filler metal qualification as per Section IIC.

BRAZING METALS, BRAZING FLUXES, TUNGSTEN ELECTRODES, SHIELDING GASES: Classification as per AWS, intended use, testing requirements. Shielding gases - Types, characteristics, physical properties, shielding properties, applications. Problems based on brazing metals, brazing fluxes, tungsten electrodes, shielding gases based on material to be joined, properties required / applications. Filler metal qualification as per Section IIC.

REFERENCES:

18YN14 DESIGN OF WELDMENTS


WELD DESIGN FOR STATIC LOADING: Material or section properties, Weld design stress calculation for welds, design under different types of loading like tension, compression, bending, shear, torsion and shock

WELD DESIGN FOR DYNAMIC LOADING: Basic details of fatigue and fatigue failure, S-N curve, Goodman diagram, factors affecting fatigue life of welded joint , methods of improving fatigue life of welded structures-design for fatigue loading, weld design using fracture toughness value (Kc).


REFERENCES:

18YN15 WELDING OF NICKEL ALLOYS


REFERENCES:
CASTING

18YN16 ADVANCED CASTING TECHNIQUES

INVESTMENT CASTING: Investment casting - pattern and mould materials - types of waxes - tests for pattern waxes - dewaxing methods - additives, resins, fillers used in investment casting - purpose of addition - process parameters - techniques and production of investment moulds - shaw process - full mould process - CLA and CLV processes - replicat - applications of investment casting process.

SHELL MOULDING AND CENTRIFUGAL CASTING PROCESSES: Shell moulding machines - Pattern equipment - sands, resins and other materials used for shell moulding - preparation of resin and sand mixture - process parameters - application of shell moulding - advantages of shell moulding - Types of centrifugal casting processes - calculation of mould rotary speeds - techniques, equipments and production processes - Advantages and limitations of centrifugal casting methods.

DIE CASTING AND OTHER CASTING PROCESSES: Methods, Permanent moulding, LPDC, PDC, VDC - Die casting machines - operation and details - Die materials - metals - cast by die casting method - advantages of die casting - Fluid sand process, V process - Graphite moulding process, Magnetic Moulding, Impulse moulding, high pressure moulding, ceramic moulding, cement bonded moulding.

SEMI SOLID METAL CASTING: Introduction, Rheology and Thixotropy, difference between conventional casting and semi solid metal casting processes, physical metallurgy of semi solid casting alloys, Slurry processing - Thixo Processes and Rheo processes, Mould and die preparation, furnaces, methods, machines, die casting materials and applications - Squeeze casting - methods and applications - Mechanical stirring, Magneto Hydrodynamic stirring (MHD), Non agitation: Cooling Slope casting - Solid route - Strain Induced Melt Activated (SIMA), Recrystallisation and Partial Melting (RAP), Direct Partial Remelting (DPRM), strip casting process.

REFERENCES:

18YN17 FOUNDRY METALLURGY


METALLURGY OF CAST METALS AND ALLOYS: Types, microstructures, properties, compositions, specifications IS, BS, EN and ASTM standards of various cast irons, steels, aluminium, copper, magnesium and zinc base alloys.

HEAT TREATMENT OF CASTINGS: Annealing, normalising, hardening and tempering of steels, microstructures of steels in as cast and various heat treated conditions. Construction of TTT and CCT diagrams – Austempering, martempering. Heat treatment practices for cast irons, aluminium, copper and other non ferrous alloys.

GASES IN CASTINGS, FLUIDITY, RESIDUAL STRESSES IN CASTINGS: Gases in metals and alloys, measurements of gases and Degassing Techniques - Fluidity - Definition, factors affecting fluidity and measurement of fluidity. Residual stresses in castings - Origin, effects and stress relieving operations.

