GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

Course Curriculum

Introduction to Failure Analysis

(Code:4362102)

Diploma Programme in which this course is offered	Semester in which offered
Metallurgy Engineering	6th Semester

1. RATIONALE

Introduction to Failure Analysis is a crucial subject that provides students with a comprehensive understanding of the principles and techniques used in analyzing and investigating failures in various engineering systems. This subject is essential for Metallurgy student as it equips them with the knowledge and skills necessary to identify, analyze, and prevent failures in real-world applications.

2. COMPETENCY

The course content should be taught and implemented to develop different types of skills so that students can acquire the following competency:

Analyze and evaluate the causes of failures occurs in various materials during service condition.

3. COURSE OUTCOMES (COs)

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

- Understand fundamental of failure Analysis.
- Identify various type of fractures like brittle Fracture, ductile failure, fatigue failure and creep fracture..
- Analyzed the high temperature related fracture.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
2	0	2	3	30*	70	25	25	150

(*): 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	General practices use in failure analysis	1	4
2	Case study on failure analysis of Ductile Fracture	2	4
3	Case study on failure analysis of Brittle Fracture	2	4
4	Case study on failure analysis of Fatigue Fracture	3	4
5	Case study on failure analysis of creep Fracture	3	4
6	Seminar on failure analysis in oil & gas industries	4	4
7	Characterization techniques required for failure analysis	1 to 4	4
Total Hours			28

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

This 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	**Microscopes:** Optical microscopes, scanning electron microscopes (SEM), and transmission electron microscopes (TEM) are commonly used for examining the surface and internal structures of failed components	2 to 5
2	**Non-destructive testing (NDT) equipment:** Techniques such as ultrasonic testing, magnetic particle inspection, and dye penetrant testing can be employed to detect cracks, defects, or material inconsistencies without damaging the sample.	2 to 5
3	**Mechanical testing machines:** Tensile testing machines, hardness testers, and impact testers are used to evaluate the mechanical properties of materials	2 to 5
4	**Chemical analysis tools:** Gas chromatography-mass spectrometry (GC-MS), and wet chemical analysis techniques are utilized to identify and quantify chemical compounds.	5

7. AFFECTIVE DOMAIN OUTCOMES

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

- Work as a leader/a team member.
- Follow ethical practices.
- Practice environmental friendly methods and processes. (Environment related)

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 Failure Analysis	1a. Understand importance of failure Analysis 1b. Learn general practices in failure analysis	1.1. Importance of failure analysis 1.2. Fundamental causes of failure of materials 1.3. General practices in failure analysis
Unit-II Types of failure: Ductile fracture , Brittle Fracture	2a. Understand the Ductile fatigue fracture and it's characteristics 2b. Understand the Brittle fatigue fracture and it's characteristics. 2c, Understand the Ductile to Brittle Fracture	2.1. Various types of fractures 2.2. Ductile fracture: theory and characteristics of ductile fracture 2.3. Brittle fracture: theory and characteristics of brittle fracture 2.4. Ductile to brittle fracture
Unit-III Fatigue and Corrosion Failure	3a. Understand the fatigue fracture and it's characteristics 3b. Learn about corrosion failure and it's various types	3.1. Characterization of fatigue fracture 3.2. Types of fatigue i.e., corrosion fatigue, contact fatigue 3.3. Corrosion and corrosion related failures such as hydrogen embrittlement, stress corrosion cracking.
Unit-IV High Temperature failure	4a. Understand about high temperature related failures	4.1. Characterization of High temperature failures 4.2. Creep failure 4.3. Failure of boilers 4.4. Various types of tube failures in thermal power plants

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
1.	Introduction to Failure Analysis	06	06	04	02	12
2.	Types of failure: Ductile fracture, Brittle Fracture	08	06	10	08	24
3.	Fatigue and Corrosion Failure	08	06	10	04	22
4.	High Temperature failure	06	4	06	02	12
Total		**28**	**36**	**22**	**12**	**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. **Case studies**: Students can form study groups and work on analyzing real-life case studies related to failure analysis. They can discuss and apply the concepts learned in the classroom to understand the causes and consequences of failures in different industries.

2. **Field visits**: Students can organize visits to industries or organizations where failure analysis is conducted. This will provide them with practical exposure and a better understanding of how failure analysis is applied in real-world scenarios.

3. **Guest lectures**: Students can invite experts from the field of failure analysis to deliver guest lectures or conduct workshops. This will give them the opportunity to learn from professionals and gain insights into the industry practices and challenges.

4. **Research projects**: Students can form research groups and undertake research projects related to failure analysis. They can explore new techniques, methodologies, or case studies to contribute to the existing knowledge in the field.

5. **Presentations and debates**: Students can organize presentations or debates on topics related to failure analysis. This will enhance their communication and presentation skills, as well as their ability to critically analyze different perspectives.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

Sr. No.	Unit Title	Strategies
1	Introduction to Failure Analysis	Real life examples. Demonstration of Various failure component for analyzing its failure and report writing. .
2	Types of failure: Ductile fracture, Brittle Fracture	
3	Fatigue and Corrosion Failure	
4	High Temperature failure	

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 s/he 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. Select a household appliance that has failed or is no longer functioning properly.
2. Research the common causes of failure for that specific appliance.
3. Conduct a visual inspection of the appliance to identify any visible signs of failure or damage.
5. Use appropriate tools and techniques to analyze the failed components and determine the root cause of the failure.
6. Document the findings and present a report detailing the failure analysis process and the identified cause of failure.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication with place, year and ISBN
1	Understanding How Components Fail	Donald J. Wulpi	ASM International, Materials Park, Ohio, USA Titanium: A Technical Guide, 2nd Edition
2	Analysis of Metallurgical Failures	V.J. Colangelo & F.A. Heiser	John Wiley & Sons, New York, 1974, 047116450X
3	ASM Handbook Volume 11: Failure Analysis and Prevention	William T. Becker, Roch J. Shipley,	American Society for Metals, Metals Park, Ohio. 2021, 978-1-62708-293-8
4	Metals Hand Book – Eight Edition – Factography,	F. H. Norton	American Society for Metals, Metals Park, Ohio
5	Engineering Materials – Selection and Value Analysis	H.J. Sharp	Elsevier Publishing Company Inc., New York.1966

14. SOFTWARE/LEARNING WEBSITE

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15. PO-COMPETENCY-CO MAPPING

Semester I	Introduction to Failure Analysis (Course Code: 4362102)						
	POs and PSOs						
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
Analyze and evaluate the causes of failures occurs in various materials during service condition.							
CO1: Understand fundamental of failure Analysis	3	2	1	1	2	1	3
CO2: Identify various type of fracture like	3	2	1	1	2	2	3

brittle Fracture, ductile failure, fatigue failure and creep fracture							
CO3: Analyzed the high temperature related fracture	3	2	1	2	2	1	3

Legend: '**3**' for high, '**2**' for medium, '**1**' for low or '**-**' for the relevant correlation of each competency, CO, with PO/ PSO

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Sr.	Name and Designation	Institute	Contact Detail
1	**Prof. Tushal K. Kyada** Lecturer, Metallurgy Engineering	Dr.S & S. S. Ghandhy College of Engg and Tech., Surat	tushalkyada21@Gmail.com
2	**Prof. Anjuman Kadiwala** Lecturer, Metallurgy Engineering	L. E. College (Diploma), Morbi	anjumankadiwala29@gmail.com

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