COURSE DATA

Data Subject	
Code	44433
Name	Advanced separation processes
Cycle	Master's degree
ECTS Credits	6.0
Academic year	2022 - 2023

Study (s)

Degree	Center	Acad. year	Period
2209 - M.D. in Chemical Engineering	School of Engineering	1	First term

Subject-matter

Degree	Subject-matter	Character
2209 - M.D. in Chemical Engineering	6 - Advanced separation processes	Obligatory

Coordination

Name	Department
CERISUELO FERRIOLS, JOSEP PASQUAL	245 - Chemical Engineering
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SUMMARY

The subject Advanced Separation Processes is part of the subject matter ***Process Engineering and***

Product whose overall objective is that students acquire the basic principles of chemical engineering for subsequent application to the design and analysis of the operation of chemical reactors and the different types of basic operations of the process industry. It is a compulsory subject that is taught every six months for the degree of ***Master in Chemical Engineering*** in the first half. In the curriculum of the University of Valencia it has a total of 6 ECTS credits. The subject will be taught entirely in Spanish.

This course is intended for students to apply the basic principles of chemical engineering design and performance analysis of different separation processes that are not part of the curricula of the undergraduate degree because of their characteristics and their degree of implementation or development in the Chemical Process Industry, but the knowledge of which is increasingly important: multicomponent distillation operations, membranes, and supercritical fluid extraction.

The course is divided into three thematic units. The first thematic unit is dedicated to the study of membrane separation operations: Fundamentals of operations with membranes and applications as well as the methods of calculation and design of related equipment (reverse osmosis, ultrafiltration, gas separation, pervaporation, electrodialysis). In the second unit, from the study of the theoretical foundations of the physicochemical properties of supercritical fluids, the foundations of supercritical fluid extraction are analysed. The third unit begins with the study of vapor-liquid equilibrium for multicomponent mixtures, with thermodynamic models and mapping using different types of diagrams, as a first step to address the design of multicomponent mixtures distillation units and no conventional distillation processes. The focus of the course is highly practical and applied to the calculations made in the design and analysis of separation processes. The practical part of the third block is based on the use of commercial software for the simulation of the processes described therein.

The contents of the course are: **Non-ideal Thermodynamic Models. Pressure-swing distillation. Multicomponent distillation: extractive and azeotropic**. **Membrane separation operations. Supercritical fluid extraction.**

PREVIOUS KNOWLEDGE

Relationship to other subjects of the same degree

There are no specified enrollment restrictions with other subjects of the curriculum.

Other requirements

Students with a BSc degree in Chemical Engineering not need any additional requirements.
Students from other degrees would be desirable to count with the following skills:
Possess basic knowledge of phase thermodynamic
Be familiar with the laws of conservation, approaching and resolution balances and concepts of basic or unit operation and transport process.

OUTCOMES

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- Students should apply acquired knowledge to solve problems in unfamiliar contexts within their field of study, including multidisciplinary scenarios.
- Students should be able to integrate knowledge and address the complexity of making informed judgments based on incomplete or limited information, including reflections on the social and ethical responsibilities associated with the application of their knowledge and judgments.
- Students should communicate conclusions and underlying knowledge clearly and unambiguously to both specialized and non-specialized audiences.
- Students should demonstrate self-directed learning skills for continued academic growth.

