M.Tech. Degree

INDUSTRIAL METALLURGY

SYLLABUS
FOR
CREDIT BASED CURRICULUM
(2011 - 2013)

Department of Metallurgical and Materials Engineering
National Institute of Technology
Tiruchirappalli - 620 015

JULY 2011

M.Tech. INDUSTRIAL METALLURGY

The total minimum credits required for completing the M.Tech. programme in Industrial Metallurgy is **67.**

SEMESTER – I

CODE	COURSE OF STUDY	L	T	P	C
MA 613	Engineering Mathematics	3	0	0	3
MT 651	Physical Metallurgy	3	0	0	3
MT 703	Welding processes	3	0	0	3
MT 701	Foundry Technology	3	0	0	3
MT 657	Metallography Laboratory	0	0	3	2
	Elective - I	3	0	0	3
	Elective – II	3	0	0	3
					20

SEMESTER – II

MT 614	Corrosion Engineering	3	0	0	3
MT 702	Special Casting Processes	3	0	0	3
MT 704	Metal Forming Processes	3	0	0	3
MT 706	Non Destructive Testing	3	0	0	3
MT 658	Materials testing & characterization Laboratory	0	0	3	2
	Elective – III	3	0	0	3
	Elective – IV	3	0	0	3
MT 725	Summer Industrial Training	3	0	0	3
					23

SEMESTER – III

MT 747	Project Work Phase I	0	0	30	12
					12

SEMESTER – IV

MT 748	Project Work Phase II	0	0	30	12
					12
			Total Credits		**67**

ELECTIVES

I Semester

MT 613	Mechanical Behaviour of Materials
MT 617	Computational Techniques
MT 653	Materials Characterization
MT665	Particulate Technology
MT 721	Stainless steel Technology
MT 723	Design of Castings & Weldments
MT 725	Ferrous Foundry Metallurgy

II Semester

MT 618	Metallurgical Failure Analysis
MT 622	Surface Engineering
MT 666	Total Quality Management
MT 674	Developments in Iron and Steel making
MT722	Non Ferrous Foundry Metallurgy
MT724	Advanced Materials and Processing

MA 613 ENGINEERING MATHEMATICS

L	T	P	C
3	0	0	3

Partial Differential equations – basic concepts – One dimensional heat flow equation - Two dimensional heat flow equation in steady flow in Cartesian and Polar coordinates.

Calculus of variations - Euler's equation - Variational problems in parametric form - Natural boundary condition – Conditional Extremum - Isoperimetric problems.

Numerical Solution of ODE's – Euler's, Taylor's and Runge Kutta methods – Milne's and Adams' predictor-corrector methods.

Finite difference scheme for elliptic, parabolic, and hyperbolic partial differential equations.

Introduction to Finite Element Method - Rules for forming interpolation functions - Shape functions - Application to fluid flow and heat transfer problems.

TEXT BOOKS:

1. *Desai, C.S. and Abel, J. P., Introduction to Finite Element Method, Van Nostrand Reinhold.*
2. *Elsegolts, L., Differential Equations and the Calculus of Variations, Mir Publishers.*
3. *Grewal, B.S., Higher Engineering Mathematics, Khanna Publishers.*
4. *Reddy, J.N., Introduction to Finite Element Method, Mcgraw Hill.*

MT 651 PHYSICAL METALLURGY

L	T	P	C
3	0	0	3

(*This is a core course for both WE, ME and IM specializations in MME*)

Concept of phase diagram - phases and microconstituents in steels and cast irons - equilibrium and non-equilibrium cooling of various Fe-C alloys - effects of alloying elements and cooling rate on structure and properties of steels and cast irons

Introduction to heat treatment; TTT diagram and CCT diagram - hardenability measurement, annealing - normalising - hardening and tempering - heat treatment furnaces - atmospheres - quenching media - case hardening techniques

Introduction to specifications- types of steels: plain carbon steels, alloy steels, tool steels; stainless steels types of cast irons compositions, properties and applications, heat treatment (specific examples)

Aluminium and its alloys- physical, chemical and mechanical properties of aluminium of aluminium alloys, magnesium, titanium alloys - microstructural features, typical properties and applications - heat treatment (specific examples)

Copper and its alloys: physical, chemical and mechanical properties; classification of copper alloys; lead, tin, zinc, silver, gold alloys - microstructural features - properties and applications.

