GOVERNMENT COLLEGE OF ENGINEERING, SALEM-11

(An Autonomous Institution, Affiliated to Anna University, Chennai)

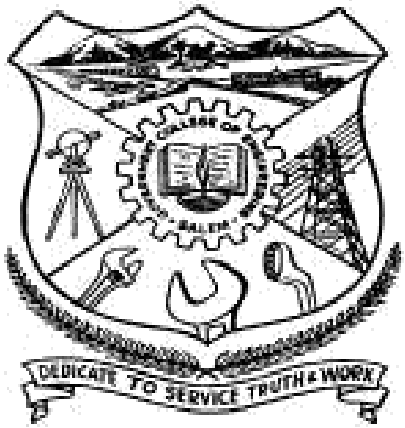
M.E., WELDING TECHNOLOGY

REGULATIONS – 2022

CURRICULUM

&

SYLLABUS



DEPARTMENT OF METALLURGICAL ENGINEERING

GOVERNMENT COLLEGE OF ENGINEERING

SALEM – 636 011

GOVERNMENT COLLEGE OF ENGINEERING, SALEM – 636 011.

Curriculum 2022 - Autonomous Courses
(For Students Admitted from 2022 – 2023)

M.E. WELDING TECHNOLOGY – Full Time

Course code	Name of the Course	Category	Hours/Week: Contact periods	Lecture	Tutorial/ Demo*	Practical	Credit	Maximum Marks: CA	FE	Total
SEMESTER I										
22WT**C**11	Advanced Mathematics and Statistics	Core	3	3	-	-	3	40	60	100
22WT**C**12	Welding Processes – I	Core	3	3	-	-	3	40	60	100
22WT**E**__	Elective - I	PEC-1	3	3	-	-	3	40	60	100
22WT**E**__	Elective - II	PEC -2	3	3	-	-	3	40	60	100
22WT**C**13	Metallography Lab	Core	4	-	-	4	2	40	60	100
22WT**C**14	Joining Lab	Core	4	-	-	4	2	40	60	100
22**MLC01**	Research Methodology and IPR	MC	3	3	-	-	3	40	60	100
22AC____	Audit course – 1	Audit	2	2	-	-	0			
TOTAL			25	17	-	8	19	**-**	**-**	**700**
SEMESTER II										
22WT**C**21	Welding Processes – II	Core	3	3	-	-	3	40	60	100
22WT**C**22	Welding Metallurgy	Core	3	3	-	-	3	40	60	100
22WT**E**__	Elective – III	PEC-3	3	3	-	-	3	40	60	100
22WT**E**__	Elective - IV	PEC-4	3	3	-	-	3	40	60	100
22WT**C**23	Quality Control in Weldments Lab	Core	4	-	-	4	2	40	60	100
22WT**C**24	Characterization Lab	Core	4	-	-	4	2	40	60	100
22WT**C**25	Mini Project	EEC	4	-	-	4	2	40	60	100
22AC____	Audit course – 2	Audit	2	2	-	-	0			
TOTAL			26	14	-	12	18	-	**-**	**700**
SEMESTER III										
22WT**E**__	Elective - V	PEC-5	3	3	-	-	3	40	60	100
22WT**E**__	Elective - VI	PEC-6	3	3	-	-	3	40	60	100
22WT**C**31	Project Phase – I	EEC	20	-	-	20	10	80	120	200
TOTAL			26	6	-	20	16			**400**
SEMESTER IV										
22WT**C**41	Project Phase – II	EEC	32	-	-	32	16	160	240	400
TOTAL			32	-	-	32	16			**400**

Total Credits for the programme = 19 + 18 + 16 + 16 = 69

PROFESSIONAL ELECTIVE COURSES (PEC)

Course Code	Name of Course
22WT**E**01	Physical Metallurgy and Heat Treatment
22WT**E**02	Welding Economics, Management and Safety
22WT**E**03	Composite Materials
22WT**E**04	Materials Characterization
22WT**E**05	Failure Analysis in Weldments
22WT**E**06	Testing and Inspection of Materials
22WT**E**07	Non - metallic Materials
22WT**E**08	Finite Element Analysis
22WT**E**09	Electrical Aspects of Welding
22WT**E**10	Total Quality System and Engineering
22WT**E**11	Automation and Robots in Welding
22WT**E**12	Welding Application Technology
22WT**E**13	Brazing, Soldering, Surfacing and Cutting
22WT**E**14	Corrosion and Surface Engineering
22WT**E**15	Design of Weldments
22WT**E**16	Industrial Safety
22WT**E**17	Welding Codes and Standards
22WT**E**18	Foundry Processes and Metallurgy
22WT**E**19	Forming Processes

AUDIT COURSES

Course Code	Name of Course
22**AC**01	English for Research Paper Writing
22**AC**02	Disaster Management
22**AC**03	Sanskrit for Technical Knowledge
22**AC**04	Value Education
22**AC**05	Constitution of India
22**AC**06	Pedagogy Studies
22**AC**07	Stress Management by Yoga
22**AC**08	Personality Development through Life Enlightenment Skills

SEMESTER - I

22WTC11 ADVANCED MATHEMATICS AND STATISTICS L T PC

3 0 03

Course Objectives:

- Tofamiliarizewiththenumericalsolutionoflinearandnon-linearequationsandfitting curves by the method of leastsquares.
- Toobtainthesolutionsofdiffusionandwaveequationbyusingtechniquesof Laplace and Fouriertransforms.
- To understand the significance of central limit theorem and testing ofhypothesis.
- To analyze the variance of factors by one way and two way classification and some standard design ofexperiments.

UNIT I CURVE FITTING AND SOLUTIONOFEQUATIONS (9)

Curve fitting by the Method of Least Squares –Fitting of straight lines, second degree parabolas and curves reducible to linear forms- Solution of Algebraic and Transcendental equations by Newton- Raphson method-Solutions of linear system of equations by Gauss Elimination, Gauss Jordan and Gauss Seidal methods**.**

UNIT III LAPLACE TRANSFORM TECHNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS (9)

Laplace transform: Definitions – Properties- Inverse Laplace transform- Solution of diffusion equation and wave equation by Laplace transform technique.

UNIT III FOURIER TRANSFORM TECHNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS (9)

Fourier transform: Definitions – Properties- Transform of elementary functions- Solution of Diffusion equation, wave equation and Laplace equation by Fourier transform technique.

UNIT IV STANDARD DISTRIBUTIONS AND TESTINGOFHYPOTHESIS (9)

Random variables- Standard discrete and continuous distributions (Binomial, Poisson, Normal, uniform and Exponential) – Central limit theorem and its significance- Testing a statistical hypothesis, Sampling distributions (t-test, F-test and Chi-square test).

UNITV ANALYSIS OF VARIANCE AND DESIGNOFEXPERIMENTS (9)

Analysis of variance -One way and Two way classifications- Principles of Design of Experiments- Some standard designs (Completely Randomized Design, Randomized Block design and Latin square design).

TOTAL = 45 Periods

COURSE OUTCOMES:

On completion of the course the students will be able to

1. Obtain the numerical solution of linear and non-linear equations and fitting curves by method of leastsquares.
2. Obtain the solutions of diffusion and wave equation involved in engineeringproblems by using Laplace and Fourier transformtechniques.
3. Gain the knowledge on statistical sampling and its applications, analysis of variance by one and two wayclassification.

TEXT BOOKS:

1. K.Sankara Rao, “Introduction to Partial Differential Equations”, Prentice Hall of India Pvt.
   Ltd., New Delhi, 2003.
2. Veerarajan.T, “Probability, Statistics and Random process”, Tata McGraw- Hill publications, second edition, New Delhi,2002.
3. Kandasamy.P, Thilagavathy.K, Gunavathi.K, “Numerical Methods” S.Chand& Co., New Delhi,2005.

REFERENCE BOOKS:

1. Grewal, B.S., “Higher Engineering Mathematics”, 43rdedition, Khanna Publishers, New Delhi2014.
2. Andrews.L.C and Shivamoggi. B, “Integral Transforms for Engineers”, Prientice Hall of India Pvt. Ltd., New Delhi,2003.
3. Peter O’Neil, “Advanced Engineering Mathematics”, 7thedition, Cengage Learning, 2012.
4. Gupta,S.C.andKapur,V.K.,“FundamentalsofMathematicalStatistics”,S.Chandand Sons, New Delhi, 11thEdition2014
5. Devore,JayL.,“ProbabilityandStatisticsforEngineeringandtheSciences”,5th Edition, Brooks- Cole, 1999.

22WTC12 **WELDING PROCESSES –I** **L T PC**

3 0 03

Course Objectives:

- To understand the various weldingprocesses.
- To gain knowledge on the principle of operation, advantages, limitationsand applications of various weldingprocesses.
- To suggest appropriate welding processes forapplications.

INTRODUCTION TO JOINING PROCESSES ANDGASWELDING (9)

Importanceofwelding,comparisonofweldingwithotherfabricationprocesses.Classification of welding processes, Heat sources for fusion welding, shielding methods, Nature and behavior of fluxes for welding, Shielding gases, Arcphysics.
Relationship between heat input and energy density, Oxy Fuel Gas Welding: Gases – setup ofequipment–Flamecharacteristics,differentkindsofflameandtheirapplications,Variants of oxy fuel gaswelding.

SHIELDED METALARCWELDING (9)

SMAW Process: Principle of the process, Electrodes, functions of flux coating, types of electrodes, Arc welding power sources and their applications, AWS Classifications of electrodes, electrode designations, defects, causes and remedies. Advantages, limitations and applications of SMAW process. Variants of SMAW process.

GAS TUNGSTEN ARC WELDING and PLASMAARCWELDING (9)

Gas Tungsten Arc Welding – Equipment, Electrodes, polarity, shielding gases, use of D.C. suppressors, arc starting and stopping, choice of filler metal composition, use of pulsed arc and GTA spot welding, other recent developments, advantages, limitations andapplications - defects, causes and remedies. Plasma arc welding: Equipment, Operating modes – melt-in technique, key-hole technique, arc- transferred and non-transferred arc, micro, low and high current plasma arc welding and theirapplications.

