Cryogenics

Faculty of	**Mechanical and Power Engineering**
Name in English	**Cryogenics**
Name in Polish	**Kriogenika**
Main field of study	**Power Engineering**
Specialization	**-**
Level of studies	**II level**
Form of studies	**full-time**
Kind of subject	**optional-specialization**
Subject code	**W09ENG-SM23564**
Group of courses	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30		30	15	
Number of hours of total student workload (CNPS)	75				
Form of crediting	Exam		Zaliczenie	Zaliczenie	
For group of courses mark final course with (X)					
Number of ECTS points	3		2	1	
including number of ECTS points for practical (P) classes					
including number of ECTS points for direct teacher-student contact (BU) classes	1,44				

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.	Advanced knowledge of thermodynamics, heat transfer and fluid mechanics
2.	Basic knowledge of low temperature physics, mechanical and material engineering
3.	Basic knowledge of process simulation software programs

SUBJECT OBJECTIVES

C1	Familiarizing students with cryogenics, cryogenic technologies and applications
C2	Familiarizing students with construction and operation of cryogenic devices and systems
C3	Practical training in safe handling of cryogenic fluids, preparing experiment and solving technical problems
C4	Practical training in measurements of working parameters, data collection and analysis
C5	Practical training in process / system calculations using process simulation software programs

SUBJECT LEARNING OUTCOMES

relating to knowledge:	
PEU_W01	understands the risk and hazard of cryogenic temperature/fluids/gases, devices and systems
PEU_W02	knows physics and mathematical background of low temperature processes
PEU_W03	knows the flow diagrams of cryogenic refrigerators and liquefiers
PEU_W04	knows the methods of reaching ultralow temperatures
PEU_W05	knows the phenomena of superfluid helium and superconductivity
relating to skills:	
PEU_U01	is able to calculate an energy balance of cryogenic system

PEU_U02	is able to estimate temperature drop in cooling processes
PEU_U03	is able to describe processes of cryogenic refrigerators and liquefiers
PEU_U04	is able to handle the cryogenic liquids in a safe way
PEU_U05	is able to perform low temperature measurements
PEU-U06	is able to model the cryogenic system in process simulation software
relating to social competences:	
PEU_K01	is able to work and cooperate in heterogeneous groups
PEU_K02	is able to communicate effectively with others in foreign language
PEU_K03	is able to active listening
PEU_K04	is able to leadership the group

PROGRAMME CONTENT

Form of classes - lecture		Number of hours
Wy1	Introduction to cryogenics, basic definitions, history Applications of cryogenics and cryogenic technologies	2
Wy2	Introduction to safety engineering in cryogenics	2
Wy3	Gas temperature decrease: process of isentropic expansion	2
Wy4	Gas temperature decrease: process of isenthalpic expansion	2
Wy5	Gas temperature decrease: process of free exhaust	2
Wy6	Cryogenic liquefiers and refrigerators with recuperative heat exchangers – Joule-Thomson, Claude and Brayton systems	2
Wy7	Liquefaction of cryogenic gases, minimal work of liquefaction Thermodynamic optimization of the liquefier stage number	2
Wy8	Gaseous cryogenic refrigerators with regenerative heat exchangers – Stirling, Gifford-McMahon, pulse tubes	2
Wy9	Gaseous cryogenic refrigerators with regenerative heat exchangers – Vuilleumier-Taconis Categorization of cryogenic liquefiers and refrigerators	2
Wy10	Temperature decrease in process of adiabatic demagnetization, magnetic refrigerators	2
Wy11	Basic properties of superfluid helium He II	2
Wy12	Superfluid helium technologies	2
Wy13	Methods of obtaining the temperatures below 1, sorption refrigerators	2
Wy14	Dilution of 3He in 4He II and solidification of 3He, dilution and Pomeranchuk refrigerators	2
Wy15	New applications of cryogenics, laser cooling	2
Suma godzin		30

laboratory		Number of hours
La1	Introduction to cryogenic laboratory, physical properties of cryogenic liquids	2
La2-3	Safety engineering in cryogenics – problem of Oxygen Deficiency Hazard, risk of storage tank failures	4
La4-5	Heat transfer at cryogenic temperatures, cryogenic thermal insulations	4
La6-7	Cryogenic liquefiers and coolers with recuperative heat exchanger – Joule-Thomson systems	4
La8-9	Cryogenic refrigerator with regenerative heat exchanger – Gifford McMahon system	4
La10-11	Determination of the critical current for HTS superconducting tapes at different temperature levels and different magnetic field levels	4
La12-13	Modelling / measurements of temperature propagation in material	4
La14	Measurements of the gas re-gasification heat exchanger	2
La15	Additional /extra laboratory, final grading	2
Suma godzin		30

project		Number of hours
Pr1	Presentation of project subjects	1
Pr2	Introduction to process simulation software programs	2
Pr3	Modelling of basic thermodynamic processes, selection of working fluid, equation of state	2
Pr4	Modelling of pressure devices, compressors, expanders, valves	2
Pr5	Modelling of heat exchangers parameters	2
Pr6	Auxiliary modules, logical blocks, indicators	2
Pr7	Modelling of complex cryogenic system 1	2
Pr8	Modelling of complex cryogenic system 2	2
Pr9	Acceptance of the students' projects	2
Suma godzin		15

TEACHING TOOLS USED	
N1	Traditional lecture with multimedia presentations
N2	Software and simulators supporting process calculations
N3	Laboratory experiments aimed at process identification and parameters measurements
N4	Individual consultancies
N5	Student individual work

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F– forming (during semester), C– concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
Lecture C	PEU_W01 -PEU_W05 PEU_K03	Final exam
Laboratory F C	PEU_U01 -PEU_U05 PEU_K01-PEU_K04	Written reports Average grade from the report's grades
Project C	PEU_U01 -PEU_U06 PEU_K01-PEU_K04	Submission of project technical documentation Project presentation and defence

PRIMARY AND SECONDARY LITERATURE

Primary literature	
1	A. Arkharov, I. Marfenina, Ye. Mikulin, Cryogenic Systems, Bauman Moscow, State Technical University Press, 2000
2	Thomas M. Flynn, Cryogenic Engineering, Marcel Dekker, USA.2005
3	Chorowski M., Kriogenika, podstawy i zastosowania, IPPU MASTA, Gdańsk 2007
4	A.Piotrowska-Hajnus, J.Fydrych, J.Poliński, Cryogenic Engineering Laboratory Handbook, Wroclaw University of Technology 2010
5	S. Mokhatab at. al., Handbook of Liquefied Natural Gas, Elsevier Inc., 2014, ISBN 978-0-12-404585-9
Secondary literature	
1	R.C. Scurlock, Low-Loss Storage and Handling of Cryogenic Liquids: The Application of Cryogenic Fluid Dynamics, Kryos Publications, United Kingdom, 2006
2	G. Ventura, L. Risegari, The Art of Cryogenics, Elsevier, USA, 2008
3	Advances in Cryogenic Engineering, Transactions of the Cryogenic Engineering Conferences
4	W. Buckel, R. Kleiner, Superconductivity: Fundamentals and Applications, Wiley-VCH, 2004

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)

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