FACULTY CHEMISTRY

SUBJECT CARD

Name of subject in Polish: Aparaty i metody inżynierii chemicznej
Name of subject in English: Chemical Processes Equipment and Methods
Main field of study (if applicable): Inżynieria chemiczna i procesowa
Specialization (if applicable): Advanced Chemical Engineering and Nanotechnology
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: obligatory
Subject code ICC024034
Group of courses NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	60		60	60	15
Number of hours of total student workload (CNPS)	180		120	120	30
Form of crediting	Examination		crediting with grade	crediting with grade	crediting with grade
For group of courses mark (X) final course					
Number of ECTS points	6		4	4	1
including number of ECTS points for practical (P) classes			4	4	1
including number of ECTS points for direct teacher-student contact (BK) classes	2		2	2	0.5

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Fundamentals of physics and general chemistry.
2. Understanding of energy, power, heat and mass transfer concepts.
3. Understanding of thermodynamics rules.
4. Basics of calculus.
5. Good knowledge of international system of units (SI).
6. Knowledge of the principles of technical drawing and the ability to use AutoCAD.

SUBJECT OBJECTIVES

C1 Acquaintance student with technological process, apparatus and equipment being part in chemical installation.
C2. Gaining by the student the basic knowledge on the work of the process equipment applied for material transportation, heat and mass transfer.
C3. Acquaintance student with design methods and selection rules for the apparatus applied in chemical installations. Rules of material selection for the equipment construction.
C4. Acquaintance students with the apparatus for measurement, manual and automatic control, applied in a chemical installations.
C5. Acquaintance students with raw materials and energy supply systems.
C6 . Analysis of current fossil fuels resources.
C7 . Analysis of possibilities of energy production from renewable resources.
C8 . Understanding of operation principles of engines producing energy from renewable resources.
C9. Analysis of current trends in electricity production from renewable resources.
C10. Analysis of problems related to energy storage.
C11. Analysis of relations between energy production/consumption and global climate changes.
C12. Getting familiar with the idea of applied a membrane processes in the clean technology.
C13. Getting familiar with types of membranes, structure of membranes modules and scheme of modules connecting.

C14. Getting familiar with pressure and diffusion membrane technics and their applications
C15. Getting familiar with equipment applied in membrane processes.
C16. Learning the methods of yield and effectiveness processes membranes determination
C17. Learning the application of membrane processes in different industrial areas.
C18. Getting familiar with drying technology and drying apparatuses.
C19. Getting familiar with microwave technology.
C20.Getting familiar with IR technology.
C21.Getting familiar with safety regulations used with microwave equipment.
C22.Knowledge of measurements techniques in microwave technology.
C23. Acquainting with modern software for simulation and design of chemical plants.
C24. Acquainting with building models of unit operations and chemical plants.
C25. Teaching of performing of simulations and design computations.
C26. Teaching of searching for and calculating physical properties of substances and mixtures in simulation software.
C27. Presentation of methods for searching for, processing and analysing calculation results.
C28. Familiarization of the student with the principles of creating and reading technological schemes.
C29. The ability to use computer-aided design in the creation and modification of technological schemes.

SUBJECT LEARNING OUTCOMES

relating to knowledge:

PEK_W01 – knows what the technological process, production installation are, and what role the different apparatus play in the process installation.
PEK_W02 – knows basic equipment applied in the chemical industry installation.
PEK_W03 – knows fundamentals of design of unit operations and selection of the apparatus and constructional materials.
PEK_W04 – knows the rules of the measurement and control equipment selection as well as safety rules applied for chemical installations.
PEK_W05 – knows the systems for raw materials and energy supply.
PEK_W06 – understands the notion of renewable and non-renewable energy source.
PEK_W07 – knows conventional and renewable energy sources and their availability.
PEK_W08 – knows the methods of electricity production from conventional and renewable energy sources.
PEK_W09 – knows the basic methodology of conception of installations producing electricity from renewable resources.
PEK_W10 – is aware of current trends in research in the domain of energy.
PEK_W11 – is able to analyze the adequacy of a system of energy production from renewable source, for a given application.
PEK_W12 – knows about advanced thermal technologies: microwaves and IR
PEK_W13 – knows about drying technology and equipment used in it

relating to skills:

PEK_U01 – can determine process parameters (pressure, pressure drop, temperature, flow-rate, power consumption, mixer revolutions).
PEK_U02 – can determine the physico-chemical properties of the substances used in a technological process.
PEK_U03– can proceed process calculations for selected unit operations.
PEK_U04 – manages to select the apparatus for measurement and control of the process installation.
PEK_U05 – is able to analyze the effectiveness of energy recovery from a given renewable source.
PEK_U06 – is able to compare the renewable energy resources regarding the efficiency of energy recovery, and the environmental impact of their exploitation.
PEK_U07 – is able to propose new potential applications using energy from renewable resources.

