National Institute of Advanced Manufacturing Technology

(Formerly National Institute of Foundry and Forge Technology)

Deemed to be University (Distinct Category)

Hatia, Ranchi 834003, Jharkhand

Syllabus

M.Tech (Foundry- Forge Technology)

Department of Foundry & Forge Technology

2025

Master of Technology (M. Tech) in Foundry & Forge Technology

Course Structure for M. Tech in Foundry-Forge Technology (2025-2027)

(Effective from July 2025)

Semester- I

Course Type/Code	Core/Elective	Subjects	Contact Time Per Week			Total Credits	Syllabus
			L	T	P		
XXX-01-01	Core 1	Technology of Ferrous Forging	3	0	0	3	View
XXX-01-02	Core 2	Technology of Ferrous Casting	3	0	0	3	View
XXX-01-03	Core 3	Technology of Non-Ferrous Casting	3	0	0	3	View
XXX-01-04	Department Elective-I	• Technology of Mould and Core Making • Modern Casting Process • Solidification of Metals and Alloys	3	0	0	3	View View View
XXX-01-05	Open Elective-I	• Physical Metallurgy & Heat treatment of casting & forging • Solidification and Deformation of Metallic Materials • Characterization of Materials	3	0	0	3	View View View
XXX-01-L01	Core Lab 1	Technology of Ferrous Forging Lab	0	0	2	1	View
XXX-01-L02	Core Lab 2	Technology of Ferrous Casting Lab	0	0	2	1	View
XXX-01-06	MLC	Research methodology and IPR	2	0	0	2	View
XXX-01-07	Seminar	Seminar 1	0	0	2	1	View
					Total Credits	**20**	

Semester- II

Course Type/Code	Core/Elective	Subjects	Contact Time Per Week			Total Credits	Syllabus
			L	T	P		
XXX-02-01	Core 4	Forging Die Design & Manufacturing	3	0	0	3	View
XXX-02-02	Core 5	Foundry Tooling and Methoding	3	0	0	3	View
XXX-02-03	Core 6	Technology of Non-Ferrous Forging	3	0	0	3	View
XXX-02-04	Department Elective-II	• Near Net Shape Process • Severe Plastic Deformation • Modern Forging Process	3	0	0	3	View View View
XXX-02-05	Open Elective-II	• Quality Assurance and Inspection Methods • Tribology in Metal Forming • Modelling and Simulation (Casting & Forging)	3	0	0	3	View View View
XXX-02-L01	Core Lab 1	Forging Die Design & Manufacturing Lab	0	0	2	1	View
XXX-02-L02	Core Lab 2	Foundry Tooling & Methoding Lab	0	0	2	1	View
XXX-02-06	PES-I	Professional & Engineering Skill-I	3	0	0	3	View
					Total Credits	**20**	

Semester- III

Course Type/ Code	Core/ Elective	Subjects	Contact Time Per Week			Total Credits
			L	T	P	
XXX-03-01		Major project dissertation Phase-I	0	0	24	12
XXX-03-02	PES-II	Professional & Engineering Skill-II	3	1	0	4
XXX-03-03	PES-III	Professional & Engineering Skill-III	3	0	2	4
					Total Credits	**20**

Semester- IV

Course Type/Code	Core/ Elective	Subjects	Contact Time Per Week			Total Credits
			L	T	P	
XXX-04-01		Major project dissertation Phase-II	0	40	20	
					Total Credits	**20**

Total Credit (Semester I to IV) : 20+20+20+20 =80

Detailed Syllabus

Semester I

Core 1 : Technology of Ferrous Forging

Total No of Lectures: 42

Module 1: Technology of open- die forging; Allowance and tolerances for free forging; Process chart for manufacture of typical components such as straight, stepped and hollow shaft, rings, discs, crank shaft, etc; [8 lectures]

Module 2: Classification, and characterization of forging equipments; Load and energy characteristics; Classification viz, pneumatic hammer, drop hammer, counter blow hammer, mechanical and hydraulic presses, upsetters, HERF machines, etc; Foundation of hammer; Recent development in forging equipment. [8 lectures]

Module 3: Methods of blank preparation; Acceptance criteria for bars & billets in forging industry, Advanced technology for production of large forging ingots. [8 lectures]

