



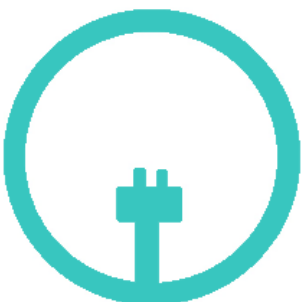
Fakulteta za  
industrijski inženiring  
Faculty of Industrial Engineering

***Razvoj industrijskega inženiringa (RII7):  
Priložnosti, potenciali, izzivi***

***Development of Industrial Engineering(RII7):  
Opportunities, Potentials, Challenges***

**Zbornik povzetkov 7. mednarodne konference**

***Book of Abstracts of 7th International Conference***







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Novo mesto, september 2022

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## Predgovor

Pred vami je zbornik recenziranih prispevkov 5. Mednarodne znanstvene konference o razvoju industrijskega inženiringa, s podnaslovom: Priložnosti, potenciali in izzivi, ki ga tradicionalno organizira Fakulteta za industrijski inženiring Novo mesto. Vabilu k sodelovanju na konferenci se je odzvalo veliko število avtorjev s skupaj 39 prijavljenimi povzetki. Še posebej smo veseli izjemnega odziva vabljenih predavateljev, ki bodo na konferenci predstavili 4 izredno zanimive in aktualne teme. Za Fakulteto, ki je nosilka razvoja posameznih ved o industrijskem inženiringu, je tak odziv potrditev pravilne usmerjenosti in trdega dela v preteklih letih in dobra popotnica tudi za letošnjo konferenco.

Vsebina posameznih prispevkov je raznolika in obravnava sodobne metode in posamezne inovativne rešitve problemov na področju industrijskega inženiringa. Uvodoma se seznanimo z 10 prispevki na področju materialov s tehnološkim potencialom. Sledi obsežen sklop 13 prispevkov s področja trajnostnih tehnolog ter sklop 6 prispevkov, ki predstavljajo strategije za zeleni prehod in trajnostno družbo. V zadnjem delu zbornika najdete 10 zanimivih prispevkov na temo regij, mest in krožnega gospodarstva.

Kot avtorji ali soavtorji posameznih prispevkov so se k sodelovanju na konferenci odzvali mednarodno uveljavljeni raziskovalci in eminentni visokošolski učitelji tako iz Slovenije kot tudi iz tujine, kar nas v programskem odboru navdaja z veseljem v pričakovanju izmenjave odličnega znanja in uspešnih praks.

dr. Tomaž Savšek  
Predsednik programskega odbora

## Preface

In front of you is a proceeding of reviewed papers of the 7th International Scientific Conference on the Development of Industrial Engineering, with the subtitle: Opportunities, Potentials and Challenges, traditionally organized by the Faculty of Industrial Engineering Novo mesto. A large number of authors responded to the invitation to participate in the conference with a total of 39 submitted abstracts were included in the selection for the proceedings. For the Faculty, which is responsible for the development of individual disciplines in industrial engineering, such a response is a confirmation of the correct orientation and hard work in recent years and a good guide for this year's jubilee conference.

The content of individual papers is diverse and deals with modern methods and individual innovative solutions to problems in the field of industrial engineering. In the beginning, we are acquainted with 10 contributions in the field of materials with technological potential. This is followed by an extensive set of 13 contributions from the field of sustainable technologies and a set of 6 contributions that present strategies for a green transition and a sustainable society. In the last part of the proceeding you can find 10 interesting contributions on the topic of regions, cities and the circular economy.

As authors or co-authors of individual papers, internationally renowned researchers and eminent professors from Slovenia and abroad responded to the conference, which fills us in the program committee with joy in anticipation of the exchange of excellent knowledge and successful practices.

dr. Tomaž Savšek  
Chairman of the Program Committee



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**Vabljena predavanja**  
**Keynote lecture**

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## Kitakyushu Circular economy vision. How Kitakyushu will become a circular city

Shiko Hayashi<sup>1</sup>

*<sup>1</sup>Global Environmental Strategies (IGES), Kitakyushu Urban Centre, Japan  
E-address: hayashi@iges.or.jp*

### Abstract

A roadmap towards the CE transition in Kitakyushu guides the city towards decarbonized, circular society. As Kitakyushu is a highly industrial city, their CE plan is based on establishing the collaboration between the industries for effective utilisation of the resources and connecting them with their highly advanced recycling area to enable resource circulation. Kitakyushu city aims to establish a firm enabling environment for the companies to practice CE and at the same time decrease their carbon footprint, as all recycling operations are powered by locally produced renewable energy.



## Fostering circular economy in cities and regions

Vesna Lavtizar<sup>1</sup>

<sup>1</sup>*Global Environmental Strategies (IGES), Japan*  
*E-address: lavtizar@iges.or.jp*

### Abstract

Regions have an incredible potential to foster the transition toward the CE by leveraging local potentials, technological advancements, and by applying circular thinking. The presentation will disclose how to design local plans that will guide the region towards sustainability through practices that not only increase the circularity but generate benefits to community wellbeing, environmental wellness and local prosperity, self-reliance and resilience.



## Circularity in Peripheral Regions: Innovation Systems and Circular Economy

Rannveig Edda Hjaltadóttir<sup>1</sup>

*<sup>1</sup>Nord University Business School, Norway*

*E-address: rannveig.hjaltadottir@nord.no*

### Abstract

Reorganising regional systems for Circular Economy (CE) can be challenging as CE transformation depends on different types of innovation, including technological, business model, supply chain, policy, and social innovation that need to function in unison as CE innovation bundles. Supporting diverse types of innovation is challenging for the actors in innovation systems as most have focused on technological innovations, this is especially challenging for peripheral regions that are organisationally thin. At the same time, the peripheral regions can have some potential advantages when it comes to CE development, including access to renewable energy, relative strength in core industries, local clusters, the level of digitalisation and use of inter-regional cooperation to access knowledge from central regions.



## Circular Bodø

Tor Gausemel Kristensen<sup>1</sup>

<sup>1</sup>Cityloops, Norway

E-address: [tor.Gausemel.Kristensen@bodo.kommune.no](mailto:tor.Gausemel.Kristensen@bodo.kommune.no)

### Abstract

A presentation of activities and innovation projects in Bodø that will influence to a more sustainable and circular practice in city development. How do we practice now, what is our ambition, and what can we learn from and to others?



## Zelena energetska tranzicija: problem ali priložnost?

### Green energy transition: problem or opportunity?

Andrej Pečjak<sup>1</sup>

<sup>1</sup>Metron inštitut, Podnart, Slovenija  
E-mail: andrej@eauto.si

#### Povzetek

Pred nami so tako tehnološki, kot tudi sociološki izzivi, ki jih lahko imenujemo problemi ali pa priložnosti. V dobrem desteletju se bo spremenilo skoraj vse od energetike do transporta in prehrane. Energetika in z njo transport se bosta elektrificirala, digitalizirala in dekarbonizirala, hitrost tega procesa pa bo odvisna od zunanjih dejavnikov kot so klimatske spremembe, politična nestabilnost, ekonomska kriza in sposobnost svetovnih ekonomij, da uvedejo nove tehnologije. Avtomobilska industrija je zagotovo ena od panog, kjer se spremembe že dogajajo in to z veliko hitrostjo. Te spremembe bodo prinesle s seboj doslej neznane probleme in zahtevna prilagajanja, bodo pa tudi vir novih priložnosti za inovativne posameznike, podjetja ali regije. S praviim predvidevanjem in pripravi na to transformacijo imamo v Sloveniji lepe možnosti, da se z repa Evrope zavijimo na pozicijo vzorčne regije, ki bo drugim kazala pot.

Ali bomo to zmogli ali ne, je na nas samih, priložnosti so tukaj in pot naprej je odprta. Ni nam treba čakati na prihodnost kajti prihodnost je že tukaj!

#### Abstract

We are entering an era of technological and sociological challenges, which could be called problems or opportunities. During the next 10 years, almost everything we use will change: from energy to transport and food production and use. Energy and transport will head up towards electrification, digitalization and decarbonisation. The speed of this process will depend upon external factors such as climate change, political instability, economic crisis and the ability of the world's economy to introduce new technologies. The automotive industry is certainly one of the industries where changes are already happening at a very high speed. Because of these changes, we will be faced with previously unknown problems and demanding adaptations, but on the other hand, they will also be a source of new opportunities for innovative individuals, companies and regions. With proper foresight and preparations, we in Slovenia have excellent chances to swing from the tail of Europe to the leading exemplary region that will show the way to go for others.

Weather we can do it or not is up to us, the opportunities are here and the way forward is open. We should not wait for the future, because the future is here!



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# **Materiali s tehnološkimi potencialom**

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## ***Materials with technological potential***





## A generalisation of the St Venant principle for a high-contrast elastic laminate

Julius Kaplunov<sup>1</sup>, Ludmila Prikazchikova<sup>2</sup>

<sup>1</sup>*Faculty of Industrial Engineering Novo mesto, Slovenia  
E-address: julius.kaplunov@fini-unm.si*

<sup>2</sup>*Keele University, Keele, UK  
E-address: l.prikazchikova@keele.ac.uk*

### Abstract

Anti-plane shear of a semi-infinite multi-layered elastic plate is considered. The plate faces are assumed to be traction free, whereas the edge is subject to a prescribed shear stress. Integral decay conditions are derived. They ensure the localisation of the emerged stress field over a narrow edge vicinity of the order of plate thickness. One of these conditions expresses the canonical St Venant principle corresponding to a self-equilibrated load. The rest of the decay conditions are associated with homogeneous deformations of soft layers, and in contrast to the former exact condition, are of an asymptotic nature. The developed framework is implemented for the formulation of boundary conditions for 1D long-wavelength equations.

**Keywords:** high contrast, laminate, asymptotic, St Venant, decay, elastic

**Article Classification:** Scientific paper



## Nanoparticle-stabilized defect lattices in soft matter: Recent experimental advances

George Cordoyiannis<sup>1,2</sup>, Marta Lavrič<sup>1</sup>

*<sup>1</sup>Institut "Jožef Stefan", Ljubljana, Slovenia*

*E-addresses: georgios.kordogiannis@ijs.si, marta.lavric@ijs.si*

*<sup>2</sup>Czech Technical University in Prague, Czech Republic*

*E-address: georgios.kordogiannis@ijs.si*

### Abstract

Strongly-chiral liquid crystals often exhibit complex structures, such as the cholesteric blue phases and the twist-grain boundary phases. The periodicity of blue phases in visible wavelengths implies a high-potential for applications; however, the progress in this direction is hindered by the narrow temperature stability range of these structures. In order to surpass this obstacle and extend the blue phase thermal stability, several strategies have been explored, from chiral and polymer doping to nanoparticles' dispersion.

We show that various types of nanoparticles, of spherical and anisotropic shape, can be used to extend the temperature stability range of blue phases and twist-grain boundary phases [1]. The mechanisms behind this effect are briefly explained. Not only does the dispersion of nanoparticles increase the stability of these structures, but it also contributes additional functionalities that could trigger applications in the fields of sensing-, optical-, micro- and nanotechnologies.

### Reference

[1] G. Cordoyiannis, M. Lavrič, V. Tzitzios, M. Trček, I. Lelidis, G. Nounesis, S. Kralj, J. Thoen and Z. Kutnjak, *Nanomaterials* 11: 2968 (2021).

**Keywords:** liquid crystals, blue phases, twist-grain boundary phases, nanoparticles, quantum dots

**Article Classification:** Scientific paper



## Spectral response of incipient ferroelectrics

Anna Razumnaya<sup>1</sup>

<sup>1</sup>*Institut "Jožef Stefan", Ljubljana, Slovenia*  
*E-address: razumnaya1@gmail.com*

### Abstract

Ferroelectrics attract a deep interest due to the outstanding properties arising from the paraelectric-ferroelectric phase transition. Harvesting the nonlinear optical and dielectric properties with remarkable piezoelectric properties makes perovskite ferroelectrics promising for modern microelectronics. A quantum paraelectric SrTiO<sub>3</sub> is a material situated in close proximity to a quantum critical point of ferroelectric transition in which the critical temperature to ferroelectric state is suppressed down to 0 K. However, the understanding of the behaviour of the phase transition in the vicinity of this point remains challenging. Here we study the Pb-doped SrTiO<sub>3</sub> solid solutions to approach the pre-critical regions of the phase diagram and study the outcome of the coexistence of quantum fluctuations and thermal motion. It will allow the discovery of the novel phase statements and physical properties useful for practical applications.

**Keywords:** quantum paraelectrics; strontium titanate; crystal structure; lattice dynamics; dielectric response

**Article Classification:** Scientific paper



## Self-shaping liquid crystals

K. Peddireddy<sup>1,2</sup>, S. Čopar<sup>3</sup>, K. V. Le<sup>4</sup>, I. Muševič<sup>3,5</sup>, Ch. Bahr<sup>2</sup>, V. S. R. Jampani<sup>1,5,6</sup>

<sup>1</sup>Max Planck Institute for dynamics and self-organization, Germany  
E-addresses: vsrao.jampani@ijs.si, softmatter@vsrjampani.com

<sup>2</sup>University of San Diego, USA

<sup>3</sup>University of Ljubljana, FMF, Ljubljana, Slovenia

<sup>4</sup>Tokyo University of Science, Tokyo, Japan

<sup>5</sup>Institut "Jožef Stefan", Ljubljana, Slovenia  
E-addresses: vsrao.jampani@ijs.si, softmatter@vsrjampani.com

<sup>6</sup>University of Luxembourg, Luxembourg  
E-addresses: vsrao.jampani@ijs.si, softmatter@vsrjampani.com

### Abstract

Liquid crystals (LCs) are partially ordered functional oils primarily used in information display devices. The constituent molecular structure of an LCs plays a crucial role in the phase formation and achieving an external field-driven elastic response in the orientational order. Beyond flat panel displays, LCs also transformed into spherical droplets and shells when suspended in an immiscible medium like any other isotropic liquids dictated by the interfacial tension. Since the 1980's many reports have shown the possibility of transforming LC droplets into various non-spherical curved structures, mainly specific to particular combinations of LC materials surrounded by aqueous surfactants. This talk will present our recent work on reversibly transforming LC droplets into linear and branched structures at a fixed volume. In detail, we have used a key strategy of achieving dynamic interfacial tension using two surfactants—one is in the LC medium, and the other is in the continuous aqueous medium—for fully reversible shape transformation in all nematic LCs. Tuning the elastic constants with the temperature drives the LC droplet into controllable fiber structures with branches and back reversibly. The dynamic interfacial tension coupled to the bulk LC phase opens a new path: nematic to SmA LC phase transition driving the fiber structures into monodispersed micro-droplets, SmC phase opens the route to generating helical fibers with an equal probability of right and left-handed helices, and SmC\* phase shows life-like self-shaping LC shell structures analogous to the bio-membranes in living systems, for future applications.

**Keywords:** liquid crystals, self-shaping, interfacial tension, emulsions, surfactants

**Article Classification:** Scientific paper



## Izboljšanje oprijemljivosti metalizirane plasti

### Improving adhesion of metal-sprayed layer

Marica Prijanovič Tonkovič<sup>1</sup>, Mitja Železnik<sup>2</sup>

<sup>1</sup>Šolski center Novo mesto, Višja strokovna šola, Slovenija  
E-naslov: marica.prijanovic@sc-nm.si

<sup>2</sup>Šolski center Novo mesto, Slovenija  
E-naslov: zeleznik.mitja1@gmail.com

#### Povzetek

Metalizacija nam omogoča oplemenitenje površine osnovne kovine ali zlitine. Tako ima osnovni material večjo odpornost proti koroziji, obrabi ali eroziji. Na dober oprijem metalizirane plasti na obdelovanec vpliva kvalitetno pripravljena površina. To je čista površina s primerno hrapavostjo na površini izdelka, na katero se nanaša zaščitno plast.

Ustrezno hrapavost površine se lahko zagotovi s peskanjem. V naši preiskavi smo ugotavljali vpliv peskanja na oprijemljivost metalizirane plasti. Izvedli smo preizkuse, kjer smo spreminjali vrsto peskalnega medija, delovni tlak, peskalne šobe, obrabo peskalnega medija, metaliziranje in odpornost na korozijo.

Za preizkuse smo uporabili konstrukcijsko jeklo. Po izvedenih preizkusih smo merili hrapavost, oprijem prekrivne plasti in debelino nanosa prevleke. Na podlagi rezultatov meritev smo določili optimalne parametre peskanja in metalizacije ter tako zadovoljili zahtevano oprijemljivost in korozijsko obstojnost prevleke.

