



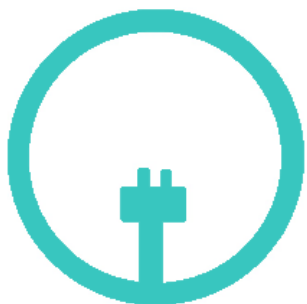
Fakulteta za
industrijski inženiring
Faculty of Industrial Engineering

***Razvoj industrijskega inženiringa (RII6):
Priložnosti, potenciali, izzivi***

***Development of Industrial Engineering(RII6):
Opportunities, Potentials, Challenges***

Zbornik povzetkov 6. mednarodne konference

Book of Abstracts of 6th International Conference





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Novo mesto, februar 2021

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Predgovor

V zahtevnih okoliščinah, ki jih doživljamo vsi, Fakulteta za industrijski inženiring Novo mesto predstavlja prispevke 6. mednarodne konference o razvoju industrijskega inženiringa. S podnaslovom "Priložnosti, potenciali, izzivi" organizatorji nakazujejo globalno zaskrbljenost, ki vpliva na življenje v vseh pogledih.

Organizatorji konference so načrtovali dogodek, katerega namen je posredovati informacije o trajnostnem razvoju in prispevati k trajnostnim ciljem in vidiku dolgoročne zdržljivosti s stališča industrijskega inženiringa, pri čemer poudarjajo na kakšen način lahko inženirske odločitve podpirajo trajnostno družbo.

Odziv avtorjev na razpis je predstavljen v Zborniku povzetkov, v katerem je 34 prispevkov, razvrščenih v pet glavnih tematskih sklopov: Strategije za trajnostno družbo, Trajnostne tehnologije, Kompleksnost upravljanja, Rešitve za trajnostni promet ter Delovno, socialno in kulturno okolje v novi dobi.

Izbruh koronavirusa je v zadnjih 14 mesecih postal osrednja težava naše družbe: omejevanje mobilnosti milijonov ljudi, vpliv na življenje in delovna mesta, prekinitve mednarodnih dobavnih verig, zaustavitev svetovnih gospodarstev in poudarjanje pomanjkljivosti našega linearnega sistema, ki temelji na pridobivanju virov in proizvodnji odpadkov. Svet se sooča s krizo, ki je neprimerljiva in ki kaže na pomanjkljivosti naše družbe.

Univerze, raziskovalci in celotna inženirska skupnost delijo globalne izkušnje, saj je večina institucij prekinila pouk v predavalnicah in prešla na spletno izobraževanje. Konferenca FINI ni izjema - po tradiciji je potekala na slikovitem Otočcu - zdaj pa bo najverjetneje na spletu, kar dokazuje, da pandemija pomembno vpliva na izmenjavo znanj med akademiki in praktiki, kar je bistvo vsake strokovne konference.

Kot odgovor na pandemijo so se vlade po vsem svetu odzvale z neprimerljivimi ekonomskimi spodbudami, da bi se ohranila delovna mesta in preprečil zastoj gospodarstva. Na pandemijo je potrebno gledati kot na redko priložnost za vzpostavitev prožnega gospodarskega okrevanja, ki vodi v trajnostno naravnano družbo. Tak cilj zahteva nove rešitve in pristope, ki bodo podjetjem omogočili dolgoročno finančno trdnost, zagotavljali zdravo družbo in napredek v vseh pogledih, brez škode za okolje, ter popravo že povzročene škode.

Organizator, Fakulteta za industrijski inženiring Novo mesto, upa, da bo ta konferenca pripomogla k prepoznavanju priložnosti, potencialov in izzivov v prizadevanju za razvoj družbe, ki razmišlja trajnostno.

zasl. prof. dr. Dorian Marjanović
Predsednik programskega odbora

Preface

In the challenging circumstances we are all experiencing, the Faculty of Industrial Engineering Novo mesto presents the 6th International Conference's contributions on the Development of Industrial Engineering. With the conference subtitle "*Opportunities, Potentials, Challenges*" the organizers have indicated all the global concerns that have influenced life in all aspects.

The conference organizers have envisaged an event that aims to communicate sustainability information and contribute to sustainability targets and long-term sustainability perspective from an industrial engineering viewpoint, emphasizing how engineering decisions could support a sustainable society.

