M.Tech. Degree

in

INDUSTRIAL METALLURGY

SYLLABUS

FOR

CREDIT BASED CURRICULUM

(For the students admitted in the year 2018)

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY

TIRUCHIRAPPALLI - 620 015

TAMIL NADU, INDIA

Programme Educational Objectives (PEO) of M.Tech. (Industrial Metallurgy)
I. Choose their careers as practicing metallurgist in manufacturing and service industries.
II. To pursue research in the areas of metallurgical engineering
III. To work and participate in multidisciplinary environments as well as to develop entrepreneur skills

	Programme Outcomes (PO)
1	The industrial metallurgy graduates are capable of applying knowledge of basic sciences, mathematics and engineering in their fields.
2	The industrial metallurgy graduates are capable of testing and conduct experiments related to their work as well as to analyze and interpret the results
3	The industrial metallurgy graduates are capable of doing design and development of processes or system keeping in view of socio-economic aspects.
4	The industrial metallurgy graduates are capable of involving and work together in a team.
5	The industrial metallurgy graduates are able to apply their knowledge and skills in solving industrial problems effectively
6	The industrial metallurgy graduates are capable to utilize the recent cutting edge technologies, innovative practices to develop new technologies
7	The industrial metallurgy graduates will undergo technical training programs and management skill development programs periodically
8	The industrial metallurgy graduates will develop eco-friendly technologies.
9	The industrial metallurgy graduates are capable of developing need basic technologies pertaining to the current industrial requirements of the country

CURRICULUM

The total minimum credits required for completing the M.Tech. Programme in Welding Engineering is **65.**

SEMESTER – I

CODE	COURSE OF STUDY	L	T	P	C
MA 613	Engineering Mathematics	3	0	0	3
MT 701	Foundry Technology	3	0	0	3
MT 703	Metal Joining	3	1	0	4
	Elective - I	3	0	0	3
	Elective – II	3	0	0	3
	Elective – III	3	0	0	3
MT 659	Metallography, Materials Testing and Characterization Laboratory	0	0	3	2
					21

SEMESTER – II

CODE	COURSE OF STUDY	L	T	P	C
MT 702	Industrial Heat treatment	3	0	0	3
MT 704	Foundry Metallurgy	3	0	0	3
MT 706	Metal Forming	3	0	0	3
	Elective – IV	3	0	0	3
	Elective – V	3	0	0	3
	Elective – VI	3	0	0	3
MT 660	Advanced Materials Processing Laboratory	0	0	3	2
					20

SEMESTER – III

CODE	COURSE OF STUDY	L	T	P	C
MT 747	Project Work Phase -I	0	0	30	12
					12

SEMESTER – IV

CODE	COURSE OF STUDY	L	T	P	C
MT 748	Project Work Phase -II	0	0	30	12
					12
		Total Credits			**65**

ELECTIVES

Sl.No	Code	Course of Study	L	T	P	C
1	MT 611	Physical Metallurgy (compulsory for non metallurgy students)	3	0	0	3
2	MT 612	Mechanical Behaviour of Materials	3	0	0	3
3	MT 613	Corrosion Engineering	3	0	0	3
4	MT 614	Design and Selection of Materials	3	0	0	3
5	MT 615	Computational Techniques	3	0	0	3
6	MT 616	Metallurgical Failure Analyses	3	0	0	3
7	MT 617	Surface Engineering	3	0	0	3
8	MT 618	Testing, Inspection and Characterization	3	0	0	3
9	MT 619	Process Modeling	3	0	0	3
10	MT 620	Statistical Quality Control and Management	3	0	0	3
11	MT 621	Particulate Technology	3	0	0	3
12	MT 622	Developments in Iron Making and Steel Making	3	0	0	3
13	MT 623	Intellectual Property Rights	3	0	0	3
14	MT 624	Non Destructive Testing	3	0	0	3
15	MT711	Stainless steel technology	3	0	0	3
16	MT712	Design of castings & weldments	3	0	0	3
17	MT713	Advanced materials processing	3	0	0	3
18	MT714	Special Casting Processes	3	0	0	3
19	MT715	Special topics in metal forming	3	0	0	3
20	MT716	Thermodynamics of Solidification	3	0	0	3

MA 613 ENGINEERING MATHEMATICS

L	T	P	C
3	0	0	3

Course objective:

1. To prepare students skillful in the area of mathematics and to think independently, logically to solve Engineering problems.

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.*

Course outcome: Upon completion of this class, the students will be able to:

1. Demonstrate an understanding of foundational mathematics in calculus, linear algebra, and differential equations [1].
2. Develop strong reasoning skills and to apply these skills creatively to make logical arguments in various contexts [1].
3. Communicate mathematical ideas effectively in speech, writing and use precise mathematical language to express results [1].
4. Capable of working collaboratively to frame and solve complex engineering problems [1, 4].