**Ključne besede:** peskanje, parametri, hrapavost, metaliziranja, oprijemljivost

**Razvrstitev:** Znanstveni članek

#### Abstract

Metallization allows us to refine the surface of the base metal or alloy. Thus, the base material has greater resistance to corrosion, wear or erosion. The quality of the prepared surface of the workpiece has an impact on the good adhesion of the metallized layer. The well-prepared surface has to be clean with appropriate roughness on which the protective layer is applied.

Appropriate surface roughness can be ensured by sandblasting. In our tests, we determined the influence of sandblasting on the adhesion of the metallized layer. We performed tests where we changed the type of blasting medium, working pressure, angle of blasting nozzles, wear of blasting medium, angle of metallization and corrosion resistance.

We used structural steel for the tests. After the tests we measured roughness, adhesion of the overlay and thickness of the coating. Based on the measurement results, we determined the optimal parameters of sandblasting and metallization and thus achieved the required adhesion and corrosion resistance of the coating.

**Key words:** sandblasting, parameters, roughness, metallization, adhesion

**Article Classification:** Scientific paper



## Barocaloric and electrocaloric effects in soft materials

Szymon Starzonek<sup>1</sup>, Sylwester J. Rzoska<sup>1</sup>, Aleksandra Drozd-Rzoska<sup>1</sup>, Andraž Rešetič<sup>2</sup>,  
Georgios Cordoyannis<sup>2</sup>

<sup>1</sup>*Institute of High Pressure Physics of the Polish Academy of Sciences, Warsaw, Poland*

*E-addresses: starzoneks@unipress.waw.pl; sylwester.rzoska@gmail.com; ola.drozdrzoska@gmail.com*

<sup>2</sup>*Institut "Jožef Stefan", Ljubljana, Slovenia*

*E-addresses: georgios.kordogiannis@gmail.com; andraz.resetic@ijs.si*

### Abstract

Electrocaloric effect is well known and studied in ceramic systems. On the other hand, barocaloric effect is widely studied in organic liquids. Both are useful for new cooling/heating high systems. In our work, we focused on these effects observed in soft materials (liquids, liquid crystals, polymers, elastomers). Combining high-pressure with temperature experiments allows to obtain a unique P-T results. Liquid-crystalline based systems exhibits a strong electric field response – called electrocaloric effect. Moreover, we observed strong barocaloric with electrocaloric effects in studied soft samples.

**Keywords:** barocaloric effect, electrocaloric effect, high pressure, soft matter

**Article Classification:** Scientific Paper



## Analiza nosilnih kovinskih konstrukcij

### Analysis of load-bearing metal structures

Mitja Muhič<sup>1</sup>

<sup>1</sup>Šolski center Novo mesto, Višja strokovna šola, Slovenija  
E-naslov: mitja.muhic@sc-nm.si

#### Povzetek

Prispevek obravnava nosilne kovinske konstrukcije in njihovo analizo nosilnosti. Pri analizi nosilnosti obravnavamo in vrednotimo napetosti in deformacije oz. pomike nosilnih materialov. Prikazan je analitičen in numeričen pristop izračuna napetosti in deformacij – pomikov. Analitičen pristop je mogoč za nosilne konstrukcije relativno enostavnih oblik in geometrij. Nosilne konstrukcije kompleksnih oblik in geometrij lahko preračunavamo s pomočjo aproksimativnih numeričnih analiz imenovanih Metoda končnih elementov (Finite element method - FEM). Metoda končnih elementov je vgrajena v programskih paketih za računalniško podprto konstruiranje (Computer aided design – CAD) in računalniško podprte inženirske analize (Computer aided engineering – CAE). V prispevku so prikazani primeri analiz nosilnih konstrukcij s programskim paketom CATIA, ki je najbolj razširjen v avtomobilski industriji. Analize prikazujejo vrednosti napetosti in deformacij pri določenih robnih pogojih in obremenitvah.

**Ključne besede:** Nosilne kovinske konstrukcije, Trdnost, Numerične analize, CAE, FEM

**Razvrstitev:** Strokovni članek

#### Abstract

The paper deals with load-bearing metal structures and their load-bearing capacity analysis. In the analysis of load-bearing capacity, we consider and evaluate stresses and deformations or displacements of load-bearing materials. An analytical and numerical approach to the calculation of stresses and strains - displacements is presented. An analytical approach is possible for load-bearing structures of relatively simple shapes and geometries. Load-bearing structures of complex shapes and geometries can be recalculated using approximate numerical analyzes called the Finite element method. The Finite element method (FEM) is built into the software packages for computer aided design (CAD) and computer aided engineering (CAE). The paper presents examples of analyzes of load-bearing structures with the CATIA software package, which is the most widespread in the automotive industry. Analyzes show values of stress and strain at certain boundary conditions and loads.

**Keywords:** load-bearing metal structures, strength, numerical analysis, CAE, FEM

**Article Classification:** Professional paper



## Uporaba tehnologije FDM za izdelavo tehnično zahtevnih izdelkov

### Using FDM technology to manufacture technically challenging parts

Tomaž Slapšak<sup>1</sup>

<sup>1</sup>*Šolski center Novo mesto Višja strokovna šola, Slovenija  
E-naslov: tomaz.slapsak@sc-nm.si*

#### Povzetek

Prispevek obravnava uporabe tehnologije 3D tiskanja, bolj specifično tehnologijo FDM, ki je komercialno najpogosteje uporabljena metoda na tem področju za pripravo tehnično zahtevnih izdelkov. Tehnologija FDM sicer ni novost na področju strojništva, vendar je v zadnjem desetletju doživela izjemen napredek in razcvet, ter popolnoma spremenila delo inženirja. Pri pripravi prispevka smo se osredotočili na uporabe tehnologije za izdelavo končnih kosov in v ta namen izdelali lasten 3D natisnjen električni skiro.

Za izbiro ustreznih materialov in postopka izdelava smo opravili izračune trdnosti, žilavosti, plastične deformacije itd. pod različnimi pogoji. Izdelava končnega produkta nakazuje, da so bile naše raziskave in teze pravilne in je tehnologija FDM prešla na raven konkurenčne tehnologije za izdelavo končnih kosov, kar nedvomno predstavlja revolucijo na tem področju, saj zaradi njene cenovne dostopnosti in visoki izkoriščenosti prostora pomeni, da je izdelava končnih kosov izjemno približanega vsakemu posamezniku.

**Ključne besede:** 3D tiskanje, FDM metoda, CAD, analiza trdnosti, analiza žilavosti, analiza plastične deformacije, električni skiro

**Razvrstitev:** Strokovni članek

#### Abstract

The paper discusses the use of 3D printing technology, more specifically FDM technology, which is the most commercially used method in this field for the preparation of technically demanding products. Although FDM technology is not new in the field of mechanical engineering, it has experienced tremendous progress and boom in the last decade, completely changing the work of an engineer. When preparing the contribution, we focused on the use of technology to produce final pieces and for this purpose produced our own 3D printed electric scooter.

To select the appropriate materials and manufacturing process, we performed calculations of strength, toughness, plastic deformation... etc. under different conditions. The production of the final product indicates that our research and theses were correct and FDM technology has moved to the level of competitive technology to produce final pieces, which undoubtedly represents a revolution in this field, because its affordability and high space utilization means that the production of final pieces extremely close to everyone.

**Keywords:** 3D printing, FDM method, CAD, strength analysis, toughness analysis, plastic deformation analysis, electric scooter

**Article Classification:** Professional paper





## Optimizacija hladilnega sistema orodja z uporabo 3D DMLS tehnologije

### Optimization of the tool cooling system using 3D DMLS technology

Matic Vogrin<sup>1,2</sup>, Aleš Adamlje<sup>2</sup>

<sup>1</sup>MARSi group d.o.o., Slovenija  
E-naslov: matic.vogrin@marsi.at

<sup>2</sup>Fakulteta za industrijski inženiring Novo mesto, Slovenija  
E-naslov: ales.adamlje@fini-unm.si, matic.vogrin@marsi.at

#### Povzetek

Optimizacija procesov z namenom ohranjanja konkurenčnosti na globalnem trgu je za dobavitelje izdelkov iz polimernih materialov postala stalna naloga. Eden ključnih elementov pri proizvodnji omenjenih izdelkov je orodje, še posebej pa oblikovni deli orodja. Zaradi vedno kompleksnejših izdelkov se za izdelavo oblikovnih delov orodja uporabljajo nove tehnologije, ki omogočajo izdelavo optimalnih funkcionalnih sestavnih delov orodja. Ena izmed pomembnejših novih tehnologij je aditivna tehnologija, ki se vse pogosteje uporablja za izdelavo oblikovnih delov orodij s trodimenzionalnimi hladilnimi kanali, ki sledijo obliki izdelka in jih s konvencionalnimi tehnologijami ne moremo izdelati. Najbolj uporabljena aditivna tehnologija, ki se uporablja za izdelavo oblikovnih delov orodja, je tehnologija laserskega spajanja slojev praškastega materiala – LPBF (*ang.* Laser Powder Bed Fusion).

V članku bo predstavljen primer kompleksne geometrije oblikovnega trna orodja za izdelavo plastičnega pokrova, pri katerem se je z uporabo aditivne tehnologije »neposrednega laserskega taljenja kovin – DMLS« znatno skrajšal proizvodni čas izdelave, hkrati pa se je povečala dimenzijska natančnost izdelka.

**Ključne besede:** optimizacija, injekcijsko brizganje, konformni hladilni sistem, tehnologija DMLS, orodni vložek

**Razvrstitev:** Strokovni članek

#### Abstract

Optimizing processes in order to maintain competitiveness on the global market has become a constant task for suppliers of products made of polymer materials. One of the key elements in the production of the aforementioned products are the tools, especially the tool parts. Since products are becoming more complex, new technologies are being used for the production of design parts of tools, which enable the production of optimal functional components of tools. One of the most important new technologies is additive technology, which is increasingly used for the production of tool parts with three-dimensional cooling channels that follow the shape of the product and cannot be produced with conventional technologies. The most widely used additive technology for the production of tool inserts is the "laser powder bed fusion technology – LPBF".

The article will present an example of the complex geometry of a tool part for the production of a plastic cover, in which the use of the "direct metal laser melting - DMLS" additive technology significantly reduced the production time, but the dimensional accuracy of the product was increased.

**Keywords:** optimization, injection molding, conformal cooling systems, DMLS technology, tool insert

**Article classification:** Professional paper



## Optimalna izbira tehnologije za izdelavo vpenjalne priprave uporabne za merjenje sil vzmeti

## Optimal selection of technology for making a clamping device useful for measuring spring forces

Kalčič Matej<sup>1</sup>, Marica Prijanovič Tonkovič<sup>2</sup>

<sup>1</sup>*Danfoss Trata, Slovenija*  
*E-naslov: matej.kalcic@danfoss.com*

<sup>2</sup>*Fakulteta za industrijski inženiring Novo mesto, Slovenija*  
*E-naslov: marica.prijanovic-tonkovic@fini-unm.si*

### Povzetek

Za izdelavo izdelkov se danes uporabljajo različne tehnologije. Pri tem je pomembno, da se proizvede kakovostne izdelke s čim manjšimi stroški. V naši raziskavi smo se ukvarjali z izdelavo namenske vpenjalne priprave, ki predstavlja del merilnika sile vzmeti v merilnem laboratoriju. Merjenje sil vzmeti je najpogostejši preizkus, ki se ga uporabi za določanje ustreznosti vzmeti glede na aplikacijo, kjer se vzmet uporablja.

Za izdelavo priprave smo revidirali različne tehnologije. Tako smo primerjali tri različne tehnologije in sicer tehnologijo 3D-tiska, injekcijsko brizganje ter klasično obdelavo CNC. Na osnovi primerjave med ceno in časom izdelave vpenjalne priprave smo jo izdelali s tehnologijo 3D-tiska po FDM postopku.

Ustreznost izdelave vpenjalne priprave smo validirali z dimenzijskimi meritvami. Rezultati meritev so potrdili skladnost z našimi zastavljenimi zahtevami na risbi, po kateri smo izdelali 3D-model. Izvedli smo tudi analizo merilnega sistema MSA, ki je potrdila stabilnost in ponovljivost skupnega merilnega sistema, katerega del je 3D natisnjena vpenjala priprava.

**Ključne besede:** CNC-obdelava, injekcijsko brizganje, FDM, 3D-tisk, izdelek, stroški

**Razvrstitev:** Strokovni članek

### Abstract

Various technologies are used to manufacture products today. Here, it is important to produce quality products with the lowest possible costs. In our research, we dealt with the production of a dedicated clamping device, which is part of the spring force tester in the measuring laboratory. Measuring spring forces is the most common test, which is used to determine the suitability of the spring for the application where the spring is used.

We revised different technologies suitable for making a clamping device. We compared three different technologies: 3D printing technology, injection molding and classic CNC machining. Based on the comparison between the price and the production time of the clamping device, we produced it using 3D printing technology, using the FDM process.

The adequacy of the production of the clamping device was validated by dimensional measurements. The results of the measurements confirmed its compliance with our set requirements on the drawing, according to which we made a 3D model. We also performed an analysis of the MSA measuring system, which confirmed the stability and repeatability of the common measuring system, which includes a 3D printed fixture.

**Keywords:** CNC machining, injection molding, FDM, 3D printing, product, cost

**Article Classification:** Professional Article



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**Trajnostne tehnologije**  
***Sustainable technologies***

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## Upoštevanje zahtev BAT smernic pri načrtovanju, izgradnji in obratovanju tehnoloških objektov

### Compliance with the requirements of the BAT guidelines in the planning, construction and operation of technological facilities

Darko Drev<sup>1</sup>, Mario Krzyk<sup>1</sup>

<sup>1</sup> Univerza v Ljubljani, Fakulteta za gradbeništvo in geodezijo, Inštitut za zdravstveno hidrotehniko, Slovenija  
E-naslovi: darko.drev@gmail.com, mario.krzyk@fgg.uni-lj.si

#### Povzetek

Zahtevo po upoštevanju najboljših razpoložljivih tehnologij z vidika varovanja okolja (BAT= best available techniques) je leta 1996 uvedla Direktiva 96/61/ES o celovitem preprečevanju in nadzoru onesnaževanja okolja. Direktiva 2010/75/EU pa je to problematiko definirala še bolj natančno. Katere so BAT tehnologije je podrobno definirano v BAT (BREF) smernicah, ki so priloga direktive. Obsegajo približno 18.000 strani. Države članice EU spremljajo razvoj novih okoljevarstvenih tehnologij in BAT smernice po potrebi posodablajo. Pri izdaji okoljevarstvenih, gradbenih in obratovalnih dovoljenj bi se morala preveriti skladnost izbranih tehnologij z zahtevami ustreznih BAT (BREF) smernic, oziroma izvesti primerjava tehnološkega načrta z zahtevami ustrezne BAT smernice. Takšno revizijo lahko izvede le ustrezen inženir, ki zelo dobro pozna obravnavano tehnologijo ter procese načrtovanja, izgradnje in obratovanja objektov. Uporaba BAT tehnologij se navadno v končni fazi pokaže ustrezno tudi kot ekonomsko najprimernejša rešitev. V prispevku smo prikazali nekaj primerov dobre in slabe prakse pri uporabi BAT tehnologij v Sloveniji.

**Ključne besede:** Najboljše razpoložljive tehnologije, BAT, varovanje okolja, ekonomsko primerne rešitve

**Razvrstitev:** Znanstveni članek

#### Abstract

The requirement to consider the best available technology from the point of view of environmental protection (BAT) was introduced in 1996 by Directive 96/61 / EC concerning integrated pollution prevention and control. Directive 2010/75 / EU has defined this issue even more precisely. BAT technologies are defined in detail in the BAT (BREF) guidelines attached to the directive. They comprise about 18,000 pages. EU member states monitor the development of new environmental technologies and update the BAT guidelines as needed. When granting environmental, construction and operating permits, the compliance of selected technologies with the requirements of the corresponding BAT (BREF) guidelines should be verified or a comparison of the technological plan with the requirements of the corresponding BAT guidelines should be performed. Such a review can only be performed by an appropriate engineer who is very familiar with the technology in question and the design, construction, and operational processes. The use of BAT technologies usually proves to be the most economically appropriate solution in the final phase. The article presents some examples of good and bad practices in the use of BAT technologies in Slovenia.