REFERENCES:

18YN18 CASTING DESIGN AND SIMULATION

REFERENCES:
59th ACM

OVERVIEW OF CASTING PROCESSES: Introduction to casting simulations, types of casting simulation software, methoding and requirement for design of castings. Optimization of casting defects- Cause and effect diagram, Fish bone diagram, WHY method and FMEA.

CASTING DESIGN AND ANALYSIS: Minimum section thickness, hot spots and hot tears, junctions, ribs, and bosses. Design for moulding, core making and cleaning. Design for continuous casting.

COMPUTER SIMULATION OF CASTING PROCESSES: Mould filling simulation, solid modeling, thermal analysis, solidification simulation, feeder size and weight calculations and cost benefits of solidification simulation. Mold-metal filling optimization.


REFERENCES:

18YN19 QUALITY CONTROL IN FOUNDRIES

INTRODUCTION TO QUALITY CONTROL: Definition of quality control- need for quality improvement and control- dissemination of quality information- quality and cost analysis-quality control and inspection-responsibility for quality control- quality control through standardization- quality control organization. Quality planning, record and documents. Reliability engineering.


METHODS OF INSPECTION AND QUALITY APPRAISAL: Requirement for inspections – inspection of castings, equipment and techniques to be used- methods to reduce energy consumption in foundry-Environmental pollution control- inspection of castings-


REFERENCES:

18YN20 FOUNDRY PRACTICE FOR FERROUS AND NON FERROUS CASTINGS


LIGHT METAL CAST ALLOYS: Introduction to Al, Mg and Ti alloys, classification, specification and standards. Moulding- sand casting, chill casting and pressure die-casting; melting- furnaces, raw materials, fluxes, dross formation and lining materials and lining conditions. Refining of molten metal -degassing, grain refinement and modifications; Post casting operations- Fettling and heat treatment, Quality control- microstructure analysis, destructive and non destructive testing, defect analysis.

REFERENCES:

MATERIALS ENGINEERING

18YN21 IRON AND STEEL MAKING

INTRODUCTION: History of iron and steel making, evolution of modern steel making, overview of steel making in India and aboard, general layout of integrated steel plants; RAW MATERIALS AND THEIR PREPARATION: metallurgical coal, Coke manufacture - by-product coke ovens, iron ores, iron ore beneficiation, agglomeration methods - principle and mechanism of sintering, pelletisation, fluxes, testing of raw materials, raw materials for steel making, steel making refractories, pre-treatment of hot metal prior to steel making.

PHYSICAL-THERMAL-CHEMICAL PROCESSES IN IRON MAKING: physical, thermal and chemical profiles, physical chemistry of blast furnace reactions - carbon-oxygen reaction, gas-solid reactions, slag-metal reactions, desulphurisation and desiliconisation, RAFT calculation: BLAST FURNACE PLANT AND PROCESS: Layout, constructional features of the blast furnace, charging equipment, burden distribution, gas cleaning, hot blast stove, operational irregularities, metal and slag, High top pressure, bell-less top, pulsed coal injection, humidification of blast, pre-reduced ore;

ALTERNATE IRON MAKING: Sponge iron production methods and smelting reduction processes.

PHYSICAL CHEMISTRY OF STEEL MAKING: Thermodynamics, kinetics and transport phenomena in steel making, refining slags, slag - metal refining reactions. STEEL MAKING PROCEEDURES: Overview of Bessemer converters, open hearth practice, Electric arc furnace steel making, LD process - plant and equipment, steel making practice, slag-metal-gas interaction, oxygen bottom blown process, combined blowing processes, CONARC process, EOF process.

SECONDARY STEEL MAKING: Deoxidation, desulphurization, ladle furnace, decarburization methods, vacuum degassing methods, injection metallurgy. STEEL INGOTS - fundamentals of solidification, rimming, capped and killed steels, ingot defects;

CONTINUOUS CASTING OF STEEL - heat transfer and solidification in continuous casting, tundish design and operation, continuous casting of slabs and blooms, metallurgical defects.