TEXT BOOKS:

1. *Avner, S. H., "Introduction to Physical Metallurgy", second edition, McGraw Hill, 1985.*
2. *Raghavan, V., "Physical Metallurgy", Prentice Hall of India, 1985.*

MT 703 WELDING PROCESSES

L	T	P	C
3	0	0	3

Classification of welding processes; Gas welding; Arc welding; arc physics, power source characteristics,

Manual metal arc welding: Concepts, types of electrodes and their applications, Gas tungsten arc welding: Concepts, processes and applications ; gas metal arc welding**,** Concepts, processes and applications ,types of metal transfer, CO_2 welding, , pulsed and synergic MIG welding, FCAW.

Submerged arc welding , advantages and limitations, process variables and their effects, significance of flux-metal combination, modern developments, narrow gap submerged arc welding, applications; electro slag and electro gas welding.

Plasma welding; Concepts, processes and applications, keyhole and puddle-in mode of operation, low current and high current plasma arc welding and their applications,

Resistance weding, Concepts, types and applications, Flash butt welding, Stud welding and under water welding

TEXT BOOKS:

1. *Parmer R. S., 'Welding Engineering and Technology', Khanna Publishers, 1997*
2. *Cary, Howard, "Morden Welding Technology', prentice Hall, 1998*

MT 701 FOUNDRY TECHNOLOGY

L	T	P	C
3	0	0	3

Comparison of Solidification route with other manufacturing routes. Types, design of patterns, Allowances material selection, manufacture of patterns

Classification of moulding proesses, mould materials, basic requirement of mould sands, preparation of mould sands, bonds formed in moulding aggregates, Resin binder processes, Sand mouldings – Bonded sand moulds and unbonded sand moulds. Core making processes, plaster moulding processes, ceramic moulding processes, investment casting processes, graphite moulding processes, permanent mould casting processes, die casting processes, types of centrifugal casting processes, continuous casting processes, new casting processes – Squeeze casting, semi solid metal casting, directional solidification processes, CLA process, Thixocasting and Rheocasting processes.

Construction use and operation of electric arc furnace [Direct and Indirect Arc], resistance furnace - core and core less induction, cupola, rotary and crucible furnaces.

Layout, mechanisation and automation, fettling, inspection and pollution control.
Casting design, methoding, Gating and Risering calculations, improvement of yield and efficiency, simple problems in gating and risering for steels and cast irons. Solidification and simulation of metal casting

Casting defects Identification, analysis and Remedies

TEXT BOOKS :

1. *Heine R.W., Loper and Rosenthal, "Principles of Metal Casting", Tata McGraw Hill. Pub. Co, 1998.*
2. *Srinivasan.N.K.,"Foundry Engg", Khanna Tech. Pub. Co, New Delhi, 1992.*
3. *ASM Handbook, Vol. 15, Casting, ASM Publication, 1998.*
4. *Jain.P.L., "Principles of Foundry Technology", Tata McGraw- Hill Publishing Co., Ltd, New Delhi 1995.*
5. *Peter Beelay, "Foundry Technology", Butterworth, Second Edition, 2001.*

MT 657 METALLOGRAPHY LABORATORY

L	T	P	C
0	0	3	2

List of Experiments

1. Study of metallurgical microscope and sample preparation
2. Microscopic examination of plain carbon steels,
3. Metallographic examination of cast irons
4. Metallographic examination of alloy steels
    - Stainless steels
    - Maraging steels
    - Tool Steels
5. Microscopic examination of Non Ferrous Metals and Alloys
    - Magnesium alloys
    - Aluminium alloys
    - Titanium alloys
    - Copper alloys
    - Super alloys
6. Microscopic Examination of Non Metallic Materials

MT 614 CORROSION ENGINEERING

L	T	P	C
3	0	0	3

Principles of corrosion phenomenon: Thermodynamics and kinetics: emf/galvanic series, Pourbaix diagram, exchange current density, passivity, Evans diagram, flade potential.

Different forms of corrosion: atmospheric/uniform, pitting crevice, intergranular, stree corrosion, corrosion fatique, dealloying, high temperature oxidation-origin and mechanism with specific examples.

Corrosion testing and monitoring: Non-Elecrochemical and Electrochemical methods: weight loss method, Tafel Linear polarization and Impedance techniques, Lab, semi plant & field tests, susceptibility test.

Corrosion prevention through design, coatings, inhibitors, cathodic, anodic protection, specific applications, economics of corrosion control.

