



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 (2019 - 2020)
1	ML6303 - Materials Structures and Properties
2	CE6306 - Strength of Materials
3	ML6603 - Composite Materials
4	ML6402 - Non-Ferrous Metallurgy
5	ML6602 - Creep and Fatigue Behaviour of Materials
6	ML6010 - Fuels, Furnaces and Refractories
7	ML6506 - Corrosion and Surface Engineering
8	ML6403 - Powder Metallurgy
9	ML6503 - Characterization of Materials
10	ML6504 - Heat Treatment of Metals and Alloys
11	ML6505 - Welding Metallurgy

PRINCIPAL

MOHAMED SATHAK A.J. COLLEGE OF ENGINEERING
34, Rajiv Gandhi Road (OMR), Siruseri, IT Park
Chennai-603 103.

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 Heterogeneous 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, Al₂O₃, Si₃N₄– 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:**

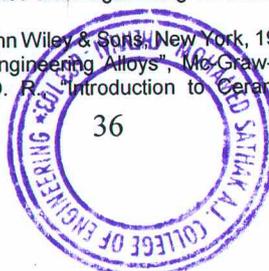
- Recognise basic nomenclature, basic microstructure, associate terms with the appropriate structure / phenomena and be able to differentiate between related structure / phenomena.
- Perform simple calculations to qualify materials properties and microstructural characteristics.
- Recognise the effect 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:

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

REFERENCES:

- 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.
- Donald R. Askeland, Pradeep P. Phule, "The Science and Engineering of Materials", 5th Edition, Thomson Learning, First Indian Reprint, 2007.
- F. N. Billmeyer, "Test Book of polymer science", John Wiley & Sons, New York, 1994.
- William F. Smith, "Structure and Properties of Engineering Alloys", Mc-Graw-Hill Inc., U.S.A 2nd edition, 1993.
- 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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OBJECTIVES:

To understand the stresses developed in bars, compounds bars, beams, shafts, cylinders and spheres.

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 (L:45+T:15): 60 PERIODS**OUTCOMES:**

- Upon completion of this course, the students can able to apply mathematical knowledge to calculate the deformation behavior of simple structures.
- Critically analyse problem and solve the problems related to mechanical elements and analyse the deformation behavior for different types of loads.

TEXT BOOKS:

1. Bansal, R.K., "Strength of Materials", Laxmi Publications (P) Ltd., 2007
2. Jindal U.C., "Strength of Materials", Asian Books Pvt. Ltd., New Delhi, 2007

REFERENCES:

1. Egor. P. Popov "Engineering Mechanics of Solids" Prentice Hall of India, New Delhi, 2001
2. Subramanian R., "Strength of Materials", Oxford University Press, Oxford Higher Education Series, 2007.
3. Hibbeler, R.C., "Mechanics of Materials", Pearson Education, Low Price Edition, 2007
4. Ferdinand P. Beer, Russell Johnson, J.r. and John J. Dewole "Mechanics of Materials", Tata McGraw Hill Publishing 'co. Ltd., New Delhi, 2005



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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



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.




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**MICROSTRUCTURE AND MECHANICAL PROPERTIES OF
ALUMINIUM METAL MATRIX COMPOSITE REINFORCED WITH
SiC AND B₄C**

Project Work

Submitted by

M.AKASH

(311816145001)

In partial fulfilment for the award of the degree

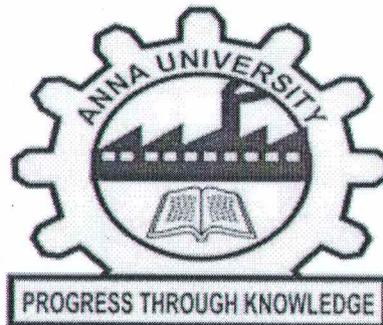
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BACHELOR OF ENGINEERING

In

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MOHAMED SATHAK A.J COLLEGE OF ENGINEERING



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ANNA UNIVERSITY, CHENNAI – 600025

APRIL 2020



MOHAMED SATHAK A.J COLLEGE OF ENGINEERING
ANNA UNIVERSITY, CHENNAI – 603103

BONAFIDE CERTIFICATE

It is certified that this project report titled “**MICROSTRUCTURE AND MECHANICAL PROPERTIES OF ALUMINIUM METAL MATRIX COMPOSITE REINFORCED WITH SiC AND B₄C**” is a bonafide work of **M.AKASH (311816145001)** who carried out the research under my supervision.