MT 701 FOUNDRY TECHNOLOGY

L	T	P	C
3	1	0	4

Course objective:

1. Gain knowledge of the concepts, operating procedures, applications, advantages and limitations of various furnaces used in foundry shop.
2. To know how the metals casting takes place by various casting process such as die casting, centrifugal casting etc.

Understanding concepts of Solidification of metal casting. 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, mechanization 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, Phase field modeling, Casting defects Identification, analysis and Remedies

TEXT BOOKS

1. *Heine R. W., Loper C. R., Rosenthal P. C., ' Principles of Metal Casting',2nd Edition, Tata McGraw Hill Publishers, 1985*
2. *Jain P. L., ' Principles of Foundry Technology', 3rd Edition, Tata McGraw Hill, 1995*

Course outcomes Upon completion of this class, students are expected to

1. Know the furnaces used in the production of metals and alloys; [1]
2. Understand melting practice that takes place in the different furnaces; [1]
3. Describe different types of molding, casting and solidification processes; [1, 7]
4. Differentiate between the different casting processes and their end products; [1]
5. Develop designs for engineering components produced via against defects; [1, 3, 9]

MT 703 METAL JOINING

L	T	P	C
3	0	0	3

Course objective:

1. To know the concepts of different materials joining technology and emphasis on underlying science and engineering principle of every processes.

Classification of welding processes, energy sources used in welding, working principle, advantages, limitations of arc welding processes –MMAW, GTAW, GMAW, SAW, ESW & EGW

Working principle, advantages and limitations of solid state welding processes. - Friction, friction stir, explosive, diffusion and ultrasonic welding.

Working principle, advantages and limitations of power beam processes: Plasma arc welding, electron beam & laser beam welding.

Principles of operation, process characteristics, types and applications – Resistance welding, Gas welding, brazing, soldering and joining of non metallic materials.

Welding metallurgy: Introduction, thermal cycles, prediction of peak temperature, pre heat and cooling rate, PWHT. Weldability of carbon steel, stainless steel & aluminum. Hot & cold cracking phenomenon, weld defects, causes and their remedies

TEXT BOOKS:

1. Parmer R. S., 'Welding Engineering and Technology', Khanna Publishers, 1997
2. *Robert W Messler, Jr. " Principles of welding, Processes, physics, chemistry and metallurgy", Wiley,2004.*
3. *Larry Jeffus, " Welding Principles and Applications" Fifth edition, Thomson, 2002*

Course outcomes: Upon completion of this class, students are expected to

1. Understand the working principle, merits and demerits of different joining processes [1]

2. Understand the working principle and importance of welding allied processes

Solve welding heat flow related problems [1, 2, 5]

3. Learn weldability and welding related problems of different materials [1, 2, 5]

MT 659 METALLOGRAPHY, MATERIALS TESTING AND CHARACTERIZATION LABORATORY

L	T	P	C
0	0	3	2

COURSE OBJECTIVE:

1. To learn the principles of material testing and characterization and to apply them for various engineering applications.

LIST OF EXPERIMENTS:

1. Study of metallurgical microscope and sample preparation
2. Microscopic examination of ferrous alloys (plain carbon steels, stainless steels, maraging steels and tool steels and cast irons).
3. Microscopic examination of non-ferrous materials (Magnesium alloys, Aluminium alloys, Titanium alloys, Copper alloys, Super alloys).
4. Tensile Testing using Hounsfield and UTM
5. Hardness Measurements (Rockwell, Vickers and Brinell)
6. Impact Testing (Izod and Charpy)
7. Determination of crystal structure and lattice parameters from XRD data
8. Crystallite size determination of materials using XRD
9. Fractography using scanning electron microscope

COURSE OUTCOMES: Upon completion of this class, the students will be able to:

1. Prepare the specimens for metallographic examination with best practice, can operate the optical microscope and understand, interpret, analyze the microstructure of materials. [1, 2]
2. Classify the different mechanical testing methods with their inherent merits and limitations. [1]
3. Apply various test methods for characterizing physical properties of materials. [1, 2]
4. Recommend materials testing techniques based upon desired results, perform basic statistical analysis on data, and summarily present test results in a concise written format. [1, 2, 5]

MT702- INDUSTRIAL HEAT TREATMENT

L	T	P	C
3	0	0	3

Course objective:

1. The heat treatment technology deals with the factors and mechanisms involved in the control of composition and properties of various materials with 'getting it right' economically, operationally, and environmentally.

Principles of Heat treatment**:** Purpose of alloying, effect of alloying elements on ferrite, cementite, Fe-Fe3C system, tempering and TTT Curves, Austenitic Transformation, Pearlitic Transformation, Bainitic Transformation, Martensitic Transformation

Chemical and Thermo mechanical heat treatment**:** Annealing, Normalizing, Hardening, mechanism of heat removal during quenching, quenching media, size and mass effect, hardenability, tempering, austempering. Carburizing, cyaniding, flame and induction hardening, residual stresses, deep freezing, thermo mechanical treatments: HTMT, LTMT, Ausforming, Isoforming, Cryoforming.