The authors' response to the call for papers is presented in the Book of Abstracts, bringing 34 contributions compiled under the five major topics: *Strategies for Sustainable Society, Sustainable Technologies, Managing Complexity, Solutions for Sustainable Transport, and Working, Social and Cultural Environment in a New Era.*

The outbreak of the coronavirus has become a major disruption to human society during the last 14 months: restricting the mobility of millions of people, impacting lives and jobs, disrupting international supply chains, bringing global economies to a halt, and highlighting the deficiencies of our linear system based on resource extraction and waste production. The world is facing an incomparable crisis that indicates the shortcomings of our society.

The universities, researchers, and the whole engineering community share the global experience, with most institutions cancelling in-person classes and moving to online-only education. The FINI conference is no exception, traditionally held in the picturesque Otočec, most likely will be held online, demonstrating that the pandemic significantly influences knowledge sharing between academics and practitioners, the essence of every professional conference.

In response to the pandemic, governments reacted with the incomparable economic stimulus made available worldwide to preserve jobs and prevent the stall. The pandemic should be seen as a rare opportunity to build a resilient economic recovery leading to a sustainable society. Such a goal requires new solutions and approaches that will enable the enterprises' long-term financial health, ensuring society's social health and progress in all the aspects without harm to the environment and restoring the harm already done.

The organizer, the Faculty of Industrial Engineering Novo mesto, hopes that this conference will help to identify opportunities, potentials, challenges in striving to develop a sustainable society.

Prof. Emerit. Dorian Marjanović, PhD
The president of the Programme Committee



Vabljeno predavanje
Keynote lecture



Lean management and Industry 4.0

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Abstract

Lean Thinking and “Lean State of Mind” are not only spreading in existing and new industries: they also have an increasingly profound influence by enhancing our professional work and daily routine. The more our work is linked to industrialization, the more critical it is to transform our work and to adjust it to the newest industrial situation. The recent “Industry 4.0” changes our work in a revolutionary way. It does not replace it!

In the past, when talking about industrial added value, what was meant was mainly the reduction of wastefulness. Today, what is meant is ecological sustainability and, more recently, in conjunction with Industry 4.0, optimum networking. The decentralized regulation and integration of intelligent objects that accompany Industry 4.0 represent a revolutionary paradigm shift with the focus still being on waste-free processes.

The underlying hypothesis of creating leaner and waste-free processes by digital networking and of enhancing resource efficiency from an economical, psychological, and lastly also ecological point of view can only be successfully realized using Lean Thinking and “Lean State of Mind.”

Implementation of more high-tech production and digital transformation, increasing technology of production processing and machining to reduce the costs and increase the capacity, is always depending on company investment ability. Implementation of Lean and company lean conversion process depends on people with mostly no needs for high investment and often bringing more efficiency in production than new or upgraded equipment. The lean conversion of the company has to be on the side with any new investment and has to be considered before it. Already established Lean Processes are the precondition for a successful implementation of Industry 4.0. The presentation will emphasize the crucial importance of Lean Thinking for Industry 4.0. A selection of available Lean tools for the Lean transformation process and the possible effects of their implementation will be presented. Further, it will be shown which problems hinder the lean transformation and what is essential to consider achieving the best results in a lean conversion process.

The case studies will show what is achievable using the Lean tools, always having in mind that the lean conversion is a never-ending improvement process based on lean thinking and lean state of mind of both: managers and shop floor staff.

Keywords: Lean Management, Lean Manufacturing, Lean Tools, Continuous Improvement Process Lean Thinking, Connecting Value Stream, Network Industry, Industry 4.0, Cyber-Physical Systems (CPS), Internet of Things (IoT)

Article classification: Scientific paper



Strategije za trajnostno družbo ***Strategies to sustainable society***



Primerjava razvrščanja in označevanja z javnimi podatki za izbrana industrijska topila

Comparison of classification and labelling with public data for selected industrial solvents

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Povzetek

Evropska unija je z uredbo CLP (1272/2008/ES) implementirala t. i. globalno harmonizirani sistem razvrščanja in označevanja nevarnih kemikalij (GHS), ki pomeni pomemben prispevek k trajnostnemu razvoju držav članic. Uredba od proizvajalcev in uvoznikov nevarnih kemikalij zahteva, da izvedejo razvrstitev in označitev nevarnosti le-teh, pa tudi da izvedejo prijavo nevarnih snovi v popis razvrščanja in označevanja pri Evropski agenciji za kemikalije. V primeru, da letna proizvodnja ali uvoz po proizvajalcu ali uvozniku presega 1 tono, sta proizvajalec ali uvoznik tudi zavezanca za registracijo snovi.

