

***National Institute of Advanced Manufacturing Technology***

***Hatia, Ranchi-834003***

***(Formerly National Institute of Foundry and Forge Technology)***

***(Centrally Funded Technical Institute, Under MHRD, Govt of India)***

***(Affiliated under Jharkhand Technical University)***

***Syllabus***

***M.Tech (Foundry-Forge Technology)***



***Department of Foundry Technology and Forge Technology***

**2021**

**Master of Technology (M. Tech) in Foundry-Forge Technology**

## M TECH (Foundry-Forge Technology)

### SEM-1

S.No.	Code	Name of subject	L	T	P	Credits
1	FF1101	Technology of Ferrous Forging	3	0	0	3
2	FF1102	Technology of Ferrous Casting	3	0	0	3
3	FF113*	<b>Elective I</b>	3	1	0	4
4	FF114*	<b>Elective II</b>	3	1	0	4
5	FF1111	Technology of Ferrous Forging Lab	0	0	2	1
6	FF1112	Technology of Ferrous Casting Lab	0	0	2	1
7	FF1103	Research Methodology and IPR	2	0	0	2
8	FF112*	Audit Course I	2	0	0	0
9	FF117*	Open Elective	3	0	0	3
<b>TOTAL</b>						<b>21</b>

**Elective I:** (i) FF1131: Technology of Molding and Core Making  
(ii) FF1132: Modern Casting Process  
(iii) FF1133: Solidification of Metals and alloys

**Elective II:** (i) FF1141: Near Net Shape process  
(ii) FF1142: Modern Forging Process  
(iii) FF1143: Severe Plastic Deformation

#### **Open Elective:**

- i. FF1171: Physical Metallurgy and Heat treatment of Casting & Forging
- ii. FF1172: Additive Manufacturing
- iii. FF1173: Characterization of Materials
- iv. FF1174: Manufacturing Processes
- v. FF1175: Metal Melting Technology
- vi. FF1176: Failure Analysis
- vii. FF1177: Design and Analysis of Experiments

### SEM-II

S. No.	Code	Name of Subject	L	T	P	Credits
1	FF1201	Forging Die Design and Manufacturing	3	0	0	3
2	FF1202	Foundry Tooling and Methoding	3	0	0	3
3	FF124*	<b>Elective III</b>	3	1	0	4
4	FF125*	<b>Elective IV</b>	3	1	0	4
5	FF1211	Forging Die Design and Manufacturing Lab	0	0	2	1
6	FF1212	Foundry Tooling and Methoding Lab	0	0	2	1
7	FF1229	Mini Project/ Modeling & Simulation(casting & Forging)	0	0	4	2
8	FF122*	Audit Course II	2	0	0	0

9	FF126*	<b>Elective V</b>	3	0	0	3
<b>TOTAL</b>						<b>21</b>

**Elective III:**

- (i) FF1241: Technology of Non Ferrous Forging
- (ii) FF1242: Tribology in metal forming
- (iii) FF1243: Modern trends in metal forming process

**Elective IV**

- i. FF1251: Technology of Non-Ferrous casting
- ii. FF1252: Mathematical Modeling and Computer application in Casting
- iii. FF1253: Methoding of Castings

**Elective V:**

- i. FF1261: Quality Assurance and Inspection Method
- ii. FF1262: Energy conservation and Pollution control
- iii. FF1263: Finite Element Method
- iv. FF1264: Material Handling
- v. FF1265: Instrumentation and automation

**SEM-III**

S. No.	Code	Name of Subject	L	T	P	Credits
3	FF2129	Dissertation-Phase I	0	0	20	10
4	FF2128	Industrial Training/ Internship	0	4 weeks	-	-
<b>TOTAL</b>						<b>10</b>

**SEM-IV**

S.No.	Code	Name of subject	L	T	P	Credits
1	FF2229	Dissertation-Phase II	0	0	32	16
<b>TOTAL</b>						<b>16</b>

**Audit course 1 & 2**

- FF 1\*21 English for Research Paper Writing
- FF 1\*22 Disaster Management
- FF 1\*23 Sanskrit for Technical Knowledge
- FF 1\*24 Value Addition
- FF 1\*25 Constitution of India
- FF 1\*26 Pedagogy Studies
- FF 1\*27 Stress Management by Yoga and aerobics
- FF 1\*28 Personality Development through Life Enlightenment Skills.

