NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL

Honors in
ADVANCED MATERIALS
SCHEME OF INSTRUCTION AND SYLLABI

for B.Tech. Program

(Effective from 2021-22)

DEPARTMENT OF MECHANICAL ENGINEERING

Scheme of Instruction
Honors in Advanced Materials

S.No.	Subject name	Semester
1	ME5604 Mechanical Behavior and Characterization of Materials	Odd
2	ME5601 Advanced Materials Processing	Odd
3	ME5611 Surface Engineering	Odd
4	ME5664 Non-Destructive Testing and Evaluation	Even
5	ME5651 Materials and Process Selection for Design	Even
6	ME5762 Powders for Additive Manufacturing	Even

Course Code: ME5601	ADVANCED MATERIALS PROCESSING	Credits 3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

CO1	Select suitable welding processes for joining different materials
CO2	Analyze metal removal mechanism in subtractive processes
CO3	Analyze and select appropriate transformation process to develop composites
CO4	Select a hybrid processor coating technology to improve the quality of products

Syllabus:

Additive Processes : Introduction welding power sources, TIG, MIG, plasma welding processes , applications and advantages, Friction welding: process variables and applications and advantages, Friction stir processing, process variables and applications and advantages, Electron beam welding , Laser beam welding: process variables and applications and advantages.

Subtractive processes: Hard turning and high speed milling - Laser Machining: Introduction to laser machining, application and advantages, Laser drilling, effect of processes parameters on machinability characteristics of materials. Laser cutting, Quality aspects in laser machining, Applications of laser micromachining, Electrical Discharge Machining.

Transformation processes: Advanced casting: Introduction, Principle of Stir casting, steps in stir casting process, Factors affecting stir casting process: stirring speed stirring time and temperature, preheat temperature of the mold, particle distribution, wettability between reinforcement and liquid metal and porosity - Advantages and application, composite preparation, analysis of composite, Squeeze casting process, advantages Slip casting: principle, applications, advantages and limitations.

Hybrid Processes: Process variables and applications and advantages Hybrid welding processes, hybrid welding process (TIG and Plasma welding, etc.), Hybrid machining processes – ECDM, EDG, ECM

Surface Coating: Coating Materials, Coating on different materials, Coating methods and its applications, Limitations.

Super Alloys: Properties, microstructure, melting and casting practice of super alloys Microstructure of Ni-base & Co-base heat-resistant casting alloys. Temperature and Time dependent Transformation - Relationship of properties to microstructure in super alloys.

Learning Resources:

Text Books:

1. Friction stir welding and processing, R.S.Mishra, ASM International, 2007.
2. Modern Arc Welding Technology, Nadkarni S.V., Oxford IBH Publishers, 1996.
3. Technology of Metal Forming Processes, Surender Kumar, Prentice- Hall, Inc., 2008.

Reference Books:

1. Superalloys: Source Book, ASM International.
2. Morphology Control of Materials and Nanoparticles, Y. Waseda, A. Muramatsu, Yoshio Waseda, Springer, 2004

Course Code: ME5604	MECHANICAL BEHAVIOR AND CHARACTERIZATION OF MATERIALS	Credits 3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

CO1	Understand the mechanical behavior of ductile and brittle materials
CO2	Analyze creep, fatigue and fracture mechanisms for various materials
CO3	Develop fracture mechanism maps and analyze the reasons for failure of materials
CO4	Select a characterization technique to evaluate the behavior of materials

Syllabus:

Introduction: A brief review of elastic and plastic deformation, dislocations and their properties. Dislocations in FCC, BCC and HCP metals, interactions with point defects and other dislocations. Tensile behavior, evaluation of strength and ductility parameters, Effect of strain rate and temperature on tensile behavior, and Protevin Le-Chatelier effect.

Creep: Types and mechanisms of creep deformation, Creep under combined stresses, deformation mechanism maps, Super plasticity, environmental effects, remaining life assessment.

