M.Tech. Degree

IN

WELDING ENGINEERING

SYLLABUS
FOR
CREDIT BASED CURRICULUM
(For the students admitted in the year 2016)

Department of Metallurgical and Materials Engineering
NATIONAL INSTITUTE OF TECHNOLOGY
Tiruchirappalli - 620 015
TAMIL NADU, INDIA

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 601	Design of Weldments	3	1	0	4
MT 603	Joining of Materials - I	3	0	0	3
	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

MT 602	Welding Metallurgy	3	0	0	3
MT 604	Welding Codes and Standards	3	0	0	3
MT 606	Joining of Materials - II	3	0	0	3
	Elective – IV	3	0	0	3
	Elective – V	3	0	0	3
	Elective – VI	3	0	0	3
MT 630	Welding Laboratory	0	0	3	2
					20

SEMESTER – III

MT 647	Project Work Phase -I	0	0	30	12
					12

SEMESTER – IV

MT 648	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	MT 625	Electrical aspects of welding	3	0	0	3
16	MT 626	Welding application technology	3	0	0	3
17	MT 627	Repair welding and reclamation	3	0	0	3
18	MT 628	Life assessment of welded structure	3	0	0	3
19	MT629	Welding economics and management	3	0	0	3
20	MT630	Additive manufacturing	3	0	0	3

Programme Educational Objectives (PEO) of M.Tech. (Welding Engineering)
I. Select their profession as Welding Engineer in Industries as well as in expanding areas of materials, power and energy-related fields.
II. Practice effectively in the emerging and modern Industrial environment with lead role and make timely development toward an establishing newer technology in welding related fields or business.
III. Pursue their careers in academia and develop entrepreneur skill

	Programme Outcomes (PO)
1	The Welding Engineering post-graduates are capable of selecting a suitable processes for producing quality weldments based on materials and applications
2	The Welding Engineering post-graduates are capable to design weld joints that serve under different loading and servicing.
3	The Welding Engineering post-graduates are capable to design a system, a component, or a process to meet desired needs within realistic constraints such as economic, environmental, social, ethical, health and safety, manufacturability, and sustainability.
4	The Welding Engineering post-graduates are capable to serve as multi-disciplinary teams.
5	The Welding Engineering post-graduates are capable to test and evaluate the weldments at various environments
6	The Welding Engineering post-graduates can assess the quality of weldments and suggest methods of producing quality joints
7	The Welding Engineering post-graduates can help in selection and design of appropriate consumables for welding involving different types of materials
8	The Welding Engineering post-graduates have the broad education necessary to understand the impact of engineering solutions in a global, economic and societal context.
9	The Welding Engineering post-graduates are capable to understand and apply the appropriate codes and standards relevant to the areas of selection of materials , consumables and testing of weldments
10	The Welding Engineering post-graduates have knowledge of contemporary /current issues.
11	The Welding Engineering post-graduates are capable to use the techniques, skills, and modern engineering tools necessary for engineering practice.
12	The Welding Engineering post-graduates can contribute in developing and adopting in energy saving and eco-friendly techniques in welding industries

MA 613 ENGINEERING MATHEMATICS

L	T	P	C
3	0	0	3

COURSE OBJECTIVE:

1.To make the students mathematically strong for solving engineering and scientific problems.

2. To train students with mathematical aspects so as to comprehend, analyse, design and create novel products and solution for the real life problems.

COURSE CONTENT

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:

- To identify, formulate and solve metallurgical engineering problems in terms of Mathematical concepts.
- To be knowledgeable about partial differential equations (PDEs) and how they serve as mathematical models for physical processes such as vibrations and heat transfer problems.
- To be familiar with the mathematical ability to design and conduct experiments, interpret and analyse data, and generating correlation of obtained results.

MT 601 DESIGN OF WELDMENTS

L	T	P	C
3	1	0	4

Course objective:

- 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.
- Learn the various types of stresses & distortions induced in a component as a result of

welding Weld joints, weld symbols, and joint design principles.

