MOHAMED SATHAK A J COLLEGE OF ENGINEERING

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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 (2017 - 2018)
1	ML6303 - Materials Structre and Properties
2	ML6505 - Welding Metallurgy
3	ML6502 - Material Aspects in Design
4	ML6503 - Characterization of Materials
5	ML6601 - Polymer Process Engineering
6	ML6603 - Composite Materials
7	ML6403 - Powder Metallurgy
8	ML6303 - Materials Structre and Properties
9	ML6501 - Theory and Applications of Metal Forming

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ML6505

WELDING METALLURGY

L T P C
3 0 0 3

OBJECTIVES

- 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, 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, differential processes and inspection techniques based on the materials and application and complexity of the component
- An ability to develop inspection procedure for the Weld ability

TEXT BOOKS:

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

REFERENCES:

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

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ML6502

MATERIAL ASPECTS IN DESIGN

L T P C
3 1 0 4

OBJECTIVES

- 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

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

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

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

UNIT IV MATERIALS PROPERTIES AND DESIGN 12

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 6

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

TOTAL (L:45+T:15): 60 PERIODS

OUTCOMES:

- Ability to use different design criteria and 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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OPTIMIZATION OF WELDING PARAMETERS ON MECHANICAL PROPERTIES OF DISSIMILAR WELDMENTS IN AUSTENITIC AND MARTENSITIC STAINLESS STEEL

Main project report

Submitted by

R.KABILAN (311814145003)

V.MARIAPPAN (311814145004)

In partial fulfilment for the award of the degree

Of

BACHELOR OF ENGINEERING

In

MATERIAL SCIENCE AND ENGINEERING

MOHAMMED SATHAK A.J COLLEGE OF ENGINEERING

ANNA UNIVERSITY: CHENNAI 600 025

APRIL 2018

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MOHAMMED SATHAK A.J COLLEGE OF ENGINEERING

BONAFIDE CERTIFICATE

It is certified that this project report titled **"OPTIMIZATION OF WELDING PARAMETERS ON MECHANICAL PROPERTIES OF DISSIMILAR WELDMENTS IN AUSTENITIC AND MARTENSITIC STAINLESS STEEL"** is a bonafide work of **R.KABILAN, V.MARIAPPAN** who carried out the research work under my supervision

HEAD OF THE DEPARTMENT	**SUPERVISOR**
23 20/4.	20-4-18.
Mr. R. MANIKANDAN,	**Mr.J. RAJESH,**
Head of the Department,	Assistant professor,
Material Science and Engineering,	Material Science and Engineering,
Mohamed Sathak A J College	Mohamed Sathak A J College
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Date of Viva Voice: 20.04.2018

23 20/4.

Internal Examiner.

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CHAPTER 6

CONCLUSION

6.1 Conclusion

- The best result is obtained for the sample no.6 (Corresponding to current (I) 161A, Welding Speed 200Mm/min, Filler Material 316L and nozzle to plate distance 4mm). The worst result in tensile testing has been obtained for the sample no. 4(corresponding to current 220 A, Welding Speed 200Mm/min,Filler Material 316L and nozzle to plate distance 4mm).
- And Dissimilar Weldments of Hardness values are also determined at the welded zone and the HAZ areas.
- Taguchi experimental design method is very useful to analyse the welding of Martensitic and Austenitic stainless steels in GTAW welding operation.

ML6503 CHARACTERIZATION OF MATERIALS

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OBJECTIVES:

- 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 8

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

UNIT II X-RAY DIFFRACTION TECHNIQUES 10

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-Scherer cameras, Seeman - Bohlin focusing cameras. Diffractometer – General feature and optics, proportional, Scintillating and Geiger counters.

UNIT III ANALYSIS OF X-RAY DIFFRACTION 9

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-

UNIT IV ELECTRON MICROSCOPY 9

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).

UNIT V CHEMICAL AND ADVANCED THERMAL ANALYSIS 9

Surface chemical composition- Mass spectroscopy and X-ray emission spectroscopy (Principle and limitations) - Energy Dispersive Spectroscopy- Wave Dispersive Spectroscopy- Quadrapole mass spectrometer. Electron spectroscopy for chemical analysis (ESCA), Ultraviolet Photo Electron 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

TOTAL: 45 PERIODS

OUTCOMES:

- Ability to perform analysis of X ray diffraction and electon microscope images and the chemical and thermal analysis datas.

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. Thomas G., "Transmission electron microscopy of metals", John Wiley, 1996.

