UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	Krmiljenje in statistični nadzor proizvodnje
Course title:	CONTROL AND STATISTICAL SUPERVISION IN MANUFACTURING
Članica nosilka/UL Member:	UL FS

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

Univerzitetna koda predmeta/University course code:	0563546
Koda učne enote na članici/UL Member course code:	3063-V

Predavanja	Seminar	Vaje	Klinične vaje	Druge oblike študija	Samostojno delo	ECTS
30		30			40	4

Nosilec predmeta/Lecturer:	Drago Bračun, Edvard Govekar

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. Predavanje: Proizvodnja kot kompleksni delovni sistem - Kompleksnost v proizvodnji - Pomen subjekta, vloga avtomatizacije, primeri iz prakse - Grafični opis kompleksnih delovnih sistemov po IDEF0 metodologiji (na primerih iz prakse) 2. Predavanje: Sistemi za vodenje in nadzor delovnih sistemov - Namen, gradniki, tipične arhitekture SCADA sistemov	1. Lecture: Manufacturing as a complex work system - Manufacturing complexity - The importance of the subject, the role of automation, practical examples - Graphic description of complex work systems according to IDEF0 methodology (based on examples) 2. Lecture: Manufacturing execution and process monitoring systems - Purpose, building blocks, typical architectures of SCADA systems

Slovenščina	English
- Komunikacije in uporabniški vmesniki	- Communications and user interfaces
- Nadzorni sistemi	- Monitoring systems
- MES in ERP sistemi	- MES and ERP systems
3. Predavanje: Avtomatska identifikacija	3. Lecture: Automatic identification
- Pregled tehnologij	- Technology overview
- Črtne in QR kode, RFID	- Bar and QR code, RFID
- Industrijski internet stvari (IIS)	- Industrial internet of things (IIS)
- Osnovni koncepti in senzorska omrežja IIS	- Basic concepts and sensor networks of IIS
4. Predavanje: Avtomatizirana kontrola procesov	4. Lecture: Automated process control
- Procesi in variabilnost	- Processes and variability
- 100% vs. statistična kontrola	- 100% vs. statistical control
- Končna vs. porazdeljena kontrola	- Final vs. distributed control
- Primeri iz prakse	- Case studies
5. Predavanje: Metode kontrole procesov	5. Lecture: Process control methods
- 100% nadzor izdelkov	- 100% inspection
- pregled kontrolnih metod (dotične/brezdotične)	- review of inspection methods (touch / non-contact)
- avtomatizirana preizkuševališča in kalibri	- automated testing devices
- primeri iz prakse	- case studies
6. Predavanje: Strojni vid (SV) v kontroli izdelkov in procesov; 100% nadzor	6. Lecture: Machine vision (MV) in product and process control; 100% inspection
- tipične aplikacije	- typical applications
- splošna struktura sistemov SV	- general structure of MV system
- merilne lastnosti in umeritev sistema	- MV system properties and calibration
- integracija	- integration
7. Predavanje: Koordinatni merilni stroji (KMS) – visoko natančne meritve izdelkov; vzorčni nadzor procesov	7. Lecture: Coordinate measuring machines (CMM) – high accurate inspection of parts; sampling control of processes
- namen in princip merjenja	- purpose and principle of measurement
- izdelava merilnega programa	- measuring program development
- interpretacija meritev	- interpretation of measurements
- primer merjenja izdelka	- an example of measuring a part
8. Predavanje: Urejanje in predstavitev variabilnih podatkov	8. Lecture: Editing and presenting variable data
- Vrste in primeri variabilnih podatkov v strojništvu	- Types and examples of variable data in mechanical engineering
- Tabele in grafi podatkov	- Tables and graphs of data
- Sipalni diagram	- Scatter diagram
- Stolpični diagram (Histogram)	- Bar chart (Histogram)
- Stebelni in listni diagram	- Stem and leaf diagram
9. Predavanje: Osnovne opisne statistike	9. Lecture: Editing and presenting variable data
- Opisne karakteristike podakov	- Types and examples of variable data in mechanical engineering
- Mere centralne tedence (srednja vrednost, mediana, mod)	- Tables and graphs of data
- Mere variabilnosti (min – max, kvartili, varianca, standradni odklon)	- Scatter diagram
- Škatljični diagram	- Bar chart (Histogram)
	- Stem and leaf diagram
10. Predavanje: Osnovne verjetnosti	10. Lecture: Basic of Probability
- Relativna pogostost, verjetnost in uporaba verjetnosti pri opisu naključnosti	- Relative frequency, probability and use of probability in describing randomness
- Povezana verjetnost	- Joint probability
- Pogojna verjetnost	- Conditional probability
- Primeri v strojništvu	

