

Advanced Materials: Their Processing and Characterization - ME5301

Description

To provide fundamental understanding of materials behaviour, their processing and manufacturability of various advanced materials including metallic materials, Composite materials, Bio materials and shape memory alloys To educate the know-how and principles of different metallurgical characterization techniques and mechanical testing methods for characterizing advanced materials

Course Content

Introduction of advanced materials, Principle of material selection for engineering applications and their manufacturability. Metallic Materials: Fundamental of metallic materials; Crystal structure of metals and alloys- Strengthening mechanisms-Phase diagrams-Heat treatment processes -iron-carbon-equilibrium diagrams-Advanced Steels and cast irons-Transformation hardening in steels-TTT diagrams. Non Ferrous Materials and High Temperature Materials: Structure, physical metallurgy, manufacturability and properties of Al, Mg and Ti alloys, Ni based super alloys. Non Metallic Materials: Non-Metallic Materials: Advanced ceramics, polymers and composites: applications, processing, mechanics and manufacturability. Modern Materials: Compositions, properties, physical metallurgy, processing/manufacturing, manufacturability & applications of: Bio materials and Shape memory alloys. Characterization: Application specific X-Ray diffraction techniques, Optical microscopy, Scanning electron microscopy, Transmission electron microscopy and various mechanical testing methods along with laboratory demonstration.

Text Books

William D. Callister, David G. Rethwisch, Materials Science and Engineering: An Introduction, 9th Edition, Wiley November 2013

Reference Books

Materials and Processing in Manufacturing – E Paul Degarmo, J T Black, Ronald A Kohser. Pub 2012, John Wiley & Sons Inc.

Light Alloys: From Traditional Alloys to Nano Crystals- I.J. Polmear, Elsevier Publication.

Composite Materials Hand book – M M Schwartz, McGraw Hill.ASM Handbook, Volume 10 - Materials CharacterizationMechanical Metallurgy- George E. Dieter, Pub 2005, 2nd Edition, McGraw Hill.Shape Memory Alloys- Corneliu Cismasiu, Sciyo Publication.

Manufacturing Metrology - ME5304

Description

The students should acquire knowledge about measuring instruments and manufacturing metrology methods. The principles of geometric dimensioning and tolerancing and understand the requirements to the measuring methods. The student should understand the requirements to metrology equipment and competence in a modern manufacturing company. The student should understand the relation between geometrical product specification, manufacturing process, and measurement method

Course Content

Measurement concepts, Traceability, Error and Uncertainty in Measurement, Uncertainties, Type A, Type B, Errors in measurement, compounding of error in measurement, Combination of uncertainties and correlation of errors Linear measurement Fixed gaging including hard gaging Go and no-go plug gages, pin gages, Thread gages, Ring gages, Air gages, Angle metrology Angle blocks, Indexing tables, Calibration by subdivision, Autocollimators, Angular interferometers Coordinate metrology CMM types, Rigid body analysis of machine errors (see machine tools), CMM probes, CMM usage, Software and measurement procedures, Task specific uncertainty, Environmental temperature variation error, Uncertainty in nominal differential expansion, Thermal effects diagram, Computation of errors due to nonstandard temperatures Form Error measurement and specification Straightness, flatness, circularity (roundness), cylindricity, profile of a surface, profile of a line, angularity, perpendicularity, parallelism, position, concentricity, symmetry, circular runout, total runout Gear and thread metrology Pitch and pitch diameter, Thread angle, Involute curves, Pitch diameter measurement over wires, Measurement of gear and thread wires Surface metrology Stylus methods, Instruments, Filters Parameters, Optical methods, Machine vision, White light interferometers, Other area instruments Nanometrology Definition of micro nano level manufacturing features, Concepts of SPM, STM. AFM for nano and micro level features Machine tool metrology and calibration Machine Tool Metrology Specification of machine errors, Standard tests for machining centers and lathes (ASME B5.54, ASME B5.57), Rigid body analysis of machine errors (see CMMs), Laser interferometer for calibration.

Text Books

- 1.J.F.W. Galyer , Charles Reginald Shotbolt, Metrology for Engineers , Cengage Learning EMEA, 1990
2. Whitehouse, D.J. , "Handbook of Surface Metrology," Institute of Physics Publishing, IOP Publishing Ltd 1994
3. Hocken, R.J. and Pereira, P.H., "Coordinate Measuring Machines and Systems", 2nd edition, CRC Press, 2011
4. Kennedy, C. W., Hoffman E. G., and Bond S.D., "Inspection and Gaging," Industrial Press, N.Y. 6th ed. 1987.
5. ASME Y14.5, B5.54, B5.57 and B89 standards

Reference Books

Bucher, Jay L. The Metrology Handbook, May 2012

Smart Manufacturing - ME5308

Description

This course aims to give exposure to 'smart manufacturing (SM)' concepts towards understanding the Factories of the Future (FoF) with the support of case studies.

