UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Toplotna obdelava in inženiring površin kovinskih materialov
Course title:	Heat Treatment and Surface Engineering of Metals

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Nanoznanosti in nanotehnologije, 3. stopnja	/	1	1
Nanosciences and nanotechnologies, 3rd cycle	/	1	1

Vrsta predmeta / Course type Izbirni / Elective

Univerzitetna koda predmeta / University course code: NANO3-531

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje work	Druge oblike študija	Samost. delo Individ. work	ECTS
15	15			15	105	5

**Navedena porazdelitev ur velja, če je vpisanih vsaj 15 študentov. Drugače se obseg izvedbe kontaktnih ur sorazmerno zmanjša in prenese v samostojno delo. / This distribution of hours is valid if at least 15 students are enrolled. Otherwise the contact hours are linearly reduced and transfered to individual work.*

Nosilec predmeta / Lecturer: Prof. dr. Vojteh Leskovšek

Jeziki / Languages:	
Predavanja / Lectures:	Slovenski ali angleški / Slovene or English
Seminar:	Angleški / English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
Zaključen študij druge stopnje naravoslovne ali tehniške smeri ali zaključen študij drugih smeri z dokazanim poznavanjem osnov področja predmeta (pisna dokazila, pogovor).	Completed second cycle studies in natural sciences or engineering or completed second cycle studies in other fields with proven knowledge of fundamentals in the field of this course (certificates, interview).

Vsebina:	**Content (Syllabus outline):**
• **Faze in strukture:** - Perlit, ferit in cementit, avstenit, martenzit in bainit • **Pretvorbe pri segrevanju:** - Premena - Toplotna obdelava na ferit in perlit - Trdota in kaljivost - Avstenit v jeklih • **Popuščanje jekel** • **Posebne toplotne obdelave:** - Nerjavna jekla	• **Phases and Structures:** - Perlite, ferite, cementite and austenite, martesite and bainite • **Transformation on heating:** - Transformation - Heat treatments to produce ferrite and pearlite - Hardness and Hardenability - Austenite in Steels • **Tempering of Steels** • **Special Heat Treatments:** - Stainless Steels

- Orodna in hitrorezna jekla - Jeklene litine • **Toplotna obdelava neželeznih zlitin** Al, Cu, Mg, Ni in Ti • **Postopki modificiranja površin:** - Mehansko modificiranje: - Toplotno modificiranje - Toplotno-kemijsko modificiranje • **Postopki za prekrivanje površin:** - Toplotno prekrivanje - Mehansko prekrivanje - Toplotno-mehansko prekrivanje - Kemično prekrivanje - Elektrokemično prekrivanje - Prekrivanje v parni fazi • **Mejni postopki:** - Ionska implantacija - Anodna oksidacija - Toplotno-kemično difuzijsko prekrivanje	- Tool and HSS Steels - Cast Irons • **Heat Treatment of non ferrous alloys** Al, Cu, Mg, Ni and Ti • **Modification of surfaces:** - Mechanical modification - Surface hardening - Thermo-chemical modification • **Surface deposition processes:** - Heat deposition - Mechanical deposition - Thermo-mechanical deposition - Chemical deposition - Electrochemical deposition - Vapour deposition • **Boundary Processes:** - Ion Implantation - Anodic oxidation - Thermo-chemical diffusion deposition

Temeljni literatura in viri / Readings:

- George E. Totten. Steel Heat Treatment, 2007, http://allaboutmetallurgy.com/wp/wp-content/uploads/2016/11/Steel-HT-Handbook-Full.pdf
- H.K.D.H. Bhaeshia, Steels, Microstructure and Properties, Third edition 2006 Butterworth- Heinemann, Oxford OX2 8DP, UK
- Peter Panjan, Miha Čekada, Zaščita orodij s trdimi PVD-prevlekami, IJS, 2005
- https://www.elsevier.com/books/coatings-tribology/holmberg/978-0-444-52750-9

