21CH600 Corrosion Science and Engineering 2-0-1-3

Course Objectives

- To introduce the thermodynamic and electrochemical aspects of corrosion
- To impart knowledge on the corrosion mechanism and corrosion testing methods for advanced engineering materials
- To demonstrate the correlation between the microstructure and corrosion of the metallic materials
- To convey the necessity of corrosion protection of materials for prevention of failures and sustainable material usage

Course Outcomes

At the end of the course, the student will be able to:

- To describe the forms, mechanism, and kinetics of corrosion
- To comprehend the correlation between the microstructure and property of the material
- To determine the probable corrosion, corrosion rate, and corrosion mechanism of the metallic material in the given environment
- To recommend a suitable corrosion protection method for sustainable materials use.

Program Outcomes

- An ability to independently carry out research/investigation and development work to solve practical problems
- An ability to write and present a substantial technical report/document
- Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
- Acquire ethical and intellectual integrity in research and apply the impact of research outcomes for the sustainable development of societ

Course Articulation Matrix

Course Outcomes – Programme Outcomes – Programme Specific Outcomes

	PO1	PO2	PO3	PO4
CO 1	1	2	-	-
CO 2	3	3	2	-
CO 3	3	3	2	-
CO 4	3	2	1	3

Syllabus

Basics of corrosion: Thermodynamics and electrochemical aspects of corrosion; EMF and galvanic series; Pourbaix diagram; Evans diagram; Corrosion mechanism – kinetics of activation polarization, kinetics of passivation polarization, mixed potential theory, diffusion, limiting current tendency; Corrosivity and passivity.

Forms of Metallic Corrosion: Uniform, pitting, crevice, intergranular, stress corrosion, corrosion fatigue, dealloying, high-temperature, biological, liquid metal attach, and exfoliation; Atmospheric corrosion of metallic materials: Steel (marine environment, nuclear power plants), aluminum alloy (marine environment), and magnesium alloys (biological medium).

Corrosion Failure Analysis: Metallic components in aircraft, aerospace, automobile, marine, and biomedical application; Advanced instrumental characterization – field emission scanning electron microscope, high-resolution transmission electron microscope, energy-dispersive x-ray spectroscopy, x-ray diffractometer, atomic force microscopy, x-ray photoelectron spectroscopy; Corrosion prevention through design, coatings, cathodic and anodic protection.

Corrosion Testing and Monitoring (*Coverage in Lab*): Quantitative measurement of corrosion rate – weight loss, accelerated corrosion, cyclic corrosion (environmental control), electrochemical – potentiodynamic polarization, cyclic voltammetry, impedance techniques, and hot-salt

Lab Experiments:

1. Potentiodynamic Polarization Test
2. Immersion Corrosion Test
3. Cyclic Corrosion Test
4. Hot-Salt Corrosion Test (Demonstration on Nickel-based Superalloy and Nuclear Grade Steel)

Text Books:

- Mars G Fontana, Corrosion Engineering, McGraw Hill (3rd Edition)
- Pierre R. Roberge, Corrosion Inspection and Monitoring, Wiley (2006)

References:

- Uhlig's Corrosion Handbook, Wiley (3rd Edition, 2011)
- Nastor Perez, Electrochemistry and Corrosion Science, Kluwer Academic Publishers (2nd Edition, 2004)
- Philip A. Schweitzer, Fundamentals of Corrosion, CRC Press (1st Edition, 2009)
- R. Winston Revie and Herbert H. Uhlig, Corrosion and Corrosion Control: An Introduction to Corrosion Science and Engineering, Wiley (4th Edition, 2008)
- Research Opportunities in Corrosion Science and Engineering, National Academic Press, Washington D.C. (2011)

Employability Aspects

The degradation of materials, including metals, concrete, polymers, and other materials costs the global economy 3 to 5% of the global Gross Domestic Product (GDP) annually. Hence, the course on "Corrosion Science and Engineering" has an imminent requirement. The course will diversify the skill set of students for employment opportunities across a broad spectrum of industries such as petrochemical, automotive, manufacturing, and production industries. Also, the course widens the opportunities for research careers of students in renowned academic institutions, research labs, research centers, and western universities.

Skill Matrix

Skill	Skill Level
Review and evaluate the corrosion of metallic materials	3
Apply comprehensive knowledge of corrosion and corrosion control engineering	2
Perform failure analysis & investigation: Metals & Coatings	1
Evaluate the corrosion testing results (corrosion rate, corrosion potential, corrosion mechanism)	3
Analyze data to provide conclusions and recommendations through technical reports	2
Determine appropriate remedial action needed for corrosion control	2

**1 – Beginner; 2 – Intermediate; 3 – Advanced*

Reference

- Association for Materials Protection and Performance (formerly NACE International), https://www.ampp.org/
- American Petroleum Institute (API), https://www.api.org
- American Society for Testing and Materials (ASTM), https://www.astm.org/

Focus of the course towards employability, entrepreneurship, skill development, and value addition

S. No.	Course	Employability	Entrepreneurship	Skill Development	Value-added
1	Corrosion Science and Engineering	✓	✓	✓	-