

OBRATOVALNA TRDNOST

UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	OBRATOVALNA TRDNOST
Course title:	OPERATIONAL STRENGTH
Članica nosilka/UL Member:	UL FS

Študijski programi in stopnja	Študijska smer	Letnik	Semestri	Izbirnost
Strojništvo, tretja stopnja, doktorski	Konstrukcijsko mehanske inženirske znanosti (smer)		Celoletni	izbirni

Univerzitetna koda predmeta/University course code:	0033436
Koda učne enote na članici/UL Member course code:	7111

Predavanja /Lectures	Seminar /Seminar	Vaje /Tutorials	Klinične vaje /Clinical tutorials	Druge oblike študija /Other forms of study	Samostojno delo /Individual student work	ECTS
90					160	10

Nosilec predmeta/Lecturer:	Jernej Klemenc, Marko Nagode
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Izvajalci predavanj:	Jernej Klemenc, Marko Nagode
Izvajalci seminarjev:	
Izvajalci vaj:	
Izvajalci kliničnih vaj:	
Izvajalci drugih oblik:	
Izvajalci praktičnega usposabljanja:	

Vrsta predmeta/Course	Izbirni predmet /Elective course
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type:

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Jeziki/Languages:

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

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:

Prerequisites:

Veljajo splošni pogoji za doktorski študij.	General prerequisites for the third level studies.
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Vsebina:

Content (Syllabus outline):

- Obratovalna trdnost v razvojnem, izdelovalnem, obratovalnem, vzdrževalnem in reciklažnem tehniškem sistemu.
- Obratovalno stanje (konstrukcija, obremenitve, vpliv okolja, zdržljivost, zanesljivost).
- Razvojni postopek (oblikovanje, vrednotenje).
- Obremenitve (mehanske, termo-mehanske, toplotne, nevtronsko sevanje, kemične).
- Obremenitve v časovnem in frekvenčnem prostoru (deterministične, naključne, stacionarne, ergodične, spektri itn.).
- Vrednotenje obremenitev (števne metode, obremenitveni kolektivi, spektri energijske gostote, verjetnost realizacije, teorija maksimumov, perioda vračanja).
- Poškodbe (mehanske, mehansko-termične, toplotne itn.).
- Trenutne poškodbe in poškodbe zaradi utrujanja.
- Poškodbeni fenomeni, kriteriji.
- Trenutne poškodbe (zlomi, trki, ekstremni dogodki).
- Utrujanje (malociklično, časovno-velikociklično, trajnodinamično).
- Hipoteze o akumulaciji poškodb.
- Poškodbe (do nastanka tehnične poškodbe, rast poškodbe).
- Malociklično in časovno utrujanje (napetostni in deformacijski pristop, modeli utrujanja, parametrični in

- Operational strength in R&D, production, operational, maintenance and recycling technical systems.
- Operational condition (structure, loads, environmental influences, durability, reliability).
- R&D process (design, evaluation)
- Loads (mechanical, thermo-mechanical, thermal, neutron radiation, chemical).
- Loads in time and frequency domain (deterministic, random, stationary, ergodic, spectra etc.).
- Evaluation of loads (counting methods, loading spectra, power spectrum density, probability of realisation, extreme-value theory, period of return).
- Damage (mechanical, thermo-mechanical, thermal etc.).
- Instantaneous damage and fatigue damage.
- Damage phenomena and criteria.
- Instantaneous damage (rupture, crash, extreme events).
- Fatigue damage (low-cycle, medium-cycle fatigue, high-cycle fatigue and durability).
- Damage accumulation hypotheses.
- Fatigue damage (until the technical crack, crack growth).
- Low-cycle and medium-cycle fatigue (stress-based and strain-based approach, fatigue damage models, parametric and non-parametric description of states and influential

