COURSE DESCRIPTION CARD - SYLLABUS

Course name
Dynamics and fatigue strength of vehicle structures

Course

Field of study
Mechanical engineering
Area of study (specialization)

Level of study
First-cycle studies
Form of study
full-time

Year/Semester
3/6
Profile of study
general academic
Course offered in
polish
Requirements
elective

Number of hours

Lecture
15
Laboratory classes
15
Other (e.g. online)
0
Tutorials
0
Projects/seminars
0

Number of credit points

3

Lecturers

Responsible for the course/lecturer:
Ph.D. (Eng). Mikołaj Spadło

e-mail: mikolaj.spadlo@put.poznan.pl

tel. 61-665 22 22

Wydział Inżynierii Mechanicznej

ul. Piotrowo 3, 60-965 Poznańl

Responsible for the course/lecturer:

Prerequisites

KNOWLEDGE: Knows the basics of machine construction, knows the methods of computer aided design,

knows the basics of material strength and metal science, knows the basics of structural mechanics (statics, stability and dynamics).

SKILLS: Can use CAD software to generate models of virtual parts and assemblies. Can build simple FEM calculation models, including: can run a calculation solver and generate results in the form of stress maps.

SOCIAL COMPETENCES: Ability to independently formulate problems of mechanical analysis of structures and to resolve related dilemmas. The ability to correctly plan and timely perform activities in the implementation of computational projects. In addition, students understands the need and knows the possibilities of continuous training.

Course objective

Provide students with knowledge of the use of modern CAE systems to simulate the dynamic response of load-bearing structures of machines and devices subjected to time-varying forces, as well as processing simulation results for the purpose of fatigue life estimation.

Course-related learning outcomes

Knowledge

1. Knows the theoretical basis of computational methods used to evaluate the dynamic behavior of parts of machines and devices. [K_W06]

2. Knows the theoretical basis of fatigue analysis methods. [K_W04]

Skills

1. Can use the finite element method to design the fatigue strength of parts of machines and devices. [K_U16]

2. Is able to define the boundary and initial conditions and define the loads, while carrying out analyzes with the use of computer calculation methods. [K_U16]

3. Is able to carry out an engineering analysis and evaluation of the results obtained from computer simulations. [K_U12]

4. Can select the methods of fatigue analysis and make conclusions in the direction of determining the resistance of load-bearing structures to loads that change in time. [K_U12]

Social competences

1. Is aware of the importance of using computer methods to optimize the design processes of machines and devices. [K_K02]

2. Understands the need for continuous updating of knowledge in the field of CAD software. [K_K01]

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Lecture: Written exam to verify the knowledge of fatigue analysis methods and procedures for the implementation of dynamic analyzes using FEM.

Laboratory: Current assessment of the progress of work after each completed unit on the basis of reports and completion of the simulation and fatigue calculations for a selected case.

Programme content

Lectures:

Lecture 1 - The role of fatigue analysis in shaping the load capacity of the structure

Discussion of the role and importance of fatigue analysis in the assessment of the strength of machine parts and devices. Also discussion of the role of dynamic analyzes in the process of generating information necessary to estimate fatigue life.

Lecture 2 - Response dynamics analyzes - modeling of loads (kinematic and force excitations)

Discussion of the basic concepts of the analysis and systematization of loads that varying in time and their definition for the purposes of performing dynamic tests with the use of FEM. Acquainting with basic concepts, including: determined and stochastic load, stationarity and spectral characteristics.

Lecture 3 - Response dynamics analyzes in a modern computer system - part 1

Overview of computer dynamic analysis procedures using the "step by step" method on a selected example in the NX Siemens system. Acquainting with basic techniques for defining boundary conditions, building a computational model and generating results.

Lecture 4 - Methods of defining damping in dynamic response simulations.

Discussion of the issues of defining damping in dynamic response simulations. Familiarization with basic concepts, including viscous damping, hysteresis damping and the Raylegh model. Introduction to modal analysis as a tool for determining the actual damping coefficients.

