VEČFAZNI TOK

UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	VEČFAZNI TOK
Course title:	MULTIPHASE FLOW
Članica nosilka/UL Member:	UL FS

Študijski programi in stopnja	**Študijska smer**	**Letnik**	**Semestri**	**Izbirnost**
Strojništvo, tretja stopnja, doktorski	Energetske, procesne in okoljske inženirske znanosti (smer)		Celoletni	izbirni

Univerzitetna koda predmeta/University course code:	0033455
Koda učne enote na članici/UL Member course code:	7210

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:	Božidar Šarler

Izvajalci predavanj:	Andrej Bombač, Matjaž Perpar, Božidar Šarler
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):**
Kompleksni sistem: vsiljena, projektirana ali ustvarjena hierarhija, spremenljive strukture dvofaznega sistema; cilj: pridobiti znanje o ločevanju skal in definiranju ciljne funkcije v več-funkcionalnih sistemih z večimi skalami.	General complex system: imposed, engineered or created hierarchy, variable structure two-phase system; aim: to learn how to choose scale separation and how to define objective function in multi-scale multi-functional systems.
Pojavne lastnosti dvofaznega toka: makro skala, vmesna skala, mikroskala; cilj: pridobiti znanje o naravi lastnosti sistema, ki se stopnjujejo v odvisnosti od referenčne skale, pridobiti znanje o vlogi tokovnih vzorcev, tokovnih režimov in strukturni funkciji in pridobiti znanje o možnih eksperimentalnih tehnikah v dvofaznem toku.	Two phase flow emergent properties: Macro scale, mesoscale, microscale; aim: to learn about the nature of system properties that escalate depending upon the reference scale, to learn about the role of flow patterns, flow regimes and structural function, also to learn about possible experimental techniques in two-phase flow.
Konstrukcijski parametri dvifaznih tokov: primarni konstrukcijski parametri, sekundarni konstrukcijski parametri; cilj: pridobiti znanje o ločevanju med sistemskimi in procesnimi parametri.	Two-phase flow design parameters: primary design parameters, secondary design parameters; aim: to learn how to distinguish between system and process parameters.
Modeliranje: ohranitven principi, topološki zakoni, konstitucijski zakoni, zakoni prehoda, teoretične in praktične omejitve. 1D modeliranje, 3D modeliranje; cilj: pridobiti znanje o uporabi povprečenja po kanalu in o lokalni in trenutni formulaciji dvofaznega toka.	Modeling: conservation principles, topological laws, constitutive laws, transfer laws, theoretical and practical constraints. 1D modeling, 3D modeling; aim: to learn how to model two-phase flow using channel averaging or to model two-phase flow using local instant formulation.
Praktične aplikacije: študentje (-ke) so spodbujani predložiti svoje lastne aplikacije, ki lahko zajamejo vse možne kombinacije tokov trdno-plin-kapljevina	Practical applications: students are encouraged to submit their own applications of interest that may cover all possible solid-gas–liquid flow

in so relevantne v velikih ali mikro-sistemih; cilj: podpora samostojnemu in neodvisnemu študiju večfaznih sistemov in pridobiti znanje o planiranju, implementaciji in predstavitvi raziskovalnega dela.	combinations relevant to large- or micro-scale devices; aim: to promote independent studies of multiphase systems and to learn how to design, implement and present research work.

Temeljna literatura in viri/Readings:

[1] C. E. Brennen: Fundamentals of Multiphase Flow, Cambridge University Press, 2005– Selected chapters.

[2] S. Levy: Two-phase Flow in Complex Systems, John Wiley & Sons, 1999– Selected chapters.

[3] A. Faghri, Z. Zhang: Transport Phenomena in Multiphase Systems, Academic Press, 2006 – Selected chapters

[4] M. Ishii, T. Hibiki: Thermo-fluid Dynamics of Two-phase Flow, Springer 2006– Selected chapters.

[5] G. Hetsroni, Handbook of Multiphase Systems, Hemisphere, 1982– Selected chapters.

Cilji in kompetence:	**Objectives and competences:**
Cilji: Namen predmeta je prikazati osnovne tehnike analize dvofaznih tokov in pokazati njihove aplikacije na široko vrsto praktičnih problemov v večfaznih sistemih. Vsebina je izjemno pomembna v široki paleti tradicionalnih inženirskih disciplin, od obstoječih, do novih multi-disciplinarnih tehnologij v procesni in kemijski industriji, energetiki, okoljski znanosti, mikroelektroniki, biotehnologiji, nanotehnologiji, znanosti o polimerih, procesiranju hrane, kriogeniki in v številnih drugih industrijskih panogah. Zaradi prevladujoče negotovosti, ki trenutno prevladujejo pri poznavanju fizikalnih potankosti, posebno v povezavi s stikom plin-kapljevina, je poudarjen pomen ohranjanja časovno odvisnih lastnosti v integralnih napravah. Pričakovati je, da bo predmet vzpodbudil študente v raziskovanje pomembnih primerjalnih postopkov še pred izgradnjo in pogonom testnih naprav. Študent bi moral biti sposoben izbrati	**Goals:** The purpose of this course is to make a thorough presentation of the basic techniques for analyzing two-phase flows and to show how they can be applied to a wide variety of practical problems in multiphase systems. The subject has immense importance in a large variety of traditional engineering disciplines, from the established to emerging multidisciplinary technologies in process, chemical, power, nuclear industry, environmental science, microelectronics, biotechnology , nano-technology, polymer science, food processing, cryogenics, and in many other industries. Due to presently prevailing uncertainties about two-phase-flow physical details, particularly at the gas-liquid interfaces, the value of preserving fluid properties and the time scale in integral experimental facilities is stressed out. It is hoped that mastering the course will encourage students in future examination of important scaling issues

