

## UČNI NAČRT PREDMETA/COURSE SYLLABUS

<b>Predmet:</b>	Nekonvencionalni izdelovalni procesi
<b>Course title:</b>	Non-traditional manufacturing processes
<b>Članica nosilka/UL Member:</b>	UL FS

Študijski programi in stopnja	Študijska smer	Letnik	Semestri
Strojništvo - projektno aplikativni program, prva stopnja, visokošolski strokovni	Proizvodne tehnologije (smer)	2. letnik	2. semester

**Univerzitetna koda predmeta/University course code:** 0563505

**Koda učne enote na članici/UL Member course code:** 3056-V

Predavanja	Seminar	Vaje	Klinične vaje	Druge oblike študija	Samostojno delo	ECTS
30		30			40	4

**Nosilec predmeta/Lecturer:** Andrej Lebar, Joško Valentinčič

**Vrsta predmeta/Course type:** Izbirni strokovni predmet /Elective specialised course

**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.

**Vsebina:**

**Content (Syllabus outline):**

<p>1. Elektroerozija:</p> <ul style="list-style-type: none"> <li>☐ karakterizacija razelektritev s pomočjo napetostnega in tokovnega signala v reži in vodenje procesa;</li> <li>☐ krmiljenje velikost reže;</li> <li>☐ dielektriki.</li> </ul> <p>2. Potopna elektroerozija:</p> <ul style="list-style-type: none"> <li>☐ Pravilna izbira obdelovalnih parametrov</li> <li>☐ vpliv obdelovalnih parametrov na rezultate obdelave.</li> </ul> <p>3. Potopna elektroerozija:</p> <ul style="list-style-type: none"> <li>☐ prehod od grobe k fini obdelavi;</li> </ul>	<p>1. Electrical discharge machining (EDM):</p> <ul style="list-style-type: none"> <li>☐ characterization of discharges by means of a voltage and current signal in the gap and process control;</li> <li>☐ control of the size of the gap;</li> <li>☐ dielectrics.</li> </ul> <p>2. Die-sinking EDM:</p> <ul style="list-style-type: none"> <li>☐ selection of the suitable machining parameters;</li> <li>☐ influence of machining parameters on results of machining;</li> </ul> <p>3. Die-sinking EDM:</p>
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<p>☐ elektrode - izbira materiala, izdelava, obraba;  ☐ CNC krmiljeno orbitalno gibanje; stroji - koncepti in pregled trga;  ☐ primeri izdelkov.</p> <p>4. Žična elektroerozija:  ☐ obdelovalni parametri - pravilna izbira in njihov vpliv na rezultate obdelave;  ☐ sistem vodenja žice;  ☐ materiali žic;  ☐ prehod od grobe k fini obdelavi;  ☐ stroji - koncepti in pregled trga;  ☐ primeri izdelkov.</p> <p>5. Uporaba elektroerozije v orodjarstvu:  ☐ komplementarnost s konvencionalnimi tehnologijami,  ☐ primeri iz prakse.</p> <p>6. Rezanje z vodnim curkom (VC) in abrazivnim vodnim curkom (AVC):  ☐ VC - oblikovanje curka, princip odnašanja materiala, kontinuiran in pulzni curek, področja uporabe;  ☐ AVC - tvorjenje abrazivnega vodnega curka;  ☐ princip odnašanja materiala.</p> <p>7. Rezanje z VC in AVC:  ☐ obdelovalni parametri - pravilna izbira in njihov vpliv na rezultate obdelave;  ☐ obdelovalnost materialov in kvaliteta rezanja.</p> <p>8. Rezanje z vodnim in abrazivnim vodnim curkom:  ☐ visokotlačne črpalke - tipi in karakteristike;  ☐ stroji - koncepti in pregled trga.</p> <p>9. Rezanje z vodnim in abrazivnim vodnim curkom:  ☐ področja uporabe - čiščenje, fragmentacija, prehrabena industrija, medicina, rezanje, struženje, graviranje;  ☐ primeri izdelkov.</p> <p>10. Lasersko rezanje:  ☐ interakcija laserskega žarka z materialom,  ☐ pomen absorpcije žarka v material,  ☐ vpliv rodu laserskega žarka, premera, dolžine gorišča in polarizacije na rezanje.</p> <p>11. Lasersko rezanje:  ☐ obdelovalni parametri, rezalni plini, položaj gorišča, značilnosti obdelave, stroji - koncepti in pregled trga;  ☐ primeri izdelkov.</p> <p>12. Aditivne tehnologije:  ☐ koraki 3D tiskanja,  ☐ delitev aditivnih tehnologij po standardu ISO/ASTM52900-15,  ☐ osnovni koncept fotopolimerizacije v kadi, brizganja veziva, brizganje materiala, ekstrudiranje materiala, spajanje slojev praškastega materiala, nalaganje krojenih plasti, direktno energijsko odlaganje.