GAS METAL ARC WELDING and FLUX COREDARCWELDING (9)

Gas Metal Arc Welding**-** Principle of operation, Metal transfer mechanisms, Equipment, shielding gases, electrodes, Pulsed GMAW, Synergic GMAW, Cold Metal Transfer. Advantages, disadvantages and applications of GMAW.
Fluxcoredarcwelding–Processfeatures,Equipment,ElectrodemanufactureandElectrode classification. Advantages, disadvantages and applications of Flux Cored Arcwelding.

SUBMERGED ARC WELDING and STUDARCWELDING (9)

Submerged arc welding – Principle of operation, Equipment, Flux classification, Basicity index, Electrodes, Variations of Process, Defects, Advantages, Disadvantages and Applications.
Stud arc welding - Equipment, operation, Stud arc welding gun, Ferrules. Defects, Advantages, Disadvantages and applications in Stud Arc welding.

Total: 45 periods

Course Outcomes: Upon completion of this course, the students will be able to:

- Identify and list the broad classification of various weldingprocesses.
- Explain the principle of operation, advantages, limitations and applications of SMAW process.
- Explain the principle of operation, advantages, limitations and applications of GTAW and PAWprocesses.
- Explaintheprincipleofoperation,advantages,limitationsandapplicationsofGMAWand FCAWprocesses.
- Explain the principle of operation, advantages, limitations and applications of SAW, SW and CAWprocesses.

RECOMMENDED BOOKS:

1. Howard B. Cary, “Modern Welding Technology”, Prentice Hall, 6th Ed.,2017
2. Parmar R.S. “Welding Processes and Technology” Khanna Publishers, 2nd Ed.,2005.
3. Nadkarni. S.V. “Modern Arc Welding Technology” Oxford IBH Publishing Co.2005.
4. AWSWeldingHandbook.9thedition Volume1,“WeldingScienceandTechnology”,2013.
5. AWS Welding Handbook. 9thedition. Volume 2, “Welding Processes”,2013.
6. ASM Handbook, “Welding, Brazing and Soldering” Vol. 6, ASM2017.
7. ASM Handbook, “Welding Fundamentals and Processes” Vol. 6A, ASM2017
8. Lancaster J.F. “The Physics of Welding”, Pergamon Press, 2nd Ed.,1986.

22WTC13	METALLOGRAPHY LAB	L	T	P	C
		0	0	4	2

Course objective: To learn about sample preparation and metallurgical microstructure of metal in various product form and their conditions and same to be apply in various applications

List of experiments

1. Study of metallurgical microscope and specimen preparation
2. Macro examination of samples
3. Microstructure of carbon steels and alloy steels
4. Microstructure of cast irons
5. Microstructure of non-ferrous alloys
6. Microstructure of heat treated/processed samples
7. Grain size measurement
8. Study of weld bead characteristics
9. Microstructure of weldments (Similar and Dissimilar)
10. Microhardness survey of weldments

Course Outcomes: Upon completion of this course, the students will be able to:

- Prepare the specimens for suitable metallographic examination with best practices.
- Perform macro examinations with aid of profile projector
- Able to operate metallurgical microscopes and examine the specimens.
- Identify, analyze and interpret various microstructure of materials

22WTC14 **JOINING LAB** **L T P C**
0 0 4 2

Course objective: To gain knowledge in simple operation of welding machines, practical aspects of welding processes and able to apply in various joining applications

List of Experiments

1. Study and Demo of Welding Machines
2. Arc – Striking and Weld Bead Practices by SMAW process
3. Preparation of joints by SMAW process
4. Weld Bead Practices by GTAW process
5. Weld Bead Practices by GMAW process
6. Friction welding of metals
7. Friction Stir welding of metals
8. Ultrasonic welding of metals and plastics
9. Weldability test for Hot cracking
10. Weldability test for Cold cracking

Course Outcomes: Upon completion of this course, the students will be able to:

- Generate arc in different welding machines for various welding processes.
- Identify the process parameters and their effects during welding
- Selection of process parameters for bead practices
- Perform welding to produce butt and fillet joints.
- Identity the anomalies in weld bead.

22AC01- ENGLISH FOR RESEARCH PAPER WRITING

COURSE OBJECTIVES:

1. To help the learners to realize the necessity of English in writing a Research paper
2. To enable the learners to write different sections of a research paper
3. To train the learners to become better writers of research papers

COURSE OUTCOMES:

At the end of the course, students will be able

1. To understand and appreciate the role of English in writing a good research paper
2. To apply their knowledge in writing a research paper
3. To analyze and assess the quality of their research paper

UNIT I

Research paper and its importance, Structure of a research paper, Planning and preparation.

UNIT II

English in research papers, Basic word order, Collocation, Being concise, Redundancy, Common errors.

UNIT III

Key factors that determine the style of a paper, Journal's background, Passive form, Right tense forms, Cohesion and coherence.

UNIT IV

Hedging and criticizing, Paraphrasing, Plagiarism, Ensuring quality of the paper and Useful phrases.

UNIT V

Key skills in writing Title, Abstract, Introduction, Review of Literature, Discussion and Conclusion, Highlighting findings.

TEXT BOOK:

Adrian Wallwork, "English for Writing Research Papers," Springer New York Dorecht Heidelberg London, 2016

REFERENCE BOOKS:

1. Howe, Stephen. "Phrase Book for Writing papers and Research in English,"Cambridge University Press, 2012.
2. Goldbort R. "Writing for Science," Yale Universitypress, 2006.
3. Gabor L Lovei. "Writing and Publishing Scientific Paper," Open Book Publishers, 2021

22MLC01 RESEARCH METHODOLOGY & IPR L T P C
3 0 0 3

Course Objectives:

- To develop the subject of their research
- Development required in writing research proposals, reports and dissertation

INTRODUCTION TO RESEARCH (9)

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting are search problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations.

EFFECTIVE LITERATURE STUDIES APPROACHES, ANALYSIS (9)

Developing the theoretical framework of research-Developing operational statements problems-Criteria for evaluating research approach-Hypothesis: parametric and non-parametric testing-Establishing the reliability and validity of findings with literature review and experiment documentation, Plagiarism, Research ethics,

EFFECTIVE TECHNICAL WRITING, HOW TO WRITE REPORT, PAPER (9)

Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

NATURE OF INTELLECTUAL PROPERTY (9)

Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

PATENT RIGHTS AND IPR (9)

Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System. New developments in IPR;IPRofBiologicalSystems,ComputerSoftwareetc.TraditionalknowledgeCaseStudies, IPR and IITs.

Total=45 Periods

Course Outcomes:

At the end of this course, students will be able to

- Understand research problem formulation.
- Analyze research related Information
- Follow research ethics
- Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
- Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
- Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

RECOMMENDED BOOKS:

1. Stuart Melville and Wayne Goddard, “Research methodology: an introduction for science & engineering students’”
2. Wayne Goddard and Stuart Melville, “Research Methodology: An Introduction”
3. Ranjit Kumar, 2 nd Edition, “Research Methodology: A Step by Step Guidefor beginners”
4. Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd,2007.
5. Mayall , “Industrial Design”, McGraw Hill,1992.
6. Niebel , “Product Design”, McGraw Hill,1974.
7. Asimov, “Introduction to Design”, Prentice Hall,1962.
8. Robert P. Merges, Peter S. Menell, Mark A. Lemley, “Intellectual Property in New Technological Age”,2016.
9. T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand,2008

22WTC21 WELDING PROCESSES–II L T P C
3 0 0 3

Course Objectives:

- To understand the various special/ advanced welding processes.
- To gain knowledge on the principle of operation, advantages, limitations and applications of various special/ advanced welding processes.

ELECTRON BEAM AND LASERBEAMWELDING (9)

Heat generation and regulation, equipment details in typical set-up, electron beam welding in different degrees of vacuum, advantages, disadvantages and applications.

Laser Beam Welding: Laser sources for welding, Principles of operation, advantages, limitations, and applications.

Introduction to Hybrid Welding Process.

ELECTRO SLAG WELDING ANDRESISTANCEWELDING (9)

Electro slag welding - Heat generation, principles of operations, wire and consumable guide techniques, selection of current, voltage and other process variables, nature of fluxes and their choice, applications, variants of electro slag welding, Electrogas welding.

Resistance welding - Principles of contact resistance, surface preparation, calculation of current, time and voltage for spot welding – Temperature distribution, spot welding cycle, inter-relationship between process variables, choice of electrode material, seam welding, projection welding. Flash welding, Upset welding, Percussion welding, High frequency welding.

SOLID STATEWELDINGPROCESSES (9)

Advantages of solid state welding processes over conventional welding processes. High temperature solid state welding, Low temperature solid state welding, Fundamental principles, Overview of various solid state welding processes. and principles of operation, applications.

Cold pressure welding, Induction pressure welding, Explosive welding, Diffusion welding, Ultrasonicwelding,Forgewelding,Rollwelding–Principlesofoperation,equipment,process characteristics advantages, limitations and applications.

FRICTION AND FRICTIONSTIRWELDING (9)

Friction Welding- Theoretical considerations, Process characteristics, Friction Welding machines and equipments, welding variables, weld properties, Joint design, Applications.

Friction Stir Welding - Principles of operation, Important welding parameters - tool rotation and traverse speeds, tool tilt and plunge depth, tool design. Generation and flow of heat. Advantages, limitations and applications. Flaws and defects in FSW. Friction surfacing and friction processing.

OTHER JOINING PROCESSES, CUTTINGANDSURFACING (9)

Adhesive bonding – Concept, Procedure, Testing of Adhesive bonded joints, types of adhesive bonded joints, Sandwich Construction, selection and types of adhesives. Welding of plastics, Underwater Welding. Thermit Welding, Brazing and Soldering -Fundamentals, Types, brazing and soldering alloys and their classification. Thermal cutting – Oxy-fuel cutting, arc cutting, plasma arc cutting, laser cutting. Surfacing.