UNDER THE GUIDENCE OF

Ms. P.Jeyabharathi, M.E,
Asst. Professor,
Material Science & Engineering,
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HEAD OF THE DEPARTMENT

Dr. R. Senthil Kumar, M.E., PhD.,
Head of Department,
Material Science & Engineering,
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Date of Viva voce: 22.09.2020



Internal Examiner



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External Examiner

CHAPTER-6

CONCLUSION

In summary, Aluminium 6061 reinforced by 3% and 6% silicon carbide and boron carbide were fabricated by bottom pour type stir casting furnace process, from the experimental results the following conclusions were obtained.

- The microstructure consists Dendrite of aluminium solid solution show segregation. Other constituents are inter dendritic network of silicon (dark gray) rounded Cupper Aluminate and Manganese Phosphate.
- The microstructure consists Dendrite of aluminium solid solution show segregation. Other constituents are inter dentritic network of silicon.
- The hardness of the aluminium composite increased by increasing the volume fraction of the reinforcements.
- Uniform distribution of the silicon carbide and boron carbide particles has been observed.




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**OPTIMIZING THE SONICATION PARAMETER TO ATTAIN HIGH
YEILD OF GRAPHENE**

A Project Work

Submitted by

R.UDHAYA RAGHAV

(311816145005)

In partial fulfilment for the award of the degree

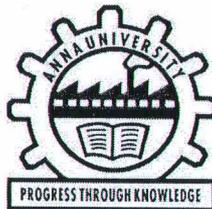
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MOHAMED SATHAK A.J COLLEGE OF ENGINEERING



ANNA UNIVERSITY, CHENNAI – 600025

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BONAFIDE CERTIFICATE

It is certified that this project report titled “**OPTIMIZING THE SONICATION PARAMETER TO ATTAIN HIGH YEILD OF GRAPHENE**” is a bonafide work of **R. UDHAYA RAGHAV (311816145005)** who carried out the research under my supervision.



UNDER THE GUIDENCE OF

Mr. R PRABU,
Asst. Professor,
Material Science & Engineering,
MSA.J College of Engineering,
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HEAD OF THE DEPARTMENT

Dr. R. Senthil Kumar, M.E., PhD.,
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Date of Viva voce:22.09.2020



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External Examiner



CHAPTER 5

CONCLUSION

The principle idea of this project is to “identify an industrial level graphene production process parameter”. Graphene is synthesized via liquid phase exfoliation of probe sonication method. We extracted samples at different interval of time. Those sample where characterized in UV-Vis-Spectroscopy, which tells us that higher energy and more time exfoliation of graphene is linearly increasing.

The synthesized graphene where characterized by TEM, XRD and UV-Vis-Spectroscopy. The morphology is analysed by TEM. The structural characteristic, where analysed by XRD. In UV-Vis-Spectroscopy, we further conform the graphene by absorption peak.




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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

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:

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

REFERENCES:

1. Clark and Varney, "Physical Metallurgy for Engineers", Affiliated East West Press, New Delhi, 1987
2. William F. Smith, "Structure and Properties of Engineering Alloys", McGraw Hill, USA, 1993.
3. W.H. Dennis, "Metallurgy of the Nonferrous Metals", Sir Isaac Pitman and Sons, London, 1967.



OBJECTIVES:

- The useful life of components is often limited by the fracture, fatigue and creep properties of the materials used. The students study the fundamental processes leading to failure of technical components.

UNIT I INTRODUCTION

9

Strength of perfect crystal - Lattice resistance to dislocation movement – Elastic properties of dislocation – Dislocation multiplication – Slip and twinning in crystalline solid.

UNIT II HIGH – TEMPERATURE DEFORMATION RESPONSE

9

Creep Of Solids – Temperature stress – Strain rate relation- Deformation mechanism –Super plasticity- deformation mechanism maps - LM parameter— Extrapolation procedure for creep rupture data – materials for elevated temperature rules.

