

BVM ENGINEERING COLLEGE [AN AUTONOMOUS INSTITUTION]

2PE01: MATERIAL SCIENCE AND PHYSICAL METALLURGY CREDITS - 4 (LTP:3,0,1)

Course Objective:

To enable students to acquire and use the basic concept of selection, processing & non-destructive testing of materials with a special focus on ferrous & non-ferrous metals/alloys for their engineering applications.

Teaching and Assessment Scheme:

Teaching Scheme (Hours per Week)			Credits	Assessment Scheme				
L	T	P		C	Theory Marks		Practical Marks	
			ESE		CE	ESE	CE	
3	0	2	4	60	40	20	30	150

Course Contents:

Unit No.	Topics	Teaching Hours
1	Introduction to Material Science & Physical Metallurgy: Classification of engineering materials, Engineering requirements of materials, Factors affecting selection of engineering materials for engineering applications through Structure-Property-Performance co-relationship, Introduction to levels of structures based on level of observation (Macro, Micro, Crystal, etc.), Co-relation of properties with type of structures and methods/tools to reveal them.	03
2	Crystal Imperfections & Diffusion Processes: Ideal & imperfect crystals, Types of imperfections, Effects of crystal imperfections on properties of materials, Significance of imperfections, Strengthening mechanisms in metals/alloys using imperfections. Diffusion Processes: Types, Mechanisms, Laws of diffusion and Applications of diffusion in engineering processes.	06
3	Effects of strain hardening on properties: Recovery, Recrystallization & Grain growth of strain hardened materials and their effects on properties of materials.	02
4	Solidification of Metals & Alloys and Principles of Alloy Formation: Solidification: Crystallization, Mechanism of crystallization – nucleation & growth, Factors influencing nucleation & growth, Nucleation and growth during freezing of pure metal and alloy ingot casting and resulting structures, Effects of structures on mechanical properties of metals/alloys, Methods to control grain structure resulting from solidification, Solidification	10

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Unit No.	Topics	Teaching Hours
	<p>defects such as porosity, shrinkage, pipe, etc. & remedies for eliminating or reducing them.</p> <p>Principles of Alloy Formation: Terminology used in phase equilibrium, Unary & Binary phase equilibrium diagrams, Gibb's phase rule, Constitution of Alloys: Purpose of alloying, solid solutions & compounds, Hume-Rothery rules, Cooling curves for pure metal, compound & solid solutions, Binary phase equilibrium diagrams: Isomorphous system, lever rule & chemical composition rule, different reactions like eutectic, euctectoid, peritectic & peritectoid on phase diagrams, Non-equilibrium cooling & concept of coring.</p>	
5	<p>Iron-Iron Carbide Phase Equilibrium Diagram & Heat Treatments of Steels: Introduction, Allotropy of iron, Iron-Iron Carbide equilibrium system-phases & their properties, various reactions of the iron-iron carbide equilibrium diagram, Alloy groups on iron-iron carbide equilibrium diagram & their characteristics in general, Equilibrium cooling of hypoeutectoid, eutectoid & hypereutectoid steels, their resulting microstructures and correlated properties and applications. IS and ISO Coding, Different specifications & designations of steels and cast irons.</p> <p>Heat Treatment of Steels: Introduction & definition, Time-Temperature-Transformation Diagram (TTT-diagram), Isothermal & Continuous Transformations (CCT), Heat treatment processes with thermal cycles for plain carbon steels such as different types of Annealing, Normalizing, Hardening, Tempering, Austempering and Case hardening methods: Carbursing, Nitriding, Cyaniding, Flame hardening, Induction Hardening, and Applications of above methods in industrial practices, Concept of Hardenability & its significance.</p>	10
6	<p>Alloy Steels and Cast Irons:</p> <p>Alloy Steels: Introduction, General effects of alloying elements on ferrite and carbide, formation, Transformation temperature, Types of Alloy Steels: Chromium, Manganese, Molybdenum Steels, Stainless Steels and there ISO Codification.</p> <p>Tool Steels: Classification, properties, applications, IS & ISO Codifications.</p> <p>Cast Irons: Introduction & Classification, Iron-Iron carbon & Iron-Iron carbide diagrams, Transformation resulting into White cast iron, Grey cast iron, Malleable cast iron, Nodular cast iron (SG iron) and Alloy cast irons, their microstructures, correlated properties and applications, IS codifications for cast irons.</p>	11

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Unit No.	Topics	Teaching Hours
	Non-ferrous Metals & Alloys: Compositions, Properties & Application of Aluminum & its alloys and Copper & its alloys.	
*	Non Destructive Testing: (To be covered in Laboratory Practical) Introduction, advantages, disadvantages of Non Destructive Testing (NDT), Comparison of NDT with Destructive Testing (DT), Basic Elements of any NDT Method, Non Destructive testing of materials such as Dye (Liquid) Penetration Testing, Magnetic Particle Testing, Ultrasonic Testing. Radiography Testing with their principle, capability of the methods, the steps in test methods, relative merits, demerits and applications	
	Total	42

List of References:

1. Donald R. Askeland and Pradeep P. Phule, “*The Science and Engineering of Materials*”, 6th Edition, Cengage Learning.
2. W F Smith, “*Principles of Materials Science and Engineering*”, McGraw Hill.
3. R. Balasubramaniam, “*Callister’s Material Science and Engineering*”, 2/e, Wiley India
4. Sydney H. Avner, “*Physical Metallurgy*”, Tata McGraw-Hill.
5. Baldev Raj, T. Jayakumar and M. Thavasimuthu, “*Practical Non-Destructive Testing*”, Narosa Pub. House.
6. Richard A. Flinn and Paul K. Trojan, “*Engineering Materials and their Applications*”, Jaico Publishing House.
7. James F. Shackelford, “*Introduction to Material Science for Engineers*”, 7th Edition (International); Pearson/Prentice Hall (2009).
8. George F. Vander Voort, “*ASM Handbook Vol. 9: Metallography and Microstructure*”, ASM International (2004).
9. K. I. Parashivamurthy, “*Materials Science and Metallurgy*”, Pearson Education.
10. James A. Jacobs, Thomas F. Kilduff, “*Engineering Material Technology*”, 5th Edition, Pearson/Prentice Hall (2004).
11. Michael F. Ashby & David R. H. Jones, “*Engineering Material 2: An Introduction to Microstructure, Processing & Design*”, 3rd edition, Butterworth-Heinmann (2006).
12. Robert E. Reed Hill, “*Physical Metallurgy Principles*”, Second Edition, Cengage Learning (2010).

Course Outcomes (COs):

At the end of this course students will be able to

1. Develop understanding of structure-property-performance relationship for the material selection with a special focus on metals/alloys.
2. Understand the rationale of given heat treatment cycle for ferrous and nonferrous group of materials for the given engineering application.
3. Learn the basic skills of metallographic practices and understand the basic concept of nondestructive testing for detecting internal defects in the material.
4. To understand the mechanism of solidification & appreciate its significance in casting/welding.