

INŽENIRSTVO KAKOVOSTI

UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	Inženirstvo kakovosti
Course title:	Quality Engineering
Članica nosilka/UL Member:	UL FS

Študijski programi in stopnja	Študijska smer	Letnik	Semestri	Izbirnost
Strojništvo - Razvojno raziskovalni program, druga stopnja, magistrski	Proizvodno strojništvo (smer)	2. letnik	1. semester	obvezni

Univerzitetna koda predmeta/University course code:	0566841
Koda učne enote na članici/UL Member course code:	6050-M

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			65	5

Nosilec predmeta/Lecturer:	izr. prof. dr. Davorin Kramar
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Izvajalci predavanj:	
Izvajalci seminarjev:	
Izvajalci vaj:	
Izvajalci kliničnih vaj:	
Izvajalci drugih oblik:	
Izvajalci praktičnega usposabljanja:	

Vrsta predmeta/Course type:	Obvezni strokovni predmet na smeri Proizvodno strojništvo, ki je izbirni strokovni predmet na ostalih smereh./Compulsory specialised course in the study of Production Engineering, which is an elective specialised course in other fields of study.
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Jeziki/Languages:	Predavanja/Lectures:	Slovenščina
	Vaje/Tutorial:	Slovenščina

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

Prerequisites:

Izpolnjevanje pogojev za vpis v Magistrski študijski program II. stopnje Strojništvo - Razvojno raziskovalni program.	Meeting the enrollment conditions for the Master's study programme of Mechanical Engineering - Research and Development program.
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Vsebina:

Content (Syllabus outline):

1. Predavanje: Osnove kakovosti
 - opredelitev kakovosti
 - 8 determinant kakovosti izdelka
 - 5 determinant kakovosti storitve
 - kultura kakovosti
 - guruji kakovosti in razvojne stopnje kakovosti
2. Predavanje: Osnovna orodja kakovosti (7QC)
 - Kontrolni list
 - Histogram
 - Pareto diagram
 - Diagram vzrokov in posledic (Ishikawa diagram)
 - Korelacijski diagram
 - Kontrolna karta
 - Diagram poteka
3. Predavanje: Stroški kakovosti (CoQ)
 - definicija stroškov kakovosti
 - vrste stroškov kakovosti
 - sistem za določevanje stroškov kakovosti
 - uporaba CoQ pri odločanju
 - razlike med kakovostjo izdelka in kakovostjo storitev
4. Predavanje: Krog stalnih izboljšav (PDCA)
 - model stalnih izboljšav procesa
 - 8 korakov pri reševanju problema
 - metodi 5x zakaj in 5x kako
 - metoda osem disciplin (8D)
5. Predavanje: Sistem vodenja kakovosti (ISO 9001)
 - kontrola in obvladovanje kakovosti (QC), zagotavljanje (QA), vodenje (QM)
 - standardi družine ISO 9000 in smernice
 - vključevanje v proizvodne sisteme
 - presoja kakovosti (audit); postopek certificiranja
6. Predavanje: Politika kakovosti v podjetju
 - vodenje sistema kakovosti in politika podjetja
 - model konteksta organizacije
 - model politike kakovosti podjetja
 - učinkovitost politike kakovosti (KPI)
 - funkcije izgube kakovosti (QLSs)
7. Predavanje: Napredno načrtovanje kakovosti izdelka (APQP) in plan nadzora
 - osnove načrtovanja kakovosti proizvoda; matrika odgovornosti
 - načrtovanje in opredelitev programa
 - načrtovanje in razvoj proizvoda
 - načrtovanje in razvoj procesa
 - validacija proizvoda in procesa, povratne informacije, presoja in korektivni ukrepi
 - plan nadzora
8. Predavanje: Statistični nadzor procesa (SPC)
 - uvod v SPC, kakovost in variacije
 - Normalna (Gaussova) porazdelitev in ppm