Total: 45 periods

Course Outcomes: Upon completion of this course, the students will be able to:

- Explaintheprincipleofoperation,advantages,limitationsandapplicationsofvarioussolid state weldingprocesses.
- Explain the principle of operation, advantages, limitations and applications of FRW and FSWprocesses.
- Explain the principle of operation, advantages, limitations and applications of EBW and LBWprocesses.
- Explain the principle of operation, advantages, limitations and applications of ESW and Resistance weldingprocesses.
- Explain the principle and features of various special joining techniques and thermal cutting methods.

RECOMMENDEDBOOKS:

1. AWS Welding Handbook. 9thedition. Volume 2, Welding Processes,2013.
2. Schwartz M.M., “Metals Joining Manual”, McGraw Hill Books.1979.
3. Metals Handbook (Welding, Brazing and Soldering) Vol. 6, 10thEdition. ASM1995.
4. Howard B.Cary, “Modern Welding Technology”, Prentice Hall, 6thEd.,2017.
5. Tylecote R.F., “The Solid Phase Welding of Metals”, Edward Arnold Publishers Ltd. London.1968.
6. Christopher Davis, “Laser Welding - Practical Guide”, Jaico Publishing House,1994.
7. Parmar R.S. “Welding Processes and Technology” Khanna Publishers, 2ndEd.,2005.
8. ASM Handbook, “Welding Fundamentals and Processes” Vol. 6A, ASM2017

22WTC22 **WELDING METALLURGY** **L T P C**
3 0 0 3

Course Objectives:

- 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 and welding of alloy steels, carbon steels and stainless steels.

HEAT FLOW INARCWELDING (9)

Heat flow-Basic heat transfer equations, temperature distributions and cooling curves-Influence of heat input, Joint Geometry, plate thickness, preheating and other factors. Comparison of welding processes based on these considerations. Solidification – Epitaxial growth – weld metal solidification – cellular and columnar structures – effect of welding parameters – absorption of gases – gas/metal and slag/metal reactions.

WELDABILITY ANDWELDABILITYTESTING (9)

Concept of Weldability, Factors affecting Weldability, Welding Defects, Causes and remedies,Crackingphenomenainwelding,Characterizationofweldments,Weldabilitytests – cold cracking tests, hot cracking tests, Internal restraint tests, External restraint tests, Mechanical tests for weldments-Tension tests and Bend tests.

WELDABILITY OF CARBON STEELS AND LOWALLOYSTEELS (9)

Formation of different microstructural zones in welded plain-carbon steels, C-Mn and low alloysteels.Phasetransformationinweldmetalandheataffectedzones.Hydrogeninduced cracking, Carbon equivalent, preheating, Post heating and post weld heat treatment, Hot cracking – compositional features – Effect of S and P, Reheat cracking and Lamellar cracking.

WELDABILITY OFSTAINLESS STEEL (9)

Introduction to stainless steel classification, effect of alloying elements, Austenitising elements, Ferritising elements, Weldability of austenitic stainless steels – Hot cracking – constitution diagrams – Schaffler, Delong, WRC diagrams, Mode of solidification, Sensitisation, Sigma embrittlement. Metallurgical difficulties in welding of ferritic, martensitic and duplex stainless steels, selection of filler metals.

WELDABILITY OF OTHER ALLOYS ANDDISSIMILARWELDING (9)

Welding of cast irons, High Cr steels, Maraging Steels – Process, procedure and filler metal selection, weldability problems encountered and solutions.

Weldability of Al alloys, Cu Alloys, Ti Alloys and Ni Alloys – Selection of welding process and procedure appropriate for each material.

Dissimilar welding: Metallurgical problems in dissimilar welding- calculation of dilution- methods of controlling dilution - techniques of dissimilar welding.

Total: 45 periods

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

- To understand heat flow in welding, structures formed and effect of various parameters.
- To gain knowledge in various types of weldability tests.
- Toknowaboutweldabilityofcarbonsteelsandlowalloysteelsandweldabilityissues.
- To understand welding of stainless steels.
- To get familiar in the area of welding of cast iron.

RECOMMENDED BOOKS:

1. Parmar R.S., “Welding Engineering and Technology”, Khanna Publishers.1997.
2. Lancaster J.F., “Metallurgy of Welding”, George Allen & Unwin. Boston.1980.
3. Kou. S., “Welding Metallurgy”, John Wiley & Sons.1987.
4. Granjon. H., “Fundamentals of Welding Metallurgy”, Jaico Publishing House. New Delhi1994.
5. Norman Bailey, “Weldability of Ferritic Steels”, Jaico Publishing House.1997
6. AWS Welding Hand book. 8thedition. Vol-1. Welding Technology.1998

22WTC23 **QUALITY CONTROL IN WELDMENT LAB** **L T PC**
0 0 4 2

Courseobjective: To learn about welding measuring gauges, principles of material testing and inspection documents(reports) for quality control in weldingapplications.

List of experiments

1. Study of Welding Gauges and Measuring Equipments
2. Preparation of WPS and PQR
3. Preparation of Welder qualification test
4. Tensile test of weldments
5. Bend test of weldments
6. Impact test of weldments (notch location - weld metal, HAZ and parent material) - room temperature and low temperature
6. Fit-up inspection
7. Visual Inspection
8. Dye-Penetrant Testing and Magnetic Testing Examination
9. Radiographic Film Interpretation
10. Study of Inspection, Testing and Plan(ITP)
11. Review of MTCs (Material/Mill Test Certificate) and BTCs (Batch Test Certificate) - Raw materials and Welding Consumables

Course Outcomes: Upon completion of this course, the students will be able to:

- Gain knowledge in practical aspects of welding gauges and their applications.
- Hands on experience in Material testing and their sample preparation.
- Exposure of Quality control documents - Read and understand the various reports
- Read and understand welding documents (WPS, PQR &WPQ).

22WTC24 **CHARACTERIZATION LAB** **L T P C**
0 0 4 2

Course Objective:
To learn the principles of material characterization and to apply them for various engineering applications.

List of Experiments

1. Identification of Planes by Stereographic projection
2. Indexing of patterns in XRD graphs
3. Estimation of precise lattice parameter of cubic crystals.
4. Determination of crystallite size and r.m.s. strain for mechanically alloyed powder
5. Interpretation of Thermal analytical curves.
6. Analysis of SEM fractographs.
7. Analysis of TEM images of metals and alloys.
8. Determination of volume fraction of phases using image analysis.
9. Determination of nodularity and nodule count in cast iron using image analysis.
10. Corrosion rate determination by a) weight loss method, b) effect of inhibitor
11. Evaluation of corrosion characteristic by Polarization technique.

Course Outcomes: Upon completion of this course, the students will be able to:

- Observe and explain the Wulff net diagram, Stereographic projections and pole figure.
- Interpret the DSC curves, analyze the SEM and TEM images of metal and alloys.
- Determine the Volume fraction of phases using image analysis
- Determine the nodularity and nodule count in cast iron.
- Determine the corrosion rate of specimens by weight loss method
- Analyze the effect of inhibitor on rate ofcorrosion
- Evaluate the corrosion characteristics by Polarization method

22AC02 DISASTER MANAGEMENT

Course Objectives: -Students will be able to:

. Learn to demonstrate a critical understanding of key concepts in disaster riskreduction andhumanitarian response.
. Critically evaluatedisasterriskreductionandhumanitarianresponsepolicyandpractice from multipleperspectives.
. develop an understanding of standards of humanitarian response and practical relevanceinspecific types of disasters and conflict situations.
. critically understand the strengths and weaknesses of disaster management approaches,planning and programming in different countries, particularly their home country or the countriesthey work in.

Syllabus

Units	CONTENTS	Hours
1	**Introduction** Disaster: Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude.	4
2	**Repercussions Of Disasters And Hazards:** Economic Damage,Loss Of Human And Animal Life, Destruction OfEcosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man- made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.	4
3	**Disaster Prone Areas In India** Study Of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics	4
4	**Disaster Preparedness And Management** Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard;EvaluationOf Risk: Application Of Remote Sensing, Data From MeteorologicalAndOtherAgencies,MediaReports:GovernmentalAnd Community Preparedness	4
5	**Risk Assessment** Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global And National Disaster Risk Situation. Techniques Of Risk Assessment, Global Co-Operation In Risk Assessment And Warning, People's Participation In Risk Assessment. Strategies for Survival.	4
6	**Disaster Mitigation** Meaning, Concept And Strategies Of Disaster Mitigation, Emerging TrendsInMitigation.StructuralMitigationAndNon-StructuralMitigation, Programs Of Disaster Mitigation In India.	4

SUGGESTED READINGS:

1. R.Nishith, Singh AK, “Disaster Management in India: Perspectives, issues and strategies “’New Royal bookCompany.
2. Sahni, PardeepEt.Al. (Eds.),” Disaster Mitigation Experiences And Reflections”, Prentice Hall Of India, NewDelhi.
3. GoelS.L.,Disaster Administration And Management Text And Case Studies” ,Deep&Deep Publication Pvt. Ltd., New Delhi.

PROFESSIONAL ELECTIVE COURSES

22WTE01 PHYSICAL METALLURGY AND HEAT TREATMENT L T P C

3 0 0 3

Course Objectives:

- To impart knowledge on the phase diagrams, properties and applications of ferrous and non-ferrous alloys so as to identify and select suitable materials for various engineering applications.
- To know the fundamental concepts of various heat treatment processes.

PHASE DIAGRAMS (9)

Phases, solid solution types, compounds, Hume- Rothery rules; Gibb's phase rule; Binary isomorphous alloy systems – composition and amount of phases, development of microstructure – equilibrium and non-equilibrium cooling, Fe-C Equilibrium diagram - effects of alloying elements **–** Ferrite and Austenite Stabilizers, TTT and CCT diagrams.

FERROUS ALLOYS (9)

Plain carbon steels – low alloy and Q and T steels dual phase steels – ultra high strength steels - maraging steels – HSLA steels – High Cr steels - processing, properties & applications.

Stainless steels-effects of chromium and nickel – ferritic and Austenitic, martensitic, duplex and precipitation hardened stainless steels. Types of Cast Irons- Gray Cast iron, white iron, malleableiron,S.G.Iron and alloy cast irons -physicalmetallurgy,composition of castirons, properties and applications.

