



MOHAMED SATHAK A J COLLEGE OF ENGINEERING
Sponsored by Mohamed Sathak Trust
(Approved by AICTE, New Delhi and Affiliated to Anna University, Chennai)
Siruseri IT Park, Egattur, Chennai 603 103

B.E – MATERIAL SCIENCE AND ENGINEERING

S.NO	Name of the course that include experiential learning through Project work/ Internship
1	CE8395 - Strength of Materials for Mechanical Engineers
2	ML8303 - Materials Structures and Properties
3	ML8304 - Processing of Iron and Steel
4	ML8401 - Mechanical Behaviour of Materials
5	ML8402 - Corrosion and Surface Engineering
6	ML8403 - Non-Ferrous Metallurgy
7	ML8491 - Powder Metallurgy
8	ML8404 - Physical Metallurgy
9	ML8501 - Theory and Applications of Metal Forming
10	ML8502 - Material Aspects in Design
11	ML8503 - Characterization of Materials
12	ML8504 - Heat Treatment of Metals and Alloys
13	ML8602 - Composite Materials
14	ML8603 - Welding Metallurgy
15	ML8604 - Non Destructive Materials of Evaluation
16	ML8011 - Alloy Casting Processes




PRINCIPAL

MOHAMED SATHAK A.J. COLLEGE OF ENGINEERING
No.34.Rajiv Gandhi Salai (OMR), SIPCOT - IT Park
Siruseri, Chennai - 603 103.

OBJECTIVES:

- To understand the concepts of stress, strain, principal stresses and principal planes.
- To study the concept of shearing force and bending moment due to external loads in determinate beams and their effect on stresses.
- To determine stresses and deformation in circular shafts and helical spring due to torsion.
- To compute slopes and deflections in determinate beams by various methods.
- To study the stresses and deformations induced in thin and thick shells.

UNIT I STRESS, STRAIN AND DEFORMATION OF SOLIDS 9

Rigid bodies and deformable solids – Tension, Compression and Shear Stresses – Deformation of simple and compound bars – Thermal stresses – Elastic constants – Volumetric strains – Stresses on inclined planes – principal stresses and principal planes – Mohr's circle of stress.

UNIT II TRANSVERSE LOADING ON BEAMS AND STRESSES IN BEAM 9

Beams – types transverse loading on beams – Shear force and bending moment in beams – Cantilevers – Simply supported beams and over – hanging beams. Theory of simple bending– bending stress distribution – Load carrying capacity – Proportioning of sections – Flitched beams – Shear stress distribution.

UNIT III TORSION 9

Torsion formulation stresses and deformation in circular and hollow shafts – Stepped shafts– Deflection in shafts fixed at the both ends – Stresses in helical springs – Deflection of helical springs, carriage springs.

UNIT IV DEFLECTION OF BEAMS 9

Double Integration method – Macaulay's method – Area moment method for computation of slopes and deflections in beams - Conjugate beam and strain energy – Maxwell's reciprocal theorems.

UNIT V THIN CYLINDERS, SPHERES AND THICK CYLINDERS 9

Stresses in thin cylindrical shell due to internal pressure circumferential and longitudinal stresses and deformation in thin and thick cylinders – spherical shells subjected to internal pressure – Deformation in spherical shells – Lamé's theorem.

TOTAL: 45 PERIODS**OUTCOMES:**

Students will be able to

- Understand the concepts of stress and strain in simple and compound bars, the importance of principal stresses and principal planes.
- Understand the load transferring mechanism in beams and stress distribution due to shearing force and bending moment.
- Apply basic equation of simple torsion in designing of shafts and helical spring
- Calculate the slope and deflection in beams using different methods.
- Analyze and design thin and thick shells for the applied internal and external pressures

TEXT BOOKS

1. Bansal, R.P., "Strength of Materials", Laxmi Publications (P) Ltd., 2016
2. Jindal U.C. "Strength of Materials", Asian Books Pvt. Ltd., New Delhi, 2009

REFERENCES:

1. Egor. P.Popov "Engineering Mechanics of Solids" Prentice Hall of India, New Delhi, 2002
2. Ferdinand P. Beer, Russell Johnson, J.r. and John J. Dewole "Mechanics of Materials", Tata McGraw Hill Publishing 'co. Ltd., New Delhi, 2005.
3. Hibbeler, R.C., "Mechanics of Materials", Pearson Education, Low Price Edition, 2013
4. Subramanian R., "Strength of Materials", Oxford University Press, Oxford Higher Education Series, 2010.

OBJECTIVE:

- The subject introduces the correlation of properties of materials and their structure. It revises student's knowledge of crystal structure and phase diagrams of various alloy systems. The course not only covers metals, mainly ferrous and non-ferrous alloys, but also structures and properties of ceramics, polymers, elastomers and composites.

UNIT I STRUCTURE OF SOLIDS

9

Overview of Crystal Structure – Solid Solutions-Hume Rothery Rules-Crystal Imperfections- Point Defects- Line Defects-Surface Defects-Bulk Defects-Critical nucleus size and Critical Free energy- Mechanism of Crystallisation- Nucleation-Homogeneous and Heterogenous Nucleation-Growth - Single crystal -Polycrystalline Materials - Basic principles of solidification of metals and alloys. Growth of crystals- Planar growth – dendritic growth – Solidification time - Cooling curves - Non-crystalline solids- Glass Transition Temperature.

UNIT II PHASE DIAGRAMS

9

Phase Rule –Unary System- Binary Phase diagrams- Isomorphous systems-Congruent phase diagrams - Free energy Composition curves- Construction -Microstructural changes during cooling- Tie Line- Lever Rule- Eutectic, Peritectic, Eutectoid and Peritectoid reactions- Typical Phase diagrams – Cu-Zn System – Pb-Sn system- Ag-Pt system-Iron-Iron carbide Equilibrium Diagram

UNIT III FERROUS AND NON FERROUS MATERIALS

9

Classification of steels and cast iron –Microstructure– Effect of alloying elements on steel- Ferrous alloys and their applications - Factors affecting conductivity of a metal – Electrical Resistivity in alloys – Thermal conductivity of metals and alloys - High Resistivity alloys –Some important applications of Titanium alloys, Nickel alloys, Copper alloys, Magnesium alloys and Aluminium alloys.

UNIT IV ENGINEERING CERAMICS

9

Types - Crystal Structures - Silicate Ceramics - Glasses – Glass Ceramics – Advanced ceramics-Functional properties and applications of ceramic materials –SiC, Al₂O₃, Si₃N₄– Super hard materials - Tungsten carbide and Boron nitrides – Graphene. – Applications to bio engineering

UNIT V COMMODITY AND ENGINEERING POLYMERS

9

Classification of polymer – Mechanisms of polymerisation – Copolymers – Examples- Defects in polymers- Thermoplastics - Thermosets (PP, PS, PVC, PMMA, PET,PC, PA, ABS, PI, PAI, PPO, PPS, PEEK, PTFE, Polymers – Urea and Phenol formaldehydes)– Engineering plastics - Advanced Polymeric materials -Liquid crystal polymers - Conductive polymers – High Performance fibres– Photonic polymers- -Elastomers-Applications.

OUTCOMES:**TOTAL: 45 PERIODS**

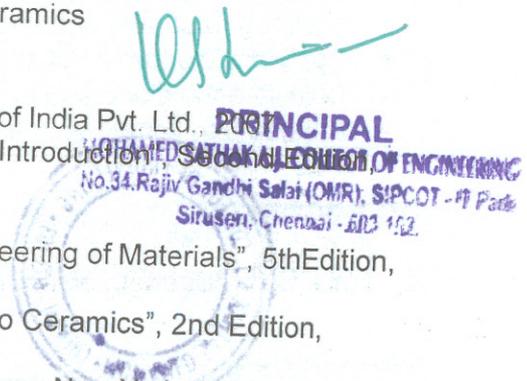
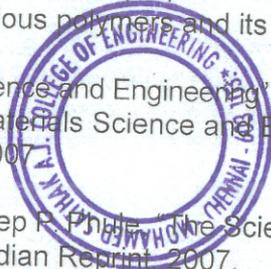
- To have the knowledge of overview crystal structures and mechanism of crystallization
- Able to understand and classify the phase diagrams.
- Able to recognize basic nomenclature, basic microstructure, associate terms with the appropriate structure / phenomena
- To have the knowledge on structure properties correlation in ceramics
- Able to understand the various polymers and its application.