<p>neparametrični popisi stanj in vplivnih parametrov).</p> <ul style="list-style-type: none"> • Trajnodinamično utrujanje (metode za ugotavljanje zdržljivosti, Palmgreen-Minerjeve hipoteze: originalna, modificirana, Haibachova itn.). • Obratovalna trdnost (raztrosi obremenitvenih in zdržljivostnih stanj, verjetnost okvare). • Kriteriji za vrednotenje razvojnih rešitev (RMS kriteriji). • Efektivnost izdelkov in sistemov (pripravljenost za obratovanje, zanesljivost, elastičnost). • Zanesljivost (preseki verjetnostnih prostorov, metode opredeljevanja, ugotavljanja in merjenja). • Modeliranje zanesljivosti (vpliv strukture, modeli). • Računalniška podpora modeliranju zanesljivosti (standardna, specifična, komercialna). • Metode verifikacije modelov. • Eksperimenti v obratovalni trdnosti (preskusi za ugotavljanje obremenitvenih in obratovalnih stanj, preskusi materialnih parametrov, preskusi za podporo modeliranju in simulacijam, preskusi za ugotavljanje poškodb). • Preskuševališča (standardna, specifična). • Merilne tehnike v obratovalni trdnosti. 	<p>parameters).</p> <ul style="list-style-type: none"> • High-cycle fatigue and durability (methods for evaluating durability, Palmgreen-Miner hypotheses: original, modified, Haibach's etc.). • Operational strength (scatter of load states and durability, probability of fault). • Criteria for evaluation of R&D solutions (RMS criteria). • Effectiveness of products and systems (readiness for operation, reliability, elasticity). • Reliability (cross-section of probability spaces, methods for definition, determination and measurement). • Reliability models (influence of structure, models). • Computer aided reliability modelling (standard, specific and commercial software equipment). • Methods for validation of models. • Experiments in operational strength (test for determination of loading and operating conditions, test of materials, test for supporting modelling and simulations, fatigue damage tests). • Test stands (standard, specific). • Experimental techniques in operational strength.
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Temeljna literatura in viri/Readings:

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| <p>[1] O. Buxbaum: Betriebsfestigkeit, Verlag Stahleisen, 1992.</p> <p>[2] E. Haibach: Betriebsfestigkeit: Verfahren und Daten zur Bauteilberechnung, VDI, 1989.</p> <p>[3] J.D. Andrews, T.R. Moss: Reliability and risk assessment, Longman Scientific & Technical, 1993.</p> <p>[4] A. Birolini: Quality and reliability of technical systems: theory, practice, management, Springer Verlag, 1994.</p> <p>[5] C.E. Ebeling: An introduction to reliability and maintainability engineering, McGraw-Hill, 1997.</p> <p>[6] D.J. Smith: Reliability, maintainability, and risk: practical methods for</p> |
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engineers, Butterworth-Heinemann; Woburn, 2001.

[7] J. Lemaitre, J.L. Chaboche: Mechanics of solid materials, Cambridge University Press, 2000. – Izbrana poglavja

[8] S. Suresh: Fatigue of Materials, Cambridge University Press, 2004.

[9] N.E. Dowling: Mechanical behaviour of materials, Prentice Hall, 1999.

Farahmand: Fatigue and fracture mechanics of high risk parts, Chapman & Hall, 1997

Cilji in kompetence:

Cilji:

Izbira relevantnega področja
Obratovalne trdnosti, pregled bazične in
specifične literature, strukturiran
pristop k uporabi osvojenih znanj na
izbrani aplikaciji ter izdelava seminarja.

Kompetence:

Študenti osvojijo znanja za samostojno
aplikativno in raziskovalno delo s
področja razvojnih vrednotenj glede na
izbrane vsebine. Poleg tega osvojijo tudi
znanja za vodenje postopkov razvojnih
vrednotenj.

Objectives and competences:

Goals:

The selection of the relevant field of
Operational strength, survey of basic
and specific literature, structured
approach to the use of the acquired on a
selected application and elaboration of a
seminar.

Competences:

Students master the knowledge to work
applicative and scientifically on their
own in the field of development
evaluations according to the selected
topics. Apart from this they get the
knowledge of how to manage the
development evaluation procedures.

Predvideni študijski rezultati:

Znanje in razumevanje:

Izbira relevantnega področja
Obratovalne trdnosti, pregled bazične in
specifične literature, strukturiran
pristop k uporabi osvojenih znanj na
izbrani aplikaciji ter izdelava seminarja.

Študenti osvojijo znanja za samostojno
aplikativno in raziskovalno delo s
področja razvojnih vrednotenj glede na
izbrane vsebine. Poleg tega osvojijo tudi
znanja za vodenje postopkov razvojnih
vrednotenj.

Intended learning outcomes:

Knowledge and understanding:

The selection of the relevant field of
Operational strength, survey of basic
and specific literature, structured
approach to the use of the acquired on a
selected application and elaboration of a
seminar.

Students master the knowledge to work
applicative and scientifically on their
own in the field of development
evaluations according to the selected
topics. Apart from this they get the
knowledge of how to manage the
development evaluation procedures.

