

## UČNI NAČRT PREDMETA/COURSE SYLLABUS

<b>Predmet:</b>	TOPLOTNA OBDELAVA IN OPLEMENITENJE POVRŠIN
<b>Course title:</b>	HEAT TREATMENT AND SURFACE TREATMENT OF MATERIALS

<b>Študijski programi in stopnja</b>	<b>Študijska smer</b>	<b>Letnik</b>	<b>Semestri</b>
Strojništvo, tretja stopnja, doktorski	Proizvodno inženirske znanosti, kibernetika in mehatronika (smer)		Celoletni

Univerzitetna koda predmeta/University course code:

Predavanja	Seminar	Vaje	Klinične vaje	Druge oblike študija	Samostojno delo	ECTS
90					160	10

Nosilec predmeta/Lecturer:

Izvajalci predavanj:	Roman Šturm
Izvajalci seminarjev:	
Izvajalci vaj:	
Izvajalci kliničnih vaj:	
Izvajalci drugih oblik:	
Izvajalci praktičnega usposabljanja:	

Vrsta predmeta/Course type:

<b>Jeziki/Languages:</b>	Predavanja/Lectures:	Slovenščina, Angleščina
	Vaje/Tutorial:	Slovenščina, Angleščina

<b>Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:</b>	<b>Prerequisites:</b>
Veljajo splošni pogoji za doktorski študij.	General prerequisites for the third level studies.

### Vsebina:

Fizikalne, kemične in metalurške osnove toplotnih, kemo - termičnih in različnih postopkov oplemenitenja površin. Difuzija, difuzijski zakoni, difuzijski mehanizmi in aktivacijska energija, Kirkendallov efekt, vplivi na difuzivnost. Strjevanje kovin, termodinamika in kinetika kristalizacije kovin, tvorba kali, kritična velikost kali in narava strjevanja. Standardni postopki toplotne obdelave, zaostale notranje napetosti, deformacije izdelkov med in po toplotni obdelavi, atmosfere v peči, kontrolirane zaščitne in aktivne atmosfere, nadzorovanje atmosfer v pečeh, teoretične osnove gašenja kovin, koodeliranje toplotnih razmer pri segrevanju in gašenju, modelni preizkusi. Novejši postopki toplotne obdelave s toplotno, električno, žarkovno in kombinirano energijo. Vplivni parametri pri posameznih procesih. Oplemenitenje površin: nitriranje v plazmi,

### Content (Syllabus outline):

Basic physical, chemical and metallurgical concepts of heat treatments and thermo-chemical treatments of surface treatments. Diffusion, diffusion laws, diffusion mechanisms, activation energy, Kirkendall effect, influences on diffusivity. Solidification of metals, thermodynamics and kinetics of crystallization, forming of nucleus, critical nucleus size, nature of solidification. Standard processes of heat treatment, residual stresses, deformation of a sample during and after the heat treatment, atmosphere in a furnace, controlled protection atmosphere and active atmosphere, control of atmosphere in a furnace, theoretical basics of metal quenching, modeling of heat conditions during heating and quenching, model testing. New processes for heat treatment using different forms of energy: heat, electrics, laser beam and combined forms.

<p>karbonitriranje v plazmi, ionska implantacija, kemijsko nanašanje zaščitnih prevlek iz parne faze (CVD), reaktivno ionsko prekrivanje (PVD prevleke), nitridne, karbonitridne in diamantne prevleke, Toyota postopek nanašanja difuzijskih prevlek, modifikacija površin z laserskim in elektronskim snopom.</p> <p>Toplotna obdelava v vakuumu in toplotna obdelava v fluidiziranem sloju, vakuumske naprave, sredstva in načini gašenja.</p> <p>Termo - mehanska obdelava železnih in neželeznih zlitin z ali brez polimorfni transformacij, načrtovanje in optimiranje termomehanske obdelave. Teorija plastične deformacije kovin, relaksacije in rekristalizacije v toplem stanju.</p>	<p>Influencing parameters at individual processes.</p> <p>Surface treatment: plasma nitriding, plasma carbonitriding, ion implantation, chemical vapor deposition (CVD), physical vapor deposition (PVD), diamond coatings, Toyota procedure of diffusion coating deposition, surface modification using laser and electronic beam. Vacuum heat treatment, heat treatment in fluidized bed, vacuum furnaces, quenching media and procedures.</p> <p>Thermo-mechanical treatment of ferrous and non-ferrous alloys with and without polymorphic transformations, planning and optimization of thermo-mechanical treatment.</p> <p>Theory of plastic deformation of metals, theory of relaxation and relaxation at elevated temperatures.</p>
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#### Temeljna literatura in viri/Readings:

<p>[1] Steel Heat Treatment Handbook, 2nd edition, Eds.: George E. Totten, M.A.H. Maurice; Marcel Dekker Inc, New York, 1997.</p> <p>[2] Chryssolouris, G.: Laser machining: theory and practice.- New York; Berlin: Springer-Verlag, 1991.- (Mechanical engineering series).</p> <p>[3] Steen, W.M.: Laser material processing.- London; Berlin: Springer-Verlag, 1991.</p> <p>[4] Advanced surface coatings: a handbook of surface engineering / ed. by D.S. Rickerby and A. Matthews.- Glasgow; London: Blackie &amp; Son; New York: Chapman and Hall, 1991.</p> <p>[5] Selected journals: Materials science and engineering.- Heat treatment of metals.- Surface science.- Materials science forum surface engineering.- HTM: Härterei-Technische Mitteilungen.- Metal heat treating.</p>
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#### Cilji in kompetence:

<p><b>Cilji:</b> Študentu podati pregled in znanje s področja fizikalnih procesov, ki potekajo v času različnih postopkov toplotne obdelave.</p> <p><b>Kompetence:</b> Študent osvoji osnovno znanje načrtovanja in izvajanja postopkov toplotne obdelave. Prav tako ve, katere lastnosti materialov lahko pričakuje pred in po taki obdelavi. Študent zna sam poiskati in uporabiti podatke iz ustrezne strokovne literature.</p>	<p><b>Objectives and competences:</b></p> <p><b>Goals:</b> The principal goal is to give a student overview and knowledge of physical processes taking place during various heat treatments.</p> <p><b>Competences:</b> The student acquires basic competence in planning and execution of heat treatment procedures. He also masters the material properties before and after such a treatment. Student is capable to find and use relevant data from specific specialized literature.</p>
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#### Predvideni študijski rezultati:

<p>Študent osvoji osnovno znanje načrtovanja in izvajanja postopkov toplotne obdelave. Prav tako ve, katere lastnosti materialov lahko pričakuje pred in po taki obdelavi. Študent zna sam poiskati in uporabiti podatke iz ustrezne strokovne literature.</p>	<p><b>Intended learning outcomes:</b> The student acquires basic competence in planning and execution of heat treatment procedures. He also masters the material properties before and after such a treatment. Student is capable to find and use relevant data from specific specialized literature.</p>
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#### 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><b>Learning and teaching methods:</b> Lectures, laboratory practice &amp; 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>
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#### Načini ocenjevanja:

<p>Ustni izpit, poročilo o seminarskem delu. Pogoj za opravljanje ustnega izpita je uspešno izdelano in</p>	<p><b>Delež/Weight</b></p>	<p><b>Assessment:</b> Oral exam, report on seminar work. The condition for admission to oral exam is successful</p>
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pozitivno ocenjeno seminarsko delo. Način (pisni izpit, ustno izpraševanje, naloge, projekt): • projektni seminar (20%) • ustno izpraševanje (80%)		completion of seminar work, rewarded with a passing grade. Method (written exam, oral examination, assignments, project): • project seminar (20%) • oral examination (80%)
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**Reference nosilca/Lecturer's references:**

**prof. dr. Roman ŠTURM**

ŠTURM, Roman, ŠTEFÁNIKOVÁ, Mária, STEINER PETROVIČ, Darja. Influence of pre-heating on the surface modification of powder-metallurgy processed cold-work tool steel during laser surface melting. *Applied Surface Science*, ISSN 0169-4332. [Print ed.], Jan. 2015, vol. 325, str. 203-210, ilustr., doi: [10.1016/j.apsusc.2014.11.050](https://doi.org/10.1016/j.apsusc.2014.11.050).

SUŠNIK, Janez, GRUM, Janez, ŠTURM, Roman. Effect of pulse laser energy density on TiC cladding of aluminium substrate. *Tehnički vjesnik*, ISSN 1330-3651, 2015, vol. 22, nr. 6, str. 1553-1560, ilustr., doi: [10.17559/TV-20150221215735](https://doi.org/10.17559/TV-20150221215735).

STEINER PETROVIČ, Darja, ŠTURM, Roman. Fine-structured morphology of a silicon steel sheet after laser surface alloying of Sb powder. *Strojniški vestnik*, ISSN 0039-2480, Jan. 2014, vol. 60, no. 1, str. 5-11, Sl 5, ilustr., doi: [10.5545/sv-jme.2013.1347](https://doi.org/10.5545/sv-jme.2013.1347).

ŠTURM, Roman, ŽNIDARŠIČ, Matjaž, GRUM, Janez. Crack-growth behavior of laser surface-alloyed low-carbon steel. *Journal of materials engineering and performance*, ISSN 1059-9495, Sep. 2013, vol. 22, iss. 9, str. 2542-2549, ilustr., doi: [10.1007/s11665-013-0549-4](https://doi.org/10.1007/s11665-013-0549-4)],

ŠTURM, Roman, GRUM, Janez, BOŽIČ, Slavko. Influence of the alloying elements in Al-Si alloys on the laser remelting process. *Lasers in engineering*, ISSN 0898-1507, 2012, vol. 22, no. 1/2, str. 47-61.