SYLLABUS

1. Information regarding the programme

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

2.1 Name of the discipline	**Thermal integration and pinch technology – CME7333**						
2.2 Course coordinator	Assoc. Prof. Dr. Eng. Calin-Cristian Cormos						
2.3 Seminar coordinator	Assoc. 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	Mandatory

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

3.1 Hours per week	3	Of which: 3.2 course	2	3.3 seminar/laboratory	1
3.4 Total hours in the curriculum	42	Of which: 3.5 course	28	3.6 seminar/laboratory	14

Time allotment:	hours
Learning using manual, course support, bibliography, course notes	28
Additional documentation (in libraries, on electronic platforms, field documentation)	35
Preparation for seminars/labs, homework, papers, portfolios and essays	28
Tutorship	14
Evaluations	3
Other activities:	-

3.7 Total individual study hours	108
3.8 Total hours per semester	150
3.9 Number of ECTS credits	6

4. Prerequisites (if necessary)

4.1. curriculum	• Not the case
4.2. competencies	• Not the case

5. Conditions (if necessary)

5.1. for the course	• The students will close the mobile phones • Delays will not be tolerated
5.2. for the seminar /lab activities	• The students will close the mobile phones • For laboratory work the students will wear protective clothes

	• The installations under operation will not be leave unatended • 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. Specific competencies acquired

Professional competencies	• Definition of notions, concepts, theories and detailed models in the field of chemistry and chemical process engineering and utilisation in profesional 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 C1.5 Aplicarea conceptelor şi teoriilor avansate din domeniul ingineriei chimice de proces pentru elaborarea proiectelor si rezolvarea problemelor • 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, equipments and units from a (bio)chemical system using CAD instruments • Utilisation of advanced design concepts for identification of possible solutions in complex process and equipments design for (bio)chemical systems using CAD instruments • Evaluation and critical analysis of processes, equipmens 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, equipments 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 sustanaible development • Application of professional knowledge for efficient resource management for product quality improvement and compliance with sustainable development principles • Resource management for non-polution and low energy consumption technologies • Utilisation of criteria and evaluation methods of risk asssessment, safety operation and management • Utilisation of quantitative and qualitative methods in new project design in respect to quality and resource management principles
Transversal competencies	• Independent execution of complex professional duties and research projects using computer-aided techniques and comply with professional ethics and moral • Planning, monitoring and assuming professional duties of underline group. Proving the coordonation capabilities, analytical thinking, adaptability and flexibility, colaboration with team members • Auto-evaluation of professional performances and establish the needs of continous learning, documentation in the work fields in corelation with the labour market

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

7.1 General objective of the discipline	• 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	• Aquisition of the basic knowledge about thermal integration of the processes • Aquisition of the basic knowledge about the energy management of the industrial processes, performing pinch analysis, capital and energy trade-off • Aquisition of the basic knowledge about the most important energy conversion processes, carbon capture and storage technologies, modeling and simulation of energy conversions

8. Content

8.1 Course	Teaching methods	Remarks
8.1.1. Recapitulative elements of mathematical modeling and simulation of chemical processes. Conceptual design of chemical processes. Importance and methodology, engineering method. Ierarhical approach in plant design. Design data.	Presentation; Explanation Convesation; 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 Convesation; 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 Convesation; 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 Convesation; 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 Convesation; Description; Debate	
8.1.6. Estimation of capital costs for heat exchanger network. Total (capital and energy) costs. Optimisation of HEN	Presentation; Explanation Convesation; Description; Debate	
8.1.7. Exemplification for capital and energy costs estimation for industrial case studies	Presentation; Explanation Convesation; 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 fesable	Presentation; Explanation Convesation;	

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, controlability of a heat integrated process.	Description; Debate	
8.1.9. Mathematical modeling, simulation of energy conversion processes (gasification, combustion, electro-chemical processes). Conceptual design of energy conversion processes.	Presentation; Explanation Convesation; 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 thermodinamic cycles, methods for increasing energy efficiency. Gas and steam turbines.	Presentation; Explanation Convesation; 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 (casification of coal and lignite) coupled with chemical processes (hydrogen, methanol, ammonia synthesis).	Presentation; Explanation Convesation; 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 oxi-combustion processes. Sub-critical and super-critical power plants. Flue gas desulphurisation and denitrification. Techno-economic evaluations of steam power plants.	Presentation; Explanation Convesation; Description; Debate	
8.1.14. Renewable energy conversion processes (solar, wind, therm-chemical cycles etc.). Hydrogen energy chain. Hydrogen production, fuel cells.	Presentation; Explanation Convesation; Description; Debate	