PEK_U08 –Can carry out mixture separation on laboratory scale applying processes of microfiltration and reverse osmosis.
PEK_U09 –Can carry out the process of pervaporation and dialysis.
PEK_U10 - Can describe mathematically the work of membrane bioreactor and carry on verifying experiment.
PEK_U11 –Can select the membrane material for a specific membrane process.
PEK_U12- Can build the mathematical model of the process and to perform simulations.
PEK_U13- Can perform sensitivity analyses, optimisation calculations and to set design specifications.
PEK_U14- Can perform simulations and design calculations of chosen unit operations.
PEK_U15- Can perform an analysis of physical properties and to determine physical data necessary for computations.
PEK_U16- Can create and read a technological scheme.
PEK_U17- Can use the methods of computer aided design in the creation and modification of technological schemes.

relating to social competences:

PEK_K01 – can discuss the problems of the work conditions and equipment selection for chemical technology installation.
PEK_K02 – can work in a team.
PEK_K01 – is able to discuss the issues related to energy production from conventional (fossil, nuclear) sources;
PEK_K03 – is able to present the arguments for the reorientation of countries energy politics towards the renewable sources;
PEK_K04 – is able to take part and argue in discussions about global warming, its causes and consequences.
PEK_K05 – how to appreciate the quality of an experimental result ;
PEK_K06 – how to critically evaluate the veracity of statistical analysis of any data.

PROGRAMME CONTENT

	Lectures	**Number of hours**
	Chemical Process Equipment	
Lec1	Technological process. Unit processes and unit operations. Scheme of a technological system. Rules of the equipment selection.	2
Lec2	Equipment and methods for raw materials, semi-products, products, wastes storage.	2
Lec3	Means of transport for the materials. Friction losses during the process of fluids transportation in the pipelines.	2
Lec4	Equipment for grinding, mixing, sedimentation, filtration and spinning.	2
Lec5	Equipment for heat transfer.	2
Lec6	Equipment for evaporation and liquid solutions concentration.	2
Lec7	Equipment for cristalization.	2
Lec8	Equipment for absorption and distillation.	2
Lec9	Equipment for extraction and adsorption.	2
Lec10	Chemical reactors.	2
Lec11	Rules of the apparatus design and the selection of constructional materials.	2

Lec12	Equipment for measurement and control in the chemical installations.	2
Lec13	Systems of raw materials and Energy supply.	2
Lec14	Technical safety in a production installation.	2
Lec15	Written exam.	2
	Total hours	**30**
Membrane Processes		
Lec1	An introduction to the course. A chemical and structural classification of membranes. The idea of clean and cleaning technologies. The types of membrane processes.	2
Lec2	The types of membrane modules. A possibility of modules connection. An yield and effectiveness of membrane processes.	2
Lec3	Pressure processes – micro, ultrafiltration – basics and application. Fouling – prevention methods.	2
Lec4	Pressure processes – nanofiltration, reverse osmosis – basics and application. Application of membranes in drinking water production.	2
Lec5	An introduction to diffusion membrane processes – gas and vapor separation, pervaporation – an idea of process, properties of membranes, and an application.	2
Lec6	A membrane distillation and extraction. The liquid membranes.	2
Lec7	A dialysis – basics of process and application. The factors decrease an effectiveness of membrane process.	2
Lec8	The most popular application of membrane process in industry	2
Lec9	Drying processes – background	2
Lec10	Dryers – apparatuses	2
Lec11	Microwave technology	2
Lec12	Microwave equipment	2
Lec13	Measurements methods in microwave technology	2
Lec14	Infrared technology and equipment	2
Lec15	Specific risk management and safety procedures in chemical engineering thermal technologies	2
	Number of hours	**30**
Renewable Energy Sources		
Lec 1	Introduction. Notion of energy and energy source. Energy production vs. modern world's needs. Energy and planet overpopulation.	2
Lec 2	Non-renewable energy sources. Coal, oil, natural gas. Nuclear energy.	2
Lec 3	Biofuels.	2
Lec 4	Hydro energy.	2
Lec 5	Geothermic energy. Wind energy.	2
Lec 6	Solar (thermal) energy.	2
Lec 7	Solar (photovoltaic) energy.	2