## Detailed Syllabus

### Semester I

#### FF1101: 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**

## **FF1102: Technology of Ferrous Casting**

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

**Module III:** 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 IV:** 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.

**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. Principles of Metal Casting by [Richard Heine](#), [Carl Loper](#), [Philip Rosenthal](#)
4. Metal Casting Principles and Techniques by Lerner Yury, Posinasetti Nageswara

## **Elective I**

### **FF1131: Technology of Mould and Core Making**

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

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

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

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

**Total No. of Lectures :42**

**Reference Books;**

**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

### **FF1132: Modern Casting processes**

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

**Module II:** Modification in casting design with reference to foundry and metallurgical principles. Principles design and methods involved in gating and risering of ferrous and non-ferrous castings.

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

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

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

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

**Total No. of Lectures :42**

**Reference Books;**

**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

### **FF1133: Solidification of Metals and Alloys**

**Module I:** 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 II:**Structure of cast metals and alloys. Distribution of solutes during solidification, and segregations.

**Module III:**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 IV:**Casting grain structure; columnar, dendritic and cellular dendritic growth, multiphase microstructures.

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

**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. 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

### **Elective II**

#### **FF1141: 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



## **FF1141: Modern Forging Process**

Plastic Deformation Processes , Cold Forging , Warm Forging , Hot Forging	8 L
Flashless Forging, High Energy Rate Forging , Super plastic Forming	8 L
Isothermal Forging, Powder Forging, Liquid Forging, Orbital Forging	8 L
Electrical Upsetters; Automatic Horizontal Presses, Rheo – Forging, Reduce Roll Design and Preform Design	10 L
Long Forging Machine, Hot Isostatic Press etc	8 L

### **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

## **FF1143: 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**

### **FF1171: Physical Metallurgy and Heat treatment of Casting & Forging**

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

**Module IV:** 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 V:** 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 VI:** 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

## **FF1172: Additive Manufacturing**

**Module I:** Basic principles of RP processes, Classification of RP processes.

**Module II:** Various industrial RP systems like stereolithography, fused deposition modeling, selective laser sintering, laminated object manufacturing, 3D printing, ballistic particle modeling, etc.

**Module III:** Role of rapid prototyping and rapid tooling in product development. Process planning for rapid prototyping, STL file generation, Defects in STL files and repairing algorithms, Slicing and various slicing procedures, Accuracy issues in rapid prototyping,

**Module IV:** Strength of RP parts, Surface roughness problem in rapid prototyping, Part deposition orientation and issues like accuracy, surface finish, build time, support structure, cost, etc.

**Module V:** Rapid tooling techniques, such as laminated metallic tooling and direct metal laser sintering.

**Module VI:** Introduction to reverse engineering -Point cloud data generation methods and processing techniques -Integration of reverse engineering and rapid prototyping.

**Total No. of Lectures :42**

### **Reference Books:**

1. Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing by Brent Stucker, David W. Rosen, and IAN GIBSON.
2. Additive Manufacturing of Metals: From Fundamental Technology to Rocket Nozzles, Medical Implants, and Custom Jewelry by John O. Milewski
3. The 3D Printing Handbook: Technologies, Design and Applications by Ben Redwood, Brian Garret, and Filemon Schöffner

## **FF1173: Characterization of Materials**

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

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

**Module II:** 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 II:** Thermal Analysis like DTA, DSC, TGA, TMA, etc.

**Module II:** 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

## **FF1174: Manufacturing Processes**

**Module I:** General structure and properties of engineering materials, classification of common materials, their unique properties and applications.

**Module II:** Metals and alloys, glass and ceramics, polymeric materials and composites, behavior, testing and manufacturing properties of these materials.