Weld design for static loading: Designing for strength and rigidity, Material – section properties, design under different loading.

Weld design for dynamic loading: Design for fluctuating and impact loading - dynamic behavior of joints - stress concentrations - fatigue analysis - fatigue improvement techniques - permissible stress- life prediction. Principles and methods and practical approach for crack arresting

Concept of stress intensity factor - LEFM and EPFM concepts - brittle fracture- transition temperature approach - fracture toughness testing, application of fracture mechanics to fatigue, weldments design for high temperature applications.

Welding residual stresses - causes, occurrence, effects and measurements - thermal and mechanical relieving; types of distortion - factors affecting distortion - distortion control methods - prediction - correction, jigs, fixtures and petitioners

TEXT BOOKS

1. *Parmer . R. S. " Welding Engineering and Technology", Khanna Publications, 1999*
2. *Gray T. G. E. 'Rational Welding Design', Butterworths, 1982*
3. *Hertzberg R.W., 'Deformation and Fracture of Mechanics of Engineering Materials', John Wiley, 1996*
4. *Dieter G.,'Mechanical Metallurgy', Tata McGraw Hill, 1988*
5. *Bhattacharya.M, 'Weldment Design',Association of Engineers,1991*

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

- Design weld joints for strength and rigidity under static loading conditions.
- Design weld joints for dynamic loading and high temperature applications.
- Analyze and predict the life of weld joints subjected to fatigue and evaluate the effect of stress concentration on fatigue life of such joints.
- Estimate the ductile to brittle transition temperatures based on fracture toughness testing and understand the LEFM and EPFM concepts in Fracture Mechanics to propose solutions for improvements to fatigue life.
- Identify the various types of stresses and distortions to a component during welding and takes measures to minimize or eliminate such effects.

MT 603 JOINING OF MATERIALS - I

L	T	P	C
3	0	0	3

Course objective:

- Understand the various manual and automated welding processes available.
- Gain knowledge of the concepts, operating procedures, applications, advantages and limitations of various welding processes

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

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

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

Plasma welding; Concepts, processes and applications, keyhole and puddle-in mode of operation, low current and high current plasma arc welding and their applications; Magnetically impelled arc butt (MIAB) welding

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

TEXT BOOKS

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

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

- Identify and list a broad classification of the various welding processes.
- Explain the various manual metal arc welding processes and their Applications.
- Explain the process, advantages, limitations and practical applications of Submerged Arc Welding, Electro slag and Electro gas welding.
- Explain the concepts, various operating procedures and applications of Plasma Welding and magnetically impelled arc butt (MIAB) welding.
- Explain the concepts and applications of various types of Resistance welding processes including Flash Butt welding, Stud Welding and Under water welding.

MT 659 METALLOGRAPHY, MATERIALS TESTING AND CHARACTERIZATION LABORATORY

L	T	P	C
0	0	3	2

COURSE OBJECTIVE: 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:

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

MT 602 WELDING METALLURGY

L	T	P	C
3	0	0	3

Course objective:

- To gain understanding of heat flow and temperature distribution on weld components based on weld geometry
- To understand the solidification structure and growth morphology on weld joins in relation to the welding parameters
- Study phase transformations in weld joints with aid of CCT, Schaffler and Delong diagrams
- Gain knowledge of process, difficulties, and microstructures formed during welding of some specific alloys such as Cu, Al, Ti and Ni alloys and the remedial measures to minimize or eliminate the occurrence of weld defects.

