Manufacturing Engineering Section

Syllabus for Comprehensive Examination

METAL FORMING

Fundamentals 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; Phenomenological models (Zener-Hollomon, Johnson-Cook) for temperature and strain rate effect- Isotropic and Anisotropic yield criteria; Isotropic and kinematic hardening; Analysis of representative yield criteria and hardening models; Forming limit diagrams-analysis and evaluation techniques; Crystallographic texture and its significance in metal forming.

Friction and contact modelling; Factors affection friction in metal forming; Adhesion theory of friction (Coloumb friction model); Shear friction theory (Sticking friction model); Stribeck curve; Effect of friction and Lubrication in metal forming

Processes- Principles, Mechanics and Governing equations of: Forging- Extrusion- Wire drawing- Hot and Cold rolling – Deep drawing-Bending-Superplastic forming-Microforming-Incremental forming-High Speed forming.

Recommended Book(s):

Text books:
1.	Marciniak, Duncan and Hu - Mechanics of Sheet Metal Forming- 2nd edition, Butterworth-Heinemann (2002) (Chapters 1-6, 8,10)
2.	Hosford and Caddell - Metal Forming:Mechanics & Metallurgy – 4th edition, Cambridge University Press (2014) (Chapters 1-8, 12-17, 19)

Reference Books:
1.	Vollertsen (Ed) - Micro Metal Forming – Springer (2013)
2.	ASM Handbook on Sheet Metals – Volume 14b

ELECTRICAL CIRCUITS, ANALOG & DIGITAL ELECTRONICS AND CONTROL SYSTEM

Electrical Circuits:

Series and Parallel circuits, DC circuit analysis; Network Theorems and DC Bridge circuits; Capacitors, Inductors and Transient Analysis; AC Bridge Circuits;

Analog Electronics:

Transistor amplifier, Common-Emitter, Common-Base and Common Collector amplifiers, Negative Feedback, Operational Amplifier, Inverting, Non-inverting, Instrumentation - amplifiers, Active Filters: Low pass, High pass, Band pass and Band stop, Waveform generators, Pulse shaper - Schmitt Trigger circuit, Analog to Digital & Digital to Analog Converters.

Digital Electronics:

Number Systems: Binary, Octal, Hexadecimal numbers, GRAY Code, Code conversion – Binary to GRAY and vice versa, Boolean Algebra, Digital Gates, Combinational Logic circuits, Sequential Logic circuits – Flip-Flops, Digital counters.

Control system:

Need for Control System, Open loop and Closed Loop control, Different types of closed controller: On-Off, P, PI, PD and PID controllers, Controller Design, Stability analysis.

Reference books:

- Theory and Problems of Basic Circuit Analysis – Second Edition, John O'Malley, Schamum's Outline Series –McGraw Hill, 1992.
- Electronic Principles, Albert Malvino & David Bates, McGraw-Hill Education, 2015
- Digital Computer Electronics – An Introduction to Microcomputers, Albert Paul Malvino, Tata McGraw Hill Publishing Company,
- Modern Control Engineering; Katsuhiko Ogata, Pearson Education, 2011

FUNDAMENTALS OF MACHINING

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 approaches for modelling force in turning, milling and drilling, modelling of machining temperature, tool wear, tool life, modified Taylor's equation, advanced tool materials. Finishing and superfinishing processes like grinding, lapping, honing etc.

overview of unconventional machining (UCM) processes, historical development of various UCM; process characteristics, analyses and applications of WJM, AWJM, USM, EDM, LBM, EBM, etc.

Reference Books:
- Metal Cutting Theory and Practice: A. Bhattacharya; Publisher: East West Press Pvt Ltd.
- Nonconventional Machining: P.K. Mishra; Publisher: Narosa Publishing House
- Fundamentals of Machining and Machine Tools: G. Boothroyd and W.A. Knight; Publisher: McGraw-Hill Inc., US

ADVANCED MATERIALS: THEIR PROCESSING AND CHARACTERIZATION

Metallic Materials: Fundamental of metallic materials; Atomic structure and Crystal structure- Imperfection of Solids-Slip systems-Strengthening mechanisms-Phase diagrams-Heat treatment processes -iron-carbon-equilibrium diagrams-Advanced Steels and cast irons-Transformation hardening in steels-TTT diagrams-CCT diagrams.

Non Ferrous materials: Structure, physical metallurgy, manufacturability and properties of Al, Mg and Ti alloys.

