

MSE4124: FAILURE ANALYSIS AND CASE STUDIES

Effective Term

Semester B 2022/23

Part I Course Overview

Course Title

Failure Analysis and Case Studies

Subject Code

MSE - Materials Science and Engineering

Course Number

4124

Academic Unit

Materials Science and Engineering (MSE)

College/School

College of Engineering (EG)

Course Duration

One Semester

Credit Units

3

Level

B1, B2, B3, B4 - Bachelor's Degree

Medium of Instruction

English

Medium of Assessment

English

Prerequisites

AP2102/MSE2102 Introduction to Materials Engineering
AP3110/MSE3110 Deformation and Fracture

Precursors

Nil

Equivalent Courses

AP4124 Failure Analysis and Case Studies

Exclusive Courses

Nil

Part II Course Details

Abstract

To provide the students with an understanding of the various failure mechanisms in materials and to develop their ability in performing failure analysis of engineering components, through the study and practice on actual engineering failure cases.

Course Intended Learning Outcomes (CILOs)

CILOs		Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Recognize and describe common engineering failure mechanisms.		x		
2	Generate the procedures for conducting a failure investigation.		x	x	
3	Evaluate the choice of instruments and methods of failure analysis.		x	x	
4	Analyse failed engineering components using instruments.		x	x	x
5	Hypothesize the possible failure causes and generate a plan to obtain the root cause of failure.		x	x	x

A1: Attitude

Develop an attitude of discovery/innovation/creativity, as demonstrated by students possessing a strong sense of curiosity, asking questions actively, challenging assumptions or engaging in inquiry together with teachers.

A2: Ability

Develop the ability/skill needed to discover/innovate/create, as demonstrated by students possessing critical thinking skills to assess ideas, acquiring research skills, synthesizing knowledge across disciplines or applying academic knowledge to real-life problems.

A3: Accomplishments

Demonstrate accomplishment of discovery/innovation/creativity through producing /constructing creative works/new artefacts, effective solutions to real-life problems or new processes.

Teaching and Learning Activities (TLAs)

TLAs	Brief Description	CILO No.	Hours/week (if applicable)	
1	Lecture	To cover basic concepts between failure mechanisms and causes.	1, 2, 3, 5	3 hours/week for 4 weeks
2	Discussion (internet)	Through technical communication, reinforce self-learning of aspects of failure analysis.	1, 2, 3, 5	1 hour/week for 3 weeks
3	Laboratory	Analyse failed engineering components.	1, 2, 3, 4, 5	3 hours/week for 2 weeks
4	Case Studies	Simulate the failure analysis process through real life cases.	1, 2, 3, 5	3 hours/week for 8 weeks

5	Mini-project	Evaluate failure analysis work carried out by a certain party.	1, 2, 3, 5	3 hours/week for 2 weeks
---	--------------	--	------------	--------------------------

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks (e.g. Parameter for GenAI use)
1	Discussion (internet)	1, 2, 3, 5	10	
2	Laboratory	1, 2, 3, 4, 5	15	
3	Case Studies	1, 2, 3, 5	20	
4	Mini-project	1, 2, 3, 5	25	
5	Tests	1, 2, 3, 5	30	

Continuous Assessment (%)

100

Examination (%)

0

Assessment Rubrics (AR)**Assessment Task**

1. Discussion (internet)

Criterion

CAPACITY for SELF-DIRECTED LEARNING to research on failure cases and present the associated ideas

Excellent (A+, A, A-)

High

Good (B+, B, B-)

Significant

Fair (C+, C, C-)

Moderate

Marginal (D)

Basic

Failure (F)

Not even reaching marginal levels

Assessment Task

2. Laboratory

Criterion

ABILITY to EXPLAIN the fracture or failure, ABILITY to FORMULATE a failure analysis plan, and CAPACITY for SELF-DIRECTED LEARNING to analysis a sample using instruments

Excellent (A+, A, A-)

High

Good (B+, B, B-)

Significant

Fair (C+, C, C-)

Moderate

Marginal (D)

Basic

Failure (F)

