COURSE DESCRIPTION CARD - SYLLABUS

Course name
Machine diagnostics and vibroacoustics [S1MiBM2>DiWM]

Course

Field of study
Mechanical Engineering

Year/Semester
3/5

Area of study (specialization)
–

Profile of study
general academic

Level of study
first-cycle

Course offered in
Polish

Form of study
full-time

Requirements
compulsory

Number of hours

Lecture
30

Laboratory classes
30

Other
0

Tutorials
0

Projects/seminars
0

Number of credit points

5,00

Coordinators

Lecturers

Prerequisites

Fundamentals of mechanical engineering, machine construction, technical drawing, machine dynamics, metrology. fundamentals (statistics), mechanics, electronics and information technology. Ability to self-educate and acquire knowledge on the basis of resources: library (including e-resources) and Internet resources (e.g. eKursy).

Course objective

Teaching basic knowledge and in the field of technical diagnostics (in particular vibroacoustic diagnostics) and the ability to recognise and assess the technical condition of machines and their components, fault detection and identification. Teaching knowledge concerning the sources of vibroacoustic phenomena. To familiarise with methods of measuring and analysing vibrations and noise of machines and equipment. To raise awareness of the negative impact of vibration and noise of machinery and equipment on engineering structures, the natural environment and the working environment. To acquire the ability to measure and evaluate vibrations and noise in accordance with the methodology set out in standards and regulations. To become familiar with methods of minimising vibroacoustic impacts.

Course-related learning outcomes

Knowledge:
Upon completion of the course, the student has knowledge of the objectives and methods of technical

daidnostics at the stage of design, manufacture and operation of technical objects. He/she knows typical causes and effects of operational failures and malfunctions of machines and their components and how to eliminate them. Knows methods and techniques for supervising (monitoring) the condition of machines. Knows: methods of condition assessment and classification. Knows methods and techniques for identifying defects, damage and malfunctions of machinery equipment. Knows how to eliminate them. Upon completion of the course, the student knows the specifics of sources of vibrations and noise occurring in machines and equipment and production processes. He/she knows the methodology of measurement and analysis of vibrations and noise. He/she is familiar with measurement quantities and measures parameterising noise and vibrations. Is familiar with the basic standards and regulations concerning the assessment of vibroacoustic impacts on the working and living environment and on technical infrastructure. Knows organisational and technical methods of minimising vibration and noise.

Skills:
At the end of the course, the student is able to assess the general technical and operational condition of machinery (in particular rotating machinery) based on the methodology contained in the standards. He/she is able to make sound operating decisions (continued operation, servicing, repair, overhaul, decommissioning) . He/she is able to perform measurements and analyses of vibroacoustic signals and interpret them and relate them to the technical condition of machinery and equipment. Students will be able to identify damages, defects, malfunctions of machines and equipment and determine recommendations for their repair. He/she is able to selectively analyse the content of standards and other source materials (resources) in the field of technical diagnostics. At the end of the course, the student is able to identify sources of vibration and noise in machines, equipment and production processes and determine their specifics. He/she is able to perform measurements and analyses of vibrations and noise. He/she is able to interpret the obtained results of vibration and noise measurements and relate them to the limits contained in standards and regulations. He is able to assess the impact of vibrations and noise on the working and living environment and technical infrastructure. Is able to propose technical and organisational solutions to minimise the impact of vibration and noise on the anthropotechnical environment. Be able to carry out a report on the studies and tests carried out.