Heat flow - temperature distribution-cooling rates - influence of heat input, joint geometry, plate thickness, preheat, significance of thermal severity number

Epitaxial growth - weld metal solidification - columnar structures and growth morphology- effect of welding parameters - absorption of gases - gas/metal and slag/metal reactions

Phase transformations- weld CCT diagrams - carbon equivalent-preheating and post heating- weldability of low alloy steels, welding of stainless steels use of Schaffler and Delong diagrams, welding of cast irons

Welding of Cu, Al, Ti and Ni alloys – processes, difficulties, microstructures, defects and remedial measures

Origin - types - process induced defects, - significance - remedial measures**,** Hot cracking - cold cracking -lamellar tearing - reheat cracking - weldability tests - effect of metallurgical parameters,

TEXT BOOKS

1. *Linnert G. E.,'Welding Metallurgy', Volume I and II, 4th Edition, AWS, 1994*
2. *Granjon H., 'Fundamentals of Welding Metallurgy', Jaico Publishing House, 1994*
3. *Kenneth Easterling, 'Introduction to Physical Metallurgy of Welding', 2nd Edition, Butterworth Heinmann, 1992*
4. *Saferian D., 'The Metallurgy of Welding', Chapman and Hall, 1985*
5. *Jackson M. D., 'Welding Methods and Metallurgy', Grffin, London, 1967*
6. *Mishra. R.S and Mahoney. M.W, Friction Stir Welding and Processing, ASM, 200*

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

- Explain the influence of heat input and temperature distribution across a welded structure based on weld geometry.
- Correlate the solidification behavior and structure of weld zone with the welding parameters.
- Analyze and predict the weldability of low alloy steels and cast irons based on weld CCT , Shaffler and Delong diagrams.
- Identify the origin and types of process induced defects and conduct weldability tests.
- Apply remedial measures to minimize defects in welding of Cu, Al, Ti and Ni alloys based on proper understanding of the processes used and microstructural study of weld joints.

MT 604 WELDING CODES AND STANDARDS

L	T	P	C
3	0	0	3

Course objective:

- Understand the various codes and standards on welding applications.
- Gain knowledge to apply a specific code for a given welding application

Design requirements, allowable stress values, workmanship and inspection, introduction to welding codes and standards, AWS D1.1

Process and product standards for manufacturing of pipe - welding procedure and welder qualification, field welding and inspection, API 1104 and API5L

Design requirements, fabrication methods, joint categories, welding and inspection, post weld heat treatment and hydro testing, ASME II, V, VIII and IX

Welding procedure specification, procedure qualification records, performance qualification, variables

Introduction to materials standards and testing of materials, consumables testing and qualification as per ASME/AWS requirements

REFERENCES

1. *AWS D1.1 Structural Welding Code*
2. *API 5L*
3. *API 1104*
4. *ASME Section VIII - Division 1*
5. *ASME Section IX*
6. *ASME Section II Part A and C*

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

- Identify various design requirements and applicability of AWS D 1.1.
- Apply API 1104 and AP15L for pipe welding applications.
- Apply ASME II, V, VIII and IX for boiler fabrication.
- Understand and apply WPS, PQR and performance qualification variables for a specific welding application.
- Understand different materials standard, testing methods and consumable testing.

MT 606 JOINING OF MATERIALS - II

L	T	P	C
3	0	0	3

Course objective:

- Understand the various manual and automated welding processes available.
- Gain knowledge of the concepts, operating procedures, applications, advantages and limitations of various welding processes

Friction welding: Concepts, types and applications. Friction stir welding: Metal flow phenomena, tools, process variables and applications and induction pressure welding: Process characteristics and applications

Explosive, diffusion and ultrasonic welding, principles of operation, process characteristics and applications

EBW: Concepts, types and applications. LBW: Physics of lasers, types of lasers, operation of laser welding setup, advantages and limitations, applications

Soldering: Techniques of soldering, solders, phase diagram, composition, applications Brazing: Wetting and spreading characteristics, surface tension and contact angle concepts, brazing fillers, role of flux and characteristics, atmospheres for brazing, adhesive bonding

