

ENERGIJSKI IN SNOVNI TOKOVI V INDUSTRIJI

UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	Energijski in snovni tokovi v industriji
Course title:	ENERGY AND MATERIAL FLOWS IN INDUSTRY
Članica nosilka/UL Member:	UL FS

Študijski programi in stopnja	Študijska smer	Letnik	Semestri	Izbirnost
Strojništvo - projektno aplikativni program, prva stopnja, visokošolski strokovni	Industrijsko inženirstvo (smer)	2. letnik	2. semester	obvezni

Univerzitetna koda predmeta/University course code:	0563547
Koda učne enote na članici/UL Member course code:	3064-V

Predavanja /Lectures	Seminar /Seminar	Vaje /Tutorials	Klinične vaje /Clinical tutorials	Druge oblike študija /Other forms of study	Samostojno delo /Individual student work	ECTS
30		30			40	4

Nosilec predmeta/Lecturer:	Iztok Golobič, Lidija Rihar, Tomaž Berlec
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Izvajalci predavanj:	
Izvajalci seminarjev:	
Izvajalci vaj:	
Izvajalci kliničnih vaj:	
Izvajalci drugih oblik:	
Izvajalci praktičnega usposabljanja:	

Vrsta predmeta/Course type:

Izbirni strokovni predmet /Elective specialised course

Jeziki/Languages:

Predavanja/Lectures:

Slovenščina

Vaje/Tutorial:

Slovenščina

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:**Prerequisites:**

Izpolnjevanje pogojev za vpis v Visokošolski strokovni študijski program I. stopnje Strojništvo - Projektno aplikativni program.

Meeting the enrollment conditions for the MECHANICAL ENGINEERING - Project Oriented Applied Programme.

Vsebina:**Content (Syllabus outline):**

1. Kontinuirani procesi in procesni tokovi:
 - Snov in snovne spremembe, primeri iz kemične, farmacevtske, prehranske, metalurške, papirne in tekstilne industrije;
 - Saržni in kontinuirani procesi.
2. Splošna tokovna shema procesa v procesni industriji:
 - Proces: kemične in biokemične reakcije, fizikalni procesi, raba energije, regeneracija in recikliranje, krožno gospodarstvo;
 - Splošna tokovna procesna shema.
3. Snovni in energijski tokovi v proizvodnem sistemu:
 - Snovni tokovi, vpliv mehanike fluidov in prenosa snovi v industrijskem sistemu;
 - Energijski tokovi, vpliv prenosa toplote v industrijskem sistemu.
4. Učinkovitost energijskih in snovnih tokov:
 - Energijska in eksergijska analiza;
 - Stroškovna analiza kontinuiranih tokov.
5. Načrtovanje in validacija kontinuiranih snovnih procesov:
 - Kvalifikacija načrtovanja, kvalifikacija montaže, kvalifikacija delovanja;
 - Kvalifikacije po zagonu, revalidacija.
6. Vodenje kontinuiranih procesnih sistemov:

1. Continuous processes and process flows:
 - Materials and material transformations, examples from chemical, pharmaceutical, food, metallurgical, paper and textile industry;
 - Batch and continuous processes.
2. General flowchart of a process in process industry:
 - Processes: chemical and biochemical reactions, physical processes, energy use, regeneration and recycling, circular economy;
 - General flowchart of a process.
3. Material and energy flows in a manufacturing system:
 - Material flows, influence of fluid mechanics and mass transfer in an industrial system;
 - Energy flows, influence of heat transfer in an industrial system.
4. Efficiency of energy and material flows:
 - Energy and exergy analysis;
 - Cost analysis of continuous flows.
5. Planning and validation of continuous processes:
 - Design qualification, installation qualification, operational qualification;
 - Qualification after start-up, revalidation.
6. Managing continuous process systems:

<ul style="list-style-type: none"> - Nadzorni sistemi, procesni parametri; - Vodenje in varnost pri obratovanju. <p>7. Ravnanje z odpadki, trdninskimi, kapljeviti in plinstimi emisijami:</p> <ul style="list-style-type: none"> - Ravnanje z odpadki; - Trdninske, kapljevite in pliniste emisije kontinuiranih procesov v industriji. <p>8. Definicija in osnovne značilnosti procesne (tekoče, kontinuirane) proizvodnje:</p> <ul style="list-style-type: none"> - Razlike med procesno in kosovno (serijsko proizvodnjo); - Izbor najprimernejše organizacijske strukture; - Primeri iz industrijskega okolja. <p>9. Določitev glavnega procesa in podprocesov:</p> <ul style="list-style-type: none"> - Določitev takta glavnega procesa glede na zahteve trga; - Dimenzioniranje kapacitet; - Določitev potrebnih površin glavnega in pomožnih procesov. <p>10. Izvedba tekoče proizvodnje:</p> <ul style="list-style-type: none"> - Prednosti in slabosti tekoče proizvodnje glede zalog in vezave kapitala; - Oskrba z materialom pri tekoči proizvodnji (just in sequence). <p>11. Projektiranje proizvodnega procesa pri tekoči proizvodnji:</p> <ul style="list-style-type: none"> - Izračun serijskosti; - Merjenje podobnosti izdelkov (gručenje); - Izračun koeficienta podobnosti izdelkov; - Metode za uravnoteženje toka pri eno in več predmetnih tokovih. <p>12. Izračun kazalnikov procesne proizvodnje:</p> <ul style="list-style-type: none"> - Ekonomske učinkovitosti procesne proizvodnje; - Toka vrednosti; - Dodane vrednosti. <p>13. Planiranje naročil pri tekoči proizvodnji:</p> <ul style="list-style-type: none"> - Agregatno planiranje; - Operativni plani; - Dnevni plani proizvodnje. <p>14. Metode za hitro prilagajanja tekoče proizvodnje spremembam</p>	<ul style="list-style-type: none"> - Control systems, process parameters; - Operation management and safety. <p>7. Handling of waste and solid, liquid and gaseous emissions:</p> <ul style="list-style-type: none"> - Waste handling; - Solid, liquid and gaseous emissions of continuous processes in the industry. <p>8. Definition and basic characteristics of process (continuous) production:</p> <ul style="list-style-type: none"> - Differences between continuous and individual (batch production); - Selection of the most appropriate organizational structure; - Industrial examples. <p>9. Determination of the main process and sub-processes:</p> <ul style="list-style-type: none"> - Setting the main process takt according to market requirements; - Capacity dimensioning; - Determination of required areas for main and auxiliary processes. <p>10. Execution of continuous production:</p> <ul style="list-style-type: none"> - Advantages and disadvantages of continuous production in terms of inventory and bonding of capital; - Supply of material in continuous production (just in sequence). <p>11. Designing the production process for continuous production:</p> <ul style="list-style-type: none"> - Calculation of seriality (batch); - Measurement of product similarity (clustering); - Calculation of product similarity coefficient; - Methods for balancing flow for one- or more-object flows. <p>12. Calculation of production process indicators:</p> <ul style="list-style-type: none"> - Economic efficiency of production process; - Value stream; - Added value. <p>13. Planning of orders in continuous production:</p> <ul style="list-style-type: none"> - Aggregate planning; - Operational plans; - Daily production plans. <p>14. Methods for rapidly adapting the continuous production to changes of orders:</p>
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naročil: - Minimizacija časov prehoda na variantni izdelek; - Minimizacija časov zaustavitve zaradi čiščenja in vzdrževanja. 15. Študentska predstavitev seminarskega dela: - Timsko projektno delo; - 3 minutna predstavitev in diskusija.	- Minimizing the transition time to a variant product; - Minimize shut down time for cleaning and maintenance. 15. Student presentation of seminar work: - Team project work; - 3-minute presentation and discussion.
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Temeljna literatura in viri/Readings:

1. Slack N., Brandon-Jones A.: Operations and process management, 5th ed., Pearson, London, 2018.
2. Nash M.A., Poling S.R.: Mapping the total value stream, CRC Press, 2008.
3. Geankoplis, C. J., Hersel, A. A., Lepek, F. H., Transport Processes and Separation Process Principles. 5th Edition, Prentice Hall, 2018.
4. Reay, D., Ramshaw, C., Harvey, A., Process Intensification: Engineering for Efficiency, Sustainability and Flexibility. 2nd Edition, 2013.
5. Geankoplis, C. J., Hersel, A. A., Lepek, F. H., Transport Processes and Separation Process Principles. 5th Edition, Prentice Hall, 2018.
6. Towler, G., Sinnott, R., Chemical Engineering Design: Principles, Practice and Economics of Plant and Process Design 2nd Edition, Butterworth-Heinemann, 2012.
7. Agalloco, J. P., Carleton, F. J., Validation of Pharmaceutical Processes 3rd Edition, CRC Press, 2007.
8. Bunn, G. P., Good Manufacturing Practices for Pharmaceuticals. 7th Edition, CRC Press; 2019.
9. Oechslein, C., GMP Fundamentals - A Step-by-Step Guide for Good Manufacturing Practice. 2nd Edition, Maas & Peither AG GMP Publishing, 2018.
10. Center for Chemical Process Safety, Guidelines for Auditing Process Safety Management Systems. 2nd Edition, Wiley-AIChE, 2011.
11. VDI Gesellschaft, VDI Heat Atlas. 2nd Edition, Springer, 2010.
12. Green D.W., Southard, M. Z., Perry's Chemical Engineers' Handbook, 9th Edition, McGraw-Hill Education; 2018.

Cilji in kompetence:

- Cilji:
1. Spoznati moderne koncepte procesne proizvodnje.
 2. Spoznati problematiko energijskih in snovnih tokov v industrijskem okolju.
 3. Spoznati problematiko kontinuirane proizvodnje v zahtevnih procesnih okoljih, kot sta farmacija in prehrabena industrija.
 4. Spoznati namen in načine procesne proizvodnje.
 5. Spoznati problematiko in cilje vodenja procesne proizvodnje.

Objectives and competences:

- Objectives:
1. To learn about modern concepts of process production.
 2. To learn about energy and material flows in an industrial environment.
 3. To learn about continuous production in demanding process environments such as pharmaceutical and food industry.
 4. To learn about the purpose and methods of process production.
 5. To understand the problems and goals of process production

<p>Kompetence:</p> <ol style="list-style-type: none"> 1. Sposobnost uporabe pridobljenega znana pri reševanju problemov vodenja procesne proizvodnje v praksi. (S1-PAP, P1-PAP) 2. Sposobnost razčlenitve lažjih strokovnih nalog pri vodenju procesne proizvodnje na podnaloge ob razumevanju osnovnega koncepta procesa kontinuiranih energijskih in snovnih tokov. (S4-PAP, P3-PAP) 3. Usposobljenost za vodenje tehnološke enote ali projekta vodenja procesne proizvodnje ob upoštevanju osnovnih okoljskih omejitev. (S7-PAP, P5-PAP) 	<p>management.</p> <p>Competences:</p> <ol style="list-style-type: none"> 1. The ability to use the attained knowledge solving the problems of managing process production in the practice. Understanding the laws of physics and the phenomena behind the operating principles of products and technologies. (S1-PAP, P1-PAP) 2. The ability to break down easy professional tasks in managing process production into subtasks. Mastering the fundamental specialised knowledge in managing process production and the fundamental complementary sciences. (S4-PAP, P3-PAP) 3. The ability to manage a technological unit or process production management project. Knowing the main environmental restrictions and problems. (S7-PAP, P5-PAP)
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Predvideni študijski rezultati:

<p>Znanja:</p> <p>Z1: Poglobljeno strokovno teoretično in praktično znanje na področju vodenja procesne proizvodnje, podprto s širšo teoretično in metodološko osnovo.</p> <p>Spretnosti:</p> <p>S1.1 Izvajanje kompleksnih operativno-strokovnih opravil na področju vodenja procesne proizvodnje, ki vključujejo tudi uporabo metodoloških orodij.</p> <p>S1.2 Obvladovanje zahtevnih, kompleksnih delovnih procesov pri vodenju procesne proizvodnje ob samostojni uporabi znanja v novih situacijah.</p> <p>S1.3 Diagnosticiranje in reševanje problemov vodenja procesne proizvodnje v različnih specifičnih delovnih okoljih, povezanih s področjem izobraževanja in usposabljanja.</p> <p>S1.4 Osnova za izvirna dognanja/stvaritve in kritično refleksijo.</p>
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Intended learning outcomes:

<p>Knowledge:</p> <p>Z1: In-depth professional theoretical and practical knowledge in the field of process production management, supported by a broader theoretical and methodological basis.</p> <p>Skills:</p> <p>S1.1 Execution of complex operational and professional tasks in the field of production process management, including the use of methodological tools.</p> <p>S1.2 Mastering difficult, complex work processes in production process management while independently using the knowledge in new situations.</p> <p>S1.3 Diagnosing and problem solving of process production management in various specific work environments related to the field of education and training.</p> <p>S1.4 Basis for original findings /</p>

	creations and critical reflection.
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Metode poučevanja in učenja:	Learning and teaching methods:
<p>P1 Avditorna predavanja podprta s interaktivnim prikazom praktičnih primerov.</p> <p>P2 Avditorne vaje z reševanjem praktičnih primerov.</p> <p>P3 Laboratorijske vaje s timskim reševanjem aplikativnih problemov in uporabo programske opreme ter njihova predstavitev z razpravo.</p>	<p>P1 Lectures supported by interactive presentation of practical examples.</p> <p>P2 Tutorials solving practical examples.</p> <p>P3 Laboratory exercises with team solving application problems, using software and presenting them with discussion..</p>

Načini ocenjevanja:	Delež/ Weight	Assessment:
- Teoretične vsebine (predavanja):	50,00 %	- Theoretical contents (lectures):
- Samostojno delo na vajah:	20,00 %	- Independent work in exercises:
- Delo na laboratorijskih vajah (vključno s poročili):	20,00 %	- Laboratory work (including reports):
- Seminar:	10,00 %	- Seminar:

Reference nosilca/Lecturer's references:

<p>Iztok Golobič:</p> <ol style="list-style-type: none"> 1. LAMPRET, Marko, BUKOVEC, Venčeslav, PATERNOST, Andrej, KRIŽMAN, Srečko, LOJK, Vito, GOLOBIČ, Iztok. Industrial energy-flow management. <i>Applied energy</i>. 2007, letn. 84, str. 781-794.. [COBISS.SI-ID 9989147]. 2. VOGLAR, Jure, ZUPANČIČ, Matevž, PEPERKO, Aljoša, BIRBARAH, Patrick, MILJKOVIC, Nenad, GOLOBIČ, Iztok. Analysis of heater-wall temperature distributions during the saturated pool boiling of water. <i>Experimental thermal and fluid science</i>. 2019, vol. 102, str. 205-214, [COBISS.SI-ID 16368923]. 3. VOGLAR, Jure, GREGORČIČ, Peter, ZUPANČIČ, Matevž, GOLOBIČ, Iztok. Boiling performance on surfaces with capillary-length-spaced one- and two-dimensional laser-textured patterns. <i>International journal of heat and mass transfer</i>. 2018, vol. 127, part a, str. 1188-1196, [COBISS.SI-ID 16149019]. 4. SITAR, Anže, SEDMAK, Ivan, GOLOBIČ, Iztok. Boiling of water and FC-72 in microchannels enhanced with novel features. <i>International journal of heat and mass transfer</i>. 2012, vol. 55, str. 6446-6457, [COBISS.SI-ID 12409883]. 5. CIMERMAN, Franc, ZUPANČIČ, Matevž, GOLOBIČ, Iztok. Faktor stisljivosti zemeljskega plina = Compressibility factor of natural gas. <i>Svet strojništva</i>. 2016, letn. 5, št. 6, str. 12-17. [COBISS.SI-ID 15443227]. <p>Tomaž Berlec:</p> <ol style="list-style-type: none"> 1. JORDAN, Eva, KUŠAR, Janez, RIHAR, Lidija, BERLEC, Tomaž. Portfolio analysis of a lean six sigma production process. <i>Central European journal of operations research</i>. 2019, vol. 27, iss. 3, str. 797-813, ilustr. ISSN 1435-246X.

