School of Engineering

Module Guide

Module title: Chemical Engineering Processes 2 ENG_6_477

Level: 6

Module Leader: Professor Basu Saha
Email: b.saha@lsbu.ac.uk
Room number: FW-316

Other Staff Teaching: Dr Donglin Zhao
Email: donglin.zhao@lsbu.ac.uk
Room number: FW-301

Assessment of the module

The module is assessed by closed book examination 70% and coursework 30%

Examination

The examination will be held in January 2020[1]

Coursework

Component	Hand out date	Hand in date	Feedback date
Separation Processes 15%	18 October 2019	1 November 2019	22 November 2019
Reaction Engineering 15% (in-class test)	27 September 2019 (students will be informed about the in-class test)	6 December 2019	8 January 2020

Feedback guideline

Feedback will normally be given to students within 15 working days after the final submission of an assignment or in-class test as advised by the module leader.

General feedback, applying to all students, would be placed on the module VLE site within 15 working days.

[1] The examination timetable will be circulated late in 2019 for January exams.

What skills you will develop in this module

Knowledge and Understanding

- Carry out the design of apparatus for the advanced separation, heat transfer, and reaction systems, including multicomponent mixtures and multistage processes.
- Use a mathematical approach to design, optimisation and control of chemical reactors.
- Examine heat and mass transfer effects associated with chemical reaction.

Intellectual Skills

- Express ideas in structural and mathematical terms so that quantitative evaluation is facilitated.
- Evaluate the strengths and limitations of advanced separation, heat transfer, and reaction systems.
- Understand the fundamental aspects of heterogeneous catalysis and how these principles can be used to improve catalytic performance. The understanding of the role of chemical kinetics and transport effects would help in the optimal design of catalytic reactors.

Practical Skills

- Perform calculations for more complex separation problems such as separation of multi-component mixtures by distillation and gas absorption.
- Able to design equipment for the separation of complex systems.
- Perform reactor-sizing calculations and manipulate key relationships.
- Carry out modelling and optimisation of reactors to account for complexities including multiple reactions, pressure and temperature effects.

Transferable Skills

- Apply mathematical and scientific reasoning to engineering problems.
- Design and analyse engineering solutions (often) based on imperfect data.
- Be familiar with industry practices relevant to the module.

Short description of the module

This module is aimed at developing student’s understanding of the design on advanced separation and reaction processes and enhancing student’s ability to apply learned fundamental knowledge to chemical and petrochemical processing applications. In separation part, more complex separation problems such as separation of multi-component mixtures by distillation and gas absorption are studied, together with adsorption and solvent extraction. The design of column internals is also be covered. The advanced reaction engineering section covers heterogeneous catalysis, heat transfer in chemical reaction and mass transfer with chemical reaction. The module is suitable for students taking the BEng (Hons) or MEng in Chemical Engineering, with previous knowledge of Thermodynamics; Fluids and Separation; Chemical Engineering Processes 1.

Evaluation of the module

This module is assessed using Module Evaluation Questionaires (MEQs). There is also the opportunity to provide feedback on the module at the student-staff course board meetings.

Learning resources

Reading List

Core reading materials:

1. Henley, E.J., Seader, J.D. and Roper, D.K. (2011). Separation Process Principles, International Student Version, 3rd Edition, Wiley.
2. Coulson, J. M. and Richardson, J. F. (1990/1991). Chemical Engineering, Vols. 1 and 2, 4th Edition, Pergamon.
3. Coulson, J. M. and Richardson, J. F. (1999). Chemical Engineering, Vol. 6, 3rd Edition, Pergamon.
4. Levenspiel, O. (1999). Chemical Reaction Engineering, 3rd Edition, Wiley. Smith, J.M.(1981). Chemical Engineering Kinetics, Mc Graw Hill.
5. Smith, J.M. (1981). Chemical Engineering Kinetics, Mc Graw Hill.

Optional reading materials:

6. Rousseau, R. W. (Ed.). (1987). Handbook of Separation Process Technology, Wiley.
7. Kister, H. Z. (1992). Distillation Design, McGraw-Hill.
8. Fogler, H. C. (2006). Elements of Chemical Reaction Engineering, 4th Edition, Prentice Hall International Series, Pearson Education Inc.
9. Froment, G. F., Bischoff, K.B. and De Wilde, J. (2011). Chemical Reactor Analysis and Design, 3rd Edition, Wiley.
10. Saha, B. (Ed.) (2016), Catalytic Reactors, De Gruyter, Germany.