Module 4: Factors affecting metal flow in the die, such as forgeability, friction, lubrication, die temperature, shape and size factors. [8 lectures]

Module 5: Forging of steel, Forging of Stainless Steel, Forging of high Speed Steel, Problems of gases, overheating and burning of steels. [8 lectures]

Module 6: Forging defects and their remedial measures. [2 lectures]

Ref books:

1. Forging plant (DFRA forging handbook) by A Thomas
2. A MANUAL ON FUNDAMENTALS OF FORGING PRACTICE by A. M. Sabroff
3. Cold and Hot Forging: Fundamentals and Applications by T. Altan, G. Ngaile, and G. Shen
4. Forging Die Design by A Thomas
5. ASM Handbook: Forming and Forging Vol 14 5

Core 2: Technology of Ferrous Casting

Total No. of Lectures :42

Module 1: Basic of solidification, Basic steps in casting production, materials and types of patterns, Conventional, molding and core making practice. Routine sand testing, Methoding, Melting and Casting practices; Common casting defects.

Module 2: Fe-C phase diagrams; classification, properties and applications of cast irons and steel. Solidification behavior and effect of alloy additions.

Module 3: Melting furnaces used for iron and steel: electric arc furnace, induction furnace, cupola, rotary furnace. Melting practices and melt controls for iron and steel. De-oxidation and degassing of steel;

Module 4: Inoculation and alloying of cast irons. Production of grey, S.G., C.G. and malleable irons. Moulding and core making practice for iron and steel. Gating and feeding practices for iron and steel. Fettling, cleaning and heat treatments of castings; Defect analysis.

Reference Books:
1. Foundry Technology by P.L. Jain
2. ASM Handbook Volume 15: Casting, ISBN: 978-0-87170-711-6
3. Principles of Metal Casting by Richard Heine, Carl Loper, Philip Rosenthal
4. Metal Casting Principles and Techniques by Lerner Yury, Posinasetti Nageswara

Core 3: Technology of Non-Ferrous casting

Module 1: Non-ferrous alloys based on Al, Cu, Zn and Mg. their properties and applications. solidification and microstructure of important non ferrous alloys.

Module 2: Melting, fluxing, degassing and pouring practices. Filtration of non- ferrous melts. Melt treatment: modification and grain refinement.

Module 3: Charge calculation, hardeners. Oxidation and gas absorption in metals and alloys, detection of gases.

Module 4: Mould and core practices, metal-mould reaction, gating and feeding practices. Defect analysis, salvaging of castings.

Total No. of Lectures :42
Reference Books:

1. ASM Handbook Volume 15: Casting, ISBN: 978-0-87170-711-61
2. Complete Casting Handbook, 1st Edition, Metal Casting Processes, Techniques and Design by John Campbell.
3. Materials Processing During Casting by Fredriksson
4. Foundry Technology by Peter Beeley

DEPARTMENT ELECTIVE I

Technology of Mould and Core Making

Total No. of Lectures :42

Module 1: Sand occurrence, classification and characteristics of different types of sand, grain size, shape and distributions.

Module 2: Binders :Clay, Linseed oil, dextrin, sodium silicate, molasses, their characteristics and quality tests.

Module 3: Green and dry sand practices, carbon dioxide and shell process. Role and function of additives & washes in conventional mould & core making processes. 6

Module 4: Moulding practices, Odd side, three part, loam, sweep & pit moulding, skeleton patterns, stack moulding, core assembly. Core making practices :- small and large cores, swept cores ,loam cores, skeleton cores. Mould and core venting, reinforcement & drying.

Module 5: Machines for sand mixing and preparation of moulds & cores like mixer, muller, jolting, Squeezing, jolt-squeezing, slinging, blowing and shooting machines. Their functions & characteristics.

Module 6: Core location, closing and weighting of moulds. Sand reclamation methods & equipment. Casting defects mainly attributed to moulding and core making practices and materials.