REFERENCES:

18YN22 PRINCIPLES OF NON FERROUS EXTRACTION METALLURGY


METHODS OF EXTRACTION: Ore, mineral, methods of beneficiation and their principles. Pyrometallurgy-calcination, roasting and smelting, hydrometallurgy -leaching, solvent extraction, ion exchange and precipitation, electrometallurgy - electrolysis and electro refining, material and energy balance.

REFINING: methods of refining -ion exchange, solvent extraction, gaseous reduction, cementation, liquid –liquid extraction, liquration, zone refining, Extraction metals from oxide ores- magnesium, aluminium, tin.

METAL EXTRACTION: extraction of metals from sulphide ores- copper, zinc, nickel. Extraction of metals from halides ore-titanium and rare earth metals, uranium, thorium. Extraction of precious metals –gold, silver and platinum.

REFERENCES:
18YN23 PHYSICAL METALLURGY OF STAINLESS STEELS


SELECTION OF STAINLESS STEELS: Selection of stainless steels – marine, constructional, chemical storage tanks, Bio medical implants, instruments in medical, high temperature applications, instrumentation, case studies.

REFERENCES:

18YN24 PHYSICAL METALLURGY OF STRUCTURAL STEELS


HIGH STRENGTH STRIP STEELS: Low carbon strip steels and factors affecting cold formability, cold forming behavior process route followed for production of low carbon steel strip and effect of alloying elements on yield strength after temper rolling – Formability of high strength strip steel, coating of steel and Applications.

MICRO ALLOYED STEELS: Recent trends, Strengthening mechanism and Modern concepts of thermo mechanical controlled processing. Physical metallurgy concepts in explaining Strengthening mechanisms. Microstructural control to restrict brittle fracture in high strength line pipe steels, nano size particles and its effects.

MEDIUM STRENGTH AND HIGH STRENGTH STEELS: Secondary hardened steels and maraging steels, Effect of alloying elements such as Cr, Mo, Ti and Al on the microstructure, strength and fracture resistance of maraging steel. Recent trends in Secondary hardened steels. Third generation of AHSS steels, TWIP steels and TRIP steels and their applications. Low density steels and electrical steels and recent developments.

REFERENCES:

18YN25 HEAT TREATMENT AND SURFACE MODIFICATION

HEAT TREATMENT EQUIPMENT: Furnaces, Calibration of thermocouple, Quenching methods, fixtures, control of furnace atmosphere, temperature control, Design of heat treatment furnaces.


HEAT TREATMENT OF FERROUS ALLOYS: Stainless steels, Tool steels and Cast irons, maraging steels, HSLA steels and dual phase steels.


HEAT TREATMENT DEFECTS: Causes and remedies for defects.
SURFACE MODIFICATION TECHNIQUES: Flame and induction hardening, Carburising, nitriding, carbonitriding, bonding, electron beam and laser beam hardening, PVD and CVD processes, sputter coating, ion plating, ion implantation, spray coatings, shot peening, laser cladding, plasma coating.

REFERENCES:

18YN26 ENVIRONMENTAL DEGRADATION OF METALS


REFERENCES:

18YN27 NON-DESTRUCTIVE TESTING

NDE AS QUALITY TOOL: Historical disasters that affected the development of NDT, Concepts of Non-Destructive testing, NDT Qualification and Certification, Discontinuities and Defects, Introduction to codes and standards for NDT.

SURFACE TECHNIQUES: Visual Testing (VT), Direct and remote inspection, LASER Shearography, Penetrant Testing (PT): Principle and mechanics Applicability and limitations, Dyes, developers and cleaners, Fluorescent penetrant test. Practical demonstrations on VT and PT.