- <https://link.springer.com/article/10.1007/s10100-019-00613-4>, DOI: [10.1007/s10100-019-00613-4](https://doi.org/10.1007/s10100-019-00613-4). [COBISS.SI-ID [16472091](#)], [JCR, SNIP, WoS do 24. 9. 2021: št. citatov (TC): 4, čistih citatov (CI): 2, čistih citatov na avtorja (CIAu): 0,50, Scopus do 1. 7. 2021: št. citatov (TC): 7, čistih citatov (CI): 5, čistih citatov na avtorja (CIAu): 1,25]
2. **BERLEC, Tomaž**, POTOČNIK, Primož, GOVEKAR, Edvard, STARBEK, Marko. A method of production fine layout planning based on self-organising neural network clustering. *International Journal of Production Research*. 2014, vol. 52, iss. 24, str. 7209-7222, ilustr. ISSN 0020-7543. DOI: [10.1080/00207543.2014.910619](https://doi.org/10.1080/00207543.2014.910619). [COBISS.SI-ID [13421083](#)], [JCR, SNIP, WoS do 9. 8. 2021: št. citatov (TC): 5, čistih citatov (CI): 4, čistih citatov na avtorja (CIAu): 1,00, Scopus do 25. 3. 2021: št. citatov (TC): 5, čistih citatov (CI): 4, čistih citatov na avtorja (CIAu): 1,00]
 3. **BERLEC, Tomaž**, TANŠEK, Blaž, KUŠAR, Janez. Selection of the most suitable material handling system in production. *International journal of simulation modelling*. Mar. 2021, vol. 20, no. 1, str. 64-75, ilustr. ISSN 1726-4529. http://www.ijssimm.com/Full_Papers/Fulltext2021/text20-1_542.pdf, DOI: [10.2507/IJSIMM20-1-542](https://doi.org/10.2507/IJSIMM20-1-542). [COBISS.SI-ID [54449411](#)], [JCR, SNIP]
 4. **BERLEC, Tomaž**, KUŠAR, Janez, RIHAR, Lidija, KAVČIČ, Tadeja. *Optimalna naročila, serije, skladišča za TEM Čatež v okviru projekta KOC EEI 4.0*. Ljubljana: Fakulteta za strojništvo, Laboratorij za proizvodne sisteme, 2018. 67 f., ilustr. [COBISS.SI-ID [16315675](#)]
 5. TERSEGLAV, Lan, GOSAR, Žiga, KUŠAR, Janez, **BERLEC, Tomaž**. Vpliv avtomatizacije procesa namestitve lepilnega traku na učinkovitost proizvodnje. V: **BERLEC, Tomaž** (ur.), **BROJAN, Miha** (ur.), **DROBNIČ, Boštjan** (ur.). *[Zbornik del]*. 5. študentska tehniška konferenca ŠTeKam, Ljubljana, 12. 9. 2019. Ljubljana: Fakulteta za strojništvo, 2019. F. 98-105, ilustr. ISBN 978-961-6980-61-6. [COBISS.SI-ID [16786203](#)]