Na primeru nekaj industrijsko pomembnih topil za specifične namene smo analizirali, kakšne razvrstitve nevarnosti so zavezanci prijavili v popis in kakšne v registracijo ter jih poskušali ovrednotiti glede na javno dostopne toksikološke in ekotoksikološke podatke.

Pravilna interpretacija toksikoloških in ekotoksikoloških podatkov je namreč ključna za pravilno razvrščanje, označevanje in pakiranje topil kot potencialno nevarnih snovi in je osnova za zaščito okolja, predvsem pa za zaščito zaposlenih v industriji. Preko objavljenih prijav nas je zanimala tudi dostopnost teh topil v EGP.

Ključne besede: CLP, GHS, ECHA, nevarne kemikalije, industrijska topila

Razvrstitev: Znanstveni članek

Abstract

With the CLP Regulation (1272/2008 / EC), the European Union implemented the so-called globally harmonized classification and labelling system for hazardous chemicals (GHS), which makes an important contribution to the sustainable development of the member states. The Regulation requires the manufacturers and importers of hazardous chemicals to carry out the classification and labelling of hazardous chemicals, as well as to report hazardous substances to the classification and labelling inventory at the European Chemicals Agency. If the annual production or import per manufacturer or importer exceeds one (1) tonne, the manufacturer or importer is also obliged to register the substance.

Using a sample of some industrially important solvents for specific purposes, we analysed which hazard classifications were reported in the inventory and which for registration, and tried to evaluate them according to publicly available toxicological and ecotoxicological data.

The correct interpretation of toxicological and ecotoxicological data is crucial for the correct classification, labelling and packaging of solvents as potentially hazardous substances and is the basis for the protection of the environment and, above all, the protection of employees in industry. In analysing the reports of hazard classifications, we were also interested in the accessibility of these solvents in the EEA.

Keywords: CLP, GHS, ECHA, hazardous chemicals, industrial solvents

Article classification: Scientific paper



Razvoj ojačenih celičnih mrežastih struktur, proizvedenih z aditivno tehnologijo

Developing reinforced cellular lattice structures fabricated with additive manufacturing technology

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Povzetek

Visoko zmogljive strukture se uporabljajo v številnih aplikacijah, kjer je visoka zmogljivost mehaničnih lastnosti ob ohranjanju nizke teže izdelka bistvenega pomena. To raziskovalno delo je osredotočeno na povečanje mehanskih lastnosti pravilne šesterokotne celice z ohranjanjem nizke mase strukture. Študija temelji na raziskavi zasnovane ojačane pravilne šesterokotne celične strukture. Da bi razumeli mehanski odziv celic na obremenitve, smo izvedli študijo pravilne in ojačane šesterokotne celice v obeh enoosnih ravninskih smereh. Tlačni eksperiment je bil izveden na celični geometriji pravilnega šesterokotnika, medtem ko je bilo natezno testiranje izvedeno na nateznih preizkušancih, ki so vsebovali geometrijo pravilne celice kot tudi geometrijo razvitih okrepljenih celic. Vzorci so bili izdelani s PolyJet aditivno tehnologijo. S primerjalno analizo smo proučevali vpliv na deformacijo pod enoosno obremenitev v obeh ravninskih smereh z eksperimentalnim, numeričnim in analitičnim pristopom. Rezultati so pokazali, da se načini odpovedi pravilnega neojačenega šesterokotnika razlikujejo med različnimi smermi obremenitve, medtem ko so mehanske lastnosti v linearno-elastičnem območju vzorcev podobne. Rezultati so pokazali do 625-odstotno povečanje mehanskih lastnosti obravnavanih ojačenih celičnih struktur, pri čemer je enkratno ojačana celica zabeležila najvišje povečanje mehanskih lastnosti v sorazmerju s številom ojačitev. Podatki numerične evalvacije so v skladu z eksperimentalnim testiranjem, medtem ko so analitične vrednosti pridobljene z večjimi odstopanji. Ugotovitve, pridobljene s tem raziskovalnim delom, pripomorejo k postopku oblikovanja in razvoju konstrukcij s prilagojenimi mehanskimi lastnostmi, pri čemer se ohranijo karakteristike nizke teže izdelka z zahtevanimi mehanskimi lastnostmi.