</p>	<p>☐ transition from rough to fine machining;  ☐ electrodes - material selection, manufacture, wear;  ☐ CNC-controlled orbital movement; machines - concepts and market overview;  ☐ product examples.</p> <p>4. Wire EDM:  ☐ selection of the suitable machining parameters;  ☐ influence of machining parameters on results of machining;  ☐ wire guiding system;  ☐ wire materials;  ☐ transition from rough to fine machining;  ☐ machines - concepts and market overview;  ☐ product examples.</p> <p>5. EDM processes in toolmaking:  ☐ complementarity with conventional technologies,  ☐ practical examples.</p> <p>6. Water jet (WJ) and abrasive water jet (AWJ) cutting:  ☐ WJ - formation of the jet, principles of material removal, continuous and pulsating jet, applications;  ☐ AWJ - formation of an abrasive water jet;  ☐ principles of material removal.</p> <p>7. WJ and AWJ cutting:  ☐ selection of the suitable machining parameters;  ☐ influence of machining parameters on results of machining;  ☐ machinability of materials and quality of the cut.</p> <p>8. WJ and AWJ cutting:  ☐ high pressure pumps - types and characteristics;  ☐ machines - concepts and market overview.</p> <p>9. WJ and AWJ te:  ☐ applications and fields of use- cleaning, fragmentation, food industry, medicine, cutting, turning, engraving;  ☐ examples of products.</p> <p>10. Laser cutting:  ☐ interaction of the laser beam with the material,  ☐ the importance of the absorption of the beam into the material,  ☐ the influence of laser mode, diameter, focal length and polarization on cutting.</p> <p>11. Laser cutting:  ☐ machining parameters, cutting gasses, focus position, machining characteristics;- machines - concepts and market overview;  ☐ product examples.</p> <p>12. Additive manufacturing:  ☐ 3D printing steps,  ☐ classification of additive technologies according to ISO/ASTM52900-15,  ☐ the basic concept of vat photopolymerization, binder</p>
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<p>13. Praktični primeri uporabe aditivnih tehnologij:</p> <ul style="list-style-type: none"> <li>☐ prototipiranje, orodjarstvo, medicina;</li> <li>☐ naknadna obdelava.</li> </ul> <p>14. Mikro izdelovalne tehnologije:</p> <ul style="list-style-type: none"> <li>☐ mikrosistemske in mikroinženirske tehnologije,</li> <li>☐ primeri iz prakse.</li> </ul> <p>15. Vpliv obravnavanih tehnologij na okolje, ukrepi za varno ravnanje s stranskimi produkti, zaščita delavnega okolja.</p>	<p>jetting, material jetting, material extrusion, powder bed fusion, sheet lamination, direct energy deposition.</p> <p>13. Practical examples of the use of additive technologies:</p> <ul style="list-style-type: none"> <li>☐ prototyping, tooling, medicine;</li> <li>☐ post-processing.</li> </ul> <p>14. Micro manufacturing technologies:</p> <ul style="list-style-type: none"> <li>☐ microsystems and microengineering technologies,</li> <li>☐ practical examples.</li> </ul> <p>15. Environmental impact of the technologies considered, measures for safe handling of by-products, protection of the working environment.</p>
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#### Temeljna literatura in viri/Readings:

1. J. Valentinčič idr.: Alternativne tehnologije, učbenik za tretji letnik visokošolskega strokovnega študijskega programa I. stopnje, Fakulteta za strojništvo, Ljubljana 2012.
2. M.P. Groover: Fundamentals of Modern Manufacturing – Materials, Processes, and Systems, 4th edition, John Wiley and Sons, 2010.
3. B. Guitrau, E.: The Electrical Discharge Machining Handbook. – Hanser Gardner Publications, Cincinnati, OH, USA, 1997.
4. A.W. Momber and R. Kovačević: Principles of Abrasive Water Jet Machining – Springer-Verlag London, 1998
5. J. Powel: CO2 Laser Cutting, Springer, 1993.