**Module III:** Concepts of manufacturing, basic principles of engineering manufacturing; shaping, joining, removal and regenerative processes,

**Module IV:** Methods of applications of common manufacturing processes; performing by casting, forging, rolling, melting, injection and compression moulding, extrusion and drawing, press tool work, powder processing etc.

**Module V:** Finishing by machining, grinding and superfinishing, Non-traditional manufacturing by chemical, electrochemical, electrophysical and mechanical processes.

**Total No. of Lectures :42**

### **Reference Books:**

1. A Textbook of Manufacturing Technology by R. K. Rajput
2. Manufacturing Technology by P. N. Rao
3. Manufacturing Processes and Systems, 9ed, by Jairo Munoz Phillip F. Ostwald

## **FF1175: Metal Melting Technology**

**Module I:** Melting furnaces for ferrous and non ferrous foundries. Electric and fuel fired furnaces.

Recent developments in energy considerations.

**Module II:** Melting practice for carbon steel and alloy steel, stainless steel, Manganese steel, high alloy aircraft, quality steel and super alloys.

**Module III:** Secondary refining, melting of cast iron-gray, malleable C.G., S.G., Ni-hard, Ni-resist, high silicon iron.

**Module IV:** Inoculation methods and materials. Melting practice of non-ferrous alloys of Al, Cu, Mg, Zn and Ni, Refining, Deoxidation, degassing and grain refinement treatments.

**Module V:** Shop floor melt quality tests, Rapid solidification, Near net shape casting.

**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

**FF1176: Failure Analysis**

**Credit: 03**

**Lecture Hour: 42**

**Objective:** To impart knowledge on the analysis of the probability of failure under various service conditions and methods to ensure safety.

**Module I**

Importance of failure analysis for casting and forge components, Steps in typical failure analysis: Collection of background data, Selection of failed and unfailed samples for examination, Preliminary examination. 6L

**Module II**

Non-destructive evaluation; Mechanical testing; Macroscopic and Microscopic examination.

8L

**Module III**

Determination of failure mode; Chemical analysis; Fracture mechanics considerations; Sample preparation methods for failure analysis. 6L

**Module IV**

Failure mode identification methods; Failure mechanisms; Wear failures, adhesive, abrasive, erosive, corrosive wear, Corrosion failures. 6L

**Module V**

Elevated temperature failures; Causes of failure in components: Misuse or Abuse, Assembly errors etc. Hydrogen embrittlement, Liquid metal embrittlement, Creep and stress rupture.

10L

## **Module VI**

Selection of suitable testing methods for failure analysis; Prevention of Failure and Recommendations to prevent reoccurrence. 4L

### **REFERENCE BOOKS**

1. "Understanding How Components Fail" by Donald J. Wulpi; ASM International Publication.
2. "Analysis of Metallurgical Failures: by Vito J. Colangelo; Francis A. Heiser Wiley Publication.
3. ASM Handbook Vol.11 - Failure Analysis and Prevention, ASM International Publication, 1995.
4. "Metallurgy of Failure Analysis" by A K. Das; by McGraw-Hill Professional Publication.
5. Metallurgical Failure Analysis by Charlie R. Brooks; Ashok Choudury; McGraw-Hill Publication.
6. Handbook of Case Histories of Failure Analysis, Vol 2. by A Esaklul Khlefa.

## **FF1177: DESIGN AND ANALYSIS OF EXPERIMENTS**

Overview and basic principles; Simple designs and analysis of variance (ANOVA); Block designs, Latin squares and related designs; Full factorial designs; 2-level full factorial and fractional factorial designs; Mixture Design; Taguchi Methods; Overview of response surface methods and designs; Designs with random factors, nested designs and split plot designs; Examples of scientific and engineering applications; DOE software. (42)

### Reference Books:

1. Design and Analysis of Experiments; Douglas C. Montgomery, Paperback, 2013.
2. Taguchi Techniques for Quality Engineering; Phillip J. Ross, McGraw Hill; ISBN-13: 978-0070539587