Course Content

Part-A - Introduction to Smart Manufacturing Philosophy: Introducing the concept of 4th generation ideas and technologies, Digital transformation, What and why: From Industry 1.0 to Industry 4.0 (I4.0), introducing smart manufacturing (elements to incorporate: intelligence, self-learning, continuous learning, autonomy), Virtual manufacturing, Factories of Future (FoF) – convergence of manufacturing plant (process, equipment), models, mechatronics (sensors actuators, controllers), ICT (data analytics, networking, IIoT).

Part-B - Enabling Technologies of Smart Manufacturing: Cyber physical systems (CPS): layered architecture of CPS, cyber security. Industrial Internet of Things (IIoT): Introduction to IoT, IoT vs IIoT, layered architecture of IoT, Cloud computing, Fog computing. Digital Twin (DT): Definition of a digital twin, Digital thread, Augmented Reality (AR), Virtual reality (VR), Mixed reality (MR), Case studies based on Unity software. Communication & Networking: Basic networking, Networking protocols, Computer networks, Internet protocols, M2M Connectivity: Proposal for seamless M2M connectivity. Data science: data analytics – making sense from the manufacturing data, dashboards design, big data. AI and ML: Role of AI/ML in SM with case studies (online learning, self-learning, deep learning, generative AI, large language models). Cloud manufacturing: Implementing a cloud IoT solution for manufacturing operations Part- C - Case Studies related to Smart Manufacturing.

Text Books

1. The Fourth Industrial Revolution, Klaus Schwab
2. Cloud-Based Cyber-Physical Systems in Manufacturing, Lihui Wang and Xi Vincent Wang
3. Industry 4.0
4. The Industrial Internet of Things, Alasdair Gilchrist
4. Introduction to IoT, Sudip Misra, Anandarup Mukherjee, Arijit Roy
5. Industrial AI, Jay Lee

Reference Books

1. Handbook of Industry 4.0 & SMART Systems, Diego Galar Pascual, Pasquale Daponte, Uday Kumar
2. Advanced Human-Robot Collaboration in Manufacturing, L. Wang, Xi V. Wang, József V.Z. Kemény
3. Computer control of manufacturing system, Yoram Koren
4. CAD/CAM: Theory & Practice, Ibrahim Zeid.
5. Automation, Production Systems, and Computer-integrated Manufacturing, M.P. Groover.

Mechatronics Systems for Manufacturing - ME5309

Description

The course aims to introduce mechatronics and automation systems for applications in manufacturing processes, with the following specific goals, ? To introduce mechatronics systems design from the perspective of sensors, mathematical models, controllers, and actuators for industrial manufacturing processes. ? To provide an overview of modern and advanced control techniques for mechatronic systems in manufacturing. ? To give a practical exposure through case studies and examples of mechatronics system design in manufacturing.

Course Content

Part-A:: Introduction to Mechatronics Systems in Manufacturing Automation and Control Technologies: Introduction to Levels of Automation, Industrial Control Systems, CIM Rigid automation: Part handling, Flexible automation, How to realize automation - Definition of Mechatronic Systems. Mechatronic System Components: Hardware Components for Automation and Process Control, Sensors and Data Acquisition Systems, Signal Conditioners, Actuators, Microcontrollers, Coding Embedded Systems. Motivating Examples of Mechatronic Systems in Manufacturing: Industrial Robotics, Applications of Industrial Robots: Material Handling Robots, Automated Inspection, Process and Assembly Automation, etc.

Part-B:: Systems Theory for Control of Mechatronic Systems Mathematical Description of Systems: Linear Time Invariant (LTI) Systems (Op-Amp Circuit Implementation), Linearization, Discrete Time Systems, LTI State Equation Solutions, Application Example: Dynamic model of robots: Newton Euler Approach. Stability, Controllability and Observability: Input-Output Stability of LTI Systems, Internal Stability, Controllability Indices, Observability Indices, Discrete-time State Equations, Controllability after sampling. State Feedback and State Estimators: State Feedback Transformation, Regulation and Tracking, Robust Tracking and Disturbance Rejection, State Estimator, Feedback from Estimated States. Application Example: Regulation and trajectory tracking control in robots. Advanced Control and Learning-based Techniques: Interaction modelling and control: Impedance, Stiffness, Admittance Control. Optimal Control, Model Predictive Control (MPC), Learning-based MPC, Data Driven Modelling and Control. Application to Collaborative Robots. Example Implementation - Industrial Robot Control Systems: Impedance control in industrial manipulators using joint angles and end-effector force feedback (Modelling+Controller Design).