NON –FERROUSALLOYS (9)

Physical metallurgy, composition, properties and applications of Cu alloys, Al Alloys, Ti alloys, Ni alloys and Mg alloys.

HEAT TREATMENT PROCESSES: (9)

Annealing - types, Normalizing, Hardening - Retained austenite -measurement and methods of its elimination, Hardenability studies- Jominy end quench test, Grossman's experiments, Tempering Austempering and Martempering, Heat treatment of gray cast irons, white cast irons, malleabilising and S.G.irons. Heat treatment of aluminium alloys and copper alloys.

CASE HARDENING: (9)

Introduction, Carburising: Principle, carbon potential, application of Fick's law, methods of carburising, heat treatment after carburising, structure, properties and common problems in carburising. Nitriding: introduction, steels used, effect of microstructure, white layer, nitriding methods, Carbo nitriding, Cyaniding, Induction and Flame hardening: principle, methods, operating variables. Measurement of case depth.

Total: 45 periods

Course Outcomes: Upon completion of this course, the students will be able to:

- Understand the formation of solid solutions, construct the phase diagrams and understand the TTT and CCTdiagrams.
- Understand the principal effects on properties of the major alloying elements used in steels and analyze the basic structure and properties of different types of castirons.
- Gain knowledge on the properties and applications of some important non-ferrous metals such as Cu, Al, Ti, Ni, Mg and their alloys.
- Explain the various heat treatment processes for specific alloys.
- Elaborate the various case hardening processes.

RECOMMENDED BOOKS:

1. Raghavan V. “Physical Metallurgy – Principles and Practice”, Prentice Hall of India, 2nd Edition,2011.
2. Williams D Callister, “Material Science and Engineering” Wiley India Pvt Ltd, Revised Indian Edition2007.
3. Flinn.R.A.andTrojan.P.K.“EngineeringMaterialsandtheirApplications”,4th Edition, Jaico,1999.
4. Kenneth G.Budinski and Michael K. Budinski, “Engineering Materials”, Prentice Hall of India Private Limited, 4th Indian Reprint2002
5. Metals Hand book. 10th edition. Volumes1,2 and 3, ASM.2018.
6. Rajan and Sharma "Heat Treatment Principles and Techniques" – Prentice Hall of India (P)
   Ltd, New Delhi, 2009.
7. Vijendra Singh,"Heat Treatment of Metals", Standard Publishers Distributors, Delhi, First edition 1998.
8. Romesh.C.Sharma, “Principles of Heat Treatment of Steels”, New Age International Pvt. Ltd. Publishers, New Delhi, 2008.

22WTE02 WELDING ECONOMICS, MANAGEMENT AND SAFETY L T PC

3 0 03

Course Objective:

To design a system, a component, or a process to meet desired needs within realistic constraints such as Factors influencing welding cost, Estimation of welding time, costing for welding, plant layout setup, Safety practices in welding & its manufacturability and sustainability.

FACTORS INFLUENCINGWELDING ECONOMICS (9)

Weldingdesign-selectionofelectrodes,size,typeandmetalrecovery–electrodeefficiency, sub, thrown away electrodes – over welding and joint fit – up welding position - operation factor – jigs, fixtures, positioners, Operatorefficiency.

ESTIMATION OFWELDINGTIME (9)

Needfortimestandard–definitionofstandardtime-variousmethodsofcomputingstandard time – analytical calculation – computerisation of time standards.

ESTIMATION ANDCOSTINGFORWELDING (9)

Definitionofterms–compositionofweldingcosts,costofconsumables –labourcost–cost over heads - formulae for total cost – cost curves for different processes like GMAW, SAW, ESW, Mechanization in welding – job shop operation.

PROCESS AND PLANTLAYOUT (9)

Process vs product lay out – construction – service consideration – employees- services, welding shop equipment, oxy acetylene stations- resistance welding stations – inert gas welding stations – arc welding stations – crane forges - jigs and fixtures; power tools - blast cleaning supplies- welding equipment repair shop - proper arrangement of the above in the welding shop for maximum convenience and ease of production.

SAFE PRACTICESIN WELDING (9)

Selectionandinstallationofequipments,safehandlingequipment-fireprevention-eyeand face protection - respiratory protection - ventilation -protective extra clothing -electric shock- safety analysis.

Planning for welding operations, production control planning for welding processes- pre-production planning- routing - scheduling. Activating, monitoring, materials management in welding-Inventorycontrol-Basicaspectsoffinancialmanagementandman-powerplanning.

Total: 45periods

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

- To gain knowledge on various factors influencing the weldingcost.
- Able to estimate the standard welding time using various methods for thewelding processes.
- Able to calculate the welding cost for the different weldingprocess.
- Able to gain knowledge on various requirements on setting up a weldingplant layout.
- To gain knowledge on safety measures during welding processes andplanning operations.

RECOMMENDED BOOKS:

1. ASM Metals Handbook, Vol.6, “Welding, Brazing and Soldering”, ASM, New York, 1998.
2. AWS Welding Handbook, vol.5, “Engineering Costs, Quality and Safety”, 9th edition, AWS,2015.
3. John Norrish, “Arc Welding Processes - Technologies and process control”, Woodhead Publishing and Maney Publishing on behalf of The Institute of Materials, Minerals & Mining,2006.
4. Standard Data for Arc Welding – The Welding Institute, U.K.,1994.
5. Bathy. J., “Industrial Administration and Management”,1984.
6. The Procedure Handbook of Arc Welding, 12th Edition, Lincoln Electric, USA,2003.

22WTE03 COMPOSITE MATERIALS

INTRODUCTION TO COMPOSITES: (9)

Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

REINFORCEMENTS: (9)

Preparation-layup, curing, properties and applications of glassfibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

MANUFACTURING OF METAL MATRIX COMPOSITES: (9)

Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering.Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties andapplications.

MANUFACTURING OF POLYMER MATRIX COMPOSITES: (9)

Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties andapplications.

STRENGTH OF COMPOSITES: (9)

Laminar Failure Criteria-strength ratio, maximum stress criteria, maximumstrain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

Total:45 periods

TEXT BOOKS:

1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.
2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted byR. Balasubramaniam, John Wiley & Sons, NY, Indian edition,2007.

RECOMMENDED BOOKS:

1. Hand Book of Composite Materials-ed-Lubin.
2. Composite Materials – K.K.Chawla
3. Composite Materials Science and Applications – Deborah D.L.Chung.
4. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and StephenW.Tasi

22WTE04 MATERIALS CHARACTERIZATION L T PC
3 0 0 3

Course Objective:

To acquire knowledge on various characterizations, chemical and thermal analysis tools and analyses the metallurgical components using those tools.

METALLOGRAPHICTECHNIQUES (9)

Resolution, depth of focus and components and working of Metallurgical Microscope, polarized light, phase contrast, interference, hot stage and quantitative metallographic techniques-grain size and volume fraction. In-situ metallography, specimen preparation techniques.

X-RAYDIFFRACTIONTECHNIQUES (9)

ContinuousandCharacteristicspectrum–Bragg'slaw–Diffractionmethods–Laue,rotating crystal and powder methods. Intensity of diffracted beams – structure factorcalculations.

APPILICATIONS OFX-RAYDIFFARACTION (9)

Diffractometer – general feature and optics – proportional scintillating and Geiger counters. X-ray diffraction application in determination of crystal structure, lattice parameter and residual stress – quantitative phase estimation.

ELECTRONMICROSCOPY (9)

Construction and operation of Transmission Electron Microscopy – Diffraction effects and image formation, specimen preparation techniques, elemental analysis by wavelength dispersive and energy dispersive systems. Construction and operation of ScanningElectron Microscopy,Scanning Transmission Electron Microscopy, Scanning Probe Microscope and Atomic force microscopy. Evaluation of samples by abovemicroscope.

ADVANCED CHEMICAL AND THERMALANALYSISMETHODS (9)

X-ray fluoroscopy, Spectroscopy- principles, Atomic Absorption Spectroscopy, Optical Emission Spectroscopy, Auger spectroscopy. Differential Thermal Analysis, Differential Scanning Calorimetry and Thermo Gravimetry Analysis, Stressanalysis.

Total:45 periods

Course Outcomes: Upon completion of this course, the students will be able to:

- Know the principles of metallurgical microscope, X-ray Diffractrometer (XRD), Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM), Thermal analysis anddilatometer.
- Describe the various sample/specimen preparation techniques for XRD, SEM, TEM and thermal analysis and quantitativemetallography
- Determine crystal structure, lattice parameter, phase identification, solvus line estimation and residual stress analysis usingXRD
- 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 microchemicalanalyses.
- Evaluation of the specimen chemical and thermal analysis advancedmethods.

RECOMMENDED BOOKS:

1. P.C.Angelo, “Materials Characterisation”, Elsevier (India) Pvt. Ltd, Haryana,2013,
2. Philips V.A. “Modern Metallographic Techniques and their Applications”, Wiley Interscience,1971.
3. Cullity B.D., “Elements of X- ray Diffraction”, 2nd Edition, Addison Wiley,1978.
4. ASM Metals Handbook, Vol.10, Material Characterization, ASM, New York,1998.
5. Thomas. G, “Transmission Electron Microscopy of Metals”, John Wiley.1961.
6. Smallman R.E., “Modern Physical Metallurgy”, 4th Edition, Butterworths.1985.
7. Loretto. M.H., “Electron Beam Analysis of Materials”, Chapman and Hall,1984.

22WTE05 FAILURE ANALYSIS IN WELDMENTS L T PC

3 0 0 3

Course Objective:

To understand the concepts on failure and fracture analysis of weldments and to design new materials that can withstand catastrophic failures of weldments at different environment.

INTRODUCTION TOFAILUREANALYSIS (9)

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

WELDMENTSURFACEFAILURES (9)

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.

WELDMENT CREEP ANDFATIGUEFAILURES (9)

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 on weldment failures.

FAILURE OFWELDEDPRODUCTS (9)

Causesoffailureinforgeweldments,failureofweldedironandsteelcastings,improperheat treatment of weldments, stress concentration by weldments, in-service weldment failures. Procedure for weld failure analysis and dataextraction.