## **SEM II:**

### **FF1201: Forging Die Design & Manufacturing**

**42 Lectures**

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

II. 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

III. 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

IV. 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

V. Instruction for mounting, setting and working of dies, Die material selection, Die Wear, Factors minimizing die wear, Die failure analysis, Die life improvement 7

VI. 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 by T. Altan

## **FF1202: Foundry Tooling and Methoding**

**Module I:** Pattern Equipment for quality production of castings.

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

**Module III:** Special design features for high pressure moulding machines.

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

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



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

**Module VII:** Riser : 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

**Elective III**

**FF1241: 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 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**

#### **FF1242: 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

**FF1243: Modern Trends in Metal Forming Processes:**

Total No of lectures: 42

Course Contents:

Module 1: Limitation of conventional metal forming methods	[4 lectures]
Module 2: Powder rolling and its various variants, spray rolling	[7 lectures]
Module 3: Direct strip process	[4 lectures]
Module 4: Powder, spray, rotary and isothermal forging	[10 lectures]
Module 5: Hydrostatic and powder extrusion	[6 lectures]
Module 6: Conform process, Hydroforming	[4 lectures]
Module 7: Applications of these processes for making conventional and specialty products.	[7 lectures]

Ref Books: 1. ASM Metal Handbook Forming and Forging vol 14

2. Metal Forming :Process, Tools, Design by [Mohsen Kazeminezhad](#)

3. Plasticity: Fundamentals and Applications by P.M. Dixit, U.S. Dixit

4. Metal Forming : Technology and Process Modeling by U S Dixit and Narayanan

## **Elective IV**

### **FF1251: Technology of Non-Ferrous casting**

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

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

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

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

**Total No. of Lectures :42**

#### **Reference Books:**

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

### **FF1252: Mathematical Modeling and Computer application in Casting**

**Module I:** Mathematical modeling: Basic equations of diffusive, convective heat, mass, momentum transfer, turbulent system and concept of friction factor, heat & mass transfer coefficients and correlations.

**Module II:**Formulation of mathematicalmodel. Case studies.Numerical solution of partial differential equations.

**Module III:**Physical Simulation: Experimental design based on dimensional analysis, similarity criteria, case studies.

**Module IV:** Casting Design: Selection of any component, Design of pattern, selection of foundry technique, design of gating and feeding system, Simulation of casting, prediction of defects and finding of solution, validation of model; Structure-property relationship, Processing – microstructure correlation using finite element and phase field simulation methods.

**Total No. of Lectures: 42**

**Reference Books:**

1. Douglas C. Montgomery, *Design and Analysis of Experiments* (7<sup>th</sup> Edition), Wiley Student Edition, 09.
2. S. P. Gupta, *Statistical Methods*, S. Chand & Sons, 37<sup>th</sup> revised edition, 08
3. William W. Hines, Douglas C. Montgomery, David M. Goldsman, *Probability and Statistics for Engineering*, (4<sup>th</sup> Edition), Wiley Student edition, 06.
4. Advanced Engineering Mathematics (9<sup>th</sup> Edition), Erwin Kreyszig, Wiley India (13)

**FF1253: Methoding of Castings**

**Module I:** Principles of fluid flow.

**Module II:** Types and design of gating system.

**Module III:** Use of ceramic filters in gating system.

**Module IV:** Principles of solidification and heat transfer.

**Module V:** Design of risers -Improving risering efficiency-Insulating and exothermic sleeves. Introduction to design of castings-Selection of parting line-Design and construction of pattern and core box, Computer simulation of casting processes: Prediction of mould filling, solidification, residual stress and microstructure evolution and their role in design of casting, gating and risering.

**Reference Books:**

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

**Total No. of Lectures :42**

## **Elective V:**

### **FF1261: Quality Assurance and Inspection Methods**

- Introduction to total quality management, quality Policy, product reliability and life cycle. 6
- Taguchi's philosophy and robust product and process design, Six sigma concept. 5
- Quality circles, Quality audits, ISO-9000 prerequisites different systems and their structure. 5
- Probability distribution: Normal distribution, Control charts for attributes and variables, special control charts. 10
- 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.