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ML6601 **POLYMER PROCESS ENGINEERING** **L T P C**
3 0 0 3

OBJECTIVES:

- The subject exposes students to the basics of polymer, polymerisation, condensation, their properties and overview of manufacturing.

UNIT I POLYMERIZATION 9

Fundamentals of polymers – monomers – functionality - Classification – characterization –. Types of Polymerization: cationic polymerization – anionic polymerization – coordination polymerization – free radical polymerization. Copolymerization concepts - Simple condensation reactions – Extension of condensation reactions to polymer synthesis – functional group reactivity. Polycondensation – kinetics of polycondensation - Carother's equation – Linear polymers by polycondensation – Interfacial polymerization – crosslinked polymers by condensation – gel point.

UNIT II MOLECULAR WEIGHTS OF POLYMERS 9

Number average and weight average molecular weights – Degree of polymerization – molecular weight distribution – Polydispersity – Molecular weight determination- Different methods – Gel Permeation Chromatography

UNIT III TRANSITIONS IN POLYMERS 9

First and second order transitions – Glass transition, Tg – multiple transitions in polymers – experimental study – significance of transition temperatures. Crystallinity in polymers – effect of crystallization – factors affecting crystallization, crystal nucleation and growth – Relationship between Tg and Tm – Structure–Property relationship.

UNIT IV SOLUTION PROPERTIES OF POLYMERS 9

Size and shape of the macromolecules – Solubility parameter – polymer/solvent interaction parameter – temperature – size and molecular weight. Solution properties of polymers. Importance of Rheology – Newtonian and Non-Newtonian flow behaviour – Polymer melts Rheology.

UNIT V POLYMER PROCESSING 9

Overview of Features of Single screw extruder –Tubular blown film process - Coextrusion.- Injection Moulding systems – Compression & Transfer Moulding - Blow Moulding – Rotational Moulding – Thermoforming – Vacuum forming -Calendering process – Fiber Spinning process –Structural Foam Moulding – Sandwich Moulding.Processing for Thermosets- Reaction Injection Moulding & Reinforced Reaction Injection Moulding.

TOTAL: 45 PERIODS

OUTCOMES:

- Use of techniques for polymer processing.
- Ability to develop structure – property relationship in polymer.

TEXT BOOKS:

1. G. Griskey, "Polymer Process Engineering", Chapman & Hall, New York , 1995.
2. D. H. Morton Jones, "Polymer Processing", Chapman & Hall, New York, 1995.

REFERENCES:

1. Billmayer Jr. and Fred. W., "Textbook of Polymer Science", WileyTappers, 1965.
2. David, J. W., "Polymer Science and Engineering", Prentice Hall,1971.
3. Schmidt, A. K. and Marlies, G. A., "High Polymers - Theory and Practice", McGraw Hill,1948.
4. McKelvey, J. M., "Polymer Processing", John Wiley, 1962.
5. Rodriguez, F., Cohen.C., Oberic.K and Arches, L.A., Principles of Polymer Systems, 5th Edition, Taylor and Francis, 2003.
6. Crawford R.J, "Plastics Engineering" 3rd Edition, Pergamon Press, London 1987

ML6603 **COMPOSITE MATERIALS** **L T P C**
3 0 0 3

OBJECTIVES:

- 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, automotiveindustries

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 (Qij), 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:

- Use of different material to design composites
- Use of different techniques to process different types of composites and know the limitations of each process
- Use of Mathematical techniques to predict the macroscopic properties of different Laminates

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ML6403 **POWDER METALLURGY** **L T P C**
3 0 0 3

OBJECTIVES:

- 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 atomisation 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 8

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 10

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:

- Upon completion of this course, the students can able to apply the student will have knowledge about powder metallurgical material and their fabrication processes.

TEXT BOOKS:

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

REFERENCES:

1. Sinha A. K., "Powder Metallurgy", Dhanpat Rai & Sons. New Delhi, 1982
2. R.M. German, "Powder Metallurgy and Particulate Materials Processing", Metal Powder

SYNTHESIS AND CHARACTERISATION OF FERROELECTRIC POLYMER COMPOSITE

Main project report

Submitted by

V.SURENTHAR(311814145005)

M.S.THEEPANANTH(311814145007)

In partial fulfilment for the award of the degree

Of

BACHELOR OF ENGINEERING

In

MATERIAL SCIENCE AND ENGINEERING

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APRIL 2018

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MOHAMED SATHAK A.J. COLLEGE OF ENGINEERING, CHENNAI

BONAFIDE CERTIFICATE

It is certified that this project report titled **"SYNTHESIS AND CHARACTERISATION OF FERROELECTRIC POLYMER COMPOSITE"** is a bonafide work of **V.SURENTHAR, M.S.THEEPANANTH** who carried out the research work under my supervision and guidance. Certified further, that to the best of my knowledge, the work reported herein does not form part of any other thesis or dissertation on the basis of which a degree or an award was conferred on an earlier occasion on this or any other candidate.

