COURSE DESCRIPTION

Heat integration and pinch technology

Academic year: 2026 - 2027

1. Programme-related data

1.1. Higher Education Institution	Universitatea Babes-Bolyai
1.2. Faculty	Chemistry and Chemical Engineering
1.3. Department	Chemical Engineering
1.4. Field	Chemical Engineering
1.5. Level of study	Master
1.6. Degree programme / Qualification	Advanced chemical process engineering / Master
1.7. Form of education	Full time

2. Course-related data

2.1. Course title	**Heat integration and pinch technology**			Course code	**CME7333**
2.2. Course coordinator	Prof. PhD Eng. Calin-Cristian Cormos				
2.3. Seminar coordinator	Prof. PhD Eng. Calin-Cristian Cormos				
2.4. Year of study	II	2.5. Semester	3	2.6. Type of assessment	Exam
2.7. Course status		Compulsory		2.8. Course type	Core subject

3. Total estimated time (hours per semester of teaching activities)

3.1. Number of hours per week	4	of which: 3.2. course	2	3.3. seminar	2
3.4. Total of hours in the curriculum	56	of which: 3.5. course	28	3.6. seminar	28
Time allocation for individual study (IS) and self-taught activities (ST)					**hours**
Learning from textbooks, course materials, bibliography, and notes (IS)					25
Additional research in the library, on subject-specific electronic platforms, and on-site					20
Preparing seminars/ laboratories/ projects, assignments, reports, portfolios, and essays					15
Tutoring (professional guidance)					6
Examinations					3
Other activities					-
3.7. Total hours of individual study (IS) and self-taught activities (ST)			69		
3.8. Total hours per semester			125		
3.9. Number of credits			5		

4. Prerequisites (where applicable)

4.1. curriculum-related	Not the case
4.2 skills-related	Not the case

5. Specific conditions (where applicable)

5.1. course-related	• The students will close the mobile phones • Delays will not be tolerated
5.2. seminar-related	• The students will close the mobile phones • For laboratory work the students will wear protective clothes • The installations under operation will not be leave unattended • The project / calculations will be given to the course coordinator in the following week after performing the work

	• Delays will be penalised with 0.5 points/day • Food is prohibited in the laboratory

6.1. Competencies resulting from the completion of the degree programme ***(as referred to in the curriculum)*****[1]**

Professional competencies	
Competency code	**Competency**
PC1	Description, analysis and use of elaborate theories and concepts in the fields of chemistry and process advanced chemical engineering
PC2	Technological design of processes, equipment and apparatus specific to process engineering for the improvement of performances of biochemical and chemical processes by using computer-assisted instruments (CAD) and principles of long-term development
PC3	Development and use of mathematical models and simulators in process engineering for diagnosis of problems, analysis of optimum operating systems and control of (bio)chemical processes
PC4	Development of processes, apparatus and equipment specific to process engineering by promoting new solutions for process intensification, optimum operation and control
PC5	Identifying and defining a research theme in the field of chemical engineering process, elaboration and implementation of a plan for achieving the objectives proposed and valuing the scientific research results obtained
Transversal competencies	
Competency code	**Competency**
TC1	Independent execution of complex professional assignments and autonomous development of project-research activities by using computer-assisted techniques and by observing the norms of professional ethics and moral conduct
TC2	Planning, monitoring, and assuming the duties of a subordinate professional group. Demonstrating the capacity of coordination, analytical thinking, adaptability and flexibility, collaboration with team members
TC3	Self-assessment of professional performances and determining the continuous training needs, permanent information and documentation in the field of activity and related areas, according to the needs of the labour market

6.2. Learning outcomes relevant to the degree programme (as referred to in the curriculum)[2]

Learning outcomes targeted by the subject		
Competency code	**Knowledge and comprehension**	**Specific academic skills**
PC1 **PC4** **TC1**	1. Formulation of solutions to solve complex chemical engineering problems based on knowledge, identification and application of advanced concepts, methods and theories in the field of chemical engineering and chemistry	1. Critical analysis and application of advanced principles, methods, and techniques for the evaluation, design, and development of new products and technologies
PC1 **PC3** **TC1**	2. Explain and understand the operation of devices, equipment and processes in the chemical process industries based on software environments that describe their behaviour using complex analytical or statistical mathematical models	2. Use of mathematical models for technological design and their implementation in automatic control systems, in order to obtain optimal solutions for economically and energetically operation, associated to low environmental impact

[1] The professional and/or transversal skills targeted by the subject for which the course description is prepared will be copied from the curriculum of the degree programme. For each competency, the complete entry, including the competency code, will be copied with the exact wording that appears in the curriculum, without any changes. If no competency is copied from either of the two categories, the row corresponding to that category is deleted from the table.