Heat treatment of Ferrous alloys:Heat treatment of Plain carbon, Alloy and structural steels and Cast Iron

Non-ferrous metals and alloys: Precipitation hardening, aging treatment, study of copper, aluminum, Mg and nickel and their alloysFurnaces: Heat treatment furnaces and their design, atmosphere control vacuum heat treatment etc.

Defects in Heat treatment and their remedies, Economics of heat treatment

Text Books:

1. Heat Treatment Principle and Techniques by Rajan,Sharma
2. Principles of Heat treatment of steels by R C Sharma, New Age International, 2007
3. The steel Handbook by AlokNayar, McGraw-Hill Education, 2001

Reference Books:

1. Handbook of Heat Treatment of steels by K H Prabhudev, Tata McGraw-Hill Publication.
2. Hand book on Heat Treatment of steels-Tata McGraw-Hill Education.

Course Outcomes:

1. The student will have the ability to understand the advantages of heat treatment like increasing the strength of material, improve machining, improving formability, restore ductility after a cold working operation. Thus it is a very enabling manufacturing process that can not only help other manufacturing process, but can also improve product performance by increasing strength or other desirable characteristics. [1, 7, 9]

MT 704 FOUNDRY METALLURGY

L	T	P	C
3	0	0	3

Course objective:

1. To comprehend the basic principles of physical metallurgy of ferrous and non-ferrous alloys and apply those principles for engineering applications.

Apply the basic principles of physical metallurgy for developing new alloys and composites.

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 cast irons as per IS,BS and ASTM- Metallurgical aspects of gating and risering of ferrous alloys, fluidity of ferrous alloys.

Typical non-ferrous casting alloys(such as aluminium, magnesium, copper and other commercially important non-ferrous alloys), specifications, properties, industrial applications, melting and composition control, deoxidation, gating and risering techniques.

Solidifications of ferrous and non –ferrous metals. Directional solidification of ferrous metals and its alloys, modelling of solidification for both ferrous and non-ferrous metals

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.

5. John R.Brown, “FOSECO Non Ferrous Foundry Man’s Hand Book”, Butterworth, 2000.

6. Murphy,A.J.,Ed.,"Non Ferrous Foundry Metallurgy",Pergamon,USA,1984

Course outcomes: By successful completion of this course, the student will be able to

1. Understand the casting aspects of ferrous and non-ferrous alloys. [1]
2. Identify the phases present in different alloy systems. [1, 2]
3. Understand the structure-property correlation in different ferrous and non-ferrous alloys [1, 2]
4. Apply the basic principles of ferrous foundry metallurgy for selection of materials for specific applications [1,3, 9]
5. Apply the basic principles of non-ferrous foundry metallurgy for selecting materials for specific applications [1, 3, 9]

MT 706 METAL FORMING

L	T	P	C
3	0	0	3

Course objective:

1. To know the concepts of metal forming and associate technologies and apply them to the conventional and advanced materials manufacturing for various structural applications.

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. Incremental forming, fine blanking, 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.

Course outcomes: At the end of this course, the students would be able to:

- Apply the concept of plastic deformation for metals and alloys to convert them in to useful shapes for intended engineering applications [1, 2, 3, 5, 9]
- Differentiate the various metal forming technology and choose the appropriate one for required engineering applications [1, 5, 9]
- Provide the successful solution to the various materials design and selection criteria for demanding engineering applications. [3, 5,9]
- Analyze various operational and materials parameters influencing the metal forming quality. [3, 5, 9]
- Classify various metal forming technology (forging, rolling, extrusion etc.) and associated forming equipments [2]
- Define various secondary forming procedures like stretch forming, deep drawing blanking and associated equipments [1]

MT 660 ADVANCED MATERIALS PROCESSING LABORATORY

L	T	P	C
0	0	3	2

COURSE OBJECTIVE: The objective of this laboratory course is to provide an insight for the latest developments in materials processing.

LIST OF EXPERIMENTS:

1. Fabrication of nanostructured coatings by plasma electrolytic processing
2. Mechanochemical synthesis of nanostructured compounds
3. Microwave synthesis of nanosized ceramic powders
4. Diffusion bonding of Materials
5. Equichannel angular processing of materials
6. Cryorolling of materials
7. Vacuum arc melting of materials
8. Spark plasma sintering of materials
9. Microwave sintering of materials
10. In-situ synthesis of metal matrix composites by casting

COURSE OUTCOMES: After the completion of this course, the student will be able to:

1. Understands the working principles of different advanced processes [1]
2. Synthesize nanostructured materials by advanced processing methods. [2, 3, 6]
3. Perform experiments with best practices and understands the advantages and limitations of different processes [2]
4. Interpret and analyze the data and present the results in a concise written format [2]
5. Recommend a suitable process for modifying the material properties. [3, 9]

MT 747 PROJECT WORK PHASE –I

L	T	P	C
0	0	30	12

COURSE OBJECTIVE:

To know in depth exploration of a topic of special interest and to explain, apply relevant theories and laws in the chosen area.