Cladding, Surfacing and Cutting

TEXT BOOKS

1. *Schwartz M.,' Materials and Applications - Metal Joining Manual', McGraw-Hill, 1979*
2. *Nadkarni S.V., 'Modern Arc Welding Technology', Oxford IBH Publishers, 1996*
3. *Christopher Davis, 'Laser Welding - A Practical Guide', Jaico Publishing House, 1994*
4. *Parmar R S, Welding Engineering and Technology, Khanna Publishers, 1997*
5. *Mishra. R.S and Mahoney. M.W, Friction Stir Welding and Processing, ASM,2007*

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

- Explain the principle of friction welding and its variants.
- Explain the process, advantages, limitations and practical applications of explosive welding, electron beam welding and laser welding.
- Explain the concepts, various operating procedures and applications of soldering and brazing.
- Explain the concepts and applications of various types of cladding, surfacing and cutting.

MT 630 WELDING LABORATORY

L	T	P	C
0	0	3	2

COURSE OBJECTIVE: To gain knowledge on practical aspects of different welding processes and able to apply them for various engineering applications.

LIST OF EXPERIMENTS

1. Arc striking practice.
2. Bead-on-plate welding
3. Effect of welding parameters on weld bead by
   - GTA welding
   - GMA welding
   - Submerged arc welding
4. Microstructural observation of weldments
   - Carbon steel
   - Stainless steel
   - Aluminium alloy
   - Titanium alloy
   - Dissimilar joints
5. Practice for preparation of welding procedure specification.
6. Practice for preparation of procedure qualification record.

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

1. Select process parameters by bead on plate trial.
2. Gain knowledge in practical aspects of GTAW, GMAW SAW.
3. Gain knowledge on welding of carbon steel, stainless steel, aluminum, titanium and dissimilar joints.
4. To carryout recommend testing techniques for welded joints.

MT 647 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.
Knowledge on the chosen topic and apply the knowledge, experience, and skills learned.
Produce a thesis of publishable quality.
Effectively present and defend research orally.

MT 648 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.
- Acquire knowledge on the chosen topic and apply the knowledge, experience, and skills learned.
- Produce a thesis of publishable quality.
- Effectively present and defend research orally.

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.

Het 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

2. Define and differentiate engineering materials on the basis of structure and properties for engineering applications

3. Select proper processing technologies for synthesizing and fabricating different materials

4. Analyse the microstructure of metallic materials using phase diagrams and modify the microstructure and properties using different heat treatments.

MT 612 MECHANICAL BEHAVIOUR OF MATERIALS

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

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.

Strengthening mechanisms, work hardening, solid solution strengthening, grain boundary strengthening, particle hardening, 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 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
2. Understand the yielding behavior and dislocation influence on plastic deformation
3. Understand the various strengthening mechanisms and high temperature deformation
4. Understand testing methods like hardness, compression, and fatigue.

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
2. Determine the corrosion rate by weight loss method, electrical resistance method, potentionstatic polarization experiment and atmospheric corrosion using color indicator method
3. Analyze galvanic corrosion, pitting corrosion and stress corrosion cracking
4. Estimate the corrosion resistance by IGC susceptibility test, salt spray test and coating thickness

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
2. Know different methods for materials selection
3. Know different methods for process selection
4. Selection of materials for Specific engineering applications and processes.

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
2. analysis methods and apply the appropriate ones to solve real problems
3. gain hands-on experience in using data analysis tools

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
2. Learn the various factors affecting/causing failures
3. Design new materials that can withstand failures, based on the environmental considerations and applications

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
2. Know the types of Pre-treatment methods to be given to surface engineering
3. Select the Type of Deposition and Spraying technique with respect to the application
4. Study of surface degradation of materials
5. Asses the surface testing methods and Comprehend the degradation properties

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, 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.

