

PROCESI VARJENJA

UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	PROCESI VARJENJA
Course title:	WELDING PROCESSES
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:	0033467
Koda učne enote na članici/UL Member course code:	7312

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

Nosilec predmeta/Lecturer:	Damjan Klobčar
-----------------------------------	----------------

Izvajalci predavanj:	Damjan Klobčar
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):**

Fizikalne, kemične in metalurške zakonitosti varilnih in varjenju sorodnih procesov in postopkov spajanja in toplotnega rezanja. Analiza varilnega obloka, plazme, elektronskega in svetlobnega snopa, toplotne, mehanske in kemične energije. Toplotni pojavi pri varjenju in varjenju sorodnih postopkih ter pri postopkih toplotnega rezanja kovin in nekovin. Pregled obločnih postopkov varjenja, pregled postopkov varjenja s kemično, mehansko in svetlobno energijo, pregled drugih postopkov spajanja materialov.

Dodajni materiali in kompatibilnost dodajnega in osnovnega materiala. Nastanek zvara, oziroma spoja. Varivost in varjenje kovin in zlitin, odvisnosti med sestavo in lastnostmi materiala, zvara oziroma spoja, termičnim varilnim ciklusom v povezavi z lastnostmi varjene konstrukcije. Zaščitni mediji obloka in taline vara (plini, plinske mešanice in praški). Key-hole efekt, Marangonijev efekt. Analiza zaostalih napetosti in deformacij ter odprava le-teh v zvarnih spojih in celotni konstrukciji. Matematično moduliranje procesov med varjenjem. Zagotavljanje kvalitete in kontrola zvarnih spojev, atestiranje varilnega osebja, certificiranje postopkov, proizvodov in sistemov.

Physical, chemical, and metallurgical phenomena of welding and welding related processes and processes of joining and thermal cutting. Analysis of welding arc, plasma arc, electron beam and beam of light, thermal, mechanical and chemical energy. Thermal phenomena of welding and welding related processes and processes of thermal cutting of metals and nonmetals. Overview of the arc welding processes, processes of welding with a chemical and mechanical energy, the energy of light, and the other processes of the material joining.

Consumable materials and the compatibility of consumable and base material. The formation of weld or welding joint. Weldability and welding of metals and alloys, the relationships between composition and material properties of weld or welding joint, thermal welding cycle in connection with properties of welded construction. Shielding medium of arc and weld bead (gasses, gas mixtures and powders). Key-hole effect, Marangony effect. The analysis of residual stresses and deformations and their suppress in welding joints and in all the constriction. Mathematical modeling of processes during welding. Quality assurance and control of welding joints, attesting of welding personnel, certification of processes, products and systems.

Temeljna literatura in viri/Readings:

- [1] Tušek, Janez. Varjenje in sorodne tehnike spajanja materialov v neločljivo zvezo, Fakulteta za strojništvo, 2015, str. XII, 467, COBISS.SI-ID - 282414848, ISBN - 978-961-6536-75-2.
- [2] O'Brien, Annette. Welding Handbook. Ninth edition. Vol. 1 - Welding Science and Technology, Miami, FL: American Welding Society, 2001. COBISS.SI-ID - 38102021
- [3] O'Brien, Annette. Welding Handbook. Ninth edition. Vol. 2 - Welding Processes, Part 1, Miami, FL: American Welding Society, 2004. COBISS.SI-ID - 173761
<https://search.ebscohost.com/login.aspx?direct=true&db=e000xww&AN=1839114&lang=sl&site=ehost-live>
- [4] O'Brien, Annette. Welding Handbook. Ninth edition. Vol. 3 - Welding Processes, Part 2, Miami, FL: American Welding Society, 2007.
<https://search.ebscohost.com/login.aspx?direct=true&db=e000xww&AN=1839115&lang=sl&site=ehost-live>
- [5] O'Brien, Annette. Welding Handbook. Ninth edition. Vol. 4 - Materials and Applications, Part 1, Miami, FL: American Welding Society, 2011.
<https://search.ebscohost.com/login.aspx?direct=true&db=e000xww&AN=1839116&lang=sl&site=ehost-live>
- [6] O'Brien, Annette. Welding Handbook. Ninth edition. Vol. 5 - Materials and Applications, Part 2, Miami, FL: American Welding Society, 2015.
<https://search.ebscohost.com/login.aspx?direct=true&db=e000xww&AN=1839117&lang=sl&site=ehost-live>
- [7] Rak, Inoslav. Tehnologija varjenja. 1. izd., Modrijan, 2008, str. 460. [COBISS.SI-ID - 239269376]
- [8] Jeffus, Larry F. Welding: principles and applications. 67th ed., International ed., Thomson Delmar Learning Delmar Cengage Learning, 2008, str. XXVX, 91176, COBISS.SI-ID - 29767429 15628597.
- [9] Kou, Sindo. Welding metallurgy. 2nd ed., John Wiley & Sons, 2003, str. XIV, 461, COBISS.SI-ID - 12047387.