Bibliography

1. Douglas J. M., Conceptual design of chemical processes, McGraw-Hill Book Company, New York, U.S.A, 1988
2. W. D. Seider, J. D. Seader, D. R. Lewin, Process design principles, John Wiley / Sons, 1999
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. B. Linnhoff, A user guide on process integration for efficient use of energy, Rugby Institution of Chemical Engineers, 1997
6. Higman C, Van der Burgt M, Gasification, Burlington, Elsevier Science, 2003
7. Kitto J.B., Stultz S.C., Steam – its generation and use, The Babcot & Wilcox Company, ed. 41, 2005
8. Smith R., Chemical process – Design and integration, Wiley, 2005
9. Cormos C., Decarbonizarea combustibililor fosili solizi prin gazeificare, Presa Universitara Clujana, 2008

8.2 Seminar / laboratory	Teaching methods	Remarks
8.2.1. Introduction in mathematical modeling and simulation softwares for chemical processes (ChemCAD, Aspen, HYSYS, Pro/II). Case studies: simulation of chemical processes in steady-state and dynamic conditions (e.g. batch distilation).	Explanation; Conversation; Description; Problematisation	
8.2.2. Case studies: simulation of chemical processes in dynamic conditions, performing senzitivity studies, controlability.	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 costs estimation.	Explanation; Conversation; Description; Problematisation	
8.2.5. Capital cost estimation for the heat exchanger network. Controlability of the heat integrated schemes.	Explanation; Conversation; Description; Problematisation	
8.2.6. Heat and power integration in industrial plants. Modeling 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. Modeling 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. Modeling 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. Modeling 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. Modeling 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. Modeling 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. Modeling and simulation of steam power plants (super-critical) with and without CO_2 capture	Explanation; Conversation; Description; Problematisation	
8.2.13. Modeling and simulation of steam power plants (super-critical) with and without CO_2 capture	Explanation; Conversation; Description; Problematisation	
8.1.14. Modeling and simulation of coal gasification processes coupled with chemical instalations. Case study: methanol / ammonia / urea production.	Explanation; Conversation; Description; Problematisation	

Bibliography

1. Douglas J. M., Conceptual design of chemical processes, McGraw-Hill Book Company, New York, U.S.A, 1988
2. W. D. Seider, J. D. Seader, D. R. Lewin, Process design principles, John Wiley / Sons, 1999

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. B. Linnhoff, A user guide on process integration for efficient use of energy, Rugby Institution of Chemical Engineers, 1997
6. Higman C, Van der Burgt M, Gasification, Burlington, Elsevier Science, 2003
7. Kitto J.B., Stultz S.C., Steam – its generation and use, The Babcot & Wilcox Company, ed. 41, 2005
8. Smith R., Chemical process – Design and integration, Wiley, 2005
9. Cormos C., Decarbonizarea combustibililor fosili solizi prin gazeificare, Presa Universitara Clujana, 2008

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 requested by possible employment sectors setted by RNCIS.

10. Evaluation

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 Corect solving the numerical applications	Written exam – the acces to the exam is conditioned by the presentation of seminar / laboratory works Exam fraud is punished by expelsion from the exam and from the whole programme according to the rules set up in ECST UBB	80 %
10.5 Seminar/lab activities	Correct responses – deep understanding of the concepts treated in the seminar / laboratory Quality of the individual projects / works Activity during the seminar / laboratory	Seminar and laboratory works will be given in the last week of didactic activity	20 %
10.6 Minimum performance standards			

- Grade 5 both in laboratory / seminar 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	Signature of course coordinator	Signature of seminar coordinator
31.03.2015	Assoc. Prof. Eng. Calin Cormos	Assoc. Prof. Eng. Calin Cormos

Date of approval

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Signature of the head of department

Prof. Eng. Vasile-Mircea Cristea