UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	TEORIJA TURBINSKIH STROJEV
Course title:	TURBOMACHINERY THEORY

Študijski programi in stopnja	**Študijska smer**	**Letnik**	**Semestri**
Strojništvo, tretja stopnja, doktorski	Ni členitve (študijski program)		Celoletni

Univerzitetna koda predmeta/University course code: 7016

Predavanja	**Seminar**	**Vaje**	**Klinične vaje**	**Druge oblike študija**	**Samostojno delo**	**ECTS**
90					160	10

Nosilec predmeta/Lecturer:	Marko Hočevar, Mihael Sekavčnik

Izvajalci predavanj:	Matevž Dular, Marko Hočevar, Mihael Sekavčnik
Izvajalci seminarjev:	
Izvajalci vaj:	
Izvajalci kliničnih vaj:	
Izvajalci drugih oblik:	
Izvajalci praktičnega usposabljanja:	

Vrsta predmeta/Course type:	Izbirni predmet /Elective course

Jeziki/Languages:	Predavanja/Lectures:	Slovenščina, Angleščina
	Vaje/Tutorial:	Slovenščina, Angleščina

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**
Veljajo splošni pogoji za doktorski študij.	General prerequisites for the third level studies.

Vsebina:	**Content (Syllabus outline):**
• Razvrstitev turbinskih strojev in osnove dinamike tekočin v turbinskih strojih • Osnovni principi , analiza in delovne karakteristike turbinskih strojev • Ne viskozni tok skozi kaskado rotorja turbostroja • Tridimenzionalni neviskozni in kvaziviskozni tok v pretočnem traktu turbinskih strojev • Izračun tokovnih lastnosti v pretočnem traktu turbinskih strojev • Hlajenje in prenos toplote v turbinskih strojih • Kavitacija v turbinskih strojih • Nestacionarnosti pri obremenitvah izven optimalnega obratovalnega področja kompresorjev (rotirajoče odlepljanje – rotating stall, goltnost – surge) • Nadzvočni tok v turbinskih strojih • Popis in analiza značilnih fizikalnih pojavov in relevantne raziskovalne aktivnosti na področju: o vodnih turbin o črpalk	• Classification of turbomachinery and fundaments of turbomachinery fluid dynamics; • Basic principles, analyses and performance characteristics of turbomachinery; • In-viscid fluid flow through the turbomachinery cascade; • 3-D in-viscid and quasi-viscid fluid flow within turbomachinery flow channel; • Calculation of flow dynamics within the turbomachinery flow channels; • Cooling and heat transfer in trubomachinery; • Cavitation in turbomachinery; • Off-design operation of turbo-compressors (rotating stall and surge); • Supersonic flow in turbomachinery; • Determination and analysis of typical physical phenomena and relevant research activities in the field of: o water turbines

o parnih in plinskih turbin o turbinskih kompresorjev	o pumps o steam and gas turbines o turbo-compressors

Temeljna literatura in viri/Readings:

[1] Pfleiderer, C., Petermann, N.: Strömungsmaschinen.- 7. Aufl.- Berlin etc.: Springer, 2004
[2] Raabe, J.: Hydro power: the design, use and function of hydromechanical, hydraulic and electrical equipment.- Düsseldorf: VDI, 1985
[3] Lakshminarayana, B.: Fluid dynamics and heat transfer of turbomachinery.- New York etc.: J. Wiley & Sons, 1996
[4] B.Širok, M.Dular, B.Stoffel. Kavitacija. 1. natis. Ljubljana: i2, 2006. 164 str., ilustr., graf. prikazi.
[5] Saravanamuttoo H., Rogers G., Cohen H.: Gas turbine theory, 5th Edition, Prentice Hall, 2001

