UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	Nekonvencionalni izdelovalni procesi
Course title:	Non-traditional manufacturing processes
Članica nosilka/UL Member:	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):**
1. Elektroerozija: - karakterizacija razelektritev s pomočjo napetostnega in tokovnega signala v reži in vodenje procesa; - krmiljenje velikost reže; - dielektriki. 2. Potopna elektroerozija: - Pravilna izbira obdelovalnih parametrov - vpliv obdelovalnih parametrov na rezultate obdelave. 3. Potopna elektroerozija: - prehod od grobe k fini obdelavi;	1. Electrical discharge machining (EDM): - characterization of discharges by means of a voltage and current signal in the gap and process control; - control of the size of the gap; - dielectrics. 2. Die-sinking EDM: - selection of the suitable machining parameters; - influence of machining parameters on results of machining; 3. Die-sinking EDM:

 elektrode - izbira materiala, izdelava, obraba;
 CNC krmiljeno orbitalno gibanje; stroji - koncepti in pregled trga;
 primeri izdelkov.

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.

5. Uporaba elektroerozije v orodjarstvu:
 komplementarnost s konvencionalnimi tehnologijami,
 primeri iz prakse.

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.

7. Rezanje z VC in AVC:
 obdelovalni parametri - pravilna izbira in njihov vpliv na rezultate obdelave;
 obdelovalnost materialov in kvaliteta rezanja.

8. Rezanje z vodnim in abrazivnim vodnim curkom:
 visokotlačne črpalke - tipi in karakteristike;
 stroji - koncepti in pregled trga.

9. Rezanje z vodnim in abrazivnim vodnim curkom:
 področja uporabe - čiščenje, fragmentacija, prehrambena industrija, medicina, rezanje, struženje, graviranje;
 primeri izdelkov.

10. Lasersko rezanje:
 interakcija laserskega žarka z materialom,
 pomen absorpcije žarka v material,
 vpliv rodu laserskega žarka, premera, dolžine gorišča in polarizacije na rezanje.

11. Lasersko rezanje:
 obdelovalni parametri, rezalni plini, položaj gorišča, značilnosti obdelave, stroji - koncepti in pregled trga;
 primeri izdelkov.

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.

 transition from rough to fine machining;
 electrodes - material selection, manufacture, wear;
 CNC-controlled orbital movement; machines - concepts and market overview;
 product examples.

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.

5. EDM processes in toolmaking:
 complementarity with conventional technologies,
 practical examples.

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.

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.

8. WJ and AWJ cutting:
 high pressure pumps - types and characteristics;
 machines - concepts and market overview.

9. WJ and AWJ te:
 applications and fileds of use- cleaning, fragmentation, food industry, medicine, cutting, turning, engraving;
 examples of products.

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.

11. Laser cutting:
 machining parameters, cutting gasses, focus position, machining characteristics;- machines - concepts and market overview;
 product examples.

12. Additive manufacturing:
 3D printing steps,
 classification of additive technologies according to ISO/ASTM52900-15,
 the basic concept of vat photopolymerization, binder

13. Praktični primeri uporabe aditivnih tehnologij: - prototipiranje, orodjarstvo, medicina; - naknadna obdelava. 14. Mikro izdelovalne tehnologije: - mikrosistemske in mikroinženirske tehnologije, - primeri iz prakse. 15. Vpliv obravnavanih tehnologij na okolje, ukrepi za varno ravnanje s stranskimi produkti, zaščita delavnega okolja.	jetting, material jetting, material extrusion, powder bed fusion, sheet lamination, direct energy deposition. 13. Practical examples of the use of additive technologies: - prototyping, tooling, medicine; - post-processing. 14. Micro manufacturing technologies: - microsystems and microengineering technologies, - practical examples. 15. Environmental impact of the technologies considered, measures for safe handling of by-products, protection of the working environment.

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 Willey 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 – Sprnger-Verlag London, 1998
5. J. Powel: CO2 Laser Cutting, Springer, 1993.

Cilji in kompetence:	**Objectives and competences:**
Cilji: 1. Poglobljeno poznavanje karakteristik obdelovalnih postopkov za uspešno načrtovanje izdelkov in za določitev optimalnih obdelovalnih parametrov. 2. Poglobljeno poznavanje fizikalnih principov odnašanja materiala in delovanja naprav. 3. Poznavanje vpliva obravnavanih izdelovalnih procesov na okolje. Kompetence: 1. S1-PAP, S2-PAP, S5-PAP, P8-PAP: Sposobnost načrtovanja izdelka za učinkovito izdelavo z obravnavanimi postopki. 2. S1-PAP, S12-PAP, P7-PAP: Določitev optimalnih obdelovalnih parametrov za učinkovito izdelavo. 3. S4-PAP, S11-PAP: Sposobnost analize izdelovalnega procesa in uvedbe ustreznih izboljšav. 4. S9-PAP, S15-PAP, S16-PAP, P5-PAP: Sposobnost kritične presoje uporabljenih izdelovalnih procesov glede vpliva na okolje.	Objectives: 1. In-depth knowledge of the properties of machining processes for successful product design and for determining optimum machining parameters. 2. In-depth knowledge of the physical principles of material removal and equipment operation. 3. Knowledge of the environmental impact of the manufacturing processes under consideration. Competences: 1. S1- PAP, S2- PAP, S5- PAP, P8- PAP: The ability to design a product for efficient manufacturing with the processes under consideration. 2. S1- PAP, S12- PAP, P7- PAP: Determination of the optimal machining parameters for efficient manufacturing. 3. S4- PAP, S11- PAP: Ability to analyze the manufacturing process and make appropriate improvements. 4. S9- PAP, S15- PAP, S16- PAP, P5- PAP: Ability to critically evaluate the environmental impact of the manufacturing processes used.

Predvideni študijski rezultati:	**Intended learning outcomes:**

Znanja: Z1: Poglobljeno strokovno teoretično in praktično znanje na področju nekonvencionalnih proizvodnih tehnologij, podprto s širšo teoretično in metodološko osnovo. Spretnosti: 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.	Knowledge: Z1: Thorough professional theoretical and practical knowledge in a selected field of expertise that is supported with a broad theoretical and methodological basis. Skills: 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.

Metode poučevanja in učenja:	**Learning and teaching methods:**
P1 Avditorna predavanja z reševanjem izbranih - za področje značilnih - teoretičnih in praktično uporabnih primerov. P2 Obravnava snovi po urejeni in vnaprej razloženi sistematiki. P3 Avditorne vaje, kjer se teoretično znanje s predavanj podkrepi z računskimi primeri. P5 Uporaba študijskega gradiva v obliki: knjige, e-verzija predstavitve predavanj. P6 Interaktivna predavanja P7 Študij literature in razprava P8 Izdelava in predstavitev aplikativnih seminarskih nalog P10 Uporaba anket v realnem času P15 Uporaba video vsebin kot priprava na predavanja in vaje	P1 Auditorial lectures with solving selected field-specific theoretical and applied use cases. P2 Presenting the content according to the explained system. P3 Auditorial exrecises, in which theoretical content from the lectures is supplemented with practical examples. P5 Application of study material (description needs to be added, max. one line per material, e.g. textbook, e-book, printed lecture presentaions, etc.). P6 Interactive lectures. P7 Literature study and discussion. P8 Making and presenting applied seminar exercises. P10 Application of questionaries in real time. P15 Application of videos for preparations to the lectures and exercises.

Načini ocenjevanja:	**Delež/Weight**	**Assessment:**
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:

1. 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.
2. **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, ORBANIĆ, 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. ORBANIĆ, 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.