REFERENCES:

18YN28 CERAMICS AND POLYMERS

CERAMICS CRYSTAL SYSTEMS: Crystal Structures of Ceramics (Pauling's Rules), Silicate Structures, Structures of Covalent ceramics, problems on crystal systems, Structures of Glasses and properties, Simple problems involving Packing Fraction, critical radius ratio and density. Defects In Ceramics-Problems.


INTRODUCTION TO POLYMERS: Classification-thermoset, thermoplastics and elastomers. Structure of polymers- crystalline and amorphous polymers - concept of Glass Transition Temperature (Tg), Polymerization- types and mechanisms with examples, Degree of polymerization - molecular weight of polymers-problems, Polymer additives-Examples and properties, Applications of engineering plastics. Elastomers - types, properties, examples. and application.


REFERENCES:

18YN29 COMPOSITES

INTRODUCTION: Composite material – definition – classification. Examples and applications for each class.


POLYMER MATRIX COMPOSITES: Types- Processing-Thermal matrix composites – Hand layup and spray technique, filament winding, Pultrusion, resin transfer moulding, autoclave moulding-Thermoplastic matrix composites-Injection moulding, Film stacking – Diaphragm forming – Thermoplastic tape laying, Mechanical properties –Applications.

METAL MATRIX COMPOSITES: Matrices and reinforcements. Processing – Solid state, liquid state, deposition and insitu techniques MMCs applications.


CARBON / CARBON COMPOSITES: Processing, Properties and Applications.

PARTICULATE COMPOSITES: Types - True particulate and Dispersion strengthened composites - Function and examples of dispersoids - Particle size - interparticle spacing calculation- Examples of particulate composites. LAMINAR COMPOSITES: Types - Layered and honeycomb structures – examples manufacture and applications. Joining of composite materials, design of composites.

REFERENCES:

Total L: 45
18YN30 NANOSTRUCTURED MATERIALS

STRUCTURE AND PROPERTIES OF NANOMATERIALS: Definition-classification of nano materials-structure of nano materials-comparison with conventional materials; basic concepts - relationship between grain size and properties - physical properties- color, conductivity, Thomson effect, optical properties - surface plasmon effect, chemical properties - reactivity, mechanical properties - strength, hardness of nano sized particles.


CONSOLIDATION AND SPECIFIC NANOMATERIALS: Problems in consolidation, use of glove box, FAST technique – process variables, examples; High pressure shock consolidation – explosive forming, nano coatings – dip, plasma spray; Nano structures with high application potential: carbon nano structures – fullerenes, nano tubes, Quantum dots, GaN wires, nano TiO₂, nano ZnO – properties, applications and advantages.

APPLICATIONS: Structural – Continuous coatings for corrosive environments, electronic and optical applications-thin and multi layer capacitors, sensors and quantum dots, energy storage devices – fuel cells, catalysts, solar cells, efficient micro batteries, biomedical- valves for artificial hearts, internal drug release devices, case studies.

REFERENCES:

Total L: 45

18YN31 EMERGING MATERIALS

HIGH TEMPERATURE MATERIALS: Introduction– High and low temperature materials, superconductors, supra magnetic materials, high entropy alloys, dispersion strengthened alloys - their advantages and applications, intermetallics, superalloys, Refractories


METALLIC ANDCERAMICS MATERIALS: High strength alloys, quasicrystals, immiscible alloy systems and in-situ composites, metallic glasses, single crystals, metallic foams, shape memory alloys-advantages and applications. Insulators, ceramic matrix composites, biomaterials - their need, advantages and properties. Thin films, coatings, Glass Ceramics.


REFERENCES:

Total L: 45

18YN32 MATERIALS SELECTION


Total L: 45
MATERIALS SELECTION PROCESS: Materials selection methods: Screening, Ranking- weighted ranking, Performance indices-Materials selection charts, Deriving property limits and material indices, Structural indices. Shape factors, Efficiency of standard sections, Material limits for shape factors, Material indices which include shape, The microscopic or microstructural shape factor, Co-selecting material and shape.