COURSE OUTCOMES: At the end of this course, the students would be able to:

Interpret theories and doctrines, and give recommendations where appropriate. [1, 2]
Knowledge on the chosen topic and apply the knowledge, experience, and skills learned. [1, 5]
Produce a thesis of publishable quality. [1]
Effectively present and defend research orally. [1]

MT 748 PROJECT WORK PHASE –II

L	T	P	C
0	0	30	12

COURSE OBJECTIVE:

To know in depth exploration of a topic of special interest and to explain, apply relevant theories and laws in the chosen area.

COURSE OUTCOMES: At the end of this course, the students would be able to:

Interpret theories and doctrines, and give recommendations where appropriate. [1, 2]
Acquire knowledge on the chosen topic and apply the knowledge, experience, and skills learned. [1, 5]
Produce a thesis of publishable quality. [1]
Effectively present and defend research orally. [1]

MT 611 PHYSICAL METALLURGY

(Compulsory for non metallurgy students)

L	T	P	C
3	0	0	3

COURSE OBJECTIVE: To develop an understanding of the basis of physical metallurgy and correlate structure of materials with their properties for engineering applications.

COURSE CONTENT

Introduction to engineering materials. Atomic structure and inter atomic bondings, theoretical concept of crystalline materials – types of packing, voids and packing factors for each of the packings, concept of alloy design using lattice positions and intristitial voids. Planes and directions and imperfections in solids. Polymorphism and allotropy.

Diffusion, energetic of solidification Nucleation and growth-dealing homogeneous and heterogeneous nucleations and growth of solids, dendritic growth in pure metals, constitutional super cooling and dendritic growth in alloys.

Phase diagrams – solid solution –types, Hume –Rothery rule. Phase diagrams – Binary- types – Lever rule. Solidification of different types of solid solutions – Iron-Carbon diagram – Effect of alloying element on Iron-carbon diagram. Ternary phase diagrams- Understanding of isotherms and isopleths.

Heat treatment of ferrous alloys; Annealing, Normalising, TTT and CCT diagrams, Hardening – hardenability measurements, tempering. Thermo mechanical treatments. Heat treatment furnaces – atmospheres – quenching media – case hardening techniques.

Basic concept of dislocations their types and its interactions.Dislocations and strengthening mechanisms strengthening by grain-size reduction, solid solution strengthening, strain hardening, dispersion hardening and other recent modes of hardening.

Text Books

1. *Avner, S. H., "Introduction to Physical Metallurgy", second edition, McGraw Hill, 1985.*
2. *William F. Hosford, Physical Metallurgy, Taylor & Francis Group, 2008*
3. *Raghavan, V., "Physical Metallurgy", Prentice Hall of India, 1985*
4. *Donald R Askland and Pradeep P Phule "Essentials of Materials Science and Engineering, Baba Barkha NathPrinters, Delhi.*
5. *Willam D. Callister, Jr. Materials Science and Engineering, Wiley India Pvt. Ltd.*
6. *Vijendra Singh, Physical Metallurgy, Standard Publishers.*

COURSE OUTCOMES: Upon completion of this class, the students will be able to:

1. Describe the basic crystal structures (BCC, FCC, and HCP), recognize other crystal structures, and their relationship with the properties [1]

2. Define and differentiate engineering materials on the basis of structure and properties for engineering applications [1, 3, 5]

3. Select proper processing technologies for synthesizing and fabricating different materials [1, 3, 5, 6]

4. Analyse the microstructure of metallic materials using phase diagrams and modify the microstructure and properties using different heat treatments. [1, 2, 3, 6, 9]

MT 612 MECHANICAL BEHAVIOUR OF MATERIALS

L	T	P	C
4	0	0	4

COURSE OBJECTIVE: To understand the concepts on materials failure and fracture analysis of materials and to design new materials that can with stand catastrophic failures at different environment.

COURSE CONTENT

Definition of stress, strain, transformation of coordinate systems, tensor notations, relationship between stress and strain in elastic materials, concept of principal stress and principal strain, stress invariants, modulus, Hook's law and understanding of stiffness and compliance tensors, elastic anisotropy,

Yield criteria, equivalent stress and plastic strain, Theoretical shear of perfect crystal, Mohs circle, concept of dislocations and dislocation theory, edge and screw dislocations, dislocation interactions, kink and jog, sessile and glissiles, partial dislocations, dissociation of dislocations, Thomson tetrahedral, Lomer-Cottress barriers.

Polymer elasticity and viscoelasticity, types of reinforcements and their influence, types of composites, high temperature degradation, creep and stress rupture, deformation mechanism maps, superplasticity and hot working.

Hardness, types of hardness measurements, comparison among hardness methods and scales, nanoindentation, compression testing, comparison between tension and compression studies of materials, shear testing, shear modulus, torsion and twist.