Lec 8	Energy production/consumption vs. clamate changes. Energy storage.	1
	Total hours	**15**
Laboratory		
Chemical Process Equipment		
La1	Liquid mixer examination..	5
La2	Examination of heat exchangers of different types..	5
La3	Absorption in a packed column.	5
La4	Continuous and batch rectification.	10
La5	Liquid-liquid extraction.	5
	Total hours	**30**
Membrane processes		
La1	Microfiltration – getting familiar with microfiltration installation, determination a permeate stream, retention coefficient of components mixture. Getting familiar with fouling phenomenon.	5
La2	Ultrafiltration – getting familiar with ultrafiltration installation, fractionation conception, and cut – off definition. Balancing of membrane systems.	5
La3	Nanofiltration – learning about the mixed separation mechanism, i.e. sieve and diffusion ones. A comparison of permeate stream decline (MF, UF and NF) and the different mechanisms of transport.	5
La4	Pervaporation – getting familiar with pervaporation installation, determination a selectivity and enrichment coefficient and learning about a collection of permeate in vacuum condition	5
La5	Dialysis – getting familiar with hemodialysis module and the system of stream regulation in this type of module. Determination of mass transfer and dialysis coefficient.	5
La6	Membrane extraction – getting familiar with mechanism of membrane extraction, selection of process conditions, developing a partition coefficient. A comparison to classic process of extraction.	5
		30
Seminar		
Renewable Sources of Energy		
Se1	Coal gasification. Clean coal. CO_2 Sequestration and use.	2
Se2	Fracking of oil and gas. Gas exploitation vs. renewable energy sources.	2
Se3	Nuclear energy: ‘fusion’ or ‘fision’? Security of nuclear power plants. New generation reactors.	2
Se4	Zero emission cars. Alternative transportation fuels.	2
Se5	Small scale hydro- and wind energy: possibilities, cost, environmental impact.	2
Se6	Small scale solar installations (thermal and photovoltaic). Cost.	2
Se7	Energy storage: why? at which extend? Cost? New solutions.	2
Se8	Energy production/consumption and climate changes. Pollution. Species extinction.	1
	Total hours	**15**
Project		**Number of hours**

Aspen – optimisation of unit processes		
Pr1, Pr2	Presentation of passing rules. Discussion on usage of simulation software in chemical and process engineering. Introduction into Aspen Plus interface. Rules of appropriate choice of physical properties models. Simulation of flash distillation and rectification	4
Pr3, Pr4	Sensitivity analysis and design specification	4
Pr5	Fundamentals of hydraulic calculations. Calculations of pressure drops in pipelines. Simulation of the operation of media displacement equipment. The issue of cavitation	2
Pr6	Specifying properties of solid-state materials, including granular materials. Simulation of separation of solid materials	2
Pr7	Test 1	2
Pr8, Pr9	Analysis and estimation of physical properties of pure components and mixtures	4
Pr10	Simulation of extraction process	2
Pr11	Specifying chemical reactions. Available models of reactors. Simulation of the operation of chemical reactors	2
Pr12	Elements of heat exchange calculations – introduction to Aspen Exchanger Design and Rating	2
Pr13	Optimisation of chemical plant operation	2
Pr14	Topics to choose from: simulation of a chosen chemical plant operation or regression of physical parameters or elements of economic calculations	2
Pr15	Test 2	2
	Total hours	**30**
Industrial plant engineering and design		
Pr1	Introduction into the environment of AutoCAD Plant 3D. Familiarization with the user interface.	2
Pr2	Creating and managing a project in AutoCAD Plant 3D. Files management. Familiarization with the different work spaces.	2
Pr3-4	P&ID drawing - creating a design and a technological drawing in 2D. Inserting process equipment into the installation diagram. Pipelines. Adding fittings. Adding descriptions to the technological drawing.	4
Pr5	Modeling of steel constructions in 3D model.	2
Pr6-9	Industrial plant 3D Project. Addition and configuration of process equipment Connecting equipment with pipelines, addition of fittings.	8
Pr10	Working with the specification editor and part catalog - AutoCAD Plant 3D Spec Editor.	2
Pr11-12	Documentation - creating and printing 2D documentation in AutoCAD Plant 3D.	4
Pr13-14	Design data management and reporting in AutoCAD Plant 3D. Data exchange with other applications - AutoCAD, Inventor Professional, Excel.	4
Pr15	Presentation and submission of the final project documentation in AutoCAD Plant 3D.	2
	Total hours	**30**

TEACHING TOOLS USED

N1. Lecture.
N2. Discussion.
N3. Computer and oral presentation.
N4. Various media resources (internet, press, TV).
N5. Experiment.
N6. Report of the work.
N4. Every week test of knowledge.
N6. Description of the results with the use of graphical computer programs.
N7. Selected membranes application presentation.
N8. Consultations.