Cilji in kompetence:

Cilji:

Študentu prikazati vlogo, pomen, lastnosti in uporabnost vseh procesov spajanja v splošni industriji in v znanosti. Razjasniti uporabnost posameznih procesov spajanja za vse vrste materialov. Razložiti vedenje dodatnih materialov med procesi spajanja s kemičnega, metalurškega, konstrukcijskega vidika. Pojasniti delo z varilnim oblokom, laserskim žarkom, elektronskim snopom in s plazmo.

Kompetence:

Študent osvoji znanja iz varilnih procesov, samostojno odloča o

Objectives and competences:

The role, meaning, properties and application of all welding processes in general industry and science is shown to the student. The applicability of individual welding processes for all types of welding materials is clarified. The behavior of consumable materials during the joining is explained from chemical, metallurgical, and a constructional point of view. The manipulation with the welding arc, laser beam, electron beam and plasma arc is explained.

Competences:

A student conquers the knowledge of

<p>raziskavah in o metodah raziskovalnega dela pri posameznih procesih spajanja. Študent mora meti sposobnost uporabe pridobljenega znanja v praksi in pri raziskovalnem delu, pri iskanje novih znanj iz različnih virov, ima sposobnost za samostojno raziskovalno in znanstveno delo ter prevzemati odgovornost, ima sposobnost za delo v skupini in je sposoben odločanja in vodenja, je etičen in zna kritično in pošteno ocenjevati sodelavce, zna upravljati s časom, je sposoben za ustno in pisno komuniciranje, pozna strokovno izrazoslovje področja v angleškem ali nemškem jeziku.</p>	<p>welding processes, and independently decides about research and methods of research work for particular joining processes. A student has to be able to use the acquired knowledge in practice, at research work, at searching of new knowledge from different sources, has the ability for independent research and scientific research as well as to contract an obligation, has the ability to work in a team and the ability of making decisions and leadership, is ethical and knows to critically and fairly judge the coworkers, knows to manage the time, is able to communicate orally and in writing, knows the professional terminology in English and German language.</p>
---	--

Predvideni študijski rezultati:

<p>Študent osvoji znanja iz varilnih procesov, samostojno odloča o raziskavah in o metodah raziskovalnega dela pri posameznih procesih spajanja. Študent mora meti sposobnost uporabe pridobljenega znanja v praksi in pri raziskovalnem delu, pri iskanje novih znanj iz različnih virov, ima sposobnost za samostojno raziskovalno in znanstveno delo ter prevzemati odgovornost, ima sposobnost za delo v skupini in je sposoben odločanja in vodenja, je etičen in zna kritično in pošteno ocenjevati sodelavce, zna upravljati s časom, je sposoben za ustno in pisno komuniciranje, pozna strokovno izrazoslovje področja v angleškem ali nemškem jeziku.</p>	<p>A student conquers the knowledge of welding processes, and independently decides about research and methods of research work for particular joining processes. A student has to be able to use the acquired knowledge in practice, at research work, at searching of new knowledge from different sources, has the ability for independent research and scientific research as well as to contract an obligation, has the ability to work in a team and the ability of making decisions and leadership, is ethical and knows to critically and fairly judge the coworkers, knows to manage the time, is able to communicate orally and in writing, knows the professional terminology in English and German language.</p>
---	--