Ključne besede: aditivna proizvodnja, matematična študija, eksperimentalna študija, šesterokotne celice, numerična študija, ojačitev, relativna gostota

Razvrstitev: Znanstveni članek

Abstract

High performance structures are nowadays used extensively in several applications where the property of high stiffness to low weight ratio is essential. This research work is focused on increasing the mechanical properties of regular hexagonal cell by maintaining the low weight of the structure. This study is based on increasing performance with a novel design of reinforced structures. To understand the overall response of cells, a study of the regular and reinforced hexagonal cell was performed under both in-plane loading conditions. Compression experiment was performed on a regular hexagonal cell, while the tensional properties were tested on the regular cell as well as on developed reinforced cells, which consisted of one up to three times reinforced cell. Samples were fabricated with PolyJet additive manufacturing technology. With comparative analysis, we studied the effect on uniaxial deformation in both in-plane directions by applying the experimental, numerical and analytical approaches. Experimental results show up to 625% performance increase of developed reinforced structures, while the performance is not necessarily related to the relative density of the cell. The highest increase of performance with respect to number of reinforcements recorded one time-reinforced cell. The values of the numerical study were in agreement with the experimental testing, while the values of analytical models showed greater deviations. These findings could contribute to the designing process of the final part with acquired mechanical properties by maintaining the light-weight characteristic of the structure.

Keywords: additive manufacturing, analytical study, experimental study, hexagonal cellular solid, numerical study, reinforcement, relative density

Article classification: Scientific paper



Electrocaloric effect in smectic liquid crystals

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Abstract

The electrocaloric effect (ECE) is observed as heating or cooling of an electrocaloric material upon adiabatically switching an electric field on or off. It relies on the exchange between entropic reservoirs related to field-dependent material ordering and other degrees of freedom. We demonstrate theoretically and experimentally that liquid crystals (LCs) are suitable candidates as efficient electrocaloric materials. LCs combine a unique combination of order, liquid character, and softness. The latter leads to a relatively strong macroscopic response even to a weak external stimulus. In the theoretical study, we model LCs ordering using a Landau-de Gennes-Ginzburg phenomenological approach. We present conditions under which the largest electrocaloric response is expected, particularly near phase transitions. We show analytically, how the presence of smectic A layering enhances the electrocaloric effect. Our theoretical findings are in qualitative agreement with our high precision calorimetry conducted on 8CB and 12CB LCs. We obtained an electrocaloric temperature response of 6.5 K, which is so far the largest measured response in LCs. ECE has promising potential for numerous applications, for example in environmentally friendlier heating, cooling, and waste heat recovery devices with an improved coefficient of performance. We present an electrocaloric active regeneration mechanism exploiting LCs as an active regenerator, which could significantly improve the cooling power to mass ratio.

Keywords: electrocaloric response, smectic liquid crystals, phenomenological modelling, calorimetry, electrocaloric effect-based applications

Article classification: Scientific paper



Prisotnost in spreminjanje endoklimatskih fizikalnih faktorjev, ki lahko vplivajo na učinkovitost izvajanja kontrole kvalitete produktov v slovenskih tehnoloških podjetjih

Presence and change of endoclimatic physical factors that may affect the effectiveness of product quality control in Slovenian technology companies

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Povzetek

Dejavniki, ki vplivajo na točnost meritev, so človeške narave, na katere vpliva uporabnik, in tehnološke, za katere je odgovoren proizvajalec merilnega sistema. Endoklimatski fizikalni dejavniki, ki so prisotni v delovnem procesu, lahko pomembno vplivajo na učinkovitost izvajanja kontrole kvalitete produktov. Težavo predstavljajo predvsem dnevna nihanja oz. spreminjanja izraženosti in intenzivnosti le-teh, ker je večina merilnih naprav kalibrirana na določeno vrednost kritičnih faktorjev. V nadaljevanju predstavljamo rezultate analize prisotnosti in dnevnega spreminjanja osvetljenosti, temperature, prahu, vlage, dima in mehanskih vibracij v proizvodnih prostorih vzorčnih tehnoloških podjetij.