11. Predavanje: Porazdelitev verjetnosti - Histogram in porazdelitev verjetnosti - Binomska porazdelitev in primeri v strojništvu - Gaussova porazdelitev in primeri v strojništvi - Pravilo seštevanja Gaussovih spremenljivk 12. Predavanje: Osnovne sklepne statistike - Osnovni pojmi (populacija, vzorec, statistično sklepanje) - Gaussova populacija - Ocena parametrov gaussove populacije - Primerjava dveh Gaussovih populacij s praktičnimi primeri uporabe v proizvodnji 13. Predavanje: Avtomatsko spremljanje stanja procesov - Osnovni gradniki sistema - Značilke podatkov - Vrste in izbira modelov 14. Predavanje: Izgradnja modela - Statistični pragovni model - Sipalni diagram in korelacijski koeficient - Linearni parametrični model 15. Predavanje: Praktična primera spremljanje stanja proizvodnih procesov - Vtiskovanje ojnice - Vibroakustična končna kontrola kompresorjev	- Mechanical engineering cases 11. Lecture: Probability distributions - Histogram and probability distribution - Binomial distribution and cases in mechanical engineering - Gaussian distribution and examples in mechanical engineering - The rule of summation of Gaussian variables 12. Lecture: Basic inferential statistics - Basic concepts (population, sample, statistical reasoning) - Gaussian population - Estimation of parameters of a Gaussian population - Comparison of two Gaussian populations with practical use cases in production 13. Lecture: Automatic process state monitoring - The basic building blocks of the system - Data features - Types and selection of models 14. Lecture: Model Building - Statistical threshold model - Scattering diagram and correlation coefficient - Linear parametric model 15. Lecture: A practical example of monitoring the state of production processes - Monitoring of crankshaft stamping - Vibro-acoustic final control of compress

Temeljna literatura in viri/Readings:

1. Fundamentals of Industrial Instrumentation and Process Control, William C. Dunn, McGraw-Hill Education; 2 edition, 2018
2. Condition Monitoring and Control for Intelligent Manufacturing, L. Wang, Springer London, 2006.
3. Machine Vision: Automated Visual Inspection: Theory, Practice and Applications, J.Beyerer, Springer-Verlag Berlin Heidelberg, 2016.
4. Douglas C. MONTGOMERY, George C. RUNGER, *Applied statistic and probability for engineers*, Third eddition, 2003, John Wiley and Sons.
5. Edvard GOVEKAR, *Naključni pojavi : elektronski zapiski in interaktivni učbenik*. Univerza v Ljublani, Fakulteta za strojništvo, 2005. http://lab.fs.uni-lj.si/lasin/www/teaching/np/predavanja.htm. [COBISS.SI-ID 11321371]

Cilji in kompetence:

Objectives and competences:

Cilji: 1. Spoznati sisteme za krmiljenje in nadzor proizvodnje. 2. Spoznati metode avtomatiziranega nadzora izdelkov. 3. Spoznati osnovne metode statistike za spremljanje in vrednotenje proizvodnih procesov	Objectives: 1. Understand manufacturing execution, monitoring and control systems. 2. Learn the methods of automated product control. 3. To learn basic methods of statistics for monitoring and evaluation of production processes Competences:

Kompetence:	1. S1-PAP + P4-PAP: The ability to understand and to use monitoring and control systems in production processes
1. S1-PAP + P4-PAP: Sposobnost razumevanja in uporabe sistemov vodenja in nadzora proizvodnje.	2. S1-PAP + P4-PAP: The ability to understand and to use product and proces inspection methods in practice.
2. S1-PAP + P4-PAP: Sposobnost razumevanja in uporabe metod nadzora izdelkov in procesov v praksi.	3. S1-PAP + P4-PAP: The ability to use the knowledge of the basics statistics in monitoring, evaluation and control of production processes.
3. S1-PAP + P4-PAP: Sposobnost uporabe pridobljenega znanaj osnov statistike pri spremljanju, vrednotenju in krmiljenju proizvodnih procesov.	

Predvideni študijski rezultati: **Intended learning outcomes:**

Znanja:	Knowledge:
Z1: Predmet je obravnava različne sisteme za krmiljenje in nadzor proizvodnje, kot tudi metode zbiranja in analize proizvodnih podatkov. S pridobljenimi kompetencami bodo študenti v praksi sposobni uporabljati različne sisteme za krmiljenje in nadzor proizvodnje ter analizirati in interpretirati proizvodne podatke.	Z1: The course deals with various systems for monitoring and control of production process, as well as with methods for collecting and analyzing of manufacturing data. With the acquired competences, students will be able in practice to use different systems for monitoring and control of production process and to analyze and interpret production data.
Spretnosti:	Skills:
S1.1: Osnovno razumevanje kompleksnosti in variabilnosti v proizvodnji.	S1.1: Basic understanding of complexity and variability in production.
S1.1: Uporaba sistemov krmiljenja in nadzora proizvodnje.	S1.1: Use of manufacturing control and monitoring systems.
S1.2: Analiza in interpretacija variabilnih proizvodnih podatkov.	S1.2: Analysis and interpretation of variable production data.