Metode poučevanja in učenja:

<p>Predavanja, laboratorijske vaje, seminarsko delo, e-izobraževanje, konzultacije. Seminarsko delo v čim večji meri navezuje se na področje doktorskega raziskovanja. Študij z uporabo priporočene literature.</p>	<p>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.</p>
---	--

Načini ocenjevanja:

Delež/Weight

Assessment:

Ustni izpit, poročilo o seminarskem delu. Pogoji za opravljanje ustnega izpita je uspešno izdelano in pozitivno ocenjeno • <ul style="list-style-type: none"> • naloge 30% • projektno delo 30% • ustno zagovor 40% 		Oral exam, report on seminar work. The condition for admission to oral exam is successful completion • <ul style="list-style-type: none"> • assignments (30%) • project seminar (30%) • oral examination (40%)
---	--	--

Ocenjevalna lestvica:

Grading system:

5 - 10, pri čemer velja, da je pozitivna ocena od 6 - 10	5 - 10, a student passes the exam if he is graded from 6 to 10
--	--

Reference nosilca/Lecturer's references:

izr. prof. dr. Damjan Klobčar

OZANER, Ozan Can, KLOBČAR, Damjan, SHARMA, Abhay. Machining strategy determination for single- and multi-material wire and arc additive manufactured thin-walled parts. *Materials*. Mar. 2023, vol. 16, iss. 5, str. 1-20, ilustr. ISSN 1996-1944. <https://www.mdpi.com/1996-1944/16/5/2055>, DOI: [10.3390/ma16052055](https://doi.org/10.3390/ma16052055).

AYAD, Mohammad, LAPOSTOLLE, Lucas, RONDEPIERRE, Alexander, LE BRAS, Corentin, ÜNALDI, Selen, DONIK, Črtomir, KLOBČAR, Damjan, BERTHE, Laurent, TRDAN, Uroš. New methodology of dynamical material response of dissimilar FSWed Al alloy joint under high strain rate laser shock loading. *Materials & design*. Oct. 2022, vol. 222, str. 1-15, ilustr. ISSN 0264-1275.

<https://www.sciencedirect.com/science/article/pii/S026412752200702X>, DOI: [10.1016/j.matdes.2022.111080](https://doi.org/10.1016/j.matdes.2022.111080)

KLOBČAR, Damjan, PUŠAVEC, Franci, BRAČUN, Drago, GARAŠIĆ, Ivica, KOŽUH, Zoran, VENCL, Aleksandar, TRDAN, Uroš. Influence of friction riveting parameters on the dissimilar joint formation and strength. *Materials*. Sep. 2022, vol. 15, iss. 19, str. 1-12, ilustr. ISSN 1996-1944. <https://www.mdpi.com/1996-1944/15/19/6812>, DOI: [10.3390/ma15196812](https://doi.org/10.3390/ma15196812).

BALOŠ, Sebastian, DRAMIĆANIN, Miroslav D., JANJATOVIC, Petar, ZABUNOV, Ivan, KLOBČAR, Damjan, BUŠIĆ, Matija, GRILLI, Maria Luisa. Metal oxide nanoparticle-based coating as a catalyzer for A-TIG welding : critical raw material perspective. *Metals*. 2019, vol. 9, iss. 5, f. 1-12, ilustr. ISSN 2075-4701. <https://www.mdpi.com/2075-4701/9/5/567>, DOI: [10.3390/met9050567](https://doi.org/10.3390/met9050567).