relevantni model za obravnavani fizikalni problem in prav tako biti sposoben verificirati dobljene rezultate. **Kompetence:** Pridobljeno razumevanje osnovnih principov v znanosti o večfaznih sistemih in tehnologijah. Študent (-ka) bi moral biti sposoben učinkovito uporabiti to znanje in pridobiti kritičen odnos do eksperimentalnih ali računskih rezultatov.	before test facilities for complex systems are built and operated. They should be capable to select the relevant model for the considered physical problem and also to verify the obtained results. **Competences:** A student acquires understanding of the basic principles of multiphase science and technology. Therefore she/he should be capable to efficiently use such knowledge as well as critical assessment of the experimental or calculated results.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Pridobljeno razumevanje osnovnih principov v znanosti o večfaznih sistemih in tehnologijah. Študent (-ka) bi moral biti sposoben učinkovito uporabiti to znanje in pridobiti kritičen odnos do eksperimentalnih ali računskih rezultatov.	A student acquires understanding of the basic principles of multiphase science and technology. Therefore she/he should be capable to efficiently use such knowledge as well as critical assessment of the experimental or calculated results.

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. Način (ustno izpraševanje, projekt): • projekt (seminarska naloga) (70%) • ustno izpraševanje (30%)		Oral exam, report on seminar work. The condition for admission to oral exam is successful completion of seminar work, rewarded with a passing grade. Method (oral examination, project): • project (seminar assignment) (70%) • oral examination (30%).

Reference nosilca/Lecturer's references:

prof. dr. Božidar ŠARLER

OBERTHUER, Dominik, ŠARLER, Božidar, BELŠAK, Grega, MAČEK, Marjan. Double-flow focused liquid injector for efficient serial femtosecond crystallography. Scientific reports, ISSN 2045-2322, 2017, vol. 7, str. 1-7, ilustr. http://www.nature.com/articles/srep29734.

KOSEC, Gregor, ŠARLER, Božidar. Local RBF collocation method for Darcy flow. Computer modeling in engineering & sciences, ISSN 1526-1492. Tiskana izd., 2008, vol. 25, no. 3, str. 197-208.

PERNE, Matija, ŠARLER, Božidar, GABROVŠEK, Franci. Calculating transport of water from a conduit to the porous matrix by boundary distributed source method. Engineering analysis with boundary elements, ISSN 0955-7997. [Print ed.], 2012, vol. 36, no. 11, str. 1649-1659, doi: 10.1016/j.enganabound.2012.06.001.

ŠARLER, Božidar. Solution of a two-dimensional bubble shape in potential flow by the method of fundamental solutions. Engineering analysis with boundary elements, ISSN 0955-7997. [Print ed.], 2006, vol. 30, no. 3, str. 227-235.

KOSEC, Gregor, ŠARLER, Božidar. Simulation of macrosegregation with mesosegregates in binary metallic casts by a meshless method. Engineering analysis with boundary elements, ISSN 0955-7997. [Print ed.], 2014, vol. 45, str. 36-44, doi: 10.1016/j.enganabound.2014.01.016.

KOSEC, Gregor, ZALOŽNIK, Miha, ŠARLER, Božidar, COMBEAU, Hervé. A meshless approach towards solution of macrosegregation phenomena. Computers, materials & continua, ISSN 1546-2218, 2011, vol. 22, no. 2, str. 169-195.

VERTNIK, Robert, ZALOŽNIK, Miha, ŠARLER, Božidar. Solution of transient direct-chill aluminium billet casting problem with simultaneous material and interphase moving boundaries by a meshless method. Engineering analysis with boundary elements, ISSN 0955-7997. [Print ed.], 2006, vol. 30, no. 10, str. 847-855.

ŠARLER, Božidar, GOBIN, Dominique, GOYEAU, Benoît, PERKO, Janez, POWER, Henry. Natural convection in porous media - dual reciprocity boundary element method solution of the Darcy model. International journal for numerical methods in fluids, ISSN 0271-2091, 2000, vol. 33, issue 2, str. 279-312.