TEXT BOOKS:

- V. Raghavan, "Materials Science and Engineering", Prentice –Hall of India Pvt. Ltd., 2008
- William D. Callister, Jr., "Materials Science and Engineering an Introduction", Second Edition, John Wiley & Sons, Inc., 2007

REFERENCES:

- Donald R. Askeland, Pradeep P. Phule, "The Science and Engineering of Materials", 5th Edition, Thomson Learning, First Indian Reprint, 2007.
- Kingery, W. D., Bowen H. K. and Uhlmann, D. R., "Introduction to Ceramics", 2nd Edition, John Wiley & Sons, New York, 1976.
- F. N. Billmeyer, "Test Book of polymer science", John Wiley & Sons, New York, 1994.
- Sidney H. Avner, "Introduction to Physical Metallurgy", Tata Mc-Graw-Hill Inc, 2/e, 1997.
- W. Bolton, "Engineering materials technology", 3rd Edition, Butterworth & Heinemann, 2001.
- William F. Smith, "Structure and Properties of Engineering Alloys", Mc-Graw-Hill Inc., U.S.A, 2nd edition, 1993.



OBJECTIVE:

- The course covers the production of iron and steel from raw material, primary processing to refinement to special steels.

UNIT I RAW MATERIALS AND BURDEN PREPARATION

9

Iron ore classification, Indian iron ores, limestone and coking coal deposits, problems associated with Indian raw materials, Iron ore beneficiation and agglomeration, Briquetting, sintering, Nodulising and pelletizing, testing of burden materials, burden distribution on blast furnace performance.

UNIT II PRINCIPLES AND PROCESSES OF IRON MAKING

9

Blast furnace parts, construction and design aspects, ancillary equipment for charging, preheating the blast, hot blast stoves, gas cleaning, Blast furnace operation, irregularities and remedies, Blast furnace instrumentation and control of furnace Compositional control of metal and slag in blast furnace, modern trends in blast furnace practice. Reduction of iron ores and oxides of iron by solid and gaseous reductions-thermodynamics and kinetics study of direct and indirect reduction, Gruner's theorem, blast furnace reactions. C-O and Fe-C-O equilibria, Rist diagrams, Ellingham diagram, material and heat balance- Sponge Iron making.

UNIT III PRINCIPLES OF STEEL MAKING

9

Development of steel making processes, physico-chemical principles and kinetic aspects of steel making, carbon boil, oxygen transport mechanism, desulphurisation, dephosphorisation, Slag Theories, slag-functions, composition, properties and theories, raw materials for steel making and plant layout.

UNIT IV STEEL MAKING PROCESSES

9

Open Hearth process- constructional features, process types, operation, modified processes, Duplexing, pre-treatment of hot metal. Bessemer processes, Side Blown Converter, Top Blown processes-L.D, L.D.A.C., Bottom blown processes, combined blown processes, Rotating oxygen processes-Kaldo and Rotor, Modern trends in oxygen steel making processes-Electric Arc and Induction furnace-constructional features. Steel Classifications and Standards- National and International.- Alloy Designation.

UNIT V STEEL LADLE METALLURGY

9

Production practice for plain carbon steels, low alloy – stainless, tool and special steels, modern developments. Secondary steel making processes, continuous steel casting process – Deoxidation and teeming practice. Principle, methods and their comparison, Killed, Rimmed and Capped steels, Degassing practices, ingot production, ingot defects and remedies. Recent trends in steel making technology.

TOTAL: 45 PERIODS**OUTCOMES:**

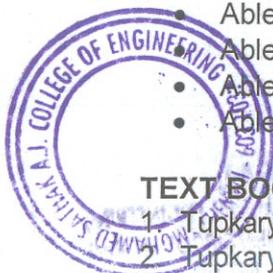
- Able to explain the operation of burden
- Able to understand the principles and processes of iron making
- Able to understand the principles of steel making
- Able to understand the different protocols for steel making
- Able to appreciate the ladle metallurgy for alloy steel.

TEXT BOOKS:

- Tupkary, R. H. "Modern Iron Making", 4th edition, Khanna Publishers, New Delhi.
- Tupkary, R. H., "Modern Steel Making", 4th Edition, Khanna Publications, New Delhi.

REFERENCES:

- Ahindra Ghosh and Amit chatterjee, "Iron Making and Steel Making – Theory and Practice", Prentice Hall of India Private Ltd., New Delhi 2008.
- Biswas, A. K., "Principles of blast furnace iron making: theory and practice", SBA Publications, Kolkata, 1994.




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OBJECTIVE

- The students having studied the basics of material structures and properties and strength of materials shall be introduced to dislocation theories of plasticity behaviour, various strengthening mechanisms and fracture mechanics. It will expose students to failure mechanisms due to fatigue and creep as well as their testing methods.

UNIT I ELASTIC AND PLASTIC BEHAVIOUR

9+6

Elastic behavior of materials - Hooke's law, plastic behaviour: dislocation theory - Burger's vectors and dislocation loops, dislocations in the FCC, HCP and BCC lattice, stress fields and energies of dislocations, forces on and between dislocations, dislocation climb, intersections of dislocations, Jogs, dislocation sources, multiplication of dislocations, dislocation pile-ups, Slip and twinning.

UNIT II STRENGTHENING MECHANISMS

9+6

cold working, grain size strengthening. Solid solution strengthening. martensitic strengthening, precipitation strengthening, dispersion strengthening, fibre strengthening, examples of above strengthening mechanisms from ferrous and non-ferrous systems, simple problems. Yield point phenomenon, strain aging and dynamic strain aging

UNIT III FRACTURE AND FRACTURE MECHANICS

9+6

Types of fracture, basic mechanism of ductile and brittle fracture, Griffith's theory of brittle fracture, Orowan's modification. Izod and Charpy Impacts tests, Ductile to Brittle Transition Temperature (DBTT), Factors affecting DBTT, determination of DBTT.

Fracture mechanics-introduction, modes of fracture, stress intensity factor, strain energy release rate, fracture toughness and determination of K_{IC} , introduction to COD, J integral.

UNIT IV FATIGUE BEHAVIOUR AND TESTING

9+6

Fatigue: Stress cycles, S-N curves, effect of mean stress, factors affecting fatigue, structural changes accompanying fatigue, cumulative damage, HCF / LCF, thermomechanical fatigue, application of fracture mechanics to fatigue crack propagation, fatigue testing machines.

UNIT V CREEP BEHAVIOUR AND TESTING

9+6

Creep curve, stages in creep curve and explanation, structural changes during creep, creep mechanisms, metallurgical factors affecting creep, high temperature alloys, stress rupture testing, creep testing machines, parametric methods of extrapolation. Deformation Mechanism Maps according to Frost/Ashby.

TOTAL 75 PERIODS**OUTCOMES**

- Ablity to understand the mechanism involved in elastic and plastic behaviour of metals.
- Ablity to apply their knowledge of strengthening mechanism in ferrous and non ferrous sytems.
- Ablity to understand about the fundamental of fracture mechanics
- Able to apply their knowldege in real time fatigue failures
- Ablity to evaluate and Justify the safe use of materials for engineering application in high temperature.

TEXT BOOKS:

- Dieter, G.E., "Mechanical Metallurgy", McGraw-Hill, SI Edition, 1998
- Davis. H. E., Troxell G.E., Hawk E. W. "The Testing of Engineering Materials", McGraw-Hill, 1982.