Corrosion & its control in industries: Power, Process, Petrochemical, ship building, marine and fertilizer industries. Some case studies-Corrosion and its control in different engineering materials: concrete structures, duplex, super duplex stainless steels, ceramics, composites and polymers.Corrosion auditing in industries, Corrosion map of India.

TEXT BOOKS.

1. Fontana. M.G., Corrosion Engineering, Tata McGraw Hill, 3rd Edition, 2005.
2. Jones.D.A. Principles and Prevention of Corrosion, 2nd Edition, Prentice Hall, 1996.

MT 702 SPECIAL CASTING PROCESSES

L	T	P	C
3	0	0	3

Introduction to special casting techniques-Shell moulding machines - pattern equipments - sands, resins and other materials used in shell moulding - closing of shells - dimensional tolerances -applications of shell moulding - comparison of shell moulding with other competitive methods.
Types of centrifugal casting processes - calculation of mould rotary speeds - techniques and equipments used in production processes - advantages and limitations of centrifugal casting methods.

Introduction - Pattern and mould materials used in investment casting - technique and production of investment moulds and castings - dimensional tolerances - applications of investment casting process - Shaw process - comparison with other processes - full mould process.

Die casting machines - operation details - die materials - materials cast by die casting method. Die design - comparison with other processes. low pressure die casting. Metal Injection Moulding.

Fluid sand process - V Process - Rheo,thixo and compo casting processes - squeeze casting, Magnetic moulding, Hot box process, cold box process. No-bake processes, Graphite moulding process,Plaster moulding process-High Pressure moulding and continuous casting

TEXT BOOKS:

1. *Beeley, P.R., "Foundry Technology",2nd edition, Butterworths, Heinmann,oxford,2001.*
2. *Clegg,A.J.,"Precision Casting Processes",Pergamon Press,London,U.K,1991*
3. *Barton,H.K., "Die Casting Processes", Odhams Press Ltd,1985.*
4. *Dumond,T.C.,"Shell Moulding and Shell Moulded Castings",ReReinhold publishing corporation Inc.,1984*
5. *Doehler,E.h.,"Die casting",Mcgraw Hil Book Co,Newyork,1991*
6. *Heine, Loper and Rosenthal, "Principles of Metal Casting", Tata McGraw Hill Publishing Co,1995*
7. *"ASM Handbook", Vol. 15, Casting, ASM Publication, 1998.*

MT 704 METAL FORMING PROCESSES

L	T	P	C
3	0	0	3

Yielding criteria of von Mises and Tresca. Levy-Von Mises equations and Prantl Reuses equations for ideal plastic and elastic plastic solids respectively. Yield Locus. Methods of load calculation including slab method, slip line field theory, FEM, upper and lower bound methods.

Texture effects. Metallurgical factors affecting recrystallization temperature and grain size. Effect of temperature, strain rate, hydrostatic pressure, Microstructure. Residual stresses, Friction and lubrication mechanisms. Lubricants in rolling, forging, extrusion, wire drawing, sheet metal forming. Tool design

Types of rolling mills, Geometrical factors and forces, Factors affecting rolling load and minimum thickness, Roll pass design, wheel and tyre production. Rolling defects,Processes and equipment, Forgeability, effect of various factors, definitions. Selection of equipment, die design, parting line, flash, draft, tolerance. Defects, causes and remedies.

High velocity forming methods, superplastic forming, hydroforming, isothermal forging. Principles and processes. FLD and LDR**,** CAD, CAM in forming use of softwares like OPTRIS, DEFORM, etc. Workability.

Sol-gel and other processes for powders. Slip casting, extrusion injection moulding, HIP and CIP (Isostatic pressing), sintering. Blow moulding,Blow and Injection Moulding. Compression and transfer Moulding, Pultrusion. Filament Moulding. Resin Transfer Moulding.

TEXT BOOKS:

1 *Dieter, G.E., "Mechanical Metallurgy", McGraw Hill, 2001.*
2 *ASM "Metals Handbook, Vol. 14, Forming & Forging", ASM, Metals Park, Ohio, USA, 1998.*
3 *Kurt Lange, "Handbook of Metal Forming", Society of Manufacturing Engineers, Michigan, USA, 1985.*
4 *Belzalel Avitzur, "Metal Forming- Processes and Analysis", Tata McGraw Hill, 1977.*
5 *Pat.L.Manganon, "Principles of Materials Selection for Engineering Design", Prentice Hall Int. Inc,1999*
6 *Knigery,W.D., Ceramic Fabrication Processes, John Urley, 1950.*
7 *ASM, "Metals Handbook, Vol. I", Properties and selection, McGraw Hill, 2001.*