Cilji in kompetence:	**Objectives and competences:**
Cilji: Študenti: • razumejo vlogo in pomen poznavanja teorije turbinskih strojev; • razumejo mehanizme energijskih pretvorb v turbinskih strojih v najširšem smislu; • poznajo teoretične nastavke za popis značilnih tokovnih lastnosti na posameznih področjih turbinskih strojev; • poznajo metodologijo sodobnega raziskovalnega dela pri snovanju, numeričnem modeliranju dinamike toka v pretočnem traktu turbinskih strojev in eksperimentalnem delu na ravni energijskih karakteristik celotnega turbinskega stroja kakor tudi značilnih pojavov na mikr-ravni; • znajo določiti osnovne karakteristike turbinskih strojev, ki so vgrajeni v energetske sisteme; • poznajo potrebne podatke in analize energetskih postrojenj za vgradnjo turbinskih strojev v najširšem smislu. **Kompetence:** Študent: • je usposobljen za samostojno in izvirno znanstveno-raziskovalno delo na področju turbinskih strojev; • pridobi vpogled v aktualno znanstveno literaturo s področja turbinskih strojev in je seznanjen z relevantnimi problemi raziskovalne skupnosti; • je sposoben planirati in izvajati raziskovalno delo do končnega cilja raziskav; • je usposobljen za numerično modeliranje značilnih fizikalnih pojavov v turbinskih strojih; • je usposobljen za eksperimentalno raziskovanje pojavov v turbinskih strojih; • pridobi strokovne podlage za oblikovanje pretočnih traktov turbinskih strojev; • je sposoben diagnosticirati vzroke za napake v delovanju turbinskih strojev; • pozna vlogo in delovanje perifernih sklopov turbinskih strojev (tesnjenje, kompenzacija aksialnih sil, hladilni sistemi itd.); • pozna vlogo in delovanje širšega postrojenja, v katerega je turbinski stoj vgrajen; • je usposobljen za opravljanje raziskovalnega dela z modelnimi turbinskimi stroji in uporabljati teorijo	**Goals:** The student: • understands the role and importance of the expertise of the turbomachinery theory; • understands the principles of energy conversion in turbomachinery in general meaning; • understands the theoretical approaches to describe characteristic flow phenomena for typical parts of turbomachinery; • understands the methodology of contemporary research activities for designing, numerical modeling of fluid flow within the flow channel of turbomachinery and experimental activities in the field of determination of energy characteristics of the whole turbomachinery as well as typical micro-scale-phenomena; • is able to determine basic characteristics of turbomachinery which are part of complex power systems; • is able to obtain relevant data and perform analysis of energy-conversion systems for the purposes of turbomachinery integration; **Competences:** The student: • is qualified to perform independent original research activities in the field of turbomachinery; • acquires thorough insight of relevant scientific literature in the field of turbomachinery including the contemporary research-community issues; • is able to plan and execute specific research activities that lead towards the research goals; • is qualified for numerical modeling of typical turbomachinery flow phenomena; • is qualified for experimental research activities in the field of turbomachinery; • acquires the expert guidelines for turbomachinery-flow-channel design; • is able to diagnose the malfunctions in turbomachinery operation; • is acquainted with the role and performance of auxiliary turbomachinery components (sealing, compensation of axial forces, cooling systems, etc.); • is acquainted with performance of complex power system in which the turbomachinery is integrated; • is able to perform model tests and use the similarity theory in the field of turbomachinery;

podobnosti turbinskih strojev; • je usposobljen za strokovno presojo ustreznosti izbora turbinskih strojev za vgradnje v tehniške sisteme.	• is qualified for expert assessment of turbomachinery-integration suitability

Predvideni študijski rezultati:	**Intended learning outcomes:**
Študent: • je usposobljen za samostojno in izvirno znanstveno-raziskovalno delo na področju turbinskih strojev; • pridobi vpogled v aktualno znanstveno literaturo s področja turbinskih strojev in je seznanjen z relevantnimi problemi raziskovalne skupnosti; • je sposoben planirati in izvajati raziskovalno delo do končnega cilja raziskav; • je usposobljen za numerično modeliranje značilnih fizikalnih pojavov v turbinskih strojih; • je usposobljen za eksperimentalno raziskovanje pojavov v turbinskih strojih; • pridobi strokovne podlage za oblikovanje pretočnih traktov turbinskih strojev; • je sposoben diagnosticirati vzroke za napake v delovanju turbinskih strojev; • pozna vlogo in delovanje perifernih sklopov turbinskih strojev (tesnjenje, kompenzacija aksialnih sil, hladilni sistemi itd.); • pozna vlogo in delovanje širšega postrojenja, v katerega je turbinski stoj vgrajen; • je usposobljen za opravljanje raziskovalnega dela z modelnimi turbinskimi stroji in uporabljati teorijo podobnosti turbinskih strojev; • je usposobljen za strokovno presojo ustreznosti izbora turbinskih strojev za vgradnje v tehniške sisteme.	The student: • is qualified to perform independent original research activities in the field of turbomachinery; • acquires thorough insight of relevant scientific literature in the field of turbomachinery including the contemporary research-community issues; • is able to plan and execute specific research activities that lead towards the research goals; • is qualified for numerical modeling of typical turbomachinery flow phenomena; • is qualified for experimental research activities in the field of turbomachinery; • acquires the expert guidelines for turbomachinery-flow-channel design; • is able to diagnose the malfunctions in turbomachinery operation; • is acquainted with the role and performance of auxiliary turbomachinery components (sealing, compensation of axial forces, cooling systems, etc.); • is acquainted with performance of complex power system in which the turbomachinery is integrated; • is able to perform model tests and use the similarity theory in the field of turbomachinery; • is qualified for expert assessment of turbomachinery-integration suitability

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, laboratorijske vaje, seminarsko delo, e-izobraževanje, konzultacije. Seminarsko delo v čim večji meri navezujoče se na področje doktorskega raziskovanja. Študij z uporabo priporočene literature.	Lectures, laboratory practice & seminar work, e-education, consulting. The seminar work is related, as much as possible, to the student's doctoral research field. Study on a recommended literature basis.