**Keywords:** Best available technologies, BAT, environmental protection, economically viable solutions

**Article Classification:** Scientific paper



## Elastocaloric Fatigue of Liquid Crystal Elastomers

Matic Morgan<sup>1</sup>, Zdravko Kutnjak<sup>1</sup>, Brigita Rožič<sup>1</sup>

<sup>1</sup>*Institut "Jožef Stefan",, Jožef Stefan International Postgraduate School, Slovenia  
E-addresses: matic.morgan@ijs.si, zdravko.kutnjak@ijs.si, brigita.rozic@ijs.si*

### Abstract

With an increase in environmental awareness, we have seen a surge in the search for environmentally friendlier heat-management devices. Liquid crystal elastomers (LCEs) show some promising properties for the development of eco-friendly cooling devices with low energy consumption.

It has been shown experimentally that LCEs produce a noticeable temperature difference when observing the elastocaloric effect. Here we report initial measurements of the fatigue of LCEs. Several LCE samples were stretched and retracted for varying amounts of times and their mechanical and thermodynamical properties were measured along the way. A downward drift in the isotropic-nematic phase transition was observed, as well as an increase in the obtained elastocalorically induced temperature difference. Several thousand cycles of stretching and retracting were performed without any significant wear of the LCEs. We observed that longer samples tore significantly less and could withstand many more cycles than shorter samples. LCEs with different chemical parameters were tested and compared.

These findings are a positive step towards our final goal of creating a working heat-management device with LCEs as the working material and a regenerative cycle for increased efficiency.

**Keywords:** liquid crystal elastomers, elastocaloric effect, heat-management, novel materials, solid-state cooling, alternative cooling technology

**Article Classification:** Scientific paper



## Razvoj in uporabnost inteligentnih sistemov v logistiki

### Development and usefulness of intelligent systems in logistics

Sašo Murtič<sup>1</sup>, Ingrid Franko Uhernik<sup>1</sup>

<sup>1</sup>Fakulteta za industrijski inženiring Novo mesto, Slovenija  
E-naslovi: saso.murtic@fini-unm.si, ingrid.frankouhernik@fini-unm.si

#### Povzetek

V članku bodo na kratko predstavila prepoznavne postopke, razvoj in uporabnost inteligentnih sistemov, ki so skozi primere dobre prakse uporabljeni v avtomatskem sprejemanju pošiljk s sistemom DWS - Dimensioning Weighing Scanning in sicer v podjetjih, ki se ukvarjajo z manipulacijo pošte in poštnih pošiljk. Inteligentni sistemi DWS - Dimensioning Weighing Scanning so v industriji primerni za nabavo, razvrščanje, skladiščenje ter pošiljanje posameznih surovin, polizdelkov ali izdelkov za montažo končnega produkta industrije. Področje raziskave sva usmerila v iskanje sistemov, ki so sposobni obvladovati naraščanje prometa paketnih storitev, ki ga poštne organizacije morajo obvladovati, obenem poštne organizacije stremijo k čim večji produktivnosti ter sledijo trendom avtomatizacije delovnih procesov. Raziskava je usmerjena v proučevanje tistih logističnih sistemov DWS – Dimensioning Weighing Scanning, ki so uporabni v področju sprejema in pošiljanja pošte, pri čemer jih uporabljajo za sprejem paketov pogodbenih strank, s katerimi poštne organizacije imajo sklenjene dolgoročne pogodbe za oddajo paketov. DWS sistem je sestavljen iz večjih programskih sklopov ali gradnikov, ki so namenjeni komunikaciji med sestavnimi deli DWS (SICK/SIEMENS) sprejemnega sistema in internim sistemom PS. Predstavljena je uporabnost inteligentnih sistemov, ki so po svoji tehnološki izvedbi zelo uporabni in dokaj prilagodljivi na različnih področjih industrije, druge proizvodnje ali celo oblikah storitvene dejavnosti na različnih področjih. Skozi raziskavo smo ugotovili, da so v poštnih organizacijah z uvedbo DWS v veliki meri racionalizirali postopke sprejema paketov, z manj delavci so v krajšem času in s pomočjo sistema sprejeli oziroma na sprejemu obdelali bistveno večje število paketov, s čemer so dvignili produktivnost organizacije. Uporaba DWS - Dimensioning Weighing Scanning omogoča boljšo, hitrejšo in konkurenčno ponudbo na trgu.

**Ključne besede:** logistika, inteligentni sistemi, uporabnost in prilagodljivost

**Razvrstitev:** Znanstveni članek

#### Abstract

In this article, we will briefly present the recognizable procedures, development and usability of intelligent systems, which through examples of good practice are used in automatic acceptance of shipments with DWS - Dimensioning Weighing Scanning, namely in companies engaged in mail and mail manipulation. DWS - Dimensioning Weighing Scanning intelligent systems are suitable in the industry for the purchase, sorting, storage and shipment of individual raw materials, semi-finished products or products for the assembly of the final product of the industry. We focused our research on finding systems that are able to cope with the growing traffic of parcel services that postal organizations need to manage, while postal organizations strive for maximum productivity and follow the trends of workflow automation. We focused our research on those DWS - Dimensioning Weighing Scanning logistics systems that are useful in the field of receiving and sending mail, using them to receive parcels from contracting parties with which postal organizations have long-term parcel delivery contracts. The DWS system consists of major software packages or widgets intended for communication between the components of the DWS (SICK / SIEMENS) receiving system and the internal PS system. We present the usefulness of intelligent systems, which are very useful in terms of their technological implementation and quite flexible in various fields of industry, other production or even forms of service activity in various fields. packages, with fewer employees in a shorter time and with the help of the system received or processed a significantly larger number of packages at the reception, which increased the productivity of the organization. Using DWS - Dimensioning Weighing Scanning enables a better, faster and more competitive offer on the market.

**Keywords:** logistics, intelligent systems, usability and flexibility

**Article Classification:** Scientific Paper



## Priprava suhega zraka za namen zahtevnih tehnoloških procesov

### Preparation of dry air for the purpose of challenging technological processes

Anton Nemanič<sup>1</sup>, Damjan Balabanič<sup>2</sup>

<sup>1</sup>Krka d.d., Slovenija  
E-mail: anton.nemanic@krka.biz

<sup>2</sup>Fakulteta za industrijski inženiring Novo mesto, Slovenija  
E-mail: damjan.balabanic@fini-unm.si

#### Povzetek

V industriji se pripravlja zrak na ustrezne parametre s pomočjo klimatskih naprav. Če želimo zrak uporabiti v tehnološkem procesu, ga je treba razvlažiti. Razvlaževanje zraka poteka na različne načine. Bolj smotrno je razvlaževanje zraka s klimatskim sistemom v prvi stopnji, kjer nastopata hladilna voda in glikolska mešanica, kot pa razvlaževanje zraka samo s hladilno vodo. Če razvlažujemo s pomočjo glikolskega hlajenja, podaljšamo življenjsko dobo sušilnemu kolesu. Glikolsko razvlaževanje zraka zmanjša obratovalne stroške in je okoljsko bolj sprejemljivo kot pa razvlaževanje le s sušilnim kolesom.

Z učinkovitim razvlaževanjem zraka dosežemo ustrezne parametre zraka, ki nam jih diktirajo zahtevni tehnološki procesi, ki bazirajo na ustrezno pripravljenem zraku in se največkrat pojavljajo v kemijski, živilski, avtomobilski in farmacevtski industriji. Ti procesi zahtevajo stopnjo absolutne vlažnosti zraka pod 0,5 g/kg, kar je s klasičnim razvlaževanjem nemogoče doseči.

S teoretičnim in empiričnim pristopom proučujemo ustrezen način razvlaževanja zraka. Na osnovi vsega skupaj se izdelava izračun, ki temelji na termodinamičnih zakonitostih, pri tem se poslužujemo tudi praktičnih izkušenj, ki temeljijo na osnovi obstoječega stanja.

**Ključne besede:** glikolska mešanica, granulacija, klimatski sistem, priprava zraka, suh zrak, tehnološki proces

**Razvrstitev:** Znanstveni članek

#### Abstract

We use HVAC systems in the industry to reach the required parameters of air. Air must be dehumidified if it is to be used in a technological process. Dehumidification can be done in several ways. Dehumidification of the air by the HVAC system using a glycol-water mixture at the first stage is more rational than dehumidification by cooling water only. Dehumidification by glycol cooling extends the service life of a drying wheel. Air dehumidification by glycol brings down operation costs and is more acceptable environment-wise than dehumidification exclusively by a drying wheel.

We achieve the required air parameters essential for the demanding technological processes by effective air dehumidification. The demanding technological processes in chemical, food, automotive, and pharmaceutical industries most often rely on suitably prepared air. They require absolute air humidity rates below 0.5 g/kg, which can not be achieved by standard dehumidification. We take theoretic and empirical approaches to finding the optimal ways for air dehumidification. Taking all that into account, we do calculations based on thermodynamic properties and also consider the empiric experience from the existing practices.

**Keywords:** glycol mixture, granulation, HVAC system, air preparation, dry air, technological process

**Article Classification:** Scientific paper



## Visokozmogljivo računanje optimalnega prileganja 3D objektov

### High-performance computation of optimum matching of 3D scans

Jožica Piškur<sup>1</sup>, Marko Rudolf<sup>1</sup>, Andrej Dobrovoljc<sup>1</sup>, Janez Povh<sup>1</sup>

<sup>1</sup>Razvojni center Novo mesto d.o.o., Slovenija

E-naslovi: jozica.piskur@rc-nm.si, marko.rudolf@rc-nm.si, andrej.dobrovoljc@rc-nm.si, janez.povh@rc-nm.si

#### Povzetek

V prispevku bomo predstavili rezultate projekta, v katerem smo razvili rešitev za visokozmogljivo računanje optimalnega prileganja 3D objektov. Pred računanjem optimalnega prileganja se je ustvaril 3D posnetek željenega izdelka, katerega se je dodalo v bazo podobnih izdelkov (npr. rezkalnih svedrov). Pri računanju pa smo v bazi 3D objektov iskali najboljši približek oz. ujemanje zadnje skeniranemu 3D objektu. 3D objekte imamo shranjene v formatu STL. Kakovost poravnave (ujemanja) dveh 3D objektov merimo z RMSE (root-mean-square).

Obstoječa programska okolja omogočajo enostaven zajem, obdelavo in primerjavo dveh 3D objektov. Zelo zamuden in neefektiven pa takšen postopek postane, če želimo 3D objekt primerjati z 10 ali več 3D objekti iz baze, kaj šele, če je baza velika nekaj 1000 – ena primerjava traja 1-6 minut, 1000 primerjav pa vsaj 1000-krat dlje. K problemu smo pristopili na dva načina. V obeh načinih uporabljamo programsko okolje Spyder, ki je osnovna platforma za programski jezik Python. V prvem načinu problem rešujemo z uporabo knjižnice macro recorder, kjer smo pred-definirane klike in ukaze s pomočjo tipkovnice v programskem okolju Geomagic Design X 2022 združili v izvršljivo datoteko. To je izboljšalo časovno učinkovitost, saj ni bilo potrebe po ročnem izvajanju ukazov preko grafičnega vmesnika. V drugem načinu pa ne uporabljamo okolja Geomagic, ampak problem analize in primerjave rešujemo znotraj Python skripte z uporabo knjižnic trimesh, registration ter proximity, kjer vsak par 3D skenov oz. objektov poravnamo in izvršimo primerjavo. Vse skupaj smo aplicirali na realnem primeru primerjave 3D objektov rezkalnih svedrov za enega od industrijskih naročnikov.

**Ključne besede:** 3D skeniranje, Python, Geomagic Design X, rezkar, sveder

**Razvrstitev:** Strokovni članek

#### Abstract

In this paper, we will present the results of a project in which we developed a solution for high-performance computation of the optimal fit of 3D objects. Before computing the optimal fit, a 3D snapshot of the desired product was created and added to a database of similar products (e.g., milling drills). The 3D objects are stored in STL format. The quality of the alignment (match) of two 3D objects is measured by RMSE (root-mean-square).

Existing software environments make it easy to capture, process and compare two 3D objects. However, it becomes very time-consuming and inefficient to compare a 3D object with 10 or more 3D objects from a database, let alone a database of several 1000 objects - one comparison takes 1-6 minutes, and 1000 comparisons take at least 1000 times longer. We approached the problem in two ways. In both ways we use the Spyder programming environment, which is the underlying platform for the Python programming language. In the first way, the problem is solved using the macro recorder library, where predefined clicks and keyboard commands are compiled into an executable file in the Geomagic Design X 2022 programming environment. This improved time efficiency as there was no need to manually execute commands via the GUI. In the second mode, we do not use the Geomagic environment, but solve the analysis and comparison problem within a Python script using library trimesh, registration and proximity, where each pair of 3D scans or objects is aligned, and the comparison is executed. We have applied all this to a real-world example of comparing 3D objects of milling drills for an industrial client.

**Keywords:** 3D scans, Python, Geomagic Design X, cutting drill

**Article Classification:** Professional paper





## Ergonomski vakuumski dvizni sistemi

### Ergonomic vacuum lifters

Boštjan Fortuna<sup>1</sup>

<sup>1</sup>J. Schmalz GmbH, Nemčija  
E-naslov: Boštjan.Fortuna@schmalz.com

#### Povzetek

Večina delovnih procesov še vedno vključuje določene oblike ročne manipulacije bremen. Neprimerne tehnike, neustrezne ergonomske razmere na delovnem mestu in visoke frekvence ponavljajočih gibov so pogosto vzrok poškodb pri delu in predstavljajo veliko tveganje za zdravje zaposlenih. Bolečine v hrbtu so najpogostejša zdravstvena težava v EU za odsotnost z dela. S pomočjo različnih organizacijskih in tehničnih ukrepov lahko zmanjšamo tveganja za varnost in zdravje delavca.

Vakuumski dvizni sistemi zagotavljajo ergonomsko delovno okolje. Pomagajo preprečiti zdravstvene težave, ki nastanejo zaradi dvigovanja in premikanja težkih bremen. Pri podjetju Schmalz proizvajamo rešitve vakuumskih dviznih sistemov iz aluminijastih komponent. Sodobni žerjavni sistemi tudi kot samostojna rešitev, nudijo lahke premike z uporabo zelo majhne sile in podpirajo ergonomsko delo operaterja. Ergonomija delovnega mesta in produktivnost zaposlenih sta tesno povezani. Ljudje potrebujejo pomoč pri ravnanju s tovorom, še posebej, če se ta tovor premika ročno. Predstavljena bo uporaba intuitivnih in enostavnih vakuumskih dviznih rešitev, ki pomagajo zaposlenim zmanjšati fizično obremenitve, katere povzročajo številni ponavljajoči se premiki, vključeni v proizvodne, montažne in logistične procese. To prispeva k izboljšanju zdravja zaposlenih in jim omogoča varčevanje z energijo. Hitrejše rokovanje, ki ga omogočajo vakuumske dvizne rešitve, prav tako pospešuje pretok materiala in vodi k večji produktivnosti.

**Ključne besede:** ergonomija, vakuum, manipulacija, dvizni sistemi, varnost, učinkovitost, zdravje, produktivnost

**Razvrstitev:** Strokovni članek

#### Abstract

Most work processes still involve certain forms of manual load handling. Improper techniques, inadequate ergonomic conditions in the workplace, and a high frequency of repetitive movements are often the cause of injuries at work and pose a major risk to the health of employees. Back pain is the most common health problem for absence from work in EU. With the help of various organizational and technical measures, we can reduce risks to the safety and secure health of the workers.

Vacuum lifting systems provide an ergonomic working environment. They help prevent health problems caused by lifting and moving heavy loads. At Schmalz, we produce vacuum lifting system solutions that are fully compatible with crane systems made of aluminum components. Modern crane systems also as a stand-alone solution, offer shifts using very low operator force and support ergonomic work. Ergonomics workplace and employee productivity are closely linked. People need help handling a load, especially if that load is being moved by hand. In paper will be presented the use of intuitive and simple vacuum lifting solutions which helps employees reduce the physical strain caused by the many repetitive shifts involved in the production, assembly and logistics processes. This contributes to improving the health of employees and enables them to save energy. Faster handling, enabled by our solutions, also speeds up material flow and leads to higher productivity.