Part-C:: Manufacturing Mechatronics Systems - Case Studies Case studies in flexible automation, controls in manufacturing processes, automation in manufacturing processes.

Some example case studies:

1. Flexible Automation for Small-to-Medium Enterprises – Importance of flexible automation to meet changing demands for SMEs over bigger OEMs through metal foundry case studies.
2. Controls in Manufacturing Processes – Model Predictive Control (MPC) for temperature control in Friction Stir Welding (FSW) manufacturing process.
3. Automation for Production Systems – Increase in production capacity in shoe assembly using an industrial robot in industrial manufacturing.

MANUFACTURING STREAM - COURSE SYLLABUS

4. Automation for Sustainable Technologies – Multiple orders of magnitude increase in production rate of solar collectors using industrial robots for solar energy harvesting.
5. Automation in Manufacturing – Development of advanced control systems for improved robustness of the stamp forming processes.

Text Books

Mikell P. Groover, Automation, Production Systems, and Computer-integrated Manufacturing, 7th Edition,
Prentice Hall
Chi-Tsong Chen, Linear Systems Theory and Design, 3rd Edition,
Oxford University Press
B. Siciliano, L. Sciavicco, G. Villani, G. Oriolo: "Robotics: Modelling, Planning and Control", Springer, 2009 (3rd Edition)

Reference Books

The Mechatronics Handbook, CRC Press LLC, 2002
Mechatronics System Design, Devdas Shetty & Richard A. Kolk
Norman S. Nise, Control Systems Engineering, Wiley

Machining Science & Technology - ME6333

Description

To offer an overview of various machining processes including conventional and unconventional machining processes To teach the students how to analyse process mechanics in depth To educate the students to model few salient machinability parameters To enable the student to correlate process mechanics and quality of machined part

Course Content

Overview of conventional machining processes: operating parameters, MRR, specific energy, general discussion on impact of process parameters on machinability and machined surface quality. Geometry of single point turning tool in ASA, ORS, NRS and MRS, tool angle conversions, single point tool grinding, dynamic and work reference system, geometry of drill, milling cutters. Chip formation mechanics, chip flow in orthogonal machining and oblique cutting, restricted cutting edge effect, effective rake angle. Analytical approach for modelling force in turning, milling and drilling, tool wear, tool life, modified Taylor's equation, advanced tool materials. Finishing and superfinishing processes: Grinding, lapping, honing etc., Emerging technologies: high speed high feed machining, multi-layered/multi-stripped coating on cutting tools, state of the art coating technologies, green machining, sustainability, machining of advanced materials-case studies. Overview of unconventional machining processes, Historical development of various UCM; mechanism, characteristics and applications of WJM, AWJM, AFM, USM, EDM, PAM, LBM, EBM, hybrid machining; Future trends in UCM. Case studies on machining advanced materials through unconventional and hybrid machining route.

Text Books

Fundamentals of Machining and Machine Tools: G. Boothroyd and W.A. Knight Metal Cutting Theory and Practice: A. Bhattacharya Nonconventional Machining: P.K. Mishra

Reference Books

Metal Cutting Principles: M.C. Shaw Non-traditional manufacturing processes: G.F. Bendict

Advanced Sheet Metal Forming - ME6334

Description

- To provide a comprehensive knowledge of different sheet metal forming processes and their application to manufacture sheet metal components with different geometries from micro to macro scale level.
- To give an exposure on recent advancements in sheet metal forming technologies in terms of processes, principles, tooling, process mechanics and computational modelling.
- To impart the know-how of correlating sheet metal forming operations – crystallography texture – formability in order to understand the process mechanism and optimize the processing route.

Course Content

Part-A: Fundamentals of sheet metal forming: Importance of sheet metals in industries; sheet metal vs bulk metal deformation; plastic behavior of sheet metals- flow curves, work hardening, load instability; anisotropic properties of sheet; strain rate and temperature sensitivity of the materials on mechanical and anisotropic properties; Overview of common sheet metal forming processes; Experimental formability evaluation techniques- theoretical modelling of forming limit diagram. Crystallographic texture and its significance in metal forming – basics of texture, influence on deformation behavior and formability (for fcc, bcc, hcp materials).

