GUJARAT TECHNOLOGICAL UNIVERSITY

METALLURGY ENGINEERING (21)
MATERIAL DEGRADATION AND PREVENTION
SUBJECT CODE: 2162108
B.E. 6th SEMESTER

Type of course: Engineering Science

Prerequisite: Knowledge of Elements of Metallurgy and basic science skills

Rationale: The Material Degradation and Prevention course is to prepare students for careers in metallurgy engineering where knowledge of processes leading to degradation of materials and Prevention can be applied to the advancement of technology. Knowledge of Characteristic features, causes and remedial measures of both mechanical and chemical degradation of materials is must for a metallurgist to select a candidate material for a given engineering application as well as to provide solution of a given material degradation problem. This course will enable students to solve different metallurgical problems upon graduation while at the same time, provide a firm foundation for the pursuit of graduate studies in metallurgy engineering.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks			Practical Marks			
				ESE (E)	PA (M)		ESE (V)		PA (I)	
					PA	ALA	ESE	OEP		
4	0	2	6	70	20	10	20	10	20	150

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	Introduction and scope of the subject. Types of processes leading to degradation of materials viz. Oxidation, Corrosion, Wear, Creep and Fatigue. Technological importance of corrosion study, Corrosion as useful process, Factors affecting corrosion, Corrosion rate expressions. Faradays' laws of electrolysis, current density, Electrochemical principles of corrosion, Cell analogy, electrode potential, Reference electrodes. e.m.f. and galvanic series - their uses in corrosion studies. Thermodynamics and Kinetics of Electrode Processes-Polarization Curves, Over-Potential, Passivity and Transpassivity, Nernst's Equation, Pourbaix diagram for Metal Water System.	**14**	**23.5**
2	Characteristic features, causes and remedial measures of different forms of corrosion: Dry & Wet corrosion, Uniform, Galvanic, Crevice, Pitting, Crevice, Erosion, Intergranular, Selective leaching, Stress corrosion cracking, Hydrogen Damage, Liquid metal attack, Liquid metal embrittlement, Chemical degradation of non-metallic materials like rubbers, plastics, ceramics etc.	**10**	**17**
3	Introduction to high temperature corrosion, Pilling-Bedworth ratio, Oxidation kinetics, Prevention of high temperature corrosion, high temperature alloy design, Use of coatings.	**05**	**8**
4	Corrosion control: Principles of corrosion prevention, Material selection, Design considerations, Control of environment including Inhibitors and Passivators, Coatings – metallic, inorganic, organic, Electroplating of copper, Nickel and Chromium, electroless plating, Anodising, Galvanizing, Thermal spraying, Alloy plating, Cathodic and anodic protection. Chemical and electrochemical	**12**	**20**

	polishing: Phosphating, Chromating, Chemical colouring. Corrosion testing methods.		
5	Wear of materials, Analytical methods of wear, Wear resistant materials, Wear resistant coatings, Surface modification to improve wear resistance.	**05**	**8**
6	Recent trend in surface engineering: Physical vapour deposition (PVD), Evaporation, Sputtering, Ion plating, Chemical vapour deposition (CVD). Use of Laser and plasma in surface engineering. Surface modification by directed energy beams. Surface modification by Friction stir processing: Surface composites. Novelty of surface composition and microstructure, Specific industrial applications.	**14**	**23.5**
	Total	**60**	100

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
15	**30**	**30**	**10**	**10**	**05**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Emerging Trend in Corrosion Control – Evaluation, Monitoring and Solution, Editors: A. S. Khanna, K. S. Sharma and A. K. Sinha, Academia Books International
2. Surface Modification Technologies - An Engineer's Guide by T. S. Sudarshan, Marcel Dekker
3. Electroplating and Other Surface Treatments - A Practical Guide' by C. D. Varghese, TMH
4. Surface Treatments for Protection, The Institute of Metallurgists
5. Wear of Metals by A. D. Sarkar
6. Surface Engineering, ASM
7. Introduction to High Temperature Corrosion and Oxidation by A. S. Khanna, Quest publication
8. Corrosion Engineering, 2nd ed., M. Fontana Mc Grew Hill, 1987
9. Corrosion and Corrosion Control, 3rd ed., H.H.Uhlig Wiley, 1986
10. An introduction to electrometallurgy- Satya Narayan & Rajendra Sharan, Standard Publishers & Distributors, New Delhi
11. An introduction to metallic corrosion & its prevention by Rajnarain

Course Outcome:

After learning the course the students should be able to:

1. Explain principles and different terms of corrosion.
2. Classify and explain Characteristic features, causes and remedial measures of different forms of corrosion.
3. Explain the high temperature corrosion principles and its prevention methods.
4. Describe the principal and different methods of corrosion protection.
5. Understand and explain working of different metallic coating processes.
6. Explain corrosion rate expressions and testing methods.
7. Explain wear testing and prevention methods.
8. Describe advancements in surface engineering.
9. Demonstrate the ability to use the core concepts of engineering application in Material Degradation and Prevention.
10. Demonstrate the ability to select the candidate material for a given metallurgical application considering environmental aspects.
11. Analyze causes of material degradation problem and suggest methods of minimization it to obtain qualitative solutions of metallurgical operation.

List of Experiments:

1. To study electrochemical principles and types of corrosion.
2. To study & observe pitting corrosion in stainless steel.
3. To determine corrosion rate of given sample by weight loss method.
4. To determine corrosion rate of given sample by Tafel extrapolation method.
5. To study different types of corrosion protection methods.
6. To study Electroplating process and perform the electroplating of copper on a given base metal.
7. To study and perform the Anodizing of Aluminium in H_2SO_4 Solution.
8. To study different hot dipping process
9. To measure the wear rate of given specimen.
10. To Study Ion beam implantation for surface modification.

Design based Problems (DP)/Open Ended Problem:

1. Chart of Characteristic features, causes and remedial measures of different forms of corrosion.
2. Problems based on Faraday's laws, Nernst's Equation and weight loss in corrosion.
3. Chart of different corrosion prevention methods.
4. Chart of wear mechanism and prevention methods.
5. Collection and Study of various samples of degraded materials (corrosion and wear).
6. Group discussion and Presentations on Recent trend in surface engineering.
7. Any other problem decided by faculty based on syllabus.

Major Equipment: Ultrasonic cleaner, oven, single pan balance, potentiostat, electrolytic tank, anodizing tank, wear test unit etc.

List of Open Source Software/learning website:

1. http://nptel.iitm.ac.in/
2. www.ocw.mit.edu

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.