Cilji in kompetence:	**Objectives and competences:**
Cilj predmeta je usposobiti študenta za znanstveno raziskovalno in razvojno delo na področju tehnologij toplotne obdelave in inženiringa površin kovinskih materialov. Cilj se navezuje na kompetence: modeliranja procesov in proizvodnega management, pridobljeno znanje bo omogočilo uporabo znanstvenih metod za reševanje kompleksnih znanstveno-raziskovalnih nalog, vodenja razvojnih in raziskovalnih programov, kot tudi za razvoj in uporabo novih tehnologij s ciljem revitalizacije in modernizacije proizvodnje. Sposobnost za samostojno in skupinsko raziskovalno in razvojno delo, sposobnost uporabe	The objective of the course is to train a student for R&D in the field of technologies of heat treatment and surface engineering of metallic materials, for selected applications. This objective is related to competences: modelling of processes and production management, gained knowledge will allowed using of scientific methods for solving of complex scientifically-research tasks, guidance of developmental and of research programs, as also for development and use of new technology with goal of revitalization and modernizations of production, ability to carry out independent as well as team R&D work, ability to use the knowledge in

znanja v praksi in delno tudi razvoj integralnega načina mišljenja ter sposobnost za komunikacijo s strokovnjaki drugih disciplin in področij.	practice, and partially also to the development of an integral way of thinking and the ability to communicate with experts from other disciplines and fields.
Predvideni študijski rezultati (izidi):	**Intended learning outcomes:**
• usposobiti študente za razumevanje, načrtovanje in izvedbo postopkov toplotne obdelave, pri katerih kovinske dele namerno izpostavimo temperaturno-časovnem ciklusu, da dosežemo želeno mikrostrukturo in s tem želene mehanske, fizikalne in kemijske lastnosti; • usposobiti študente za razumevanje in načrtovanje ter izvajanje postopkov inženiringa površin, ki temeljijo na novih spoznanjih v okviru fizike trdne snovi in termodinamike procesov, na razvoju senzorjev in na razvoju in uporabi matematičnih modelov in programske opreme za vodenje procesov; • veliko število obstoječih postopkov toplotne obdelave, modificiranja in prekrivanja površin, ki jih koristimo s ciljem povečati odpornost proti obrabi in trajni dinamični trdnosti strojnih elementov in orodij, se vse bolj uveljavlja v industrijski praksi, pojavljajo pa se tudi novih postopki; • vsak od postopkov je specifičen, tako z vidika podobnosti mehanizmov in pogojev obrabe kot tudi z vidika uporabnosti obdelovanih materialov in tehnoloških posebnosti uporabe. Zato je pravilni izbor postopka vedno povezan s celovito analizo vseh vplivnih dejavnikov; • doktorand bo usposobljen za delo: v raziskovalnih laboratorijih za materiale, na inštitutih in centrih za razvoj proizvodov in tehnologije v industriji; • kot predavatelj na fakultetah in srednjih šolah, v proizvodnji, v oddelkih za karakterizacijo materialov v kontroli kakovosti v industriji; • kot podjetnik v ustanavljanju in vodenju podjetja, temelječega na znanju; • aktivno in kritično spremljanje razvoja novih metod uporabe materialov na področju avtomobilizma, energije in ekologije.	• to educate students for understanding and planning and conducting of processes of heat treatment at which metallic parts intentionally emphasize temperature-time cycle, that we achieve desired microstructure and mechanical, physical and chemical characteristics wanted with this; • to educate students for understanding and planning and implementing of processes of surface engineering that based upon on new findings in frame of solid-state physics and of thermodynamics of processes, on development of sensors and on development and uses of mathematical models and software for direction of processes; • namely, extensive number of existent procedures of heat treatment, modifications and coverings of surfaces, which them serve with goal to increase resistance against wear out and fatigue strength of machine elements and of tools, all are asserting oneself more in industrial practice, and new procedures also occur; • each of procedures is specific so from point of view of similarity of mechanisms and of conditions of wear out, as also from point of view of usability of treated materials and of technological specialities of use. That is why correct selection of procedure is connected with complete analysis of all influential factors always; • doctor of this direction is trained for work: in research laboratories for materials, on institutes and centres for development of products and technology in industry, as lecturer on faculties and secondary schools; • in production, in departments for characterization of materials in control of quality in industry, as entrepreneur in establishing and direction of company based on knowledge; • actively and critically monitoring the development of new methods of using materials in the automotive, energy and ecology field.