- Students should possess and understand foundational knowledge that enables original thinking and research in the field.
- Be able to apply the scientific method and the principles of engineering and economics to formulate and solve complex problems in processes, equipment, facilities and services in which matter changes its composition, state or energy content, these changes being characteristic of the chemical industry and of other related sectors such as pharmacology, biotechnology, materials science, energy, food or the environment.
- Conceive, plan, calculate and design processes, equipment, industrial facilities and services in the field of chemical engineering and other related industrial sectors in terms of quality, safety, economics, rational and efficient use of natural resources and environmental conservation.
- Know how to establish and develop mathematical models by using appropriate software in order to provide the scientific and technological basis for the design of new products, processes, systems and services and for the optimisation of others already developed.
- Integrate knowledge and handle the complexity of formulating judgments and decisions, based on incomplete or limited information, which take account of the social and ethical responsibilities of professional practice.
- Adapt to changes and be able to apply new and advanced technologies and other relevant developments with initiative and entrepreneurship.
- Have skills for independent learning in order to maintain and enhance the specific competences of chemical engineering which enable continuous professional development.
- Be able to access information tools in different areas of knowledge and use them properly.
- Be able to assess the need to complete their technical, scientific, language, computer, literary, ethical, social and human education, and to organise their own learning with a high degree of autonomy.
- Be able to defend criteria with rigor and arguments and to present them properly and accurately.
- Be able to take responsibility for their own professional development and specialisation in one or more fields of study.
- Design products, processes, systems and services for the chemical industry and optimise others already developed, on the basis of the technologies of various areas of chemical engineering including transport processes and phenomena, separation operations and engineering of chemical, nuclear, electrochemical and biochemical reactions.
- Apply critical reasoning to their knowledge of mathematics, physics, chemistry, biology and other natural sciences, obtained through study, experience and practice, in order to establish economically viable solutions to technical problems.
- Conceptualize engineering models; apply innovative methods in problema solving and applications suitable for the design, simulation, optimization and control of processes and systems.

- Be able to solve unfamiliar and ill-defined problems that have specifications in competition by considering all possible methods of solution, including the most innovative ones, and selecting the most appropriate, and correct implementation by evaluating the different design solutions.

LEARNING OUTCOMES

1. Know and be able to apply the thermodynamic models for the determination of liquid-vapor equilibrium of multicomponent mixtures.
2. Be able to select properly the thermodynamic model according to the type of mixture to be separated to obtain reliable results in the design and simulation of the separation process.
3. Be able to use the residue curve maps and pseudobinary diagrams to plan column sequences for extractive and / or azeotropic distillation operations.
4. Know and acquire skills in the handling of simulators for the rigorous design and optimization of rectification columns of multicomponent mixtures, as well as for the determination of equilibrium between phases of these mixtures.
5. Know the membrane separation processes and their classification based on the driving force and be able to select the most suitable one according to the required application.
6. Know the synthetic membranes, their classification based on their chemical nature and structure, and the properties of the materials used in their manufacture and be able to select the most suitable one according to the required application.
7. Know the membrane modules and their classification based on their geometry, type of flow and multiple configurations. Be able to select the most suitable one according to the required application.
8. Know the models of transport of species through membranes, and the related phenomena: concentration polarization, gel layer formation and cake deposition, as well as know how to apply them to the design of equipment for the main membrane separation operations: Reverse Osmosis, Ultrafiltration, Gas Permeation, Pervaporation and Dialysis.
9. Know the extraction with supercritical fluids, its fundamentals, industrial applications, and theoretical models for the design of equipment.

DESCRIPTION OF CONTENTS

1. Fundamentals of membrane separation processes

The membrane as a separating element. Models of transport through the membrane.

2. Pressure driven membrane processes

Reverse osmosis, Ultrafiltration and Microfiltration.

3. Concentration driven membrane processes

Gas separation, Pervaporation and Dialysis.

4. Supercritical fluid extraction

Physicochemical properties of supercritical fluids. Thermodynamic phase equilibrium. General design considerations. Industrial applications.

5. Vapor-liquid equilibrium for multicomponent mixtures

Fugacity and activity coeficients, vapor-liquid equilibrium ratio (K values). Nonideal thermodynamic models.

6. Ternary Diagrams

Pseudobinary diagrams. Residue curve maps: nodes, saddles, separatrixes and distillation regions.

7. No conventional distillations

Pressure-swing distillation, extractive distillation and azeotropic distillation (homogeneous and heterogeneous).

WORKLOAD

ACTIVITY	Hours	% To be attended
Theory classes	32,00	100
Classroom practices	15,00	100
Laboratory practices	10,00	100
Seminars	3,00	100
Development of group work	10,00	0
Development of individual work	10,00	0
Study and independent work	20,00	0
Readings supplementary material	2,50	0
Preparation of evaluation activities	20,00	0
Preparing lectures	10,00	0
Preparation of practical classes and problem	2,50	0
Resolution of case studies	15,00	0
TOTAL	**150,00**	

TEACHING METHODOLOGY

Theoretical activities

- Explanatory development of the subject with the student's participation in resolving specific issues.
- Carrying out individual evaluation tests.