Fatigue of materials, S-N curves, life data presentation, influence of stress, linear elastic fracture mechanics in fatigue, crack growth studies, Paris law, metallurgical aspects of fatigue failures, concepts of remedial measures, creep-fatigue interaction, theoretical strength, Griffith equation, Brittle fracture, ductile fracture, fracture mechanics, fracture maps.

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*
4. *Thomas H. Courtney, "Mechanical Behavior of Materials", 2nd Edition, 2013, Overseas Press India Private Limited, ISBN : 81-88689-69-6*
5. *Norman E. Dowling, "Mechanical Behavior of Materials", International Editirion (4th), Contributed by K. Sivaprasad and R. Narayanasamy, 2013, Pearson Education Limited. ISBN : 13:978-0-273-76455-7*

COURSE OUTCOMES: At the end of this course, the students would be able to:

1. Understand the relationship between stress and strain [1]
2. Understand the yielding behavior and dislocation influence on plastic deformation [1]
3. Understand the various strengthening mechanisms and high temperature deformation [1]
4. Understand testing methods like hardness, compression, and fatigue. [1, 2]

MT 613 CORROSION ENGINEERING

L	T	P	C
3	0	0	3

COURSE OBJECTIVE: To provide a practical knowledge about corrosion and its prevention in engineering field.

COURSE CONTENT

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.

COURSE OUTCOMES: At the end of this course, the student will be able to

1. Do electro and electroless plating of Cu, Al alloys [1, 2]
2. Determine the corrosion rate by weight loss method, electrical resistance method, potentionstatic polarization experiment and atmospheric corrosion using color indicator method [1, 2]
3. Analyze galvanic corrosion, pitting corrosion and stress corrosion cracking [1, 2]
4. Estimate the corrosion resistance by IGC susceptibility test, salt spray test and coating thickness [1, 2]

MT 614 DESIGN AND SELECTION OF MATERIALS

L	T	P	C
3	0	0	3

COURSE OBJECTIVE: To know different types of materials and properties and to select better materials for different applications.

COURSE CONTENT

Technologically important properties of materials - Physical, chemical, mechanical, thermal, optical, environmental and electrical properties of materials. Material property charts - Modulus – density, strength-density, fracture toughness-strength, Types of design, Design tools and materials data – Materials and shape – microscopic and micro structural shape factors – limit to shape efficiency Comparison of structural sections and material indices – case studies

Service, Fabrication and economic requirements for the components – Methodology for selection of materials – Collection of data on availability, requirements and non functional things- its importance to the situations – case studies

Classifying process- -systematic selection of process – Selection charts - Ranking of processes – case studies - Influence of manufacturing aspects and processing route on properties of materials and its influence on selection of materials.

Selection of materials for automobile, nuclear, power generation, aerospace, petrochemical, electronic and mining industries.

TEXT BOOKS

1. M.F. Ashby, "Materials Selection in Mechanical Design' – Third edition, Elsevier publishers, Oxford, 2005.

2. Gladius Lewis, "Selection of Engineering Materials", Prentice Hall Inc, New Jersey, USA, 1995.

3. Charles.J.A. and Crane,F.A.A., "Selection and Use of Engineering Materials", Butterworths, London, UK, 1989.

COURSE OUTCOMES: Upon completion of the course, the student will be able to:

1. Understand types of materials and properties [1]
2. Know different methods for materials selection [1]
3. Know different methods for process selection [1, 6, 7]
4. Selection of materials for Specific engineering applications and processes. [1, 3, 9]

MT 615 COMPUTATIONAL TECHNIQUES

L	T	P	C
3	0	0	3

COURSE OBJECTIVE: To introduce the general concepts and methods for computational data analysis and to develop skill and tools for analyzing

COURSE CONTENT
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*

COURSE OUTCOMES: At the end of this course, the students would be able to:

1. understand the capabilities provided by various data [1, 2]
2. analysis methods and apply the appropriate ones to solve real problems [2, 3]
3. gain hands-on experience in using data analysis tools [1, 7]

MT 616 METALLURGICAL FAILURE ANALYSIS

L	T	P	C
3	0	0	3

COURSE OBJECTIVE: To understand the concepts on materials failure and fracture analysis of materials and to design new materials that can with stand catastrophic failures at different environment.

COURSE CONTENT

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.

Analysis of wear failure. Corrosion failures- factors influencing corrosion and wear failures, Procedure for analyzing wear and corrosion failures, various types of hydrogen damage failures.

Causes of failure in forming, 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.*

COURSE OUTCOMES: At the end of this course, the students would be able to:

1. Understand the concepts of types of failures and analysis [1, 2]
2. Learn the various factors affecting/causing failures [1, 2]
3. Design new materials that can withstand failures, based on the environmental considerations and applications [1, 2, 3, 5, 9]

MT 617 SURFACE ENGINEERING

L	T	P	C
3	0	0	3

COURSE OBJECTIVE: To analyse the various concepts of surface engineering and comprehend the design difficulties.

