

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)		Celoletni	izbirni

Univerzitetna koda predmeta/University course code: 0033467

Koda učne enote na članici/UL Member course code: 7312

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: 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

Temeljna literatura in viri/Readings:

- [1] Brazing handbook / prepared by AWS Committee on Brazing and Soldering.- 4th ed.- Miami: American Welding Society, 1991
- [2] Welding handbook. Vol. 3, Materials and applications. Part 1 / editor William R. Oates.- 8th ed.- Miami: American welding society, 1996
- [3] Ninth Edition, Volumen 1, Welding Science and Technology; Welding Handbook AWS 550 N. W. Lejeeune road Miami FL 33126, 2006
- [4] Ninth Edition, Volumen 2, Welding Processes Part 1; Welding Handbook AWS 550 N. W. Lejeeune road Miami FL 33126, 2006
- [5] N. N.: Ninth Edition, Volumen 3, Welding Processes Part 2; Welding Handbook AWS 550 N. W. Lejeeune road Miami FL 33126, 2008
- [6] Mohler, R.: Practical Welding Technology, Industrial pressinc, 200 Madison Avenue, New York, 2006
- [7] Steen, W.M.: Laser material welding.- 2nd ed.- London, 1998
- [8] Marfels, W.: Der Lichtbogenschweißer: Leitfadens für Ausbildung und Praxis / Marfels, Orth.- 9.- überarbeitete und erweiterte Aufl.- Düsseldorf: DVS-Verlag, 1997 (Die schwiesstechnische Praxis; Band 2,
- [9] Ceramic to metal joining: 250 references from the METADEX database / prepared by the editors of Materials Information in cooperation with ASM Information; Bethesda, MD: Cambridge Scientific Abstracts,2000.- (Search-in-print report; C 501)
- [10] Welding of aluminium: 250 references from the METADEX database / prepared by the editors of Materials Information in cooperation with ASM International & the Institute of Materials.- London: Materials Information; Bethesda, MD: Cambridge Scientific Abstracts, 2005.- (Search-in-print report; ALU006)
- [11] Welding of dissimilar metals: 250 references from the METADEX database / prepared by the editors of Materials Information in cooperation with ASM International & the Institute of Welding.

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,

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

<p>elektronskim snopom in s plazmo.</p> <p>Kompetence:</p> <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>beam, electron beam and plasma arc is explained.</p> <p>Competences:</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>
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<p>Predvideni študijski rezultati:</p> <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>Intended learning outcomes:</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>
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<p>Metode poučevanja in učenja:</p> <p>Predavanja, laboratorijske vaje, seminarsko delo, e-izobraževanje, konzultacije. Seminarsko delo v čim večji meri navezuje se na področje doktorskega raziskovanja. Študij z</p>	<p>Learning and teaching methods:</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</p>
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uporabo priporočene literature.	literature basis.
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Načini ocenjevanja:	Delež/ Weight	Assessment:
Ustni izpit, poročilo o seminarskem delu. Pogoji za opravljanje ustnega izpita je uspešno izdelano in pozitivno ocenjeno • naloge 30% • projektno delo 30% • ustno zagovor 40%		Oral exam, report on seminar work. The condition for admission to oral exam is successful completion • assignments (30%) • project seminar (30%) • oral examination (40%)

Reference nosilca/Lecturer's references:

doc.dr. Damjan Klobčar

1. KLOBČAR, Damjan, TUŠEK, Janez, BIZJAK, Milan, SIMONČIČ, Samo, LEŠER, Vladka. Active flux tungsten inert gas welding of austenitic stainless steel AISI 304. *Metalurgija*, ISSN 0543-5846, lis. 2016, vol. 55, nr. 4, str. 617-620, ilustr. http://hrcak.srce.hr/index.php?show=clanak&id_clanak_jezik=231945. [COBISS.SI-ID 14709787], [SNIP, WoS do 5. 7. 2016: št. citatov (TC): 0, čistih citatov (CI): 0, Scopus do 29. 1. 2017: št. citatov (TC): 1, čistih citatov (CI): 1]
2. SKUMAVC, Andrej, TUŠEK, Janez, NAGODE, Aleš, KLOBČAR, Damjan. Thermal fatigue study of tungsten alloy WNi28Fe15 clad on AISI H13 hot work tool steel. *Surface & coatings technology*, ISSN 0257-8972. [Print ed.], Jan. 2016, vol. 285, str. 304-311, ilustr., doi: [10.1016/j.surfcoat.2015.09.044](https://doi.org/10.1016/j.surfcoat.2015.09.044). [COBISS.SI-ID 14404123], [JCR, SNIP, WoS do 24. 12. 2017: št. citatov (TC): 4, čistih citatov (CI): 4, Scopus do 12. 11. 2017: št. citatov (TC): 5, čistih citatov (CI): 5]
3. PODRŽAJ, Primož, JERMAN, Boris, KLOBČAR, Damjan. Welding defects at friction stir welding. *Metalurgija*, ISSN 0543-5846, Apr./Jun. 2015, vol. 54, no. 2, str. 387-389, ilustr. [COBISS.SI-ID 13744411], [SNIP, WoS do 24. 12. 2017: št. citatov (TC): 13, čistih citatov (CI): 13, Scopus do 28. 1. 2018: št. citatov (TC): 16, čistih citatov (CI): 16]
4. KLOBČAR, Damjan, TUŠEK, Janez, SMOLEJ, Anton, SIMONČIČ, Samo. Parametric study of FSSW of aluminium alloy 5754 using a pinless tool. *Welding in the world*, ISSN 0043-2288, Mar. 2015, vol. 59, iss. 2, str. 269-281, ilustr., doi: [10.1007/s40194-014-0208-x](https://doi.org/10.1007/s40194-014-0208-x). [COBISS.SI-ID 13806875], [JCR, SNIP, WoS do 28. 1. 2018: št. citatov (TC): 7, čistih citatov (CI): 7, Scopus do 27. 10. 2017: št. citatov (TC): 8, čistih citatov (CI): 8]
5. SMOLEJ, Anton, KLOBČAR, Damjan, SKAZA, Branko, NAGODE, Aleš, SLAČEK, Edvard, DRAGOJEVIČ, Vukašin, SMOLEJ, Samo. Superplasticity of the rolled and friction stir processed Al-4.5 Mg-0.35Sc-0.15Zr alloy. *Materials Science & Engineering. A, Structural materials: Properties, Microstructure and Processing*, ISSN 0921-5093. [Print ed.], Jan. 2014, vol. 590, str. 239-245, ilustr., doi: [10.1016/j.msea.2013.10.027](https://doi.org/10.1016/j.msea.2013.10.027). [COBISS.SI-ID 1315679], [JCR, SNIP, WoS do 28. 1. 2018: št. citatov (TC): 18, čistih citatov (CI): 15, Scopus do 27. 1. 2018: št. citatov (TC): 18, čistih citatov (CI): 15]
6. KLOBČAR, Damjan, KOSEC, Ladislav, KOSEC, Borut, TUŠEK, Janez. Thermo

fatigue cracking of die casting dies. *Engineering failure analysis*, ISSN 1350-6307. [Print ed.], Mar. 2012, vol. 20, no. [1], str. 43-53, doi: [doi:10.1016/j.engfailanal.2011.10.005](https://doi.org/10.1016/j.engfailanal.2011.10.005). [COBISS.SI-ID [12133403](#)], [[JCR](#), [SNIP](#), [WoS](#) do 28. 1. 2018: št. citatov (TC): 35, čistih citatov (CI): 32, [Scopus](#) do 25. 12. 2017: št. citatov (TC): 42, čistih citatov (CI): 39]