MT 706 – NON-DESTRUCTIVE TESTING

L	T	P	C
3	0	0	3

Visual Inspection- tools, applications and limitations. Liquid Penetrant Inspection - principles, types and properties of penetrants and developers. Advantages and limitations of various methods of LPI. Magnetic particle inspection- principles, applications, advantages and limitations

Ultra sonic testing(UT) - Nature of sound waves, wave propagation - modes of sound wave generation - Various methods of ultrasonic wave generation, types of UT Principles, applications, advantages, limitations, A, B and C scan - Time of Flight Diffraction (TOFD)

Radiography testing (RT) – Principles, applications, advantages and limitations of RT. Types and characteristics of X ray and gamma radiation sources, Principles and applications of Fluoroscopy/Real-time radioscopy - advantages and limitations - recent advances.

Eddy current testing - Principles, types, applications, advantages and limitations of eddy current testing.

Thermography - Principles, types, applications, advantages and limitations. Optical & Acoustical holography- Principles, types, applications, advantages and limitations. Case studies: weld, cast and formed components.

TEXT BOOKS:

1. Practical Non – Destructive Testing, Baldev raj, Narosa Publishing House(1997).
2. Non-Destructive Testing, B.Hull and V.John, Macmillan (1988)
3. Krautkramer, Josef and Hebert Krautkramer, Ultrasonic Testing of Materials, 3rd edition, New York, Springer-Verlag (1983).

MT658 MATERIALS TESTING & CHARACTERIZATION LABORATORY

L	T	P	C
0	0	3	2

List of Experiments

1. Tensile Testing
2. Hardness Measurements
3. Impact Testing
   All above tests will include ferrous and nonferrous alloys.
4. Determination of crystal structure parameters from XRD data
5. Scanning electron microscopy study: surface morphology, coating thickness measurement, fractured surfaces

MT725 SUMMER INDUSTRIAL TRAINING

L	T	P	C
0	0	30	3

Industrial training for one month in various metallurgical process industries during summer vacation period

MT 613 MECHANICAL BEHAVIOUR OF MATERIALS

L	T	P	C
3	0	0	3

Strength of materials- basic assumptions, elastic and plastic behaviour, stress–strain relationship for elastic behaviour, elements of plastic deformation of metallic materials. Mohr's circle, yielding theories

Elements of theory of plasticity, dislocation theory properties of dislocation, stress fields around dislocations, application of dislocation theory to work hardening, solid solution strengthening, grain boundary strengthening, dispersion hardening

Ductile and brittle fracture, Charpy and Izod testing, significance of DBTT, ECT, NDT and FATT; elements of fractography - Griffith's theory, LEFM– COD and J integral – determination of K_{IC}, COD and J integral

Characteristics of fatigue failure, initiation and propagation of fatigue cracks, factors affecting fatigue strength and methods of improving fatigue behaviour – testing analysis of fatigue data, mechanics of fatigue crack propagation, corrosion fatigue

Introduction to creep - creep mechanisms, creep curve, variables affecting creep, accelerated creep testing, development of creep resistant alloys, Larsen Miller parameter - Manson Hafred parameter

TEXT BOOKS:

1. *Dieter G. E., 'Mechanical Metallurgy', 3rd Edition, McGraw Hill, 1988*
2. *Suryanarayana, 'Testing of Metallic Materials', Prentice Hall India, 1979.*
3. *Rose R. M., Shepard L. A., Wulff J., 'Structure and Properties of Materials', Volume III, 4th Edition, John Wiley, 1984*

MT 617 COMPUTATIONAL TECHNIQUES

L	T	P	C
3	0	0	3

Design of Experiments: Factorial Design, Taguchi Techniques, ANOVA

Artificial Intelligence: ANN, fuzzy Logic, Genetic Alogorithm, Applications in Materials Engg.,

Numerical Fluid Flow and Heat Transfer: Classification of PDE, Finite differences, Steady and unsteady conduction, explicit and implict method

Finite element Methods: Introduction to I-D FEM; Problems in structural Mechanics using 2D elements, Plane stress, plain strain, axisymmetric analysis; three dimensional analysis.