RELIABILITY (9)

Reliability concept and hazard function, life prediction, condition monitoring, application of Poisson,exponentialandWeibulldistributionforreliability,bathtubcurve,parallelandseries system, mean time between failures and lifetesting.

Total: 45 periods

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

- Understand the concepts of types of failures andanalysis
- Learn the various factors affecting/causing failures ofweldments
- Designnewmaterialsthatcanwithstandfailures,especiallyinweldmentsconsidering different environment.
- To understand failure in weldedproducts.
- To learn various concepts inreliability.

RECOMMENDED BOOKS

1. Colangelo.V.J. and Heiser.F.A., “Analysis of Metallurgical Failures”, John Wiley and Sons Inc. New York, USA,1987.
2. Das, A.K., “Metallurgy of Failure Analysis”, Tata McGraw Hill, New Delhi,1992.
3. DonaldJ.Wulpi,“Understandinghowcomponentsfail”,ASMInternational,3rdEdition, 2013.
4. ASM Metals Handbook “Failure Analysis and Prevention”, ASM Metals Park. Ohio, Vol.10, 10thEdition,1995.

22WTE06 TESTING AND INSPECTION OF MATERIALS L T PC
3 0 0 3

COURSE OBJECTIVE:

- To impart knowledge in destructive and non-destructive testing with case studies.
- To provide an understanding of the basic principles of various testing and inspection.

TENSILE TESTS: (9)

Introduction: Types of testing, Introduction to material properties (structure sensitive and insensitive), ASTMtesting standards. Engineering stress and strain, True stress – True strain curves, Relationship between thetensile properties, Hollomon, Ludwig equation, Ductility measurement in tension test, Effect of strain rate onflow properties, Plastic Instability (Necking), Hot tensile tests, Testing machines – types, Testing procedures, specimen dimensions, Notch tensile test, Anisotropy of tensile properties. Bend tests

HARDNESS TESTS AND IMPACT TESTS: (9)

Definition, Types of hardness tests- Vickers, Brinell, Rockwell and Rockwell superficial hardness tests,Precautions - Relative merits and demerits, Hardness conversion, Rebound hardness test, Microhardnesstests - Vickers and Knoop hardness tests, Concept of nano indentation. Izod and Charpy Impact tests.Instrumented Charpy test, Drop-weight Test and other large scale tests.

LIQUID PENETRANT, MAGNETIC PARTICLE AND EDDY CURRENT INSPECTION: (9)

Visual inspection, Liquid penetrant inspection: Principle, applications, advantages and limitations, Dyes,developers and cleaners, Fluorescent penetrant test. Magnetic particle inspection: Principles, applications,magnetisation methods, magnetic particles, demagnetisation. Advantages and limitations. Eddy current testing: Principle, application and Instrumentation of Eddy current testing.

RADIOGRAPHY TESTING: (9)

X-rays and Gamma rays, Production of X-rays, properties. Gamma ray sources, characteristics of Gammarays. Absorption of rays, scattering, types and use of filters and screens, geometric factors, Inverse square,law, characteristics of films – grain fineness, density, speed, contrast, characteristic curves, Penetrameters,Exposure charts, Radiographic equivalence. Fluoroscopy, Xero-Radiography, Safety with X-rays and Gamma rays, Industrial computed tomography (ICT).

ULTRASONIC TESTING AND NDT STANDARDS: **(9)**

Types of Ultrasonic waves, principles of wave propagation, characteristics of ultrasonic waves, Inspectionmethods - pulse echo, Transmission and resonance techniques, Types of scanning, Test block, IIW -reference blocks. Introduction to Time of flight diffraction (TOFD) and Phased array Ultrasonic Testing.API codes on pipelines and refinery equipments and storagetanksforrefineryservice,ASME–BoilerandPressurevesselcodeSectionII,V,VIII & IX, ASME code for pressure pipings - the purpose of respective code only. Welding Procedure Specifications, Procedure Qualification Records, Welder Performance Qualification.

Total: 45periods

COURSE OUTCOME: Upon completion of this course, the students will be able to:

- Understandthebasicsandoverviewofdestructivetestingsuchastensiletest,impact test and hardnesstest.
- Understand the recent developments, modifications and applications in surface NDT and apply them in real time problems associated with failure analysis and regular testing forindustries.
- Know about X ray radiography and gamma ray radiography indetail.
- Gain knowledge about ultrasonic inspection and relateddetails
- Troubleshoottheproblemsinvolvedontheshopfloorinfabricationindustrieswiththe help of knowledge in codes, standards andspecifications.

RECOMMENDED BOOKS:

1. Dieter G. E., “Mechanical Metallurgy”, SI metric Edition, McGraw Hill Books,1988.
2. Baldevraj., Jayakumar.T., Thavasimuthu. M., “Practical Non-destructive Testing”, Narosa Publishers.1997.
3. AWSWeldingHandbook,vol.5,“EngineeringCosts,QualityandSafety”,7th Ed,AWS, 1997
4. Hull, “Non Destructive Testing”, ELBS Edition,1991.
5. McGonnagle. W.J. “Non-Destructive Testing”, Gordon and Breach, 2nd Ed.,1971.
6. ASM Metals Hand Book. Vol. 9. Non-destructive Testing and Inspection_,1988.
7. Codes and Standards- ASNT, AWS D1.1, API1104, ASME- Boiler & Pressure Vessel Code – Section II, V, VIII,IX.
8. ASNT Nondestructive Testing Handbooks, Third Edition, American Society for NondestructiveTesting

22WTE07 NON-METALLIC MATERIALS L T PC

3 0 0 3

Course objective:

To know various types of polymers, ceramics and composites and its related concepts, understand processing and behaviour of it.

INTRODUCTIONTOPOLYMERS (9)

Classification- thermoset, thermoplastics and elastomers. Structure of polymers-crystalline and amorphous polymers-concept of Glass Transition Temperature (Tg). Polymerization-types and mechanisms with examples Degree of polymerization -molecular weight of polymers- problems. Polymer additives. Structure, properties and applications of polyethylene, polypropylene, polyvinyl chloride, polystyrene, Polymethyl methacrylate, PTFE, polyamides, polyesters, polycarbonates and polyurethanes. Engineering rubbers, natural rubber. Styrene, butadiene rubber, nitrile rubbers,

PROCESSING AND BEHAVIOUROFPOLYMERS (9)

BriefdescriptionofequipmentsandprocessdetailsofExtrusion,injectionmoulding,Reaction and Reinforced Reaction Injection moulding, thermoforming, Blow moulding, compression moulding and calendaring. Viscoelasticity- creep and stress relaxation in polymers. Yielding and fracture of polymers. Crazing ofpolymers.

ENGINEERINGCERAMICS (9)

Review of bonding types in ceramics – calculation of percentage ionic character. Ceramic crystal structures: Sodium chloride, cesium chloride, alumina, spinel and fluorite structures - examples. Co-ordination number and ionic radius ratio - Pauling's Rules. Simple problems involving Packing Fraction, critical radius ratio and density. Properties and applications of SiC, Cubic Boron Nitride, PSZ, Barium Titanate, Iron ferrites, etc

PROCESSING OF CERAMICS AND GLASSES (9)

Brief description of slip and slurry casting, applications. Powder processing equipment and process details of hot pressing. Hot Isostatic Pressing and Cold Isostatic pressing, Liquid Phasesintering.Typesofglasses,structure,propertiesandapplications.Blowing,pressing, drawing, rolling and casting, Pilkington process for floatglass.

COMPOSITES (9)

Polymer Matrix Composites: Polymer matrix resins, Reinforcement fibers – various types of fibers. PMC processes - Hand lay-up processes, Spray up processes, Compression moulding, Resin transfer moulding, Pultrusion, Injection moulding. Fiber reinforced plastics (FRP), Glass fiber reinforced plastics (GRP).

Ceramic Matrix composites: Ceramic matrix - oxide ceramics, non-oxide ceramics, alumina, silicon nitride. Reinforcements – particles, fibers, whiskers. Sintering - Hot pressing, Cold isostatic pressing, Hot isostatic pressing

Total = 45 periods.

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

- Gain knowledge on polymers and select different polymer materials for various applications.
- Understand different methods to synthesize polymermaterials.
- Know the structure and properties of different ceramics.
- Understand the properties and applications of important ceramic materials andglass.
- Emphasis the need of modern materials like composites over conventional metaland alloys.

RECOMMENDED BOOKS:

1. Raymond Seymour, “An Introduction to Polymer Chemistry”, McGraw-Hill Book Co., New York,USA,1971.
2. Michel Barsoum, “Fundamentals of Ceramics”, McGraw-Hill Publishing Co. Singapore,1997.
3. Kingery W.D., “Introduction to Ceramics”, John Wiley, USA,1960.
4. Mathews F.L. and Rawlings R.D., “Composite materials: Engineering and Science”, Chapman and Hall, London, England, 1st edition,1994.
5. Chawla K.K., “Composite materials”, Springer – Verlag,1987.
6. Bhargava., “Engineering Materials- Polymers, Ceramics and Composites”, Prentice Hall of India Ltd’ NewDelhi.
7. Gowariker V R., Viswanathan NV, Jayadev Sreedhar, “Polymer Science”, New Age International P Ltd.,2005

22WTE08 **FINITE ELEMENT ANALYSIS** **L T PC**

3 0 0 3

Course Objective:

To provide the basic FEM modeling and to analyze and solve metallurgical problems using those methods.

TWODIMENSIONALPROBLEMS (9)

Poisson equation – Laplace equation – Weak form – Element matrices for triangular and rectangular elements – Evaluation of integrals – Assembly – Axi-symmetric problems – Applications – Conduction and convection heat transfer – Torsional cylindrical member – Transient analysis - Theory of elasticity – Plane strain – Plane stress – Axi-symmetric problems– Principle of virtual displacement

ISOPARAMETRIC ELEMENTS ANDITSAPPLICATIONS (9)

Introduction – Bilinear quadrilateral elements – Quadratic quadrilaterals – Hexahedral elements - Numerical integration – Gauss quadrature – Static condensation – Load considerations – Stress calculations – Examples of 2D and 3D applications

NON-LINEAR PROBLEMS ANDERRORESTIMATES (9)

Introduction-Iterative Techniques-Material non-Linearity-Elasto Plasticity-Plasticity-Visco plasticity-Geometric Non linearity-large displacement Formulation-Application in Metal Forming Process and contact problems- Error norms and Convergence rates- high refinement with adaptivity-Adaptive refinement

DYNAMICPROBLEM (9)

DirectFormulation-Free-TransientandForcedResponse-SolutionProcedures-Subspace Iterative Technique -Houbolt- Wilson- Newmark - Methods –Examples

FLUIDMECHANICS (9)

Governing Equations of Fluid Mechanics-Inviscid and Incompressible Flow-Potential Formulations-Slow Non- Newtonian Flow-Navier Stokes Equation-Steady and Transient Solutions.