REFERENCES

- Hayden, H. W. W. G. G. Moffatt, J. Moffatt and J. Wulff, The Structure and Properties of Materials, Vol.III, Mechanical Behavior, John Wiley & Sons, New York, 1965.
- Honey combe R. W. K., "Plastic Deformation of Materials", Edward Arnold Publishers, 1984.
- Wulff, The Structure and Properties of Materials, Vol. III "Mechanical Behavior of Materials", John Wiley and Sons, New York, USA, 1983.
- Suryanarayana, A. V. K., "Testing of Metallic Materials", Prentice Hall India, New Delhi, 1979.

OBJECTIVE:

- The subject provides knowledge on various types of corrosion, their kinetics, testing and methods of protection as well as introduction to tribology.

UNIT I INTRODUCTION

12

Introduction to tribology, surface degradation, wear and corrosion, types of wear, adhesive, abrasive, oxidative, corrosive, erosive and fretting wear, roles of friction and lubrication-, expressions for corrosion rate. emf and galvanic series - merits and demerits -Pourbaix diagram for iron, magnesium and aluminium. Forms of corrosion - Uniform, pitting, intergranular, stress corrosion. corrosion fatigue. dezincification. erosion corrosion, crevice corrosion - Cause and remedial measures - Pilling Bedworth ratio - High temperature oxidation-Hydrogen embrittlement - Remedial Measures.

UNIT II KINETICS OF CORROSION

8

Exchange current density, polarization - concentration, activation and resistance, Tafel equation; passivity, electrochemical behaviour of active/passive metals, Flade potential, theories of passivity, Effect of oxidizing agents

UNIT III CORROSION OF INDUSTRIAL COMPONENTS

8

Corrosion in fossil fuel power plants, Automotive industry, Chemical processing industries, corrosion in petroleum production operations and refining, Corrosion of pipelines.- wear of industrial components

UNIT IV TESTING

8

Purpose of corrosion testing - Classification - Susceptibility tests for intergranular corrosion-Stress corrosion test. Salt spray test humidity and porosity tests, accelerated weathering tests. ASTM standards for corrosion testing and tests for assessment of wear

UNIT V PROTECTION METHODS

9

Organic, Inorganic and Metallic coatings, electro and Electroless plating and Anodising - Cathodic protection, corrosion inhibitors - principles and practice - inhibitors for acidic neutral and other media. Special surfacing processes - CVD and PVD processes, sputter coating. Laser and ion implantation, Arc spray, plasma spray, Flame spray, HVOF.

TOTAL: 45 PERIODS**OUTCOMES:**

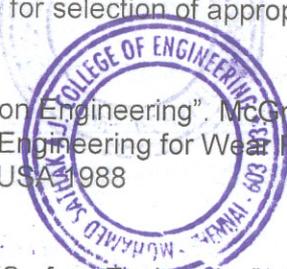
- Ability to describe about the fundamental of corrosion and identify different corrossions.
- Ability to understand the theory involved in kinetics of corrosion.
- Ability to identify the corrosion types occurs in different industries.
- Ability to understand the various corrosion tests and its importance.
- Ability to apply the knowledge for selection of appropriate corrosion protection method.

TEXT BOOKS:

1. Fontana and Greene. "Corrosion Engineering". McGraw Hill Book Co. New York. USA1986.
2. Kenneth G Budinski. "Surface Engineering for Wear Resistance". Prentice Hall Inc., Englewood Cliff., New Jersey. USA1988

REFERENCES:

1. ASM Metals Handbook. Vol.5. "Surface Engineering". ASM Metals Park. Ohio. USA. 1994.
2. ASM Metals Handbook. Vol.13,"Corrosion". ASM Metals Park. Ohio. USA. 1994
3. Denny A. Jones,"Principles and Prevention of Corrosion" 2nd Edition, Prentice Hall of India,1996.
4. Raj Narayan. "An Introduction to Metallic Corrosion and its prevention", Oxford & 1BH, New Delhi,1983.
5. Uhlig. H.H. "Corrosion and Corrosion Control". John Wiley & Sons. New York. USA. 1985.



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Sivasekari, Chennai 603 103.

OBJECTIVE:

- To understand the structure, property relations of nonferrous alloys with special emphasis on engineering applications.

UNIT I COPPER AND COPPER ALLOYS

9

Methods of Production of Copper, Properties and applications of metallic copper. Major alloys of copper and designation- Brasses. Phase diagram of industrially relevant portion. Different compositions, characteristics and uses. Bronzes: Tin bronze. Composition, properties and uses. Other bronzes like Cu-Al, Cu-Si, Cu-Mn and Cu-Be alloys. Cu-Ni alloys. Typical microstructure of copper alloys.

UNIT II ALUMINIUM AND ITS ALLOYS

9

Methods of Production of Aluminium- Properties of metallic aluminium. Alloys of aluminium and designation, classification. Wrought and cast alloys. Heat treatable and nonheat treatable alloys. Age hardening of Al-Cu alloy. Al-Mg-Si, Al-Zn-Mg and Al-Li alloys. Typical microstructure of aluminium alloys. Applications of Al alloys in Automobile and Aircraft industries.

UNIT III MAGNESIUM AND TITANIUM ALLOYS

9

Methods of Production of Magnesium- properties and uses. Magnesium alloys and designation. Methods of Production of Titanium- unique characteristics of the metal- alpha, alpha+beta and beta titanium alloys- major types. Titanium aluminides – their properties and uses. Typical microstructure of magnesium and titanium alloys- Applications of Ti alloys in Aircraft, Chemical and Medical industries.

UNIT IV NICKEL AND ZINC ALLOYS

9

Methods of Production of Nickel-Properties and uses of nickel. Nickel alloys and designation – their properties and uses. Nickel aluminides. Methods of Production of Zinc-Use of zinc in corrosion protection of ferrous materials. Zinc alloys – properties and uses. Typical microstructure of nickel and zinc alloys.

UNIT V LEAD, TIN AND PRECIOUS METALS

9

Methods of Production of Lead and Tin-Major characteristics and applications of lead and tin and their alloys and designation. Low melting nature of solder alloys. Gold, silver and platinum – nobility of these metals. Engineering properties and applications of these metals and their alloys. Typical microstructure of solder alloys

TOTAL: 45 PERIODS**OUTCOMES:**

Upon completion of this course, the students can able to

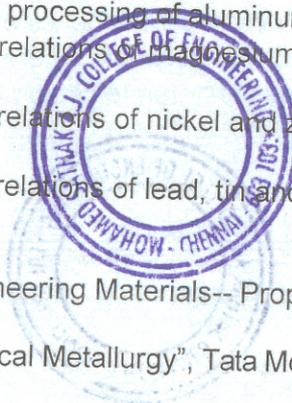
- To understand the structure, property relations of copper and copper alloys
- To understand the heat treatment and processing of aluminum alloys
- To understand the structure, property relations of magnesium and titanium alloys on engineering applications
- To understand the structure, property relations of nickel and zinc alloys on engineering applications
- To understand the structure, property relations of lead, tin and precious metals on engineering applications

TEXT BOOKS:

- K.G.Budinski and M.K.Budinski, "Engineering Materials-- Properties and Selection", PHI Learning Pvt. Ltd., New Delhi, 2009.
- Sidney H. Avner, "Introduction to Physical Metallurgy", Tata McGraw-Hill, 2nd Edition, 1997.

REFERENCES:

- Ahindra Ghosh, Hem Shanker Ray, "Principles of Extractive Metallurgy", New Age International, Reprint 2001.
- Balram Gupta, "Aerospace Materials", Vol. 1, 2 and 3, S. Chand and Co., New Delhi, 1996.
- Clark and Varney, "Physical Metallurgy for Engineers", Affiliated East West Press, New Delhi, 1987
- William F. Smith, "Structure and Properties of Engineering Alloys", McGraw Hill, USA, 1993.
- W.H. Dennis, "Metallurgy of the Nonferrous Metals", Sir Isaac Pitman and Sons, London, 1967.



