GUJARAT TECHNOLOGICAL UNIVERSITY

AUTOMOBILE ENGINEERING (02) /MECHANICAL ENGINEERING (19)

MATERIAL SCIENCE & METALLURGY

SUBJECT CODE: 2131904

B.E. 3RD SEMESTER

Type of Course: Engineering

Prerequisite: Zeal to learn the subject

Rationale: Basic principles of science are used to study the structure-properties relationships of various materials for their proper applications in this subject. Especially study of different types of ferrous and non-ferrous metals and alloys, in terms of their composition, structure, properties and applications; non-destructive testing are included in this course to understand the basic concept of selection and processing of metals and materials for their applications.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks			Practical Marks			
				ESE (E)	PA (M)		PA (V)		PA (I)	
					PA	ALA	ESE	OEP		
3	0	2	5	70	20	10	20	10	20	150

Sr. No.	Topics	Teaching Hrs.	Module Weightage
1.	Introduction to Material Science Metallurgy: Classification of Engineering Materials, Engineering requirements of materials, , Criterion for selection of materials for engineering applications through Structure-Properties-Performance correlationship; Introduction to levels of internal structure like macro, micro, crystal and atomic and their correlated properties; Methods/Tools to reveal the different levels of structure.	3	5%
2.	Crystal geometry and Crystal Imperfections: Unit Cell, Crystal structure, Bravise lattice, atomic packing, coordination number, crystal structures of metallic elements, crystal directions and planes, Miller indices, Polymorphism or Allotropy. Crystal structure and correlated properties. diffusion processes; Crystallization: Mechanism of crystallization – nucleation and growth, factors influencing nucleation and growth Imperfections in crystals and their effect on properties, Solute strengthening	5	8%
3.	Plastic Deformation: Deformation by slip, Mechanism of slip, Slip in different lattice structures, Deformation by twinning, Strain hardening , Effect of strain hardening on properties, Recovery, Recrystallization and Grain Growth and their effect on properties of ductile metals.	3	5%
5.	Solidification of metals and an alloy, Nucleation and Growth during freezing of pure metal and alloy ingot/a casting Resultant macrostructures; Effects of Structure on Mechanical Properties, Methods to control the grain structure resulting from solidification, Solidification defects like porosity and shrinkage and remedies.	4	7%
6.	Phase and Phase equilibrium: Unary and Binary equilibrium phase diagrams, Gibb's free energy for thermodynamic stability of phases, Gibb's phase rule, solid solutions and compounds, Hume-Rothery rules; cooling curves, lever rule, Different reactions like eutectic, eutectoid, peritectic and peritectoid; Non-equilibrium cooling;	3	9%

7.	Allotropy of Iron, Iron-Iron-Carbide equilibrium system-phases and their properties of the Iron-Iron Carbide equilibrium diagram, different reactions of the Iron-Iron Carbide equilibrium system, Alloy groups (Wrought Irons, Steels and Cast Irons) of Iron-Iron Carbide equilibrium system and their characteristics in general, Equilibrium cooling of eutectoid, hypoeutectoid and hypereutectoid steels, their resultant microstructures and hence correlated properties and applications. . IS and ISO Codification, Different specifications and designations of steels	5	15%
8.	Heat Treatment of Steels: Time-Temperature-Transformation Diagram, Isothermal and continuous transformations; Austenitic grain size control/grain refinement, study of effects like temper-brittleness, overheating and burning of steels Study of Heat-Treatment processes with heat treatment cycles for plain C steels such as Different types of Annealing, Normalizing, hardening and tempering, full hardening and case hardening methods; Applications of above processes for the industrial practices.	5	15%
9.	Alloy steels: Purpose of alloying; General effect of alloying elements on ferrite, carbide, transformation temperature, hardenability and tempering. Types: Chromium, Manganese, Molybdenum and Manganese steels. IS Codification. Tool Steels: Classification, properties, applications and IS and ISO Codification.	2	5%
10.	Cast Iron: Iron-Iron Carbide and Iron-carbon diagrams, Transformations resulting into White Cast Iron, Grey Cast Iron, Malleable Cast Iron, S. G. Iron, Alloy Cast Iron. Their microstructures and correlated properties and applications. IS Codification.	3	6%
12.	Non-ferrous alloys: alloys of copper, aluminium, magnesium titanium. Other alloys of lead, tin, zinc, nickel, manganese, white metals and bearing alloys.	3	6%
13	Powder Metallurgy: Application and advantages, Production of powder, Compacting, Sintering, Equipment and process capability.	3	5%
14	Non Destructive testing of materials such as Radiography Testing, Dye Penetration Testing, Magnetic Particle Testing, Ultrasonic Testing. Eddy current testing with their Principle of non-destructive testing, the test methods, relative merits, demerits and applications.	4	10%
15.	Metallography: Structure of Metals, Macro-examination: Macro-etching; Microscopic examinations: Specimen Preparation, etching, grain size measurement; Chemical analysis of steel and Iron for Carbon, Sulphur & Phosphorous.	*	4%