Total: 45 periods

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

- Demonstrate understanding of FE formulation for axi- symmetric problems in heat transfer andelasticity
- To identify the primary and secondary variables of the problem and choose correct nodal degrees of freedom and develop suitable shape functions for an isoparametric element.
- Able to solve contact problems by using the techniques of non-linear equations of equilibrium
- Understand to solve the dynamic flow problems by iterativemethods
- Solve non Newtonian Flow-Navier Stokes Equation by FEequations.

RECOMMENDED BOOKS:

1. Cook, Robert Davis et al “Concepts and Applications of Finite ElementAnalysis”, Wiley, John & Sons,1981.
2. Desai C.S. and Abel J.F., “Introduction to Finite Element Method”, Affiliated East-West Press,1972.
3. Chandrupatla, Belagundu, “Finite Elements in Engineering”, Prentice Hall of India Private Ltd.,2002.
4. O.C. Zienkiewicz and R.L. Taylor, Finite element methods Vol I &Vol II, McGraw Hill,1989,1992.
5. K.J. Bathe, Finite element procedures, PHI Ltd.,1996.

22WTE09 ELECTRICAL ASPECTS OF WELDING L T PC

3 0 03

Course Objectives:

- Tounderstandthestaticanddynamiccharacteristicsofelectricarcanditsassociated power characteristics.
- To gain knowledge on the operating principles of various types of welding power sources.

ELECTRICAL CHARACTERISTICS OF WELDING ARC ANDPOWERSOURCES (9)

Physical phenomena occurring in welding arc-potential distribution-static and dynamic arc characteristics-types of forces in arc, arc blow-causes of arc blow, steps to reduce arcblow - methods of arc initiation- methods of arc maintenance - requirements for a welding power source-V-Icharacteristicofaweldingpowersource-externalstaticV-Icharacteristic-constant current characteristic- constant voltage characteristic-selection of V-I characteristic for a welding process – dynamic V-I characteristic - simple problems on static V-I characteristic-arc lengthcontrol.

WELDING TRANSFORMERS ANDROTATINGMACHINES (9)

Requirementsofweldingtransformer–typesofweldingtransformer-highreactance-external reactor – integral reactor – saturable reactor – all characteristic- rotating machine – series generator –separately excited- self excited – split pole dc welding generator – out put characteristic – multi operator dc welding generator – duty cycle and simpleproblems.

SOLID STATE WELDINGPOWERSOURCES (9)

Rectification principles – uncontrolled, controlled – basic inverter principles – solid state electronic power regulation systems – SCR phase control, transistor series regulator – secondary switched transistor (PWM technique)- primary rectification – inverter control – hybrid designs –features of solid state electronic power source design – advantagesof solid state powersources.

CONTROLS INARCWELDING (9)

Open loop control and close loop control- electric wire feed-automatic control techniques-IGBT,MOSFET-monitoringofprocess-resistancespotweldingmonitoringandcontrol-seam tracking devices- sensors for seam tracking devices- robotic arc welding system- adaptive control in automated welding system- data acquisition in welding- expert system inwelding.

ELECTRICAL MEASUREMENTS IN WELDING AND SPECIALPOWERSOURCES (9)

Measurements of welding current, voltage, temperature, load and displacement in welding process-digital storage oscilloscope, LVDT, thermocouples, Hall Effect current sensors, Mechanicalsensors,LASERdetectors,DCshunt,pulsedweldingpowersources,synergetic welding powersources.

Total: 45 periods

Course Outcomes: Upon completion of this course, the students will be able to:

- Explain the static and dynamic characteristics of electric arc and its associated power characteristics.
- Select the right choice of welding powersources.
- Recognize and list the wire feed systems and seam trackingdevices.
- Measure the welding current, voltage, temperature, load anddisplacement.
- To gain knowledge in electrical measurements in welding and special powersources.

RECOMMENDED BOOKS:

1. John Norrish, “Arc Welding processes” - Institute of Physics Publishing Bristol1992.
2. R.S.Parmar,“WeldingProcessesandTechnology”KhannaPublishers2nd Ed.,2005.
3. Howard B.Cary “Arc Welding Automations”, Marcel Dekker inc, Newyork1995.
4. Md.IbrahimKhan“WeldingScienceandTechnology,NewageInternationalNewDelhi 2007.
5. Pan Jiluan “Arc Welding control” CRC Press Washington D.C.2003.
6. TheProcedureHandbookofArcWelding,twelfthEdition,LincolnElectric,USA,1973.

22WTE10 TOTAL QUALITY SYSTEM AND ENGINEERING LT PC
3 0 0 3

Course Objectives:

- To learn the different techniques of total quality management and the management principles used in engineering and different management systems.
- To learn the methods of statistical quality control and process capability

INTRODUCTION (9)

Principles of Quality Management – Pioneers of TQM –Quality Cost-Quality System-Customer Orientation –Bench marking – Re-engineering - Concurrent Engineering.

MANAGEMENT SYSTEMS (9)

Leadership – Organizational Structure- Team Building- Information Systems and Documentation –Quality Auditing – Brief overview of ISO 9001:2015, ISO/TS 16949:2014, ISO 14001:2015, OHSAS 18001:2007, ISO 50001:2011

TECHNIQUES OF TQM (9)

FMEA, Quality Function Deployment, Quality Circles, KAIZEN, POKA YOKE, Taguchi Methods, 5S, Six Sigma, TPM, Single vendor Concept, J.I.T.

STATISTICAL QUALITY CONTROL (9)

Methods and Philosophy of statistical process control –Control Charts for Variables and Attributes–CumulativesumandExponential-weightedmovingaveragecontrolcharts-other SPC techniques –Process CapabilityAnalysis

ACCEPTANCE SAMPLING (9)

Acceptance sampling Problem –Single Sampling Plans for Attributes –Double, Multiple and sequential sampling, Military standards – The Dodge – Romig Sampling plans.

Total: 45 periods

COURSE OUTCOME: Upon completion of this course, the students will be able to:

- Analyze quality and cost of thesystems
- Gain knowledge on the different quality auditingsystems
- Gain knowledge on the different techniques and concepts of Total Quality Management.
- Analyze different Statistical process for qualitycontrol.
- Solve problems on different samplingmethods.

RECOMMENDED BOOKS:

1. Mohamed Zairi, “Total Quality Management for Engineers”, Woodhead Publishers, 2013.
2. Montgomery Douglas C, “Introduction to Statistical Quality Control”, John Wileyand Sons Inc., New Delhi,2013.
3. Fiegenbaum.A.V, “Total Quality Control”, Mc Graw Hill Inc., New Delhi,2008.
4. Eugene Grant et al, “Statistical Quality Control”, 7thedition, Mc Graw Hill, New Delhi, 2000.

22WTE11 AUTOMATION AND ROBOTS IN WELDING L T PC

3 0 0 3

Course Objectives:

- To compile and work with the automated equipments and its processing are Automation of arc welding processes and other related weldingprocesses.
- ToemulatetheAutomatedweldingequipment,Arcandworkmotionandstandardized arcweldingmachines,controlsandsensorsandgainknowledgeonoperationsusing therobots.

AUTOMATION OF ARC WELDING PROCESSES (9)

Need for automation in welding, introduction to semi-automatic mechanized, automatic, robotic and adaptive control welding. Automatic welding system – factors affecting welding productivity– advantages and disadvantages of welding automation. Arc welding processes suitableforautomationanddegreeofautomationpossibleindifferentweldingprocesseslike GMAW, FCAW, SAW, GTAW, PAW and Studwelding.

AUTOMATION OF OTHER RELATED PROCESSES (9)

Automation of Resistance welding, EBW, and Laser beam Welding, Solid State welding. Automationofoxygencutting,ArcandPlasmacutting,Laserbeamcutting,thermalspraying.

AUTOMATED WELDING EQUIPMENT, ARC AND WORK MOTION DEVICES (9)

Weldingpowersources,typeofelectrodewirefeedersandelectrodewiredispersingsystem – spools, coils, rods, drums, pay off packs, typical adaptors and spiders. Types of welding torches used in automated welding and functions of torches. Types of standardized arc motion devices – Tractor, carriages, side beam carriages, manipulators and Gantry carriages. Work motion devices – Universal positioners, turning rolls, head and tail stock positioners. Combination of arc and work motiondevices.

STANDARDIZED ARC WELDING MACHINES, CONTROLSANDSENSORS (9)

Standardized arc welding equipment, types of standardized welding machines – seamers, welding lathes, weld – around machines, nozzle welders and bore welders. I beam welders andstripwelders.Standardizedweldingmachinesformaintenancework.Automaticwelding ofpipesandtubesIntroductiontosomededicatedarcweldingmachines.Temporaryportable automated tooling for welding control functions involved in a mechanized total welding system sensor systems – introduction andclassification.

ROBOTIC ARC WELDING (9)

Introduction to flexible automatic welding. Robotic arc welding system, types of welding Robots – Revolute, Cartesian, Spherical, Cylindrical and Scara – Hybrid robots far welding, features of welding robot, robotic part – holding positioners, Teaching the robot, some case studies of robotic application in welding.

Total: 45 periods

COURSE OUTCOME: Upon completion of this course, the students will be able to:

- Gain knowledge on automation of the arc weldingprocesses.
- Gain knowledge on the different kinds of weldingprocesses.
- Gain knowledge on the welding equipments and work motions of the automated devices.
- Gain detailed knowledge on standardized arc welding machines, controls and sensors.
- Get familiarized in the area of Robotic Arcwelding.