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 No. 21, Prabhakaran Road, Siruseri, Chennai - 603 103.
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OBJECTIVE:

- This course teaches powder preparation, characterization, compaction and sintering. This knowledge is essential to understand powder metallurgy applications in aerospace, automobile and machining materials.

UNIT I POWDER MANUFACTURE AND CONDITIONING

12

Mechanical methods Machine milling, ball milling, atomization, shotting- Chemical methods, condensation, thermal decomposition, carbonyl Reduction by gas-hydride, dehydride process, electro deposition, precipitation from aqueous solution and fused salts, hydrometallurgical method. Physical methods: Electrolysis and atomization processes, types of equipment, factors affecting these processes, examples of powders produced by these methods, applications, powder conditioning, heat treatment, blending and mixing, types of equipment, types of mixing and blending, Self-propagating high-temperature synthesis (SHS), sol-gel synthesis- Nano powder production methods.

UNIT II CHARACTERISTICS AND TESTING OF METAL POWDERS

8

Sampling, chemical composition purity, surface contamination etc. Particle size. and its measurement, Principle and procedure of sieve analysis, microscopic analysis: sedimentation, elutriation, permeability. Adsorption methods and resistivity methods: particle shape, classifications, microstructure. specific surface area. apparent and tap density. green density. green strength, sintered compact density, porosity, shrinkage.

UNIT III POWDER COMPACTION

7

Pressure less compaction: slip casting and slurry casting. pressure compaction- lubrication, single ended and double ended compaction, isostatic pressing, powder rolling, forging and extrusion, explosive compaction.

UNIT IV SINTERING

9

Stage of sintering, property changes, mechanisms of sintering, liquid phase sintering and infiltration, activated sintering, hot pressing and Hot Isostatic Pressing (HIP), vacuum sintering, sintering furnaces-batch and continuous-sintering atmosphere, Finishing operations – sizing, coining, repressing and heat treatment, special sintering processes- microwave sintering, Spark plasma sintering, Field assisted sintering, Reactive sintering, sintering of nanostructured materials.

UNIT V APPLICATIONS

9

Major applications in Aerospace, Nuclear and Automobile industries- Bearing Materials-types, Self lubrication and other types, Methods of production, Properties, Applications. Sintered Friction Materials-Clutches, Brake linings, Tool Materials- Cemented carbides, Oxide ceramics, Cermets- Dispersion strengthened materials.

TOTAL: 45 PERIODS**OUTCOMES:**

- Ability to understand and describe about various ways of producing metal powders.
- Have the knowledge of metal powder characterization.
- Ability to describe the various powder compaction process
- Ability to select appropriate sintering techniques based on the requirements.
- Ability to appreciate the role of powder metallurgy component in various fields.

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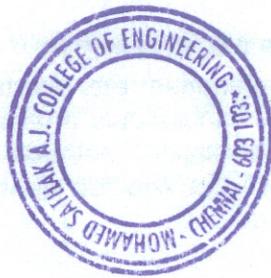
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10/1, Rajiv Gandhi Salai (OMR), SIPCOT - IT Park
Siruseri, Chennai - 603 103.

TEXT BOOKS:

- Anish Upadhya and G S Upadhaya, "Powder Metallurgy: Science, Technology and Materials, Universities Press, 2011
- P.C.Angelo and R.Subramanian., "Powder Metallurgy: Science, Technology and Application" Prentice Hall, 2008

REFERENCES:

1. ASM Handbook. Vol. 7, "Powder Metallurgy", Metals Park, Ohio, USA, 1990.
2. Animesh Bose., "Advances in Particulate Materials", Butterworth - Heinemann. New Delhi, 1995.
3. Erhard Klar., "Powder Metallurgy Applications, Advantages and Limitations", American Society for Metals, Ohio, 1983.
4. Kempton. H Roll., "Powder Metallurgy", Metallurgical Society of AMIE, 1988.
5. R.M. German, "Powder Metallurgy and Particulate Materials Processing", Metal Powder Industries Federation, Princeton, NJ, 2005.
6. Ramakrishnan. P., "Powder Metallurgy-Opportunities for Engineering Industries", Oxford and IBH Publishing Co., Pvt. Ltd, New Delhi, 1987.
7. Sands. R. L. and Shakespeare. C. R. "Powder Metallurgy", George Newes Ltd. London, 1966
8. Sinha A. K., "Powder Metallurgy", Dhanpat Rai & Sons. New Delhi, 1982



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OBJECTIVE:

- Students of Materials Science and Engineering are offered an in depth study of the physical metallurgy

UNIT I PHASE TRANSFORMATION

8

Basics of thermodynamic & kinetics: equilibrium - configurational entropy - free energy of mixing - miscibility gap - chemical potential. Diffusion - uphill diffusion - downhill diffusion - atomic mechanisms of diffusion, Fick's 1st and 2nd law - solution to the diffusion equation - error functions - application of the non-steady state diffusion, spinodal decomposition

UNIT II DIFFUSION CONTROLLED PHASE TRANSFORMATION

10

Nucleation and growth - Types of nucleation - Concept of free energy during solidification - Thermodynamics of homogeneous nucleation - critical nucleus size and critical free energy change - constitutional super cooling - Extension to heterogeneous nucleation - Nucleation rate and growth rate - overall transformation rate. Concept of Activation energy - Arrhenius equation - Johnson Mehl - Avrami equation. Pearlitic transformations- spinodal decomposition

UNIT III DIFFUSIONLESS TRANSFORMATIONS

10

Martensite transformation - Definition - characteristic features of Martensitic transformation in steels - morphology of Martensite - lath and acicular martensite - Crystallography of martensitic transformation - Martensite in non-ferrous systems - Thermoelastic martensite - Shape Memory effect - Examples and applications of shape memory alloys.

UNIT IV PRECIPITATION REACTIONS

7

Precipitation from solid solutions, thermodynamic considerations, structure and property during ageing, sequence of ageing, formation of G-P zones and intermediate precipitates, theories of precipitation hardening, effect of time, temperature and alloy compositions, precipitation free zones, crystallographic aspects of transformation, coarsening kinetics.

UNIT V ANNEALING

8

Cold working and hot working. Recovery - polygonization and dislocation movements in polygonization. Recrystallisation - effect of time, temperature, strain and other variables, mechanism of nucleation and growth. Grain growth - Grain growth law, geometrical collisions, preferred orientation, secondary recrystallisation.

TOTAL : 45 PERIODS**OUTCOMES**

- Ability to solve problems involving steady state and non steady state diffusion of varying degrees of complexity
- To understand the phase transformation in terms of thermodynamics.
- To understand the diffusionless transformation in ferrous and non ferrous systems.
- To understand the precipitation strengthening mechanism in terms of thermodynamics.
- To understand the structure property correlation in annealing.

TEXT BOOKS:

1. Raghavan. V., "Phase Transformations", Prentice - Hall of India, New Delhi, 2007.
2. Romesh C. Sharma, "Phase transformation in Materials", CBS Publishers & Distributors, New Delhi, 2002.

REFERENCES:

1. Anil Sinha, "Physical Metallurgy Handbook", 1st Edition, McGraw-Hill Professional, 2002.
2. George E. Totten and D. Scott MacKenzie, "Handbook of Aluminum. Vol. 1: Physical Metallurgy and Processes", 1st Edition, CRC, 2003.
3. Reed Hill. R. E. "Physical Metallurgy Principles", Affiliated East West Press. New Delhi. 1992.
4. Thomas H. Courtney, "Mechanical Behaviour of Materials", McGraw-Hill Co., NY. 1990.
5. William F. Hosford, "Physical Metallurgy, Materials Engineering Series", Vol. 26, Taylor & Francis CRC Press, 2005.



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 Srinagar, Chennai - 603 103

OBJECTIVE:

- The basic knowledge on plasticity taught in mechanical metallurgy is extended to theory and applications of metal forming. Various metal forming processes and their analysis are studied in detail.

