SEE4115: ENERGY CATALYSIS AND REACTION ENGINEERING

Effective Term
Semester A 2022/23

Part I Course Overview

Course Title
Energy Catalysis and Reaction Engineering

Subject Code
SEE - School of Energy and Environment

Course Number
4115

Academic Unit
School of Energy and Environment (E2)

College/School
School of Energy and Environment (E2)

Course Duration
One Semester

Credit Units
3

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

Medium of Instruction
English

Medium of Assessment
English

Prerequisites
SEE3101 Engineering Thermofluids II

Precursors
SEE3102 Power Plant Engineering

Equivalent Courses
Nil

Exclusive Courses
Nil

Part II Course Details

Abstract

The course aims to educate students on the basic and creative aspects of Energy-related catalysis. By establishing necessary basics and fundamentals in reaction engineering, the course further looks into the core catalytic processes in typical oil and gas refineries, which are currently our biggest source of energy. Lectures will also be given on the production of ultraclean fuels through gas-to-liquid and coal-to-liquid processes, which hold the future of fossil fuel utilisation. Importantly, the future of fossil fuel and its integration as part of clean Energy future is discussed. This shall provide students with an unbiased and holistic view of fossil fuel utilisation. Further Energy-related catalytic processes such as that in fuel cells, photocatalytic water splitting, biofuel conversion and carbon dioxide reduction will also be taught. The knowledge gained from the course shall provide students with essential knowledge in innovative catalytic processes, as well as their importance in securing a clean energy future.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Describe the importance of fossil fuel and its relevance to future clean Energy future.	10	x	x	
2	Measure and analyse kinetics of reactions from the point of reaction orders; Describe the different types of reaction models such as Langmuir-Hinshelwood and shrinking core model.	25		x	x
3	Describe various innovative catalysts synthesis techniques and catalytic processes in oil and gas refineries such as reforming, partial oxidation, water-gas-shift, methanol synthesis, methanation, Fischer-Tropsch synthesis, gas-to-liquid (conversion of natural gas to syngas and further to liquid fuels) and coal-to-liquid (conversion of coal to syngas and further to liquid fuels).	25		x	
4	Design functional heterogeneous catalysts for various innovative catalytic processes based on established fundamental properties such as surface acidity/basicity, reducibility and hydrogen spillover, oxygen mobility.	15	x	x	
5	Describe the application of advanced catalysis in creative energy technologies and relevant environmental remediation.	25	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	Regular lectures to enrich students with the required science and reaction engineering fundamentals for energy catalysis	1, 2, 3, 4, 5	
2	Tutorial	Mathematical-based in-class exercise to consolidate the skills of students in reaction engineering and energy catalysis	1, 2, 3, 4, 5	
3	Lab-based experiment	Hands-on task in constructing and assessing energy-related catalytic reactions	2, 3, 5	
4	Test	Oral examination at the end of semester to assess the ability of students in describing the fundamentals and applications of reaction engineering in solving energy catalysis problems	1, 2, 3, 4, 5	

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks (e.g. Parameter for GenAI use)
1	Assignments	1, 2, 3, 4, 5	60	
2	Lab work and report	2, 3, 5	20	
3	Class test	1, 2, 3, 4, 5	20	

Continuous Assessment (%)

100

Examination (%)

0

Examination Duration (Hours)

N/A

Additional Information for ATs

Examination duration: N/A
Percentage of coursework, examination, etc.: 100% by coursework

To pass a course, a student must do ALL of the following:
1) obtain at least 30% of the total marks allocated towards coursework (combination of assignments, pop quizzes, term paper, lab reports and/ or quiz, if applicable);
2) obtain at least 30% of the total marks allocated towards final examination (if applicable); and
3) meet the criteria listed in the section on Assessment Rubrics.

Assessment Rubrics (AR)

Assessment Task
1. Assignments

Criterion
Ability to apply mathematical skills in solving various reaction engineering and energy catalysis problems

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. Lab work and report

Criterion
Ability to apply hands-on skills in designing catalysts and assessing energy-related catalytic reactions, and further report writing

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. Class test

Criterion
Oral examination to assess the ability of students in describing the fundamentals and applications of reaction engineering in solving energy catalysis problems

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

Reaction engineering; catalysts design; advanced catalysis; fossil fuel; ultraclean fuel; gas-to-liquid; coal-to-liquid; fuel cells; photocatalysis; biofuel conversion; carbon dioxide reduction.

Reading List

Compulsory Readings

	Title
1	Fogler, H.S., Elements of Chemical Reaction Engineering, Prentice Hall PTR, 2006
2	Niemantsverdriet, J.W., Spectroscopy in Catalysis: An Introduction, Wiley-VCH, Weinheim, 2000
3	Chorkendorff, I., Niemantsverdriet, J.W., Concepts of Modern Catalysis and Kinetics, Wiley-VCH, Weinheim, 2007
4	Kamat, P.V. Meeting the clean energy demand. Nanostructure architectures for solar energy conversion, J. Phys. Chem. C, 2007, 111, 2834.
5	Somorjai, G.A., Frei, H., Park, J.Y. Advancing the frontiers in nanocatalysis, biointerfaces and renewable energy conversion by innovations of surface techniques, J. Am. Chem. Soc., 2009, 131, 16589.

Additional Readings

	Title
1	Nil