Social competences:
The student understands the importance of engineering diagnostics in terms of economics and human and environmental safety. The student is aware of the importance of engineering actions and responsibility connected with issuing opinions and decisions concerning exploitation of machines and devices. The student understands the importance of protecting the working and living environment and technical infrastructure from vibration and noise in terms of health, economy and safety. The student is aware of the importance of engineering activities and responsibility related to issuing opinions and decisions. He/she is aware of the role of engineering staff in technical development, shaping the human living and working environment. Knows how to think and act creatively and proactively. Is able to organise teamwork and actively cooperate on tasks.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Laboratory:
Short entrance tests before each laboratory exercise. Assessment of knowledge and skills, as well as activity while performing experiments. Evaluation of the degree of mastery of course content, skills and acquired competences on the basis of the quality of individually produced reports. The subject matter and computational correctness, the completeness of the report and the ability to formulate conclusions, remarks and observations are checked. Laboratory credit conditions: completion and passing of a set of laboratory exercises and obtaining the required minimum score for the input tests and reports.
Lecture:
Written form or remote tests on the eKursy platform: 10 - 20 topics covering the whole of the lecture material, laboratory material and topics indicated for independent study.
Assessment criteria apply to laboratory and lecture:
below 60 % nd. 60-67 % dst. 68-74 % dst plus 75-83 % db. 84-91 % db plus 92-100 % bdb.

Programme content

Lectures:
1. Basic terminology, definition and division of diagnostic symptoms. Symptom life curve of a technical

object.
2. Diagnostics in the individual stages of technical systems life (structural, operational control, technological processes diagnostics).
3. Methods for testing the technical condition of machinery, its components and subassemblies.
4. Measures and characteristics of WA signals as diagnostic symptoms.
5. Standard evaluation of the technical condition of machines on the basis of broadband vibration measurements.
6. Defects, damage to shafts and rotors: unbalance, cracking, bending, misalignment, abrasion. Causes of formation, effects, methods of detection.
7. Rolling bearings. Defects and damage, causes of formation. Phases of technical degradation of rolling bearings. Methods of assessing technical conditions, e.g.: acoustic emission ultrasonic methods, vibration measurements and analysis (including SPM), lubricant contamination testing, thermal methods.
8 Diagnosis of gears . Calculation of gearbox characteristic frequencies and determination of measurement bands. Methods for testing and evaluation of technical condition: visual endoscopic testing, vibroacoustic (band measurements and spectral analysis of vibrations), analytical ferrography.
9. Diagnosis of selected types of components and machines: belt transmissions, electric motors, flow machines and others.
10. The field of vibroacoustics of machinery equipment and working environment. Specificity of vibroacoustic phenomena in frequency and amplitude terms.
11. Sources of vibration and noise in machinery and equipment their specifics and methods of estimation.
12. Introduction to noise measurement and analysis - basic concepts, sound pressure sound field, noise parametric quantities and measures. Technical equipment used for noise measurement.
13. Noise in the working environment (sounds in the audible band, infra- and ultrasound). Noise generated by machinery and equipment - methodology for measuring and assessing the impact of noise on humans.
14. Methodology of determining the sound power level of machinery and equipment (technical and indicative methods).
15. Introduction to the measurement and analysis of mechanical vibrations. Measurement quantities parameterising vibrations. Equipment and devices used for the measurement and analysis of vibrations.
16. Methodology of measurement and evaluation of mechanical vibrations in the working environment (local and general vibrations affecting machine and equipment operators).
17. Methodology for assessing the impact of machinery and equipment vibration on the environment and technical infrastructure. Assessment of the effects of environmental vibration on machinery and equipment.
18. Technical and organisational methods of reducing vibration and noise in machinery (acoustic enclosures and screens, passive and active methods of vibration and noise, sound-absorbing systems, vibration eliminators and vibration isolators).
Laboratory:
1. Assessment of the technical and operating conditions of a rotating machine (centrifugal fan) on the basis of standard vibration measurements.
2. Identification of rotor defects and damage on the basis of measurements of amplitudes and phase relationships of vibrations recorded on bearing supports.
3. Assessment of electric rotor unbalance conditions based on vibration spectral analysis (selection of measuring magnitude, measurement point and direction, determination of relationships between unbalance and rotational component value for different vibration measurement configurations).
4. Assessment of the technical conditions of rolling bearings using ultrasonic methods (Amprobe, Ultraprobe) and the SPM method.
5. Testing of rolling element bearings. Identification of degradation phases of rolling bearings on the basis of measurements and spectral analysis of vibrations and noise emitted by the bearing.
6. Diagnosis of gears. Identification of characteristic frequencies in the vibration spectrum. Selection of measurement bands for identification of technical conditions of shafts, gears and bearings. Evaluation of the sensitivity of gauges and measurement bands to gearbox damage.
7. Diagnosis of belt transmission. Identification of components in the vibration spectrum associated with pulley (rotor) imbalance and V-belt damage. Synthesis of spectrum components and creation of a periodicity spectrum - vibration assessment of belt transmission components.
8. Determination of sound power levels of machinery and equipment (indicative method).
9. Investigating and evaluating the vibration effects of mechanised equipment on operators (local vibration)