COURSE CONTENT

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*

COURSE OUTCOMES: Upon completion of the course, the student will be able to:

1. Define different forms of processing techniques of surface engineering materials [1]
2. Know the types of Pre-treatment methods to be given to surface engineering [1]
3. Select the Type of Deposition and Spraying technique with respect to the application [1, 2, 3]
4. Study of surface degradation of materials [1]
5. Asses the surface testing methods and Comprehend the degradation properties [1, 2]

MT 618 TESTING, INSPECTION AND CHARACTERIZATION

L	T	P	C
3	0	0	3

COURSE OBJECTIVE: To provide an understanding of the basic principles of various testing, Inspection and characterization tools and use those tools to analyze metallurgical components.

COURSE CONTENT

Purpose and importance of destructive tests – Concepts, and method of Tensile, hardness, bend, torsion,compression test, fatigue and creep testing.

Purpose and limitations of NDT, Concepts, operating principles, advantages, limitations, of liquid penetrant and magnetic particle testing, eddy current testing, ultrasonic testing radiography, acoustic emission, thermal imaging method. Comparison of NDT methods and selection of NDT methods.

Tools of characterisation - Light microscopy, basic principles and special techniques. X-ray diffraction and its applications in materials characterization.

Electron microscopy, Construction, operation and applications of scanning electron microscope (SEM), transmission electron microscope (TEM),

Thermal analysis: Thermo gravimetric analysis, differential thermal analysis, differential scanning calorimetry & dilatrometry, methods for instrumental chemical analysis.

TEXT BOOKS:

1. *Non-destructive testing*, B.Hull And V.John, Macmillan, 1988.
2. *Modern Physical Metallurgy and Materials Engineering*, R. E. Smallman, R. J. Bishop, sixth edition, Butterworth-Heinemann, 1999.
3. Materials Characterisation, P.C.Angelo, Elsevier (India) Pvt. Ltd, Haryana, 2013,

COURSE OUTCOMES: By successful completion of this course, the student will be able to

1. Know various destructive and non destructive methods of testing materials [1]
2. Know the principles of metallurgical microscope, X-ray Diffractrometer (XRD), Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM), Thermal analysis and Dilatometer [1, 2, 7]
3. Describe the various sample/specimen preparation techniques for XRD, SEM, TEM and thermal analysis and quantitative metallography [1, 2, 7]
4. Determine crystal structure, lattice parameter, phase identification, solvus line estimation and residual stress analysis using XRD [1, 2, 7]
5. Select the appropriate tool to characterize the material by knowing its merits and demerits. Analyze the material in lattice level by using different modes of TEM like bright and dark field imaging, selected area diffraction and microchemical analyses. [1, 2, 7]
6. Evaluate the specimen by thermal analysis and dilatometry. [1, 2, 7]

MT 619 PROCESS MODELING

L	T	P	C
3	0	0	3

COURSE OBJECTIVE: To provide an understanding of the basic principles of modeling and use those methods to analyze and solve metallurgical Processes.

COURSE CONTENT

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

TEXTBOOKS:

1. Szekely J., Themelis N. J., ‘Rate Phenomena in Process Metallurgy’, Wiley, 1971
2. P.S. Ghosh Dastidar, “Computer Simulation of Flow and Heat Transfer”, Tata McGraw Hill, New Delhi, 1998

COURSE OUTCOMES: At the end of this course, the students would be able to:
1. understand the capabilities provided by various modeling methods [1, 7]
2. analysis methods and apply the appropriate ones to solve real problems [1, 2, 7]
3. gain hands-on experience in using software packages. [1, 7]

MT 620 STATISTICAL QUALITY CONTROL AND MANAGEMENT

L	T	P	C
3	0	0	3

COURSE OBJECTIVE: To learn the concepts of quality control and quality management and their applications related to the manufacture of metallurgical products.

COURSE CONTENT

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

COURSE OUTCOMES: At the end of this course, the students would be able to:

1. Understand the basic concepts in quality control and management [1]
2. Learn the statistics and probability and distribution functions related to quality management [1]
3. Understand the process of inspection, sampling and their statistical approach in quality management in industry [1, 2, 7]

MT 621 PARTICULATE TECHNOLOGY

L	T	P	C
3	0	0	3

COURSE OBJECTIVE: To introduce the importance non-conventional processing routes for different materials and its importance for advanced materials manufacturing.

COURSE CONTENT

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.*

COURSE OUTCOMES: At the end of this course, the students would be able to:

1. Describe the basic mechanism of powder production for variety of materials to meet the demand of the research and industrial needs [1, 3, 5, 9]
2. Characterize the various powders (materials) based on the engineering applications Differentiate the processing routes for various powders (materials) and associated technology [1, 2]
3. Define modern day processing routes and apply them successfully to materials processing [1, 5, 9]
4. Apply the powder metallurgy concepts to design new materials for advanced engineering materials [1, 5, 9]
5. Apply the concepts of particulate processing to produce non-conventional materials which are difficult to produce other techniques [1, 6, 9]

MT 622 DEVELOPMENTS IN IRON MAKING AND STEEL MAKING

L	T	P	C
3	0	0	3

COURSE OBJECTIVE: To study the concepts and various processing techniques involved in the field of iron and steel making.