UNIT III CYCLIC STRESS AND STRAIN FATIGUE

9

Macrofractography fatigue failures - cyclic stress and strain controlled fatigue - Fatigue life estimation for notched components – Crack initiation mechanisms-factors affecting fatigue-size, temp, surface condition-microstructure-soderburg and goodman equation

UNIT IV FATIGUE CRACK PROPAGATION

9

Stress and crack lengths correlations with FCP – Fracture modes in Fatigue – Microscopic fracture mechanisms – Crack growth behavior at Δk extremes – Influences – Micro structural aspects of FCP in metal alloys-paris equation-fatigue life prediction

UNIT V ANALYSIS OF ENGINEERING FAILURES

9

Typical defects – Microscopic surface examination – metallographic and fractographic examination – Component failure analysis – Fracture surface preservation – Cleaning and replication techniques and image interpretation.

TOTAL: 45 PERIODS**OUTCOMES:**

- Identify the fracture due to creep and fatigue
- Use of suitable mathematical equation to predict ability the crack growth rate
- Ability to perform failure analysis

TEXT BOOKS:

1. Richard. W. Hertzberg, "Deformation and Fracture Mechanism of Engineering Materials", 4th Edition, John Wiley and Sons, 1996.
2. Anderson, T. L., " Fracture Mechanics: Fundamentals and Applications", 2nd Edition, CRC Press, 1995.

REFERENCES:

1. Courtney, T. H., " Mechanical Behaviour of Materials", McGraw-Hill, 1990
2. Jones, D. R. H, " Engineering Materials 3, Materials Failure Analysis- Case Studies and Design Implications", Pergamon, 1993.
3. Hull & Bacon "Introduction to Dislocations", 3rd Edition, Pergamon Press, 1984.
4. Frost & Ashby, "Deformation - Mechanism Maps", 1st Edition, Pergamon Press, 1982.
5. Suresh, S., " Fatigue of Materials", 2nd Edition, Cambridge University Press, 1998.
6. Cadek, J., " Creep in Metallic Materials", Elsevier, 1988.
7. Ashok Saxena, " Nonlinear Fracture Mechanics for Engineers", CRC Press, 1998.


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OBJECTIVES

- Knowledge on different source of fuel
- Knowledge about different types of furnaces
- Different types of refractories used for furnaces application
- Knowledge on issues in environment

UNIT I FUNDAMENTALS

9

Thermal Energy, conversion. Heat Transfer, conduction, radiation, convection. Thermoelectric effect. thermocouples, Peltier effect. Temperature measurement.

UNIT II FUELS

9

Thermal energy conversion. Fossil fuels, availability, deposits, calorific content. Nuclear Fuels, Solar and geothermal heating.

UNIT III FURNACES

9

Firing, electric resistance, Radiation, Induction. Temperature control-PID. Multi zone furnaces. Batch and tunnel furnaces.

UNIT IV REFRACTORIES

12

Bricks, Monolithic and castables. Manufacturing and properties of refractories. Refractories for iron and steel industry-Coke oven, blast furnace, LD converter, continuous casting, EAF and functional refractories. Refractories for Cement and non ferrous metallurgical industries.

UNIT V ADVANCED ISSUES

6

Energy and environment, environmental optimization, Recycling of thermal energy. Emissions control.

TOTAL:45 PERIODS**OUTCOMES**

- Use of different fuels for energy generation system
- Use of refractories in furnance
- Ability to discuss the issues in environmental.

TEXT BOOKS:

1. Gupta.O.P., "Elements of Fuels, Furnaces and Refractories",4th Edition, Khanna publishers,New Delhi, 2000.
2. Nandi D.N. "Handbook on Refractories" Tata Mcgraw – Hill publishing Co New Delhi 1991

REFERENCES

1. Chester, J.H. "Refractories, Production and Properties", Iron and Steel Institute, London, 1973.
2. Robert E.Fisher, "Advances in Refractory Technology", Ceramic Transaction, Vol.4, 1990, American Ceramic Society, Westerville,Ohio, USA.
3. Suryanarayana A.V.K, "Fuels, Furnaces, Refractories and Pyrometry", BS Publications, 2005.
4. Robert D.Reed, "Furnace Operation", Gulf Publishing Co., Paris, 1991.
5. Shaha A.K, "Combustion Engineering and Fuel Technology", Oxford & IBH Publishing Co., New Delhi, 1974.
6. Daniel Rhodes, Kilns: Design, "Construction and Operation", Chilton Book Co., Pennsylvania, 1974
7. Samir Sarkar, "Fuels and Combustion", 2nd Edition, Orient Longman, Bombay, 1990



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OBJECTIVES:

- 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 oxidising 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**

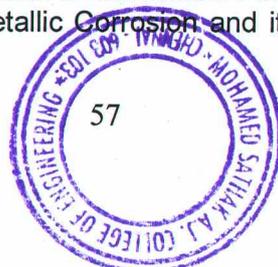
- Ability to control the factors affects the metal corrosion.
- Ability to measure the corrosion rate.
- Ability to prevent corrosion by coatings and inhibitors, etc.