*** Topic should be cover during laboratory session only.**

References:

1. Callister's Material Science and Engineering, 2/e R. Balasubramaniam, Wiley India.
2. Elements of Material Science and Engineering, 6/e, Lawrence H. Van Vlack, Pearson Education.
3. The Science and Engineering of Materials 6/e, Donald R. Askeland and Pradeep P. Phule, Cengage Learning.
4. Principles of Materials Science and Engineering, W F Smith, McGraw Hill.
5. Materials Science and Metallurgy, K. I. Parashivamurthy, Pearson Education.
6. Physical Metallurgy, Sydney H. Avner, Tata McGraw-Hill.
7. Practical Non-Destructive Testing, Baldev Raj, T. Jayakumar and M. Thavasimuthu, Narosa Pub. House.
8. ASM Handbook Vol. 9: Metallography and Microstructure, Ed. George F. Vander Voort, ASM International 2004.

Course Outcomes: At the end of this course students will be able to:

1. Understand the basic concept of Material Science and Metallurgy.
2. Know about the ferrous and non ferrous metals and alloys and their applications.
3. Understand different non-destructive testing methods.
4. Find the causes and prevention of metallic corrosion.
5. Judge the Scope and limitations of different materials.

List of Practical:

1. To get acquainted with the operation, construction, use and capabilities of a metallographic microscope
2. To study procedure of specimen preparation for microscopic examination and to carry out a specimen preparation.
3. To understand what is micro examination, importance of micro examination and to study various ferrous, non-ferrous microstructures.
4. To identify the different types of material available for design, manufacturing and processing of various components based on structure-property-performance-processing relationships.
5. To show the effect of different quenching media (Oil, Water and Brine) on the hardness of medium carbon steel.
6. To understand the concept of hardenability and its relevance to heat treatment procedure to be adopted in practice.
7. To find out the effect of varying section size on hardenability of steel and obtain hardness distribution curves of hardened steel cross-section.
8. Study of different heat treatment processes- annealing, normalizing, hardening and tempering, surface and casehardening to improve properties of steel during processes and applications.
9. To understand the procedure of testing, nature of indication, the capability and sensitivity of the liquid penetrant test and the magnetic particle test.
10. To understand the procedure of testing, nature of indication, the capability and sensitivity of the Eddy current test and the Ultrasound test.

Open Ended Problem:

1. Design a machine / evolve a procedure to manufacture porous/spongy metals and demonstrate the same.
2. Design a bimetallic strip to be used as a thermostat.
3. Design a machine to determine friction coefficient between two metals. One of the materials is available in the form of 5mm dia. pins.
4. Develop an experimental setup/apparatus to determine thermal critical point of a metal.
5. Design a machine to determine the strength of Bamboo - tension, compression.
6. Students may be asked for metallography to prepare specimens for microstructure analysis. Moreover they may be asked to provide design of heat treatment cycles of specific types of steels for their applications, e.g., design heat treatment cycle for tool steel.
7. Students may be asked to choose a material for given application based on structure-property-performance relationship. Also they should give specification and designation of a chosen material.

Major Equipment: Metallurgical microscope with computerized image analysis system, Standard specimen set of steel, cast iron and non- ferrous metals and alloys, Spectrometer, Muffle furnace, standard specimens of steels and cast iron for heat treatment, Hardness tester, Universal tensile testing machine.

ACTIVE LEARNING ASSIGNMENTS: Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the

students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.