M.Tech. Degree

WELDING ENGINEERING

SYLLABUS
FOR
CREDIT BASED CURRICULUM
(2011-2013 Batch)

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

July 2011

M.Tech. WELDING ENGINEERING

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	Physical Metallurgy	4	0	0	4
MT 605	Design of Weldments	3	0	0	3
MT 603	Welding Processes - I	3	0	0	3
	Elective - I	3	0	0	3
	Elective - II	3	0	0	3
MT 619	Physical Metallurgy 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	Welding Processes - II	3	0	0	3
	Elective – III	3	0	0	3
	Elective – IV	3	0	0	3
	Elective – V	3	0	0	3
MT 629	Welding Metallurgy 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

MT 611	Electrical Aspects of Welding	3	0	0	3
MT 615	Selections of Materials	3	0	0	3
MT 617	Computational Techniques	3	0	0	3
MT 619*	Surface Engineering	3	0	0	3
MT 621	Testing, Inspection and Characterization	3	0	0	3
MT 614	Corrosion Engineering	3	0	0	3
MT 616	Welding Application Technology	3	0	0	3
MT 618	Metallurgical Failure Analysis	3	0	0	3
MT 624	Repair Welding and Reclamation	3	0	0	3
MT 626	Life Assessment of Welded Structures	3	0	0	3
MT 628	Process Modeling	3	0	0	3
MT 630	Welding Economics and Management	3	0	0	3
MT 632	Statistical Quality Control and Management	3	0	0	3

* Code number is prone for change

MA 613 ENGINEERING MATHEMATICS

L	T	P	C
3	0	0	3

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

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

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

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

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

References

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

MT 601 PHYSICAL METALLURGY

L	T	P	C
4	0	0	4

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.

Basic concept of dislocations their types and its interactions. Concept of alloying steels and non-ferrous metals such as aluminum, magnesium, titanium zinc and copper, 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 dealing unary, binary, ternary and quaternary phase diagrams. Understanding of isotherms and isopleths.

Phases and micro constituents in steels and cast irons- equilibrium and non-equilibrium cooling of different Fe-C alloys. Effect of alloying elements and cooling rate on structure and properties of steels and cast irons. TTT and CCT diagrams – hardenability measurements,

annealing, normalizing and tempering. Heat treatment furnaces – atmospheres – quenching media – case hardening techniques.

Introduction to specifications – types of steels, alloy steels, tool steels; stainless steels. Types of cast irons – compositions, properties and applications, specific heat treatment.

Dislocations and strengthening mechanisms strengthening by grain-size reduction, solid solution strengthening, strain hardening, Recovery, recrystallization and grain growth, dispersion hardening and other recent modes of hardening.

Fundamentals of fracture – ductile and brittle fracture, principles of fracture mechanics, impact fracture testing, crack initiation and propagation, crack propagation rate, factors affecting fatigue life – Environmental effects. Assessment of fractography.

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.*

MT 603 WELDING PROCESSES - I

L	T	P	C
3	0	0	3

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

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

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

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

MT 605 DESIGN OF WELDMENTS

L	T	P	C
3	0	0	3

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 behaviour 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*

MT 619 PHYSICAL METALLURGY LABORATORY

L	T	P	C
0	0	3	2

List of Experiments

1. Study of metallurgical microscope and sample preparation
2. Microscopic examination of plain carbon steels, stainless steels, maraging steels and tool steels
3. Microscopic examination of cast irons
4. Microscopic examination of
    - Magnesium alloys
    - Aluminium alloys
    - Titanium alloys
    - Copper alloys
    - Super alloys
5. Demonstration of hardness measurements - micro and macro, and evaluation of tensile properties

MT 602 WELDING METALLURGY

L	T	P	C
3	0	0	3

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, 2007*

MT 604 WELDING CODES AND STANDARDS

L	T	P	C
3	0	0	4

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*

MT 606 WELDING PROCESSES - II

L	T	P	C
3	0	0	3

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*

MT 629 WELDING METALLURGY LABORATORY

L	T	P	C
0	0	3	2

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.