Metode poučevanja in učenja:	Learning and teaching methods:
Uvodna predstavitev. Seminarsko skupinsko delo. Vključevanje v projekte za razvoj sposobnosti uporabe opreme. Uporaba raziskovalne opreme v reševanju izbranega problema, obdelava izmerjenih signalov, analiza rezultatov, priprava seminarske predstavitve.	Introductory presentation. Seminar team work. Participation in projects for the development of ability to use research equipment. Solving selected problem with research equipment, analysis of measured signals, analysis of results, preparation of the seminar presentation.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	Assessment:
Seminarska naloga. Zagovor seminarske naloge, pri katerem dokaže osvojitev vseh študijskih izidov z vsaj po enim konkretnim primerom.	50 % 50 %	Seminar work. Defense of the seminar work where the student demonstrates the achievement of all learning outcomes with at least one specific case for each outcome.

Reference nosilca / Lecturer's references:

1. PODGORNIK, Bojan, PUŠ, Gašper, ŽUŽEK, Borut, LESKOVŠEK, Vojteh, GODEC, Matjaž. Heat treatment optimization and properties correlation for H11-type hot-work tool steel. *Metallurgical and materials transactions. A, Physical metallurgy and materials science*, ISSN 1073-5623, Feb. 2018, vol. 49, iss. 2, str. 455-462, ilustr. https://link.springer.com/article/10.1007%2Fs11661-017-4430-1, doi: 10.1007/s11661-017-4430-1. [COBISS.SI-ID 1378730]
2. PODGORNIK, Bojan, LESKOVŠEK, Vojteh. Eficácia do tratamento criogênico profundo no aprimoramento de propriedades de aços ferramenta. *Industrial heating*, ISSN 2178-0110, Dez. 2017, no. 37, str. 54-62, ilustr. http://www.sunniva.com.br/arquivos/ih/2017.12-%20baixa.pdf. [COBISS.SI-ID 1374634]
3. PODGORNIK, Bojan, LESKOVŠEK, Vojteh. Overview : special issue on heat treatment and surface engineering. *Materials performance and characterization*, ISSN 2379-1365, 2017, vol. 6, iss. 5, [2-3] str. https://www.astm.org/DIGITAL_LIBRARY/JOURNALS/MPC/TOC/652017.htm. [COBISS.SI-ID 1369258]
4. LESKOVŠEK, Vojteh, PODGORNIK, Bojan. Tool Steels : Fracture Toughness. V: COLAS, Rafael (ur.), TOTTEN, George E. (ur.). *Encyclopedia of iron, steel, and their alloys*, (Metals and Alloys Encyclopedia Collection). Boca Raton: CRC Press: Taylor & Francis group, 2016, str. 3687-3719, ilustr., doi: 10.108/E-EISA-120049739. [COBISS.SI-ID 1212842]
5. LESKOVŠEK, Vojteh, GODEC, Matjaž, KOGEJ, Peter. Strengthening via the formation of strain-induced martensite and the effects of laser marking on the microstructure of austenitic stainless steel. *Metallurgical and materials transactions. A, Physical metallurgy and materials science*, ISSN 1073-5623, June 2014, vol. 45, iss. 6, str. 2819-2826, ilustr., doi: 10.1007/s11661-014-2213-5. [COBISS.SI-ID 13377307], [JCR, SNIP]