Lidija Rihar:

1. JORDAN, Eva, **BERLEC, Tomaž**, **RIHAR, Lidija**, KUŠAR, Janez. Simulation of cost driven value stream mapping. *International journal of simulation modelling*. Sep. 2020, vol. 19, no. 3, str. 458-469, ilustr. ISSN 1726-4529. http://www.ijssimm.com/Full_Papers/Fulltext2020/text19-3_527.pdf, DOI: [10.2507/IJSIMM19-3-527](https://doi.org/10.2507/IJSIMM19-3-527). [COBISS.SI-ID [27881731](#)], [JCR, SNIP, WoS do 18. 2. 2022: št. Citatov (TC): 1, čistih citatov (CI): 1, čistih citatov na avtorja (CIAu): 0,25, Scopus do 24. 1. 2022: št. Citatov (TC): 3, čistih citatov (CI): 3, čistih citatov na avtorja (CIAu): 0,75], kategorija: 1A2 (Z, A1/2)
2. **BERLEC, Tomaž**, KUŠAR, Janez, **RIHAR, Lidija**, STARBEK, Marko. Selecting the most adaptable work equipment. *Strojniški vestnik*. Jun. 2013, vol. 59, no. 6, str. 400-408, si 72, ilustr. ISSN 0039-2480. DOI: [10.5545/sv-jme.2013.959](https://doi.org/10.5545/sv-jme.2013.959). [COBISS.SI-ID [12950299](#)], [JCR, SNIP, WoS do 9. 8. 2021: št. citatov (TC): 2, čistih citatov (CI): 2, čistih citatov na avtorja (CIAu): 0,50, Scopus do 3. 12. 2019: št. citatov (TC): 2, čistih citatov (CI): 2, čistih citatov na avtorja (CIAu): 0,50]. kategorija: 1A3 (Z)
3. KUŠAR, Janez, **BERLEC, Tomaž**, **RIHAR, Lidija**, STARBEK, Marko. Adaptability of work equipment. *Technics technologies education management : journal of society for development of teaching and business processes in new net environment in BiH*. 2014, vol. 9, no. 1, str. 236-245, ilustr. ISSN 1840-1503. [COBISS.SI-ID [13388059](#)], [SNIP], kategorija: 1A4 (Z)
4. **RIHAR, Lidija**, **BERLEC, Tomaž**, KUŠAR, Janez. Cognitive factors and risk

management of concurrent product realisation : chapter 4. V: DE FELICE, Fabio (ur.), PETRILLO, Antonella (ur.). *Theory and application on cognitive factors and risk management : new trends and procedures*. Rijeka: InTech, 2017. Str. [63]-86, ilustr. ISBN 978-953-51-3295-0. <https://www.intechopen.com/books/theory-and-application-on-cognitive-factors-and-risk-management-new-trends-and-procedures/cognitive-factors-and-risk-management-of-concurrent-product-realisation>, DOI: [10.5772/intechopen.68398](https://doi.org/10.5772/intechopen.68398). [COBISS.SI-ID [15570459](#)], kategorija: 3B (Z, A1/2)

5. KUŠAR, Janez, **RIHAR, Lidija**, BERLEC, Tomaž, STARBEK, Marko. Project driven concurrent realization of orders. V: GOLOBIČ, Iztok (ur.), CIMERMAN, Franc (ur.). *Engineering - development and innovations for new employments 2014 : proceedings of the 4th AMES International Conference, Ljubljana, Slovenia, October 23th, 2014*. 1st ed. Ljubljana: Association of Mechanical Engineers of Slovenia - AMES, 2015. Str. 35-42, ilustr. ISBN 978-961-91393-8-7. [COBISS.SI-ID [14125083](#)], kategorija: 4D (Z)