**Keywords:** ergonomics, vacuum, manipulation, lifting systems, safety, efficiency, health, productivity

**Article Classification:** Professional paper



## Ocena točnosti in dolgoročne stabilnosti merilnika koncentracije ogljikovega dioksida

### Evaluation of accuracy and long term stability of carbon dioxide concentration meter

Mitja Veber<sup>1</sup>

<sup>1</sup>Šolski center Novo mesto, Slovenija  
E-naslov: mitja.veber@sc-nm.si

#### Povzetek

Običajna koncentracija ogljikovega dioksida v zraku je 400 ppm, pri višjih koncentracijah pa že govorimo o slabem zraku. Koncentracija CO<sub>2</sub> predstavlja tudi mero za spremljanje koncentracije drugih trdih in kapljevinskih delcev v zraku. Učinkovito prezračevanje zato prištevamo med glavne inženirske ukrepe za preprečevanje aerogenega prenosa mikroorganizmov. Izvajanje teh ukrepov je postalo še posebej pomembno po izbruhu COVID-19. Na podlagi priporočil Svetovne zdravstvene organizacije (WHO), so pri Evropskem združenju za ogrevanje, prezračevanje in klimatizacijo (REHVA) pripravili praktične nasvete za prezračevanje stavb, ki jih je v svoja priporočila vključil tudi Nacionalni inštitut za javno zdravje (NIJZ). V priporočilih je bilo zapisano, naj se vsaj v učilnice, v katerih je prezračevanje odvisno od odpiranja oken, namesti merilnik CO<sub>2</sub> s prikazom »semaforja« s katerim se vizualizira potreba po dodatnem prezračevanju. Na Šolskem centru Novo mesto smo se zato odločili, da razvijemo lasten merilnik in semafor, ki bo prek Wi-Fi omrežja Eduroam povezan na centralni strežnik za spremljanje delovanja in beleženje podatkov. V študijo smo vključili 12 merilnikov, ki smo jih pred namestitvijo v prostore umerili. Po umerjanju je sledilo vrednotenje točnosti, pri katerem smo primerjali odzive našega merilnika z referenčnim merilnikom koncentracije CO<sub>2</sub> in deklarirano točnostjo proizvajalca senzorja, za celotno merilno območje. Sledila je namestitev merilnikov v dvanajst učilnic, kjer so ostali dobra dva meseca. Po odstranitvi začasno nameščenih merilnikov smo z namenom ugotavljanja dolgoročne stabilnosti ponovili postopek vrednotenja točnosti. V prispevku bomo podali oceno točnosti in dolgoročne stabilnosti našega merilnika in opredelili njegovo uporabnost za ciljni namen.

**Ključne besede:** merjenje, CO<sub>2</sub>, točnost, lezenje

**Razvrstitev:** Strokovni članek

#### Abstract

The usual concentration of carbon dioxide in the air is 400 ppm, and at higher concentrations we are already talking about bad air. The concentration of CO<sub>2</sub> is also a measure for monitoring the concentration of other solid and liquid particles in the air. Effective ventilation is therefore considered one of the main engineering measures to prevent the aerogenic transfer of microorganisms. The implementation of these measures has become especially important after the outbreak of COVID-19. Based on the recommendations of the World Health Organization (WHO), the European Association for Heating, Ventilation and Air Conditioning (REHVA) prepared practical advice for the ventilation of buildings, which was also included in recommendations prepared by the National Institute of Public Health (NIJZ). In the recommendations, it was written that, at least in the classrooms in which ventilation depends on opening the windows, a CO<sub>2</sub> meter should be installed with a "traffic light" display that visualizes the need for additional ventilation. At the Novo mesto School Center, we therefore decided to develop our own meter and traffic light, which will be connected to the central server via the Eduroam Wi-Fi network for monitoring performance and recording data. We included 12 meters in the study, which were calibrated before being installed in the premises. After the calibration, an accuracy evaluation followed, in which we compared the responses of our meter with a reference CO<sub>2</sub> concentration meter and the declared accuracy of the sensor manufacturer, for the entire measurement range. This was followed by the installation of meters in twelve classrooms, where they remained for two months. After removing the temporarily installed gauges, we repeated the accuracy evaluation process in order



to determine the long-term stability. In this paper, we will give an assessment of the accuracy and long-term stability of our meter and define its usefulness for the intended purpose.

**Keywords:** measurement, CO<sub>2</sub>, accuracy, creep

**Article Classification:** Professional paper



## Odpravljanje izbrizgov pri uporovnem varjenju

### Elimination of weld spatters in resistance welding

Robert Strahinič<sup>1</sup>, Marko Malnarič<sup>2</sup>, Vili Malnarič<sup>3</sup>

<sup>1</sup>TPV Automotive d.o.o., Slovenija  
E-naslov: r.strahinic@tpv.si

<sup>2</sup>TPV Automotive d.o.o., Slovenija  
E-naslov: m.malnarič@tpv.si

<sup>3</sup>SiEVA d.o.o. PE Novo mesto, Slovenija  
E-naslov: v.malnarič@tpv.si

#### Povzetek

Uporovno bradavičasto varjenje je proces pri katerem s pomočjo toplote, ki nastane zaradi notranje električne upornosti materiala, in tlaka v nerazdružljivo celoto spojimo dva kosa. En od pogostih izzivov pri tem procesu je pojava izbrizgov na površinah, ki so pomembne za funkcijo tega izdelka. Pri tem ima enega od največjih vplivov hitrost sledenja pomične elektrode, saj mora ob nenadnem taljenju materiala zvarjencev pomična elektroda v zelo kratkem času temu slediti, kar je povezano z visokim pospeškom gibljivih delov. Z namenom primerjanja dinamike gibanja pri različnih režimih varjenja, so bili na gibljivi elektrodi s pomočjo pospeškmera pomerjeni pospeški iz katerih je bil nato določen časovni potek pomikov. Na podlagi rezultatov meritev je bila skonstruirana optimirana gibljiva elektroda z vgrajenimi mehanizmom podprtim s krožnikastimi vzmetmi, ki ima zaradi inovativne zasnove veliko manjšo vztrajnost gibljivih delov v primerjavi s staro obliko elektrode in posledično bistveno bolje sledi dinamiki varilnega procesa.

**Ključne besede:** uporovno bradavičasto varjenje, izbrizgi, merjenje pospeškov, vztrajnost, krožnikaste vzmeti

**Razvrstitev:** Strokovni članek

#### Abstract

Resistance projection welding is a process in which two pieces are joined into an inseparable whole by means of the heat generated by the internal electrical resistance of the material and external pressure. One of the common challenges in this process is the occurrence of the weld spatters on the surfaces that are important for the function of this product. Due to the rapid melting of the material during welding, a proper electrode follow-up motion must be ensured. That means that large accelerations occur at the moving electrode. In order to compare the dynamics of different welding regimes, the accelerations were measured at the moving electrode. Using numerics, measured accelerations were converted into displacements. Based on the measurement results, an optimized moving electrode was constructed. The new electrode design has built-in Belleville spring mechanism which reduces the inertia of the system and has a significantly better follow-up motion.

**Keywords:** Resistance projection welding, weld spatters, acceleration measurement, inertia, Belleville springs

**Article Classification:** Professional paper



## Pomen DFMA pri dizajniranju lahkih izdelkov v avtomobilski industriji

### Importance of DFMA in designing lightweight automotive products

Davor Tramte<sup>1</sup>, Tomaž Savšek<sup>2</sup>, Jurij Švegelj<sup>3</sup>

<sup>1</sup>TPV Automotive d.o.o., Slovenija  
E-naslov: d.tramte@tpv.si

<sup>2</sup>Fakulteta za industrijski inženiring Novo mesto, Slovenija  
E-naslov: tomaz.savsek@fini-unm.si

<sup>3</sup>TPV Automotive d.o.o., Slovenija  
E-naslov: j.svegelj@tpv.si

#### Povzetek

Lahka gradnja je eden izmed ključnih trendov v avtomobilski industriji zadnjih nekaj desetletij. Slednje je predvsem posledica regulative, ki proizvajalce s cilji za zmanjšanje izpustov CO<sub>2</sub> sili k zmanjšanju mase vozil in je aktualna zaradi povečanja dosegov električnih vozil. V osnovi je cilj dizajniranja po principih lahke gradnje doseči čim nižjo maso izdelka pri danih robnih pogojih. V praksi se predvsem v zgodnjih razvojnih fazah izkaže, da robni pogoji zajemajo funkcijske in prostorske zahteve, tehnološke pa se pogosto zanemarja. Resnično uspešne lahke produkte lahko dobimo, če smernice dizajna za izdelavo in sestavo (DFMA) upoštevamo že v najzgodnejših fazah. Tako smo za naročnika v fazi razvoja koncepta prednje obese najprej definirali tehnološke robne pogoje in integrirali različna izkustvena in programska procesna vrednotenja v ključne razvojne stopnje izdelka. Taka razvojna zasnova novega koncepta je omogočila ohranitev funkcionalnosti in nizke mase naročnikovega izhodiščnega koncepta ter njegovo bistveno izboljšanje v smislu izvedljivosti za izdelavo.

**Ključne besede:** AHSS, AutoForm, DFMA, lahka gradnja, MacPherson vzmetenje, MKE, prednja obesa

**Razvrstitev:** Strokovni članek

#### Abstract

Lightweight design has been the key trend of the automotive industry for the past couple of decades. As regulations demand reduced CO<sub>2</sub> emissions, manufacturers are forced to decrease vehicle weight which is also relevant for extending EV range. In essence, the goal of lightweight design is minimal product weight within the given boundary conditions. In practice, boundary conditions in early development stages usually entail functional and spatial requirements, whereas technological are often neglected. Taking design for manufacture and assembly guidelines (DFMA) into account at the earliest development stages results in successful lightweight products. Therefore, we have first defined technological boundary conditions and integrated various experience and software-based technological evaluations at key product development stages when designing a front control arm concept for our client. By using this approach to new concept development, we kept the functionality and low weight of the initial client concept but significantly improved its manufacturability.

**Keywords:** AHSS, AutoForm, DFMA, lightweight design, MacPherson suspension, FEM, front control arm

**Article Classification:** Professional paper



## Primer študije digitalizacije prilagojene ponudbe trgovca z živili z uporabo storitev v oblaku

### Case study on the digitalisation of a personalised offer of a retailer using cloud services

Tomaž Aljaž<sup>1</sup>, Albert Zorko<sup>2</sup>

<sup>1</sup>Fakulteta za industrijski inženiring Novo mesto, Slovenija  
E-naslov: tomaz.aljaz@fini-unm.si

<sup>2</sup>Fakulteta za informacijske študije v Novem mestu, Slovenija  
E-naslov: albert.zorko@fis-unm.si

#### Povzetek

Podjetja na informacijsko tehnologijo gledajo kot na konkurenčno prednost prihodnosti. V zadnjih letih se je izkazalo, da imajo IT rešitve pomemben vpliv na izboljšanje poslovnih procesov in zadovoljstvo strank ter omogočajo organizacijam konkurirati na svetovnem trgu. Trgovci z živili niso izjema. Običajno stranke dobimo splošne, tedenske ponudbe, z izdelki v promocijah. Le-te niso prilagojena za posamezno stranko, temveč gre za širši izbor izdelkov. V članku je predstavljena rešitve prilagojene ponudbe kot dodatek rednim splošnim tedenskim ponudbam, ki so na razpolago strankam večje trgovske verige. Rešitev vključuje digitalizacijo in avtomatizacijo izdelave letakov za promocije in prilagojene ponudbe. Omogoča pošiljanje ponudbe na več kanalov, od katerih so najbolj pomembne mobilna aplikacija, elektronska pošta ali fizični letaki. To je doseženo s strojnimi učenjem preteklih nakupov strank in integracijo podatkov med ERP sistemom in storitvami v oblaku, ter pošiljanje le-teh na različne kanale.

**Ključne besede:** računalništvo v oblaku, strojno učenje, digitalizacija poslovanje, informacijska tehnologija, personalizacija

**Razvrstitev:** Strokovni članek

#### Abstract

Businesses see Information Technology (IT) as the competitive advantage of the future. In recent years, IT solutions have proven to have a significant impact on improving business processes and customer satisfaction, enabling organisations to compete in the global marketplace, retailers are no exception. Typically, customers are given general, weekly offers, with products on promotions. These are not tailored to the individual customer but are covering a broader range of products. This paper presents a customised offer solution as a complement to the regular generic weekly offers available to customers of a major retail chain. The solution involves digitising and automating the production of flyers for promotions and personalised offers. It allows the offer to be sent via several channels, the most important of which are the mobile application, email, or physical leaflets. This is achieved by machine learning of customers' past purchases and data integration between the ERP system and cloud services and sending them to different channels.

**Keywords:** Cloud Computing, machine learning, digitalization, information technology, personalization

**Article Classification:** Professional paper



## Izboljšana metoda določanja vzdolžnega profila vozišča na osnovi vertikalnih nihanj merilnega vozila

### Improved method for determining the longitudinal profile of the road based on the vertical oscillations of the measuring vehicle

Miroslav Adlešič<sup>1</sup>, Darko Kokot<sup>1</sup>, Damir Vrančič<sup>2</sup>

<sup>1</sup>Zavod za gradbeništvo Slovenije (ZAG), Slovenija  
E-naslov: miroslav.adlesic@zag.si, darko.kokot@zag.si

<sup>2</sup>Institut "Jožef Stefan", Ljubljana, Slovenia  
E-naslov: damir.vrancic@ijs.si

#### Povzetek

Vzdolžna ravnost voznih površin je karakteristika, ki poleg varnosti in udobnosti vožnje postaja vedno bolj pomembna tudi s stališča gospodarjenja s cestnim omrežjem. V Sloveniji stanje vzdolžne ravnosti vrednotimo z indeksom neravnosti IRI (International Roughness Index), ki je v svetu najpogostejša mera za oceno vzdolžne ravnosti vozne površine. Na Zavodu za gradbeništvo Slovenije (ZAG) uporabljamo za ugotavljanje vzdolžne ravnosti voznih površin lastno merilno napravo ZAG-VP (ZAG-Vzdolžni Profilometer). Rezultat meritve je neprekinjen zapis vzdolžnega profila vozišča na podlagi katerega izračunamo indeks IRI. Kakovostno izmerjen vzdolžni profil vozne površine je zato ključnega pomena za objektivno oceno stanja ravnosti vozne površine. V članku je predstavljena analiza merilne zmogljivosti naprave ZAG-VP, ki temelji na uporabi izboljšane metode določanja vzdolžnega profila vozišča. Metoda omogoča neposredno primerjavo izmerjenega ZAG-VP profila z referenčnim – geodetsko posnetim profilom. Ključni cilj raziskave je bil ugotoviti merilno natančnost in točnost naprave s pomočjo analize rezultatov meritev na testnem cestnem odseku ob upoštevanju zahtev veljavnih mednarodnih standardov ter na osnovi ugotovitev uvrstiti napravo ZAG-VP v točnostni in natančnostni razred po klasifikacijski metodi ASTM E950/E950M. V raziskavi smo z opredelitvijo potencialnih virov merilne negotovosti ocenili tudi velikost skupne merilne negotovosti izmerjenega vzdolžnega profila vozišča in podali predloge za njeno lažje obvladovanje ter nakazali smernice morebitnega nadaljnjega razvoja merilne naprave ZAG-VP.

**Ključne besede:** vzdolžni profil ceste, vzdolžna ravnost, vertikalno nihanje vozila, udobnost vožnje, meritve

**Razvrstitev:** Strokovni članek

#### Abstract

The longitudinal evenness of the road surface is a measure that is becoming increasingly important for the management of the road network. In Slovenia, longitudinal evenness is assessed with the International Roughness Index (IRI), which is the most common measure of longitudinal evenness of road surfaces worldwide. The Slovenian Building and Civil Engineering Institute (ZAG) uses a self-developed measuring device, the ZAG-VP, to determine the longitudinal profile of a road surface. The result of the measurement is a continuous record of the longitudinal profile of the road, which is used to calculate the IRI. A high quality measurement of the profile is therefore essential for an objective assessment of the condition of the road surface. This paper presents an analysis of the performance of ZAG-VP based on the improved method for determining the longitudinal profile of the road. The method allows a direct comparison of the measured profile with a reference profile provided geodetically. The main objective of the study was to determine the measurement accuracy and precision of the device by analysing the measurement results on a test road section, taking into account the requirements of the applicable international standards and to classify the ZAG-VP device in the class of accuracy and precision according to ASTM E950/E950M. In the study, by identifying potential sources of measurement uncertainty, we also assessed the magnitude of the overall measurement uncertainty, we made suggestions to improve device management, and provided guidelines for the possible further development of the ZAG-VP.