Additional details

Module Title:	Chemical Engineering Processes 2
Module Level:	6
Module Reference Number:	CPE_6_477
Credit Value:	20
Student Study Hours:	200
Contact Hours:	52
Private Study Hours:	148
Pre-requisite Learning:	Thermodynamics; Fluids and Separation; Chemical Engineering Processes 1.
Course(s):	BEng/MEng Chemical and Process Engineering
Year and Semester:	Year 3, Semester 1
Module Coordinator:	Professor Basu Saha
MC Contact Details:	b.saha@lsbu.ac.uk; FW-316
Teaching Team & Contact Details:	Dr Donglin Zhao donglin.zhao@lsbu.ac.uk; FW-301
Subject Area:	Chemical and Energy Engineering
Summary of Assessment Method:	Exam (70%) and Coursework (30%)
External Examiner appointed for module:	Details of the external examiner can be obtained from the course director.

Aims of the Module

- To study more complicated separation processes with multiple components and non-ideal mixtures
- To provide students with sufficient knowledge to allow them to design equipment for the separation of complex systems.
- To develop a mathematical approach to reactor design and a practical approach to safe operation.
- To extend the knowledge of heat, mass and momentum transfer in chemical reactions, acquired during the earlier years of the course.

Introduction to studying the Module

Overview of the Main Content

Part A (Dr Donglin Zhao)

Complex Ideal Binary Distillation Processes
Multiple feeds and side streams, cold reflux, logarithmic plots for high purity products.

Distillation of Multi-component Mixtures
Equilibrium in ideal multi-component mixtures, bubble point and dew point calculation. Calculations based on pseudo-binary systems, short-cut calculations, rigorous plate-to-plate calculations – design approach and rating approach. Estimation of plate efficiency.

Hydrodynamics of Distillation Columns
Introduction to tray design and tray column sizing.

Non-ideal Mixtures
Vapour-liquid equilibria in non-ideal mixtures, prediction and extrapolation of equilibrium data. Azeotropic distillation, extractive distillation, solvent extraction and distillation, heterogeneous azeotropes, steam distillation for batch processes.

Stage-wise and Multi-component Gas Absorption
Kremser equation, Kremser Souders and Brown equation. Design approach and rating approach for the design of multi-component gas absorption processes.

Hydrodynamics of Absorption Columns
Introduction to packing design and packed column sizing.

Adsorption Processes and Solvent Extraction
Adsorption isotherms, batch adsorption, continuous adsorption (fixed bed, counter-current), regeneration cycles.
Solvent extraction: equilibrium, batch extraction, continuous stage-wise extraction.

<u>Part B (Professor Basu Saha)</u>
Heat Transfer and Chemical Reaction
Thermal effects in chemical reactors. Temperature effects on equilibrium constants and on rate coefficients.
Reactor design for exothermic reactions; optimum temperature profiles, temperature profiles for complex reactions, real temperature profiles. Well-mixed systems with steady feed, parametric sensitivity for the plug flow reactor.
Heterogeneous Catalysis
Introduction to heterogeneous catalysis, catalytic reactions and materials, catalyst selectivity, activity and lifetime, catalyst supports, promoters and poisoning, deactivation of catalysts. Catalysis for inorganic chemical industry, petrochemical industry and environmental applications.
Diffusion in catalytic particles: isothermal gaseous diffusion; molecular diffusion; Knudsen diffusion; surface diffusion; liquid diffusion. Effectiveness factors and Thiele modulus.
Adsorption: Types of adsorption, adsorption isotherms.
Heterogeneous Kinetics: Langmuir-Hinshelwood-Hougen-Watson (LHHW) and Eley-Rideal (E-R) kinetic models.
Mass Transfer with Chemical Reaction
Fluid-fluid reactions, slow reaction, fast reaction, enhancement factor, instantaneous reaction; liquid-liquid systems; gas-side resistance to mass transfer. Gas-liquid reactor design, absorption with chemical reaction.

Overview of Types of Classes

The module will be delivered by combination of lectures and problem solving classes. Details of times and locations are given in the published class timetables.

Lectures:

- Professor Basu Saha 2h/w, weeks 1-12, 16

- Dr Donglin Zhao 2h/w, weeks 1-12, 16

Importance of Student Self-Managed Learning Time

Student responsibility in the learning and development process will be emphasised. Students are required to undertake directed self-study and prepare solutions/discussions to questions relative to various topic areas. Students will be encouraged to identify for themselves particular problems of difficulty and where appropriate, for the resolution of these. Students must regularly access the Moodle site for this module. They should download the class/lecture materials from the Moodle site, and do the recommended reading, before each lecture/class. Where appropriate, students are also expected to download the relevant questions and study them in advance of each lecture, in order to derive maximum benefit from lecture time.

Employability

This module helps to improve student’s ability of applying mathematic models to design and evaluate engineering equipment such as absorbers, distillation columns and reactors. The students are trained to predict or extrapolate necessary data and to make sensible decisions based on impact data. This is particularly important for their future employment in Chemical, Petrochemical and Energy industries.