Course Unit	Chemical Engineering Project	Field of study	Chemical Process Engineering/Thermodynamics and Transport Phenomena
Bachelor in	Chemical Engineering	School	School of Technology and Management
Academic Year	2023/2024	Year of study	3
Level	1-3	ECTS credits	6.0
Type	Semestral	Semester	2
Code	9125-755-3203-00-23		

Workload (hours)	Contact hours	T	TP	PL	TC	S	E	OT	O
162		-	-	60	-	-	-	-	-

T - Lectures; TP - Lectures and problem-solving; PL - Problem-solving, project or laboratory; TC - Fieldwork; S - Seminar; E - Placement; OT - Tutorial; O - Other

Name(s) of lecturer(s): Paulo Miguel Pereira de Brito

Learning outcomes and competences

At the end of the course unit the learner is expected to be able to:
1. Design reaction and separation unities using knowledge from different scientific areas.
2. Get more experience in solving real problems and present more autonomous work.
3. Evaluate the needed data for the development of a project, their consistency, precision and importance in terms of the final configuration.
4. Understand the open nature of a project, and decide taking into consideration the multiplicity of factors that caracheterize it.
5. Plan and write project reports that must include flux diagrams, material and energy balances, and equipment specifications.
6. Develop and train oral communication competences, and take decisions based on scientific, ethical, social or legal reasons.
7. Improve teamwork, cooperation, discipline, responsability, and scientific and technique skills.
8. Develop proper skills in specific areas promoting a better integartion at an industrial level.

Prerequisites

Before the course unit the learner is expected to be able to:
1. Apply and understand fundamental concepts on Thermodynamics.
2. Apply and understand fundamental concepts on Transport Phenomena.
3. Apply and understand fundamental concepts on Chemical Processes Engineering.

Course contents

Introduction to Process Synthesis. Preliminary Steps for Process Synthesis. Heuristic Rules for Process Synthesis. Synthesis of Separation Sequences. Heat and Power Integration. Mass Integration.

Course contents (extended version)

1. Introduction to Process Synthesis
   - Product and process engineering steps; (a) Create and assess the primitive problem.
   - (b) Find chemicals or chemical mixtures with desired properties, (c) Process creation.
   - (d) Development of a base case process, (e) Detailed process synthesis.
   - (f) Detailed design, equipment sizing and optimization. Environmental protection. Safety.
2. Preliminary Steps for Process Synthesis
   - Preliminary database creation: compilation of thermophysical properties.
   - Safety, environmental and price data for the chemical substances.
   - Evaluation of laboratorial experiments to carry out.
   - Preliminary process synthesis. Synthesis steps: (a) Eliminate differences in molecular type.
   - (b) Distribute the chemicals, (c) Eliminate differences in composition.
   - (d) Temperature, pressure and phase change and (e) Task integration.
   - Example in the production of vinyl chloride.
3. Heuristic Rules for Process Synthesis
   - The concept of heuristic rule.
   - Heuristics in the selection of raw materials and reaction paths.
   - Distribution of chemicals: (a) Use an excess of one chemical reactant or inert substances.
   - (b) Purges, (c) Side reactions and (d) Combining separation and reaction processes.
   - Separations involving liquid, vapor or two-phase mixtures.
   - Adding or removing heat from reactors: (a) Excess reactant, an inert diluent, (b) Cold/hot shots.
   - (c) External heating/cooling and (d) Intermediate heating/cooling.
   - Heuristics for pumping and compression.
4. Synthesis of Separation Sequences
   - Common industrial separation methods and some fundamental separation principles.
   - Selecting separation methods. Separate vapor/liquid feeds or effluents.
   - Separation factor in the selection of appropriated methods for liquid mixtures.
   - Sequencing of ordinary distillation columns. Algorithm to select pressure and condenser type.
   - Number of sequences for ordinary distillation. Identifying the best sequences using heuristics.
   - Complex columns for ternary mixtures. Sequencing of VL separation systems.
5. Heat and Power Integration.
   - Introduction. Capital and energy costs. Approximate capital costs by heat exchangers sizing.
   - Minimum utility targets.
   - Temperature-interval, composite curve and linear programming methods.
   - Importance in the selection of the minimum approach temperature in the heat exchangers (DTmin).
   - The pinch point. Minimum cold and hot utilities.
   - Maximum energy recovery (MER) networks. Rules for stream matching at the pinch.
   - Minimum number of heat exchangers. Breaking heat loops to reduce the number of heat exchangers.
   - Identifying heat paths and perform energy relaxation.
   - Stream splitting: combining the minimum number of heat exchangers and MER. Stream splitting rules.
   - Threshold temperature, selection of DTmin and multiple utilities.
6. Mass Integration
   - Introduction. Minimum mass separation agent (MSA).
   - Concentration interval and composite curve methods.
   - MSA networks.
   - Rules for stream matching at the pinch. Minimum number of mass exchangers.

Recommended reading

1. W. D. Seider; J. D. Seader e D. R. Lewin, Product and Process Design Principles, 2nd Edition, John Wiley & Sons, 2004.
2. M. O. Ferreira e S. P. Pinho, Manual da Disciplina de Projeto de Engenharia Química, Escola Superior de Tecnologia e de Gestão, Bragança, 2007.
3. R. Turton; R. C. Bailie, W. B. Whiting e J. A. Shaeiwitz, Analysis, Synthesis, and Design of Chemical processes, 2nd Edition, Prentice-Hall, 2002.

Recommended reading

4. R. Smith, Chemical Processes: Design and Integration, 2nd Edition, John Wiley & Sons, 2005.
5. D. Erwin, Industrial Chemical Process Design, McGraw-Hill Professional, 2002.

Teaching and learning methods

Theoretical analysis of fundamental tools and concepts for the comprehension, application and calculations related to design in chemical engineering. Presentation of practical examples and model exercises solving with critical analysis. Discussion and evaluation of the proposed projects. Critical analysis and interpretation of scientific issues and homework .

Assessment methods

1. Alternative 1 - (Regular, Student Worker) (Final, Supplementary)
   - Projects - 40% (Problem solving and critical analysis.)
   - Final Written Exam - 60%
2. Alternative 2 - (Regular, Student Worker) (Supplementary, Special)
   - Final Written Exam - 100%

Language of instruction

English

Electronic validation

Paulo Miguel Pereira de Brito	Hélder Teixeira Gomes	António Manuel Esteves Ribeiro	José Carlos Rufino Amaro
21-02-2024	13-03-2024	13-03-2024	16-03-2024