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.. Engelwood Cliff., New Jersey. USA 1988

REFERENCES:

1. Denny A. Jones,"Principles and Prevention of Corrosion" 2nd Edition, Prentice Hall of India,1996.
2. Uhlig. H.H. "Corrosion and Corrosion Control". John Wiley & Sons. New York. USA. 1985.
3. ASM Metals Handbook. Vol.5. "Surface Engineering". ASM Metals Park. Ohio. USA. 1994.
4. ASM Metals Handbook. Vol.I3,"Corrosion". ASM Metals Park. Ohio. USA. 1994
5. Raj Narayan. "An Introduction to Metallic Corrosion and its prevention", Oxford & 1BH, New Delhi,1983.



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**FAILURE ANALYSIS OF STEEL AND TITANIUM TUBES FROM
FOSSIL FUEL POWER PLANT**

Project Work

Submitted by

H.ASHRAF HUSSAIN

(311816145002)

In partial fulfilment for the award of the degree

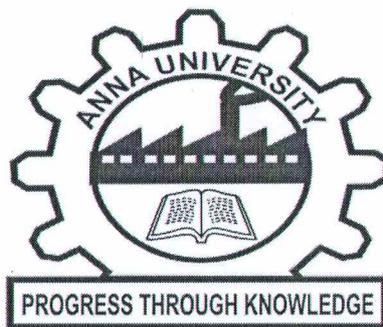
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In

MATERIAL SCIENCE AND ENGINEERING

MOHAMED SATHAK A J COLLEGE OF ENGINEERING



ANNA UNIVERSITY, CHENNAI – 600025

APRIL 2020




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BONAFIDE CERTIFICATE

It is certified that this project report titled “**FAILURE ANALYSIS OF STEEL AND TITANIUM TUBES FROM FOSSIL FUEL POWER PLANT**” is a bonafide work of **H.ASHRAF HUSSAIN (311816145002)** who carried out the research under my supervision.



UNDER THE GUIDENCE OF

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CHAPTER V

CONCLUSION

Steel tube :

1. Based on the evidences obtained in the present investigation, it is concluded that tube was failed mainly due **ash corrosion/hot salt corrosion** on the fireside surface of the tube.
2. Stagnated regions created near to tube supports, responsible for accumulation of ash deposits and enhance the degradation of the tube.
3. Chemical composition of the tube material is alright with the standard specification i.e SA 213 Gr T11.
4. **Ash corrosion/ hot salt corrosion** on fireside surface of the tube is mainly due to the usage of bad quality coal as feed material.

Titanium tube:

1. Sea water inside and steam outside the tubes and operating parameter including temperature , pressure and flow velocity will not cause corrosive wear to the **titanium tube**.
2. According to the results from chemical composition, metallographic structure, microscopic morphology and mechanical properties of **titanium tubes** all meet international standards. Hence the material is qualified.
3. Internal wall of some boring was poorly processed with asperities and non-uniform innerdiameter which led to eccentric contact wear under the action of vibration.
4. the sagging iron oxide creayed by **galvanic corrosion** of support plate which made internal wall of the boring unsmooth and the position of corrosion products changed because of vibration that caused three boidy

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contact wear.

5. During inspection or repair , some foreign particle deposited into the internal boring by airflow, resulting in the three body abrasive wear .

In conclusion , the cause of failure are maily the combination of eccentric contact wear and three body contact wear due to processing defect of internal boring , corrosion product deposit and sagging and foreign particles.




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




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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-Scherrer 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:**

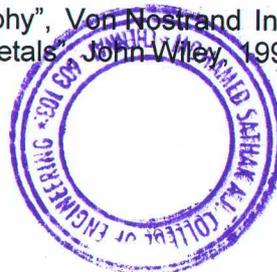
- Ability to perform analysis of X ray diffraction and electron microscope images and the chemical and thermal analysis datas.

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.