#### Cilji in kompetence:

<p>Cilji:</p> <ol style="list-style-type: none"> <li>1. Poglobljeno poznavanje karakteristik obdelovalnih postopkov za uspešno načrtovanje izdelkov in za določitev optimalnih obdelovalnih parametrov.</li> <li>2. Poglobljeno poznavanje fizikalnih principov odnašanja materiala in delovanja naprav.</li> <li>3. Poznavanje vpliva obravnavanih izdelovalnih procesov na okolje.</li> </ol> <p>Kompetence:</p> <ol style="list-style-type: none"> <li>1. S1-PAP, S2-PAP, S5-PAP, P8-PAP: Sposobnost načrtovanja izdelka za učinkovito izdelavo z obravnavanimi postopki.</li> <li>2. S1-PAP, S12-PAP, P7-PAP: Določitev optimalnih obdelovalnih parametrov za učinkovito izdelavo.</li> <li>3. S4-PAP, S11-PAP: Sposobnost analize izdelovalnega procesa in uvedbe ustreznih izboljšav.</li> <li>4. S9-PAP, S15-PAP, S16-PAP, P5-PAP: Sposobnost kritične presoje uporabljenih izdelovalnih procesov glede vpliva na okolje.</li> </ol>	<p>Objectives:</p> <ol style="list-style-type: none"> <li>1. In-depth knowledge of the properties of machining processes for successful product design and for determining optimum machining parameters.</li> <li>2. In-depth knowledge of the physical principles of material removal and equipment operation.</li> <li>3. Knowledge of the environmental impact of the manufacturing processes under consideration.</li> </ol> <p>Competences:</p> <ol style="list-style-type: none"> <li>1. S1- PAP, S2- PAP, S5- PAP, P8- PAP: The ability to design a product for efficient manufacturing with the processes under consideration.</li> <li>2. S1- PAP, S12- PAP, P7- PAP: Determination of the optimal machining parameters for efficient manufacturing.</li> <li>3. S4- PAP, S11- PAP: Ability to analyze the manufacturing process and make appropriate improvements.</li> <li>4. S9- PAP, S15- PAP, S16- PAP, P5- PAP: Ability to critically evaluate the environmental impact of the manufacturing processes used.</li> </ol>
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#### Predvideni študijski rezultati:

#### Intended learning outcomes:

<p><b>Znanja:</b> Z1: Poglobljeno strokovno teoretično in praktično znanje na področju nekonvencionalnih proizvodnih tehnologij, podprto s širšo teoretično in metodološko osnovo.</p> <p><b>Spretnosti:</b> S1.2 Obvladovanje zahtevnih, kompleksnih delovnih procesov ob samostojni uporabi znanja v novih delovnih situacijah. S1.3 Diagnosticiranje in reševanje problemov v različnih specifičnih delovnih okoljih, povezanih s področjem izobraževanja in usposabljanja.</p>	<p><b>Knowledge:</b> Z1: Thorough professional theoretical and practical knowledge in a selected field of expertise that is supported with a broad theoretical and methodological basis.</p> <p><b>Skills:</b> S1.2 Executing complex operationa-professional tasks that incorporate usage of methodological tools. S1.3 Problem diagnostics and solving in different and specific working environments that are linked to the teaching and training content.</p>
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<b>Metode poučevanja in učenja:</b>	<b>Learning and teaching methods:</b>
<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 znanje s predavanj podkrepi z računskimi primeri.</p> <p>P5 Uporaba študijskega gradiva v obliki: knjige, e-verzija predstavitev predavanj.</p> <p>P6 Interaktivna predavanja</p> <p>P7 Študij literature in razprava</p> <p>P8 Izdelava in predstavitev aplikativnih seminarskih nalog</p> <p>P10 Uporaba anket v realnem času</p> <p>P15 Uporaba video vsebin kot priprava na predavanja in vaje</p>	<p>P1 Auditorial lectures with solving selected field-specific theoretical and applied use cases.</p> <p>P2 Presenting the content according to the explained system.</p> <p>P3 Auditorial exercises, in which theoretical content from the lectures is supplemented with practical examples.</p> <p>P5 Application of study material (description needs to be added, max. one line per material, e.g. textbook, e-book, printed lecture presentations, etc.).</p> <p>P6 Interactive lectures.</p> <p>P7 Literature study and discussion.</p> <p>P8 Making and presenting applied seminar exercises.</p> <p>P10 Application of questionnaires in real time.</p> <p>P15 Application of videos for preparations to the lectures and exercises.</p>