Practical activities

- Learning by means of solving problems, exercises, and case studies through which skills on different aspects of the subject are acquired. The following types of activities will be undertaken:

- Classes of problems and questions in the classroom.

- Discussion and solving sessions of problems and exercises previously worked by students.

- Realization of evaluated numerical questions/problems.

- Computer simulation practices: Training on using the simulator Aspen HYSYS®; practical application of knowledge and skills to the design, simulation, and optimization of rectification columns of multicomponent mixtures.

EVALUATION

The assessment of student learning will be carried out in the **first call** using two models:

Model A: The assessment of student learning is based on a continuous assessment taking into account the activities (questionnaires and submitted works), an objective test of the laboratory and an exam to be carried out in the official date. The questionnaires will be evaluated considering two Blocks (Block I: Units 1 to 4 and Block II: Units 5 to 7), so that if the student gets in the questionnaires of one of the Blocks an average mark equal to or higher than 4 (out of 10), the student is exempted to perform in the exam the theoretical part of that Block. Throughout the semester the performance of two works consisting of the study of a typical case will be offered. Both these works and the objective laboratory test constitute ***non-recoverable activities***. If the student chooses this type of evaluation, the student must have completed all questionnaires, submitted all the proposed works, and obtained both in the objective laboratory test and in the exam a mark equal or greater than 4 (out of 10). Once these requirements have been reached, the final mark of the subject will be obtained taking into account the following cases:

A1. If the student has obtained an average mark greater than or equal to 4 in the questionnaires of the two Blocks, the final mark will be obtained as the weighting between the average marks of the questionnaires (15%), submitted works (20%), laboratory test (20%) and a practical exam (45%).

A2. If the student has obtained an average mark greater than or equal to 4 in the questionnaires of only one of the Blocks, the final mark will be obtained as the weighting between the average mark of the passed questionnaire (7.5%), submitted works (20%), laboratory test (20%) and theoretical-practical exam (52.5%).

A3.If the student has obtained an average mark lower than 4 in the questionnaires of the two Blocks, the final mark will be obtained as the weighting between the average marks of the submitted works (20%), laboratory test (20%) and theoretical-practical exam (60%).

Model B: The assessment of the course with this model will be realized through an objective exam of all the contents of the subject (minimum note 4) that will consist of both theoretical-practical questions and problems and it will be realized in the official date. The final mark with this model will be obtained as the average mark described in the Model A3.

The subject will be considered exceeded when the average final mark obtained is equal to or greater than 5 (out of 10). In both model A and model B, if the mark of the exam is lower than 4, the final mark of the subject will be the one obtained in the exam.

In the **second call** the evaluation modality will be B.

REFERENCES

Basic

- Introducción a la Termodinámica en Ingeniería Química, 7a ed. , Joe M. Smith, Hendrick C. Van Ness y Michael M. Abbott, McGraw-Hill, 2014 (http://links.uv.es/A3RmkY0)
- Conceptual Design of Distillation Systems, M.F. Doherty y M.F. Malone, McGraw-Hill, 2001
- Fundamentals of Multicomponent Distillation, C.D. Holland, McGraw-Hill, 1981
- Rate Controlled Separations, P.C. Wankat, Elsevier Science Publishers, 1990
- Membrane Technology and Applications, Richard W. Baker, McGraw Hill, 2012 (http://ebookcentral.proquest.com/lib/univalencia/detail.action?docID=977928
- Supercritical Fluid Extraction: Principles and Practice, M. McHugh; V. Krukonis Butterworth-Heinemann, 1994

Additional

- Distillation Principles and Practice, J.G. Stichlmair y J.R. Fair, Wiley-VCH, 1998
- Basic Principles of Membrane Technology, M. Mulder , Kluwer Academic Publishers, 1996