COURSE DESCRIPTION CARD - SYLLABUS

Course name
Diagnostics and vibroacoustick machines [N1Mech2>DiWM]

Course

Field of study
Mechatronics

Year/Semester
3/6

Area of study (specialization)
–

Profile of study
general academic

Level of study
first-cycle

Course offered in
Polish

Form of study
part-time

Requirements
compulsory

Number of hours

Lecture
8

Laboratory classes
16

Other
0

Tutorials
0

Projects/seminars
0

Number of credit points

3,00

Coordinators

Lecturers

Prerequisites

Student knows fundamentals of theory of machines and mechanisms, engineering metrology and measurements as well as methods of results analysis. Student is able to perform basic measurements. Student has ability of self-learning and knowledge acquiring, basing on library (including e-resources) and Internet resources (e.g. eKURSY)

Course objective

Acquiring knowledge in the field of technical diagnostics (in particular vibroacoustic diagnostics) and the ability to recognize and assess the technical condition of machines and their components, detect and identify damage, as well as knowledge about the sources of vibroacoustic phenomena in machines, methods of measuring and analyzing vibrations and noise of machines and devices. Raising awareness of the negative impact of vibrations and noise emitted by machines and devices on engineering structures, the natural environment and the work environment. Acquiring the ability to measure and assess vibrations and noise in accordance with the methodology specified in standards and regulations and learning methods for minimizing vibroacoustic impacts.

Course-related learning outcomes

Knowledge:
After completing the course, the student has knowledge of the objectives and methods of technical

diagnostics at the stage of designing, manufacturing and operating of technical objects. The student knows the typical causes and effects of operational damage and irregularities in the functioning of machines and their components and knows how to eliminate them. The student knows the methods and techniques of supervising (monitoring) the condition of machines and knows the methods of assessing and classifying the technical condition. The student knows the methods and techniques of identifying defects, damage to machines and devices and how to eliminate them. After completing the course, the student knows the specifics of sources of vibration and noise occurring in machines and devices and production processes. The student knows the methodology of measuring and analysing vibrations and noise and the basic standards and regulations regarding the assessment of vibroacoustic infuence on the work environment, life and technical infrastructure, and also knows the organizational and technical methods of minimizing vibrations and noise.

Skills:
After completing the course, student is able to assess the general technical condition of machines (in particular rotating machines). Student is able to make the right decisions regarding the operation of machines [K1-U09].
After completing the course, the student is able to assess the technical condition and operating condition of machines (especially rotary machines) based on the methodology included in standards. Student is able to make good operating decisions (further work, servicing, repair, withdrawal from service). The student is able to perform measurements and analyses of vibroacoustic signals and interpret them and, on their basis, determine the technical condition of machines and devices. The student is able to identify damages, defects, irregularities in the functioning of machines and devices and provide recommendations for their repair. After completing the course, the student is able to identify sources of vibrations and noise in machines, devices and production processes and determine their specificity. The student is able to perform measurements and analyses of vibrations and noise as well as to interpret the obtained measurement results and refer them to the limit values included in standards and regulations. The student is able to assess the impact of vibrations and noise on the working and living environment and technical infrastructure and is also able to propose technical and organizational solutions aimed at minimizing vibroacoustic impacts on the anthropotechnical environment. The student is able to prepare a report on the performed research and tests.

Social competences:
The student understands the importance of technical diagnostics in terms of economics and the safety of people and the environment. The student is aware of the importance of engineering activities and the responsibility associated with issuing opinions and decisions regarding the operation of machines and devices. The student understands the importance of protecting the working and living environment and technical infrastructure from vibrations and noise in terms of health, economics and safety. The student is aware of the importance of engineering activities and the responsibility associated with issuing opinions and decisions and is aware of the role of engineering staff in technical development, shaping the human living and working environment. The student knows how to think and act creatively and proactively and is able to organize teamwork and actively cooperate in the scope of the tasks performed.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Lecture
Lecture
Written or remote tests (via eKURSY platform): 10-20 issues covering the entire lecture and laboratory material and issues indicated for own studies (self-studying).
Laboratory classes:
Short entry tests before each laboratory exercise. Assessment of knowledge and skills, as well as activity during carried out experiments. Evaluation of mastery of course content, skills and acquired competencies based on the quality of individually (or in a group) prepared reports. The substantive and computational correctness, report completeness and the ability to specifying conclusions, remarks and observations are verified. Necessary condition to pass the laboratory: passing a set of laboratory exercises and getting the required number of points from entry tests and reports.
Grading scale both laboratory and lecture (exam): below 60% unsatisfactory; 60-67% satisfactory, 68-75% satisfactory plus; 76-83% good; 84- 91% good plus; 92 -100% very good