ELECTIVES

MT 611 ELECTRICAL ASPECTS OF WELDING

L	T	P	C
3	0	0	3

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 material; 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.*

MT 615 SELECTIONS OF MATERIALS

L	T	P	C
3	0	0	3

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

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

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

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

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

TEXT BOOKS

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

MT 613 MECHANICAL BEHAVIOUR OF MATERIALS

L	T	P	C
3	0	0	3

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

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

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

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

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

TEXT BOOKS

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

MT 617 COMPUTATIONAL TECHNIQUES

L	T	P	C
3	0	0	3

Design of Experiments: Factorial Design, Taguchi Techniques, ANOVA

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

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

Finite element Methods: Introduction to I-D FEM; Problems in structural Mechanics using 2D elements, Plane stress, plain strain, ax symmetric 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*
2. *Taguchi techniques for quality engineering – Philip J.Ross, McGraw-ill book Company*
3. *Cerjak H., "Mathematical Modeling of Weld Phenomenon-2", The Institute of Materials, 1995.*

MT 619 SURFACE ENGINEERING

L	T	P	C
3	0	0	3

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

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

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

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

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

TEXT BOOKS

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

MT 621 TESTING, INSPECTION AND CHARACTERIZATION

L	T	P	C
3	0	0	3

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 characterization - 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.

MT 614 CORROSION ENGINEERING

L	T	P	C
3	0	0	3

Electrochemical and thermodynamic principles - Nernst equation and electrode potential of metals, standard electrodes and reference electrodes, E.M.F. and galvanic series, Pourbaix diagram and its importance for iron, aluminium and magnesium

Exchange current density, different forms of polarisation: activation, concentration, resistance polarisation, Tafel equation, electrochemical behaviour of active-passive metals, Flade potential, theories of passivity

Atmospheric, pitting, dealloying, stress corrosion cracking, intergranular corrosion, corrosion fatigue, fretting corrosion, high temperature oxidation, catastrophic and internal oxidation

On - site investigation and laboratory analysis - corrosion testing - laboratory, semi plant service and field tests; corrosion in ceramics, polymers and remedial measures

Corrosion prevention, design improvement, cathodic and anodic protection, coatings (metallic and non-metallic), and corrosion inhibitors - economic aspects of corrosion control and corrosion auditing in industries - corrosion map of India

TEXT BOOKS

1. *Fontana M. G, Greene N. D, 'Corrosion Engineering', McGraw Hill, 2nd Edition, 1978*
2. *Raj Narayan, 'An Introduction to Metallic Corrosion and its Prevention', Oxford and IBH, 1983*
3. *Denny Jones, 'Principles and Prevention of Corrosion', Prentice Hall of India, 1996.*

MT 616 WELDING APPLICATION TECHNOLOGY

L	T	P	C
3	0	0	3

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*

MT 618 METALLURGICAL FAILURE ANALYSIS

L	T	P	C
3	0	0	3

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

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

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

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

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

TEXT BOOKS:

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

MT 624 REPAIR WELDING AND RECLAMATION

L	T	P	C
3	0	0	3

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*

MT 626 LIFE ASSESSMENT OF WELDED STRUCTURES

L	T	P	C
3	0	0	3

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.

MT 628 PROCESS MODELING

L	T	P	C
3	0	0	3

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

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

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

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

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

TEXT BOOKS

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

MT 630 WELDING ECONOMICS AND MANAGEMENT

L	T	P	C
3	0	0	3

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*

MT 632 STATISTICAL QUALITY CONTROL AND MANAGEMENT

L	T	P	C
3	0	0	3

Variations; analysis of variance, statistical tools, statistical quality control; control charts; process capability analysis; statistical process control.

Inspection; inspection by sampling; acceptance sampling; statistical approaches; single, double and multiple sampling plans; statistical design of experiments.

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.

Reliability – concept; difference between reliability and quality; different measures of reliability; time to failure distributions; MTBF; MTTF; concept of risk analysis.

TEXT BOOKS

1. *B.L. Hansen, P.M. Ghare, 'Quality Control and Application', PHI – EEE, 1997.*