**Keywords:** road longitudinal profile, longitudinal evenness, vehicle vertical oscillation, ride comfort, measurements

**Article Classification:** Professional paper



## Načrtovanje naprave za merjenje kvalitete zraka v zaprtih prostorih

### Indoor air quality measure device design

Jure Petric<sup>1</sup>

<sup>1</sup>*Šolski center Novo mesto, Višja strokovna šola, Slovenija  
E-naslov: jure.petric@sc-nm.si*

#### Povzetek

Kvaliteta zraka je pomemben faktor, ki vpliva na naše zdravje in počutje. Problematiko rešujemo s pogostim zračenjem zaprtih prostorov, na kar pa pogosto pozabimo. V ta namen je bila izdelana naprava za merjenje prisotnosti CO<sub>2</sub>, temperaturo in vlago v prostoru. Krmiljenje naprave in zajem podatkov je bil izveden na tehnologiji Internet stvari (*Internet of Things - IoT*). Naprava tako ni shranjevala podatkov lokalno, ampak jih je posredovala strežniku. Ta je imel vgrajen tudi spletni strežnik, ki pa je podatke nato uporabniku pokazal v numerični in grafični obliki. Pretok podatkov je bil opravljen s protokolom MQTT, izris podatkov pa z Node-RED.

Samo merjenje in informiranje uporabnikov glede kvalitete zraka z numeričnimi podatki ni zadostno, saj ima dostop do danih podatkov le posameznik. Da bi spodbudili uporabnike zaprtih prostorov k prezračevanju, ima naprava vgrajeno še zvočno in svetlobno informiranje, ki se vklopi, ko vrednost CO<sub>2</sub> naraste nad določeno vrednost, in izklopi, ko se ta nivo normalizira.

Za napravo je bilo načrtovano tudi plastično ohišje, ki je skrbelo za varnost uporabnikov, saj je preprečevalo neposreden dotik prevodnih delov tiskanega vezja. Ločilo je tudi merilni del naprave z ostalimi komponentami in s tem preprečevalo vpliv temperature elementov na samo izvajanje meritve temperature prostora.

Za zniževanje stroškov projekta je bila celotna naprava načrtovana z odprtokodno oziroma zastonsko programsko opremo.

**Ključne besede:** Node-RED, ESP8266, IoT, MQTT, CO<sub>2</sub>, Raspberry Pi, Arduino, Linux

**Razvrstitev:** Strokovni članek

#### Abstract

Air quality is an important factor, that affects our health and well-being. We solve this problem with frequent ventilation of enclosed spaces, which we often forget. For this purpose, a device for measuring the amount of CO<sub>2</sub>, temperature and humidity in the room was made. Device control and data acquisition was performed on the technology Internet of Things (IoT). The device did not store the data locally, instead it transferred it on to the server. The server also had a built-in web server, which could display the data to the user in a numerical and graphical form. The data flow was performed with the MQTT protocol and the data plot with the Node-RED protocol.

Measuring and informing users about air quality with numerical data alone is not enough, as the access to the displayed data is on individual-base. To encourage indoor users to ventilate the room, a sound and light interface device is built-in, which turns on when the CO<sub>2</sub> value rises above a certain value and turns off when this level normalizes.

For this device a plastic housing was also designed, which took care of the safety of users, as it prevented direct contact of the conductive parts of the circuit board. It also separated the measuring part of the device from other components, preventing the influence of elements temperature on the performance of measuring the room temperature.

**Keywords:** Node-RED, ESP8266, IoT, MQTT, CO<sub>2</sub>, Raspberry Pi, Arduino, Linux

**Article Classification:** Professional paper





## BeltPICK robotska celica z naprednim 3D strojnim vidom za manipulacijo raznovrstnih raztresenih kosov s proizvodnega traku

### BeltPICK robot cell equipped with advanced 3D machine vision for handling scattered parts on the production line

Igor Lekše<sup>1</sup>, Boštjan Piletič<sup>1</sup>, Jože Pezdirč<sup>1</sup>, Mario Žganec<sup>2</sup>, Tomaž Savšek<sup>1</sup>

<sup>1</sup>TPV Automotive d.o.o., Slovenija

E-naslov: [i.lekse@tpv.si](mailto:i.lekse@tpv.si), [b.piletic@tpv.si](mailto:b.piletic@tpv.si), [j.pezdirc@tpv.si](mailto:j.pezdirc@tpv.si), [t.savsek@tpv.si](mailto:t.savsek@tpv.si)

<sup>2</sup>ALPINEON d.o.o., Slovenija

E-naslov: [mario.zganec@alpineon.si](mailto:mario.zganec@alpineon.si)

#### Povzetek

V TPV Automotive se je uspešno zaključil razvojno raziskovalni inovacijski projekt BeltPICK. BeltPICK je robotska celica z naprednim 3D strojnim vidom za manipulacijo raznovrstnih raztresenih kosov s proizvodnega traku, ki je plod lastnega razvoja in znanja, ki sta ga v projekt prispevala podjetje TPV Automotive in malo inovativno podjetje Alpineon.

Namen projekta je bil razvoj in raziskave v smeri reševanja razvojnih izzivov in priložnosti pri maloserijski in pri velikoserijski proizvodnji, ki so prisotne pri robotski manipulaciji kosov iz embalažnih enot, kjer se kosi nahajajo v raztresenem stanju. Cilj projekta BeltPICK je bil razvoj nove inovativne visokotehnološke robotizirane celice, ki s pomočjo naprednega 3D strojnega vida in robotsko roko manipulira raznovrstne raztresene kose s proizvodnega traku. Pri tem smo razvili več novih prebojnih rešitev, ki predstavljajo napredek na področju stanja tehnike. Skrajšanje časa manipulacije smo dosegli s kombinacijo vhodnega traku, optimizacije sistema strojnega vida, sekundarnega skeniranja v preletu ter z inovativno zasnovo robotske celice. Razvoj je potekal v smeri univerzalnega sistema, ki je sposoben pobiranja in orientiranja več vrst kosov raznovrstnih oblik iz raztresenega stanja, ki se sočasno nahajajo na vstopnem traku, kar predstavlja ključno konkurenčno prednost robotske celice BeltPICK. Projekt, ki je trajal 24 mesecev, se je zaključil s končno validacijo celice v operativnem okolju industrijskega proizvodnega procesa v avtomobilski industriji.

Robotska celica BeltPICK predstavlja povsem nov visokotehnološki produkt, namenjen uporabi v tovarnah prihodnosti. Podjetjem z velikoserijsko in maloserijsko proizvodnjo omogoča proizvodnjo izdelkov z visoko dodano vrednostjo. Sistem ima velik tržni potencial v tovarnah prihodnosti na globalni ravni, tako v avtomobilskem sektorju, kot tudi drugih sektorjih, kot je industrija bele tehnike in farmacija.

Zahvala: Raziskovalno delo delno financira Evropska unija iz evropskega sklada za regionalni razvoj v okviru Operativnega programa Naložbe za rast in delovna mesta za programsko obdobje 2014 do 2020, po pogodbi št. C2130-20-096932 (BeltPICK).

**Ključne besede:** 3D strojni vid, tovarne prihodnosti, avtomobilska industrija

**Razvrstitev:** Strokovni članek

#### Abstract

The BeltPICK development research and innovation project was successfully completed at TPV Automotive. BeltPICK is a robotic cell with advanced 3D machine vision for the manipulation of various scattered parts on the production line, which is the result of in-house development and know-how contributed to the project by the company TPV Automotive and the small innovative company Alpineon.



The purpose of the project was development and research in the direction of solving development challenges and opportunities in small and big volume production, which are present in the robotic manipulation of parts from packaging units, where the pieces are located in a scattered state. The goal of the BeltPICK project was the development of a new innovative high-tech robotic cell that uses advanced 3D machine vision and a robotic arm to manipulate various scattered parts on the production line. In doing so, we have developed several new breakthrough solutions that represent progress in the field of state-of-the-art technology. Shortening the manipulation time was achieved through a combination of the entrance belt, optimization of the machine vision system, secondary scanning in flight and an innovative design of the robotic cell. The development took place in the direction of a universal system, which is capable of picking up and orienting several types of parts of various shapes from a scattered state, which are simultaneously located on the entrance belt, which represents the key competitive advantage of the BeltPICK robotic cell. The project, which lasted 24 months, concluded with the final validation of the cell in the operational environment of an industrial production process in the automotive industry.

The BeltPICK robotic cell represents a completely new high-tech product intended for use in the factories of the future. It enables companies with large-scale and small-scale production to produce products with high added value. The system has great market potential in factories of the future globally, both in the automotive sector and in other sectors such as white goods and pharmaceuticals.

This research is partially funded by the European Union, European Regional Development Fund, within the scope of the framework of the programme for investments in growth and jobs 2014-2020, contract No. C2130- 20-096932 (BeltPICK).

**Keywords:** 3D machine vision, factories of the future, automotive industry

**Article Classification:** Professional paper



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# **Strategije za zeleni prehod in trajnostno družbo**

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## ***Strategies for a green transition and a sustainable society***



## Prenova in nadgradnja delovnih procesov v podjetju Robeta d.o.o.

### Work Processes Redesign and Upgrade in Robeta Ltd.

Klara Štavdekar<sup>1</sup>, Mitja Cerovšek<sup>1</sup>

<sup>1</sup>Fakulteta za industrijski inženiring Novo mesto, Slovenija  
E-naslovi: klara.stavdekar@students.fini-unm.si, mitja.cerovsek@fini-unm.si

#### Povzetek

Prenova in nadgradnja poslovnih oz. delovnih procesov podjetjem omogoča dobavo individualiziranih produktov, zmanjšanje časa proizvodnega cikla in optimizacijo stroškov dela. Proizvodna podjetja, ki prenavo in nadgradnjo poslovnih procesov uskladijo s potrebami strank, serviserjev in distributerjev, lahko povečajo zadovoljstvo strank in kakovost svojih produktov ter izboljšajo odzivnost trgovcev in hitrost dobav. Z analizo in prenavo proizvodnega procesa se povečata uspešnost in vrednost podjetja, kar pozitivno vpliva tudi na njegove finančne kazalnike. Prenova omogoča pravočasno naročanje materiala in učinkovitejše planiranje proizvodnih kapacitet ter posledično vpliva na zmanjšanje potrebnega časa, stroškov dodatnega dela in materiala.

Izziv podjetij, tudi v industriji predelave kombijev v avtodome, predstavljata konstruiranje in dobava individualiziranih in notranje raznolikih modelov avtodomov glede na trende na različnih trgih, za kar pa je ključnega pomena razvoj skladnega in učinkovitega postopka konfiguriranja naročila.

Na primeru podjetja Robeta d.o.o. smo analizirali obstoječe stanje procesa prodaje in naročanja avtodoma (kreiranja naročila avtodoma) ter procesa proizvodnje. Pripravili smo model izboljšanega procesa kreiranja naročila. Razvili smo obrazec in konfigurator, ki omogoča izvajanje standardiziranega poteka naročila. Z razvojem sprememb in dopolnitev smo eliminirali razhajanja med prodajalcem, kupcem in proizvajalcem avtodomov Robeta d.o.o. Z uvedbo izboljšav ter informatizacijo procesa kreiranja naročila za poslovne uporabnike smo izboljšali odnos med proizvajalcem (podjetjem Robeta) in končnim uporabnikom (fizično osebo). S tem smo prispevali k izboljšanju uporabniške izkušnje v odnosih B2B in B2C ter zmanjšali stroške prodajnega in proizvodnega procesa.

**Ključne besede:** prenova in nadgradnja delovnih procesov, digitalizacija, informatizacija, konfigurator

**Razvrstitev:** Znanstveni članek

#### Abstract

Work process redesign and upgrade enable companies to supply individualized products, reduce production cycle time and optimize labor costs. Manufacturing companies that align their work process redesign and upgrade with the needs of customers, service providers, and distributors can increase customers' satisfaction and the quality of their products, as well as improve the responsiveness of retailers and the speed of deliveries. By analyzing and renovating the production process, the company's performance and value increase, which positively affects its financial indicators. The renovation enables timely material orders and more efficient planning of production capacities; consequently, it reduces the required time and costs of additional work and material.

The challenge for companies, even in the van conversion industry, is to design and deliver individualized and internally diverse camper van models according to trends in different markets, for which the development of a consistent and efficient order configuration process is crucial.

In the case of Robeta Ltd, we have analyzed the existing state of the process of selling and ordering a camper van (creating the camper van order) and the production process. We have prepared a model of the improved order creation process. We have developed a form and a configurator that enable the standardized order process implementation. By developing changes and additions, we have eliminated discrepancies between the seller, the buyer, and the manufacturer of Robeta Ltd camper vans. By introducing improvements and informatizing the order



creation process for business users, we have improved the relationship between the manufacturer (the company Robeta) and the end user (natural person). With this, we have contributed to the improvement of the B2B and B2C user experience and reduced the sales and production process costs.

**Keywords:** Work process redesign and upgrade, digitalization, informatization, configurator

**Article Classification:** Scientific paper



## Izbira ustrezne strategije vzdrževanja izolatorja

### Selection of appropriate isolator maintenance strategy

Kristian Peklaj

*Lek d.d., Slovenija*

*E-naslov: kristian.peklaj@students.fini-unm.si*

#### Povzetek

Kot skrbniki laboratorijske opreme v mikrobiološkem laboratoriju podjetja Lek, d. d., v enoti Ljubljana smo poskušali ugotoviti, ali je dozdajšnja strategija vzdrževanja izolatorjev ustrezna in učinkovita. Namen diplomske naloge je bil ugotoviti lastnosti dozdajšnje strategije in na podlagi pregleda drugih mogočih strategij dognati, ali bi bila katera druga strategija nemara ustrežnejša. Zanimalo nas je, ali vzdržujemo preveč ali premalo. Predstavili smo glavne strategije vzdrževanja in kazalnike. Našteli smo vsa dozdajšnja predpisana opravila, ki so se izvajala z namenom vzdrževanja izolatorja. V sklopu naloge smo pregledali dozdajšnjo dokumentacijo izvedenih posegov na izolatorju QC\_MIK\_IZOL1. Opravljena sta bila popis in trajanje vseh načrtovanih in nenačrtovanih dogodkov. Pregledali smo vsa poročila in opombe iz preteklih izvedenih vzdrževanj. Ob pomoči rezultatov raziskave, izračunov stroškov in kazalnikov smo ugotovili, da opravila, ki jih izvajamo kot preventivno vzdrževanje po času, res učinkujejo in preprečujejo težave, medtem ko z opravili preventivnega vzdrževanja po stanju ne dosežemo zelenih ciljev. Okvare se še vedno pojavljajo, diagnostika naprave nam ni v korist. Ugotovili in dokazali smo, da bi lahko komponente, ki so del preventivnega vzdrževanja po stanju, predvsem zaradi možnosti redundance, vzdrževali korektivno ob okvarah. Tako bi imeli namesto kombinacije preventivnega vzdrževanja po času in stanju kombinacijo preventivnega vzdrževanja po času in korektivnega vzdrževanja. Glede na dozdajšnje izkušnje in ugotovitve s spremembo strategije ne bi ogrozili varnosti, okolja ali dobička podjetja. Dokazali smo, da bi z uvedbo nove strategije napravi zvišali razpoložljivost in znižali stroške vzdrževanja.

**Ključne besede:** farmacija, izolator, kazalniki, preventivno, razpoložljivost, stroški, učinkovitost, vzdrževanje

**Razvrstitev:** Strokovni članek

#### Abstract

As laboratory equipment managers in the microbiological laboratory of the company Lek d.d. at Ljubljana unit, we tried to determine whether the current strategy for the maintenance of isolators is appropriate and effective. The purpose of the diploma thesis was to determine by the characteristics of previous strategies, and based on reviews of other possible strategies. It was determined whether which strategy would be better considered. We wondered if we were maintaining too much or too little. We presented the main maintenance strategies and indicators. We have listed all the previously prescribed tasks that have been carried out for maintaining the insulator. As part of the task, we reviewed the current documentation of performed interventions on the QC\_MIK\_IZOL1 insulator. We made an inventory and duration of all planned and unplanned events. We reviewed all reports and notes from past maintenance actions. With the help of research results, cost calculations, and key performance indicators, we found that actions performed as preventive maintenance over time are efficient and that they prevent problems. While performing preventive maintenance by condition, we do not achieve the desired goals. Defects are still occurring, diagnostic devices are not in our favor. We found and demonstrated that components that are part of preventive maintenance by condition, mainly due to the possibility of redundancy, could be maintained correctively in the event of failures. Instead of combination of preventive maintenance by time and condition, a combination of preventive maintenance by time and corrective maintenance should result in better outcome. Based on experience and findings we believe that, changing the strategy would not jeopardize the safety, environment or profits of the company. We demonstrated that introducing a new combination of strategies would increase availability of isolator and reduce maintenance costs.

