M. Tech. DEGREE

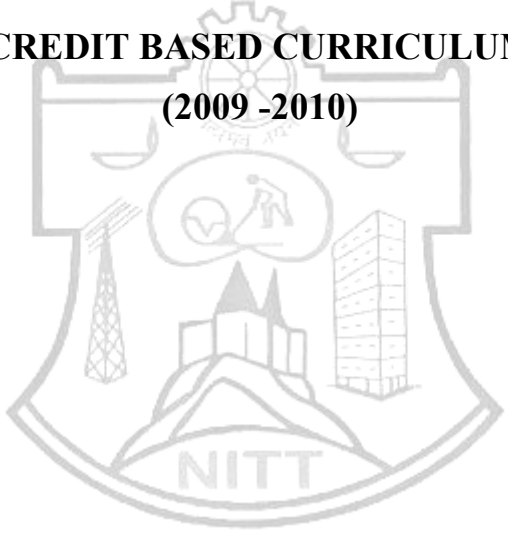
MATERIAL SCIENCE AND ENGINEERING

SYLLABUS

FOR

CREDIT BASED CURRICULUM

(2009 -2010)



DEPARTMENT OF MATERIAL SCIENCE AND ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY
TIRUCHIRAPPALLI – 620 015, INDIA.

M.Tech. MATERIALS SCIENCE AND ENGINEERING

The total minimum credits required for completing the M.Tech. programme in Materials Science & Engineering is **64.**

SEMESTER – I

Code	Course of Study	L	T	P	C
MA 613	Engineering Mathematics	3	0	0	4
MT 601	Physical Metallurgy	3	0	0	3
MT 605	Materials Characterization	3	0	0	3
MT 655	Thermodynamics and Kinetics	3	0	0	3
MT 657	Metallography Laboratory	3	0	3	2
	Elective - I	3	0	0	3
	Elective – II	3	0	0	3
					20

SEMESTER – II

Code	Course of Study	L	T	P	C
MT 652	Ceramic Science and Technology	3	0	0	4
MT 654	Composites and Polymers	3	0	0	3
MT 656	Nanomaterials and Technology	3	0	0	3
MT 658	Materials Testing & characterization	3	0	0	3
	Materials Testing & characterization Laboratory	3	0	3	2
	Elective – III	3	0	0	3
	Elective – IV	3	0	0	3
	Elective – V				**20**

SEMESTER III

Code	Course of Study	L	T	P	C
ME 697	Project work - Phase I	0	0	30	12

SEMESTER IV

Code	Course of Study	L	T	P	C
ME 698	Project work - Phase II	0	0	30	12

Total Credits 64

ELECTIVES

(I Semester)

Code	Course of Study	L	T	P	C
MT 613	Mechanical Behavior of Materials	3	0	0	3
MT 615	Selection of Materials	3	0	0	3
MT 617	Computational Techniques	3	0	0	3
MT621	Non Destructive Testing	3	0	0	3
MT 659	Manufacturing Processes	3	0	0	3

II Semester

Code	Course of Study	L	T	P	C
MT 614	Corrosion Engineering	3	0	0	3
MT 618	Metallurgical Failure Analysis	3	0	0	3
MT 622	Surface Engineering	3	0	0	3
MT 660	Biomaterials	3	0	0	3
MT 662	High Temperature Materials	3	0	0	3
PR 618	Computer Aided Design and Manufacturing	3	0	0	3
PH 608	Thin Film Technology and Application	3	0	0	3
PH 610	Electrical, Magnetic and Optoelectronic Materials	3	0	0	3

Reserve Electives

Code	Course of Study	L	T	P	C
MT 628	Process Modeling	3	0	0	3
MT 665	Particulate Technology	3	0	0	3
MT 666	Statistical Quality Control and Management	3	0	0	3
MT 670	Polymer Processing	3	0	0	3
MT 671	Nuclear Materials	3	0	0	3
MT 673	Severe Plastic Deformations	3	0	0	3
PR 621	Finite Element Methods (reserve elective)	3	0	0	3
PR 629	Theory of Plasticity (reserve elective)	3	0	0	3

MA613 ENGINEERING MATHEMATICS

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 601 PHYSICAL METALLURGY

(*This is a core course for both WE and ME 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 605 MATERIALS CHARACTERIZATION