10 Lectures

### 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.

### **FF1262: Energy conservation and Pollution control**

**Credit: 03**

**Lecture hours: 42 hours**

**Course Syllabus**

Energy – Sources, types and important aspects: Introduction to energy sources: How energy is produced and consumed, and ways in which it impacts society and the environment. (8L)

Physical understanding of issues and problems involved with the generation, storage, transport, and usage of various forms of energy in technological society, Principles of energy conversation. (8L)

Types of energy resources as Renewable and Non-renewable energy, fossil fuels and hydropower, nuclear, solar, and wind energy, and issues related to energy conservation in everyday life. (10L)

Pollution: Quantification of environmental pollution, various parameters and indexes. Types of environmental pollution and pollutants. (5L)

Causes, effects and control measures of – Air pollution, Water pollution, Soil/land pollution, Noise pollution, Radioactive pollution and Thermal pollution. Role of an individual in prevention of pollution. (11L)

**References:**

1. A textbook of Environmental Chemistry and Pollution Control:  
Dr. S. S. Dara and Dr. D. D. Mishra
2. Environmental studies:  
Dr. Suresh K. Dhameja
3. Energy and the Environment, 2nd Edition:  
Robert A. Ristinen and Jack J. Kraushaar.
4. Environmental Studies:  
Anindita Basak (Pearson Publications).
5. Introduction to Environmental Engineering and Science:  
Gilbert M. Masters (Prentice-Hall Publications).
- 6.. Environmental Pollution and Control. Butterworth-Heinemann USA  
Vesilind, P.J., Peirce, J.J., & Weiner R.F.

**FF1263: Finite Element Method**

1. Introduction: Physical problem, Mathematical modeling and Finite Element Solutions, FEM as an integral part of Computer Aided Design. 5L

2. General procedure used in FEM: Discretization, Formulation, Solving and post Processing. 6L

3. Mathematical Formulation: Types of 2D and 3D Elements and their properties, types of shape functions (Langrange and Hermite) Principle of virtual work and principle of minimum potential energy', consistent mass and lumped mass formulation, principle of minimization weighted residual and variational Methods, imposing of boundary conditions, formulation for isoparametric elements. 9L

4. Application of FEM –i) Static analysis-direct stiffness method, plan stress and strain elements, axisymmetric elements, nonlinear analysis, composite materials, time dependent loads,

determination of temperature distribution and thermal stresses, ii) Dynamic analysis-spring and dashpot elements, Eigen value analysis, frequency analysis, transient analysis. 9L

5. Computer implementation of FE procedures-various iterative methods used in static and dynamic analysis, inter-elemental continuity, convergence rate, refinement of FE solution, Validation of FE solutions, review of softwares in FEM. 9L

### **References:**

- 1) Klaus Jurgen Bathe, "Finite element Procedures", 1996 Edition, Prentice Hall of India Pvt. Ltd.
- 2) J N. Reddy,"An Introduction to finite Element Method", 1984 Edition, McGraw Hill book Pvt. Ltd.
- 3) O.C. Zienkiewicz, "The Finite Element Method" 1994 Edition, Tata McGraw Hill book Pvt. Ltd.
- 4) T.R. Chandrupatia and A.D. Belegundu, Introduction to finite Elements in Engineering" 2nd edition Prentice Hall of India Pvt. Ltd.
- 5) S.S. Rao, "The Finite Element Method in Engineering" 2nd Edition, Pergamon Press Oxford England.
- 6) RD. Cook, D.S. Malkas, M.E. Pleshan, 'Concept and applications of Finite Element analysis' 3rd Edition, John Wiley and Sons Publication.

