

SYLLABUS

1. Information regarding the programme

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| 1.1 Higher education institution | Babes-Bolyai University |
| 1.2 Faculty | Chemistry and Chemical Engineering |
| 1.3 Department | Chemical Engineering |
| 1.4 Field of study | Chemical Engineering |
| 1.5 Study cycle | Master |
| 1.6 Study programme / Qualification | Advanced chemical process engineering |

2. Information regarding the discipline

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|----------------------------|---|--------------|---|-------------------------|---|------------------------|------------------|
| 2.1 Name of the discipline | Heat integration and pinch technology (Thermal integration and pinch technology) – CME7333 | | | | | | |
| 2.2 Course coordinator | Prof. Dr. Eng. Calin-Cristian Cormos | | | | | | |
| 2.3 Seminar coordinator | Prof. Dr. Eng. Calin-Cristian Cormos | | | | | | |
| 2.4. Year of study | II | 2.5 Semester | 3 | 2.6. Type of evaluation | E | 2.7 Type of discipline | DF/ Mandatory |

3. Total estimated time (hours/semester of didactic activities)

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|--|-------|----------------------|----|-------------|----|
| 3.1 Hours per week | 4 | Of which: 3.2 course | 2 | 3.3 seminar | 2 |
| 3.4 Total hours in the curriculum | 56 | Of which: 3.5 course | 28 | 3.6 seminar | 28 |
| Time allotment: | hours | | | | |
| Learning using manual, course support (including electronic format), bibliography, notes | 25 | | | | |
| Additional documentation (in libraries, on electronic platforms, field documentation) | 20 | | | | |
| Preparation for seminars/labs, homework, papers, portfolios and essays | 15 | | | | |
| Tutorship | 6 | | | | |
| Evaluations | 3 | | | | |
| Other activities: | - | | | | |
| 3.7 Total individual study hours | 69 | | | | |
| 3.8 Total hours per semester | 125 | | | | |
| 3.9 Number of ECTS credits | 5 | | | | |

4. Prerequisites (if necessary)

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| 4.1. curriculum | <ul style="list-style-type: none"> Not the case |
| 4.2. competencies | <ul style="list-style-type: none"> Not the case |

5. Conditions (if necessary)

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| 5.1. for the course | <ul style="list-style-type: none"> The students will close the mobile phones Delays will not be tolerated |
| 5.2. for the seminar /lab activities | <ul style="list-style-type: none"> 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 |

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| | <ul style="list-style-type: none"> • 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 |
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6. Specific competencies acquired

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| Professional competencies | <ul style="list-style-type: none"> • Definition of notions, concepts, theories and detailed models in the field of chemistry and chemical process engineering and utilisation in professional activity • Utilisation of thorough knowledge in the field of chemistry and chemical engineering for explanation and interpretation of chemical processes • Identification and application of concepts, methods and advanced theories for complex problem solving in the field of chemical engineering • Critical analysis and utilisation of principles, methods and advanced work techniques for qualitative and quantitative assessments of chemical engineering processes • Application of concepts and advanced theories in the field of chemical engineering for process design with focus on thermal integration of the plant • Language definition and identification of advanced concepts for process and units design from industrial plants and fundamentals of computer-aided design (CAD) • Utilisation of advanced design concepts for interpretation of design solutions for process, equipment's and units from a (bio)chemical system using CAD instruments • Utilisation of advanced design concepts for identification of possible solutions in complex process and equipment's design for (bio)chemical systems using CAD instruments • Evaluation and critical analysis of processes, equipment and units based on concepts, theories, models, methods and design practice for identification of suitable design solutions • Formulation, development and elaboration of creative solutions for process, equipment's and units design from industrial systems, integrated design based on CAD instruments • Identification of concepts, specific resource management and quality assurance theories in process industries in the context of sustainable development • Application of professional knowledge for efficient resource management for product quality improvement and compliance with sustainable development principles • Resource management for non-pollution and low energy consumption technologies • Utilisation of criteria and evaluation methods of risk assessment, safety operation and management • Utilisation of quantitative and qualitative methods in new project design in respect to quality and resource management principles |
| Transversal competencies | <ul style="list-style-type: none"> • Independent execution of complex professional duties and research projects using computer-aided techniques (for modelling and simulation as well as PowerPoint presentation of the various assessed process design options) and comply with professional ethics and moral • Planning, monitoring and assuming professional duties of underline group. Proving the coordination capabilities, analytical thinking, adaptability and flexibility, collaboration with team members • Auto-evaluation of professional performances and establish the needs of continuous learning, documentation in the work fields in correlation with the labour market |

7. Objectives of the discipline (outcome of the acquired competencies)

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| 7.1 General objective of the discipline | <ul style="list-style-type: none"> To get familiar with basic concepts, theories and models in the field of thermal integration and pinch analysis applied to chemical and energy conversion processes |
| 7.2 Specific objective of the discipline | <ul style="list-style-type: none"> Acquisition of the basic knowledge about thermal integration of the processes Acquisition of the basic knowledge about the energy management of the industrial processes, performing pinch analysis, capital and energy trade-off Acquisition of the basic knowledge about the most important energy conversion processes, carbon capture and storage technologies, modelling and simulation of energy conversion systems and chemical processes |

8. Content

| 8.1 Course | Teaching methods | Remarks |
|--|---|---------|
| 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 grand composite curves, rules of pinch analysis. Informatic methods for performing pinch analysis. | Presentation; Explanation Conversation; Description; Debate | |
| 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 etc.) | Presentation; Explanation Conversation; Description; Debate | |

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| 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 fuels: power plants on natural gas / coal / lignite, coal gasification. 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 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, 2021. | | |
| 8.2 Seminar / laboratory | Teaching 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 | |

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| 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 turbines. | Explanation; Conversation; Description; Problematisation | |
| 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, 2021.

9. Corroborating the content of the discipline with the expectations of the epistemic community, professional associations and representative employers within the field of the program

- By instructing the theoretical and practical concepts of Thermal integration and pinch analysis course, the students will get the knowledge in accordance with the competencies from diploma supplement and qualifications from ANC.

10. Evaluation

| 10. Evaluation | | | |
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| Type of activity | 10.1 Evaluation criteria | 10.2 Evaluation methods | 10.3 Share in the grade (%) |
| 10.4 Course | Correct responses – deep understanding of the concepts treated in the course | Written exam - the access to the exam is conditioned by the presentation of seminar and individual works | 80 % |
| | Correct solving the numerical applications | Exam fraud is punished by expulsion from the exam and from the whole programme according to the rules set up in ECST UBB | |
| 10.5 Seminar/lab activities | Correct responses – deep understanding of the concepts treated in the seminar / laboratory | Seminar and individual works will be given in the last week of didactic activity | 20 % |
| | Quality of the individual projects / works | | |
| | Activity during the seminar / laboratory | | |
| 10.6 Minimum performance standards | | | |
| <ul style="list-style-type: none">➤ 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. | | | |

Date
14.04.2022

Signature of course coordinator
Prof. Eng. Calin-Cristian Cormos


Signature of seminar coordinator
Prof. Eng. Calin-Cristian Cormos




Date of approval

Signature of the head of department

26.04.2022



Prof. Eng. Graziella Liana Turdean