N9. Computer simulations with the use of Aspen Plus and Aspen Exchanger Design and Rating software.
N10. Computations of physical and chemical properties of substances and mixtures with the use of Aspen Properties software.
N11. Individual work in simulation software.

N12. Using Autodesk Plant 3D software, AutoCAD, Autodesk Inventor.
N13. Preparing the project.

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming (during semester), P – concluding (at semester end)	Learning outcomes number	Way of evaluating learning outcomes achievement
P1 (lecture 1)	PEK_W01-PEK_W11.	Exam
P2 (lecture 2)	PEK_W12-PEK_W18	Presentation on a chosen aspect/application of renewable energy sources will be graded
P3 (lab. 1)	PEK_U01, PEK_U02, PEK_U03, PEK_U04.	Test at the begining of each lab. (70%), report evaluation (30%).
P4 (lab. 2)	PEK_U11- PEK_U14	Test at the begining of each lab. (50%) + laboratory activity (25%) + report (25%)
F1, F2 (project 1)	PEK_U12- PEK_U15.	Partial test no 1, Partial test no 2.
P5 (project 1)		50%F1+50%F2
P6 (project 2)	PEK_U16-PEK_U17	Project report
P7 (seminar 1)	PEK_U05- PEK_U07. PEK_U08- PEK_U10.	Presentation on a chosen aspect/application of renewable energy sources will be graded

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] R. Koch, A. Noworyta, *Procesy mechaniczne w inżynierii chemicznej*. WNT 1992.
[2] A. Skoczylas, J. Dziak, Procesy cieplne w inżynierii chemicznej, Oficyna Wydawnicza PWr 2015.
[3] R.Koch, A. Kozioł, Dyfuzyjno-cieplny rozdział substancji. WNT 1994.
[4] J.R. Couper, W.R. Penney, J.R. Fair, S.M. Walas, Chemical Process Equipment, Elsevier 2005.
[4] D.W. Green, R.H. Perry, Perry's chemical engineers' handbook, 8-th ed., McGraw-Hill 2007.
[5] R.Ehrlich, H.A. Geller, Renewable Energy, CRC Press 2017.

[6] R. Rautenbach – Procesy membranowe, Wyd. Naukowo-Techniczne, W-wa 1996
[7] M.Bodzek, K.Konieczny – Techniki membranowe w ochronie środowiska, Gliwice 1997
[8] A.Narębska – Membrany i membranowe techniki rozdziału, Toruń 1997

[9] K. Al-Malah, Aspen Plus® Chemical Engineering Applications, Wiley, Hoboken, 2017.
[10] R. Schefflan, Teach Yourself the Basics of Aspen Plus. Wyd. 2., Wiley, 2016.
[11] Pomoc programu Aspen Plus.

[12] Tickoo S., AutoCAD Plant 3D 2018 for Designers, ADCIM Technologies; 4th edition, 2017
[13] Toghraei M., Piping and Instrumentation Diagram Development, Wiley-Aiche, 2019
[14] Metaxas A.C., Meredith R.J., Industrial Microwave Heating (Energy Engineering), The Institution of Engineering and Technology (June 30, 1988)

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[1] T. Hobler, Ruch ciepła i wymienniki, WNT 1986
[2] T. Hobler, Dyfuzyjny ruch masy i absorbery, WNT 1976,
[3] Z. Ziołkowski, Destylacja i rektyfikacja w przemyśle chemicznym, WNT 1978
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[5] A.Trusek-Holownia – Membrane bioreactors- models for bioprocess design, NY 2011.
[6] J. Haydary, Chemical Process Design and Simulation: Aspen Plus and Aspen Hysys Applications, Wiley, 2019.
[7] S. I. Sandler, Using Aspen Plus in Thermodynamics Instruction: A Step-by-Step Guide. Wiley, 2015.
[8] R. Turton, J. A. Shaeiwitz, D, Bhattacharyya, W. B. Whiting, Analysis, Synthesis and Design of Chemical Processes. Wyd. 5., Prentice Hall, 2018.
[9] M. Mulder, Basic Principles of membrane technology, Kluwer Academic Publishers, 1991
[10] R.D. Noble, S.A. Stern, Membrane separation technology. Principles and applications, Elsevier, 1995
[11] Martyn S. Ray, Chemical Engineering Design Project: A Case Study Approach, 2nd edition, CRC, 1998

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