Metode poučevanja in učenja:

Predavanja, laboratorijske vaje,

Learning and teaching methods:

Lectures, laboratory practice & seminar

seminarsko delo, e-izobraževanje, konzultacije. Seminarsko delo v čim večji meri navezuje se na področje doktorskega raziskovanja. Študij z uporabo priporočene literature.	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.
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Načini ocenjevanja:

Delež/ Weight

Assessment:

Ustni izpit, poročilo o seminarskem delu. Pogoji za opravljanje ustnega izpita je uspešno izdelano in pozitivno ocenjeno seminarsko delo. Način (pisni izpit, ustno izpraševanje, naloge, projekt) • projekt (seminarska naloga) (70%) • ustno izpraševanje (30%)		Oral exam, report on seminar work. The condition for admission to oral exam is successful completion of seminar work, rewarded with a passing grade. Method (written exam, oral examination, assignments, project) • project (seminar work) (70%) • oral examination (30%)
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Reference nosilca/Lecturer's references:

prof. dr. Marko NAGODE

GOSAR, Aleš, NAGODE, Marko. Dissipated energy-based fatigue lifetime calculation under multiaxial plastic thermo-mechanical loading. International journal of damage mechanics, ISSN 1056-7895, Jan. 2015, vol. 24, no. 1, str. 41-58, ilustr., doi: 10.1177/1056789514520802.

NAGODE, Marko. Finite mixture modeling via REBMIX. Journal of algorithms and optimization, ISSN 2312-7767. [Print ed.], Apr. 2015, vol. 3, no. 2, str. 14-28, ilustr., doi: 10.5963/JAO0302001.

FRANKO, Mitja, NAGODE, Marko. Probability density function of the equivalent stress amplitude using statistical transformation. Reliability engineering & systems safety, ISSN 0951-8320. [Print ed.], 2015, vol. 134, str. 118-125, ilustr., doi: 10.1016/j.ress.2014.10.012.

NAGODE, Marko, LÄNGLER, Frank, HACK, Michael. A time-dependent damage operator approach to thermo-mechanical fatigue of Ni-resist D-5S. International journal of fatigue, ISSN 0142-1123. [Print ed.], May 2011, vol. 33, iss. 5, str. 692-699, ilustr., doi: 10.1016/j.ijfatigue.2010.11.009.

NAGODE, Marko. Continuous damage parameter calculation under thermo-mechanical random loading. MethodsX, ISSN 2215-0161, 2014, vol. 1, str. 81-89, ilustr., doi: 10.1016/j.mex.2014.07.004.

prof.dr. Jernej KLEMENC

KLEMENC, Jernej. Influence of fatigue-life data modelling on the estimated reliability of a structure subjected to a constant-amplitude loading. Reliability engineering & systems safety, ISSN 0951-8320. [Print ed.], Oct. 2015, vol. 142, str. 238-247

ŠKRLEC, Andrej, KLEMENC, Jernej, FAJDIGA, Matija. Parameter identification for a low-density-foam material model using numerical optimisation procedures. Engineering computations, ISSN 0264-4401, 2014, vol. 31, iss. 7, str. 1532-1549

MIKLAVEC, Matej, KLEMENC, Jernej, KOSTANJEVEC, Andrej, FAJDIGA, Matija. Fatigue strength of a hybrid joint formed between a PA6-GF60 polymer matrix and a S420MC steel insert. Materials & design, ISSN 0264-1275, Oct. 2013, vol. 51, str. 493-500

KLEMENC, Jernej, FAJDIGA, Matija. Joint estimation of E-N curves and their scatter using evolutionary algorithms. International journal of fatigue, ISSN 0142-1123. [Print ed.], Nov. 2013, vol. 56, str. 42-53, ilustr., doi: 10.1016/j.ijfatigue.2013.08.005. [COBISS.SI-ID 13042971]

KLEMENC, Jernej, FAJDIGA, Matija. Estimating S-N curves and their scatter using a differential ant-stigmergy algorithm. International journal of fatigue, ISSN 0142-1123. [Print ed.], 2012, vol. 43, str. 90-97, ilustr., doi: 10.1016/j.ijfatigue.2012.02.015. [COBISS.SI-ID 12242203]

KLEMENC, Jernej, RUPP, Andreas, FAJDIGA, Matija. Dynamics of a clapper-to-bell impact. International Journal of Impact Engineering, ISSN 0734-743X. [Print ed.], Jun. 2012, vol. 44, iss. 6, str. 29-39, doi: 10.1016/j.ijimpeng.2011.12.006. [COBISS.SI-ID 12166171]

BIŽAL, Ana, KLEMENC, Jernej, FAJDIGA, Matija. Modelling the fatigue life reduction of an AlSi9Cu3 alloy caused by macro-porosity. Engineering with computers, ISSN 0177-0667, Apr. 2015, vol. 31, iss. 2, str. 259-269, ilustr., doi: 10.1007/s00366-013-0345-7. [COBISS.SI-ID 13241627]

KLEMENC, Jernej, JANEŽIČ, Miha, FAJDIGA, Matija. Modelling the dependency of the Smith-Watson-Topper parameter on the cycles-to-failure using serial hybrid neural networks. Fatigue & fracture of engineering materials & structures, ISSN 8756-758X, 2012, vol. 35, iss. 9, str. 809-825, ilustr., doi: 10.1111/j.1460-2695.2011.01617.x. [COBISS.SI-ID 12336667]