COURSE DESCRIPTION CARD - SYLLABUS

Course name

THE NEW PARADIGM FOR LIGHTWEIGHT DESIGN – BIOMIMETIC STRUCTURAL OPTIMIZATION

Course

Proposed by Discipline	Year/Semester
Mechanical Engineering	II/3, III/5
Type of studies	Course offered in
Doctoral School	English
Form of study	Requirements
full-time	elective

Number of hours

Lecture	Tutorials	Projects/seminars
4		

Number of credit points

1

Lecturers

Responsible for the course/lecturer:

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Responsible for the course/lecturer:

Prerequisites

Knowledge: knowledge of methods of geometry modelling in CAD systems, basic knowledge of the construction of computer systems, basic knowledge in the field of structural analysis.

Skills: ability to use computer systems, the CAD system in the basic scope, model geometry in a CAD system and use finite element method in practice.

Social competencies: ability to work in a team, understanding the need to learn and acquire new knowledge.

Course objective

Transfer of knowledge about methods and processes related to advanced virtual design. Indication of the role of structural optimization in the design process. In the course new paradigm for structural optimization without volume constraint is presented. Since the problem of stiffest design (compliance minimization) has no solution without additional assumptions, usually the volume of the material in the design domain is limited. The biomimetic approach, based on trabecular bone remodeling phenomenon is used to eliminate the volume constraint from the topology optimization procedure. Instead of the volume constraint, the Lagrange multiplier is assumed to have a constant value during the whole optimization procedure. With the use of the new optimization paradigm, it is possible to minimize the compliance by obtaining different topologies for different materials. It is also possible to obtain different topologies for different load magnitudes. Both features of the presented approach are crucial for the design of lightweight structures, allowing the actual weight of the structure to be minimized.

Course-related learning outcomes

Knowledge

A PhD student who graduated from doctoral school knows and understands:

1) global achievements, covering theoretical foundations as well as general and selected specific issues of structural optimization, to the extent that enables revision of existing paradigms, [P8S_WG/SzD_W01]

2) key developmental trends of of structural optimization. [P8S_WG/SzD_W02]

Skills

A PhD student who graduated from doctoral school can:

1) use knowledge from mathematics, mechanics, computer science to creatively identify formulate and innovatively solve complex problems or to perform research tasks. A PhD student can:

- characterize the goals of structural optimization,
- apply practical structural optimization algorithms in the industrial environment, [P8S_UW/SzD_U01]

2) A PhD student can:

- characterize the goals of structural optimization,
- apply practical structural optimization algorithms in the industrial environment. [P8S_UW/SzD_U01]

Social competences

A PhD student who graduated from doctoral school is ready to:

1) describe the algorithms and available software in the field of structural optimization and critically assess achievements within structural optimization discipline. [P8S_KK/SzD_K01]

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

PQF code	Methods for verification of learning outcomes	Assessment criteria
W01, W02	Short answer questions (concerning the area of structural optimization) in context of the new design paradigm	Test for: - level of knowledge, - application of knowledge, - potential problem-solving skills
U01	Short answer questions (concerning the area of structural optimization) in context of the new design paradigm	Test for: - level of knowledge, - application of

		knowledge, - potential problem-solving skills
K01	Short answer questions (concerning the area of structural optimization) in context of the new design paradigm	Test for: - level of knowledge, - application of knowledge, - potential problem-solving skills

Programme content

1. Well known MATLAB topology based optimization code, developed by Ole Sigmund, is used as a tool for the new approach presentation. The code was modified and the comparison of the original and the modified, biomimetic optimization algorithm is also presented.

2. The biomimetic optimization method reflects the real process of trabecular bone remodeling phenomenon. Cosmoprojector – the optimization system is presented in details. The industry ready optimization system joins in one procedure optimization of shape and topology. New paradigm for lighweight design allows to start from the existing solution and natural implementation of multi load-case approach.

Teaching methods

Lecture: multimedia presentation including illustrations and examples.

Bibliography

Basic

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2. M. Nowak, J. Sokołowski, and A. Żochowski, “Biomimetic approach to compliance optimization and multiple load cases”, J. Optim. Theory Appl., vol. 184, no. 1, pp. 210–225, 2020, doi: 10.1007/s10957-019-01502-1.

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M. Bendsoe, C. Soares – eds., vol. 227, pp. 207–218, 1993, doi: 10.1007/978-94-011-1804-0_14.

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Additional

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Breakdown of average student's workload

	Hours	ECTS
Total workload	25	1,0
Classes requiring direct contact with the teacher	4	0,2
Student's own work (literature studies, preparation for tutorials, project preparation, consultations with the teacher) [1]	21	0,8

[1] delete or add other activities as appropriate