UNIT I STRESS - STRAIN TENSOR

9

State of stress, components of stress, symmetry of stress tensor, principle stresses, stress deviator, Von Mises, Tresca Yield criteria, comparison of yield criteria, Octahedral shear stress and shear strain, Slip, twinning, Forming load calculations, Strain Rate Tensor.

UNIT II FUNDAMENTALS OF METAL FORMING

9

Classification of forming process- Mechanics of metal working, Flow stress determination, Effect of temperature, strain rate and metallurgical structure on metal working, Friction and lubrication. Deformation zone geometry, Workability, Residual stresses.

UNIT III FORGING AND ROLLING

9

Forging-Hot, Cold and Warm Forging – types of presses and hammers. Classification, Open die forging and Closed die forging, die design, forging in plane strain, calculation of forging loads, use of software for analysis - forging defects – causes and remedies, residual stresses in forging. Rolling: Classification of rolling processes, types of rolling mills, hot and cold rolling, rolling of bars and shapes, forces and geometrical relationship in rolling, analysis of rolling load, torque and power, rolling mill control, rolling defects- causes and remedies.

UNIT IV EXTRUSION AND DRAWING

9

Direct and indirect extrusion, variables affecting extrusion, deformation pattern, equipments, port – hole extrusion die, hydrostatic extrusion, defects and remedies, simple analysis of extrusion ,tube extrusion and production of seamless pipe and tube. Drawing of rod, wires and tubes.

UNIT V SHEET METAL FORMING AND OTHER PROCESSES

9

Forming methods – Shearing, Fine and Adiabatic blanking, bending, stretch forming, deep drawing, defects in formed part, sheet metal formability, forming limit diagram. High velocity forming, Comparison with conventional forming, Explosive forming, Electro hydraulic, Electro Magnetic forming, Dynapark and petroforge forming.

TOTAL : 45 PERIODS

OUTCOMES:

- Ability to understand the plastic deformation of metals in terms of stress-strain tensor.
- Ability to understand the fundamentals and various factors contributing towards metal forming.
- Ability to understand and describe about various forging and rolling processes.
- Ability to identify the root causes and remedies of extruded and drawn components.
- Ability to differentiate the conventional and un-conventional metal forming techniques.

TEXT BOOKS:

- Dieter. G. E., "Mechanical Metallurgy", Mc Graw – Hill Co., SI Edition, 1995.
- Surender Kumar, "Technology of Metal Forming Processes", PHI, New Delhi, 2008.

REFERENCES:

- Avitzur, "Metal Forming – Process and Analysis", Tata McGraw – Hill Co., New Delhi, 1977.
- Dr.Sadhu Singh, "Theory of plasticity and Metal Forming Processes", Khanna Publishers, 2005.
- Kurt Lange, "Handbook of Metal Forming", Society of Manufacturing Engineers, Michigan, USA, 1998.
- Nagpal G. R., "Metal Forming Processes", Khanna Pub., New Delhi, 2000
- Shiro Kobayshi, Altan. T, "Metal Forming and Finite Element Method", Oxford University Press, 1987.
- William F. Hosford and Robert M. Caddell, "Metal Forming Mechanics and Metallurgy", Cambridge Press,2011.

OBJECTIVE:

- Material Properties have to suit the purpose of an application. When designing a machine or component, many factors have to be considered and optimised. This course covers most issues for mechanical design optimisation.

UNIT I MATERIAL SELECTION IN DESIGN

9+6

Introduction – relation of materials selection to design – general criteria for selection – performance characteristics of materials – materials selection process – design process and materials selection – economics of materials – recycling and materials selection

UNIT II MATERIALS PROCESSING AND DESIGN

9+6

Role of Processing in Designing – classification of manufacturing processes – types of processing systems – factors determining process selection. Design for manufacturability, assembly, machining, casting, forging and welding

UNIT III MANUFACTURING CONSIDERATIONS IN DESIGN

9+6

Surface finish – texture – dimensional tolerances in fitting – interchangeability – selective assembly – geometric tolerance. Selection of fits and tolerances

UNIT IV MATERIALS PROPERTIES AND DESIGN

9+6

Stress – Strain diagram – design for strength, rigidity – design under static loading, variable loading, eccentric loading – stress concentration. Design examples with shaft design, spring design and C-frames.

UNIT V MATERIALS IN DESIGN

9+6

Design for brittle fracture, fatigue failure, corrosion resistance. Designing with plastics, brittle materials

TOTAL : 75 PERIODS**OUTCOMES:**

- Able to understand the importance of materials selection.
- Able to design the process flow of manufacturing process.
- Ability to use different design criteria for manufacturing process.
- Ability to describe the case study on design.
- Ability to use different failure criteria for safe design of components.

TEXT BOOKS:

1. Dieter George E, Engineering Design, A materials and processing approach, 3rd Edition, McGraw Hill, 2000
2. Bhandari, "Design of Machine Elements", Tata McGraw Hill, 2006

REFERENCE:

1. CES Materials Selector, GRANTA Design and M. F. Ashby, 2007



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PRINCIPAL
 MOHAMED SATHAK A.J. COLLEGE OF ENGINEERING
 Siruseri, Chennai - 603 103

OBJECTIVE:

- Characterisation of materials is very important for studying the structure of materials and to interpret their properties. The students study the theoretical foundations of metallography, X-ray diffraction, electron diffraction, scanning and transmission electron microscopy as well as surface analysis.

UNIT I METALLOGRAPHIC TECHNIQUES

Macro examination - applications, metallurgical microscope - principle, construction and working, metallographic specimen preparation, optic properties - magnification, numerical aperture, resolving power, depth of focus, depth of field, different light sources lenses aberrations and their remedial measures, various illumination techniques-bright field, dark field, phase-contrast polarized light illuminations, interference microscopy, high temperature microscopy; quantitative metallography – Image analysis

9

UNIT II X-RAY DIFFRACTION TECHNIQUES

Crystallography basics, reciprocal lattice, X-ray generation, absorption edges, characteristic spectrum, Bragg's law, Diffraction methods – Laue, rotating crystal and powder methods. Stereographic projection. Intensity of diffracted beams – structure factor calculations and other factors. Cameras- Laue, Debye-Scherrer cameras, Seeman - Bohlin focusing cameras. Diffractometer – General feature and optics, proportional, Scintillating and Geiger counters.

9

UNIT III ANALYSIS OF X-RAY DIFFRACTION

Line broadening, particle size, crystallite size, Precise parameter measurement, Phase identification, phase quantification, Phase diagram determination X-ray diffraction application in the determination of crystal structure, lattice parameter, residual stress – quantitative phase estimation, ASTM catalogue of Materials identification.

9

UNIT IV ELECTRON MICROSCOPY

Construction and operation of Transmission electron microscope – Diffraction effects and image formation, specimen preparation techniques, Selected Area Electron Diffraction, electron-specimen interactions, Construction, modes of operation and application of Scanning electron microscope, Electron probe micro analysis, basics of Field ion microscopy (FIB), Scanning Tunneling Microscope (STM) and Atomic Force Microscope (AFM).

9

UNIT V PRINCIPLE AND APPLICATIONS

Surface chemical composition- Mass spectroscopy and X-ray emission spectroscopy (Principle and limitations) - Energy Dispersive Spectroscopy- Wave Dispersive Spectroscopy - Quadrupole mass spectrometer, Electron spectroscopy for chemical analysis (ESCA), Ultraviolet Photoelectron Spectroscopy (UPS), X ray Photoelectron Spectroscopy (XPS), Auger Electron Spectroscopy (AES), Electron Energy Analysers, Secondary ion mass spectrometry - Applications. Unit meshes of five types of surface nets - diffraction from diperiodic structures using electron, Low Energy Electron Diffraction (LEED), Reflection High Energy Electron Diffraction (RHEED)-TGA.