RECOMMENDED BOOKS:

1. Howard B.Cary“Arc welding Automation”- Marcel Dekker, New York1995
2. AWS Welding Handbook, Vol. 3, 9th edition, A W S.,2015.
3. AWS Welding Handbook, vol.5, “Engineering Costs, Quality and Safety”, 9th edition, AWS,2015.
4. The Procedure Handbook of Arc Welding, 13th Edition, Lincoln Electric, USA,1994.
5. Proceedings of the International Conference on Assembly Automation, British Welding Institute,1985.
6. Kozyrev, Industrial Robots Handbook, Mir Publishers,Moscow,1985.

22WTE12 WELDING APPLICATION TECHNOLOGY L T PC
3 0 0 3

Course Objective:

- To understand thematerials,
- process, fabrication techniques used in welding of pressure vessels, piping and pipelines, shipyards, railways, chemical plants andstructural.
- To gain knowledge of the materials, processes, fabrication, inspection and stringent quality control procedures used in oil and gas industries and chemicalplants.
- To learn about welding economics such as weldment deposition rates for different welding processes, welding cost estimation, standard data for cost estimation and comparative cost study for various weldingprocedure.

WELDING OF STRUCTURALS ANDPRESSUREVESSELS (9)

STRUCTURALS: Types of structural elements and their welding, materials used in bridges and welding of bridges.

PRESSUREVESSELS:Materialselectionandfactorsaffectingit,fabricationofconventional pressurevessels–weldingprocessesused,nozzlewelding,tubetotubeplatewelds,flanges, vessel ends, fabrication of clad pressure vessels. Weldability aspects of pressure vessel steels.

WELDING OF STORAGE TANKSANDPIPINGS (9)

Welding of vertical storage tanks and Hortonsphere.

WELDING OF PIPING AND PIPELINES: pipe steels and electrodes, types of joints and welding, backing welds rings, fittings, alloys used for piping, pipe welding procedures, preheating and PWHT, offshore pipework, pipelines and pipeline welding, under water pipeline welding.

WELDINGIN CHEMICAL PLANTS, CRYOGENICS & MICRO JOINING TECHNIQUES (9)
CHEMICAL PLANTS: Welding of oil-refinery components and fertilizer plant components. CRYOGENICS: Materials used for cryogenic applications, problems of welding. Welding processes and procedures used for welding cryogenic materials.

MICRO JOINING TECHNIQUES: Various techniques used for joining of electronic circuits and other micro joining applications**.**

WELDING OFSHIP STRUCTUREANDRAILWAYS (9)
SHIP STRUCTURE: Main parts of ship structure, materials for ship building, unit and block method of ship construction, welding of submarine steels, welding of offshore structures.

RAILWAYS: Materials used for locomotive subassemblies, rail coaches, wagons and its subassemblies, rails and welding processused

WELDING OF AEROSPACEAND AUTOMOBILE (9)
AEROSPACE: Main parts of aerospace structure, materials for aircrafts building, method of aircraft construction, welding of aircraft structures.

AUTOMOBILE: Main parts in Automobiles, Materials used for automobile subassemblies, welding of automobile components.

Total: 45 periods

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

- Select the suitable welding procedures for the fabrication of structural elements and conventional pressure vessels and solve the difficulties in welding of pressure vessel steels.
- Choose the correct materials, electrodes, type of joint, welding processes andfittings for the fabrication of storage tanks, piping as well aspipelines.
- Solve the problems involved in welding of oil refinery components, fertilizer components and cryogenicmaterials.
- Explain the shipbuilding activities and solve the problems involved in welding of submarine steels and railwaymaterials.
- Gain knowledge on materials used in Aerospace and Automobile components and their weldments.

RECOMMENDED BOOKS:

1. S.V.Nadkarni, “Modern Arc Welding Technology”, Oxford-IBH Publishers, New Delhi, 7th edition1996.
2. R.S.Parmar, “Welding Engineering and Technology”, Khanna Publishers, New Delhi, 1st edition1997.
3. AWS Welding Handbook, Sec.5 – Applications of Welding, 5th Edition,1967.
4. AWS Welding Handbook, Vol.4, 7th Edition,1991.
5. ASM Metals Handbook, Vol.6, Welding, Brazing and Soldering, ASM, New York, 1998.
6. Howard B. Cary, "Modern Welding Technology", Prentice Hall, New Jersey, USA, 1989.

22WTE13 BRAZING, SOLDERING, SURFACING AND CUTTING L T PC

3 0 0 3

Course Objective: To understand the fundamental concepts, applications, advantagesand limitations of brazing, soldering, surfacing andcutting

FUNDAMENTALS OF BRAZING AND SOLDERING (9)

Wettingandspreadingcharacteristics,surfacetensionandcontactangleconcepts.Fillingof horizontal and vertical capillary joints. Capillarydams.

FLUXES AND ATMOSPHERES FOR BRAZING AND SOLDERING (9)

Role of flux and characteristics constituents of flux, grouping and applications Fluxes used for specific braze metal flux removal and related corrosion problem. Atmosphere for brazing and atmosphere for brazing specific base metal Metallurgy of filler metal for brazing and soldering. Joint design and fixturing for brazing.

SOLDERING AND BRAZING PROCESSES (9)

Handsoldering,flamesolderingfurnacesoldering,hotgasblanketsoldering,wavesoldering, etc.,torchbrazingfurnacebrazing,inductionbrazing,dipbrazingresistancebrazing,vaccum brazing, etc., applications of brazing soldering-brazing and solderingdefects.

SURFACING (9)

Thermal spraying, plasma spraying, laser surface alloying and modification. Surfacing spraying to improve wear resistance and corrosion resistance. CVD, PVD and ion implantation. Cladding and its applications.

THERMAL CUTTING PROCESSES (9)

Oxygencutting-oxyfuelgas,metalpowder,chemicalfluxandoxygenarccutting.Arccutting processes- carbon arc, air carbon arc cutting. Metal and plasma arc cutting, High energy beam cutting, laser beam cutting, water jet cutting and under watercutting.

Total: 45 periods

COURSE OUTCOME: Upon completion of this course, the students will be able to:

- Explain the concepts of brazing andsoldering.
- Understand the fluxes and atmosphere for brazing andsoldering.
- To gain knowledge about brazing andsoldering.
- To understand surfacing techniques
- To get familiar in the areas of thermal cuttingprocesses.

RECOMMENDED BOOKS

1. Schwartz. M., “Brazing – for the Engineering Technologies”, Champan and Hall, 1995.
2. Manko. H.H., “Solders and Soldering”.2nd Edition, McGraw Hill1979..
3. Udin, Funk, and Wulf ., “Welding forENGINEERS”.
4. ASM Metals Hand Book Vol. 6 “Welding and Brazing”,1988.
5. Lancaster .J .F . “Metallurgy of Welding, Brazing and Soldering” 3rd edition. George Allen & Unwin.1980.
6. Brooke, “Indusrial Brazing”, Bcton.1975.

22WTE14 CORROSION AND SURFACE ENGINEERING L T PC
3 0 03

Course Objective:

To provide a practical knowledge about corrosion and surface engineering, with its application in engineering field.

MECHANISMS AND TYPES OF CORROSION (9)

Principles of direct and Electro chemical Corrosion, Hydrogen evolution and Oxygen absorption mechanisms – Galvanic corrosion, Galvanic series-specific types of corrosion such as uniform, Pitting, Intergranular, Cavitations, Crevice Fretting, Erosion and Stress Corrosion –Factors influencing corrosion

TESTING AND PREVENTION OF CORROSION (9)

Corrosion testing techniques and procedures- Corrosion Testing ASTM Standards, Pitting CorrosionTest,HydrogenInducedCracking(HIC)Test,SulphideStressCorrosionCracking (SSCC) Test- Prevention of Corrosion-Design against corrosion –Modifications of corrosive environment –Inhibitors – Cathodic Protection –Protective surfacecoatings.

CORROSION BEHAVIOROFMATERIALS (9)

Corrosion of steels, stainless steel, Aluminum alloys, copper alloys, Nickel and Titanium alloys- corrosion of Polymers, Ceramics and Composite materials.

SURFACE ENGINEERING FOR WEAR ANDCORROSIONRESISTANCE (9)

Diffusion coatings –Electro and Electroless Plating –Hot dip coating –Hardfacing-Metal spraying, Flame and Arc processes- Conversion coating –Selection of coating for wear and Corrosion resistance.

THIN LAYERENGINEERINGPROCESSES (9)

Laser and Electron Beam hardening –Effect of process variables such as power and scan speed - Physical vapor deposition, Thermal evaporation, Arc vaporization, Sputtering, Ion plating - Chemical vapor deposition – Coating of tools, TiC, TiN, Al_2O_3 and Diamondcoating – Properties and applications of thincoatings.

Total: 45 periods

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

- Know the different types of corrosion and theirmechanism
- Estimate corrosion resistance by differenttests
- Understand corrosion behavior of different metals at differentconditions
- Define different forms of processing techniques of surface engineeringmaterials
- Select the type of deposition and spraying technique with respect toapplication

RECOMMENDED BOOKS:

1. Fontana. G., Corrosion Engineering, McGraw Hill,1985.
2. Kenneth G.Budinski, Surface Engineering for Wear Resistance, Prenticehall,1992.
3. ASM Metals Hand Book –Vol. 5, Surface Engineering,1996.
4. Denny A Jones, “Principles and prevention of corrosion”, 2nd edition, Prentice Hall, New Jersey,1995.
5. ASM International, Surface Engineering for Corrosion and Wear Resistance,2005.
6. Schweitzer. P.A., Corrosion Engineering Hand Book, 3rd Edition, Marcel Decker, 1996.

22WTE15 DESIGN OF WELDMENTS L T PC

3 0 0 3

Course Objective:

To design a system, a component, or a process to meet desired needs within realistic constraints such as design basics, weld design for static loading, weld design for dynamic loading, distortion and residual stresses and failure analysis of the manufacturing.