[2] The learning outcomes relevant for the degree programme and targeted by the subject for which the course description is prepared will be listed. The entries, copied without any changes from the Curriculum by subject type (Core Subject/Specialisation Subject/Complementary Subject), are listed under the corresponding competency.

PC4 **TC2**	3. Knowledge of advanced concepts for analysis, intensification and synthesis of processes, devices and equipment specific to process engineering	3. Creative use of the analysis, intensification and synthesis of chemical processes in the development of innovative products/technologies and in the improvement of the decision-making act related to their optimal management

7. Subject-specific learning outcomes

Knowledge and comprehension
1. Master student knows the main elements used in the design, thermal integration and operation of modern production systems for reducing the environmnetal impact and a sustainable developement of industrial systems
2. Master student understands how to apply modern evaluation and integration techniques for sustainable development of modern production systems
3. Master student applies adequate working tools of energy integration for chemical process design in view of sustainable developemnt
4. Master student makes the difference between various techno-economic and environmnetal impact performance indicators used for process analysis
Specific academic skills
1. Master student identifies the main research and development directions of thermal integration for sustainable development of industrial production systems
2. Master student makes the difference between integration and intensification methods applied in design and operation of industrial production systems
3. Master student applies modern paradigms of chemical engineering to improce the techno-economic indicators and to reduce the environmnetal impact of industrial sector

8. Contents

8.1. Course	**Teaching and learning methods**	**Remarks**[3]
8.1.1. Recapitulative elements of mathematical modelling and simulation of chemical processes. Conceptual design of chemical processes. Importance and methodology, engineering method. Hierarchical approach in plant design. Design data.	Presentation; Explanation; Conversation; Description; Debate	
8.1.2. Elements of economic engineering. Capital and operational costs. Cost estimation methods. Equipment amortisation, calculation methods, present value of money, cash-flow calculation. Process indicators for rentability and profitability. Economic potential on the process.	Presentation; Explanation; Conversation; Description; Debate	
8.1.3. Data collection for design of chemical and thermo-chemical processes. Carbon capture and storage technologies applied to energy conversion processes. Techno-economic evaluation of energy conversion. Capital and operational costs estimation.	Presentation; Explanation; Conversation; Description; Debate	
8.1.4. Energy integration of the process. Introduction in pinch analysis: importance, fundamental principles, determination of minimum heat and cooling duties, cascade diagrams, temperature – enthalpy diagrams and	Presentation; Explanation; Conversation; Description; Debate	

[3] For example, organisational aspects, recommendations for students, specific aspects relating to the course/seminar, such as inviting experts in the field, etc.

grand composite curves, rules of pinch analysis. Informatic methods for performing pinch analysis.		
8.1.5. Design of heat exchanger (HX) network. Energy integration of the plant. Calculation of the heat exchanger number and heat transfer area estimation. Estimation of capital costs with heat exchanger network.	Presentation; Explanation; Conversation; Description; Debate	
8.1.6. Estimation of capital costs for heat exchanger network. Total (capital and energy) costs. Optimisation of HEN	Presentation; Explanation; Conversation; Description; Debate	
8.1.7. Exemplification for capital and energy costs estimation for various industrial case studies (e.g. energy conversion systems, CO_2 capture technologies using chemical gas-liquid absorption etc.)	Presentation; Explanation; Conversation; Description; Debate	
8.1.8. Design of heat exchanger network. Energy integration of the plant. Design of the HX network above and below the pinch point. Stream feasible combinations. Cycles and paths. Rules for breaking cycles and restoring the minimum temperature difference. Reduction of the HX number. Advantages and disadvantages of the pinch analysis, economic evaluation of the HX network, controllability of a heat integrated process.	Presentation; Explanation; Conversation; Description; Debate	
8.1.9. Mathematical modelling, simulation of energy conversion processes (gasification, combustion, electro-chemical processes). Conceptual design of energy conversion processes.	Presentation; Explanation; Conversation; Description; Debate	
8.1.10. Heat and power integration. Energy conversion processes based on fossil and renewable fuels: power plants on natural gas / coal / lignite / biomass / biogas, coal gasification, biogas reforming. Fundamentals of thermo-technique. Brayton and Rankine thermodynamic cycles, methods for increasing energy efficiency. Gas and steam turbines.	Presentation; Explanation; Conversation; Description; Debate	
8.1.11. Design of Heat Recovery Steam Generator (HRSG). Heat and power integration study in case of coal gasification. Energy conversion processes (gasification of coal and lignite) coupled with chemical processes (hydrogen, methanol, ammonia synthesis).	Presentation; Explanation; Conversation; Description; Debate	
8.1.12. Fossil fuels decarbonisation. Carbon capture and storage: pre-combustion, post-combustion capture. Solvents used for CO_2 capture.	Presentation; Explanation; Conversation; Description; Debate	
8.1.13. Combustion and oxy-combustion processes. Sub-critical and super-critical power plants. Flue gas desulphurisation and denitrification. Techno-economic evaluations of steam power plants.	Presentation; Explanation; Conversation; Description; Debate	