9

TOTAL: 45 PERIODS



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OUTCOMES:

- Able to understand the physics behind the various metallographic techniques.
- Ability to describe the principle, construction and working of XRD techniques
- Ability to analysis the X-ray diffraction data
- Ability to describe the principle, construction and working of electron microscopy.
- Ability to identify the appropriate spectroscopy technique for required information.

TEXT BOOKS:

1. Cullity, B. D., "Elements of X-ray diffraction", 3rd Edition, Addison-Wesley Company Inc., New York, 2000
2. Phillips V A, "Modern Metallographic Techniques and their Applications", Wiley Eastern, 1971.

REFERENCES:

1. Brandon D. G, "Modern Techniques in Metallography", Von Nostrand Inc. NJ, USA, 1986.
2. D. A. Skoog, F. James Leary and T. A. Nieman, "Principles of Instrumental Analysis", Fifth Edition, Saunders Publishing Co., 1998
3. Haines, P.J., "Principles of Thermal Analysis and Calorimetry", Royal Society of Chemistry (RSC), Cambridge, 2002.
4. Thomas G., "Transmission electron microscopy of metals", John Wiley, 1996.
5. Weinberg, F., "Tools and Techniques in Physical Metallurgy", Volume I & II, Marcel and Decker, 1970.
6. Whan R E (Ed), ASM Handbook, Volume 10, Materials Characterisation", Nineth Edition, ASM international, USA, 1986.




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MOHAMED SATHAK A.J. COLLEGE OF ENGINEERING
No.34.Rajiv Gandhi Salai (OMR), SIPCOT - IT Park
Siruseri, Chennai - 603 103.



OBJECTIVE:

The course covers the fundamental aspects of the theory and practice of heat treatment of metals and alloys. It provides a comprehensive understanding of the various transformation reactions associated with the changes in microstructure and property that occur due to controlled heat treatment.

UNIT I TRANSFORMATIONS IN STEELS

Allotropic changes in Iron, Iron-Iron carbide equilibrium diagram – transformations on heating and cooling - influence of alloying elements – general principles of heat treatment of steels – isothermal and continuous cooling transformations in steels – Time-Temperature-Transformation curves (TTT-diagrams), continuous cooling transformations – CCT-diagrams - effect of alloying additions on TTT diagrams, mechanism and kinetics of pearlitic, bainitic and martensitic transformations – precipitation hardening **9**

UNIT II HEAT TREATMENT PROCESSES

Annealing- Types, Normalising, Hardening & Quenching –Mechanisms-hardenability studies – Jominy end-quench test, Grossman's experiments, tempering – Hollomon & Jaffe tempering correlations, tempering – tempered brittleness – effects of alloying elements on tempering, austempering and martempering, precipitation hardening, thermomechanical treatment, intercritical heat treatment, polymer quenching, sub-zero treatment – cryogenic quenching, patenting **9**

UNIT III CASE HARDENING

Introduction, carburisation – principle – carbon potential – mechanism – application of Fick's law – depth of carburisation and its control – methods of carburising – heat treatment after carburising-structure, properties and defects in carburising, nitriding – mechanism – retained austenite – Remedy- effect of microstructure – nitriding methods, ion-nitriding and nitro-carburising, boronising, chromising, cyaniding and carbonitriding, induction and flame hardening, Laser and Electron beam hardening and welding – principles – methods – operating variables, measurement of case depth **9**

UNIT IV FURNACES, ATMOSPHERE AND PROCESS CONTROL

Various heating atmosphere used for heat treatment, temperature and atmosphere control – carburising atmosphere and carbon potential measurement, Temperature Measurement Control devices – Nitriding gas atmospheres, quenching media and their characteristics, Stages of Quenching, Various Heat Treatment furnaces- Roller and Mesh type continuous furnaces- fluidised bed furnaces, vacuum furnace, cryo-chamber, cryo-treatment of steels, sealed quenched furnace, plasma equipment-Elements of Process control systems-PLC ,PID controllers and continuous monitoring systems. **9**

UNIT V HEAT TREATMENT OF SPECIFIC ALLOYS

Heat treatment of special purpose steels – tool steels, high speed steels, maraging steels, SLA steels and die steels, heat treatment of cast irons – gray cast irons, white cast irons and S.G.irons, austempering of S.G.Iron, heat treatment of non-ferrous alloys – aluminium alloys, copper alloys, nickel alloys and titanium alloys, defects in heat treated parts – causes and remedies. **9**

OUTCOMES:

- Able to understand and describe the basic concepts of phase transformations in steels.
- Able to differentiate thermal and thermomechanical heat treatment processes.
- Ability to understand the various case hardening techniques and its process.
- To have the knowledge on different types of furnaces.
- Able to identify the proper heat treatment technique for required microstructure in alloy steel.

TOTAL: 45 PERIODS**TEXT BOOKS:**

1. Rajan, T. V., Sharma, C. P., Ashok Sharma., "Heat Treatment Principles And Techniques"

Prentice-Hall of India Pvt. Ltd., New Delhi, 2002

2. Sydney H. Avner, "Introduction to Physical Metallurgy", Tata McGraw Hill, New Delhi, 1997.

REFERENCES:

1. ASM Hand book "Heat Treating", Vol.4., ASM International, 1999.
2. Novikov, "Theory of Heat Treatment of Metals", MIR Publishers, Moscow, 1978.
3. Prabhudev. K. H. "Handbook of Heat Treatment of Steels", Tata McGraw-Hill Publishing Co., New Delhi, 1988.
4. Vijendra Singh, "Heat Treatment of Metals", Second Edition, Standard Publishers Distributors New Delhi, 2009.



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MOHAMED SATHAK A.J., COLLEGE OF ENGINEERING
No.34.Rajiv Gandhi Salai (OMR), SIPCOT - IT Park
Siruseri, Chennai - 603 103.



OBJECTIVE:

- Composites are a relatively new class of materials. In this course the students learn about the benefits gained when combining different materials into a composite. The Motive is to make the students to understand different processing methods, issues, properties and testing methods of different composite materials

UNIT I INTRODUCTION TO COMPOSITES

8

Fundamentals of composites - need for composites – enhancement of properties - classification of composites – Matrix-Polymer matrix composites (PMC), Metal matrix composites (MMC), Ceramic matrix composites (CMC) – Reinforcement – particle reinforced composites, Fibre reinforced composites. Applications of various types of composites. Fiber production techniques for glass, carbon and ceramic fibers

UNIT II POLYMER MATRIX COMPOSITES

12

Polymer resins – thermosetting resins, thermoplastic resins – reinforcement fibres – rovings – woven fabrics – non woven random mats – various types of fibres. PMC processes - hand lay up processes – spray up processes – compression moulding – reinforced reaction injection moulding - resin transfer moulding – Pultrusion – Filament winding – Injection moulding. Fibre reinforced plastics (FRP), Glass Fibre Reinforced Plastics (GFRP). Laminates- Balanced Laminates, Symmetric Laminates, Angle Ply Laminates, Cross Ply Laminates.-applications of PMC in aerospace, automotive industries

UNIT III METAL MATRIX COMPOSITES

9

Characteristics of MMC, various types of metal matrix composites alloy vs. MMC, advantages of MMC, limitations of MMC, Reinforcements – particles – fibres. Effect of reinforcement - volume fraction – rule of mixtures. Processing of MMC – powder metallurgy process - diffusion bonding – stir casting – squeeze casting, a spray process, Liquid infiltration In-situ reactions-Interface-measurement of interface properties- applications of MMC in aerospace, automotive industries

UNIT IV CERAMIC MATRIX COMPOSITES AND SPECIAL COMPOSITES

9

Engineering ceramic materials – properties – advantages – limitations – monolithic ceramics - need for CMC – ceramic matrix - various types of ceramic matrix composites- oxide ceramics – non oxide ceramics – aluminium oxide – silicon nitride – reinforcements – particles- fibres- whiskers. Sintering - Hot pressing – Cold isostatic pressing (CIPing) – Hot isostatic pressing (HIPing). applications of CMC in aerospace, automotive industries- Carbon /carbon composites – advantages of carbon matrix – limitations of carbon matrix carbon fibre – chemical vapour deposition of carbon on carbon fibre perform. Sol-gel technique- Processing of Ceramic Matrix composites.