DESIGNBASICS (9)

Types of joints, Types of welds, variants of joints, selection of weld type, weld joints for structural tubular connections, welding symbols, weld dimensions, NDT symbols. Principles of weld joint design – General and specific designprinciples.

WELD DESIGN FORSTATICLOADING (9)

Material or section properties, Weld design stress calculation for welds, design under different types of loading like tension, compression, bending, shear, torsion and shock

WELD DESIGN FORDYNAMICLOADING (9)

Basic details of fatigue and fatigue failure, S-N curve, Goodman diagram, factors affecting fatigue life of welded joint, methods of improving fatigue life of welded structures, design for fatigue loading, weld design using fracture toughness value (K_{IC}).

DISTORTION ANDRESIDUALSTRESSES (9)

Weldingresidualstresses–causes,occurrence,effects–thermalandmechanicalrelieving.
Types of distortion – factors affecting distortion –distortion control methods – prediction-correction, jigs, fixtures andpositioners.

FAILURE ANALYSIS IN DESIGN ASPECTS (9)

Failureanalysis–methodology,approaches,toolsandtechniquesoffailureanalysis,modes of failure, failure data retrieval, procedural steps for investigation of a failure for failure analysis. Case studies in design ofweldments.

Total: 45 periods

COURSE OUTCOMES:

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

- Gain knowledge on design basics of the weldingoperations.
- Gain knowledge on the weld design for static loadingprocesses.
- Gain knowledge on the weld design for dynamic loadingprocesses.
- Gain detailed knowledge on factors influencing the distortion and residualstresses.
- Get familiarized in the failure analysissector.

RECOMMENDED BOOKS:

1. Blodgett. O. W., Design of Weldments, James F. Lincoln Arc Welding Foundation, 1991.
2. R.S.Parmar, Welding Engineering and Technology 2nd edition,2010.
3. Gurney T.R. Fatigue of Welded Structures. Cambridge University Press,1980.
4. Rolfe. T., Barsom. J., Fracture and Fatigue Control of Structures – Applications of Fracture Mechanics, Prentice Hall,1987.
5. ASM Metals Hand Book. Failure Analysis and Prevention. Vol. 11. ASM2002.
6. Das, A.K., Metallurgy of Failure Analysis, Tata McGraw Hill, New Delhi,1997.
7. Donald J. Wulpi, Understanding how components fail, ASM International, 3rd Edition, 2013.
8. Colangelo.V.J. and Heiser.F.A., “Analysis of Metallurgical Failures”, John Wileyand Sons Inc. New York, USA,1987.

22WTE16 INDUSTRIAL SAFETY L T PC

3 0 0 3

INDUSTRIAL SAFETY: (9)

Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

FUNDAMENTALS OF MAINTENANCE ENGINEERING: (9)

Definition and aimofmaintenanceengineering,Primaryandsecondaryfunctionsandresponsibilityofmaintenancedepartment, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life ofequipment.

WEAR AND CORROSION AND THEIR PREVENTION: (9)

Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

FAULT TRACING: (9)

Faulttracing-conceptandimportance,decisiontreeconcept,needand applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment'slike,I.Anyonemachinetool,ii.Pumpiii.Aircompressor,iv.Internalcombustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

PERIODIC AND PREVENTIVE MAINTENANCE: (9)

Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexitiesanditsuse,definition,need,stepsandadvantagesofpreventivemaintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept andimportance

Reference:

1. Maintenance Engineering Handbook, Higgins & Morrow, Da InformationServices.
2. Maintenance Engineering, H. P. Garg, S. Chand andCompany.
3. Pump-hydraulic Compressors, Audels, Mcgrew HillPublication.

Foundation Engineering Handbook, Winterkorn, Hans, Chapman & HallLondon

22WTE17 WELDING CODES AND STANDARDS L T PC

3 0 03

OverviewandIntroductorytreatmentofcodesandstandardsinthereference–Nonumerical problems, written document procedures andqualification

Course Objective: To acquire knowledge on various welding codes and standards related to various engineering applications.

STRUCTURAL WELDING CODES (9)

Design requirements, allowable stress values, workmanship and inspection, introduction to welding codes and standards

PETROLEUM PIPING FABRICATION (9)

Process and product standards for manufacturing of pipe – welding procedure and welder qualifications, field welding and inspection, API 1104 and API 5L

PRESSUREVESSELFABRICATION (9)

Designrequirementsfabricationmethods,jointcategories,weldingandinspection,postweld heat treatment and hydrotesting.

WELDING PROCEDURE AND WELDER QUALIFICATION (9)

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

MATERIALSANDCONSUMABLES (9)

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

Total: 45 periods

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

- Identify various design requirements and applicability of AWS D1.1.
- Apply API 1104 and AP15L for pipe weldingapplications.
- Apply ASME II, V, VIII and IX for boilerfabrication.
- Understand and apply WPS, PQR and performance qualification variables for a specific weldingapplication.
- Understand different materials standard, testing methods and consumabletesting.

RECOMMENDED BOOKS:

1. AWS D1.1 Structural Welding Code
2. API 1104
3. ASME Section VIII – Division 1
4. ASME SectionIX
5. ASME Section II Part A andC
6. APIδA

22WTE18 FOUNDRY PROCESSES AND METALLURGY L T P C

3 0 0 3

Course Objectives:
1. To know the basic concept of metal casting technology
2. To apply the concept to produce new materials

MOULDING MATERIALS AND PATTERNS (9)
Introduction to foundry operations, patterns - functions, types, allowances, selection of pattern materials,colour codes, core boxes, moulding practice, ingredients of moulding sand and core sand, Testing of Moulding sands. Sand preparation.

MOULDING AND CASTING TECHNIQUES (9)
Sand moulding: green sand moulding, dry sand moulding, skin dry sand moulding, shell moulding, carbondi-oxide process, permanent mould casting, die casting, centrifugal casting, plaster mould casting,investment casting, squeeze casting, full mouldprocess,Rheocasting,Thixo casting.

DESIGN OF CASTINGS (9)
Elements of gating system, types, design of gating system with examples, functions of risers, types of risers,Chvorinov's rule, design and positioning of riser with examples, use of chills, exothermic compounds etc.,riser efficiency, yield calculations. Use of softwares for foundry applications

QUALITY CONTROL, FETTLING, INSPECTION AND AUTOMATION (9)
Quality control : composition control in steels and cast irons. Simple problems on charge calculations. Cleaning and repair of castings. Casting defects and remedies. Heat treatment of castings. Inspection of casting. Principles of mechanisation, automation and foundry layout. Sand reclamation and Pollution control in foundries.

FOUNDRY METALLURGY (9)
Melting practice and Metallurgy of steels, alloy steels, cast irons, aluminium alloys, copper alloys andmagnesium alloys, Solidification of Castings, Fluidity, Definition, Factors affecting and Measurement of Fluidity, inoculation in cast irons, modification in Al-Si system, Slag-Metal Reactions , Gases in Metalsand Degassing Technique

Total: 45 periods

Course Outcome
1.Explain the solidification of casting, effect of solidification range, fluidity and factors affectingfluidity
2.Discuss the cast iron categories, their types and different heat treatment methods likegraphitization, spherodization etc and denote the ASTM standards for all the varieties
3.Discuss the alloying element effect on the steels and mention the precaution to be taken in moulding and melting of steels
4.Describe the casting methods employed for fabrication of non-ferrous alloys
5. Mention the melting procedure that is adopted for the various alloys like steels, stainless steels,discuss the slag-metal reactions

Reference Books:

1.Heine R W., Loper, C.R.Rosenthal, P.C., "Principles of Metal Casting" ,Tata-McGraw Hill Publishing
Co Ltd, New Delhi, 2011.
2. Jain P.L ,"Principles of Foundry Technology", Tata McGraw Hill Publishing Co Ltd, New Delhi,

22WTE19 FORMING PROCESSES L T P C

3 0 0 3

FUNDAMENTALS OF METAL FORMING (9)

Yield criteria: Von Mises, Tresca yield criteria. Comparison of yield criteria, Octahedral shear stress and shear strain- Forming load calculations. Fundamentals of metalforming: Flow stress determination, Temperature in metal forming, Hot, Cold and Warm working, Strain rate effects, Metallurgical structures, friction and lubrication, Residual stresses.

FORGING AND ROLLING (9)

Forging: Forging-types of presses and hammers, Classification, Open die forging - Forging of disks - Closed die forging - Die design, Calculation of forging loads - Defects, causes and remedies. Rolling: Rolling of Blooms, billets, slabs and sheet, types of rolling mills. Forces and geometrical relationship in rolling. Analysis of rolling load. Defects causes and remedies.

EXTRUSION AND DRAWING (9)

Extrusion: Direct and Indirect extrusion, equipments, container less extrusion port hole extrusion die, hydrostatic extrusion, defects and remedies. Analysis of extrusion, tube extrusion and production of seamless pipe and tube. Hydrostatic extrusion. Equal Channel Angular Extrusion. Defects causes and remedies, Drawing of rods, wires and tubes. Introduction to Superplasticity.

SHEET METAL WORKING AND HIGH VELOCITY FORMING (9)

Sheet Metal Forming: Bending, spinning, stretch forming, deep drawing. Cutting methods - Shearing, blanking, Punching. Defects and applications.High velocity forming methods: Explosive forming, Electro hydraulic, Magnetic pulse forming and pneumatic method, Dynapak method. Formability tests: Effect of strain hardening coefficient (n value), strain rate sensitivity (m value), plastic strain ratio (r value) on formability. Introduction to formability limit diagram.

POWDER METALLURGY (9)

Steps in P/M, advantages and disadvantages. Powder production methods-physical, chemical and mechanical methods. Compaction-Pressure and pressure-less compaction techniques. Hot and Cold isostatic pressing, Sintering- solid state and liquid phase sintering. Microwave sintering, Typical applications.

Total : 45 periods

REFERENCE BOOKS :

1. Dieter, G.E., Mechanical Metallurgy, McGraw Hill Co, SI Edition, 1995
2. ASM Metals Handbook, Vol.14, Forming and Forging, Metals Park, Ohio, USA, 2001.
3. Sinha, A.K., Powder Metallurgy, Dhanpat Rai and Sons, New Delhi, 1992.