Non Metallic Materials: Composites with polymer matrix- metal matrix and ceramic matrix - Fabrication methods of in-situ, ex-situ and Nano composites-Mechanics of composites-Machining and joining of composites

Characterization: Principle, Application and Applied theory of: Hardness testing-Tensile testing-Fatigue testing -Optical Microscopy- Electron microscopy techniques and XRD analysis.

Reference books:

1. William D. Callister, Materials Science and Engineering: An Introduction, 7th Edition, Wiley India (Chapters 1-11,16)
2. M.W. Hyer, Stress Analysis of Fiber Reinforced Composite Materials
3. ASM Handbook, Volume 10 - Materials Characterization
4. Mechanical Metallurgy- George E. Dieter, Pub 2005, 2nd Edition, McGraw Hill.

AUTOMATION AND SENSORS

Automation concepts: Definitions, types, automation achievements, Hard and soft automation, Line balancing and techniques, Automation tools, Role of CIM, Group technology, FMS

Sensors for intelligent manufacturing and condition monitoring- force, temperature, vibration, pressure, flow, optical, electrical, acoustic, pneumatics, magnetic, electro-optical and vision sensors, Sensors for CNC machine tools - linear and angular position and velocity sensors, Acoustic emission - principles and applications - concepts of pattern recognition.

Robotics: Definitions, work envelops robotic layout and its components, Laws, applications, forward and inverse kinematics, sensors-internal sensors and external sensors, selection criteria.

Reference books:

1. Serope Kalpakjian and Steven R Schmid, Manufacturing processes for engineering materials, 5th Edition, Pearson (Chapter 14, 15)

2. Tonshoff and Inasaki, Sensors in Manufacturing.

3. William Bolton, Instrumentation and control systems, 1st or 2nd Edition, Newness

DRIVES AND CONTROLS

Drives – Actuators: Electrical Actuator, Hydraulic Actuators, Pneumatic Actuators, electro-magnetic, electro-pneumatics, servo actuators, Shape memory alloys, piezoelectric, magnetostrictive actuators and their relative merits

Controls - Role of control systems in Manufacturing- Classifications, Properties and applications of open and closed loop process control system, Laplace transform, Block diagram representation and reduction, stability criteria, microprocessor in automation-data communication and network, Data acquisition and processing, filters, ADC and DAC, PLCs and PID controllers, Mechatronics, system simulation and modeling.

Reference book:

1. William Bolton, Instrumentation and control systems, 1st or 2nd Edition, Newness

FLUID POWER SYSTEMS

Physical properties of hydraulic fluids; energy and power in hydraulic systems; frictional losses in hydraulic pipelines; hydraulic pumps; hydraulic cylinders and cushioing devices; hydraulic motors; hydraulic valves; hydraulic circuit design and analysis; hydraulic conductors and fittings; ancillary hydraulic devices; maintenance of hydraulic systems; pneumatics: air preparation and components; circuits and applications; basic electrical controls for fluid power circuits; fluid logic control systems.

Reference book:

1. Anthony Esposito, Fluid Power with Applications, 7th Edition, 2009, Pearson

METROLOGY AND COMPUTER AIDED INSPECTION

Metrology concepts- Abbe's principle-need for high precision measurements- problems associated with high precision measurements.

Standards for length measurement- Shop floor standards and their classification- Light interference- Method of coincidence- Slip gauge calibration-measurement errors.

Various tolerances and their specifications, gauging principles, selective assembly, comparators.
Angular measurements - principles and Instruments, Gear and Thread measurements.

Surface and form metrology- Flatness, roughness, waviness, roundness, cylindricity, etc.
Computer Aided Metrology- principles and interfacing, software metrology.

Laser metrology- Applications of lasers in precision measurements- Laser interferometer, speckle measurements, laser scanners.

Coordinate Measuring Machine- Non contact CMM Electro optical sensors for dimensional metrology- Non contact sensors for surface finish measurements

Image processing and its application in metrology.

Reference book:

Shotbolt, C.S. and Galyer. J. Metrology for Engineers, Cassell Publ., Fifth Edition, 1990.

ENGINEERING MATHEMATICS

Ordinary Differential Equations (ODEs)

Laplace Transforms

Linear Algebra

Fourier Analysis

Partial Differential Equations (PDEs)

Power and Taylor Series

Numerical Analysis

Optimization

Data Analysis

Statistics

Reference book:

1. Erwin Kreyszig, Advanced Engineering Mathematics (2002), 8th Edition, John Wiley & Sons Inc. (See relevant chapters 1, 2, 5, 6, 7, 10, 11, 18, 20, 22, 23)