



**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

**BE-MATERIAL SCIENCE AND ENGINEERING**

S.No	Name of the course that include experiential learning through Project work/ Internship (2018 - 2019)
1	ML6505 - Welding Metallurgy
2	ML6503 - Characterization of Materials
3	ML6402 - Non-Ferrous Metallurgy
4	ML6303 - Materials Structures and Properties
5	ML6403 - Powder Metallurgy
6	ML6603 - Composite Materials
7	ML6601 - Polymer Process Engineering

**PRINCIPAL**

**MOHAMED SATHAK A.J.COLLEGE OF ENGINEERING**  
34, Rajiv Gandhi Road (OMR), Siruseri, IT Park

**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. 4<sup>th</sup> 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", 8<sup>th</sup> 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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**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:**

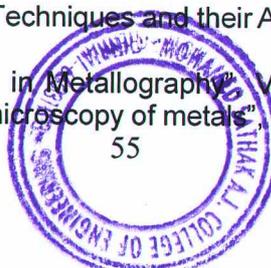
- Ability to perform analysis of X ray diffraction and electron microscope images and the chemical and thermal analysis datas.

**TEXT BOOKS:**

1. Cullity, B. D., " Elements of X-ray diffraction", 3rd Edition, Addison-Wesley Company Inc., New York, 2000
2. Phillips VA, "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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**OBJECTIVES:**

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

**UNIT I COPPER AND COPPER ALLOYS**

10

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**

8

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

- Classify types of materials based on nonferrous metals.
- Describe preparation and heat treatment and processing of nonferrous metals.
- Enumerate (or) select suitable application of alloys of non-ferrous metals.

**TEXT BOOKS:**

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

**REFERENCES:**

- 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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**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<sub>2</sub>O<sub>3</sub>, Si<sub>3</sub>N<sub>4</sub>– 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", 5th Edition, Thomson Learning, First Indian Reprint, 2007.
4. F. N. Billmeyer, "Text 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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**INVESTIGATIONS ON FSW WELDING OF DISSIMILAR  
MAGNESIUM ALLOYS**

**A FINAL YEAR PROJECT REPORT**

Submitted by

**MK REVATHI (311815145004)**

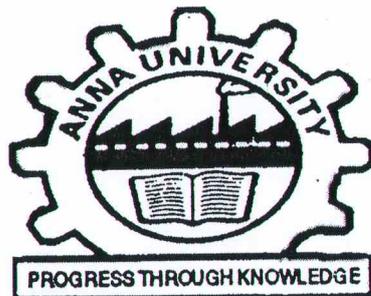
*in partial fulfillment of the award of the degree*

*of*

**BACHELOR OF ENGINEERING**

**IN**

**MATERIAL SCIENCE AND ENGINEERING**



**MOHAMED SATHAK A.J. COLLEGE OF ENGINEERING**

**ANNA UNIVERSITY: CHENNAI 600 025**

**APRIL 2019**



  
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**ANNA UNIVERSITY, CHENNAI – 603103**

**BONAFIDE CERTIFICATE**

It certified that the project report titled “**INVESTIGATIONS ON FSW WELDING OF DISSIMILAR MAGNESIUM ALLOYS**” is the bonafide training work of “**MK REVATHI (311815145004)**” who carried out the work under my supervision and guidance. Certificate 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.

**UNDER THE GUIDANCE OF**

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Assistant Professor

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**HEAD OF THE DEPARTMENT**

**Mr. R. MANIKANDAN**

Assistant Professor

Department of MSE

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Date of Viva Voce: 04/04/2019

**INTERNAL EXAMINER**

**EXTERNAL EXAMINER**



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## CHAPTER 6

### SUMMARY AND CONCLUSIONS

#### 6.1 SUMMARY

In this Chapter, the effect of FSW process parameters such as maxmanium rotation speed of tool, square tool ,axial force and on time on tensile properties of AZ31B magnesium alloy joints have been analyzed. From this investigation, following important conclusions are derived. The relationship can be effectively used to predict the tensile strength of FSW welded joints at 95% confidence level. Magnesium and its alloys have attracted great attention in industry application and academic research due to their properties such as light weight, high specific strength, stiffness, machinability and recyclability. The extruded plates of AZ31B and AZ91 magnesium alloy were machined to the required dimensions (300 mm x 150 mm x 6 mm). The smooth (unnotched) tensile specimens were prepared to evaluate yield strength, tensile strength, elongan and reduction in cross sectional area. Microstructural examination was carried out using an optical microscope.