**SYNTHESIS AND CHARACTERIZATION OF
LANTHANUM MAGNESIUM
HEXAALUMINATE FOR HIGH TEMPERATURE
APPLICATIONS**

A PROJECT REPORT

Submitted by

JAKUL CHANTHINI M.S.R

(311816145003)

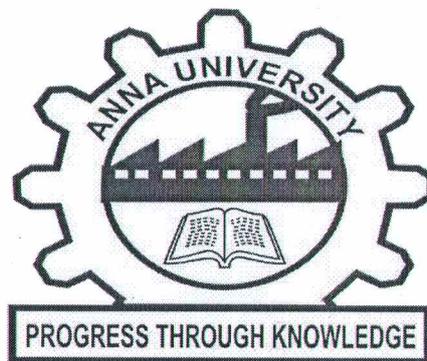
In partial fulfillment for the award of the degree

Of

BACHELOR OF ENGINEERING

In

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Handwritten signature in green ink.

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BONAFIDE CERTIFICATE

It is certified that this project report **“SYNTHESIS AND CHARACTERIZATION OF LANTHANUM MAGNESIUM HEXAALUMINATE FOR HIGH TEMPERATURE APPLICATIONS”** is a bonafide work of **JAKUL CHANTHINI M.S.R (311816145003)** who carried out the Project under my supervision.



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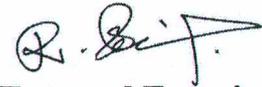
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CHAPTER 5

CONCLUSIONS

TBC is a very useful technique and has a wide application in industries as well as in automobile manufacturing.

Thermal barrier coating is to improve product and performance, reduce maintenance time, cost, save energy and reduce production cost.

The platelet structure along with small amounts of orthorhombic basic magnetoplumbite structure are visible at the highest sintering temperature.

At 1350 deg temperature formation of $\text{LaMgAl}_{11}\text{O}_{19}$ with small trace amounts of Alpha phase Al_2O_3 and MgAl_2O_4 phase is observed




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OBJECTIVES:

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

10

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

UNIT II HEAT TREATMENT PROCESSES

9

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

UNIT III CASE HARDENING

9

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

UNIT IV FURNACES, ATMOSPHERE AND PROCESS CONTROL

8

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, cryo-chamber, cryo-treatment of steels, sealed quenched furnace, plasma equipment- Elements of Process control systems-PLC ,PID controllers and continuous monitoring systems.

UNIT V HEAT TREATMENT OF SPECIFIC ALLOYS

9

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.

TOTAL: 45 PERIODS

OUTCOMES:

- Ability to select and perform heat treatment for different ferrous and non-ferrous alloy.
- Ability to identify the microstructure and analyse different phase after heat treatment.

TEXT BOOKS:

1. Sydney H. Avner, "Introduction to Physical Metallurgy", Tata McGraw Hill, New Delhi, 1997.
2. Rajan, T. V., Sharma, C. P., Ashok Sharma., "Heat Treatment Principles And Techniques" Prentice-Hall of India Pvt. Ltd., New Delhi, 2002.

REFERENCES:

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



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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:

- 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:

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



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**INVESTIGATION OF MICROSTRUCTURE AND
MECHANICAL PROPERTIES OF WELDED INCONEL
ALLOYS**

A Project Work

Submitted by

T.SYED ANWAR

(311816145004)

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 2020




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BONAFIDE CERTIFICATE

It is certified that this project report titled “**INVESTIGATION OF MICROSTRUCTURE AND MECHANICAL PROPERTIES OF WELDED INCONEL ALLOYS**” is a bonafide work of **T.SYED ANWAR (311816145004)** who carried out the project work under my supervision.

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CONCLUSION

The above investigations and study leads to the better understanding of the **Welding of dissimilar Inconel alloys (alloy 601 and 825)** welded by Gas Tungsten Arc Welding (Manual). The followings are the results observed by the above investigation.

- The dissimilar joint of Inconel 601 and Inconel 825 can be done using GTAW process by using Inconel 625 filler rod.
- The **post weld heat treatment** is done in double stage, at 850°C the carbide phases segregates on the grain boundaries.
- Increase in hardness of the weld zone is achieved after heat treatment at 850°C for 4 hours.
- The grain boundary strengthening mechanism is happened by segregation of carbides in grain boundaries after heat treatment.
- By increasing hardness on weld zone leads to decrease the tensile strength while doing heat treatment at 850°C for 4 hours.




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