COURSE DESCRIPTION CARD - SYLLABUS

Course name

Recycling of energy storage [S2TOZ1>RME]

Course

Field of study
Circular System Technologies

Year/Semester
2/3

Area of study (specialization)
Renewable raw material technologies

Profile of study
general academic

Level of study
second-cycle

Course offered in
Polish

Form of study
full-time

Requirements
compulsory

Number of hours

Lecture
30

Laboratory classes
30

Other
0

Tutorials
15

Projects/seminars
0

Number of credit points

6,00

Coordinators

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Lecturers

Prerequisites

Knows the basic methods, techniques, tools and materials used in solving simple engineering tasks. She/he is familiar with environmental protection principles related to chemical production. He/she has knowledge of raw materials, products and processes used in the chemical industry, moreover, he/she has basic information on the design, construction of various energy storage facilities. Students will be able to work individually and in a team, they will be able to plan and carry out experiments, interpret the obtained results and draw conclusions. The student understands the need for constant education and is aware of the responsibility for jointly implemented tasks, connected with teamwork.

Course objective

To acquire knowledge of methods and technologies for the recovery and recycling of energy stores in the broad sense. To master the ability to carry out laboratory experiments related to the recycling and recovery of materials from various energy storages.

Course-related learning outcomes

Knowledge:
Has advanced, structured and theoretically underpinned knowledge of the principles of the circular

economy and the reasons why it is implemented [K_W02].
Has advanced, detailed knowledge covering issues of sustainable production, principles of conduct and development trends in the closed loop economy [K_W03].
Has structured, advanced knowledge to recognise, assess the harmfulness and neutralise factors hazardous to the environment [K_W04].
Has extended knowledge to recognise and differentiate factors hazardous to the environment and knows the principles of waste neutralisation and recovery taking into account the requirements of a closed loop economy [K_W06].
Has the skills to calibrate selected waste materials and to apply appropriate recycling and recovery techniques, in compliance with current legislation [K_W11].
Has in-depth knowledge of methods of material recycling, raw material and energy recovery from waste materials necessary to design, optimise and implement innovative technological processes [K_W12].

Skills:
Has the ability to communicate verbally with specialists in the area of the circular economy and related fields [K_U01].
Is able to plan, prepare and present a presentation on the implementation of a research task and conduct a substantive discussion on a given topic [K_U02].
Is able to use the knowledge to identify and select methods of disposal/management of various industrial wastes, taking into account the principles of closed-loop economy, and to propose improvements to existing technological solutions, taking into account the applicable legal acts[K_U03].
Is able to identify and critically evaluate technical solutions for waste recycling in accordance with the principles of the closed loop economy[K_U04].
Is able to select methods of recycling, chemical recovery and disposal of various wastes and to formulate assumptions necessary to design innovative solutions based on the principles of the closed loop economy [K_U10].
Is able to plan and carry out experiments related to closed loop technologies and is able to interpret the obtained results and draw conclusions [K_U12].
Is able to evaluate the quality of reprocessed waste materials, as well as to qualify them for further use in various industries [K_U13].

Social competences:
Is aware of the personal responsibility resulting from the professional role, and of the occurrence of moral and ethical problems in the context of professional activities [K_K01].
Understands the need to popularise knowledge on sustainable production and technological solutions in a closed loop economy [K_K02].
Critically evaluates his/her knowledge, understands the need for further education and improvement of his/her professional, personal and social competences [K_K03].

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Evaluation of written answers on issues related to the topics of laboratory classes.
Ongoing control of knowledge and practical skills, correction of conducting experiments during laboratory classes. Evaluation of the final report on the obtained experimental results.
Written final credit of the course, consisting of 3-5 questions. Pass mark: 51% of the maximum total points.
In the case of online classes, the credit will take place in the form of a test consisting of several test questions and/or several open questions.

Programme content

1. Chemical and electrochemical energy storage:
- construction
- principle of operation, including thermodynamic and kinetic bases of chemical processes
- applications
2. Global market for chemical and electrochemical energy storage
3. Problems and developments in the field of chemical and electrochemical energy storage
4. Design solutions and methods of use increasing and decreasing the durability of energy storage devices

5. Recyclability of chemical and electrochemical energy storage (problems and developments), including technical-scale recycling methods and scientific developments.

Course topics

Lecture:
1. secondary storages based on lithium compounds.
2. secondary storages containing hydrogen-consuming alloys
3. fuel cell storages
4. electrical double-layer storages
5. high energy density primary storages
6. energy storage devices using compounds and carbon structures

Exercises:
1. students will learn and carry out a range of computational methods to versify and optimise the recovery precesses of active chemical materials and electrochemical energy stores.

Laboratory:
1. students will carry out a structural analysis of a primary energy store (type I) to familiarise themselves with the components present in the system, and to assess the feasibility of their use in the recycling of chemically active materials and the enclosure
2. students will carry out processes for the recovery of active materials of energy storages of the first type
3. students will carry out processes for the recovery of secondary energy storage active materials (type II)
4. students will carry out investigations into the corrosion kinetics of metallic and steel components of energy storages

Teaching methods

Lecture, problem lecture, explanation, didactic discussion, laboratory exercises, student presentation, calculations

Bibliography

Basic:
1. Praca zbiorowa, Poradnik galwanotechnika, WNT, Warszawa, 2002.
2. A. Czerwiński, Akumulatory, bateria, ogniwa, WKŁ, Warszawa 2005.
3. W. Rekść, Elektrochemia techniczna, Wyd. PP. Poznań 1990.
4. R. Dylewski, W. Gnot, M. Gonet, Elektrochemia przemysłowa, Wyd. Politechniki Śląskiej Gliwice 1999.
5. Dyrektywa 2006/66/WE Parlamentu Europejskiego i Rady z 6 września 2006 r. w sprawie baterii i akumula-torów oraz zużytych baterii i akumulatorów oraz uchylająca dyrektywę 91/157/EWG (Dz. Urz. UE L 266)
6. Ustawa z dnia 24 kwietnia 2009r.o bateriach i akumulatorach

Additional:
1. O.E. Bankole, Battery recycling technologies: recycling wastelithium ion batteries with the impact on the environment in-view, J. Environment Ecology, 4 (2013) 14-28.
2. E. Gratz, Q. Sa, D. Apelian, Y. Wang, A closed loop process for recycling spent lithium ion batteries, J. Power Sources, 262 (2014) 255-262
3. C. Hanisch, T. Loellhoeffel, J. Diekman, K.J. Markley, W. Haselrieder, A. Kwade, Recycling of lithium-ion batteries: a novel method to separate coating and foil of electrodes, J. Cleaner Production, 108 (2015) 301-311.
4. https://elibama.wordpress.com/wp-content/uploads/2014/10/v-d-batteries-recycling1.pdf

Breakdown of average student's workload

	Hours	ECTS
Total workload	150	6,00
Classes requiring direct contact with the teacher	75	3,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	75	3,00