<b>Načini ocenjevanja:</b>	<b>Delež/Weight</b>	<b>Assessment:</b>
Teoretične vsebine (predavanja)	50,00 %	Theoretical content (lectures)
Delo na laboratorijskih vajah (vključno s poročili)	20,00 %	Laboratory work (including reports)
Seminar	30,00 %	Seminar

#### Reference nosilca/Lecturer's references:

Joško Valentinčič:

- MAURIZI, Marco, SLAVIČ, Janko, CIANETTI, Filippo, JERMAN, Marko, **VALENTINČIČ, Joško**, LEBAR, Andrej, BOLTEŽAR, Miha. Dynamic measurements using FDM 3D-printed embedded strain sensors. *Sensors*, ISSN 1424-8220, 2019, vol. 19, iss. 12.
- VALENTINČIČ, Joško**, SEVŠEK, Luka, PRIJATELJ, Miha, SABOTIN, Izidor, JERMAN, Marko, LEBAR, Andrej. Towards production of microfeatures on a custom-made stereolitographic DLP printer. *Proceedings in manufacturing systems*, ISSN 2067-9238. [Print ed.], 2018, vol. 13, nr. 2, str. 51-55.

3. **VALENTINČIČ, Joško**, LEBAR, Andrej, SABOTIN, Izidor, DREŠAR, Pavel, JERMAN, Marko. Development of ice abrasive waterjet cutting technology. Journal of Achievements in Materials and Manufacturing Engineering, ISSN 2300-892X, 2017, vol. 2, no. 81, str. 76-84.
4. BISSACCO, G., **VALENTINČIČ, Joško**, HANSEN, H.N., WIWE, B.D. Towards the effective tool wear control in micro-EDM milling. The international journal of advanced manufacturing technology, ISSN 0268-3768, Mar. 2010, vol. 47, no. 1-4, str. 3-9.
5. **VALENTINČIČ, Joško**, FILIPIČ, Bogdan, JUNKAR, Mihael. Machine learning induction of a model for online parameter selection in EDM rough machining. The international journal of advanced manufacturing technology, ISSN 0268-3768, apr. 2009, vol. 41, no. 9-10, str. 865-870.

Andrej Lebar:

1. VALENTINČIČ, Joško, PRIJATELJ, Miha, JERMAN, Marko, **LEBAR, Andrej**, SABOTIN, Izidor. Characterization of a custom-made digital light processing stereolithographic printer based on a slanted groove micromixer geometry. Journal of micro- and nano-manufacturing. [Print ed.]. Mar. 2020, vol. 8.
2. PRIJATELJ, Miha, JERMAN, Marko, ORBANIČ, Henri, SABOTIN, Izidor, VALENTINČIČ, Joško, **LEBAR, Andrej**. Determining focusing nozzle wear by measuring AWJ diameter. Strojniški vestnik, ISSN 0039-2480, Oct. 2017, vol. 63, no. 10, str. 597-605.
3. TRISTO, Gianluca, BISSACCO, Giuliano, **LEBAR, Andrej**, VALENTINČIČ, Joško. Real time power consumption monitoring for energy efficiency analysis in micro EDM milling. The international journal of advanced manufacturing technology, ISSN 0268-3768, Jun. 2015, vol. 78, iss. 9, str. 1511-1521.
4. **LEBAR, Andrej**, SELAK, Luka, VRABIČ, Rok, BUTALA, Peter. Online monitoring, analysis, and remote recording of welding parameters to the welding diary. Strojniški vestnik, ISSN 0039-2480, jul.-avg. 2012, vol. 58, no. 7/8, str. 444-452.
5. ORBANIČ, Henri, BAJSIČ, Ivan, JUNKAR, Mihael, **LEBAR, Andrej**. An instrument for measuring abrasive water jet diameter. International journal of machine tools & manufacture : Design, research and application, ISSN 0890-6955. [Print ed.], sep. 2009, vol. 49, iss. 11, str. 843-849.