Not even reaching marginal levels

Assessment Task

3. Case Studies

Criterion

ABILITY to EXPLAIN in DETAIL and with ACCURACY methods and results of failure analysis

Excellent (A+, A, A-)

High

Good (B+, B, B-)

Significant

Fair (C+, C, C-)

Moderate

Marginal (D)

Basic

Failure (F)

Not even reaching marginal levels

Assessment Task

4. Mini-project

Criterion

ABILITY to EXPLAIN in DETAIL and with ACCURACY the analysis of an expert report

Excellent (A+, A, A-)

High

Good (B+, B, B-)

Significant

Fair (C+, C, C-)

Moderate

Marginal (D)

Basic

Failure (F)

Not even reaching marginal levels

Assessment Task

5. Tests

Criterion

ABILITY to EXPLAIN the technical details of a failure case

Excellent (A+, A, A-)

High

Good (B+, B, B-)

Significant

Fair (C+, C, C-)

Moderate

Marginal (D)

Basic

Failure (F)

Not even reaching marginal levels

Part III Other Information

Keyword Syllabus

- General procedures of failure analysis, classification of failure sources
Design deficiencies, material deficiencies, processing deficiencies, assembly errors, service conditions, neglect and improper operation.
- Methods and equipment for failure analysis
Sample selection and treatment, equipment for materials examination, materials analysis equipment for failure analysis, commonly used NDT methods.
- Failure mechanisms
Fatigue failures, fractography, effect of variables: part shape, type of loading, stress concentration, metallurgical factors, etc. Wear failures, adhesive, abrasive, erosive, corrosive wear. Corrosion failures, types of corrosion : uniform, pitting, selective leaching, intergranular, crevice, etc. Elevated temperature failures, creep, thermal fatigue, microstructural instability, oxidation.

Case studies

Examples of case studies: Failure investigation of an exploded gas cylinder. Failure of a chemical reactor. Failure of a high-power electrical cable. Derailment accident. Failure of multi-layer ceramic capacitors. Failure of a high strength bolt. Failure of a passenger hoist. Lifting appliance failure. Failure of a rocker arm. Cargo lift failure.

Laboratory exercise

Examples of laboratory exercises:

Initial examination of a failed component. SEM examination of a cross-section. SEM examination of a fracture surface.

Mini-project (role play)

Examples of mini-project: Gearbox housing accident. Failure of a laundry machine. Contaminations in LCD. Galvanizing vat accident. Failure of a drive shaft in an air-cargo handling vehicle.

Reading List

Compulsory Readings

Title	
1	Nil

Additional Readings

Title	
1	D R H Jones, Engineering Materials 3 – Materials Failure Analysis: Case Studies and Design Implications, 1993. (CityU Lib Cat TA409 .J67 1993)
2	D R H Jones, Failure analysis case studies: a sourcebook of case studies selected from the pages of Engineering failure analysis 1994-1996, Amsterdam; New York: Elsevier, 1998. (CityU Lib Cat TA169.5 .F35 1998)
3	J A Charles and F A A Crane, Selection and use of engineering materials, 2nd edition, Butterworths, 1989. (CityU Library Cat No TA403.C73.1989)
4	Case histories in failure analysis, American Society of Metals, 1979. (CityU Lib Cat TA460.C33)
5	C L Briant, Metallurgical aspects of environmental failures, Elsevier Science Pub, 1985. (CityU Library Cat No TA460.B69.1985)
6	H P Block and F K Geitner, Machinery failure analysis and trouble shooting, Gulf Pub Co, Houston, Texas, 1983. (CityU Library Cat No TS191.B56.1983)
7	J L McCall and P M French (ed), Metallography in failure analysis, Plenum Press, NY and London, 1977. (CityU Library Cat No TN689.2.S88.1977)
8	W Brostow and R D Corneliussen, Failure of Plastics, Hanser Publishers. (CityU Lib Cat TP1087.F37)G E Dieter, “Engineering Design - A Materials and Processing Approach” (2nd ed), McGraw-Hill (1991).
9	Journals:Engineering Failure AnalysisForensic EngineeringMaterials and DesignMaterials EngineeringMaterials PerformanceMetals and Materials