19/04/18

UNDER THE GUIDANCE OF

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Assistant Professor
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HEAD OF THE DEPARTMENT

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Date of Viva Voice: 20.04.2018

20/4.

Internal Examiner

B. Anand Ronald
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External Examiner

Dr. B. ANAND RONALD

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CHAPTER-VI

CONCLUSION

In the present work, we have prepared and studied the complex perovskite ceramics oxides having the general chemical formula $(Na_2CO_3)_{x1}.(BiO_2)_{x2}.(KOH)_{x3}.(TiO_2)_{x4}$, and the composite of PVDF and NBT. The structural (XRD), microstructural properties of the proposed compounds have been extensively studied.

Based on our results following conclusions have been drawn.

- NBT and K-modified NBT were prepared by high temperature solid-state route and the polymer ceramic composite was prepared by cold press technique.
- The formation of the ceramic in cubic structures and polymer composite were confirmed by XRD analysis.
- Studies of FTIR spectroscopy confirm formation of cubic structure of the ferroelectric ceramics and describes the vibrational study of the sample.

ML6303 **MATERIALS STRUCTURE AND PROPERTIES** **L T P C**
3 0 0 3

OBJECTIVES:

- 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 10

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 10

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 Titanium alloys, Nickel alloys, Copper alloys, Magnesium alloys and Aluminium alloys.

UNIT IV ENGINEERING CERAMICS 8

Types - Crystal Structures - Silicate Ceramics - Glasses – Glass Ceramics – Advanced ceramics- Functional properties and applications of ceramic materials –SiC, Al_2O_3, Si_3N_4– Super hard materials - Tungsten carbide and Boron nitrides – Graphene. – Applications to bio engineering

UNIT V COMMODITY AND ENGINEERING POLYMERS 8

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.

TOTAL: 45 PERIODS

OUTCOMES:

- Recognise basic nomenclature, basic microstructure, associate terms with the appropriate structure / phenomena and be able to differentiate between related structure / phenomena.
- Perform simple calculations to qualify materials properties and microstructural characteristics.
- Recognise the effect of composition and microstructure on material properties.
- Ability to perform phase equilibrium calculation and construct phase diagram.
- Select suitable ferrous and non-ferrous materials for Engineering application.

TEXT BOOKS:

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

REFERENCES:

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

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ML6501 THEORY AND APPLICATIONS OF METAL FORMING

L	T	P	C
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OBJECTIVES:

- 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 road, 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 make use of mechanical and thermodynamics principle of plastic deformation to form the components using different techniques.

TEXT BOOKS:

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

REFERENCES:

1. Kurt Lange, “Handbook of Metal Forming”, Society of Manufacturing Engineers, Michigan, USA, 1998.
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EFFECT OF DEEP COLD ROLLING PROCESS ON ALUMINIUM 6061-T6

A PROJECT REPORT

Submitted by

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in partial fulfillment for the award of the degree

of

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BONAFIDE CERTIFICATE

This it to Certified that this project report **"EFFECT OF DEEP COLD ROLLING PROCESS ON ALUMINIUM 6061-T6"** is the bonafide work of **R.THOMASRAJ AN,** who carried out the project work under my supervision and guidance.

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CHAPTER 6

CONCLUSION

The deep cold rolling process was carried out on aluminum 6061-T6 alloy by using simple and inexpensive DCR setup. The three important process parameters such as Ball diameter, Rotational speed and No of passes were taken as input parameter; micro-hardness, microstructure and tensile testing are considered as measures of process performance. The following conclusions were drawn from the experiments.

i. The optimal process parameter was identification as 18mm ball diameter, 900 rpm rotational, no of passes 5.

ii. It is also seen that low rotational speed produces a continuous chip formation and tiny chips during DCR process.

iii. The ball diameter and rotational speed plays an important role in enhancing the hardness of the treated samples.

iv. Using DCR process surface hardness of Al alloy has been increased from 60 HRB to 64 HRB.

v. From the microstructure, the grains are rearranged.

vi. Form tensile test of both specimen, 18 mm ball diameter,900rpm rotational speed, no of passes 5 has higher ultimate stress.