COURSE CONTENT

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, 198.*

COURSE OUTCOMES: At the end of this course, the students would be able to:

Understand the basics of metallurgy involved in iron and steel making [1,2]

Describe the overview of processing of iron and steel [4,6]

Understand the recent developments, modifications, and applications in the iron and steel making process and apply them in real time problems associated with the making of iron and steel industry [1,3,4,6,7]

MT 623 INTELLECTUAL PROPERTY RIGHTS

L	T	P	C
3	0	0	3

COURSE OBJECTIVE: To impart the knowledge in IPR and related areas with case studies.

COURSE CONTENT

Introduction to Intellectual Property Law – The Evolutionary Past - The IPR Tool KitPara -Legal Tasks in Intellectual Property Law – Ethical obligations in Para Legal Tasks in Intellectual Property Law - Introduction to Cyber Law – Innovations and Inventions Trade related Intellectual Property Right.

Introduction to Trade mark – Trade mark Registration Process – Post registration Procedures – Trade mark maintenance - Transfer of Rights - Inter partes Proceeding – Infringement - Dilution Ownership of Trade mark – Likelihood of confusion - Trademarks claims – Trademarks Litigations – International Trade mark Law

Introduction to Copyrights – Principles of Copyright Principles -The subjects Matter of Copy right – The Rights Afforded by Copyright Law – Copy right Ownership, Transfer and duration – Right to prepare Derivative works – Rights of Distribution – Rights of Perform the work Publicity Copyright Formalities and Registrations - Limitions - Copyright disputes and International Copyright Law – Semiconductor Chip Protection Act

Introduction to Trade Secret – Maintaining Trade Secret – Physical Secrurity – Employee Limitation - Employee confidentiality agreement - Trade Secret Law - Unfair Competation – Trade Secret Letigation – Breach of Contract – Applying State Law. Geographic indication

Managing intellectual property in a knowledge-based society. IPR and technology transfer, case studies.

TEXT BOOKS:

1. Debirag E.Bouchoux: “Intellectual Property”. Cengage learning , New Delhi
2. M.Ashok Kumar and Mohd.Iqbal Ali: “Intellectual Property Right” Serials Pub.
3. Cyber Law. Texts & Cases, South-Western’s Special Topics Collections
4. Prabhuddha Ganguli: ‘ Intellectual Property Rights” Tata Mc-Graw –Hill, New Delhi

COURSE OUTCOMES: At the end of this course, the students would be able to:

1. Understand the different types of IPR
2. Study the fundamentals of IPR laws
3. Understand scope of patent, copy right, geographic indication and trade secrete

MT 624 NON-DESTRUCTIVE TESTING

L	T	P	C
3	0	0	3

COURSE OBJECTIVE: To impart the knowledge in Non Destructive Testing with case studies.

COURSE CONTENT

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).

COURSE OUTCOMES: At the end of this course, the students would be able to:

1. Understand the basics of Non destructive testing [1]
2. Describe the overview of Non destructive testing methods [1]
3. Understand the recent developments, modifications, and applications in Non destructive testing and apply them in real time problems associated with failure analysis and regular quality testing for industries [1, 2, 3, 5, 9]

MT 711 STAINLESS STEEL TECHNOLOGY

L	T	P	C
3	0	0	3

Course objective:. To introduce the importance of metallurgical aspects for various types of steel and its importance for advanced manufacturing methods

Metallurgy and Properties of Wrought Stainless Steels, Metallurgy and Properties of Cast Stainless Steels ,melting practice in stainless steel technology, 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.

Course outcomes: By successful completion of this course, the student will be able to
Review of the selection of stainless steels for use in corrosive environments [1, 9]

Describe the practical aspects of forming, heat treating, machining, joining and surface engineering [1]

To get the knowledge of phase diagram, metallography and microstructures of various types of steel [1]

MT 712 DESIGN OF CASTINGS & WELDMENTS

L	T	P	C
3	0	0	3

Course objective:.

General rules for designing of economical moulding and coring

Design of gating and risering for various metals used in the casting

Appropriate selection of casting design in economical manner for the manufacturing components in industries

- Design weld joins operating under static and dynamic loading conditions.
- Analyze and predict the life of weld joints using the concepts of fracture mechanics and identifying the effects of stress concentration build up.

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.

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.

Course outcomes: By successful completion of this course, the student will be able to

1. Gain knowledge of the function of the different parts of the mold during the manufacture of the cast part. [1, 7]
2. Casting design issues and practices through standards [1, 3]
3. Develop key steps in new casting and can help in reduce the time involved [1, 3, 5, 6, 9]
4. Design problems involving thin sections in various types of castings [1, 3, 6, 9]
5. To improve the casting quality by analyzing the various parameters related to cast product, tooling and process on manufacturability [1, 3, 5, 6, 9]
6. Design weld joints for strength and rigidity under static loading conditions [1, 3, 9]
7. Identify the various types of stresses and distortions to a component during welding and takes measures to minimize or eliminate such effects [1, 3, 5, 6, 9]

MT713 ADVANCED MATERIALS AND PROCESSING

L	T	P	C
3	0	0	3

Course objective: To introduce the importance non-conventional processing routes for different materials and its importance for advanced materials manufacturing.