Programme content

Lectures
Basic terminology. Diagnostics in subsequent stages of the life of technical systems. Methods of diagnostic testing of machines and their components. Methods and techniques of detecting and identifying defects, damages of machines and their components. Sources of vibrations and noise in machines and their specificity. Methodology of vibroacoustic measurements. Assessment of the impact of vibrations and noise on operators, the environment and technical infrastructure. Methods of minimizing vibrations and noise of machines.
Laboratories:
Laboratory exercises carried out on real objects and on laboratory stands (small-sized models of aggregates, machines). Their aim is to exemplify the content of lectures. Assessment of technical condition based on vibration measurements and standard recommendations (PN ISO standards) - (exercise carried out on a fan station). Subsequent exercises carried out on laboratory stands containing typical machine components such as: rotors, shafts, bearings, belt transmission, gear transmission, gear pump. In the field of machine vibroacoustics, the following is carried out: assessment of the impact of vibrations and noise on machine and device operators, determination of acoustic parameters of machines and devices, testing the effectiveness of vibration and noise reduction systems. Laboratory stands are equipped with measurement and analysis systems and devices allowing for detection and identification of defects and damage to machine components and performance of vibroacoustic tests.

Course topics

Lectures.
1. Basic terminology. Definition and classification of diagnostic symptoms. Symptom life curve of a technical object.
2. Place of diagnostics in subsequent stages of the life of technical systems (design diagnostics, operational tests, diagnostics of technological processes).
3. Methods of testing the technical condition of machines, their components and elements.
4. Assessment of the technical condition of machines based on broadband vibration measurements.
5. Defects, damages of shafts and rotors: imbalance, cracking, bending, misalignment, abrasion. Causes of occurrence, effects, detection methods.
6. Rolling bearings. Defects and damages, causes of occurrence. Phases of technical degradation of rolling bearings. Methods of assessing the technical condition, including: acoustic emission, ultrasonic methods, vibration measurements and analyses (including SPM), testing of lubricant contamination, thermal methods.
7. Diagnosing gears. Characteristic frequencies of gears and determining vibration measurement bands. Methods of testing and assessment of technical condition: visual, vibroacoustic (measurements and spectral analysis of vibrations), analytical ferrography.
8. Diagnosis of selected types of components and machines: belt transmissions, electric motors, fluid-flow machines and others.
9. Sources of vibrations and noise in machines and devices, their specificity.
10. Introduction to the issues of noise measurement and analysis: basic concepts, quantities and measures parameterizing noise.
11. Noise in the work environment (sounds in the audible band, infra- and ultrasound). Methodology of measurement and assessment of the impact of machine noise on humans.
12. Methodology of determining the sound power level of machines and devices.
13. Methodology of measurement and assessment of mechanical vibrations in the work environment (impact of vibrations on machine operators).
14. Methodology of assessing the impact of machine and device vibrations on the environment and technical infrastructure.
15. Technical and organizational methods of reducing vibration and noise of machines (acoustic enclosures and screens, passive and active vibration and noise methods, sound-absorbing systems, vibration eliminators and vibro-isolators.
Laboratories:
Basic set of exercises:
1. Assessment of the technical condition and operating condition of a rotating machine (centrifugal fan) based on vibration measurements.
2. Identification of rotor defects and damage based on measurements of vibration amplitudes and phases recorded on bearing supports.
3. Assessment of the technical condition of rolling bearings using ultrasonic methods (Amprobe,