1. Lecture: The basics of quality
 - definition of quality
 - determinants of product quality
 - 5 determinants of service quality
 - a culture of quality
 - quality gurus and quality development stages
2. Lecture: Basic Quality Tools (7QC)
 - Checklist
 - Histogram
 - Pareto diagram
 - Cause and effect diagram (Ishikawa diagram)
 - Correlation diagram
 - Control card
 - Flowchart
3. Lecture: Cost of Quality (CoQ)
 - definition of CoQ
 - types of CoQ
 - a system for determining CoQ
 - use of CoQ in decision making
 - differences between product quality and service quality
4. Lecture: The Continuous Improvement Cycle (PDCA)
 - a model of continuous process improvement
 - 8 steps to solve the problem
 - 5x why and 5x how to
 - eight disciplines (8D) method
5. Lecture: Quality Management System (ISO 9001)
 - quality control (QC), assurance (QA), management (QM)
 - ISO 9000 family standards and guidelines
 - integration into production systems
 - quality audit; certification process
6. Lecture: Quality policy in the company
 - quality management and company policy
 - model context of the organization
 - a model of company quality policy
 - the effectiveness of quality policy (KPI)
 - Quality Loss Functions (QLSs)ž
7. Lecture: Advanced Product Quality Planning (APQP) and control plan
 - basics of product quality planning; responsibility matrix
 - program design and definition
 - product design and development
 - process planning and development
 - product and process validation, feedback, judgment and corrective action
 - control plan
8. Lecture: Statistical Process Control (SPC)
 - introduction to SPC, quality and variations

- SPC za attribute in za spremenljivke (kontrolne karte) - izračun kontrolnih mej, stabilnost, sposobnost procesa - prevzemno vzorčenje 9. Predavanje: Analiza merilnih sistemov (MSA) - uporaba, opis, omejitve, postopek - lokacijska, širinska in sistemska odstopanja - statistične lastnosti merilnih sistemov - študija merilnega sistema 10. Predavanje: Analiza možnih napak in njihovih posledic (FMEA) - namen, uporaba, cilji, koraki - stopnja pomembnosti napake (Risk Priority Number - RPN) - FMEA proizvoda / konstrukcije (DFMEA) - FMEA procesa (PFMEA) - FMEA ekologije (EFMEA) 11. Predavanje: Proces odobritve proizvodov (PPAP) - namen, uporaba, pristop - zahteve procesa PPAP - obveščanje odjemalca - predložitev odjemalcu; nivoji, status, hranjenje zapisov 12. Predavanje: Uporaba metode načrtovanja eksperimentov (DoE) v kakovosti I. del - pristop k načrtovanju eksperimentov - uporaba, cilji, ovire DoE - koraki metode DoE - faza planiranja eksperimenta - izbira načrta (FFD, CCD, BBD, Taguchi OA) 13. Predavanje: Uporaba metode načrtovanja eksperimentov (DOE) v kakovosti II. del - izvedba eksperimenta, analiza in interpretacija rezultatov - optimiranje procesa na osnovi odzivnih funkcij - primeri uporabe DOE iz prakse 14. Predavanje: Integriran nadzor kakovosti - kontrola kakovosti integrirana v proces - kontrola procesa v praksi - senzorika za nadzor procesa - post-procesna merilna oprema 15. Predavanje: 6 Sigma (predavanje iz prakse)	- Normal (Gaussian) distribution and ppm - SPC for attributes and variables (control charts) - calculation of control limits, stability, process capability - acceptance sampling 9. Lecture: Measurement System Analysis (MSA) - use, description, restrictions, process - location, latitude and systematic deviations - the statistical characteristics of the measurement systems - study of the measurement system 10. Lecture: Failure Mode and Effects Analysis (FMEA) - purpose, use, goals, steps - Risk Priority Number (RPN) - Product / Construction FMEA (DFMEA) - Process FMEA (PFMEA) - Ecology FMEA (EFMEA) 11. Lecture: Production Part Approval Process (PPAP) - purpose, use, approach - PPAP process requirements - informing the client - submission to the client; levels, status, record keeping 12. Lecture: Using the Design of Experiments Method (DoE) in Quality Part I - an approach to designing experiments - DOE usage, goals, obstacles - DOE method steps - experiment planning phase - design selection (FFD, CCD, BBD, Taguchi OA) 13. Lecture: Using the Design of Experiments Method (DoE) in Quality Part II - conducting the experiment, analyzing and interpreting the results - process optimization based on response functions - practical examples of DOE use 14. Lecture: Integrated quality control - quality control integrated into the process - process control in practice - process control sensors - post-process measuring equipment 15. Lecture: 6 Sigma (Lecture from Practice)
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Temeljna literatura in viri/Readings:

1. BRAČUN, Drago, KRAMAR, Davorin. Dodatno učno gradivo pri predmetu Načrtovanje in obvladovanje kakovosti : MAG 1. letnik : magistrski študijski program druge stopnje Strojništvo - Razvojno raziskovalni program. Ljubljana: Univerza v Ljubljani, Fakulteta za strojništvo, 2021. [COBISS.SI-ID [64542467](#)]

2. ENIKO, Peter, KRAMAR, Davorin. Physical model of the quality policy : chapter 3. V: ŠIBALIJA, Tatjana (ur.). A closer look at loss function, (Mathematics Research Developments). New York: Nova Science Publishers. cop. 2020 [COBISS.SI-ID [17113371](#)]
3. R. Basu: Implementing Quality – A Practical Guide to Tools and Techniques, Thomson Learning, London, 2004, [COBISS.SI-ID [7672603](#)]
4. T. Pyzdek: The Six Sigma handbook : a complete guide for green belts, black belts, and managers at all levels; [COBISS.SI-ID [7334171](#)]

Cilji in kompetence:	Objectives and competences:
Cilji: 1. spoznati osnovna orodja kakovosti in tehnike statističnega nadzora procesa 2. spoznati metodo naprednega načrtovanja kakovosti izdelka in plan nadzora 3. spoznati sistem vodenja kakovosti ISO 9001 in pomen na politiko kakovosti v podjetju 4. spozna metodo za analizo možnih napak in njihovih posledic pri snovanju izdelka, njegovi izdelavi in vplivu na okolje 5. spozna metode načrtovanja eksperimentov in njihovo uporabo pri empiričnem modeliranju in optimizaciji procesov Kompetence: 1. S7-MAG + P2-MAG: uporaba osnovnih orodij in tehnik zagotavljanja kakovosti v vseh fazah nastanka proizvoda/storitve 2. S7-MAG + P2-MAG: obvladovanje naprednega načrtovanja kakovosti izdelka 3. S9-MAG + P2-MAG: uporaba sistema vodenja kakovosti pri vključevanju v proizvodne sisteme ter vodenju politike kakovosti podjetja 4. S7-MAG + P2-MAG: analiza možnih napak in njihovih posledic na nivoju proizvoda, procesa in okolja 5. S10-MAG + P7-MAG: uporaba metod načrtovanja eksperimentov pri optimizaciji procesov na različnih področjih strojništva	Goals: 1. Learn the basic quality tools and techniques of statistical process control 2. Learn about advanced product quality planning method and control plan 3. Get to know the ISO 9001 quality management system and the importance of quality policy in the company 4. Become aware of a method for analyzing potential errors and their consequences in product design, manufacturing and environmental impact 5. Knows the methods of designing experiments and their use in empirical modeling and process optimization Competences: 1. S7-MAG + P2-MAG: Use of basic tools and quality assurance techniques at all stages of product/ service creation 2. S7-MAG + P2-MAG: Managing advanced product quality planning 3. S9-MAG + P2-MAG: the use of quality management systems in integrating into production systems and managing company quality policy 4. S7-MAG + P2-MAG: Failure mode and effects analysis at the product, process and environmental levels 5. S10-MAG + P7-MAG: Use of design of experiments methods in process optimization in various fields of mechanical engineering

Predvideni študijski rezultati:	Intended learning outcomes:
Znanja: Z2: Poglobljeno znanje inženirstva kakovosti pri načrtovanju izdelka ali procesa in vodenju podjetja za kakovost. Spretnosti:	Knowledge: Z2: In-depth knowledge of quality engineering in product or process design and quality management. Skills: S2.1 Managing the tools and methods for quality planning and control