Reference Books:

1. Foundry Technology by P.L. Jain
2. ASM Handbook Volume 15: Casting, ISBN: 978-0-87170-711-6
3. Principles of Metal Casting by Richard Heine, Carl Loper, Philip Rosenthal
4. Metal Casting Principles and Techniques by Lerner Yury, Posinasetti Nageswara

Modern Casting processes

Total No. of Lectures :42

Module 1: Recent developments in design, materials and methods of manufacture of patterns. Process details, in gradients used, process variables and economy of the processes.

Module 2: Modification in casting design with reference to foundry and metallurgical principles. Principles design and methods involved in gating and risering of ferrous and nonferrous castings.

Module 3: Recent developments in materials and methods of mould and core making such as high pressure moulding. V-process, magnetic moulding, Sodium silicate based processes, shell process, Hot box, cold box, full moulding etc.

Module 4: Moulding and sand conditioning equipments. Sand reclamation, principles, technology and scope of sand casting processes, Non-metallic mould etc. Precision casting processes.

Module 5:Principles, technology and scope of Die casting. squeeze casting processes , Continuous casting, investment casting. Slush casting.

Module 6: Special casting processes: centrifugal casting, full mould casting, vacuum shield casting, full mould casting, vacuum shield casting etc.

Module 7: Casting defects, metal-mould reactions, metal penetration and burn-out etc. general principles and objectives of foundry mechanization and lay out.

Reference Books:
1. Foundry Technology by P.L. Jain
2. ASM Handbook Volume 15: Casting, ISBN: 978-0-87170-711-6
3. Principles of Metal Casting by Richard Heine, Carl Loper, Philip Rosenthal
4. Metal Casting Principles and Techniques by Lerner Yury, Posinasetti Nageswara

Solidification of Metals and Alloys

Total No. of Lectures :42

Module 1: Basics of solidification, Thermodynamic conditions for solidification Solidification as atomic process, Nucleation and heat flow. Stability of nuclei and conditions for growth-Growth rate and heat flow relationships-Controlling factors.

Module 2: Structure of cast metals and alloys. Distribution of solutes during solidification, and segregations.

Module 3:Solidification in continuous casting. Centrifugal casting. Chilled castings-effect of pressure and other variables. Unidirectional solidification of castings and effect on properties, zone refining,

Module 4:Casting grain structure; columnar, dendritic and cellular dendritic growth, multiphase microstructures.

Module 5 : Micro & Macro segregation, Micro & Macro porosity and residual stresses in casting and other solidification defects.

Reference Books;
1. Foundry Technology by P.L. Jain
2. ASM Handbook Volume 15: Casting, ISBN: 978-0-87170-711-6
3. Science & Technology of Casting processes Edited by M. Srinivasan, 2012
4. Solidification and Solid-State Transformations of Metals and Alloys by Maria Jose Quintana Hernandez Jose Antonio Pero-Sanz Luis Felipe Verdeja
5. Solidification and Crystallization Processing in Metals and Alloys by Hasse Fredriksson, Ulla Åkerlind

OPEN ELECTIVE-I

Physical Metallurgy and Heat treatment of Casting & Forging

Module 1: Solid solutions- theories of alloying, Intermediate phases and intermetallic compounds. Common binary equilibrium diagrams and their interpretation, Introduction to ternary equilibrium diagram. Diffusional & diffusionless transformation, Concepts of structure

property processing co- relation Strengthening of metals & alloys and its mechanism.

Module 2: Solidification of metals & alloys, Casting grain structure; Ingot structure dendritic and cellular dendritic growth, multiphase microstructures. Micro & Macro segregation, Micro & Macro porosity and residual stresses in casting.

Module 3: Hot and cold working of metals & alloys, recovery, recrystallisation and grain growth. Evolution of microstructure in hot & cold forged alloy.

Module 4: Heat treatment processes; Hardening, Tempering, Annealing, Normalizing, Surface Hardening, Carburizing, Nitriding, Electron Beam Hardening and Laser Hardening; Application of Plasma in heat treating. High Temperature Carburising.

Module 5: TTT and CCT curves, Decomposition of austenite, Diffusion controlled and diffusionless transformations; Nucleation and growth of phases; Pearlitic and bainitic transformations; Mechanism of martensitic transformations.