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

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*

MT655 THERMODYNAMICS AND KINETICS

Introduction to thermodynamics and kinetics – different approaches – emphasis on metallurgical thermodynamics, transport phenomena and applications

Laws of thermodynamics and related applications – concepts of free energy and entropy – criteria for spontaneity

Introduction to solutions – partial molar entities – Gibbs Duhem relations - thermodynamic aspects of metallic solutions and salt melts – Raoult's Law and Henry's Law - regular and quasi chemical models

Thermodynamic aspects of phase diagrams – similarity in thermodynamic approach towards different classes of materials – thermodynamic aspects of defect formation in metals and ceramics – approaches used in chemical modeling

Principles of metallurgical kinetics – reaction rates and reaction mechanisms – overview of mass transfer, heat transfer and fluid flow – related applications in metallurgical processes – role of transport phenomena in mathematical and physical modeling

TEXT BOOKS

1. *Gaskell, David R., 'Introduction to Metallurgical Thermodynamics', McGraw Hill, 1973*
2. *Mohanty, A. K., "Rate Processes in Metallurgy", Prentice Hall of India (EEE), 2000*

MT 657 PHYSICAL METALLURGY LABORATORY

List of Experiments

1. Study of metallurgical microscope and sample preparation
2. Microscopic examination of plain carbon steels, stainless steels, maraging steels and tool steels
3. Microscopic examination of cast irons
4. Microscopic examination of
    - Magnesium alloys
    - Aluminium alloys
    - Titanium alloys
    - Copper alloys
    - Super alloys

MT652 CERAMIC SCIENCE AND TECHNOLOGY

Ceramics as a class of material, bonding and structure of various ceramic materials; crystal structure and defects; chronological developments, structure of silicates; polymorphic transformations, raw materials.

Non crystalline materials - structure, requirement for glass formation, Zachariasen rules, viscosity based transition points, devitrification; glass forming methods; important ceramic systems: one component system- silica; binary and ternary systems. Silicate glasses and glass ceramics;

Powder processing, pre-consolidation - shape forming processes; Fundamental Sintering mechanisms, various advanced sintering techniques; Mechnacial behaviour of structural ceramics-Brittleness of ceramics, Concept of fracture toughness and different toughness and strength measurement techniques; Concept of various toughening mechanisms;

Thermal, electrical, magnetic and optical properties of ceramic materials - emphasis on the effects of composition, microstructure, processing, temperature and atmosphere on these properties.

Introduction to specific ceramic materials – structure property correlation, processing and applications –superconductors, piezoelectrics, silicon carbide and nitride, sialons, cermets, bioceramics and bio-glass, cements, castables, refractories;

TEXT BOOKS

1. *Kingery W. D., Bowen, H. K., Uhlhmen D. R., 'Introduction to Ceramics', 2nd Edition, John Wiley, 1976*
2. *Richerson D. W., 'Modern Ceramic Engineering - Properties Processing and Use in Design, 3rd Edition, CRC Press, 2006*
3. *Chiang Y.M., Birnie D. P., Kingery W.D., Physical Ceramics: Principles for Ceramic Science and Engineering, John Wiley, 1997*
4. *Norton F. H., ' Elements of Ceramics' 2nd Edition, Addison Wesley, 1974*
5. *Van Vlack L. H., 'Physical Ceramics for Engineers', Addison Wesley, 1964*

MT654 COMPOSITES AND POLYMRES

Polymers as a class of engineering materials – comparison with metals and ceramics - classification of polymers

Polymerization – mechanisms and statistical approach – molecular weight determination

Properties, processing and applications of polymers – compounding of plastics – polymer processing – basic methods and recent developments

Introduction to composites – classification of composites – emphasis on polymer based composites – bonding and failure criteria – micro mechanics approach

Reinforcing materials – overview of different processing methods – technical and economic aspects – novel applications of composite materials

TEXT BOOKS

1. *Billmeyer F, 'Textbook of Polymer Science', Wiley Interscience, 1994*
2. *Anthoney Kelly, 'Concise Encyclopedia of Composite Materials', Pergamon, 1994*

MT656 NANO MATERIALS AND TECHNOLOGY

Pre-requisite: At least one 600 level course related to materials

Concept of nano materials – scale / dimensional aspects, Top-down and bottom-up approaches for preparing nano materials

Advantages and limitations at the nano level – thermodynamic aspects at the nano level, health and environmental issues.