**Keywords:** pharmacy, isolator, key performance indicator, preventive, availability, cost, efficiency, maintenance

**Article Classification:** Professional paper



## Vpliv koronakrize na nagrajevanje in motivacijo zaposlenih

### The impact of the corona crisis on employee rewards and motivation

Klemen Lipičar<sup>1</sup>, Iris Fink Grubačević<sup>1</sup>

<sup>1</sup>Fakulteta za industrijski inženiring Novo mesto, Slovenija  
E-naslova: klemen.f16@gmail.com, iris.finkgrubacevic@fini-unm.si

#### Povzetek

Koronakriza je prišla popolnoma nepričakovano in spremenila način življenja, kot smo ga poznali pred tem. Striktno upoštevanje vseh predpisov za ohranjanje zdravja, izolacije in delo od doma, so postali del našega vsakdana. Prav tako je koronakriza prizadela podjetja: odsotnost kadra, težave z dobavo materiala, delo od doma, finančne stiske itd. Kako pa je koronakriza vplivala na zaposlene v podjetju, kako močno je vplivala na njih in na katerih področjih delovanja? Ali so enako nagrajeni in motivirani kot pred koronakrizo?

V prispevku bomo predstavili rezultate raziskave, v katero bomo zajeli zaposlene v različnih organizacijah iz cele Slovenije. Namen raziskave bo pridobiti rezultate o vplivu koronakrize na nagrajevanje in motivacijo zaposlenih. Podatek o zadovoljstvu z nagrajevanjem in stopnji motiviranosti zaposlenih v času sprememb, je zelo pomemben dejavnik, ki vpliva na uspešnost organizacije. Rezultati raziskave lahko nakažejo smernice za reševanje stresnih situacij in pripomorejo k izboljševanju nagrajevanja in motivacije zaposlenih v organizacijah, po epidemiji Covid-19.

**Ključne besede:** Covid-19, koronakriza, nagrajevanje, motivacija, zaposleni

**Razvrstitev:** Strokovni članek

#### Abstract

The corona crisis came completely unexpectedly and changed the way we knew it before. Strict observance of all regulations for maintaining health, isolation and work from home have become part of our daily lives. The corona crisis also affected companies: lack of staff, problems with the supply of materials, work from home, financial hardship, etc. But how did the corona crisis affect the company's employees, how much did affect them and in which areas of activity? Are they as rewarded and motivated as they were before the corona crisis?

In this paper, we will present the results of a survey that will include employees in various organizations from all over Slovenia. The purpose of the research will be to obtain results on the impact of corona crisis on employee's rewards and motivation. Data on satisfaction with rewards and the level of motivation of employees in times of change is a very important factor influencing the success of the organization. The results of the research can suggest guidelines for dealing with stressful situations and help improve the reward and motivation of employees in organizations, after the Covid-19 epidemic.

**Keywords:** Covid-19, corona crisis, motivation, rewarding, employee

**Article Classification:** Professional paper



## Uredba o izvozu in uvozu nevarnih kemikalij in izzivi za industrijo

### Regulation of export and import of hazardous chemicals and challenges for the industry

Igor Simonič<sup>1</sup>

<sup>1</sup>Fakulteta za industrijski inženiring Novo mesto, Slovenija  
E-naslov: igor.simonic@fini-unm.si

#### Povzetek

Uredba (EU) št. 649/2012 Evropskega parlamenta in Sveta z dne 4. julija 2012 o izvozu in uvozu nevarnih kemikalij (poznana kot uredba PIC) omejuje izvoz iz EU nekaterih snovi ter zmesi in izdelkov, ki te snovi vsebujejo, tako, da zahteva obveščanje ali celo soglasje države prejemnice v skladu z Rotterdamsko konvencijo. Poleg snovi omenjenih v konvenciji, je s tem EU uvedla kontrolo ali celo prepoved izvoza ter uvoza še nekaterih drugih potencialno problematičnih snovi, zmesi in izdelkov. Z uveljavitvijo uredbe morajo biti izvozniki in uvozniki pozorni na omejitve in pridobivati ustrezna dovoljenja.

V prispevku bomo pregledali ključne zahteve uredbe, na kratko pojasnili postopke pridobivanja izvoznih dovoljenj in letnega poročanja o količinah izvoza in uvoza ter predstavili ključne izzive pri izpolnjevanju obveznosti, ki jih je uredba naložila izvoznikom in uvoznikom omejenih snovi. Zamude pri vlaganju zahtevkov ali celo ignoriranje uredbe namreč lahko provzročijo zastoje pri prometu ali celo globe za kršitelje.

**Ključne besede:** nevarne snovi, Rotterdamska konvencija, PIC, uvoz, izvoz, ECHA

**Razvrstitev:** Strokovni članek

#### Abstract

Regulation (EU) No. 649/2012 of the European Parliament and of the Council of 4 July 2012 concerning the export and import of hazardous chemicals (known as the PIC Regulation) restricts the export from the EU of certain substances and mixtures and articles containing these substances by requiring notification or even the consent of the country recipients in accordance with the Rotterdam Convention. In addition to the substances mentioned in the convention, the EU thereby introduced control or even a ban on the export and import of some other potentially problematic substances, mixtures and articles. With the implementation of the regulation, exporters and importers must pay attention to restrictions and obtain appropriate permits.

In this article, we will review the key requirements of the regulation and briefly explain the procedures for obtaining export permits and annual reporting on export and import volumes. In addition some challenges in fulfilling the obligations imposed by the regulation on exporters and importers of restricted substances will be presented. Delays in filing claims or even ignoring the regulation can cause delays in market supply or even fines for violators.

**Keywords:** hazardous substances, Rotterdam Convention, PIC, import, export, ECHA

**Article Classification:** Professional paper





## Učinkovitost razvoja proizvodne linije sestave prve preme vozila v proizvodnem procesu Revoz d.d.

### Effectiveness of the vehicle's front axle assembly production line development in the production process of Revoz d.d.

Marko Stojčevič<sup>1</sup>, Darko Števančec<sup>2</sup>

<sup>1</sup> *Fakulteta za industrijski inženiring Novo mesto, Slovenija*  
*E-naslov: marko.stojcevic@students.fini-unm.si*

<sup>2</sup> *Fakulteta za industrijski inženiring Novo mesto, Slovenija*  
*E-naslov: darko.stevancec@fini-unm.si*

#### Povzetek

Avtomobilski trg se spreminja, postaja vedno bolj dinamičen in konkurenčen. Spreminjajoče se razmere v tej globalni industriji so prisilile skupino Renault k večji ustvarjalnosti in inovativnosti pri izvajanju projektov. Projektno delo v podjetju Revoz d.d. od članov projektne skupine zahteva veliko strokovnega znanja in visoko mero sodelovanja. Člani projektne skupine, tako zunanji kot notranji, so morali k predstavljenemu projektu pristopiti kreativno in agilno. Razvoj in prenova proizvodne linije v podjetju Revoz d.d. sta potekala z uporabo standardnih metod izvajanja projektne dela. Projekt prenove proizvodne linije sestave prve preme vozil se je skrbno načrtoval in izvedel po načrtu; dosegel je vse cilje, ki so bili zastavljeni. Uresničenje vseh ciljev projekta je rezultat sodelovanja med projektnimi timi zunaj in znotraj podjetja ter povezovanja s strokovnjaki z različnih področij.

**Ključne besede:** avtomobilska industrija, CPM, PERT, projektna organizacija, projektni management

**Razvrstitev:** Strokovni članek

#### Abstract

The automotive market is changing, becoming increasingly dynamic and competitive. The changing conditions in this global industry have forced the Renault Group to be more creative and innovative in the implementation of projects. Project work at Revoz d.d. requires a lot of expertise and a high degree of cooperation from the members of the project team. Project team members, both external and internal, had to approach the presented project creatively and agilely. Development and renovation of the production line in Revoz d.d. took place using standard methods of project work implementation. The project of renovating the production line of the vehicle's front axle assembly was carefully planned and carried out according to the plan; it resulted into achieving all the goals that were set. The realization of all project goals is the result of cooperation between project teams outside and inside the company and connecting with experts from different fields.

**Keywords:** automotive industry, CPM, PERT, project organization, project management

**Article Classification:** Professional paper



## Vpliv interne komunikacije na poslovno uspešnost organizacije

### The impact of internal communication on an organisation's business performance

Boštjan Fortuna<sup>1</sup>, Iris Fink Grubačević<sup>2</sup>

<sup>1</sup>J. Schmalz GmbH, Nemčija  
E-naslov: [Boštjan.Fortuna@schmalz.com](mailto:Boštjan.Fortuna@schmalz.com)

<sup>2</sup>Fakulteta za industrijski inženiring Novo mesto, Slovenija  
E-naslov: [iris.finkgrubacevic@fini-unm.si](mailto:iris.finkgrubacevic@fini-unm.si)

#### Povzetek

Komunikacija je zelo pomembna veščina, ki jo izboljšujemo s spoznavanjem svojih potencialov, veščin in vrlin. Omogoča nam doseganje različnih ciljev ter vzpostavitev, razvoj in vzdrževanje medosebnih odnosov v poslovnem okolju. Organizacija lahko uspešno posluje, kadar so vsi zaposleni usmerjeni v doseganje skupnih ciljev in ko organizacija dobro upravlja z informacijami in znanjem. Interna komunikacija ima pozitiven vpliv na zaposlene in močno vpliva na njihovo medsebojno povezanost in povezanost z organizacijo. Z učinkovitim internim komuniciranjem, lahko dosežemo strateško konkurenčnost organizacije.

V prispevku bomo prikazali rezultate raziskave, v katero smo vključili zaposlene v podjetju Z. Namen raziskave bo pridobiti podatke o vplivu interne komunikacije na odnose zaposlenih v organizaciji, na njihovo večjo motivacijo, organiziranost dela ter posledično na uspešnost organizacije. Rezultati raziskave bodo služili kot smernice vodstvu podjetja za uvajanje izboljšav na področju internega komuniciranja in ravnanja z zaposlenimi.

**Ključne besede:** interna komunikacija, konflikt, medosebni odnosi, motivacija, učinkovito komuniciranje

**Razvrstitev:** Strokovni članek

#### Abstract

Communication is a very important skill that we improve by learning about our potential, skills and virtues. It enables us to achieve different goals and to establish, develop and maintain interpersonal relationships in a business environment. An organisation can operate successfully when all employees are focused on achieving common goals and when the organisation manages information and knowledge well. Internal communication has a positive impact on employees and has a strong influence on their interpersonal relationships and commitment to the organisation. Through effective internal communication, the strategic competitiveness of an organisation can be achieved.

In this paper, we will present the results of a survey involving employees at Company Z. The purpose of the research will be to obtain information on the impact of internal communication on employee relations in the organisation, on their increased motivation, work organisation and, consequently, on the performance of the organisation. The results of the survey will serve as guidelines for the management of the company to introduce improvements in the area of internal communication and employee treatment.

**Keywords:** internal communication, conflict, interpersonal relationships, motivation, effective communication

**Article Classification:** Professional paper



## Avtomatizacija vzdrževanja – stanje in priložnosti

### Automation of maintenance – status and opportunities

Saša Ciglar<sup>1</sup>

<sup>1</sup>Fakulteta za industrijski inženiring Novo mesto, Slovenija  
E-naslov: sasa.ciglar@fini-unm.si

#### Povzetek

Še vedno smo globoko v času Industrije 4.0, kjer s pametnim mreženjem strojev in industrijskih procesov, z digitalizacijo in ustvarjanjem navidezne resničnosti postavljamo inovativne visoko produktivne in učinkovite tehnološke procese, ki ustvarjajo kakovostne izdelke. Vzporedno s proizvodnjo po načelih Industrije 4.0 poznamo pojem Vzdrževanje 4.0, ki je stalen partner Industrije 4.0 skrbi za to, da industrijski procesi potekajo čim bolj nemoteno, s čim manj odpovedmi in s čim večjo razpoložljivostjo. Pametne tovarne imajo visoko stopnjo avtomatiziranosti. Posamezni proizvodni procesi so med seboj povezani v kompleksnih mrežah. Kadar govorimo o tovrstni avtomatizaciji proizvodnih procesov se nam takoj prikaže slika proizvodnih linij, polnih robotov in avtomatskih manipulatorjev, ki so med seboj povezani s tekočimi trakovi in kjer je potrebno minimalno število delavcev. Vzdrževanje tovrstne opreme je ravno tako zahteven in kompleksen proces. Postavlja se nam vprašanje v kolikšni meri lahko avtomatiziramo vzdrževalne aktivnosti iz vidika Industrije 4.0 ali celo Industrije 5.0. Ta je sicer že v fazi nastajanja in bo osredotočena na povezanost stroja in človeka ter njuno interaktivnost. Namen prispevka je predstaviti možnosti in priložnosti avtomatizacije vzdrževanja za večjo razpoložljivost proizvodnih sredstev.

**Ključne besede:** vzdrževanje, stopnja avtomatiziranosti, razširjena resničnost, strategija vzdrževanja, digitalni dvojček, razpoložljivost, napovedno vzdrževanje

**Razvrstitev:** Strokovni članek

#### Abstract

We are still deep in the era of Industry 4.0, where with smart networking of machines and industrial processes, with digitization and the creation of virtual reality, we are setting up innovative highly productive and efficient technological processes that create qualitative products. In parallel with production according to the principles of Industry 4.0, we know the concept of Maintenance 4.0, which is a permanent partner of Industry 4.0 and ensures that industrial processes run as smoothly as possible, with as few failures as possible and with as much availability as possible. Smart factories have a high level of automation. Individual production processes are interconnected in complex networks. When we talk about this kind of automation of production processes, we immediately see a picture of production lines, full of robots and automatic manipulators, which are connected to each other by conveyor belts and where a minimum number of workers is required. Maintenance of this type of equipment is just as demanding and complex process. The question arises to what extent we can automate maintenance activities from the point of view of Industry 4.0 or even Industry 5.0. This is already in the development phase and will be focused on the connection between machine and man and their interactivity. The purpose of the article is to present the possibilities and opportunities of maintenance automation for higher availability of production assets.

**Keywords:** maintenance, level of automation, augmented reality, maintenance strategy, digital twin, availability, predictive maintenance.

**Article Classification:** Professional Paper



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***Regije, mesta in krožno gospodarstvo***  
***Regions, cities and the circular economy***



## Innovation in circular public procurement process: Understanding the drivers and barriers to early market dialogue

Dolores Modic<sup>1</sup>, Elena Dybtsyna<sup>1</sup>, Hanne Rendal<sup>1</sup>, Solveig Henriksen-Sharp<sup>1</sup>

<sup>1</sup>Nord University, Norway

*E-adresses: dolores.modic@nord.no, elena.dybtsyna@nord.no, hanne.rendal@student.nord.no, solveig.c.henriksen-sharp@student.nord.no*

### Abstract

Global awareness of the climate challenges reminds world leaders to introduce restorative and regenerative systems and strategies in general, as well as initiate related actions. Institutional pressures in various forms, including circular public procurement (CPP), support these courses of action. CPP is a vital innovation tool, due to the considerable purchasing power in the public sector across European countries, and in Norway. CPP aims to achieve circular goals without negative environmental impacts by eliminating waste generation and initializing or enabling circular loops.

The paper focuses on the early market dialogue in the CPP process through the lens of institutional theory. We ask primarily, what are the drivers and barriers of market dialogue in CPP? Subsidiarily, the paper explores whether these drivers and barriers vary for public procurers and private contractors. The research approach used is a qualitative case study with informants from two Norwegian municipalities and their related suppliers. The findings reveal that the market dialogue positively affects CPP by reducing the asymmetry of information, giving a clear understanding of needs, less room for mismatch in the bid, a better understanding of what the market can provide, and providing a platform for circular solutions. Lack of strategy for conducting market dialogue is a strong regulative barrier to arranging market dialogue. Information sharing and knowledge seeking are strong drivers. The identified drivers and barriers to market dialogue can benefit the public procurers when arranging the early market dialogue and contribute to process innovation in the early stage of circular public procurement.