10. Investigating and evaluating the vibration effects of transport machinery (vehicles) on operators (general vibration) - comparative study of driving comfort (car, tram, bus) optional exercise.
11. Evaluation of the effectiveness (efficiency) of acoustic screens and enclosures of machinery and equipment.
12. Study and evaluation of parasitic vibration on machinery and equipment with high sensitivity to vibration
13. Evaluation of the effects of vibrations from machinery and equipment on buildings and technical infrastructure elements.
14. Selection and testing of the effectiveness of vibration isolation systems and components of machinery and equipment.
• Laboratory exercises carried out on real objects (fan station) and laboratory workstations (small-scale models of units, machines). Stations equipped with specialised dedicated measuring and analysing systems.
• Laboratory exercises in the field of machine diagnostics are realised on stands containing typical machine components such as: rotor, belt transmission, gear transmission, bearing nodes. The workstations are equipped with specialised dedicated measuring and analysing systems enabling the detection and identification of damage to machine components.
• Exercises in the aspect of vibroacoustics are conducted on real machines and devices, and dedicated laboratory workstations (with the use of proprietary software and/or professional measuring and analysing equipment).
• A list of the currently implemented set of exercises is available on the eKursy platform.

Course topics

none

Teaching methods

none

Bibliography

Basic:
1. Inżynieria Diagnostyki Maszyn. Praca zbiorowa red. B. Żółtowski i C. Cempel, PTDT ITE PIB Radom, 2004 [in Polish].
2. Handbook of condition monitoring, Edited by B.K.N. Rao, Elsevier Science Ltd. 1996.
3. Diagnostyka Maszyn, Zasady ogólne przykłady zastosowań, Praca pod redakcją C. Cempla i F. Tomaszewskiego, Wydawnictwo MCNEMT Radom, 1992 [in Polish].
4. Engel Z., Piechowicz J., Stryczniewicz L.; Podstawy wibroakustyki przemysłowej, AGH, Kraków 2003, ISBN 83-916516-9-X [in Polish].
5. Engel Z., Ochrona środowiska przed drganiami i hałasem, PWN, 2001. [in Polish]
6. Barczewski R., Laboratorium diagnostyki systemów - instrukcje do ćwiczeń (eKursy platform) [in Polish]

Additional:
1. Cempel C., Diagnostyka Wibroakustyczna Maszyn, PWN Warszawa 1989. [in Polish]
2. Morel J., Drgania Maszyn i diagnostyka ich stanu technicznego (tłum.) PTDT, 1992. [in Polish]
3. Dwojak J. Rzepiela M., Diagnostyka drganiowa stanu maszyn i urządzeń, Biuro Gamma, Warszawa 2005. [in Polish]
4. Cempel C., Wibroakustyka stosowana, PWN Warszawa 1989. [in Polish]
5. Ciesielski R., Kwiecień A, Stypuła K., Propagacja drgań w warstwach przypowierzchniowych podłoża gruntowego , Wydawnictwo Politechniki Krakowskiej 1999. [in Polish]
6. Barczewski R., Pomiary i Badania WA - zbiór zadań (Moodle platform). [in Polish]
7. Additional materials on eKursy platform [in Polish].
8. Selected standards PN-ISO, research and measurement procedures, scientific journals: Diagnostyka [in Polish], Główny Mechanik [in Polish], Utrzymanie Ruchu [in Polish], Maintenance and Reliability.

Breakdown of average student's workload

	Hours	ECTS
Total workload	125	5,00
Classes requiring direct contact with the teacher	62	2,50
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	63	2,50