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
2. Know the principles of metallurgical microscope, X-ray Diffractrometer (XRD), Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM), Thermal analysis and dilatometer
3. Describe the various sample/specimen preparation techniques for XRD, SEM, TEM and thermal analysis and quantitative metallography
4. Determine crystal structure, lattice parameter, phase identification, solvus line estimation and residual stress analysis using XRD
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.
6. Evaluate the specimen by thermal analysis and dilatometry.

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
2. analysis methods and apply the appropriate ones to solve real problems
3. gain hands-on experience in using software packages.

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
2. Learn the statistics and probability and distribution functions related to quality management
3. Understand the process of inspection, sampling and their statistical approach in quality management in industry

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
2. Characterize the various powders (materials) based on the engineering applications Differentiate the processing routes for various powders (materials) and associated technology
3. Define modern day processing routes and apply them successfully to materials processing
4. Apply the powder metallurgy concepts to design new materials for advanced engineering materials
5. Apply the concepts of particulate processing to produce non-conventional materials which are difficult to produce other techniques

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
2. Describe the overview of Non destructive testing methods

- 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

MT 625 ELECTRICAL ASPECTS OF WELDING

L	T	P	C
3	0	0	3

Course objective:

- To gain understanding of static and dynamic characteristics of the electric arc and its associated power characteristics.
- To learn the basic principles, methods and circuit components that control operating power and the volt-ampere characteristics in electric resistance and arc welding
- To gain knowledge of the operating principles of Alternators, D.C. generators and motors used for welding.
- To understand the operation and regulation of wire feed system and controlling or arcs through the use of NC and computer controlled welding machines.

Physical phenomenon occurring in the arc, potential distribution, static and dynamic arc characteristics; types of forces and metal transfer in the arc; arc blow, power source characteristics; volt-ampere relationship and its measurement,

Basic principles, different methods of control of volt-ampere characteristics, operation, volt control, slope control, dual control, resistance welding transformers, welding rectifiers, choice of diode materials, use of thyristors, inverters

Alternators and D.C. generators for welding, three brush generator, setting of power source, characteristics of D.C. motors, synchronous motors

Wire-feed system, carriage movement control, crater filling devices, up and down slopes, seam tracking devices, magnetic control of arcs, pulsing techniques, NC and computer controlled welding machines, controls in resistance welding machines

Measurements of welding current, voltage, temperature, load and displacement, X-Y and strip chart recorders. CRO, LVDT, arc welding analyzer, resistance welding monitor

TEXT BOOKS

1. *Welding Handbook, Volume 2, 7th Edition, American Welding Society.*
2. *Richardson V. D., ' Rotating Electric Machinery and Transformer Technology', Prentice Hall of India, 1978.*

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

- Explain the physical phenomenon occurring in the arc and the types of forces and metal transfer in the arc based on measurements of power source characteristics.
- Select the right choice of diode material, thyristors and inverters based on the understanding of the basic principles and methods for controlling the volt-ampere characteristics of the electric welding machines.
- Recognize and list the wire feed systems, carriages control techniques, tracking devices and magnetically control the arc using NC and computer controlled Welding machines.
- Measure the welding current, voltage, temperature, load and displacement using equipment's such as CRO, LVDT, arc welding analyzer and resistance welding monitors.

MT 626 WELDING APPLICATION TECHNOLOGY

L	T	P	C
3	0	0	3

Course objective:

- To learn the Heat exchanges, power cycles, heating equipment's, materials and process used in making and testing of weld joints
- To understand the materials, processes, fabrication techniques used in welding of pressure vessels and in automatic welding systems used for automobile industry
- To gain knowledge of the materials, processes, fabrication, inspection and stringent quality control procedures used in Oil, gas and nuclear industries

Heat exchanges, power cycle piping, super heaters, reheaters, economiser, auxiliary pipes, materials, processes and testing/inspection

Materials, processes, fabrication techniques and field welding for pressure vessel applications

Materials, processes, fabrication and construction, use of automatic welding and systems in automobile industry, automation