Fatigue: High and low cycle fatigue, process of fatigue fracture, effect of mean stress, Cyclic stress/strain response of materials, establishment of cyclic stress/ strain curve, transition fatigue life, Coffin-Manson relationship, Evaluation of parameters, characterizing resistance against high cycle and Low cycle fatigue, Creep fatigue interaction, environmental effects, thermochemical fatigue.

Fracture Mechanics: Brief review of the basic concepts of linear elastic and elastic-plastic fracture mechanics, stress intensity parameter, J- integral and crack tip opening displacement as fracture criteria, standard procedures for experimental determination of these parameters.

Failure analysis: Analyzing Fractures, Micro mechanisms of brittle and ductile fracture, fracture mechanism maps, fractography, Visual Examination & Management of Applied Failure Analysis, Manage Failure Analysis.

Materials characterization techniques: Optical microscopy techniques, Quantitative metallography, Scanning electron microscopy: Image formation methods in SEM. Applications.

Learning Resources:

Text Books:

1. Mechanical Metallurgy, George E. Dieter, McGraw Hill, 2nd Edition, 2005.
2. Introduction to Fracture Mechanics, Hellan K, McGraw Hill, 2002.
3. Mechanical Behavior of Materials at Elevated Temperatures, J.E.Dorn, McGraw Hill, 2000.
4. Deformation and Fracture Mechanics of Engineering Materials, Richard W. Hertzberg, Richard P. Vinci, Jason L. Hertzberg, 5th Edition, Wiley, 2012.

Reference Books:

1. Engineering Materials I : Introduction to Properties, Applications and Design, M.F Ashby and David R H Jones :,2010.
2. Mechanical behaviour of Materials, Marc Andre Meyers and Krishna Kumar Chawla, 2009.

Course Code: ME5611	SURFACE ENGINEERING	Credits 3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

CO1	To understand failure micro mechanisms occurring for different service conditions and the micro mechanisms involved in failure at different service conditions
CO2	Identify the materials for surface engineering and characteristics
CO3	Understanding on the fundamental of basic surface modification techniques.
CO4	Understanding of thick layer and thin layer coating technology, mechanism and their applications.
CO5	Evaluate the metallurgical, mechanical and tribological properties of engineered surfaces.

Syllabus:

Introduction: Concept and Importance, classification of surface modification techniques, advantages and their limitations.

Surface Degradation: Causes, types and consequences of surface degradation, Forms of wear – adhesive, abrasive, surface fatigue, corrosive, fretting and erosive wear, Classical governing laws related to wear, techniques to evaluate the wear damage

Materials for Surface Engineering: Materials characteristics, their importance in surface engineering, wear resistant materials, selection of materials for engineering the surfaces for specific applications, New coating concepts including multi-layer structures, functionally gradient materials (FGMs), intermetallic barrier coatings and thermal barrier coating, Presurface treatment

Conventional surface engineering practice: Surface engineering by material removal: like etching, grinding, polishing, etc. Surface engineering by material addition: like hot dipping, Electro-plating, carburizing, Cyaniding, etc

Coating based Surface Modification Techniques: Principles and application of weld surfacing: SMAW, SAW, GMAW, Thermal spraying – flame spraying, electric arc spraying, plasma spraying, detonation gun spraying and high velocity oxy fuel spraying, Cold-Gas Spraying Method(CGSM), Principles, Process Parameters, Coating Properties

Irradiation based and beam based techniques: Laser cladding, alloying, glazing, laser and induction hardening, heat treatment of steel and remelting by laser / TIG. Microwave glazing

Thin Film coating techniques: Ion implantation, chemical vapour deposition (CVD) and physical vapour deposition (PVD), carburizing, nitriding, plasma nitriding, cyaniding

Post-Spray Treatment: Heat Treatment, Electromagnetic Treatment, Furnace Treatment, Hot Isostatic Pressing(HIP), Combustion Flame Re-melting, Impregnation Inorganic Sealants Organic Sealants Finishing Grinding Polishing and Lapping

Characterization of coatings and surfaces: Measurement of coatings thickness, porosity & adhesion of surface coatings, Measurement of residual stress & stability, Surface microscopy, topography and Spectroscopic analysis of modified surfaces.