Ultraprobe) and the SPM method.
4. Diagnosing a gear transmission. Identification of characteristic frequencies in the vibration spectrum. Determination of frequency ranges and selection of measurement bands to identify the technical condition of shafts, gears.
5. Diagnosing a belt transmission. Identification of components in the vibration spectrum related to the imbalance of pulleys, engine rotor and V-belt damage. Synthesis of spectrum components and creation of a periodicity spectrum as a basis for assessing the vibroactivity of belt transmission components.
6. Determination of the acoustic power level of machines and devices (orientation method).
7. Study and assessment of the impact of vibrations of mechanized devices on operators (local vibrations).
8. Assessment of the effectiveness of acoustic screens and enclosures of machines and devices.
9. Study and assessment of the risk of noise emitted by machines at work stations.
10. Selection and study of the effectiveness of vibration isolation systems and elements of machines and devices.
Optional exercises:
1. Assessment of electric motor imbalance based on spectral analysis of vibrations (selection of the measurement quantity, point and direction of vibration measurement, determination of the relationships between imbalance and the value of the rotational component for various vibration measurement configurations).
2. Study of rolling bearings. Identification of the degradation phases of rolling bearings based on measurements and spectral analysis of vibrations and noise emitted by the bearing.
3. Study and assessment of the impact of paraseismic vibrations on machines and devices.
4. Research and assessment of the impact of vehicle vibrations on drivers and passengers - comparative studies of ride comfort (car, tram, bus).
5. Assessment of the impact of machine and device vibrations on buildings and elements of technical infrastructure.

Teaching methods

Lectures - multimedia presentation. The content of lectures is available in electronic form before the beginning of the class, which allows comfortable and active participation in lectures.
Laboratories: the experiments are carried out on specialized didactic stands equipped with dedicated measuring and analysing systems.
Lectures and laboratories are fully supported on the eKURSY e-learning platform. There are available: lectures, multimedia, off-line webinars, source literature (magazines, selected publications, technical notes), instructions for laboratory exercises, report templates, sample reports. It is also possible to perform exercises remotely based on prepared photo and video tutorials and individual data sets. Tests, competitions, sets of exam questions, criteria on the basis of which reports are assessed are also available there.

Bibliography

Basic:
1. Inżynieria Diagnostyki Maszyn. Praca zbiorowa red. B. Żółtowski i C. Cempel, PTDT ITE PIB Radom, 2004.
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.
4. Engel Z., Piechowicz J., Stryczniewicz L.; Podstawy wibroakustyki przemysłowej, AGH, Kraków 2003, ISBN 83-916516-9-X.
5. Engel Z., Ochrona środowiska przed drganiami i hałasem, PWN, 2001.
6. Barczewski R., Laboratorium diagnostyki systemów - instrukcje do ćwiczeń (edycja elektroniczna eKursy)

Additional:
1. Cempel C., Diagnostyka Wibroakustyczna Maszyn, PWN Warszawa 1989.
2. Morel J., Drgania Maszyn i diagnostyka ich stanu technicznego (tłum.) PTDT, 1992.
3. Dwojak J. Rzepiela M., Diagnostyka drganiowa stanu maszyn i urządzeń, Biuro Gamma, Warszawa 2005.
4. Cempel C., Wibroakustyka stosowana, PWN Warszawa 1989.

5. Ciesielski R., Kwiecień A, Stypuła K., Propagacja drgań w warstwach przypowierzchniowych podłoża gruntowego , Wydawnictwo Politechniki Krakowskiej 1999.
6. Barczewski R., Pomiary i Badania WA - zbiór zadań - wersja elektroniczna (eKursy).
7. Materiały uzupełniające zawarte na portalu laboratorium na platformie eKursy.
8. Wybrane normy PN-ISO, procedury badawczo-pomiarowe, czasopisma: Diagnostyka, Główny Mechanik, Utrzymanie Ruchu, Maintenance and Reliability.
Supplementary materials available on the eKURSY e-learning platform.

Breakdown of average student's workload

	Hours	ECTS
Total workload	75	3,00
Classes requiring direct contact with the teacher	26	1,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	49	2,00