Part-B: Advanced sheet metal forming processes: (i) Manufacturing of high performance metallic sheets: Hot and cold rolling, asymmetric rolling; severe plastic deformation techniques to develop high performance sheets, nanostructured sheets and advanced foils; manufacturing routes to fabricate advanced bi-metallic sheet materials and foils. (ii) Roll forming: Roll forming tool; roll design; materials for roll forming; flexible roll forming - tool development, advantages, mechanism and process. (iii) Superplastic forming: Introduction to super plasticity; Influence of grain size; temperature and strain rate on super plasticity; Process and equipment for superplastic forming; Governing equations for superplastic forming; Instability prediction in superplastic forming; application of superplastic forming (iv) High speed forming: Electro Hydraulic Forming-principle, calculation of forming pressure, process parameters and application; Magnetic pulse forming- principles, Electromagnetic model (Maxwell equation), thermo-mechanical model using Johnson cook model, die design, process variables and application (v) Energy assisted forming: Laser and ultrasonic assisted forming processes- principle, process parameters and application. (vi) Incremental Sheet Forming (ISF): Elements of ISF – Tools, CNC control, equipment, drives; Process – Single point ISF, Two point ISF, Hybrid ISF; Applications of ISF; Process parameter, control and optimization. (vii) Micro forming: Trend in miniaturisation; Basic aspects of micro forming, size effect in micro domain; Micro-scale deformation models; Challenges associated with tool design and material handling for micro components; Application of micro formed components in MEMS, biomedical, and aerospace industries.

Text Books

- Hu, Marciniak, Duncan - Mechanics of Sheet Metal Forming- Butterworth, 2002

MANUFACTURING STREAM - COURSE SYLLABUS

Reference Books

- Vollertsen - Micro Metal Forming - Springer ASM Handbook on Sheet Metals – Volume 14b Boothroyd - Roll Forming Handbook, Taylor & Francis Giuliano- Superplastic Forming of Advanced Metallic Materials - Elsevier

Oil Hyd. & Pneumatic Systems - ME6343

Description

Fluid power has the highest power density of all conventional power-transmission technologies. The basic objective of this course is to learn the basic concepts, underlying principles, advantages, applications, and future challenges in fluid power system. The course designed to think for system level conceptualization - design, analysis and operation of circuits and detailed fault diagnostics.

Course Content

Hydraulic Systems: Introduction to Fluid power systems, Hydraulic fluids, basic laws of fluid mechanics including Pascal's Law and Bernouilli's theorem, hydraulic pumps- Pumping theory, Types, Characteristics, Constructional features, Operations, Efficiencies, Torque and Power, Control Elements-Directional Control Valves, Pressure Control Valves and Flow Control Valves, Actuators- Hydraulic Motors and Hydraulic Cylinders, Fundamentals of Hydraulic Circuit Design, Hydraulic Symbols, design and analysis of hydraulic circuits, Applications. Power packs - Filtration, Accumulators, etc. Pneumatic Systems: compressed air generation, preparation and distribution; compressors, Air dryers, pneumatic working elements; pneumatic control valves, Design and construction of simple pneumatic circuits, various possibilities of switching of signals like cascade systems, shift register circuits etc., Multi-cylinder sequence control; Emergency control and incorporation of auxiliary conditions. Proportional and Electrohydraulic Servovalves-types, constructions and applications, Basic circuits

Text Books

1. Anthony Esposito, Fluid Power with Application, Prentice-Hall, Inc., Englewood Cliffs, N.J. 07632, 1980, USA.
2. Pippenger John, Hicks Tyler G, Industrial Hydraulics, McGraw-Hill, 1962, New York.

Reference Books

1. DA Pease & Pippinger, Basic Fluid Power, Prentice Hall 1987
2. 2. Walter Ernst, Oil Hydraulic Power and its Industrial Application, Tata McGraw-Hill, 1960, London.
3. 3. Alfred Bernard Goodwin, Fluid Power Systems: Theory, Worked Examples and Problems, Macmillan, 1976
4. 4. John Watton, Fluid Power Systems: Modeling, simulation, analog and microcomputer control, Prentice-Hall, Inc., Englewood Cliffs, N.J. 07632, 1989, USA.
5. 5. Bosch Rexroth and FESTO, Hydraulics and Pneumatics Manuals