Module 6: Determination of grain size; Heat Treatment of tool and alloy Steels; Heat treatment of cast iron ; Heat treatment of weldments; Thermomechanical treatment; Heat treatment of non- ferrous metals and alloys; Theory of age-hardening; Heat Treatment defects in castings, forgings and weldments and their remedial measures. Automation & computerization of heat treating process & equipment. Controlling heat treating furnace atmosphere.

Total No. of Lectures :42

Reference Books:

1. Materials Science and Engineering, William D. Callister, Jr, John Wiley & sons
2. Modern Physical Metallurgy and Material Engineering, Science, Process, application, Smallman R.E., Bishop R J, Butterworth Heinemann, Sixth Ed., 1999.
3. Introduction to Physical Metallurgy Sidney H. Avner.
4. Physical Metallurgy: Principles and Practice, by V. R. Raghavan
5. Physical Metallurgy Principles, by Reza Abbaschian and Robert E. Reed-Hill

Characterization of Materials

Module 1: Optical Metallography techniques like polarized light microscopy, DIC, fluorescence, etc.

Module 2: Diffraction Methods like texture measurement, residual stress analysis, EXAFS, neutron diffraction, etc.

Module 3: Electron Optical and related techniques like TEM, SEM, EDS, WDS/EPMA, CBED, HREM, EELS, etc.;
Surface Analysis and related techniques like Auger, XPS, SIMS, RBS, STM, AFM, etc.
Module 4: Thermal Analysis like DTA, DSC, TGA, TMA, etc.
Module 5: Spectroscopy Techniques like optical emission spectroscopy, atomic absorption spectrometry, x-ray spectrometry, infrared spectroscopy, Raman spectroscopy, electron spin resonance, nuclear magnetic resonance, Mossbauer spectroscopy, etc.; Electrical Resistivity measurement.
Total No. of Lectures :42
Reference Books

1. Handbook of Materials Characterization, Editors: **Sharma**, Surender Kumar (Ed.)
2. Materials Characterization: Introduction to Microscopic and Spectroscopic Methods by Yang Leng.
3. Materials Characterization Techniques by Ashok Kumar, Lin Li, and Sam Zhang

Research methodology and IPR

Module I

Introduction to Research and Research Methodology, Defining the research problem, Research Design and Approaches, Sampling design and measurement techniques **4L**

Module II

Methods of Data collection, Design and analysis of experiments: Testing of Hypothesis, statistical methods, Analysis and processing data etc., Experimental Methods **8L**

Module III

Ethical considerations and Plagiarism, Technical report writing, presentation skills (Poster & Oral), Manuscript writing, Research proposals, Software (s) used for analysis of data, Funding agencies in India **7L**

Module IV

Nature and type of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT. Geographical Indications **7L**

References

1. Research Methodology: Methods and Techniques, C.R. Kothari, New Age International Publishers, 2004.
2. Research Methodology: step by step guide for beginners, Ranjit Kumar, SAGE publication London, 3rd edition, 2011.
3. Research Methods Basics, Nicholas Walliman, Routledge New York, First edition, 2011.
4. Essentials of research Methodology and Design, Geoffrey Marczyk, David DeMatteo, and David Festinger, John Wiley & Sons, Inc., 2005.
5. Fundamentals of research Methodology and Statistics, Yogesh Kumar Singh, NEW AGE INTERNATIONAL (P) LIMITED, PUBLISHERS, 2006
6. Stuart Melville and Wayne Goddard, Research methodology: an introduction for science &engineering students
7. Ranjit Kumar, 2nd Edition, ―Research Methodology: A Step-by-Step Guide for beginners
8. Halbert, Resisting Intellectual Property, Taylor & Francis Ltd ,2007.
9. Mayall, Industrial Design, McGraw Hill, 1992.