**Keywords:** circular economy, circular public procurement, market dialogue, market engagement, innovation

**Article Classification:** Scientific paper



## Ponovna uporaba in predelava gradbenih odpadkov

### Reuse and processing of construction waste

Aleš Novak<sup>1</sup>, Damjan Balabanič<sup>2</sup>

<sup>1</sup>Krka d.d., Slovenija

E-naslov: ales.novak@krka.biz

<sup>2</sup>Fakulteta za industrijski inženiring Novo mesto, Slovenija

E-naslov: damjan.balabanic@fini-unm.si

#### Povzetek

Gradbeništvo je dejavnost, ki ima velik vpliv na okolje in je največji porabnik naravnih virov, največji pridelovalec odpadkov in hkrati največji potencialni uporabnik recikliranih surovin in izdelkov iz recikliranih materialov. Gradbeni odpadki so za okolje zelo obremenjujoči zaradi svoje velikosti. S sedanjo tehnologijo in z znanimi postopki predelave lahko predelamo okoli 90 % vseh nenevarnih gradbenih odpadkov.

Poznavanje sestave odpadkov, postopka recikliranja in ločevanja odpadkov na izvoru je ključnega pomena za ponovno uporabo in predelavo gradbenih odpadkov. Z uporabo recikliranih materialov in izdelkov zmanjšamo porabo naravnih virov, obremenjevanje okolja z odlaganjem odpadkov in posledično ohranjamo okolje.

V prispevku so predstavljene možnosti ponovne uporabe in predelave različnih gradbenih odpadkov (materiali iz betona, asfalta, toplotne izolacije in industrijski odpadki, kot sta žindra in elektrofiltrski pepel). Podrobneje je predstavljena predelava odpadkov, ki nastanejo pri gradbenih delih na deponiji in na mestu nastanka. Obravnavano je področje predelave odpadkov od rušenja objekta z opisanimi postopki rušenja, ločevanje odpadkov na mestu nastanka in predelava na deponiji pri pooblaščenem predelovalcu odpadkov, ki nastanejo pri gradbenih delih. V prispevku je obravnavan tudi postopek ponovne uporabe in predelave zemeljskega izkopa s poudarkom na predelavi kamnine. Predstavljene so faze vseh potrebnih pripravljalnih del in postopkov, da se kamniti material od izkopa predela na mestu nastanka in ponovno vgradi kot nadomestni nasip med temelji za objektom kot tamponska blazina dovoznih poti in zasip jarkov komunalne infrastrukture. Z analizo cene predelave izkopanega kamnitega agregata na mestu nastanka smo prikazali, da je predelava ekonomsko ugodnejša za investitorja kot vgradnja kamnolomskega materiala.

**Ključne besede:** gradbeni odpadki, krožno gospodarstvo, ponovna uporaba, predelava, recikliranje, reciklirani materiali

**Razvrstitev:** Znanstveni članek

#### Abstract

Construction is an activity with high environmental impact and the largest consumer of natural resources, the largest waste producer, and the largest potential user of recycled (waste) materials and products made from (wasted) recycled materials. Construction waste is a major environmental nuisance due to its size. We can process around 90% of all non-hazardous construction waste using currently available technology and processing.

Knowing waste composition, the recycling process, and separating the waste at the source are vital to processing and reusing construction waste. Using recycled materials and products would reduce the consumption of natural resources and the environmental impact of waste disposal, preserving nature for current and future generations.

The paper presents the possibilities of reuse and processing of various construction waste (concrete, asphalt, thermal insulation, and industrial waste such as slag and fly ash). We focus on the waste processing from



construction activities on-site and at the landfill. The area of waste processing from the demolition of the building is discussed, with described demolition procedures, waste separation at the point of origin and processing at the landfill at an authorized processor of waste generated during construction work. The paper also discusses the process of reuse and processing of earth excavation with an emphasis on rock processing. We present the required preparatory work and procedures to process the rock material from on-site excavation and reinstate it as a replacement embankment between the foundations behind the building as a tampon cushion for access roads and backfill for the building utility trenches. By analyzing the cost of on-site processing of the quarried rock aggregate, we have shown that processing is more economically advantageous for the investor than the installation of quarried material.

**Keywords:** construction waste, circular economy, reuse, waste processing, recycling, recycled material

**Article Classification:** Scientific paper



## Izkušnje in prihodnost krožnega javnega naročanja v lokalni skupnosti

### The experience and future of circular public procurement in the local community

Peter Geršič<sup>1</sup>

<sup>1</sup>Mestna občina Novo mesto, Slovenija  
E-naslov: peter.gersic@novomesto.si

#### Povzetek

Krožno javno naročanje v lokalni skupnosti predstavlja srž koncepta krožnega gospodarstva ter usmeritve ohranjanja virov in okolja s ponovno uporabo, deljenjem ter recikliranjem materialov ali storitev. V JV Sloveniji je bilo v preteklih letih nekaj koristnih iniciativ za razvoj krožnega gospodarstva in predvsem krožnih javnih naročil, vendar je obseg izvedenih tovrstnih postopkov še vedno izjemno majhen, saj se občine še vedno redko odločajo za takšen tip javnih naročil. Razloge za takšno stanje najdemo v kompleksni javno naročniški zakonodaji ter pomanjkanju kompetenc na tem področju, del pa lahko pripišemo pomanjkanju kompetenc pri razumevanju primernih področij za krožna javna naročila, kar je povezano tudi z omejenim obsegom ponudnikov primernih predmetov javnih naročil. Del ovir za širitev obsega krožnih javnih naročil v lokalnih skupnostih je gotovo relativna majhnost posameznih občin v JV Sloveniji, ki posledično nimajo dovolj znanja in izkušenj pri zasnovi in izvedbi takšnih javnih naročil. Ugotavljamo, da se je potrebno pospeševanja krožnega gospodarstva na ravni lokalnih skupnosti (občin) lotiti preko povezovanja v skupne projekte krožnih javnih naročil, kjer bo prišlo do zelenega prenosa znanja in izkušenj. Dodatno je za razvoj krožnega gospodarstva ključno pritegniti ponudnike, ki morajo biti z jasnimi pravili in ekonomsko logiko motivirani za razvoj novih konceptov krožnega gospodarstva. Skupno sodelovanje deležnikov je tako ključno za prihodnjo vlogo javnega sektorja kot enega gonil krožnega gospodarstva.

**Ključne besede:** krožno javno naročanje, krožno gospodarstvo, lokalna samouprava, javnoinarocniska zakonodaja, jugovzhodna Slovenija

**Razvrstitev:** Strokovni članek

#### Abstract

Circular public procurement in the local community represents the core of the concept of circular economy and the orientation of preserving resources and the environment by reusing, sharing, recycling materials or services. In SE Slovenia, there have been some useful initiatives for the development of the circular economy and especially circular public procurement in the past years, but the scope of such procedures carried out is still extremely limited, as municipalities still rarely decide on this type of public procurement. The reasons for this state of affairs can be found in the complex public procurement legislation and the lack of competence in this area, and part of it can be attributed to the lack of competence in understanding suitable areas for circular public procurement, which is also related to the limited range of providers of suitable public procurement items. Part of the obstacles to expanding the scope of circular public procurement in local communities is certainly the relative small size of individual municipalities in SE Slovenia, which consequently do not have enough knowledge and experience in the design and implementation of such public procurement. We conclude that it is necessary to promote the circular economy at the level of local communities (municipalities) through integration into joint projects of circular public procurement, where the desired transfer of knowledge and experience will take place. In addition, for the development of the circular economy, it is crucial to attract providers who must be motivated by clear rules and economic logic to develop new circular economy concepts. The joint cooperation of stakeholders is thus key to the future role of the public sector as one of the drivers of the circular economy.

**Keywords:** circular public procurement, circular economy, local self-government, public procurement legislation, southeastern Slovenia

**Article Classification:** Professional Paper





## Spodbujanje prehoda na krožno gospodarstvo s pomočjo ukrepov Programa evropske kohezijske politike za obdobje 2021-2027 v Sloveniji

### Encouraging the transition to a circular economy with the help of measures of the European Cohesion Policy Program for the period 2021-2027 in Slovenia

Vesna Maksimović<sup>1</sup>

<sup>1</sup>Razvojni center Novo mesto d.o.o., Slovenija  
E-naslov: vesna.maksimovic@rc-nm.si

#### Povzetek

Kriza, s katero se trenutno spopadamo, nam je ponovno pokazala, da viri niso neskončni. Obstoječi model ekonomske rasti "vzemi-naredi-zavrzi" ni več primeren za sodobno družbo, zato je prehod v nizkoogljično krožno gospodarstvo z razlogom prednostna razvojna usmeritev za celotno gospodarstvo in eden izmed ključnih ciljev Strategije Republike Slovenije 2030 (SRS 2030). In ravno cilji SRS 2030, so bili podlaga pri pripravi ukrepov Programa evropske kohezijske politike za obdobje 2021-2027 v Sloveniji (Program).

Ugotovitev s strani Urada Republike Slovenije za makroekonomske analize in razvoj je, da Slovenija pri prehodu v nizkoogljično krožno gospodarstvo za povprečjem EU še precej zaostaja, še posebej za najboljšimi državami članicami pri večini kazalnikov, ki merijo povezanost med gospodarskim razvojem ter porabo naravnih virov in energije, odpadki in izpusti toplogrednih plinov.

Kljub relativno dobro ohranjenemu stanju okolja, je napredek skromen na področjih kakovosti zraka in racionalne rabe prostora. Zato bodo sredstva v okviru Programa namenjena podpori raziskavam in razvoju, za uporabo novih pristopov v podjetjih ter za dvig usposobljenosti podpornega okolja. Poleg tega se bodo ukrepi dopolnjevali tudi s tistimi s področja vseživljenjskega učenja in izobraževanja.

Podpora bo namenjena vzpostavitvi pogojev za prehod v nizkoogljično krožno gospodarstvo, predvsem z uvajanjem nizkoogljičnih in krožnih poslovnih modelov, s katerimi bodo podjetja lažje kljubovala izzivom in pritiskom na konkurenčnost njihovega poslovanja, ki so posledica dviga cen surovin in energentov. Pri izvajanju ukrepa bo prednost namenjena podpori tistim rešitvam, ki bodo najbolj prispevala k dvigu dodane vrednosti ter k proizvodnji izdelkov, ki v svoji življenjski dobi izkazujejo nizek ogljični odtis.

**Ključne besede:** nizkoogljično, krožno gospodarstvo, Strategija Republike Slovenije 2030, Program evropske kohezijske politike za obdobje 2021-2027 v Sloveniji

**Razvrstitev:** Strokovni članek

#### Abstract

The crisis we are currently dealing with has shown us once again that resources are not infinite. The existing model of economic growth "take-make-throw" is no longer suitable for modern society, therefore the transition to a low-carbon circular economy is a priority development direction for the entire economy and one of the goals of the Slovenian Development Strategy (SDS 2030). And precisely the goals of SDS 2030 were the basis for the preparation of the measures of the Programme for the Implementation of the EU Cohesion Policy in the period 2021-2027 in Slovenia (the Program).

The conclusion from the Office of the Republic of Slovenia for macroeconomic analysis and development is that in the transition to a low-carbon circular economy, Slovenia is still far behind the EU average, especially in comparison



with the most developed European countries in most indicators that measure the connection between economic development and the consumption of natural resources and energy, waste and greenhouse gas emissions.

Despite the relatively well-preserved state of the environment, progress is modest in the area of air quality and rational use of space. Therefore, the funds within the Program will be used to support research and development, for the use of new approaches in companies and for the capacities of the environmental support. In addition, the measures will be complemented by those in the field of lifelong learning and education.

The support will be aimed at establishing the conditions for the transition to a low-carbon circular economy, mainly through the introduction of low-carbon and circular business models, with which the companies will more easily defy the challenges and pressures on the competitiveness of their business, which is thus a consequence of the increase in the prices of raw materials and energy products. When implementing the measure, priority will be given to supporting those solutions that will contribute the most to increasing added value and to the production of products that demonstrate a low carbon footprint during their lifetime.

**Keywords:** low-carbon circular economy, local environment, Slovenian Development Strategy, Programme for the Implementation of the EU Cohesion Policy in the period 2021-2027 in Slovenia

**Article Classification:** Professional paper



## Izzivi krožnega gospodarstva v JV Sloveniji

### Challenges of the circular economy in SE Slovenia

Iris Fink Grubačević<sup>1</sup>, Ines Lipuš<sup>1</sup>

<sup>1</sup>Fakulteta za industrijski inženiring Novo mesto, Slovenija  
E-naslovi: iris.finkgrubacevic@fini-unm.si, ines.lipus@fini-unm.si

#### Povzetek

V zadnjem času je aktualno razmišljanje o načinu proizvodnje in potrošnje, katerega osnova je ponovna uporaba, popravilo, recikliranje materialov in izdelkov, ki jih vsakodnevno uporabljamo. Globalna kriza s pomanjkanjem surovin, onesnaževanjem okolja in segrevanjem, nas je usmerila k iskanju inovativnih rešitev na lokalnem nivoju oz. razvoju inovativnih modelov lokalnega krožnega gospodarstva. Temeljni koncept krožnega gospodarstva je ravno v pridobivanju novih materialov s pomočjo zbiranja in recikliranja odsluženih izdelkov. Na ta način učinkovito zmanjšujemo količino odpadkov, škodljive vplive na okolje, znižujemo stroške proizvodnje, podaljšujemo življenjsko dobo izdelkov, zvišujemo konkurenčnost, krepimo gospodarsko rast ter do neke mere zmanjšujemo odvisnost od globalnega trga. Učinkovit koncept lokalnega krožnega gospodarstva se začne v organizacijah že na samem začetku življenjskega cikla izdelka s preudarnim oblikovanjem izdelkov in izbiri proizvodnih procesov, nadalje pa tudi z ustrežno ozaveščenostjo vseh vključenih deležnikov, med drugim tudi vseh individualnih prebivalcev.

V prispevku bomo prikazali rezultate raziskave v okviru projekta NovIKroG, v katero smo vključili organizacije JV Slovenije. Namen raziskave je pridobiti podatke o razumevanju osnovne terminologije in pomena krožnega gospodarstva v regiji, ozaveščenosti o ravnanju z odpadki, skrbi za okoljem, recikliranju ter poznavanju primerov dobre prakse v lokalnem okolju.

**Ključne besede:** koncept, krožno gospodarstvo, lokalno okolje, NovIKroG, recikliranje, ozaveščenost

**Razvrstitev:** Strokovni članek

#### Abstract

Recently, there has been a current trend of thinking about the way of production and consumption, the basis of which is the reuse, repair, recycling of materials and products that we use daily. The global crisis with the lack of raw materials, environmental pollution and warming has directed us to find innovative solutions at the local level or the development of innovative models of the local circular economy. The fundamental concept of the circular economy is precisely the acquisition of new materials through the collection and recycling of end-of-life products. In this way, we effectively reduce the amount of waste, harmful effects on the environment, lower production costs, extend the life of products, increase competitiveness, strengthen economic growth and to some extent, reduce dependence on the global market. An effective concept of a local circular economy starts in organizations at the very beginning of a product's life cycle with product design and the choice of production processes, and further also with the appropriate awareness of all involved stakeholders, including all individual residents.

In this paper, we will present the results of research within the framework of the NovIKroG project, in which we included organizations of SE Slovenia. The purpose of the research is to obtain data on the understanding of the basic terminology and the importance of the circular economy in the region, awareness of waste management, care for the environment, recycling, knowledge of examples of good practice in the local environment.

**Keywords:** concept, circular economy, local environment, NovIKroG, recycling, awareness

**Article Classification:** Professional Paper



## Snovni krog odpadnega jedilnega olja

### The material cycle of waste cooking oil

Emilio Murtič<sup>1</sup>

<sup>1</sup> Komunala Novo mesto, d.o.o., Slovenija  
E-naslov: emilio.murtic@komunala-nm.si

#### Povzetek

Z vzpostavitvijo sistema zbiranja odpadnega jedilnega olja se je povečala zavest prebivalcev o potrebi po ohranjanju čistega okolja. Odpadno jedilno olje predstavlja velik ekološki problem, ki ga je z organiziranim zbiranjem mogoče zelo učinkovito in preprosto zmanjšati. Odpadna olja so dostopna ter predstavljajo dodatno okoljsko prednost, saj uporabimo snov, ki bi v večini primerov končala kot komunalni odpadki in onesnaževala podtalnico. Pozitiven vpliv zmanjševanja onesnaženja podtalnice je na varstvu okolja in ohranjanju narave ter nižjih stroških upravljanja čistilnih naprav. Trajnostni učinek projekta se izkazuje v dolgoročnem sistematičnem zbiranju odpadnega olja, ki ga gospodinjstva v gospodinskih posodah zbirajo in jih odnašajo v zbirne posode na pilotnih lokacijah.

