OPTIMIRANJE OBDELOVALNIH TEHNOLOGIJ

UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	OPTIMIRANJE OBDELOVALNIH TEHNOLOGIJ
Course title:	OPTIMIZATION OF MACHINING TECHNOLOGIES
Članica nosilka/UL Member:	UL FS

Študijski programi in stopnja	Študijska smer	Letnik	Semestri	Izbirnost
Strojništvo, tretja stopnja, doktorski	Proizvodno inženirske znanosti, kibernetika in mehatronika (smer)	1. letnik, 2. letnik	Celoletni	izbirni

Univerzitetna koda predmeta/University course code:	0033463
Koda učne enote na članici/UL Member course code:	7308

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:	Franci Pušavec

Izvajalci predavanj:	Davorin Kramar, Franci Pušavec
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:	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.

Vsebina:	**Content (Syllabus outline):**
Pregled, poznavanje in obravnava različnih možnosti izdelave in tehnologij, ki omogočajo izdelavo/obdelavo različnih vrst izdelkov. Analiza vplivnih vstopnih parametrov, v korespondenci z zahtevano obliko izdelka, materiala iz katerega je izdelek, zahtevano število kosov v seriji, zahtevano kakovostjo izdelka, itd. Tehnološka opredelitev primerno izbranih postopkov in pripadajoča optimizacija parametrov obdelave. Določevanje izvajanja metodologije optimiranja glede na cilje/motive optimizacije (cenovno, časovno, trajnostno, itd.) in zahteve procesa/končnega izdelka. Predstavitev celovitega pristopa k optimizaciji in njene izvede v smislu managementa sodobnih tehnologij, glede na razpoložljivo strojno opremo oziroma možnost investicij v opremo, zagotavljanju obvladovanje kakovosti (ISO 9000-serija), trajnostnega razvoja, itd. z enim samim ciljem – povečati dodano vrednost končnemu izdelku ob minimalnem vplivu na okolje in družbo.	Review, introduction and detailed analysis of different possible machining technologies, with their pros and cons, offering manufacturing/machining of different final products/parts. Analysis of significant input parameters in correspondence to requested part/product shape, workpiece material, extent of production series, demanded part/product quality, etc. Technological evaluation of chosen procedures and corresponding optimization of machining parameters. Determination of the optimization procedure, based on the optimization objectives and constraints (costs, time, sustainability, etc.) that are following from the final product specification. Presentation of global optimization procedure flow and its implementation in the sense of novel management technologies (available machine tool or possibilities investments into new equipment, assuring quality control (ISO 9000), sustainable development, etc. with the aim to increase the value of the final product and still minimize the influences on the environment and society.

Temeljna literatura in viri/Readings:

[1] Energy efficient manufacturing: theory and applications. Hoboken (NJ); Beverly (MA): Wiley; Scrivener Publishing, 2018, str. XIV, 451. ISBN 978-1-118-42384-4, [COBISS.SI-ID 158647811]
[2] Modern manufacturing processes. Hoboken (NJ): Wiley, 2020, str. XXI, 514. ISBN 978-1-118-07192-2, [COBISS.SI-ID 149649411]
[3] M. P. Groover, Fundamentals of modern manufacturing: materials, processes, and systems, 7th ed. Hoboken (NJ): John Wiley & Sons, 2020, str. XIV, 703, 71, 14. ISBN 978-1-119-72201-4, [COBISS.SI-ID 146641667]
[4] J. Kopač, Odrezavanje: teoretične osnove in tehnološki napotki. Ljubljana [i. e.] Domžale: [samozal.] J. Kopač, 2008, str. 264. ISBN 978-961-245-583-5, [COBISS.SI-ID 241209856]
[5] Z. Bi in X. Wang, Computer aided design and manufacturing. Hoboken, NJ; [New York, New York]: John Wiley & Sons, Inc.; ASME Press, 2020, str. XXI, 18 f., 617. ISBN 978-1-119-53421-1, [COBISS.SI-ID 44464899]