SEMESTER II:

Forging Die Design & Manufacturing

Total lecture - 42 Lectures

Module 1: Job Analysis, Steps for die design. Location of parting line, Importance of Design of flash and gutter. Determination of width and thickness. 6

Module 2: Design of edger, fuller, bender, blocker, finishing impression, Reduced Roll design, Preform design . Dovetail, cross, key and tapered key. Laws governing the design of the dies of horizontal forging machine. Design of punches and heading tools for up setter (horizontal forging machine). upsetting rule, coning Tool Design Method. 8

Module 3:.Determination of stock size, tensile strength of material at the finishing temperature while forging. Capacity calculation of drop hammer, mechanical press, Determination of capacity of trimming press. Design of trimming and piercing tool, die clearance between punch and die. Design of stripping tool. Assembly detail for trimming. 8

Module 4: Selection of the size of massive die blocks or insert dies. Production of die blocks.Technical requirements for sinking, re-sinking and rectification of dies, Die sinking methods like copy- milling, EDM, ECM etc. 7

Module 5: Instruction for mounting, setting and working of dies, Die material selection , DieWear, Factors minimizing die wear , Die failure analysis, Die life improvement 7

Module 6: Computer aided design of forging dies, Optimization of die design parameters,Optimum material utilization, Modeling and Simulation of forging process using software. 6

Reference Books:

i. Die Design by A. Thomas DFRA (UK)
ii. Cold and Hot Forging ASM (Ohio,USA)
iii. Forging Plant by A. Thomas DFRA (UK)
iv. Forging Die Design byT. Altan

Foundry Tooling and Methoding

Module 1: Pattern Equipment for quality production of castings.

Module 2: Pattern plates: types, materials used; design and constructional features suiting to various moulding machines.

Module 3: Special design features for high pressure moulding machines.

Module 4: Core Boxes: type, materials used, design and constructional features for core blowing and shooting machines.

Module 5: Special features for shell core shooters, Core print. Gravity Die casting: Die- Types, and design features. Pressure Die-casting: die- design features.

Module 6: Gating: elements of the gating system. Design of Gating system for cast iron & steel, Fluidity and its significance in casting.

Module 7: Risering : Solidification of iron and steel with reference to Fe-C diagram. Riser classification. Design of riser. Methods to achieve directional solidification.

Total No. of Lectures :42

Reference Books:

1. Foundry Technology by P.L. Jain
2. ASM Handbook Volume 15: Casting, ISBN: 978-0-87170-711-6
3. Foundry Technology by Peter Beeley
4. Pattern Making and Foundry Practice, by L. H. Hand

Technology of Non Ferrous Forging

Total No of Lectures: 42

Module 1: Classification & properties of commercial aluminum alloys & their metallurgical characteristics, Forging behavior of aluminum alloys; Heat treatment technology and industrial application of the Al-alloys. [8 lectures]

Module 2: Designation, properties and application of copper alloys forgings; Forging practices of copper, copper alloys. Heat treatment practice. [8 lectures]

Module 3: Designation, properties and application of magnesium alloys forgings; Forging and heat treatment practices of magnesium alloys. [8 lectures]

Module 4: Designation, properties, types and application of Ti alloys forgings; Forging practices and heat treatment of of Ti alloys. [8 lectures]

Module 5: Current forging technology for aerospace materials. Forging of Aluminum-Lithium alloys. [6 lectures]

Module 6: Tribological behavior during forging. [4 lectures]

Ref books:

1. Forging plant (DFRA forging handbook) by A Thomas
2.A MANUAL ON FUNDAMENTALS OF FORGING PRACTICE by A. M. Sabroff
3.Cold and Hot Forging: Fundamentals and Applications by T. Altan, G. Ngaile, and G. Shen
4.Forging Die Design by A Thomas
5.ASM Handbook: Forming and Forging Vol 14

Departmental Elective II

Near-net Shape Processes

Concept of shape, size, accuracy, tolerances and surface roughness; Economical and technological factors; improved material and energy efficiency, dimensional accuracy, product integrity and reduced manufacturing cost through near net shape processing. (06)

Foundry Processes: Shell Process; Investment casting; Ceramic Moulding; Plaster mould process; V-process; squeeze casting; rheo-casting; permanent mould casting; low pressure die casting; pressure die casting processes; centrifugal casting, spray forming, strip casting, Additive layer manufacturing, counter gravity casting, metal injection molding. (15)

Plastic Deformation Processes: Cold forging; Warm forging; hot forging; super plastic forming; Powder metal forging; Liquid forging; rheo-forging; Flashless forging; Isothermal forging; Hot die forging; Orbital forging; Semi-solid forging; Thixo-forming; Hydro forming; HERF; Additive forming processes. (16)