Optimization Methods: Classical optimization methods, unconstrained minimization . Unvariate, conjugate direction, gradient and variable metric methods, constrained minimization, feasible direction and projections. Integer and geometric programming

TEXT BOOKS:

1. *Design and analysis of experiments - Douglas C. Montgomery, 5th ed., John Wiley and Sons, 2001*
2. *Introduction to Finite Elements in Engineering - Tirupathi R. Chandrupatla and Ashok D. Belegundu, 2nd Ed., Prentice-Hall, 1997*
3. *Artificial Neural Networks - B. Yegnanarayana, Prentice-Hall of India, 1999*
4. *Taguchi techniques for quality engineering - Phillip J. Ross, McGraw-Hill Book company, 1996*
5. *Numerical heat transfer and fluid flow- Suhas V. Patankar, Hemisphere Publishing Corporation, 1980*

MT 653 MATERIALS CHARACTERIZATION

(*This is a core course for both WE and ME specializations in MME*)

L	T	P	C
3	0	0	3

Numerical aperture, limit of resolution, depth of field and depth of focus - lens defects and correction- bright field and dark field illumination - polarised light, phase contrast, interference contrast, hot-stage, in-situ techniques, quantitative metallography

Powder, rotating crystal and Laue methods, stereographic projections and reciprocal lattice; X-ray residual stress measurement

Construction and operation and applications of TEM, specimen preparation techniques;

Construction and operation and applications of SEM, elemental analysis by WDS and EDS systems - analysis of fractured surfaces

X-ray fluoroscopy, spectrometry, Auger spectroscopy, DTA, DSC and TGA, working principle, applications. Types and applications of strain gauges.

TEXT BOOKS:

1. *Smallman R. E., 'Modern Physical Metallurgy', 4th Edition, Butterworths, 1985*
2. *Philips V. A., 'Modern Metallographic Techniques and their Applications', Wiley Interscience, 1971*
3. *Cullity B. D., 'Elements of X-ray Diffraction', 4th Edition, Addison Wiley, 1978*
4. *Loretto M. H., 'Electron Beam Analysis of Materials', Chapman and Hall, 1984*

MT665 PARTICULATE TECHNOLOGY

L	T	P	C
3	0	0	3

Pre-requisite: MT 659 (Manufacturing Processes)

Introduction to particulate processing – advantages, limitations and applications of particulate processing

Science of particulate processing – issues related to particle morphology – differences in mechanical behaviour (with respect to cast and wrought materials) and related mathematical treatment - similarities and differences between metal powder and ceramic powder processing

Production and characterisation of metal and ceramic powders – compaction processes – powder properties and powder compaction – Pressing, Hot Isostatic Processing and extrusion

Sintering – thermodynamic and process aspects – recent developments in mechanical alloying and reaction milling

Production of particulate composites - application of P/M based on case studies - manufacturing of typical products – near net shape processing

TEXT BOOKS

1. *German R.M., 'Powder Metallurgy Science', Metal Powder Industries Federation, New Jersey, 1994*
2. *Kuhn H. A. and Alan Lawley, 'Powder Metallurgy Processing - New Techniques and Analysis', Oxford IBH, Delhi, 1978*

MT 721 STAINLESS STEEL TECHNOLOGY

L	T	P	C
3	0	0	3

Metallurgy and Properties of Wrought Stainless Steels, Metallurgy and Properties of Cast Stainless Steels , Powder Metallurgy of Stainless Steels, Stainless Steel Cladding and Weld Overlays,Melting and Refining Methods, Recycling Technology.

Atomospheric and Aqueous Corrosion ,Stress-Corrosion Cracking and Hydrogen Embrittlement, High-Temperature Corrosion,Corrosion of Cast Stainless Steels, Corrosion of Weldments. ASTM and EN standards on corrosion resistance testing.

Forming,Forging and Extrusion,Heat Treatment, Machining,Welding, Brazing, Soldering and Adhesive Bonding.Surface Engineering.

Metallographic Practices for Wrought Stainless Steels, Microstructures of Wrought Stainless Steels, Metallography and Microstructure of Cast Stainless Steels, Phase Diagrams.

Physical Properties, Low-Temperature Properties, Elevated-Temperature Properties, Tribological Properties, Duplex stainless steels and Martensitic stainless steels – Manufacture, Heat Treatment, Corrosion behaviour and welding.