Načini ocenjevanja:	**Delež/Weight**	**Assessment:**
Način(ustni izpit, seminarsko delo, projekt) - naloge (30%) -projektni seminar (50%) -ustno izpraševanje (20%)		Method (written exam, oral examination, assignments, project) • assignments (30%) • project seminar (50%) • oral examination (20%)

Reference nosilca/Lecturer's references:

prof.dr. Mihael SEKAVČNIK

LACKO, Rok, DROBNIČ, Boštjan, SEKAVČNIK, Mihael, MORI, Mitja. Hydrogen energy system with renewables for isolated households : The optimal system design, numerical analysis and experimental evaluation. *Energy and buildings*, ISSN 0378-7788. [Print ed.], Sep. 2014, vol. 80, str. 106-113, ilustr., doi: 10.1016/j.enbuild.2014.04.009.

LACKO, Rok, DROBNIČ, Boštjan, MORI, Mitja, SEKAVČNIK, Mihael, VIDMAR, Marjan. Stand-alone renewable combined heat and power system with hydrogen technologies for household application. *Energy*, ISSN 0360-5442. [Print ed.], Dec. 2014, vol. 77, str. 164-170, ilustr., doi: 10.1016/j.energy.2014.05.110.

DROBNIČ, Boštjan, SEKAVČNIK, Mihael, OMAN, Janez. Use of the kriging method in determining the properties of gases in large channels. *International journal of thermal sciences*, ISSN 1290-0729, Oct. 2009, vol. 48, iss. 10, str. 1901-

1907. http://dx.doi.org/10.1016/j.ijthermalsci.2009.02.019, doi: 10.1016/j.ijthermalsci.2009.02.019.
SEKAVČNIK, Mihael, GANTAR, Tine, MORI, Mitja. A single-stage centripetal pump - design features and an investigation of the operating characteristics. *Journal of fluids engineering*, ISSN 0098-2202, Feb. 2010, vol. 132, iss. 2, str. 021106-1-021106-10, doi: 10.1115/1.4000846.
SEKAVČNIK, Mihael, MORI, Mitja, NOVAK, Lovrenc, SMREKAR, Jure, TUMA, Matija. Heat transfer evaluation method in complex rotating environments employing IR thermography and CFD. *Experimental heat transfer*, 2008, letn. 21, št. 2, str. 155-168. http://dx.doi.org/10.1080/08916150701815770.

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MALNERŠIČ, Aleš, DULAR, Matevž, ŠIROK, Brane, OBERTI, Roberto, HOČEVAR, Marko. Close-range air-assisted precision spot-spraying for robotic applications : aerodynamics and spray coverage analysis. Biosystems engineering, 2016, vol. 146, str. 216-226
BIZJAN, Benjamin, MILAVEC, Matej, ŠIROK, Brane, TRENC, Ferdinand, HOČEVAR, Marko. Energy dissipation in the blade tip region of an axial fan. Journal of sound and vibration, 2016, str. 1-10
MILAVEC, Matej, ŠIROK, Brane, VIDAL DE VENTÓS, Daniel, HOČEVAR, Marko. Identification of noise generation and flow kinematics in the air gap for two different blade tip designs of an axial fan. Forschung im Ingenieurwesen, 2015, vol. 79, iss. 1, str. 29-39
MILAVEC, Matej, ŠIROK, Brane, VIDAL DE VENTÓS, Daniel, HOČEVAR, Marko. Influence of the shape of the blade tip on the emitted noise in the air-gap between the rotor and the housing of an axial fan. *Forschung im Ingenieurwesen*, 2014, vol. 78, iss. 3/4, str. 107-119
CENCIČ, Tine, HOČEVAR, Marko, ŠIROK, Brane. Study of erosive cavitation detection in pump mode of pump-storage hydropower plant prototype. Journal of fluids engineering, 2014, vol. 136, no. 5, str. 051301-1-051301-11
OSTERMAN, Aljaž, GODEŠA, Tone, HOČEVAR, Marko, ŠIROK, Brane, STOPAR, Matej. Real-time positioning algorithm for variable-geometry air-assisted orchard sprayer. Computers and electronics in agriculture, 2013, vol. 98, str. 175-18
BENEDIK, Gašper, ŠIROK, Brane, EBERLINC, Matjaž, HOČEVAR, Marko. Aerodynamic and acoustic integral characteristics of porous rotors. Forschung im Ingenieurwesen, 2011, vol. 75, no. 4, str. 243-256
ALIČ, Gregor, ŠIROK, Brane, HOČEVAR, Marko. Guard grill impact on aerodynamic integral and acoustic characteristics of an axial fan. Noise control engineering journal, 2010, vol. 58, iss. 3, str. 223-242