8.1.14. Renewable energy conversion processes (solar, wind, thermo-chemical cycles etc.). Hydrogen energy chain. Hydrogen production & utilisation.	Presentation; Explanation; Conversation; Description; Debate	

Bibliography:
1. J.M. Douglas, Conceptual design of chemical processes, McGraw-Hill Book Company, New York, U.S.A, 1988.
2. R. Smith, Chemical process: Design and integration, 2-nd edition, John Wiley / Sons, 2016.
3. W. D. Seider, J. D. Seader, D. R. Lewin, Product & process design principles, John Wiley / Sons, 2004.
4. A. Dimian, Integrated design and simulation of chemical processes, Elsevier, 2003.
5. C. Higman, M. Van der Burgt, Gasification, 2-nd edition, Gulf Professional Publishing, 2008.
6. C.C. Cormos, Decarbonizarea combustibililor fosili solizi prin gazeificare, Presa Universitara Clujana, 2008.
7. C.C. Cormos, Thermal integration and pinch technology, course support, 2026.

8.2. Seminar	**Teaching and learning methods**	**Remarks**
8.2.1. Introduction in mathematical modelling and simulation software's for chemical processes (ChemCAD, Aspen, HYSYS, Pro/II). Case studies: simulation of chemical processes in steady-state and dynamic conditions (e.g. batch distillation).	Explanation; Conversation; Description; Problematisation	
8.2.2. Case studies: simulation of chemical processes in dynamic conditions (using ChemCAD and Aspen), performing sensitivity studies, controllability.	Explanation; Conversation; Description	
8.2.3. Numeric applications for heat integration case studies and pinch analysis. Calculation of minimum heat and cooling duties, cascade diagrams, temperature – enthalpy diagrams, grand composite curves. Excel applications for pinch analysis.	Explanation; Conversation; Description; Problematisation	
8.2.4. Design of the heat exchanger network, heat transfer area estimation and calculation of the heat exchanger number. Capital and operational costs estimation.	Explanation; Conversation; Description; Problematisation	
8.2.5. Capital and operational costs estimation for the heat exchanger network. Controllability of the heat integrated schemes.	Explanation; Conversation; Description; Problematisation	
8.2.6. Heat and power integration in industrial plants. Modelling and simulation of the energy conversion processes for fossil fuels (natural gas, coal and lignite) power plants. Brayton and Rankine cycles. Simulation of Heat Recovery Steam Generator (HRSG).	Explanation; Conversation; Description; Problematisation	
8.2.7. Modelling and simulation of energy conversion processes in case of fossil fuels (coal and lignite) power plants. Integration of fuel drying process in plant design.	Explanation; Conversation; Description; Problematisation	
8.2.8. Modelling and simulation of energy conversion processes: case of coal gasification (Shell gasification technology with and without CO_2 capture). Simulation of combined cycle gas turbine (CCGT). CO_2 capture. Gas and steam	Explanation; Conversation; Description; Problematisation	

turbines.		
8.2.9. Modelling and simulation of Shell gasification technology with and without CO_2 capture. Simulation of combined cycle gas turbine. CO_2 capture. Gas and steam turbines.	Explanation; Conversation; Description; Problematisation	
8.2.10. Modelling and simulation of energy conversion processes: case of coal gasification (GE - Texaco gasification technology with and without CO_2 capture). Simulation of combined cycle gas turbine.	Explanation; Conversation; Description; Problematisation	
8.2.11. Modelling and simulation of GE - Texaco gasification technology with and without CO_2 capture. Simulation of combined cycle gas turbine.	Explanation; Conversation; Description; Problematisation	
8.2.12. Modelling and simulation of steam power plants (super-critical) with and without CO_2 capture. Assessment of various post-combustion CO_2 capture options.	Explanation; Conversation; Description; Problematisation	
8.2.13. Modelling and simulation of steam power plants (super-critical) with and without CO_2 capture. Assessment of energetic performances as well as the economic ones.	Explanation; Conversation; Description; Problematisation	
8.1.14. Modelling and simulation of coal gasification processes coupled with chemical installations. Case studies: methanol / ammonia / urea production. Poly-generation systems based on gasification process.	Explanation; Conversation; Description; Problematisation	