TEXT BOOKS:

1. *J.R.Davis, "Stainless steels", ASM speciality Hand Book ASTM International, 1996*
2. *ASM, "Source Book of Stainless Steel", ASM Publisher, 1977.*
3. *Peckner.D Bernstein.I.M, "Handbook of Stainless Steel", McGraw Hill Book Co. New York, 1977.*

MT 723 DESIGN OF CASTINGS & WELDMENTS

L	T	P	C
3	0	0	3

Designing for economical moulding – designing for sand moulding – investment castings. Design for economical coring – general rules for designing cored holes.Design problems involving thin sections, uniform sections unequal sections. Considering metal flow, riser location, feed path, mould-metal temperature effect.

Design problems involving junctions, distortion – possible design remedies.Dimensional variations and tolerances – influence of cores – influence of location of cores. Dimensions for inspection and machining.Surface finish ISI specification, effect of mould material, parting line, fillet influences. Design of gating and risering for ferrous and non-ferrous metals

Types of joints, joint efficiency, edge preparation, types of loads, design for static lading, design for cyclic loading, rigid structures, primary and secondary welds, treating a weld as a line, structural tubular connections, influence of specifications on design, symbols for welding and inspection, estimating and control of welding costs. Residual stresses, causes and effects, methods to measure residual stresses, weld distortion.

Boiler and pressure vessel codes, structural welding codes, pipelines codes.

Welding procedure specifications, welding procedure qualifications, welder performance qualifications, welding variables, filler metal qualifications, qualification of welding inspectors, welding supervisors and welding engineers, qualification of NDT personnel.

TEXT BOOKS:

1. "*Casting.Design Hand Book" , American Society for Metals,1962*
2. *Matousek R., "Enginering Design".,Blackwell Scientific Publications.,1962*
3. *Heine, Loper and Rosenthal, "Principles of Metal Casting", Tata McGraw Hill Publishing Co,1995.*
4. *Harry Peck, "Designing for Manufacture", Pitman Publications, 1983.*

MT 725 FERROUS FOUNDRY METALLURGY

L	T	P	C
3	0	0	3

Iron-carbon and Iron-graphite equilibrium diagrams, phase changes in steels, effects of alloying element in steel,Solidification of steels and cast iron. and effect of mould materials and composition. Directional solidification of castings

Types of cast iron – Effect of normal elements in cast iron. Influence of composition and cooling rate. Cast iron production methods, SG Iron production – Degree of Nodularising – Malleable iron production, CG Iron, Austempered Ductile iron and Alloy Cast iron-Inoculation and Inoculating practices

Specifications for steels and alloy castirons as per IS,BS and ASTM- Metallurgical aspects of gating and risering of ferrous alloys, fluidity of ferrous alloys.

Melting furnaces and procedures used for ferrous castings; composition control; desulphurization, dephosphorization., melting of plain carbon steels, low alloy steels and stainless steels

Heat treatment of ferrous castings - Defects in ferrous castings, their causes and remedies

TEXT BOOKS:

1. *Heine, Loper and Rosenthal, "Principles of Metal Casting", Tata McGraw Hill Publishing Co,1995*
2. *Flinn RA., "Fundamental Metal Casting"., Addison-Wesley,1963.*
3. *John R.Brown, "FOSECO Ferrous Foundry Man's Hand Book", Butterworth, 2000.*
4. *ASM Hand Book, Vol. 15, Casting, ASM Hand Book Committee, 1998.*

MT 618 METALLURGICAL FAILURE ANALYSIS

L	T	P	C
3	0	0	3

Stages of failure analysis, classification and identification of various types of fracture. Overview of fracture mechanics, characteristics of ductile and brittle fracture.

General concepts, fracture characteristics revealed by microscopy, factors affecting fatigue life Creep, stress rupture, elevated temperature fatigue, metallurgical instabilities, environmental induced failure. Some case studies failures.

Types of wear, analyzing wear failure. Corrosion failures- factors influencing corrosion failures, overview of various types of corrosion stress corrosion cracking, sources, characteristics of stress corrosion cracking. Procedure for analyzing stress corrosion cracking, various types of hydrogen damage failures.

Causes of failure in forging, failure of iron and steel castings, improper heat treatment, stress concentration and service conditions. Failure of weldments - reasons for failure procedure for weld failure analysis.

Reliability concept and hazard function, life prediction, condition monitoring, application of Poisson, exponential and Weibull distribution for reliability, bath tub curve, parallel and series system, mean time between failures and life testing.