Cilji in kompetence:	**Objectives and competences:**
Cilji: Cilj predmeta je študentu predstaviti teorijo optimiranja, optimizacijske metode in dejansko apliciranje le te na obdelovalne procese. Ob tem so študentu predstavljene metode modeliranja procesov, evalvacijske metode za določitev optimizacijskih kriterijskih funkcij in analiza vplivnih parametrov (podajanje, rezalna hitrost, globina odrezavanja, hladilno mazana sredstva, itd.). Pri predmetu se predstavijo aktualni optimizacijski postopki v neposredni povezavi z industrijskimi problemi. Zato so v predmet vključene vsebine, iz poznavanja načrtovanja eksperimentov, bank tehnoloških podatkov in optimiranja rezalnih parametrov. **Kompetence:** - Obvladovanje pristopov k načrtovanju eksperimentov obdelovalnosti. - Obvladovanje postavitve modelov procesov. - Obvladovanje postavitve kriterijskih funkcij obdelovalnega procesa. - Obvladovanje same procedure optimiranja procesov.	**Goals:** The principal goal is to introduce the student optimization theory, optimization methods and its application on industrial machining problems. Additionally process modeling methods are introduced to the student, evaluation methods for determine the stiffness function of optimization, analysis of involving parameter significances (feed, cutting speed, depth of cut, cooling/lubrication fluids, etc.). In scope of this subject, all the themes are presented in close relation to state of the art optimization procedures on real industrial cases. Therefore the the subject cover also design of experiments thematic, technological data bases and machining parameters optimization. **Competences:** - Be acquainted with design of experiments for machining performance determination. - Be acquainted with machining process models development. - Be acquainted with determination of stiffness function for the optimization. - Be acquainted with machining process optimization procedures itself.

Predvideni študijski rezultati:	Intended learning outcomes:
• Obvladovanje pristopov k načrtovanju eksperimentov obdelovalnosti. • Obvladovanje postavitve modelov procesov. • Obvladovanje postavitve kriterijskih funkcij obdelovalnega procesa. • Obvladovanje same procedure optimiranja procesov	• Be acquainted with design of experiments for machining performance determination. • Be acquainted with machining process models development. • Be acquainted with determination of stiffness function for the optimization. • Be acquainted with machining process optimization procedures itself.

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:
Ustni izpit, poročilo o seminarskem delu. Pogoj za opravljanje ustnega izpita je uspešno izdelano in pozitivno ocenjeno seminarsko delo. • seminarsko delo (60%) • ustno izpraševanje (40%)		Oral exam, report on seminar work. The condition for admission to oral exam is successful completion of seminar work, rewarded with a passing grade. • seminar work (60%) • oral examination (40%)

Ocenjevalna lestvica:	Grading system:

Reference nosilca/Lecturer's references:

prof. dr. Franci PUŠAVEC

TEŠIĆ, Saša, CICA, Djordje, BOROJEVIĆ, Stevo, SREDANOVIĆ, Branislav, ZELJKOVIĆ, Milan, KRAMAR, Davorin, PUŠAVEC, Franci. Optimization and prediction of specific energy consumption in ball-end milling of Ti-6Al-4V alloy under mql and cryogenic cooling/lubrication conditions. International journal of precision engineering and manufacturing. Green engineering. Nov. 2022, iss. 9, str. 1427–1437, ilustr. ISSN 2198-0810. https://link.springer.com/article/10.1007/s40684-021-00413-9, DOI:

10.1007/s40684-021-00413-9. [COBISS.SI-ID 110628867]

PUŠAVEC, Franci, GRGURAŠ, Damir, KOCH, Matthias, KRAJNIK, Peter. Cooling capability of liquid nitrogen and carbon dioxide in cryogenic milling. CIRP annals. 2019, vol. 68, iss. 1, str. 73-76, ilustr. ISSN 0007-8506. https://www.sciencedirect.com/science/article/pii/S0007850619300174, DOI: 10.1016/j.cirp.2019.03.016. [COBISS.SI-ID 16614427]