Oil and gas industry, materials, processes, fabrication, inspection and testing, case studies, recent trends and developments

Materials, processes, fabrication, inspection and testing, reasons for stringent quality control measures in nuclear industry

TEXT BOOKS

1. *American Welding Society, 'Guide for Steel Hull Welding', 1992*
2. *Gooch T. S., 'Review of Overlay Welding Procedure for Light Water Nuclear Pressure Vessels', American Welding Society, 1991*
3. *Winter Mark H., 'Materials and Welding in Off-Shore Constructions', Elsevier, 1986*
4. *Welding Institute Canada, 'Welding for Challenging Environments', Pergamon Press, 1996*
5. *Mishra. R.S and Mahoney. M.W, Friction Stir Welding and Processing, ASM,2007*

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

- Explain the Heat exchanges, power cycles, heating equipment's, materials and processes used in assembling, welding and testing of weld joints.
- Select the appropriate materials, processes and fabrication techniques for welding of pressure vessels, automobile components, equipment's used in oil and gas industries, and nuclear power plants.
- Carry out inspection and testing based on case studies, recent trends and developmentsand adopt stringent quality control measures in nuclear plants.

MT 627 REPAIR WELDING AND RECLAMATION

L	T	P	C
3	0	0	3

Course objective:

To acquire knowledge and to solve problems associated with failure and to update personnel on the latest technology to ensure welded structure, pressure vessel, plant and machinery would be maintained in good operating condition and at low maintenance cost.

Engineering aspects of repair, aspects to be considered for repair welding, techno-economics, repair welding procedures for components made of steel casting and cast iron, half bead, temper bead techniques, usage of Ni base filler metals

Damaged bends in gas transmission pipeline, heat exchanger repair techniques-explosive expansion, plugging, etc., creep damaged high temperature components, repair of cracked petroleum pressure vessel/reactor

Types of wear, wear resistant materials, selection of materials for various wear applications; reclamation surfacing techniques, selection of welding process for reclamation

Integrating repair/maintenance into on-going operations; radiation protection, steam generator repair, plugging

Various types of hardness tests, NDE of surface coatings, characterisation of coatings, photothermal imaging, case histories on selection application/materials combination

TEXT BOOKS

1. *Dobly R.E., Kent K.S., „Repair and Reclamation", The Welding Institute, 1986*
2. *Maintenance Welding in Nuclear Power Plants", American Welding Society, 1988*

Course outcomes:

Upon successful completion of this course, the student will be able to:

- Improve the quality of welding which will benefit the industry in terms of productivity and savings.
- Understand the types of cracks and implement proper repair method to enhance the life of welded structures like boiler, pipeline, bridges etc.
- Develop the skills to carry out practical feasible repair techniques maintaining low cost.
- Selection of repair welding and apply techno-economics for practical problems.

MT 628 LIFE ASSESSMENT OF WELDED STRUCTURES

L	T	P	C
3	0	0	3

Course objective:

- To acquire knowledge in life assessment of welded structure and ability to analyze and apply fracture mechanics design concepts to welded structures.
- Ability to apply fitness-for-service methods and standards for design of new and for life-assessment of in-service welded structures.

Historical evolution and operation of power plants and petrochemical plants-general description, temperature, pressures and materials, failure in plants-definition of failure

Toughness, DBTT, LEFM, EPFM, temper embrittlement, hydrogen embrittlement, case histories

Mechanisms, parametric extrapolation techniques - LM, OSD, MH, MB and MCM, design rules, cumulative damage, crack growth models, RLA methodology for bulk and localised damages

High and low cycle fatigue, Coffin-Manson relationship, creep fatigue interaction, failure mechanism maps, thermal fatigue (TF), thermal-mechanical fatigue (TMF), thermal-mechanical fatigue life prediction, crack growth in fatigue

Materials, damage mechanisms and RLA of boiler tubes, header, steam pipes, rotors, steam casings, valves and steam chests, steam turbine blades, high temperature bolts.Non destructive assessment methods

TEXT BOOKS:

1. Viswanathan R. „Damage Mechanisms and Life Assessment of High Temperature Components", American Society for Metals", 1989.
2. Das A.K., 'Metallurgy of Failure Analysis', Tata McGraw Hill, 1993.