### **FF1264: Material Handling**

Material handling system - principles and features of material handling system, importance, terminology, objectives and benefits of better material handling, classification of material handling equipment

Selection of material handling equipment - choice of material handling equipment, factors affecting for selection, general analysis procedures, basic analytical techniques, the unit load concept

Load lifting attachments - load chains and types of ropes used in material handling system, forged, standard and Ramshorn hooks, crane grabs and clamps; grab buckets; electromagnet; design consideration for conveyor belts; drums, sheaves, sprockets



Study of bulk material handling systems - objectives of storage; bulk material handling; gravity flow of solids through slides and chutes; storage in bins and hoppers; screw conveyor, vibratory conveyor, pneumatic & hydraulic conveyor (classification, types, principles of operation)

Automation in material handling - control of hoisting & conveying machinery, material handling in direct-line production and automated lines, safety and design; safety regulations and discipline

#### Reference Books

- 1) N. Rudenko, 'Material Handling Equipment', Peace Publishers
- 2) James M. Apple, 'Material Handling System Design', John-Wiley and Sons
- 3) John R. Immer, 'Material Handling' McGraw Hill
- 4) Colin Hardi, 'Material Handling in Machine Shops'. Machinery Publication Co. Ltd.,
- 5) M .P. Nexandrn, 'Material Handling Equipment', MIR Publication,
- 6) C. R. Cock and J. Mason, 'Bulk Solid Handling', Leonard Hill Publication Co. Ltd.,
- 7) Spivakovsy, A.O. and Dyachkov, V.K., 'Conveying Machines', Volumes I and II, MIR Publishers,
- 8) Kulwiac R. A., 'Material Handling Hand Book', John Wiley Publication

### **FF1265: Instrumentation and Automation**

- Introduction to Instruments and the representation: Typical Applications, Functional Elements, Classification of instruments, Microprocessor based instrumentation, Standards & Calibration 4L
- Introductory Instrumentation to process control. Modeling philosophies. The rationals for mathematical modeling dynamic versus steady state models. General modeling principles degrees of freedom in modeling. Control systems instrumentation. Transducers and transmitters. Transfer function models. Procedure for developing transfer function models. 10L
- Process system Engineering: Introduction to Unit operations, understanding and development of systematic procedures for the design and operation of process system, separation processes, computer-based techniques for design, operation and management of process plants, case study of chemical process plants. 10L
- Industrial Automation: Evolution of instrumentation and control, Role of automation in industries, Benefits of automation. Different types of processes. Typical examples of continuous, batch, discrete and hybrid processes. Study of Process flow, detailed P&ID, Critical loops, Safety and Alarms, Reliability and Fail-safe operation requirements, Efficient running and adhering to standards. Different standard for programming the control system Different types of control system. Controlling advance applications with DCS, SCADA and PLCs. Discussion of available and suitable feature in hybrid control system. HART, Foundation fieldbus, Profibus protocol introduction, frame structure, programming, implementation examples, Benefits, Advantages and Limitations Comparison with other fieldbus standards including Device net, Profibus, Controlnet,

CAN, Industrial Ethernet etc. Distributed Control Systems Engineering and Design DCS detail engineering, specifications, configuration and programming, functions including database management, reporting, Sequential event recording alarm management, communication, third party interface, control, display etc. Enhanced functions viz. Advance Process Control, Batch application, 18L

**References:**

1. Seborg . Process dynamic control, Wiley, 2007
2. Ernest O. Doebelin. Measurement system Application and Design. McGraw Hill International Editions, 1990
3. N. Viswanathan, Y. Narahari . Performance modeling of automated manufacturing system, Prentice Hall of India Private Limited, New Delhi, 2001
4. Warren McCabe, Julian Smith, Peter Harriott, “Unit operations of Chemical Engineering”, Mc Hills, 7th Edition 2004.
5. Lorenz T. Biegler, Egnacio e. Grossmann and Arthur W Westerberg, “Systematic Methods for chemical process design”, Prentice Hall, 1997.
6. D Warren D. Seider, J. D. Seader, Daniel R Lewin, SoemantriWidagdo, “Product and process design principles: Synthesis, Analysis and design”, Wiley, 3rd Edition 2008.