Characterization of nano materials and nano structures, important characterization techniques for nano size measurement.

Overview of properties of nano materials, Introduction to nano composites, processing of nanocomposites.

Applications in different areas such as semi conductors, sensors, nanostructured bioceramics and nanomaterials for drug delivery applications.

TEXT BOOKS

1. *Pradeep T "Nano: The Essentials", Mc Graw Hill Publishing Co. Ltd., 2007*
2. *Mick Wilson et al, "Nanotechnology", Overseas Press (India) Pvt. Ltd., 2005.*
3. *Charles P. Poole, Jr., Frank J. Owens, "Introduction to nano technology", Wiley, 2003.*
4. *Gunter Schmid, "Nanoparticles: From Theory to Applications", Wiley-VCH Verlag GmbH & Co., 2004.*

MT658 MATERIALS TESTING LABORATORY

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

MT 613 MECHANICAL BEHAVIOUR OF MATERIALS

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 615 SELECTIONS OF MATERIALS

Technologically important properties of materials, Physical, Chemical, Mechanical and Electrical properties of metals, Criteria of selection of materials like properties, cost, manufacturing process, availability, legal and safety factors.

Materials for atmospheric, soil, water, acid and alkaline resistance, Corrosion prevention coatings, material for Chemical and Petroleum industries, materials and coatings for wear resistance.

High temperature strength and stability, Hot hardness requirements, High temperature steels and super alloys, ductile to brittle transition-HSLA steel, low temperature materials.

Materials for engine components, cylinder block, head, liner, piston, ring, pin, connecting rod, crank shaft, exhaust, cam shaft, rocker arm and tappet, etc. Materials for chasis, Materials for aero structure, wings, landing gears, turbine blades, shafts, compressor blades, etc.

Nuclear fuels, control rods, coolants, clad materials etc. - Wear resistant materials - Impact resistant materials - Friction materials - Anti-friction materials - Bearing materials. Electrical & Magnetic materials, Power plant requirement, Materials with special thermal properties, Thermal expansion.

TEXT BOOKS

1. *Gladius Lewis, "Selection of Engineering Materials", Prentice Hall Inc. New Jersey USA, 1995.*
2. *Charles J A and Crane. F A.A., "Selection and Use of Engineering Materials", 3rd Edition, Butterworths, London UK, 1996.*

MT 617 COMPUTATIONAL TECHNIQUES

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 621 – NON-DESTRUCTIVE TESTING

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).*

MT659 MANUFACTURING PROCESSES

Introduction to manufacturing processes – different approaches – technical and economic considerations – significance of material properties with respect to selection of manufacturing process

Conventional casting processes – advantages and limitations – melting practices – design of castings – special casting processes

Conventional material joining processes – concept of weldability – need for dissimilar joints - machining processes – concept of machinability – material examples – developments in machining processes

Rolling – forging – extrusion – drawing - sheet metal forming – classification, advantages and limitations

Introduction to powder metallurgy – recent developments esp. in forging and mechanical alloying - concept of near net shape processing - concept and applications of rapid prototyping – emerging technologies for nano – processing

TEXT BOOKS

1. *Rao, P.N, 'Manufacturing Technology', Tata McGraw Hill, 1996.*
2. *Kalpakjian, S, 'Manufacturing Engineering and Technology', 3rd Edition, Addison-Wesly, 1995.*

MT 614 CORROSION ENGINEERING

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 618 METALLURGICAL FAILURE ANALYSIS

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

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*

MT660 BIOMATERIALS

Introduction to biomaterials; need for biomaterials; Salient properties of important material classes; Property requirement of biomaterials; Metallic implant materials, ceramic implant materials, polymeric implant materials, composites as biomaterials; Orthopedic, dental and other applications.

Biomaterials preparation and characterization; Processing and properties of different bioceramic materials; Mechanical and physical properties evaluation of biomaterials; New and novel materials for biomedical applications. Design concept of developing new materials for bio-implant applications; Nanomaterials and nanocomposites for medical applications;

Concept of biocompatibility; cell-material interactions and foreign body response; assessment of biocompatibility of biomaterials; *In-vitro* and *In-vivo* evaluation; Dissolution

study, cytotoxicity test, cell adhesion test; Antibacterial assessment: Kirby–Bauer disc diffusion method or antibiotic sensitivity test and spread plate method.

