POZNAN UNIVERSITY OF TECHNOLOGY

EUROPEAN CREDIT TRANSFER AND ACCUMULATION SYSTEM (ECTS)

COURSE DESCRIPTION CARD - SYLLABUS

Course name
Engineering of chemical reactors [S2TCh2E-KiN>IR]

Course

Field of study
Chemical Technology

Year/Semester
1/1

Area of study (specialization)
Composites and Nanomaterials

Profile of study
general academic

Level of study
second-cycle

Course offered in
english

Form of study
full-time

Requirements
compulsory

Number of hours

Lecture
15

Laboratory classes
0

Other (e.g. online)
0

Tutorials
0

Projects/seminars
15

Number of credit points

2,00

Coordinators

dr inż. Maciej Staszak
maciej.staszak@put.poznan.pl

Lecturers

dr inż. Maciej Staszak
maciej.staszak@put.poznan.pl

Prerequisites

Student has knowledge of mathematics to the extent that allows him to use mathematical methods to describe chemical processes and make calculations needed in engineering practice. Student has knowledge in the basic field related to the selection of materials used in the construction of chemical equipment and installations. Student knows the basics of kinetics, thermodynamics and catalysis of chemical processes.

Course objective

The aim of this course is to present and learn the problems related to real-life hammock reactors. Particular emphasis is placed on mathematical description, balancing and design procedures. The aim of the project course is to learn how to design reactors and instrumentation to regulate and control the reaction process. Such a project gives an opportunity to learn the basic types of unit operations cooperating together in one installation. The project covers the issues of steady and transient states. An important aspect of the subject is the use of a design support tool - Chemcad.

Course-related learning outcomes

Knowledge:

The student acquires knowledge in the area of real chemical reactors, their design, application of reactor models and taking into account different levels of complexity in the design. The student is also acquainted with specific solutions applied in practice. (K_W01, K_W03, K_W06, K_W07)
The student acquires knowledge in the area of chemical equipment design, application of thermodynamic models and taking into account different levels of complexity in the project. The student understands the necessity of using numerical procedures by the software and their significant influence on the way of conducting calculations. (K_W01, K_W03, K_W06, K_W07)

Skills:
The student is able to formulate a description of chemical processes running in reactors in a mathematical way. The student is able to identify the key elements that allow him or her to achieve the highest possible level of realism in a mathematical description. The student is able to analyse the work of a chemical reactor in the Laplace domain. The student is able to identify safety trip procedures. The student understands the basics of control of unit operations using the PID regulator loop. (K_U01, K_U06, K_U07, K_U14)
Students will be able to design using installation balance based on defined design requirements and declared flows, and then sizing the equipment. The student is able to identify key problems related to the system's non-ideality, eliminate inappropriate and illogical installation settings and conduct analysis based on the use of parametric sensitivity technique. The student is able to carry out a project for a steady state and to select control parameters in transient states for selected process parameters in a chemical reactor using a PID regulator. (K_U01, K_U06, K_U07, K_U14)

Social competences:
The student is aware of the impact of applied solutions in the project on the environment. Particular emphasis is placed on the optimization of the project due to the costs of equipment and process. (K_K02)

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Semester evaluation of the completed project, consisting of a preliminary pre-project analysis, the quality of the completed project and the preparation of the final report.

Programme content

Mathematical description of real reactors: mass balance, heat balance. Kinetics of chemical reaction. Catalysed reactions. Construction solutions of chemical tank and tube reactors, multifunctional reactors. Analysis of reactors in the laplace domain. Introduction to chemical reactor control by means of a PID regulator. Typical control systems for batch reactors operating periodically or continuously, and for tubular reactors.
Unit operations mass, ionic and heat balances. Formulating the kinetics of a chemical reaction in the classic arrhenian way and in non-classical formulations. Formulation of kinetics of catalytic reactions. Sizing of tank and tube chemical reactors, multifunctional reactors, real tank reactors operating periodically and continuously, heat exchangers, vessels, pipelines, control valves. Rating analysis for sized equipment. Control by means of a PID regulator. Design and analysis of the reaction process in the time domain.

Teaching methods

Presentation at the lecture. Derivation of balance eqautions formulated during the classes.
Project: Extensive presentation of the functions and operation of the design support tool - Chemcad. Detailed overview of individual operations required for the project, available in Chemcad. Detailed analysis and explanation of the ways of declaring the kinetics of chemical reactions with formulations significantly deviating from the classical arrhenius forms. Presentation of methods of taking into account chemical catalysts. Based on the presented examples, the students perform preliminary, test projects of single unit operations during the classes. At this stage, the teacher assists students in the use of the CAD tool, without solving any design problems.
During the final semester project, students are assisted in the functioning of the Chemcad program, but they make design decisions for which they are responsible. All solutions regarding schematic flowsheeting, media usage, apparatus selection, process settings, design requirements, design sizing are

the students' responsibility.

Bibliography

Basic:
Control and Monitoring of Chemical Batch Reactors, Fabrizio Caccavale, Mario Iamarino, Francesco Pierri, Vincenzo Tufano, Dostęp: https://link.springer.com/book/10.1007/978-0-85729-195-0

Additional:
Chemical Reactor Modeling, Multiphase Reactive Flows, Hugo A. Jakobsen, Dostęp: https://link.springer.com/book/10.1007/978-3-319-05092-8

Breakdown of average student's workload

	Hours	ECTS
Total workload	50	2,00
Classes requiring direct contact with the teacher	30	1,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	20	1,00