UNIT V MECHANICS OF COMPOSITES

7

Lamina Constitutive Equations: Lamina Assumptions – Macroscopic Viewpoint. Generalized Hooke's Law. Reduction to Homogeneous Orthotropic Lamina – Isotropic limit case, Orthotropic Stiffness matrix (Q_{ij}), Definition of stress and Moment Resultants, Strain Displacement relations. Basic Assumptions of Laminated anisotropic plates. Laminate Constitutive Equations – Coupling Interactions, Balanced Laminates, Symmetric Laminates, Angle Ply Laminates, Cross Ply Laminates. Laminate Structural Moduli. Evaluation of Lamina Properties from Laminate Tests. Quasi-Isotropic Laminates. Determination of Lamina stresses within Laminates.

TOTAL: 45 PERIODS**OUTCOMES:**

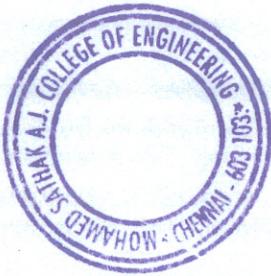
- Able to understand and describe the basic concept and classification of composite.
- To acquire the knowledge in polymer matrix composites and its processing methods.
- To acquire the knowledge in metal matrix composites and its processing methods.
- To acquire the knowledge in ceramics matrix composites and its processing methods.
- Use of Mathematical techniques to predict the macroscopic properties of different Laminates

TEXT BOOKS:

1. Mathews F. L. and Rawlings R. D., "Composite Materials: Engineering and Science", 1st Edition, Chapman and Hall, London, England, 1994.
2. Chawla K. K., "Composite materials", Second Edition, Springer – Verlag, 1998.

REFERENCES:

1. Clyne, T. W. and Withers, P. J., "Introduction to Metal Matrix Composites", Cambridge University Press, 1993.
2. Strong, A.B., "Fundamentals of Composite Manufacturing", SME, 1989.
3. Sharma, S.C., "Composite materials", Narosa Publications, 2000.
4. Broutman, L.J. and Krock, R.M., "Modern Composite Materials", Addison-Wesley, 1967.
5. ASM Hand Book, "Composites", Vol.21, ASM International, 2001.



Mohamed Sathak A.J.

PRINCIPAL
MOHAMED SATHAK A.J. COLLEGE OF ENGINEERING
No.34.Rajiv Gandhi Salai (OMR), SIPCOT - IT Park
Siruseri, Chennai - 603 103.

Mohamed Sathak A.J.
PRINCIPAL
MOHAMED SATHAK A.J. COLLEGE OF ENGINEERING
No.34.Rajiv Gandhi Salai (OMR), SIPCOT - IT Park
Siruseri, Chennai - 603 103.



OBJECTIVE:

- Welding is one of the most important fabrication processes in industry and requires both theoretical understanding and experience of materials used in industry. This can be achieved in this course.

UNIT I WELDING METALLURGY PRINCIPLES 9

Thermal cycles in welding: basic heat transfer equations, temperature distributions and cooling curves, dependence of cooling rate on heat input, joint geometry, preheat and other factors. Comparison of welding processes based on these considerations.

UNIT II PHYSICAL METALLURGY OF WELDING 9

Welding of ferrous materials: Iron - carbon diagram, TTT and CCT diagrams related to welding, effects of steel composition, formation of different microstructural zones in welded plain-carbon steels. Welding of C-Mn and low-alloy steels, phase transformations in weld and heat - affected zones, cold cracking, role of hydrogen and carbon equivalent, formation of acicular ferrite and effect on weld metal toughness.

UNIT III WELDING OF ALLOY STEELS 9

Welding of stainless steels, types of stainless steels, overview of joining ferritic and martensitic types, welding of austenitic stainless steels, hot cracking, sigma phase and chromium carbide formation, ways of overcoming these difficulties, welding of cast iron.

UNIT IV WELDING OF NON-FERROUS METALS 9

Welding of non-ferrous materials: Joining of aluminium, copper, nickel and titanium alloys, problems encountered and solutions.

UNIT V DEFECTS AND WELDABILITY 9

Defects in welded joints: Defects such as arc strike, porosity, undercut, slag entrapment and hot cracking, causes and remedies in each case. Joining of dissimilar materials, testing of weldability.

TOTAL : 45 PERIODS**OUTCOMES:**

- Ability to select and design welding materials.
- To understand the physical metallurgy behind welding
- Able to overcome on welding of steel and cast iron difficulties.
- Able to understand the problems in welding of non ferrous materials and its solutions
- Able to identify the defects in welded joints and its root causes.


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M. MOHAMMED SATHAK A.J. COLLEGE OF ENGINEERING
No.34.Rajiv Gandhi Salai (OMR), SIPCOT - IT Park
Siruseri, Chennai - 603 103.

TEXT BOOKS:

- Linnert. G. E. "Welding Metallurgy". Vol. 1 and 2. 4th Edition. A W S. USA, 1994.
- Lancaster J. F. "Metallurgy of Welding", 4th Londre: George Allen & Unwin.1987.

REFERENCES:

- "AWS Welding Hand book", 8th Edition, Vol-1, "Welding Technology", 1998.
- Henry Granjon "Fundamentals of Welding Metallurgy", Abington Pub, 1991
- Robert W. Messler "Principles of Welding: Processes, Physics, Chemistry, and Metallurgy", Wiley, 1999
- Saferian D. "The Metallurgy of Welding". Chapman and Hall, UK, 1985.
- Sindo Kuo "Welding Metallurgy", John Wiley & Sons, 2003



OBJECTIVE:

- To study and understand the various Nondestructive Evaluation and Testing methods, theory and their industrial applications.

UNIT I INTRODUCTION TO NDT

7

NDT Versus Mechanical testing, Need for Nondestructive testing Relative merits and limitations, Various physical characteristics of materials and their applications in NDT., Visual inspection – Unaided and aided- Standards

UNIT II SURFACE NDE METHODS

8

Liquid Penetrant Testing - Principles, types and properties of liquid penetrants, developers, advantages and limitations of various methods, Testing Procedure, Interpretation of results. Checking quality of consumables. Magnetic Particle Testing- Theory of magnetism, magnetization methods, pie gages, types of MPT equipment, Interpretation and evaluation of test indications, Principles and methods of demagnetization, Residual magnetism.

UNIT III THERMOGRAPHY AND EDDY CURRENT TESTING (ET)

10

Thermography- Principles, Contact and non contact inspection methods, Techniques for applying liquid crystals, Advantages and limitation - infrared radiation and infrared detectors, Instrumentations and techniques-pulsed thermography, lock in thermography, applications. Eddy Current Testing-Generation of eddy currents, Properties of eddy currents, Eddy current sensing elements, Probes, Instrumentation, reference blocks, Types of arrangement, Types of applications – coating thickness, defect detection, metal identification, advantages, Limitations, Interpretation/Evaluation.

UNIT IV ULTRASONIC TESTING (UT) AND ACOUSTIC EMISSION (AE)

10

Ultrasonic Testing-Principle, testing equipment, controls, probes -, straight beam and angle beam, T-R probes, construction, types, data representation, A-Scan, B-Scan, C-Scan – through transmission and pulse-echo techniques. Calibration blocks and reference blocks, Distance Amplitude Correction (DAC), Phased Array Ultrasound, Time of Flight Diffraction. Acoustic Emission Technique –Principle, AE parameters, instrumentation, Applications.