Biomaterials for drug delivery, timed release materials; biodegradable polymers; Blood compatible materials; Biomimetics; Bone biology: bone architecture, collagen, osteoblasts, osteoclasts, etc; Protein mediated cell adhesion;

Introduction to tissue engineering; Applications of tissue engineering; Biomaterials world wide market, technology transfer and ethical issues; Standards for biomaterials and devices.

TEXT BOOKS

1. *Hench L. Larry, and Jones J., (Editors), Biomaterials, Artificial organs and Tissue Engineering, Woodhead Publishing Limited, 2005.*
2. *Hench L. Larry, & Wilson J., (Editors), An Introduction to Bioceramics, World Scientific, 1994.*

MT662 HIGH TEMPERATURE MATERIALS

Factors influencing functional life of components at elevated temperatures, definition of creep curve, various stages of creep, metallurgical factors influencing various stages, effect of stress, temperature and strain rate

Design of transient creep, time hardening, strain hardening, expressions for rupture life for creep, ductile and brittle materials, Monkman - Grant relationship

Various types of fracture, brittle to ductile from low temperature to high temperature, cleavage, ductile fracture due to microvoid coalescence - diffusion controlled void growth; fracture maps for different alloys and oxides

Oxidation, Pilling-Bedworth ratio, kinetic laws of oxidation - defect structure and control of oxidation by alloy additions - sulphation, hot gas corrosion deposit, modified hot gas corrosion, effect of alloying elements on hot corrosion

Iron base, nickel base and cobalt base superalloys, composition control, solid solution strengthening, precipitation hardening by gamma prime, grain boundary strengthening, TCP phase - embrittlement, solidification of single crystals

TEXT BOOKS

1. *Raj R, 'Flow and Fracture at Elevated Temperatures', American Society for Metals, 1985*
2. *Hertzberg R. W, 'Deformation and Fracture Mechanics of Engineering Materials', 4th Edition, John Wiley, 1996*
3. *Courtney T.H, 'Mechanical Behaviour of Materials', McGraw Hill, 1990*

MT665 PARTICULATE TECHNOLOGY

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*

MT628 PROCESS MODELING

Pre-requisite: Exposure to process metallurgy

Mathematical modeling, physical simulation, advantages and limitations; process control, instrumentation and data acquisition systems

Review of transport phenomena, differential equations & numerical methods; concept of physical domain and computational domain, assumptions and limitations in numerical solutions, introduction to FEM & FDM, examples

Introduction to software packages– useful websites and generic information about different products - ANSYS, Thermocalc, CFD; usage of expert systems, artificial intelligence and robotics; demonstration of some software packages

Physical modeling – cold and hot models; case studies of water models, use of computers for the construction of phase diagrams, alloy design, crystallography, phase transformations and thermo chemical calculations.

Case studies from literature – pertaining to modeling of solidification / heat transfer, fluid flow, casting, welding and liquid metal treatment

TEXT BOOKS

1. *Szekely J., Themelis N. J., 'Rate Phenomena in Process Metallurgy', Wiley, 1971.*

2. *Ghosh Dastiday P.S., "Computer Simulation of Flow and Heat Transfer", Tata McGraw Hill, New Delhi, 1998.*

MT670 POLYMER PROCESSING

General features of single screw extrusion, Feed zone, compression zone and metering zone, Mechanism of flow, Analysis of flow in extruder, Extruder volumetric efficiency, and General features of twin screw extruders

Granule production and compounding, Profile production, Film blowing, Blow moulding, Extrusion blow moulding. Extrusion stretch blow moulding. Extrusion coating processes. Recent developments in extrusion technology

Screws. Nozzles. Moulds- runners, sprues, venting, mould temperature controls. Insulated runner moulds. Structural foam injection moulding. Sandwich moulding. Reaction injection moulding. Injection moulding of thermosetting materials.

Thermoforming, Calendering, Rotational Moulding, Compression Moulding, Vacuum forming, pressure forming, analysis of thermoforming. Calendaring and analysis of calendaring. Rotational moulding. Compression moulding. Transfer moulding.