Bibliography:

1. J.M. Douglas, Conceptual design of chemical processes, McGraw-Hill Book Company, New York, U.S.A, 1988.
2. R. Smith, Chemical process: Design and integration, 2-nd edition, John Wiley / Sons, 2016.
3. W. D. Seider, J. D. Seader, D. R. Lewin, Product & process design principles, John Wiley / Sons, 2004.
4. A. Dimian, Integrated design and simulation of chemical processes, Elsevier, 2003.
5. C. Higman, M. Van der Burgt, Gasification, 2-nd edition, Gulf Professional Publishing, 2008.
6. C.C. Cormos, Decarbonizarea combustibililor fosili solizi prin gazeificare, Presa Universitara Clujana, 2008.
7. C.C. Cormos, Thermal integration and pinch technology, course support, 2026.

9. Evaluation

Type of activity	9.1 Evaluation criteria[4]	9.2 Evaluation methods[5]	9.3 Percentage in the final grade
9.4. Course	Correct responses – deep understanding of the concepts treated in the course Correct solving the numerical applications	Written exam - the access to the exam is conditioned by the presentation of seminar and individual works. Exam fraud is punished by expulsion from the exam and from the whole programme according to the rules set up in ECST	85 %

[4] The evaluation criteria must directly reflect the learning outcomes targeted at the level of the degree programme respectively at the level of the subject. More specifically, the learning outcomes set out in the expected learning outcomes are assessed.

[5] Both final evaluation methods and ongoing evaluation strategies should be established.

		UBB	
9.5. Seminar/ laboratory	Correct responses – deep understanding of the concepts treated in the seminar Quality of the individual works Activity during the seminar	Seminar and individual works will be given in the last week of didactic activity	15 %
9.6 Minimum standard for passing			
• Grade 5 for both seminars works and exams • Knowledge about the basic concepts of thermal integration and pinch analysis, techno-economic evaluations of heat exchanger network, energy conversion processes and carbon capture and storage technologies.			

10. SDG labels (Sustainable Development Goals)[6]

	○	Sustainable Development Generic Label						
1 FĂRĂ SĂRĂCIE	2 FOAMETE „ZERO”	3 SĂNĂTATE ȘI BUNĂSTARE	4 EDUCAȚIE DE CALITATE	5 EGALITATE DE GEN	6 APĂ CURATĂ ȘI SANITAȚIE	7 ENERGIE CURATĂ ȘI LA PREȚURI ACCESIBILE	8 MUNCĂ DECENTĂ ȘI CREȘTERE ECONOMICĂ	9 INDUSTRIE, INOVAȚIE ȘI INFRASTRUCTURĂ
○	○	○	○	○	○	○	○	●
10 INEGALITĂȚI REDUSE	11 ORAȘE ȘI COMUNITĂȚI DURABILE	12 CONSUM ȘI PRODUCȚIE RESPONSABILE	13 ACȚIUNE CLIMATICĂ	14 VIAȚA ACVATICĂ	15 VIAȚA TERESTRĂ	16 PACE, JUSTIȚIE ȘI INSTITUȚII EFICIENTE	17 PARTENERIATE PENTRU REALIZAREA OBIECTIVELOR	No label applies
○	○	○	○	○	○	○	○	○

Date of entry:
07.04.2026

Signature of course coordinator

Prof. Eng. Calin-Cristian Cormos

Signature of seminar coordinator

Prof. Eng. Calin-Cristian Cormos

Date of approval in the department:
21.04.2026

Signature of the head of department

Prof. Eng. Graziella Liana Turdean

[6] Select a single label which, according to the *Implementation of SDG labels in the academic process*, best matches the subject. If the subject addresses sustainable development in a generic manner (i.e. by presenting/introducing the general framework of sustainable development, etc.), then the Sustainable Development generic label may be applied. If none of the labels describe the subject, select the last option: *"No label applies."*