MARUDA, Radoslaw W., KROLCZYK, Grzegorz M., FELDSHTEIN, Eugene, NIESLONY, Piotr, TYLISZCZAK, Bozena, PUŠAVEC, Franci. Tool wear characterizations in finish turning of AISI 1045 carbon steel for MQCL conditions. Wear. [Print ed.]. Jan. 2017, vol. 372/373, str. 54-67, ilustr. ISSN 0043-1648. http://www.sciencedirect.com/science/article/pii/S0043164816307451, DOI: 10.1016/j.wear.2016.12.006. [COBISS.SI-ID 15142939]

JAWAHIR, I. S., ATTIA, Helmi, BIERMANN, Dirk, DUFLOU, Joost, KLOCKE, Fritz, MEYER, D., NEWMAN, S. T., PUŠAVEC, Franci, PUTZ, M., RECH, Joël, SCHULZE, Volker, UMBRELLO, D. Cryogenic manufacturing processes. CIRP annals. 2016, vol. 65, nr. 2, str. 713-736, ilustr. ISSN 0007-8506. http://www.sciencedirect.com/science/article/pii/S0007850616302402, DOI: 10.1016/j.cirp.2016.06.007. [COBISS.SI-ID 14829851]

izr. prof. dr. Davorin Kramar

RODIĆ, Dragan, SEKULIĆ, Milenko, GOSTIMIROVIĆ, Marin, PUCOVSKY, Vladimir, KRAMAR, Davorin. Fuzzy logic and sub-clustering approaches to predict main cutting force in high-pressure jet assisted turning. *Journal of intelligent manufacturing*, ISSN 0956-5515, Jan. 2021, vol. 32, iss. 1, str. 21-36, ilustr. https://link.springer.com/article/10.1007/s10845-020-01555-4, doi: 10.1007/s10845-020-01555-4. [COBISS.SI-ID 17169691], [JCR, SNIP, WoS do 22. 1. 2023: št. citatov (TC): 9, čistih citatov (CI): 9, Scopus do 10. 1. 2023: št. citatov (TC): 8, čistih citatov (CI): 8]

TEŠIĆ, Saša, CICA, Djordje, BOROJEVIĆ, Stevo, SREDANOVIĆ, Branislav, ZELJKOVIĆ, Milan, KRAMAR, Davorin, PUŠAVEC, Franci. Optimization and prediction of specific energy consumption in ball-end milling of Ti-6Al-4V alloy under mql and cryogenic cooling/lubrication conditions. *International journal of precision engineering and manufacturing, Green engineering*, ISSN 2198-0810, Nov. 2022, iss. 9, str. 1427%1437, ilustr. https://link.springer.com/article/10.1007/s40684-021-00413-9, doi: 10.1007/s40684-021-00413-9. [COBISS.SI-ID 110628867], [JCR, SNIP, WoS do 7. 6. 2022: št. citatov (TC): 0, čistih citatov (CI): 0, Scopus do 7. 6. 2022: št. citatov (TC): 0, čistih citatov (CI): 0]

COURBON, Cedric, ŠAJN, Viktor, KRAMAR, Davorin, RECH, Joël, KOSEL, Franc, KOPAČ, Janez. Investigation of machining performance in high pressure jet assisted turning of Inconel 718 : a numerical model. *Journal of materials processing technology*, ISSN 0924-0136, Nov. 2011, vol. 211, iss. 11, str. 1834-1851, doi: 10.1016/j.jmatprotec.2011.06.006. [COBISS.SI-ID 11929883], [JCR, SNIP, WoS do 6. 2. 2023: št. citatov (TC): 55, čistih citatov (CI): 49, Scopus do 4. 2. 2023: št. citatov (TC): 63, čistih citatov (CI): 56]

ÇALŞKAN, Halil, KURBANOĞLU, Cahit, PANJAN, Peter, ČEKADA, Miha, KRAMAR, Davorin. Wear behavior and cutting performance of nanostructured hard coatings on cemented carbide cutting tools in hard milling. *Tribology international*, ISSN

0301-679X, 2013, vol. 62, str. 215-222, doi: 10.1016/j.triboint.2013.02.035. [COBISS.SI-ID 26697767], [JCR, SNIP, WoS do 28. 12. 2022: št. citatov (TC): 58, čistih citatov (CI): 53, Scopus do 21. 2. 2023: št. citatov (TC): 72, čistih citatov (CI): 65]