

GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2021(COGC-2021)

Semester-V

Course Title: Corrosion of Metal

(Code: 4352102)

Diploma Programme in which this course is offered	Semester in which offered
Metallurgy Engineering	5 th Semester

1 RATIONALE

Billions of rupees are lost due to corrosion. Since a metallurgist is responsible for extraction of metals, s/he is also the right person to suggest prevention methods to corrosion. This course is designed so that the diploma metallurgical engineer is able to acquire the basic skills in all the domains of learning so that s/he can take measures to prevent and minimize different types of corrosion in various metals.

2 COMPETENCY

The course content should be taught and curriculum should be implemented with the aim to develop required skills in students so that they are able to acquire following competencies.

- Take the suitable measures to prevent or minimize the corrosion of various metals.

3 COURSE OUTCOMES (COs)

At the end of the study of this course the student will be able to:

CO1: Discuss the basic concept of corrosion.

CO2: Understand the different theories of corrosion.

CO3: Identify various forms of corrosion.

CO4: Suggest suitable method to prevent corrosion of a given component.

4 TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	CA	ESE	CA	ESE	
3	0	4	5	30*	70	50	50	200

(*): Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessing the attainment of the cognitive domain UOs required for the attainment of the COs.

Legends: L-Lecture; T – Tutorial/Teacher Guided Theory Practice; P -Practical; C – Credit, CA - Continuous Assessment; ESE -End Semester Examination.

5 SUGGESTED PRACTICAL EXERCISES

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Measure rate of corrosion by using weight loss method of various metals/alloys in different corrosive medium like acid, alkali.	I	08
2	Observe the electrochemical nature of corrosion of different metals in acidic solution.	II	04
3	Demonstrate passivity observed during the different metal is immersed in different concentration of HNO ₃ Acid.	II	04
4	Measure electrode potential of different metals with reference to standard electrode.	II	04
5	Prepare a report on various types of corrosion as seen around you.	III	04
6	Demonstrate galvanic corrosion of metals in various media.	III	04
7	Demonstrate Intergranular corrosion under certain environmental Conditions on AISI 304 stainless steel (Austenitic stainless steel).	III	08
8	Perform electroplating of copper on mild steel for corrosion prevention as per IS code.	IV	04
9	Perform Salt spray test in caustic environment on various metals like C.I, M.S and S.S.	IV	08
10	Perform Hot Dip Galvanising for corrosion protection on mild steel as per IS code.	IV	08
Total Hours			56

Notes:

1. More Practical Exercises can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list.
2. The following are some sample 'Process' and 'Product' related skills (more may be added/deleted depending on the course) that occur in the above listed Practical Exercises of this course required which are embedded in the COs and ultimately the competency.

Sr. No.	Sample Performance Indicators for the PrOs.	Weightage in %
1	Identification of the component and Preparation of experimental Set-up	20
2	Operate equipment set-up	10
3	Observation and recording of the data correctly	10
4	Interpretation of the result and conclusion	20
5	Safety precaution and safety gadgets used	20
6	Submission of report within time limit and attendance in the laboratory	20

6 MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

These major equipment with broad specifications for the PrOs is a guide to procure them by the administrators to user in uniformity of practical's in all institutions across the state.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Digital Weighing Balance Capacity- upto 1 kg.	1
2	Muffle furnace Temperatute -upto 1500°C Heating element-Kanthal Wire	7
3	Metallurgical microscope/ Image Analyzer Magnification- upto 2000X	7
4	D.C Power Source 220 V, 50 Hz Single Phase AC	8
5	Salt spray chamber Voltage: AC 220 V, 50 Hz Power: 15 amp. Operating temperature of chamber: Ambient to 38°C Test time: 0 to 9999 Minutes, adjustable Temperature Fluctuation: 1 °C	9
6	Melting furnace Temperature -upto 2000°C Heating element-Kanthal Wire	10

7 AFFECTIVE DOMAIN OUTCOMES

The following sample Affective Domain Outcomes (ADOs) are embedded in many of the above-mentioned Cos. More could be added to fulfill the development of this course competency

- Student will observe various corroded components in surroundings and identify the types of corrosion.
- Student will apply suitable techniques to prevent/minimize the corrosion.
- Student will prepare a report on corrosion prevention techniques being used in an Industrial visit.

8 UNDERPINNING THEORY

The major underpinning theory is given below based on the higher level UOs of Revised Bloom's taxonomy that are formulated for development of the COs and competency. If required, more such UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Major Learning Outcomes	Topics and Sub-topics
UNIT-I Introduction to Corrosion	1a. Differentiate between corrosion and erosion. 1b. Measure the corrosion rate.	1.1. Corrosion and Erosion, Dry Corrosion, Wet Corrosion, Factors affecting on corrosion, Cost factors involved in corrosion 1.2. Corrosion rate measurement by weight-loss method.
UNIT-II Theories of Corrosion	2a. Explain the electrochemical behavior of corrosion. 2b. Differentiate between EMF and Galvanic Series. 2c. Discuss about passivity and polarization mechanism.	2.1. Electrochemical nature of corrosion 2.2. Electrochemical and Electrolytic Cell 2.3. Anodic-Cathodic reactions 2.4. EMF and Galvanic Series 2.5. Passivity 2.6. Polarization: Activation, Concentration and Resistance polarization
UNIT-III Forms of Corrosion	3a. Discuss the mechanism and remedies for various types of corrosion.	3.1. Classification of different types of corrosion. 3.2. Mechanism and Remedies of: (1) Uniform Corrosion (2) Galvanic Corrosion (3) Crevice Corrosion (4) Pitting Corrosion (5) Intergranular Corrosion (6) Stress Corrosion Cracking (7) Erosion Corrosion (8) Hydrogen Damage (9) Corrosion Fatigue
UNIT-IV Corrosion Prevention Techniques	4a. Classify various corrosion prevention techniques. 4b. Explain different corrosion prevention techniques.	4.1. Classification of corrosion prevention techniques 4.2. Corrosion prevention by design modification, change of environment, change of metal 4.3. Cathodic and Anodic Protection 4.4. Coating: Electroplating, Tinning, Galvanizing, Anodizing