Metode poučevanja in učenja: **Learning and teaching methods:**

P1 Avditorna predavanja z reševanjem izbranih - za področje značilnih - teoretičnih in praktično uporabnih primerov.	P1 Auditorial lectures with solving selected field-specific theoretical and applied use cases.
P2 Obravnava snovi po urejeni in vnaprej razloženi sistematiki.	P2 Presenting the content according to the explained system.
P3 Avditorne vaje, kjer se teoretično znanje s predavanj podkrepi z računskimi primeri.	P3 Auditorial exercises, in which theoretical content from the lectures is supplemented with practical examples.
P4 Laboratorijske vaje z namenskimi didaktičnimi pripomočki: merilnimi sistemi, kamerami, prenosnimi računalniki in odprtokodno programsko opremo.	P4 Laboratory exercises with special-purpose didactic devices: measuring systems, cameras, laptops and open source software.
P5 Uporaba študijskega gradiva v obliki e-zapiskov	P5 Application of study material: books, e-version of lecture presentation.
P8 Izdelava in predstavitev aplikativnih seminarskih nalog.	P8 Making and presenting applied seminar exercises.

Načini ocenjevanja:	Delež/Weight	Assessment:
Teoretična snov (predavanja).	50,00 %	Theoretical matter (lectures).

Laboratorijsko delo na vajah (vključno s poročili).	40,00 %	Laboratory work in exercises (including reports).
Projektni seminar.	10,00 %	Project seminar.

Reference nosilca/Lecturer's references:

Drago Bračun:

1. **BRAČUN Drago**, LEKŠE Igor. A visual inspection system for KTL coatings. Procedia CIRP, ISSN 2212-8271, vol. 81, 2019, vol. 81, 771-774.
2. **BRAČUN Drago**, PERDAN Boštjan, DIACI Janez. Surface defect detection on power transmission belts using laser profilometry. Strojniški vestnik. mar. 2011, vol. 57, no. 3, str. 257-266.
3. VUKAŠINOVIĆ Nikola, **BRAČUN Drago**, MOŽINA Janez, DUHOVNIK Jože. The influence of incident angle, object colour and distance on CNC laser scanning. The international journal of advanced manufacturing technology, ISSN 0268-3768, Sep. 2010, vol. 50, iss. 1/4, str. 265-274.
4. **BRAČUN Drago**, GRUDEN Valter, MOŽINA Janez. A method for surface quality assessment of die-castings based on laser triangulation. Measurement science & technology, ISSN 0957-0233. 2008, letn. 19, št. 4, 8.
5. PERHAVEC Tadej, GORKIČ Aleš, **BRAČUN Drago**, DIACI Janez. A method for rapid measurement of laser ablation rate of hard dental tissue. Optics and laser technology, ISSN 0030-3992, 2009, vol. 41, issue 4, str. 397-402.

Edvard Govekar:

1. THALER, Tilen, POTOČNIK, Primož, BRIC, Ivan, **GOVEKAR, Edvard**. Chatter detection in band sawing based on discriminant analysis of sound features. Applied acoustics, ISSN 0003-682X, 2014, letnl. 77, str. 114-121
2. THALER, Tilen, BRIC, Ivan, BRIC, Rudi, POTOČNIK, Primož, MUŽIČ, Peter, **GOVEKAR, Edvard**. Characterization of band sawing based on cutting forces. Journal of machine engineering, ISSN 1895-7595, 2012, vol. 12, no. 1, str. [41]-54, ilustr
3. POTOČNIK, Primož, **GOVEKAR, Edvard**, GRABEC, Igor. Application of psychoacoustic filtering for machine fault detection. International journal of materials & product technology, ISSN 0268-1900, 2006, letn. 27, št. 3/4, str. 229-237
4. POTOČNIK, Primož, SOKLIČ, Dejan, MUŽIČ, Peter, ABSEC, Matija, STRMEC, Tomaž, **GOVEKAR, Edvard**. Automatic detection of spring faults during assembly of reciprocating compressors. Strojniški vestnik, 2009, letn. 55, št. 7/8, str. 444-45
5. KLEMENČIČ, Jure, KOKALJ, Tadej, MUŽIČ, Peter, GRABEC, Igor, **GOVEKAR, Edvard**. Characterization of laser droplet formation by reflected light. Optics and lasers in engineering, 2006, letn. 44, št. 5, str. 398-410.