#### 6.2 CONCLUSIONS

With the reference with their tensile, hardness tests the parameters of the sample three is suggested for welding dissimilar Mg alloys. Also the micro structure , macro structure , and SEM analysis also shows that the sample three has the best structure and fusion of nuddget and parent material , so the parameter for the sample three is suggested for further welding process of the dissimilar alloys. The present investigation on FSW welding of AZ31B magnesium alloy alloys has given some important information related to the effect of welding parameters on mechanical and metallurgical properties of the joints. However, there are few other aspects need to be investigated to understand the process effectively. In this regard, following suggestions are to be considered for further research on this topic.



(i) FSW welding windows are to be developed by incorporating welding parameters

different grades of magnesium alloys to select the feasible working range of the parameters to fabricate defect-free welds.

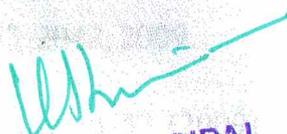
(ii) Post weld heat treatment of FSW welded magnesium alloy joints are to be established.

(iii) The relationship between yield strength of base materials and FSW welding process parameters is to be established for different tool profiles.

(iv) More importantly, the available literature on fatigue and fracture toughness behavior of FSW welded is very few.

Hence, the future research will be focused on the evaluation of fatigue and fracture toughness properties of FSW welded magnesium alloy joints.



  
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**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



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**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, 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 (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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**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, T<sub>g</sub> – 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 T<sub>g</sub> and T<sub>m</sub> – 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:**

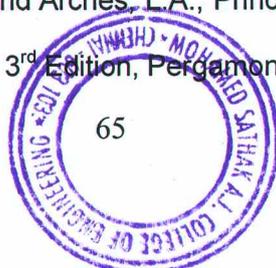
- Use of techniques for polymer processing.
- Ability to develop structure – property relationship in polymer.

**TEXT BOOKS:**

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

**REFERENCES:**

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



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**SYNTHESIS AND INVESTIGATION OF  
CORN STARCH BIOPOLYMER  
REINFORCED WITH RICE HUSK**

**A PROJECT REPORT**

*Submitted by*

**SHREENIDHI A**

*in partial fulfilment for the award of the degree*

*of*

**BACHELOR OF ENGINEERING**

*in*

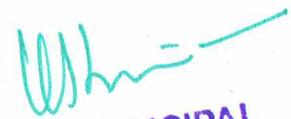
**MATERIAL SCIENCE AND ENGINEERING**

**MOHAMED SATHAK A.J COLLEGE OF ENGINEERING**



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**APRIL 2019**



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**BONAFIDE CERTIFICATE**

Certified that this project report **“SYNTHESIS AND INVESTIGATION OF CORN STARCH BIOPOLYMER REINFORCED WITH RICE HUSK”** is the bonafide work of SHREENIDHI A(311815145005) who carried out the project work under my supervision.

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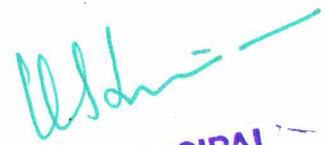
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## CHAPTER 6

### RESULT AND CONCLUSION

Generally, bio plastics are known to possess poor mechanical properties. Thus the basic corn starch was chosen as raw material, gelatinized and reinforced with rice husk to enhance its strength and durability. The method for production of biopolymer bag is blow extrusion which basically imparts strength to the material. As expected, the impact strength, thermal properties of the reinforced biopolymer are found to be a little high in comparison with the initial one. However, they tend to gradually lose the properties as they age.



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