COURSE DESCRIPTION CARD - SYLLABUS

Course name
Exploitation and diagnostics of drive systems [S2Elmob1-SPE>EiDSE]

Course

Field of study Electromobility	Year/Semester 2/3
Area of study (specialization) Energy Processing Systems	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 15	Laboratory classes 30	Other (e.g. online) 0
Tutorials 0	Projects/seminars 0	

Number of credit points

3,00

Coordinators

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Lecturers

Prerequisites

The student starting this course should have a basic knowledge of the theory of electric circuits, computer science and numerical methods. The student starting this course should have a basic knowledge in the field of construction, analysis and synthesis of electromechanical converters and measurement methods used in electrical engineering.

Course objective

Acquainting with the basic issues and concepts related to the technical diagnostics of electric drive systems and with selected operational problems requiring diagnostics. Acquisition of basic skills necessary to determine the relationship between a symptom of damage and damage to the device. Acquiring knowledge in the field of vibration measurements, processing of measurement signals in the diagnosis of electric drive systems and their interpretation in accordance with applicable standards. Acquiring the ability to use selected computational packages for modeling drive systems.

Course-related learning outcomes

Knowledge:
The student has extended and in-depth knowledge of selected areas of mathematics necessary to describe the elements, systems and systems used in electromobility.
The student has extensive knowledge in the field of programming techniques and the use of modern IT tools for the analysis and synthesis of electric systems of hybrid and electric vehicles, including traction ones.
The student has advanced and in-depth knowledge of the design, diagnostics and operation of drive systems for hybrid and electric vehicles, including traction; knows the basic processes occurring in the life cycle of technical systems of hybrid and electric vehicles, including traction ones.
The student has extensive knowledge of diagnostic methods, including non-invasive, sensor technology, signal processing and analysis of measurement data; knows the methods of diagnostics and assessment of the quality of electricity, especially in charging systems for energy storage in hybrid and electric vehicles.

Skills:
The student is able to use modern information and communication tools, advanced programming techniques and machine learning methods when collecting, processing and analyzing data.
The student is able to formulate and test hypotheses related to complex engineering problems and simple research problems in the field of electromobility, as well as to interpret the results obtained and draw critical conclusions.
The student is able to plan and carry out experiments involving computer simulations and measurements of electrical and non-electrical quantities in electric and hybrid vehicle systems and their charging infrastructure.
When formulating and solving complex and unusual engineering tasks and simple research problems, the student is able to apply a systemic approach and, using appropriate tools and apparatus, to make a critical analysis of the operation of simple and complex electric systems of hybrid and electric vehicles, including traction ones, evaluate them and propose their improvements.

Social competences:
The student understands that in the area of technology, knowledge and skills are rapidly devaluing, which requires their constant supplementation.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Lecture: credit on the basis of a test consisting of general and test questions. Rating scale 51-60% points satisfactory, 61-70% points satisfactory+, 71-80% points good, 81-90% points good +, 91-100% points very good.
Laboratory: rewarding practical knowledge gained during previous laboratory exercises, checking practical programming skills in Python (final test), assessment of knowledge and skills related to the implementation of individual and group programming projects.
Obtaining additional points for activity during classes, especially for: the ability to cooperate as part of a team practically carrying out a detailed task in the laboratory, the use of elements and techniques that go beyond the material of the lecture and laboratory exercises, aesthetic diligence of completed projects.

Programme content

Lecture:
Principles of proper and correct operation of drive systems. Environmental conditions and their influence on the operational parameters of drive systems. Wear of powertrain components. Classification of damage to electrical machines and devices. Methods of assessing the technical condition of electrical machines and devices. Diagnostic signals and their parameters. Selection of physical quantities as sources of diagnostic signals. Invasive and non-invasive measurements. Electrical measurements of selected physical quantities. Measurement converters used in diagnostics. Analog and digital processing of measured physical quantities. Systems for collecting, processing and analyzing measurement data. Computer hardware in diagnostic systems. Models of dynamic states of machines and electrical devices including damage. Monitoring of unbalance of rotating parts and bearing condition. Testing the insulation condition of electrical components. Measurements of electromagnetic disturbances emitted to the environment. Thermal imaging assessment of the condition of the device.

Examples of solutions for diagnostics and monitoring systems for electrical machines and devices.
Laboratory:
Measurement and registration of diagnostic signals of damaged electrical machines. Development of software for the visualization and analysis of diagnostic signals in the time and frequency domain. Extrapolation of the technical condition based on the results of the analysis of diagnostic signals. Inferring about the technical condition using machine learning methods. Development of a mathematical model of an electric machine, taking into account damage. Application of the developed mathematical model of a damaged electric machine to simulation calculations of selected operating states. Analysis and visualization of the obtained results of simulation calculations.

Teaching methods

Lecture: presentation of issues with the use of multimedia, examples (e.g. computational) given on the blackboard, discussion on problem issues.
Laboratory: performing laboratory exercises in teams under the supervision of the teacher.

Bibliography

Basic:
1. C. Cempel, Podstawy wibroakustycznej diagnostyki maszyn. WNT Warszawa 1982
2. W. Latek, Badanie maszyn elektrycznych w przemyśle. WMT Warszawa 1987
3. W. Paszek, Dynamika maszyn elektrycznych prądu przemiennego. HELION 1998
4. T. P. Zieliński, Cyfrowe przetwarzanie sygnałów. WKŁ Warszawa 2005
5. A. Biernat: Analiza sygnałów diagnostycznych maszyn elektrycznych, Politechnika Warszawska, 2015
6. J. Przybysz: Hydrogeneratory. Zagadnienia eksploatacyjne, Instytut Energetyki, Warszawa, 2014
7. Cz. T. Kowalski: Diagnostyka układów napędowych z silnikiem indukcyjnym z zastosowaniem metod sztucznej inteligencji, Wrocław, 2013
8. J.-C. Trigeassou, Electrical Machines Diagnosis, Wiley-Iste, 2011
9. G. Vachtsevanos, F.L. Lewis, M. Roemer, A. Hess, B. Wu, Intelligent Fault Diagnosis And Prognosis For Engineering Systems, John Wiley & Sons, 2006

Additional:
1. C. Cempel, Wibroakustyka stosowana. PWN Warszawa-Poznań 1977
2. M. Krauss, E. Woschni, Systemy pomiarowo-informacyjne PWN Warszawa 1979

Breakdown of average student's workload

	Hours	ECTS
Total workload	85	3,00
Classes requiring direct contact with the teacher	45	1,50
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	40	1,50