UNIT V RADIOGRAPHY (RT)

10

Principle and physics behind radiography - radiation interaction with matter, image formation, inverse square law, radiographic equivalence, radiographic attenuation, half value thickness, tenth value thickness, radioactivity, half life; Radiation sources – X-ray and gamma ray – equipment, construction, operation; Films –types, film speeds, film processing; Film characteristics – graininess, density, speed, contrast, characteristic curves, penetrameters, exposure charts; Radiography techniques –Digital radiography, computed radiography and computed tomography, Safety in radiography.

TOTAL: 45 PERIODS**OUTCOMES:**

- Able to understand the requirement of NDT in industries.
- Ability to test surface defects using liquid penetrant test.
- Ability to interpret eddy current test result.
- Able to describe ultrasonic and acoustic emission testing
- Able analyze the radiography testing result.

TEXT BOOKS:

1. Baldev Raj, T.Jayakumar, M.Thayasmathi "Practical Non-Destructive Testing", Narosa Publishing House, 2009.
2. Ravi Prakash, "Non-Destructive Testing Techniques", 1st Revised Edition, New Age International Publishers, 2010

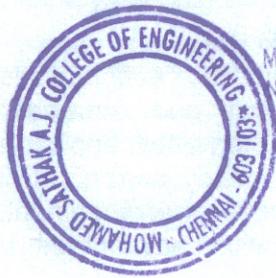


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PRINCIPAL
 MOHAMED SATHAK A.J. COLLEGE OF ENGINEERING
 No.34.Rajiv Gandhi Salai (OMR), SIPCOT - IT Park
 Siruseri, Chennai- 603 103.

REFERENCES:

1. ASM Metals Handbook, "Non-Destructive Evaluation and Quality Control", American Society of Metals, Metals Park, Ohio, USA, 200, Volume-17.
2. ASNT, American Society for Non Destructive Testing, Columbus, Ohio, NDT Handbook, Vol. 1, Leak Testing, Vol. 2, Liquid Penetrant Testing, Vol. 3, Infrared and Thermal Testing Vol. 4, Radiographic Testing, Vol. 5, Electromagnetic Testing, Vol. 6, Acoustic Emission Testing, Vol. 7, Ultrasonic Testing.
3. Charles, J. Hellier, " Handbook of nondestructive evaluation", McGraw Hill, New York 2001.
4. Paul E Mix, "Introduction to nondestructive testing: a training guide", 2nd Edition, Wiley, New Jersey, 2005
5. R. Halmshaw, "Introduction to the Non-Destructive Testing of Welded Joints" – 2nd Edition, Woodhead Publishing, 1997.

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MOHAMED SATHAK A.J. COLLEGE OF ENGINEERING
No.34.Rajiv Gandhi Salai (OMR), SIPCOT - IT Park
Siruseri, Chennai - 603 103.

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No.34.Rajiv Gandhi Salai (OMR), SIPCOT - IT Park
Siruseri, Chennai - 603 103.



ANALYSIS OF THE EFFECT OF ADDITION OF SILICON CARBIDE TO TITANIUM DIOXIDE FLUXES IN THE A-TIG WELDING OF 304 AND 316L STAINLESS STEELS

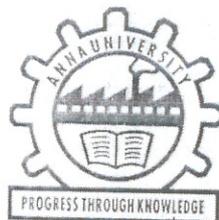
A PROJECT REPORT

Submitted by

PRASHANTH. P (311817145001)

VIJAYA VIGNESH. B (311817145002)

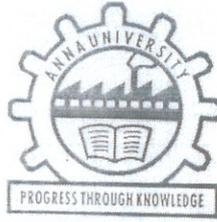
DEPARTMENT OF
MATERIAL SCIENCE AND ENGINEERING



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MOHAMED SATHAK A.J. COLLEGE OF ENGINEERING
No.34.Rajiv Gandhi Salai (OMR), SIPCOT - IT Park
Siruseri, Chennai, 603 103.

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CHENNAI 603 103

ANNA UNIVERSITY:: CHENNAI 600 025
APRIL 2021



ANNA UNIVERSITY: CHENNAI 600 025

BONAFIDE CERTIFICATE

Certified that this project report “ANALYSIS OF THE ADDITION OF SILICON CARBIDE TO TITANIUM DIOXIDE FLUXES IN THE A-TIG WELDING OF 304 AND 316L STAINLESS STEELS” is the bonafide work of “PRASHANTH. P (311817145001) and VIJAYA VIGNESH. B (311817145002) who carried out the project work under my supervision.

SIGNATURE
Mr.G.Ramesh, ME.,
HEAD OF THE DEPARTMENT
Material Science and Engineering,
Mohamed Sathak A J College of Engineering
Siruseri, OMR
Chennai - 603103



Project Viva-Voce held on : 06.08.2021

INTERNAL EXAMINER

SIGNATURE
MR.J.RAJESH, ME,
SUPERVISOR
Assistant Professor
Material Science and Engineering
Mohamed Sathak A J College of Engineering
Siruseri, OMR
Chennai – 603103

PRINCIPAL
MOHAMED SATHAK A J COLLEGE OF ENGINEERING
No.34.Rajiv Gandhi Salai (OMR), SIPCOT - IT Park
Siruseri, Chennai - 603 103.

EXTERNAL EXAMINER

ABSTRACT

Activated TIG welding is considered to be advantageous over conventional TIG welding owing to the fact that A-TIG welded weldments have increase weld penetration. This is attributed to the addition of a chemical substance known as 'activation flux'. The flux, in addition to increasing the penetration depth also confers some useful properties to the weld metal. These properties include improved strength, hardness and toughness. In this particular experimental analysis, the effect of the addition of silicon carbide powders to titania fluxes is analyzed. Hardness tests are performed on the weld metal to determine the influence of silicon carbide in improving the hardness of the weld metal. The quality of the weldments is also analyzed to determine whether there is any relation between the composition of the flux and the quality of the weld.



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MOHAMED SATHAK A.J. COLLEGE OF ENGINEERING
No.34.Rajiv Gandhi Salai (OMR), SIPCOT - IT Park,
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CHAPTER 6

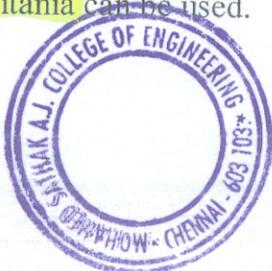
CONCLUSION

By performing visual inspection on the welded specimens we can assess the quality of TIG welds made in the presence and absence of flux. The no flux specimen was found to have the most visually appealing weld bead with no surface contaminants or slag. The specimens which were welded with the flux were all found to have a layer of slag over the weld bead and the welds looked less visually appealing. However, looking past the aesthetics of the weld bead, we can see that the welds made after the addition of flux have greatly improved penetration. The penetration depth seems to increase with the increase in the amount of Titania present in the flux.

By performing hardness tests on the weld bead we were able to determine whether the addition of flux had any impact on the hardness of the weld. The weld bead hardness of the no flux specimen was almost found to be that of the base metal. The hardness of the weld bead seems to improve with the addition of flux and was found to be highest for the 1:1 sample, which had the highest percentage of Silicon Carbide (50%). Therefore, by increasing the percentage of Silicon Carbide, we can improve the hardness of the weld.

Hence we can summarize the results of this experiment through the following points.

- Activated TIG welding was found to be an efficient alternative to TIG welding in situations where enhanced weld properties such as improved penetration and hardness are required.
- While the no flux specimen looked aesthetically pleasing, the specimens which were welded with the addition of the flux showed greater weld penetration.
- For applications where deeper penetration is required, higher percentages of Titania can be used.




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MOHAMED SATHAK A.J. COLLEGE OF ENGINEERING
No.34,Rajiv Gandhi Salai (OMR), SIPCOT - IT Park
Siruseri, Chennai - 603 103.

- For applications where **harder welds** are required, higher percentages of **Silicon Carbide** can be used.



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MOHAMED SATHAK A.J. COLLEGE OF ENGINEERING
No.34,Rajiv Gandhi Salai (OMR), SIPCOT - IT Park
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