Filament, Fabric, cloth, Mat, chopped fibres, Manufacturing methods. Semi-Automatic processing methods- cold press moulding, Automatic Process- Filament winding, centrifugal casting, pultursion and injection moulding.

TEXT BOOKS

1. *Crawford R.J., "Plastics Engineering", Pergamon Press, 2nd Edition, 1987.*
2. *Billmeyer, "Text Book Of Polymer Science", John Wiley & Sons(Asia) Pvt Ltd,1994*

MT671 NUCLEAR MATERIALS

Introduction to nuclear energy / reactors – comparison of different modes of energy generation – ecological and environmental aspects

Nuclear reactions – concept of half life, nuclear minerals – related exploration and processing

Material requirements – structural materials, coolants, shielding materials and fuel rods – fabrication requirements

Nuclear irradiation effects on structural materials – safe guards, safety and health protection
Strategic issues – current status and major needs, overview of nuclear scenario in India, nuclear scenario at international level.

TEXT BOOKS

1. *Benjamin M. M., Van Nostrand "Nuclear Reactor Materials and Applications", Reinhold Company Inc, 1983*
2. *Henley E.J., & Herbert Kouts, "Advances in Nuclear Science and Technology".*

MT673 SEVERE PLASTIC DEFORMATION

Basics of plastic deformation – Mohr's circle – yield theories – plastic stress – strain relationship – plastic work – constitute relationships – mechanical working – work hardening.

Analysis – slab analysis – upper and lower bound theorem – exact solutions – slip line field theory and its solution – numerical methods and FEM.

Severe plastic deformation by ECAP – types – microstructural variation with different processing routes – multichannel ECAP – strain distribution and texturing.

SPD by cryo rolling – process – types – microstructural variation with stress – strain distribution.

SPD by mechanical alloying – introduction – types of equipment – compaction – sintering – HIP, SIS – mechanism of sintering.

TEXT BOOKS

1. *Hosford W.F. and Caddell R.M. "Metal forming mechanics and metallurgy", Printice Hall 1983.*
2. *Altan T, Metal forming: Fundamentals and Applications (ASM Series in Metal processing)*
3. *Dieter, "Mechanical Metallurgy", Mc Graw Hill Publishers, NY,2002*

MT 666 STATISTICAL QUALITY CONTROL AND MANAGEMENT

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

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.

TEXT BOOKS

1. *Hansen B.L., P.M. Ghare, 'Quality Control and Application', PHI – EEE, 1997.*
2. *Juran J.M., and F.M.Gryna, 'Quality Planning and Analysis', McGraw Hill, New York, 2nd Edition, 1980*

MT703 INDUSTRIAL TRIBOLOGY

(Proposed subject for Ph.D. – Directed Study)

Friction and Wear: Laws of friction, types, friction coefficient, wear, types, control of wear.

Lubrication: Mechanism, boundary, Hydrodynamic & Hydrostatic lubrication, Reynolds equation in 2D and 3D flow, solid, liquid and gas lubricants, types and application.

Tests and Instrumentation in Tribology: Sliding friction and wear abrasion test, solid particle and erosion test, Special instruments for lubricant analysis such as optical , IR,AAS, NMR , XRD and chromatographic techniques,

Micro/Nano-tribology and applications – Tribology for MEMS, wear resistant coatings - New industrial applications of tribology – Nano scale wear, Micro scale scratching and Micro scale wear - Wear mapping and Nano lubrication and specialized materials selection for Nano Tribology.

Case studies in automotive, chemical industry, marine, microelectronics, Basics test (mechanisms, modeling) - Lab and industrial - Prevention, monitoring and environmental effects

TEXT BOOKS

1. *Gwidon W Stachowiak, Andrew W. Batchelor, Engineering Tribology , Elsevier, 3rd Edition, 2005*
2. *Bharat Bhushan, Principles and Applications of Tribology, John Wiley & Sons Inc., 1999.*
3. *Summers Denis J., and Smith., An Introductory guide to Industrial Tribology, Mechanical Engineering Publications Limited, London , 1994.*

MT674- DEVELOPMENTS IN IRON MAKING AND STEEL MAKING

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