

POŠKODBE STROJEV IN POVRŠIN

UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	Poškodbe strojev in površin
Course title:	MACHINE AND SURFACE DAMAGES
Članica nosilka/UL Member:	UL FS

Študijski programi in stopnja	Študijska smer	Letnik	Semestri	Izbirnost
Strojništvo - projektno aplikativni program, prva stopnja, visokošolski strokovni	Konstruiranje industrijskih sistemov (smer)	3. letnik	1. semester	obvezna

Univerzitetna koda predmeta/University course code:	0563470
Koda učne enote na članici/UL Member course code:	3053-V

Predavanja /Lectures	Seminar /Seminar	Vaje /Tutorials	Klinične vaje /Clinical tutorials	Druge oblike študija /Other forms of study	Samostojno delo /Individual student work	ECTS
30		30			40	4

Nosilec predmeta/Lecturer:	Mitjan Kalin
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Vrsta predmeta/Course type:	Izbirni strokovni predmet /Elective specialised course
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Jeziki/Languages:	Predavanja/Lectures:	Slovenščina
	Vaje/Tutorial:	Slovenščina

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

Izpolnjevanje pogojev za vpis v Visokošolski strokovni študijski program I. stopnje Strojništvo - Projektno aplikativni program.	Meeting the enrollment conditions for the MECHANICAL ENGINEERING - Project Oriented Applied Programme.
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Vsebina:

<p>1. Predavanje:</p> <ul style="list-style-type: none"> - Uvod: Pomen poškodb za gospodarstvo, vzdrževanje, ekonomski učinek. <p>2. Predavanje:</p> <ul style="list-style-type: none"> - Značilnosti inženirskih površin: Hrapavost, topografija, parametri, merjenje topografije in mehanskih lastnosti površin, standardi. <p>3. Predavanje:</p> <ul style="list-style-type: none"> - Inženirski kontakti: Topografija površin, vršički in hrapavost, GW model, indeks plastičnosti, merjenje realne kontaktne površine. Obličenje površin. <p>4. Predavanje:</p> <ul style="list-style-type: none"> - Hertzova mehanika kontakta: osnove, napetosti in deformacije brez trenja in s trenjem, kontaktna površina, deformacije. <p>5. Predavanje:</p> <ul style="list-style-type: none"> - Vzroki trenja v kontaktih: Mehanizmi trenja in izvor: adhezija, deformacija, porušitve. <p>6. Predavanje:</p> <ul style="list-style-type: none"> - Trenje v inženirskih sistemih, trenje v praktičnih primerih, napoved trenja, doseganje željenega trenja, modeliranje. <p>7. Predavanje:</p> <ul style="list-style-type: none"> - Obraba kot poškodba: Določanje obrabe, modeli, mape, napoved, merjenje, naprave za merjenje obrabe. <p>8. Predavanje:</p> <ul style="list-style-type: none"> - Utrujanje, adhezija: Vzroki, pogoji, primeri, analize, rešitve. <p>9. Predavanje:</p> <ul style="list-style-type: none"> - Abrazija, erozija, kavitacija, fretting: Vzroki, pogoji, primeri, analize, rešitve. <p>10. Predavanje:</p> <ul style="list-style-type: none"> - Oksidacija, korozija, tribokemija: Vzroki, pogoji, primeri, analize, rešitve. <p>11. Predavanje:</p> <ul style="list-style-type: none"> - Inženiring površin, osnovni postopki. Termični, kemijski, fizikalni, mehanski. Značilnosti, lastnosti, prednosti, slabosti. 	<p>Content (Syllabus outline):</p> <p>1. Lecture:</p> <ul style="list-style-type: none"> - Introduction: Importance for economy, maintenance, economic impact. <p>2. Lecture:</p> <ul style="list-style-type: none"> - Characteristics of engineering surfaces: Roughness, topography, parameters, measurement of topography and mechanical properties of surfaces, standards. <p>3. Lecture:</p> <ul style="list-style-type: none"> - Engineering contacts: Surface topography, asperities and roughness, GW model, plasticity index, measurement of real contact surface. Texturing of surfaces. <p>4. Lecture:</p> <ul style="list-style-type: none"> - Hertz contact mechanics: basics, stresses and strains with and without friction, contact area, deformations. <p>5. Lecture:</p> <ul style="list-style-type: none"> - Causes of friction in contacts: Mechanisms of friction and origin: adhesion, deformation, damage. <p>6. Lecture:</p> <ul style="list-style-type: none"> - Friction in engineering systems, friction in practical cases, friction prediction, achieving the desired friction, modeling. <p>7. Lecture:</p> <ul style="list-style-type: none"> - Wear as damage: Determination of wear, models, maps, prediction, measurements, wear testing devices. <p>8. Lecture:</p> <ul style="list-style-type: none"> - Fatigue, adhesion: Causes, conditions, cases, analyses, solutions. <p>9. Lecture:</p> <ul style="list-style-type: none"> - Abrasion, erosion, cavitation, fretting: Causes, conditions, cases, analyses, solutions. <p>10. Lecture:</p> <ul style="list-style-type: none"> - Oxidation, corrosion, tribochemistry: Causes, conditions, cases, analyses, solutions.
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<p>12. Predavanje:</p> <ul style="list-style-type: none"> - Površinske prevleke: Značilnosti prevlek, napetosti in deformacije, večplastnost, mehanske lastnosti, hrapavost, napake, debelina, tribološke lastnosti, optimizacija prevlek, izbor, uporaba. <p>13. Predavanje:</p> <ul style="list-style-type: none"> - Poškodbe v elementih in sistemih: Preoblikovanje, odrezavanje, iztiskovanje, kovanje, kotalni ležaji, drsni ležaji, zobniki, tesnila, zavore, turbine in kompresorji, motorji z notranjim zgorevanjem. <p>14. Predavanje:</p> <ul style="list-style-type: none"> - Kontaktni inženiring za tribološke rešitve: Analiza sistema, možnosti, koncepti, meritve, izvedba, mape, rešitve, uporaba. Primer. <p>15. Predavanje:</p> <ul style="list-style-type: none"> - Primeri in uporaba (Viharjenje) Refleksija vsebin: povezovanje zahtev uporabe, funkcije površin, potrebnih lastnosti površin, način izbora površinske tehnologije in validacija. 	<p>11. Lecture:</p> <ul style="list-style-type: none"> - Surface engineering, basic techniques. Thermal, chemical, physical, mechanical. Features, attributes, strengths, weakness. <p>12. Lecture:</p> <ul style="list-style-type: none"> - Surface coatings: Characteristics of coatings, stresses and strains, multilayers, mechanical properties, roughness, defects, thickness, tribological properties, optimization of coatings, selection, use. <p>13. Lecture:</p> <ul style="list-style-type: none"> - Damage of elements and systems: Drawing, cutting, extrusion, forging, rolling bearings, sliding bearings, gears, seals, brakes, turbines and compressors, internal combustion engines.. <p>14. Lecture:</p> <ul style="list-style-type: none"> - Contact engineering for tribological solutions: system analysis, possibilities, concepts, measurements, cases, maps, solutions, use. Example. <p>15. Lecture:</p> <ul style="list-style-type: none"> - Examples and usage (brainstorming) Content reflection: integrating application requirements, surface function, required surface properties, method of selecting surface technology, and validation.
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Temeljna literatura in viri/Readings:

1. Gwidon W. Stachowiak, Andrew W. Batchelor, Engineering tribology, Elsevier, 4th edition, 2014, ISBN 978-0-12-397047-3.
2. F. W. Bach, A. Laarmann, T. Wenz: Modern Surface Technology, Wiley-vch, 2006, ISBN 978-3527315321
3. K. N. Strafford, P.K. Datta, J.S. Gray: Surface engineering practice, Ellis Horwood, 1990
4. T.A. Stolarski: Tribology in Machine Design, Butterworth Heinemann, 1990

Cilji in kompetence:

- Cilji:
1. Spoznati različne poškodbe strojev in površin.
 2. Spoznati načine in možnosti ovrednotenja površin.
 3. Razumeti in znati analizirati vzroke in mehanizme za nastanek poškodb.

Objectives and competences:

- Goals:
1. To get to know various machine and surface damages.
 2. To get to know ways and possibilities of surface evaluation.
 3. To understand and know how to analyse, causes and mechanisms of

<p>4. Spoznati uporabo različnih metod za zmanjšanje poškodb strojev in površin.</p> <p>Kompetence:</p> <ol style="list-style-type: none"> 1. P1-PAP: Poznavanje splošnih teoretičnih znanj s področja poškodb strojev in površin. 2. S13-PAP, P4-PAP: Sposobnost meritev in ovrednotanja ne poškodovanih in poškodovanih površin. 3. S14-PAP, P3-PAP: Sposobnost določitev osnovnih vzrokov poškodb in mehanizmov obrabe. 4. S11-PAP, P9-PAP: Samostojna sinteza in predstavitev triboloških rešitev za prerečevanje oziroma zmanjšanje poškodb strojev. 	<p>damage.</p> <p>4. To get to know different methods to reduce damage to machines and surfaces.</p> <p>Competences:</p> <ol style="list-style-type: none"> 1. P1-PAP: Knowledge of general theoretical knowledge in the field machines and surface damages. 2. S13-PAP, P4-PAP: Ability to measure and evaluate undamaged and damaged surfaces. 3. S14-PAP, P3-PAP: Ability to identify basic causes of damage and mechanisms of wear. 4. S11-PAP, P9-PAP: Independent synthesis and presentation of tribological solutions for preventing or reducing machine damage.
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Predvideni študijski rezultati:

<p>Znanja:</p> <p>Z1: Poglobljeno metodološko poznavanje vzrokov in mehanizmov poškodb strojev in površin.</p> <p>Spretnosti:</p> <ol style="list-style-type: none"> 1. S1 Sposobnost obravnave poškodbe strojev in površin z izbiro ustezne metode. 2. S1.2 Samostojna uporaba pridobljenega znanja pri določitvi vzrokov in mehanizmov poškodb strojev in površin. 3. S1.3 Sposobnost izbire tehnik in metod za zmanjšanje oziroma preprečitev poškodb. 4. S1.4 Sposobnost nadaljnjega, samostojnega študija. 	<p>Knowledge:</p> <p>Z1: In-depth methodological knowledge of causes and mechanisms of machine and surface damages.</p> <p>Abilities:</p> <ol style="list-style-type: none"> 1. S1 Ability to deal with machine and surface damages by choosing the appropriate method. 2. S1.2 Independent use of acquired knowledge in determining the causes and mechanisms of damage to machines and surfaces. 3. S1.3 Ability to choose techniques and methods to reduce or prevent damages. 4. S1.4 Ability to further independent study.
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Metode poučevanja in učenja:

<p>P1 Avditorna predavanja z reševanjem izbranih - za področje značilnih - teoretičnih in praktično uporabnih primerov.</p> <p>P2 Obravnava snovi po urejeni in vnaprej razloženi sistematiki.</p> <p>P3 Avditorne vaje, kjer se teoretično</p>	
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Learning and teaching methods:

<p>znanje s predavanj podkrepi z računskimi primeri.</p> <p>P4 Laboratorijske vaje.</p> <p>P5 Uporaba študijskega gradiva v obliki (e-verzija predstavitve predavanj).</p> <p>P8 Izdelava in predstavitev aplikativnih seminarskih nalog.</p> <p>P14 Virtualni eksperimenti.</p> <p>P15 Uporaba video vsebin kot priprava na predavanja in vaje.</p>	
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Načini ocenjevanja:	Delež/ Weight	Assessment:
Teoretična snov (predavanja).	50,00 %	Theoretical knowledge (lecture).
Samostojno delo na vajah.	20,00 %	Independent tutorial work.
Laboratorijsko delo na vajah (vključno s poročili).	20,00 %	Lab tutorial work (with reports).
Seminar.	10,00 %	Seminar.

Reference nosilca/Lecturer's references:

Mitjan Kalin:

1. POLJANEC, Dejan, **KALIN, Mitjan**. Effect of polarity and various contact pairing combinations of electrographite, polymer-bonded graphite and copper on the performance of sliding electrical contacts. *Wear*. [Online ed.]. Apr. 2019, vol. 426/427, part b, str. 1163-1175, ilustr. ISSN 1873-2577.
2. **KALIN, Mitjan**, POLJANEC, Dejan. Influence of the contact parameters and several graphite materials on the tribological behaviour of graphite/copper two-disc electrical contacts. *Tribology international*. [Print ed.]. Oct. 2018, vol. 126, str. 192-205, ilustr. ISSN 0301-679X.
3. POLJANEC, Dejan, **KALIN, Mitjan**, KUMAR, Ludvik. Influence of contact parameters on the tribological behaviour of various graphite/graphite sliding electrical contacts. *Wear*. [Print ed.]. Jul. 2018, vol. 406-407, str. 75-83, ilustr. ISSN 0043-1648.
4. JERINA, Jure, **KALIN, Mitjan**. Aluminium-alloy transfer to a CrN coating and a hot-work tool steel at room and elevated temperatures. *Wear*. [Print ed.]. 2015, vol. 340/341, str. 82-89, ilustr. ISSN 0043-1648.
5. POGAČNIK, Aljaž, POŽAR, Tomaž, **KALIN, Mitjan**, MOŽINA, Janez. A homodyne quadrature laser interferometer for micro-asperity deformation analysis. *Sensors*. 2013, vol. 13, iss. 1, str. 703-720, ilustr. ISSN 1424-8220.