S2.1 Obvladovanje orodij in metod za načrtovanje in obvladovanje kakovosti	S2.2 Use of computer aided methods for the planned execution of experiments and the optimization of processes
S2.2 Uporaba računalniško podprtih metod za načrtno izvedbo eksperimentov in optimizacijo procesov	

Metode poučevanja in učenja:

P1 Avditorna predavanja z reševanjem izbranih - za področje značilnih - teoretičnih in praktično uporabnih primerov. P4 Laboratorijske vaje z namenski didaktičnimi pripomočki (merilni instrumenti in računalniško podprta orodja za analizo) P5 Uporaba študijskega gradiva v obliki knjig in skripta in e-verzije predstavitve predavanj. P7 Študij literature in razprava P9 Skupinsko delo – viharjenje možganov P10 Uporaba anket v realnem času	Learning and teaching methods: P1 Auditorial lectures with solving selected field-specific theoretical and applied use cases. P4 Laboratory exercises with special-purpose didactic devices (measuring instruments and computer-aided analysis tools)). P5 Application of study material (description needs to be added, max. one line per material, e.g. textbook, e-book, printed lecture presentations, etc.). P7 Literature studies and discussion P9 Teamwork - Brainstorming P10 Application of questionnaires in real time.
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Načini ocenjevanja:

Delež/Weight

Assessment:

- Teoretične vsebine (predavanja).	50,00 %	- Theoretical content (lectures).
- Samostojno delo na vajah.	20,00 %	- Independent work in exercises.
- Delo na laboratorijskih vajah (vključno s poročili).	30,00 %	- Laboratory work (including reports).

Ocenjevalna lestvica:

Grading system:

5 - 10, pri čemer velja, da je pozitivna ocena od 6 - 10	5 - 10, a student passes the exam if he is graded from 6 to 10
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Reference nosilca/Lecturer's references:

Davorin Kramar:

1. ENIKO, Peter, **KRAMAR, Davorin**. Physical model of the quality policy : chapter 3. V: ŠIBALIJA, Tatjana (ur.). A closer look at loss function, (Mathematics Research Developments). New York: Nova Science Publishers. cop. 2020, str. 95-121, ilustr. [COBISS.SI-ID [17113371](#)]
2. BOROJEVIC, S., LUKIC, Dejan, MILOŠEVIĆ, Miloš, VUKMAN, J., **KRAMAR, Davorin**. Optimization of process parameters for machining of Al 7075 thin-walled structures. Advances in production engineering & management, ISSN 1854-6250, 2018, vol. 13, no. 2, str. 125-135, ilustr. doi: 10.14743/apem2018.2.278. [COBISS.SI-ID [16188443](#)]
3. GRGURAŠ, Damir, **KRAMAR, Davorin**. Optimization of hybrid manufacturing for surface quality, material consumption and productivity improvement. Strojniški vestnik, ISSN 0039-2480, Oct. 2017, vol. 63, no. 10, str. 567-576, SI 83, ilustr., doi: 10.5545/sv-jme.2017.4396. [COBISS.SI-ID [15707931](#)]
4. SREDANOVIĆ, Branislav, CICA, Djordje, BOROJEVIĆ, Stevo, TEŠIĆ, Saša, **KRAMAR, Davorin**. Optimization of superalloy Inconel 718 micro-milling process by combined Taguchi and multi-criteria decision making method. *Journal of the Brazilian Society of Mechanical Sciences and Engineering*. [Print ed.]. 2024, vol. 46, article number 423, str. 1-14, ilustr. ISSN 1678-5878.

<https://link.springer.com/article/10.1007/s40430-024-04996-7>, [Repozitorij Univerze v Ljubljani – RUL](#), DOI: [10.1007/s40430-024-04996-7](#). [COBISS.SI-ID [224254467](#)]

5. KRAŠ, Ana, **KRAMAR, Davorin**, MILOŠEV, Ingrid. Experimental approach and assessment of Zr conversion coatings on Al alloy using response surface methodology. Corrosion science. June 2025, vol. 249, [article no.] 112824, 15 str., ilustr. ISSN 1879-0496. , [dCOBISS](#), DOI: [10.1016/j.corsci.2025.112824](#). [COBISS.SI-ID [227651331](#)]