TEXT BOOKS:

1. *ASM Metals Handbook "Failure Analysis and Prevention", ASM Metals Park. Ohio, Vol.10, 10th Edition, 1995.*
2. *Colangelo.V.J. and Heiser.F.A., "Analysis of Metallurgical Failures", John Wiley and Sons Inc. New York, USA, 1974.*

MT622 SURFACE ENGINEERING

L	T	P	C
3	0	0	3

Introduction tribology, surface degradation, wear and corrosion, types of wear, roles of friction and lubrication- overview of different forms of corrosion, introduction to surface engineering, importance of substrate

Chemical and electrochemical polishing, significance, specific examples, chemical conversion coatings, phosphating, chromating, chemical colouring, anodizing of aluminium alloys, thermochemical processes -industrial practices

Surface pre-treatment, deposition of copper, zinc, nickel and chromium - principles and practices, alloy plating, electrocomposite plating, electroless plating of copper, nickel-phosphorous, nickel-boron; electroless composite plating; application areas, properties, test standards (ASTM) for assessment of quality deposits.

Definitions and concepts, physical vapour deposition (PVD), evaporation, sputtering, ion plating, plasma nitriding, process capabilities, chemical vapour deposition (CVD), metal organic CVD, plasma assisted CVD, specific industrial applications

Thermal spraying, techniques, advanced spraying techniques - plasma surfacing, D-Gun and high velocity oxy-fuel processes, laser surface alloying and cladding, specific industrial applications, tests for assessment of wear and corrosion behaviour.

TEXT BOOKS:

1. *Sudarshan T S, 'Surface modification technologies - An Engineer's guide', Marcel Dekker, Newyork, 1989*
2. *Varghese C.D, 'Electroplating and Other Surface Treatments - A Practical Guide', TMH, 1993*

MT666 TOTAL QUALITY MANAGEMENT

L	T	P	C
3	0	0	3

Definitions of the terms - quality, quality planning, quality control, quality assurance, quality management, Total Quality Management (TQM) as per ISO 8402 - overview on TQM - The TQM axioms - Commitment - Scientific knowledge - Involvement - Consequences of total quality-Deming's fourteen points on quality management - five DDs - implementing the Deming philosophy - action plan - the Deming cycle - questions and opinions of Deming.

Developing a habit of quality - Juran quality trilogy - the universal break through sequence - comparison Juran and Deming approaches-Crosby's diagnosis of a troubled company - Crosby's quality vaccine - Crosby's absolutes for quality management - Crosby's fourteen steps for quality improvement.

Meaning - Kaizen and innovation - the Kaizen management practices - total quality control (TQC) - approaches of Faigenbaum, Ishikawa - Kaizen and TQC - Kanban systems - small group activities - quality control circles - suggestion systems - comparison of Kaizen and Deming's approach.

Affinity diagram - bar chart - block diagram - brainstorming - cause and effect analysis - customer-supplier relationship checklist - decision analysis - flow charts - force field analysis - line graph/run charts - Pareto analysis - quality costing - Quality Function Deployment (QFD) - quality project approach and the problem solving process.

The structure of ISO 9000 series quality system standards - certification process - action plan development for cases-Integrating quality into strategic management - Quality and the management cycle - Resources for Quality activities - Training for Quality - Self Managing Teams - Role of the Quality Director - Obstacles to achieving successful Strategic Quality Management.

TEXT BOOKS :

1. *Logothetics N., "Managing for Total Quality From Deming to Taguchi and SPC", Prentice Hall Pvt Ltd., New Delhi, , 1997.*
2. *Juran J.M & Gryna, F.M., "Quality Planning and Analysis From Product Development Through Use", Tata McGraw Hill Publishing Limited, New Delhi, 3rd Edition, 1995.*
3. *Deming W.E., "Out of the Crisis", MIT Press, Cambridge, MA, 1982.*
4. *Juran J.M., "Juran on Leadership for Quality - An Executive Handbook", The Free Press, New York, 1989.*
5. *Salor J.H., "TQM-Field Manual", McGraw Hill, New York, 1992.*

Crosby P.B., "Quality is Free", McGraw Hill, New York, 1979

MT674- DEVELOPMENTS IN IRON MAKING AND STEEL MAKING

L	T	P	C
3	0	0	3

Principles of ferrous process metallurgy; review of related concepts from metallurgical thermodynamics and kinetics; sequence of operations in steel plants; basic aspects of furnaces, refractories and fuels; differences between the production of carbon steels and highly alloyed steels

Overview of iron making, steel making, refining and continuous casting processes; indicative process calculations; environmental considerations; quality issues in steel plant operations