Learning Resources:

Text Books:

1. Surface engineering: Enhancing the life of tribological components, Dheerendra Kumar

Dwivedi, Springer, New Delhi, 2018.
2. Surface Engineering D.Srinivasa Rao, Daya Publishing House, 2010.

Reference Books:

1. Surface Engineering for Corrosion and Wear Resistance by J.R. Davis, ASM International, 2001
2. ASM Hand book – Surface Engineering, ASM International, vol. 5, 9th edition, 1994
3. Surface Engineering for Wear Resistances by K.G. Budinski. Prentice Hall Publisher, 1988

Online Resources:

1. https://nptel.ac.in/courses/113/105/113105086/
2. https://nptel.ac.in/courses/112/107/112107248/

Course Code: ME5664	NON-DESTRUCTIVE TESTING AND EVALUATION	Credits 3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

CO1	Understand the principles of NDT methods
CO2	Identify appropriate nondestructive testing methods for failure identification
CO3	Utilize radiography to identify underlying failure site
CO4	Analyze flaws using advanced eddy current methods
CO5	Utilize acoustic emission to identify leaks

Syllabus:

Introduction to NDT, Liquid penetrant test: Physical Principles, Procedure for penetrant testing, penetrant testing materials, Penetrant testing methods, sensitivity, Applications and limitations, typical examples.

Ultrasonic testing: Basic properties of sound beam, Ultrasonic transducers, Inspection methods, Techniques for normal beam inspection, Techniques for angle beam inspection, Flaw characterization techniques, Applications of ultrasonic testing, Advantages and limitations.

Thermography: Basic principles, Detectors and equipment, techniques, applications.

Radiography: Basic principle, Electromagnetic radiation sources, radiographic imaging, Inspection techniques, applications, limitations, typical examples.

Eddy current test: Principles, instrumentation for ECT, techniques, sensitivity, advanced eddy Current test methods, applications, limitations.

Acoustic emission: Principle of AET, Technique, instrumentation, sensitivity, applications, Acoustic emission technique for leak detection.

Magnetic particle inspection: Principle of MPT, Procedure used for testing a component, sensitivity, limitations.

NDT of Composites: Codes and Conventions - Difficulties - Few Case Studies.

Learning Resources:

Text Books:

1. Nondestructive Evaluation: Theory, Techniques and Applications, Peter J. Shull , Marcel Dekkar, 2002.
2. Non Destructive Testing Hand Book, Vol. 4, P. Mclntire (Ed.), American Society for Non Destructive Society, 2010

Reference Books:

1. Non Destructive Testing and Quality Control, ASM Metals Hand Book, Vol. 17, ASM, 1989.

Course Code: ME5651	MATERIALS AND PROCESS SELECTION FOR DESIGN	Credits 3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

CO1	Select materials as per the design requirements of a given product.
CO2	Analyze the selection strategy and attribute limits for selecting appropriate processes
CO3	Develop the shape factors for structural sections
CO4	Design and develop hybrid materials to create product personality

Syllabus:

Introduction: The families of Engineering materials, The Design process, types of design, Design tools and materials data.

Materials Selection-The basics and case studies: Introduction and synopsis, the selection strategy, attribute limits and material indices, the selection procedure, computer-aided selection, the structural index, summary and conclusions, case studies

Selection of material and shape, case studies: Introduction and synopsis, shape factors, Microscopic or micro-structural shape factors, limits to shape efficiency, exploring and comparing structural sections, material indices that include shape, co-selecting material and shape, summary and conclusions, case studies

Selecting candidate processes: A strategic view, selecting candidate processes, process information maps, Prima selection strategies, Prima categories: Casting, forming, machining processes.