Rastlinska olja se na koncu njihovega prvega dela, lahko vračajo v ponovno uporabo po opravljenem dodatnem procesiranju. Po prvem delu življenjskega cikla, olje vstopi v drugi del življenjskega cikla, kjer se lahko uporabi, kot gorivo za pogon različnih izvedb dizelskih motorjev. Trenutna praksa je, da odpadna jedilna olja zbrana v Sloveniji končajo v tujini, kjer jih večji proizvajalci biodizla predelajo v biodizelsko gorivo. Druga možnost je, da se uporabi, kot osnova za proizvodnjo različnih biorazgradljivih maziv za mazanje. Sam produkt pa je mogoče uporabiti tudi za različne inovativne produkte, kot na primer predelava v ekološke sveče.

Danes je gospodarstvo še vedno večinoma linearno, saj se le nekaj % sekundarnih materialov in virov ponovno uporabi v gospodarstvu. Podjetja in potrošniki bi lahko izkoristili ogromen potencial za ponovno uporabo, primer dobre prakse krožnega gospodarstva, v našem primeru odpadno jedilno olje, in vzpostavili snovno zanko v lokalnem okolju.

**Ključne besede:** trajnost, sekundarni materiali, krožno gospodarstvo, življenjski cikel, ponovna uporaba, lokalna snovna zanka

**Razvrstitev:** Strokovni članek

#### Abstract

With the enforcement of a system for collecting waste cooking oil, the awareness of the population about the need to maintain a clean environment has increased. Waste cooking oil is a major ecological problem that can be reduced very effectively and easily through the organized collection. Waste oils are accessible and represent an additional environmental advantage, as we utilize a substance that in most cases would end up as municipal waste and pollute groundwater. The positive impact of reducing groundwater pollution is on environmental protection and nature conservation, as well as lower management costs of the treatment plants. The sustainable effect of the project is reflected in the long-term systematic collection of waste oil, which is collected by households in household containers and taken to collection containers at pilot sites.

Vegetable oils can be returned for reuse at the end of their first part after additional processing. After the first part of the life cycle, the oil enters the second part of the life cycle, where it can be used as a fuel to drive various versions of diesel engines. The current practice is that waste cooking oils collected in Slovenia end up abroad, where major biodiesel producers convert them into biodiesel fuel. Alternatively, it can be used as a basis for the production of various biodegradable ointments. The product itself can also be used for various innovative products, such as processing into organic candles.



Today, the economy is still largely linear, with only a few % of secondary materials and resources being reused in the economy. Businesses and consumers could take advantage of the huge potential for re-use, an example of good circular economy practice, in our case waste cooking oil, and set up a material loop in the local environment.

**Keywords:** sustainability, secondary materials, circular economy, life cycle, re-use, local material loop

**Article Classification:** Professional paper



## So odpadki problem ali dober posel

### Is waste a problem or a good business

Polona Hrovat Mavsar<sup>1</sup>, Mojca Žganec Metelko<sup>1</sup>

<sup>1</sup>Knof so.p., Slovenija

E-naslovi: polona@knof.si, mojca.metelko@knof.si

#### Povzetek

Zavod Knof so.p. je socialno podjetje, ki deluje na področju socialnih inovacij in okoljevarstva. Kot socialno podjetje išče rešitve za te izzive, ki pa niso komercialne, vendar nujno potrebne za preživetje družbe in okolja. Naš namen je popularizacija trajnostnega načina življenja in oblikovanje sprememb na sistemskem nivoju. Največ delujemo na področju tekstilnih in kosovnih odpadkov, kjer razvijamo rešitve po sistemu ponovno uporabi, popravi, recikliraj. Smo ustanovitelji petih butikov ponovne uporabe, salona pohištva iz ponovne uporabe, v Krškem pa vzpostavljamo največji krožni laboratorij v Sloveniji. Pri svojem delu se povezujemo tako s podjetji kot z javnimi ustanovami, drugimi organizacijami ter posamezniki. Zadnji dve leti se zaradi slabe kakovosti materialov, ki jih prejmemo osredotočamo na razvoj sistemov recikliranja tekstila, kosovnega odpada in plastike v nove, tržno zanimive produkte. Pri oblikovanju sprememb vidimo krožno gospodarstvo kot dobro orodje in ne kot končno rešitev za zmanjševanje negativnih vplivov sodobnega potrošništva in gospodarskega razvoja na okolje in podnebne spremembe. Potrebne so spremembe mišljenja in vedenja na področju ekonomskih odnosov ter preoblikovanje diskurza o gospodarski in družbeni rasti, ki bi se osredotočal na druge okoljske in človeške kazalnike in ne le na BDP.

**Ključne besede:** socialne inovacije, okoljevarstvo, odpadki, krožno gospodarstvo, ponovna uporaba, recikliranje, razvoj

**Razvrstitev:** Strokovni članek

#### Abstract

Institute Knof so.p. is a social enterprise operating in the field of social innovation and environmental protection. As a social enterprise, we seek solutions to these challenges, which are not commercial, but absolutely necessary for the survival of society and the environment. Our purpose is the popularization of a sustainable lifestyle and the creation of changes at the systemic level. We mostly operate in the field of textile and bulky waste where we develop solutions according to the reuse, repair, recycle system. We are the founders of five reuse boutiques, a reused furniture salon, and in Krško we are establishing the largest circular laboratory in Slovenia. In their work, we cooperate with companies, public institutions and other organizations and individuals. For the last two years, due to the poor quality of the materials we receive, we have been focusing on the development of textile recycling systems, bulk waste and plastics into new, market-interesting products. When creating changes, we see the circular economy as a good tool and not as a final solution for reducing the negative impacts of modern consumerism and economic development on the environment and climate change. Changes in thinking and behavior in the field of economic relations are needed, as well as a transformation of the discourse on economic and social growth, which would focus on other environmental and human indicators and not only on GDP.

**Keywords:** social innovation, environmental protection, waste, circular economy, reuse, recycling, development

**Article Classification:** Professional paper



## Snovni krog embalaže tetrapak in higienskega papirja – primer dobre prakse

### Material cycle of used beverage cartons and hygiene paper – case study

Špela Gutnik<sup>1</sup>

<sup>1</sup>*Circular Shield d.o.o., Slovenija*  
*E-naslov: spela.gutnik@circularshield.org*

#### Povzetek

Dvig potrošnje, povečano povpraševanje, v zadnjem času pa še prekinjene dobavne verige in nova krizna območja, so ključni razlogi za to, da se danes soočamo s pomanjkanjem surovin in naraščajočimi cenami materialov. Hkrati je postalo jasno, da prekomerno izkoriščanje naravnih virov vodi v ekološko in gospodarsko katastrofo. Podjetja so in še bodo prisiljena iskati alternativne rešitve. Nujno je, da tako proizvajalci kot tudi trgovci in potrošniki postanemo bolj trajnostno naravnani. Alternativ je več – ena od njih je tudi ponovna uporaba sekundarnih materialov. To, kar je za eno industrijo odpadek, je lahko priložnost za nekoga drugega.

Sekundarni materiali niso samo industrijski ali gradbeni odpadki. Koristne sekundarne surovine najdemo tudi v zabojnikih za odpadke, ki jih polnimo ljudje. Mesta in urbana središča postajajo zelo dober vir sekundarnih surovin – eden od takšnih je uporabljena embalaža za mleko, sokove in druga tekoča živila (tetrapak). V povprečju kar 75 % te embalaže predstavlja celuloza visoke kakovosti.

V Sloveniji je že leta 2016 zaživel pilotni projekt – lokalni snovni krog odpadne embalaže tetrapak in recikliranega higienskega papirja. Lokalno zbrana embalaža se odda v predelavo prav z namenom, da se iz nje izdelata higienski papir. Končni izdelki se vrnejo nazaj v lokalno skupnost – v javne ustanove in v podjetja v tistih občinah, kjer je bila embalaža zbrana. Zato za izdelavo higienskega papirja ni treba sekati dreves, lahko ga predelamo iz odpadne embalaže tetrapak. Ta rešitev lokalni skupnosti prinaša tako okoljske kot tudi ekonomske koristi.

Gre za dober primer krožnega gospodarstva, ki se izvaja v sodelovanju z lokalno skupnostjo in ga je mogoče vzpostaviti v vsaki občini ali mestu v EU, ki ima urejen sistem ločevanja komunalnih odpadkov.

**Ključne besede:** krožno gospodarstvo, trajnost, sekundarni viri surovin, lokalna snovna zanka

**Razvrstitev:** Strokovni članek

#### Abstract

Increased consumption, rise in demand, broken supply chains and new crisis areas are key reasons for current shortages of primary materials and their extremely high prices. At the same time, it became clear to us that over-exploitation of natural resources leads to ecological and economic catastrophe. Companies are forced to look for alternative solutions. It is essential that producers, retailers, and consumers become more sustainable. There are several alternatives – the reuse of secondary materials is just one of them. What is “trash” for one industry can be “treasure” for another.

Secondary materials are not just industrial or construction waste. Useful secondary resources can also be found in waste bins that are filled by people. Cities and urban areas are a very valuable source of useful secondary materials – one of these is the beverage carton packaging. On average, 75% of this packaging is made of high-quality cellulose.

Already in 2016, a pilot project – the local material cycle of used beverage cartons and hygiene paper – has been introduced in Slovenia. Locally collected beverage cartons are processed into hygiene paper products. These



products are used in public institutions and companies in those municipalities where waste packaging was collected. Therefore, there is no need to cut trees to produce hygiene paper. We can use existing used beverage cartons.

This solution brings both environmental and economic benefits to the local community. It is a good example of a circular economy in the local community and can be set up in any EU municipality or city, that has a municipal waste separation system in place.

**Keywords:** circular economy, sustainability, secondary sources, local material loop

**Article Classification:** Professional paper





## Zeleno javno naročanje kot orodje prehoda v krožno gospodarstvo

### Green public procurement as a tool for transitioning to a circular economy

Matej Cerovšek<sup>1</sup>

<sup>1</sup>Ministrstvo za okolje in prostor, Slovenija  
E-naslov: matej.cerovsek@gov.si

#### Povzetek

Zeleno javno naročanje je naročanje blaga, storitev ali gradenj, ki imajo v primerjavi z običajnim blagom, storitvami in gradnjami v celotni življenjski dobi manjši vpliv na okolje in zagotavljajo varčevanje z naravnimi viri, materiali in energijo ter imajo enake ali boljše funkcionalnosti. Iz definicije zelenega javnega naročanja implicitno izhaja, da trenutno razširjeni klasični produkti predstavljajo negativne obremenitve za okolje, napredek v tej smeri pa je možen predvsem z vključevanjem vidikov krožnega gospodarstva.

Zeleno javno naročanje je na ravni EU trenutno prostovoljno, v prihodnjih letih pa bo postalo obvezujoče. Spremembe na področju naročanja pa še zdaleč niso edino orodje prehoda v krožni model, saj se v procesu načrtovanja proizvodov vse bolj uveljavlja pristop ekodizajna.

Javno naročanje predstavlja velik del javne potrošnje, z njim pa država identificira prioritete in daje zgled zasebnemu sektorju. Na ta način produkti postanejo konkurenčnejši in državljanom dostopnejši. V Republiki Sloveniji je vključevanje okoljskih zahtev obvezno pri 22 predmetih javnega naročanja, v prihodnje pa se bo število proizvodov in ambicioznost zahtev še okrepila.

Prispevek obravnava pomen zelenega in krožnega javnega naročanja, zakonske možnosti, ki jih daje obstoječa zakonodaja, vlogo gospodarstva ter trende na področju javnega naročanja, ki bodo v prihodnje poenostavili, z načeli krožnega gospodarstva, skladno javno potrošnjo. Glede na letos izvedeno prvo analizo učinkov zelenega javnega naročanja pri nas zeleno javno naročanje prinaša ogromne pozitivne okoljske in ekonomske učinke.

**Ključne besede:** javno naročanje, zeleno, krožno, LCA, analiza učinkov

**Razvrstitev:** Strokovni članek

#### Abstract

Green public procurement is the purchasing of goods, services or constructions that, compared to conventional goods, services and constructions, have a lower impact on the environment throughout their lifetime, ensure saving of natural resources, materials and energy, and have the same or better functionality. It implicitly follows, from the definition of green public procurement, that the current products represent negative impacts to the environment, and progress in this direction is possible primarily by including aspects of the circular economy.

Green public procurement is currently voluntary at the EU level, but will become mandatory in the following years. Changes in this area are far from being the only tool for transitioning to a circular model, as the ecodesign approach is increasingly developing.

Public procurement represents a large part of public consumption, and with it the state identifies priorities and sets an example for the private sector. In this way products become more competitive and more accessible to citizens. In the Republic of Slovenia, the inclusion of environmental requirements is mandatory for 22 product groups, and in the future this number and the ambition of the requirements will further increase.



The paper discusses the importance of green and circular public procurement, the legal options, the role of the economy and the trends in this field, which will simplify public consumption consistent with the principles of the circular economy. According to the first analysis of the effects of green public procurement carried out this year, it brings enormous positive environmental and economic impacts.

**Keywords:** public procurement, green, circular, LCA, impact analysis

**Article Classification:** Professional paper



## Vzpostavitev vitke organizacije v podjetju X

### Setting up lean management in company X

Matej Rovtar<sup>1</sup>, Mitja Cerovšek<sup>1</sup>

<sup>1</sup>Fakulteta za industrijski inženiring Novo mesto, Slovenija  
E-naslovi: matej.rovtar@students.fini-unm.si, mitja.cerovsek@fini-unm.si

#### Povzetek

V današnjem svetu kot osebe, podjetja in organizacije stremimo k temu, da poskušamo procese dela optimizirati oziroma svoj čas porabiti čim bolj učinkovito. Sleherni posameznik je v času opravljanja svojega dela zagotovo razmišljal, kako naj naredi nekaj hitreje, bolje ali pa kako naj čim hitreje zaključi neko delo, da lahko nadaljuje z drugim. Obenem se tako podjetja kot tudi ljudje soočajo s časovnimi in denarnimi izgubami ter jih pri svojem delu poskušajo zmanjševati.

Za vzpostavitev vitke organizacije v podjetju X smo uporabili točkovni Kaizen oziroma Point Kaizen in metodo 5S. V pomoč nam je bil krog PDCA in v omejenem obsegu tudi vizualni sistem Kanban. Ugotovili smo, da se je po vpeljavi metod hitrost priprave blaga izboljšala, prav tako se je izboljšala organizacijska sposobnost datotek, ki so nujno potrebne za delo, obenem pa smo s pomočjo metode 5S uredili delovne površine. Točkovni Kaizen smo uporabili pri posodobitvah programske opreme, ki prav tako predstavljajo ogromen odpadek časa.

S pomočjo metod vitke organizacije smo ugotovili, da smo zaposleni začeli k vsakemu problemu pristopati drugače, saj želimo najti rešitev, obenem pa zmanjšati odpadek gibanja in časa.

**Ključne besede:** Kaizen, Kanban, metoda 5S, odpadek, vitka organizacija

**Razvrstitev:** Strokovni članek

#### Abstract

In this day and age, we as people, companies and organizations, strive making our work processes optimised and to spend our time efficiently as much as possible. Every single person had a thought in his line of work so that he could do his job a little bit faster, better or even complete the job as soon as possible so he could continue onward. At the same time, both companies and the people face time and money losses and try to reduce them in their work.

To establish a lean organization in company x, we used point Kaizen or Point Kaizen and the 5S method. The PDCA cycle and, to a limited extent, the visual kanban system also came to our aid. We found that the speed of preparation of goods has improved, the organizational ability of our files and documents that are critical to our work improved, and at the same time we used the 5S method to arrange our work surfaces. We used point Kaizen in software updates, which also represents a huge waste of time.

With lean organization we also found out that as employees we started approaching every problem differently as such we wanted to find a solution to our problem as well as minimize waste in the form of time and unnecessary movement.

**Keywords:** Kaizen, Kanban, 5S method, waste, lean organization

**Article Classification:** Professional paper