Modifications of steel making converter operations; developments such as sub lance and dynamic control of steel making, secondary treatment including ladle metallurgy and injection metallurgy; continuous steel making; illustrative numerical problems

Modifications of continuous casting process; developments such as flow control devices in tundish, sequence casting, high speed casting, detection / prevention of caster breakouts, electromagnetic stirring, thin slab casting; strip casting; illustrative numerical problems

Current research on metallurgical slags, measurement of critical properties, use of process modeling; design and selection of slags and refractories; discussion on related binary and ternary phase diagrams

TEXT BOOKS

1. *Current literature on related topics*
2. *Tupkary R.H., 'Introduction to Modern Steel Making', Khanna Publishers, 2004 (primary text)*
3. *Bashforth G.R, 'Manufacture of Iron and Steel', Volume I - IV, Asia Publications, 1996*
4. *B. Deo, R. Boom, 'Fundamentals of steel making metallurgy', Prentice Hall International, New York, 1993 (primary reference)*
5. *Continuous casting – Vol. 1, 'Chemical and Physical Interactions during transfer operations', Iron and Steel Society, Warrendale, PA, USA, 1983*

MT 722 NON FERROUS FOUNDRY METALLURGY

L	T	P	C
3	0	0	3

Structure of liquid metals, macrostructure of pure metals and alloys-Typical casting alloys, specifications, properties, industrial applications, melting and composition control, deoxidation, gating and risering techniques.

Typical casting alloys, specifications, properties, industrial applications, melting and composition control, deoxidation, gating and risering techniques, Modification of Aluminium alloy, Cast Al Ni Co alloys.Typical casting alloys, specifications, properties, industrial applications, melting and composition control, deoxidization, gating and risering techniques.

Typical casting alloys, specifications, properties, industrial applications, melting and composition control, deoxidization, gating and risering techniques-Typical casting alloys, specifications, properties, industrial applications, melting and composition control, deoxidation, gating and risering techniques -Typical casting alloys, specifications, properties, industrial applications, melting and composition control, deoxidization, gating and risering techniques

Typical casting alloys, specifications, properties, industrial applications, melting and composition control, deoxidation, gating and risering techniques-Typical casting alloys, specifications, properties, industrial applications, melting and composition control, deoxidation, gating and risering techniques

Typical casting alloys, specifications, properties, industrial applications, melting and composition control, deoxidation, gating and risering techniques-Typical casting alloys, specifications, properties, industrial applications, melting and composition control, deoxidation, gating and risering techniques-Basic principles of deoxidation

TEXT BOOKS:

1. *Heine, Loper and Rosenthal, "Principles of Metal Casting", Tata McGraw Hill Publishing Co, 1995*
2. *Peter Beeley, "Foundry Technology",2nd Edition, Butterworths, Heinmann,Oxord,2001.*
3. *John Cambell,"Casting", Butterworth-Heinmann, 2003*
4. *American Society of Metals, "Metals Handbook, Vol. IV", A.S.M.,Metals Park, Ohio, USA, 1991.*
5. *ASM Handbook, Vol. 15, Casting, ASM Publication, 1998.*
6. *John R.Brown, "FOSECO Non Ferrous Foundry Man's Hand Book", Butterworth, 2000.*
7. *Murphy,A.J.,Ed.,"Non Ferrous Foundry Metallurgy",Pergamon,USA,1984*

MT724 ADVANCED MATERIALS AND PROCESSING

L	T	P	C
3	0	0	3

Introduction to advanced ceramics and metallic materials-advantages

Introduction-structure of nanomaterials- classification of production methods-Nanomaterials-Preparation techniques-Sol-gel method, combustion synthesis, evaporation and condensation method – Examples. Nanoceramics for electrical, magnetic, mechanical and structural functions-applications.

Pure metals, alloys, intermetallics, immiscible alloy systems and composites; their preparation and applications

Mechanical alloying-processing capabilities-process parameters - Examples of material synthesized - Rapid Solidification Processing - Melt spinning, atomization techniques - examples - Self Propagating High Temperature Synthesis - Process - Advantages -examples.

Consolidation techniques for ceramics and metallic powders-Die compaction -Hot pressing, Cold and Hot Isostatic Pressing, Powder extrusion, Equal Channel Angle Process

TEXT BOOKS :

1. *Nobru.H.Ichinose, "Introduction to Fine Ceramics", Butterworth-Heinman Ltd, NY,1992*
2. *Metals Handbook Vol. 9 "Powder Metallurgy" ASM Metals Park, Ohio, 1991.*