CASE STUDIES ON KNOWN APPLICATIONS: Automobile materials (Body and Crank shaft), Marine structural materials (Hull and Propeller), Aircraft structural materials (Wings and landing gears), Materials for space (Gas turbines and Nose), Materials for power generation machinery (Boilers and Pressure vessels), Materials for medical applications (Surgical knives and Bone replacements), Chemical and petrochemical industries (Acid storage tanks and Fuel carrying pipes).

MATERIALS SELECTION PROJECT: Students will carry out a materials selection exercise for a hypothetical design project, identifying selection parameters and potential materials with the help of materials selection software.

REFERENCES:

18YN33 POWDER METALLURGY


POWDER CHARACTERISATION: individual particle characteristics, particle flow and packing characteristics – rheological behaviour of slurries - Newtonian fluid, plastic flow, dilatant liquid, thixotropy, deflocculation, zeta potential, applications in ceramic processing, Recent Developments.

CONSOLIDATION: Dry pressing – powder flow and die filling, compaction behaviour, ejection and transfer, die wall effects, control of compaction defects, cold isostatic Pressing. Casting process - slip casting, drying processes, mechanisms, defects. shaping, surface finishing, glazing, firing – firing system, pre sintering processes, sintering and vitrification.


REFERENCES:

18YN34 COATING TECHNOLOGY

ELECTROCHEMICAL TECHNIQUES: Chemical conversion coatings, phosphating, chromating, chemical colouring, anodizing of aluminium alloys, deposition of copper, zinc, nickel and chromium - principles and practices, alloy plating, Electro deposition- Electro composite plating.


THIN FILM COATINGS: Chemical Vapour Deposition, Physical Vapour Deposition- Electron Beam- Physical Vapour Deposition, Pulsed Laser Deposition, Sputtering- magnetic sputtering, Electron beam evaporation, Diamond Like Coatings (DLC).


REFERENCES:
1. Lech Paw Lowski , Science and engineering of thermal spray coatings, John wiley and sons Inc., 1999
18YN35 METALLURGICAL FAILURE ANALYSIS AND LIFE ASSESSMENT

INTRODUCTION: Concepts of failure analysis, root-cause analysis, design deficiencies, material defects, manufacturing defects, service life anomalies, charting methods of root cause analysis, categories of failures, failure prevention concepts; Practice of failure analysis: Scope and planning, stages of failure analysis, tools and techniques, fractography

FRACTURE & FAILURES: Mechanisms of deformation and fracture, ductile and brittle fractures, fatigue fracture, intergranular fracture, thermo-mechanical fatigue, overload failures, fatigue failures creep and stress rupture failures; corrosion related failures: forms of corrosion, hydrogen embrittlement, stress corrosion cracking, Wear failures: types of wear, impact wear, erosion wear; distortion failures

MANUFACTURING ASPECTS OF FAILURE: defects in weldments, castings, formed and heat treated components, failure related to welding, casting, metal forming, and heat treatment; Case studies on analysis of industrial components like shafts, bearings, springs, tools and dies, gears, pipelines, metallic orthopedic implants, components of boilers, pressure vessels, gas turbine engines, automobile components, aircraft components

STRUCTURAL LIFE ASSESSMENT METHODS: failure analysis and life assessment of structural components and equipment, failure analysis diagrams, analysis methods for probabilistic life assessment, non destructive evaluation and life assessment, fatigue life assessment, elevated temperature life assessment

REFERENCES:

18YN36 MATERIALS MODELING

CONCEPT OF SPECIFIC HEAT, ENTHALPY, ENTROPY AND FREE ENERGY: - Maxwell’s relations. Thermodynamics of pure systems - Gibb’s free energy change with temperature in a single component system - Clausius Clapyron equation - Surface Energy & under cooling, Nucleation – homogeneous & heterogeneous nucleation.


