(*faculty stamp*)

COURSE DESCRIPTION

1. Course title: ADVANCED CRYSTALLIZATION TECHNOLOGIES – SOLID PRODUCT ENGINEERING	**2. Course code**
3. Validity of course description: 2019/2020	
4. Level of studies: 2nd cycle of higher education	
5. Mode of studies: intramural studies	
6. Field of study: MACROFACULTY – INDUSTRIAL AND ENGINEERING CHEMISTRY	RCH
7. Profile of studies: -	
8. Programme: PROCESS ENGINEERING FOR GREEN CHEMICAL TECHNOLOGIES	
9. Semester: 2 (2nd cycle of higher education)	
10. Faculty teaching the course: Department of Chemical Engineering and Process Design (RCh-3)	
11. Course instructor: Krzysztof Piotrowski, PhD, DSc. (Eng)	
12. Course classification: field	
13. Course status: elective	
14. Language of instruction: English	
15. Pre-requisite qualifications: basic knowledge of Chemistry, Chemical Technology and Unit Operations concerning separation methods	
16. Course objectives: An objective of the course is providing the students with theoretical background of processes used in modern technologies of crystalline substances production	
17. Description of learning outcomes:	

No	Learning outcomes description	Method of assessment	Teaching methods	Learning outcomes reference code
1.	Student knows theoretical backgrounds of crystallization processes and their mechanisms	examination	lecture	K_W02+++ K_W03+++ K_W07+++
2.	Student can rationally select proper technology of crystalline product manufacturing for practical cases	examination	lecture	K_U01++ K_U07++ K_U08++ K_U09+++ K_U11+++ K_U13+++
3.	Student can correctly identify main factors influencing final properties of crystalline product manufactured with the use of chosen technology	examination	lecture	K_U07+++ K_U08++ K_U09++ K_U10+++ K_U11++
4.	Student uses literature data and data processing/communication techniques, as well as modern simulation tools for modeling of crystallization processes in various scales (Monte Carlo, CFD)	examination	lecture	K_U01+++ K_U07+++ K_U09++ K_U21+++
5.	Student can use in practice modern techniques for production of crystalline substances of required properties, e.g. in pharmaceutical or optical industry	examination	lecture	K_U08+++ K_U09+++ K_U10+++ K_U13+++
6.	Student understands the necessity of further professional training and the development of his/her engineering and personal competence	observation and discussion	lecture, consultation	K_K01+++

18. Teaching modes and hours

Lecture / BA /MA Seminar / Class / Project / Laboratory

Lecture - 30 h

19. Syllabus description:

Lecture: Crystallization process – theoretical basis. Solid product engineering – crystallization as a powerful tool. Pharmaceutical products purification – general rules and practical examples. Optical properties of crystals. Reaction crystallization engineering – adjustment of product properties by rational manipulation of process conditions. Precipitation kinetics and accompanying physicochemical phenomena (precipitation diagrams, secondary changes within the precipitated phase – recrystallization, ageing, coagulation, agglomeration, kinetics of phase transformation). Computer methods for crystal product design and prediction of its potential properties. Production of crystalline materials for special applications. Reaction crystallization processes in environmental protection – pellet reactors, theoretical background and design methods. Steering of crystal properties by additives – factors influencing crystal growth. Hydrodynamics of suspension – mixing effects. Macromixing, mesomixing and micromixing phenomena. Crystal-fluid interactions in various scales. CFD methods in crystallization process design – from single crystal behavior in liquid environment to industrial crystallizer performance.

20. Examination: yes (test)

21. Primary sources:

Myerson A.S., Handbook of Industrial Crystallization, Butterworth-Heinemann, Stoneham 1993.
Jancic S.J., Grootscholten, P.A.M., Industrial Crystallization, Delft University Press, Delft 1984.
Tung H.H., Paul E.L., Midler M., McCauley J.A., Crystallization of Organic Compounds: An Industrial Perspective, Wiley 2009.
Muller G., Metois J.J., Rudolph P., Crystal Growth – From Fundamentals to Technology, Elsevier 2004.
Mullin J.W., Crystallization, Butterworth-Heinemann, 2001.
Jones A.G., Crystallization Process Systems, Butterworth-Heinemann, 2002.

22. Secondary sources:

Sangwal K., Additives and Crystallization Processes: From Fundamentals to Applications, Wiley 2007.
am Ende D.J., Chemical Engineering in the Pharmaceutical Industry: R&D to Manufacturing., Wiley 2010.
Tiekink E.R.T., Vittal J., Zavorotko M., Organic Crystal Engineering: Frontiers in Crystal Engineering, Wiley 2010.
Ramkrishna D., Population Balances. Theory and Applications to Particulate Systems in Engineering, Academic Press, 2000.

23. Total workload required to achieve learning outcomes

Lp.	Teaching mode :	Contact hours / Student workload hours
1	Lecture	30/10
2	Classes	-/-
3	Laboratory	-/-
4	Project	-/-
5	BA/ MA Seminar	-/-
6	Other	-/20
	Total number of hours	30/30

24. Total hours: 60

25. Number of ECTS credits: 2

26. Number of ECTS credits allocated for contact hours: 1

27. Number of ECTS credits allocated for in-practice hours (laboratory classes, projects): -

26. Comments:

Approved:

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(date, Instructor's signature)

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(*date , the Director of the Faculty Unit signature)*