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.

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.

Course outcomes: At the end of this course, the students would be able to:

- Describe the basic mechanism of powder production for variety of materials to meet the demand of the research and industrial needs [1]
- Characterize the various powders, nanomaterials (materials) based on the engineering applications [1, 2]
- Differentiate the processing routes for different materials like metallic glass (materials) and associated technology like Rapid Solidification Processing [1, 2, 3]
- Define modern day processing routes and apply them successfully to new materials processing for aerospace and aeronautical applications [1, 2, 3, 5, 6, 9]
- Apply the powder metallurgy concepts to synthesis new materials [1, 2, 3, 5, 6, 9]

MT 714 SPECIAL CASTING PROCESSES

L	T	P	C
3	0	0	3

Course objective: To increase the production rate, affecting economy and improving the quality of the castings.

To develop components of intricate shape and design by properly selecting the moulding and casting techniques.

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.

Course outcomes: At the end of this course, the students would be able to:

Select the appropriate pattern equipment used for shell moulding [1]

Techniques and equipments used in centrifugal casting and its types [1]

Reinforce the understanding the concepts of patterns and mould materials used in investment casting [1, 2]

MT 715 SPECIAL TOPICS IN METAL FORMING

L	T	P	C
3	0	0	3

Course objective: To know the concepts of metal forming and associate technologies and apply them to the conventional and advanced materials manufacturing for various structural applications.

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.

Course outcomes: At the end of this course, the students would be able to:

- Apply the concept of plastic deformation for metals and alloys to convert them in to useful shapes for intended engineering applications [1, 3, 5]
- Differentiate the various metal forming technology and choose the appropriate one for required engineering applications [1]
- Provide the successful solution to the various materials design and selection criteria for demanding engineering applications. [1, 3, 5, 9]
- Analyze various operational and materials parameters influencing the metal forming quality. [1, 2]
- Classify various metal forming technology (forging, rolling, extrusion etc.) and associated forming equipments [1, 7]
- Define various secondary forming procedures like stretch forming, deep drawing blanking and associated equipments [1, 2, 7]
  Identify the phases present in different alloy systems by analyzing the phase diagrams, Gating and risering techniques for modification of ferrous and its alloys [1, 2, 7]
- Apply the basic principles of de-oxidations for typical casting alloys [1]

MT716- THERMODYNAMICS OF SOLIDIFICATION

L	T	P	C
3	0	0	3

Course objective: A study of important thermodynamic functions related to solidification of metal in molds involving the characteristics of liquid-solid phase transformations, laws of thermodynamics and other functions.

To analyze solidification processing of engineering materials in terms of the phase equilibrium, transport, and interface phenomena governing microstructure development in liquid-solid transformations.

To apply these principles to industrial solidification processes, with emphasis on microstructural capabilities and limitations.

Introduction and important thermodynamic functions: Laws of thermodynamics-enthalpy, heat capacity, applications of first law to open and closed systems including chemical reactions; entropy, free energy and their interrelationships

Thermodynamics of solidification; Nucleation and growth; Pure metal solidification, Alloy Solidification, Constitutional undercooling, Mullins-Sekerka instability; Single phase solidification: Cellular and Dendritic growth; Multiphase solidification: eutectic, peritectic and monotectic; Modelling of solidification

Heterogeneous systems –equilibrium constants, Ellingham-Richardson diagrams,predominant area diagrams, principles of free energy minimization; energy balance of industrial systems; solutions-chemical potential, Raoult/Henry's law, Gibbs-Duhem equations, regular solutions, quasi chemical theory

Evolution of Phase diagrams -phase rule, free-energy-composition diagrams, solidus-liquidus lines, retrograde solidus; determination of activity and other thermodynamic parameters from phase diagrams,; thermodynamic analysis of ternary and multi component systems, interaction parameters

Principles of applications- principles of applications to molten slags and silicate melts; electrochemical methods and applications, aqueous systems; Interfaces-energy,shape, segregation at external and internal interfaces; solid electrolytes; Effect of high pressure on phase transformations; Point imperfections in crystalline solids.

Text Books:

1. Solidification Processing; Fleming, M.C., McGraw-Hill, N.Y., 1974
2. Fundamentals of Solidification by Kurz, W. and Fisher, D.J., Trans-Tech Publications, Switzerland, 1989

Course outcome:

The students will be able to analyze and understand the
Thermodynamics of solidification processes and alloys. [1]
Thermodynamic modelling of solid-liquid phase change and solutions [1, 7]
Kinetics of solidification such as nucleation, growth, and constitutional super cooling [1]