REFERENCES:

18YN37 METAL ADDITIVE MANUFACTURING

LIQUID BASED AND SOLID BASED ADDITIVE MANUFACTURING SYSTEMS: Classification – Liquid based system – Stereolithography Apparatus (SLA) - Principle, process, advantages and applications- Solid ground curing (SGC) - Solid based system – Fused Deposition Modeling - Principle, Process, advantages and applications, Laminated Object Manufacturing. Case studies: SLA, FDM , LOM.


REFERENCES:

18YN38 MICRO ELECTRO MECHANICAL SYSTEMS (MEMS) 3 0 0 3


MATERIALS FOR MEMS AND MICROSYSTEMS: Substrates and wafers-silicon as a substrate material, ideal substrates for MEMS. Single crystal Silicon and wafers crystal structure. Mechanical properties of Si. Silicon compounds-SiO2, SiC, Si3N4 and polycrystalline Silicon. Silicon piezoresistors. Gallium arsenide. Quartz-piezoelectric crystals. Polymers for MEMS. Conductive polymers.


REFERENCES:

Total L: 45
18YN39 LASER AND PLASMA PROCESSING OF MATERIALS

PRINCIPLES OF INDUSTRIAL LASERS: Principle of laser generation, optical resonators, LASER beam modifications and types of industrials lasers. LASER metallurgy -Process microstructure- fusion zone, zone of partial melting, HAZ, discontinuities- porosity, cracking, lack of fusion, incomplete penetration and undercut.

LASER WELDING AND SURFACE MODIFICATION: Process mechanisms (Key hole and Plasmas) – operating characteristics – process variations – imperfections- industrial applications –recent developments LASER surface heat treatment, LASER surface melting- Glazing, LASER direct Metal deposition– LASER surface alloying, LASER surface cladding and Hard coatings, LASER physical vapour deposition and LASER shock peening.


References:

18YN40 PROCESS MODELLING


Description of important extractive metallurgical processes (roasting, smelting, leaching, precipitation, electrolysis and refining) steps in their mathematical modelling. Concepts of batch and continuous processes in metallurgy. Determining the effect of controlling parameters, such as composition, temperature and particle size, concentration, pressure, gas/liquid/solid flow rate, stirring speed, current density and their Mathematical modeling. Case Studies on Modeling and Simulation of important metallurgical Processes. Melting of Scrap, Refining of Melt, Solidification, Re-heating, Heat Treatment, Fluid Flow in Ladle and Tundish.

Modelling of forming operations: Simple numerical models- Slab Method and the Upper Bound Method- Modelling of metal casting processes shape casting, direct chill casting and continuous casting.


18YN41 QUALITY SYSTEM MANAGEMENT

FOUNDATIONS OF TQM: Understanding quality, quality, competitiveness and customers, building quality chains, managing quality, quality in all functions, models and frame works for total quality management. Early TQM frameworks - quality award models - the four Ps and three Cs of TQM - a new model for TQM. Leadership And Commitment: The TQM approach - commitment and policy - creating or changing the culture - effective leadership - excellence in leadership.

DESIGN FOR QUALITY: Design, innovation and improvement - the design process - quality function deployment (QFD) - the house of quality - specifications and standards - design in the service sectors - failure mode effect and criticality analysis (FMEA) - The links between good design and managing the business.

PROCESS REDESIGN / ENGINEERING: Reengineering the organization - process for redesign - the redesign process - the people and the leaders. Human Resource Management: Introduction - strategic alignment of HRM policies - effective communication -
employee empowerment and involvement - training and development - teams and team work - review, continuous improvement and conclusions - organizing people for quality - quality circles or kaizen teams.


REFERENCES:

AUDIT COURSES

18YN81 ENGLISH FOR RESEARCH PAPER WRITING
vide Manufacturing Engineering 18PP81

18YN82 RESEARCH METHODOLOGY AND IPR
vide Manufacturing Engineering 18PP82