Designing Hybrid materials and case studies: Introduction and synopsis, filling holes in material property space, hybrids of type 1, 2, 3, 4, Summary and conclusions, case studies

Information and knowledge sources for design: Introduction and synopsis, Information for materials and processes, screening information, supporting information, ways of checking and estimating data, Summary and conclusions

Materials and industrial design: Introduction and synopsis, the requirements pyramid, product character, using materials and processes to create product personality - Summary and conclusions.

Learning Resources:

Text Books:

1. Engineering Materials, M.F. Ashby: 4th Edition, Elsevier, 2005.
2. Materials Selection in Mechanical Design, M.F. Ashby: Butterworth Heinemann, 2005.
3. Materials Selection and Design, ASM Publication, Vol.20: ASM, 1997.
4. The Principles of Materials Selection and Design, Prentice Hall International, Pat L. Mangonon: Inc.1999.

Reference Books:

1. Process selection from Design to Manufacture, K.G.Swift and J.D.Booker, BH Publication.

Course Code: ME5762	POWDERS FOR ADDITIVE MANUFACTURING	Credits 3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

CO1	Distinguish and compare powder manufacturing techniques
CO2	Identify the characterization techniques for powder formulation
CO3	Differentiate between conventional powder compaction and modern compaction techniques
CO4	Analyse the sintering mechanism of powder compacts
CO5	Develop mechanical components through additive manufacturing techniques

Detailed Syllabus

General Concepts: Introduction and History of Powder Metallurgy and powders for additive manufacturing.

Powder Production Techniques: Different Mechanical and Chemical methods, Atomisation of Powder, other emerging processes, Performance Evaluation of different Processes, processing of metal powders, production and qualification of polymer powders.

Characterization Techniques: Particle Size & Shape Distribution, Electron Microscopy of Powder, Interparticle Friction, Compressionability, Powder Structure, Chemical Characterization

Microstructure Control in Powder: Importance of Microstructure Study, Microstructures of Powder by Different techniques

Powder Shaping: Particle Packing Modifications, Lubricants & Binders, Powder Compaction & Process Variables, Pressure & Density Distribution during Compaction, Isostatic Pressing, Injection Molding, Powder Extrusion, Slip Casting, Tape Casting, Analysis of Defects of Powder Compact

Metal powders in additive manufacturing: powders for direct energy deposition, powder for powder bed fusion process, requirements for powders used in additive manufacturing, handling of metal powders.

Sintering: Theory of Sintering, Sintering of Single & Mixed Phase Powder, Liquid Phase Sintering, Sintering Variables, Modern Sintering Techniques, Physical & Mechanical Properties Evaluation, Structure-Property Correlation Study, Modern Sintering techniques, Defects Analysis of Sintered Components.

Application of Powder metallurgy parts, Additive manufactured parts and A few case studies.

Text Books:

1. Powder Metallurgy Technology, G. S Upadhyaya, Cambridge International Science Publishing, 2002. 2nd Edition.
2. Powder Metallurgy Science, Technology and Materials, Anish Upadhyaya, Gopal Shankar Upadhyaya, Taylor & Francis Group, 2018.
3. Powder Metallurgy- Science, Technology and Applications, P. C. Angelo and R. Subramanian, PHI, New Delhi, 2008.

Reference Books:

1. J. S. Hirschhorn: Introduction to Powder Metallurgy, American Powder Metallurgy Institute, Princeton, NJ, 1976.
2. ASM Hand Book, vol. 7: Powder Metallurgy, ASM International
3. Advances in Powder Metallurgy: Properties, Processing and Applications, Isaac Chang, Yuyuan Zhao, Woodhead Publishing Series in Metals and Surface Engineering, Elsevier, 2013.
4. Powder Metallurgy, S. A. Tsukerman, Pergamon publishing, 1965, 1st Edition.

Online Resources:

1. https://www.epma.com/
2. https://www.pmai.in/
3. https://www.hoganas.com/en/powder-technologies/additive-manufacturing-metal-powders/
4. https://www.metalpowder.sandvik/en/products/applications/additive-manufacturing/
5. https://nptel.ac.in/courses/113/106/113106098/