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

- An ability to select and design welding materials, processes and inspection techniques based on application, fabrication and service conditions.
- An ability to develop welding procedures that specify materials, processes and inspection requirements.
- An ability to design welded structures and components to meet application requirements of static and fatigue loading.
- An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

MT 629 WELDING ECONOMICS AND MANAGEMENT

L	T	P	C
3	0	0	3

Course objective:

- To acquire knowledge in welding economics in selection of process, consumables and work piece materials.
- To acquire knowledge in management.

Welding design, selection of electrodes, size, type and metal recovery, electrode efficiency, stub thrown away, overwelding and joint, fit - up welding position operation factor, jigs, fixtures, positioners, operator efficiency

Need for time standards, definition of standard time, various methods of computing standard time, analytical calculation, computerisation of time standards

Definition of terms, composition of welding costs, cost of consumables, labour cost, cost overheads, formulae for total cost, cost curves for different processes like CO_2 , SAW, ESW, etc., mechanisation in welding, job shop operation

Process vs product layout, construction, service consideration, employees, services, process services, etc., different work stations in shop floor and their arrangements

Selection and installation of equipment, safe handling of equipment, production control, planning for welding processes and materials, inventory control; basic aspects of financial management and man power planning

REFERENCES

1. *Bathy J., „Industrial Administration and Management, 1984*
2. *Pendar J. A., „Welding Projects - A Design Approach,1977*
3. *Welding Institute U.K., „Standard Data for Arc Welding,1994*

Course outcomes: On completion of this course, students should be able to

- Know the importance of effective costing.
- Know the factors influencing welding costs.
- Understand how to reduce welding costs and calculation of cost of a welding project.
- Know the meaning, importance, types and characteristics of maintenance system and organization of a maintenance department.
- Understand and solve problems relating to calculation of welding cost of given projects.
- Apply management skills in details ways for reducing welding cost.

MT 630 ADDITIVE MANUFACTURING

L	T	P	C
3	0	0	3

Course objectives:

- To know the principle methods, areas of usage, possibilities and limitations as well as environmental effects of the Additive Manufacturing technologies
- To be familiar with the characteristics of the different materials those are used in Additive Manufacturing.

Overview – History – Need-Classification -Additive Manufacturing Technology in product development-Materials for Additive Manufacturing Technology – Tooling – Applications.

Basic Concept – Digitization techniques – Model Reconstruction – Data Processing for Additive Manufacturing Technology: CAD model preparation – Part Orientation and support generation – Model Slicing –Tool path Generation – Softwares for Additive Manufacturing Technology: MIMICS, MAGICS.

Classification – Liquid based system – Stereolithography Apparatus (SLA) - Principle, process, advantages and applications – Solid based system –Fused Deposition Modeling – Principle, process, advantages and applications, Laminated Object Manufacturing, Wire Arc Additive Manufacturing

Selective Laser Sintering – Principles of SLS process – Process, advantages and applications, Three Dimensional Printing – Principle, process, advantages and applications- Laser Engineered Net Shaping (LENS), Electron Beam Melting.

Customized implants and prosthesis: Design and production. Bio-Additive Manufacturing- Computer Aided Tissue Engineering (CATE) – Case studies

REFERENCES

1. Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, 2nd Ed. (2015), Ian Gibson, David W. Rosen, Brent Stucker

Course outcomes:

1. Upon completion of this course, the students can able to compare different method and discuss the effects of the Additive Manufacturing technologies and analyse the characteristics of the different materials in Additive Manufacturing.