Lecture 5 - Dynamic simulations in a modern computer system - part 2

Discussion of the methods of processing the results of dynamic analyzes and their role in fatigue life estimation.

Lecture 6 - Fatigue analysis - basic concepts

Overview of the phenomenon of metal fatigue. Acquainting with basic terms and concepts, including: types of stresses and deformations, fatigue material characteristics, elements of fracture mechanics, sources of intensification of the wear process (notch, temperature, frequency of loads, etc.)

Lecture 7 - Fatigue analysis methods

Discussion of modern methods of fatigue analysis, including: counting fatigue cycles from a time history (Rainflow method), failure accumulation hypotheses, methods of capturing the influence of average stresses, number of cycles and multidimensionality of the stress tensor. Conducting a discussion on the

source and scale of errors in the sustainability estimation process. Presentation of the fatigue life determination procedure.

Laboratories:

Lab 1 - NX Siemens software interface

Getting to know the NX Siemens software interface and how to operate it. Development of simple geometries, superimposition of finite element meshes and implementation of preliminary static analyzes.

Laboratory 2 - Building a virtual model

Development of a detailed 3D CAD model of the part indicated by the tutor. Depending on the model, the implementation of screw fasteners, bolt connections or contact couplings.

Laboratory 3 - Preparation of simulation calculations and generating dynamic response of the structure.

Superimposing a finite element mesh, imposing excitations and performing dynamic analyzes. Generation of time-varying characteristics, including: forces in nodes, reactions in supports and von Mises stresses, and principal stresses. Visualization of the behavior of the structure.

Laboratory 4 - Processing the results of dynamics simulation

Processing of stress courses using the Rainflow method and the Palmgren-Miner damage accumulation hypothesis. Generation of the basic Rainflow matrix and determination of the damage factor using a spreadsheet.

Laboratory 5 - Estimation of the fatigue life of selected structural nodes, part 1

Carrying out fatigue analyzes with the use of processed stress waveforms and basic fatigue characteristics, such as the Wholer diagram. Including further processing of waveforms using the selected method of the influence of mean stresses on fatigue strength and implementation of the P-M damage accumulation hypothesis.

Laboratory 6 - Estimation of the fatigue life of selected structural nodes, part 2

Carrying out fatigue analyzes with the use of processed stress waveforms and two-parameter fatigue characteristics, such as the fatigue plane. Determination of the sources of discrepancies and quantitative estimation of inference errors.

Laboratory 7 - Construction Upgrades.

Introduction of design changes increasing the fatigue capacity and repeated calculations. Consolidation of knowledge and discussion on the impact of the implemented design solutions on durability.

Laboratory 8 - Summary and final classes

Student's independent work covering the estimation of the fatigue strength for a part of the working machine selected by the tutor.

Teaching methods

1. Lecture with multimedia presentation

2. Laboratories - own design and analytical work with the use of NX Siemens software

Bibliography

Basic

1. Reiner Anderl, Peter Binde Simulations with NX, Hanser Publications, 2018

2. Łodygowski T., Kąkol W., Metoda elementów skończonych w wybranych zagadnieniach mechaniki konstrukcji inżynierskich, Poznań, WPP 1994

3. Kocańda S., Szala J.: Podstawy obliczeń zmęczeniowych. Wydawnictwo Naukowe PWN, Warszawa, 1997.

4. Bendat J.S., Piersol A.G.: Random Data: Analysis and Measurement Procedures, 4th Edition

2010

5. User manual NX Siemens 2020

Additional

1. Kleiber M., Wprowadzenie do metody elementów skończonych, Poznań, WPP 1984

2. Kleiber M., Numeryczna analiza statycznych i dynamicznych zagadnień stateczności konstrukcji, Poznań, WPP 198

Breakdown of average student's workload

	Hours	ECTS
Total workload	75	3,0
Classes requiring direct contact with the teacher	40	1,5
Student's own work (literature studies, preparation for laboratory classes/tutorials, preparation for tests/exam, project preparation) [1]	35	1,5

[1] delete or add other activities as appropriate