9 SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Introduction to Corrosion	06	6	2	2	10
II	Theories of Corrosion	12	6	6	4	16
III	Forms of Corrosion	12	6	10	8	24
IV	Corrosion Prevention Techniques	12	4	10	6	20
Total		42	22	28	20	70

Legends: R = Remember; U = Understand; A = Apply and above levels (Bloom's revised taxonomy)

Notes:

1. This specification table shall be treated as a general guideline for students and Teachers. The actual distribution of marks in the question paper may slightly vary from above Table.
2. Ask the questions from each topic as per marks weightage. Numerical questions are to be asked only if it is specified. Optional questions must be asked from the same topic.

10 SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related co-curricular activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group

1. Make a chart for various types of corrosion and corrosion prevention techniques.
2. Collect various corroded components and identify type of corrosion.
3. Prevent various corrosion of some component by suitable techniques.
4. Group discussion on environmental issues due to corrosion.

11 SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

- a) Massive open online courses (MOOCs) may be used to teach various topics/sub topics.
- b) Guide student(s) in undertaking micro-projects
- c) 'L' in section No. 4 means different types of teaching methods that are to be employed by teachers to develop the outcomes.
- d) About 20% of the topics/sub-topics which are relatively simpler or descriptive in nature is to be given to the students for self-learning, but to be assessed using different assessment methods.
- e) With respect to section No.10, teachers need to ensure to create opportunities and provisions for co-curricular activities.
- f) Guide students on how to address issues on environment and sustainability.
- g) Encourage students to read codes and standards.

12 SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be individually undertaken to build up the skill and confidence in every student to become problem solver so that he/she contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should not exceed three.

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than 16 (sixteen) student engagement hours during the course. The student ought to submit micro-project by the end of the semester to develop the industry-oriented COs.

A suggestive list of micro-projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

1. Prepare a chart for various corrosion.
2. Prepare a model of electrolytic cell.
3. Observe various corrosion in surroundings and make a report.
4. Apply suitable techniques to prevent/minimize the corrosion of component.

13 SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
1	Corrosion Engineering	Mars G. Fontana	Publisher: Tata McGraw Hill Edu. Pvt Ltd. Place: New Delhi Year: 2005, Eighth reprint: 2009 ISBN-10: 0-07-060744-3 ISBN-13: 978-0-07-060744-6
2	Corrosion and Corrosion Control: An Introduction to Corrosion Science and Engineering	R. Winston Revie, Herbert H. Uhlig	Publisher: John Wiley & Sons Year: 2008 ISBN: 9780471732792
3	An Introduction to Metallic Corrosion and Its Prevention	Raj Narayan	Publisher: Oxford & IBH Publishing Company Place: New Delhi Year: 1983
4	An Introduction to Electrometallurgy	Dr. R. Sharan, Satya Narain	Publisher: Standard Publication Place: Delhi

GTU - COGC-2021 Curriculum

GTU - COGC-2021 Curriculum

			Year: 2011 (New Edition) ISBN-10: 8180142450 ISBN-13: 978-8180142451
5	Corrosion Prevention and Protection- Practical solutions	V.S.Sastri and Edward Ghali, Mimoun Elboujdaini	Publisher: John Wiley & Sons Year: 2007 ISBN-10: 9780470024027 ISBN-13: 978-0470024027
6	ASM Handbook volume 13A, Corrosion		

14 SOFTWARE/LEARNING WEBSITES

- <https://vlab.amrita.edu/?sub=3&brch=190&sim=361&cnt=4>
- <https://corrosion-lab.netlify.app/>
- <http://www.presentingscience.com/vac/corrosion/popuplab.htm>
- <https://www.edumedia-sciences.com/en/media/569-rust>
- <https://archive.nptel.ac.in/courses/113/104/113104082/>

15 PO-COMPETENCY-CO MAPPING

Semester V	Corrosion of Metal (Course Code: 4352102)						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/development of solutions	PO 4 Engineering Tools, Experimentation & Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Management	PO 7 Life-long learning
Competency	Take the suitable measures to prevent or minimize the corrosion of various metals.						
CO1: Discuss the basic concept of corrosion.	3	--	1	--	--	1	1
CO2: Understand the different theories of corrosion.	3	1	2	2	--	1	2
CO3: Identify various forms of corrosion.	3	2	2	2	1	2	2
CO4: Suggest suitable method to prevent corrosion of a given component.	3	2	2	2	1	2	2

16 COURSE CURRICULUM DEVELOPMENT COMMITTEE**GTU Resource Persons**

S. No.	Name and Designation	Institute	Contact details
1.	NIRMALKUMAR G. PATEL Lecturer, Metallurgy Engineering	Dr. S. & S.S. Ghandhy College of Engineering and Technology, Surat	nirgpatel@gmail.com
2.	ROHAN J. PATEL Lecturer, Metallurgy Engineering	Government Polytechnic, Bhuj	patelrohan930@gmail.com