Electro Forming: Principles of electro deposition; production of dies and moulds by electro forming processes. (05)

Reference Books;

1. Foundry Technology by P.L. Jain
2. ASM Handbook Volume 15: Casting, ISBN: 978-0-87170-711-6
3. ASM Handbook: Volume 14, Forming and Forging; ISBN: 0-87170-007-7

Modern Forging Process

Plastic Deformation Processes , Cold Forging , Warm Forging , Hot Forging

Flashless Forging, High Energy Rate Forging , Super plastic Forming

Isothermal Forging, Powder Forging, Liquid Forging, Orbital Forging

Electrical Upsetters; Automatic Horizontal Presses, Rheo – Forging, Reduce Roll Design and Preform Design

Long Forging Machine, Hot Isostatic Press etc

Ref Books:

1. ASM Handbook: Forming and Forging Vol 14
2. A MANUAL ON FUNDAMENTALS OF FORGING PRACTICE by A. M. Sabroff
3. Cold and Hot Forging: Fundamentals and Applications by T. Altan, G. Ngaile, and G. Shen

Severe Plastic Deformation:

Total No of lectures: 42

Module 1: introduction, different types of severe plastic deformations. [10 lectures]

Module 2: microstructural characterization and modeling of severe plastic deformation materials [9 lectures]

Module 3 :microstructure evolution during severe plastic deformation processing [10 lectures]

Module 4: physical and mechanical properties of severe plastic deformation materials [10 lectures]

Module 5: future horizons for severe plastic deformation materials: applications and commercialization [3 lectures]

Ref books:

1. Severe Plastic Deformation Technology by A Rosochowski
2.Theory of Plasticity by Chakarabarti
3.Investigations and Applications of Severe Plastic Deformation by Lowe, Terry, Valiev, Ruslan Z. (Eds.)
4.Severe Plastic Deformation: Methods, Processing and Properties by Ghader Faraji,H.S. Kim, Hessam Torabzadeh Kashi

OPEN ELECTIVE II

Quality Assurance and Inspection Methods

1. Introduction to total quality management, quality Policy, product reliability and life cycle.
2. Taguchi's philosophy and robust product and process design, Six sigma concept.
3. Quality circles, Quality audits, ISO-9000 prerequisites different systems and their structure.
4. Probability distribution: Normal distribution, Control charts for attributes and variables, special control charts.
5. Acceptance sampling: Introduction, sampling plan, OCC curve.
6. Destructive, Non destructive and metallurgical testing methods for casting and forging, Fracture analysis: microscopic and macroscopic fracture appearance features, Casting and forging defects.

References:

1.Douglas C. Montgomery, "Introduction to Statistical Quality Control", John Wiley & Sons, Inc., 2005.
2.ASM Handbook vol 11, Failure Analysis and Prevention, ASM International, 2002.
3.ASM Handbook vol 8, Mechanical Testing and Evaluation, ASM International, 2000.
4.ASM Handbook vol 17, Non-destructive Evaluation and Quality Control, ASM International, 1992.

Tribology in Metal Forming

Total No of Lectures: 42

Module 1: Background and importance of Tribology, A system approach to tribology. [5 lectures]

Module 2: Characterization of tribosurfaces [5 lectures]

Module 3: Mechanics of solid contacts [3 lectures]

Module 4: Theory of friction and frictional heat generation, role of contact temperature. [5 lectures]

Module 5: Different modes of wear, Tribological testing techniques and analysis of the worn surfaces [6 lectures]

Module 6: Lubrication, Importance and properties of lubricants [8 lectures]

Module 7: Different wear resistant materials, Recent research results illustrating the performance of surface coatings, bulk materials and composite materials in tribological contacts. [10 lectures]

Ref Books:

1. ASM Handbook Friction, Lubrication, and Wear Technology Vol 18
2. Mechanical Tribology Materials, Characterization, and Applications by George E. Totten, Hong Liang
3. Tribology–Friction and Wear of Engineering Materials by I.M. Hutchings, Butterworth-Heinemann, Oxford (1992)
4. Contact Mechanics by K.L. Johnson, Cambridge University Press
5. Introduction to Tribology By Bharat Bhushan