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. C3330-18-952007 (EAGLE).

Ključne besede: EAGLE, endoklima, kakovost izdelka, merilni sistemi

Razvrstitev: Strokovni članek

Oblika predavitve: Poster

Abstract

Factors affecting the accuracy of measurements are of human nature, influenced by the user, and technological ones, for which the manufacturer of the measuring system is responsible. Endoclimatic physical factors present in the work process can significantly affect the effectiveness of the implementation of product quality control. The main problem are daily fluctuations or changes in the expression and intensity of the factors, because most measuring devices are calibrated to a certain value of critical factors. Further, we present the results of the analysis of the presence and daily change of lighting, temperature, dust, humidity, smoke and mechanical vibrations in the production facilities of sample technology companies.

Acknowledgment: The research work is partly funded by the European Union from the European Regional Development Fund under the Operational Programme for Investments in Growth and Jobs for the programming period 2014 to 2020, under contract no. C3330-18-952007 (EAGLE).

Keywords: eagle, endoclimate, product quality, measurement methods

Article classification: Professional paper

Type of presentation: Poster



Sistem za simulacijo širjenja motenj v industrijskem okolju

A system for simulating the propagation of disturbances in an industrial environment

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Povzetek

V proizvodnem procesu se pogosto pojavljajo motnje v obliki vibracij, katerih vir je delovanje težkih naprav v industrijskem okolju, kot so npr. večtonske stiskalnice. Vibracije se širijo po celotnem proizvodnem prostoru in posledično povzročajo nihanja strojnih elementov v tem prostoru. Poznavanje in obvladovanje vibracij je ključnega pomena za kakovostno načrtovanje tehnološkega procesa med postopkom proizvodnje izdelkov.

Izdelana je maketa na laboratorijskem nivoju za simulacijo vibracij in drugih tipov motenj v industrijskem okolju. Z uporabo makete je mogoče izvajati večparametrično analizo vpliva vibracij na strojne elemente, ki so del tehnološkega postopka v proizvodnji. Maketa omogoča simulacijo vira motnje in spremljanja motnje v realnem času, ki se po podlagi in tudi preko konstrukcij, vgrajenih v proizvodnem prostoru, prenaša v obliki vibracij. Model vsebuje sistem pospeškomerov, analizator signalov in drugo pripadajočo opremo ter sistem za obdelavo in vrednotenje eksperimentalnih podatkov.

Ključne besede: vibracije, tehnološki proces, simulacija motenj, večparametrična eksperimentalna analiza

Razvrstitev: Znanstven prispevek

Oblika predstavitve: Poster

Abstract

In the production process, we often observe disturbances in the form of vibrations which occur due to the operation of heavy devices in the industrial environment such as multi-tone presses. Vibrations propagate throughout the production area and consequently cause oscillations of machine elements in that area. Knowledge and control of vibrations are crucial for quality planning of the technological process during product manufacturing.

A model at the laboratory scale is made to simulate vibrations and other types of disturbances in the industrial environment. Using the model, it is possible to perform a multiparametric analysis of the impact of vibrations on machine elements that are part of the technological process in production. The model enables the simulation of the source of disturbance and the monitoring of the disturbance in real time, which is transmitted in the form of vibrations along the base and also through the constructions installed in the production area. The model includes a system of accelerometers, a signal analyser and other related equipment, as well as a system for processing and evaluating experimental data.

Keywords: vibrations, technological process, simulation of disturbances, multiparametric experimental analysis

Article classification: Scientific paper

Type of presentation: Poster



Experimental dynamic analysis of elastic plate with thin coating

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Abstract

Multi-layered engineering structures with contrast material and geometric parameters are often subject to intensive dynamic loading drastically affecting their performance. The contrast properties of layered structures also bring a number of challenges in experimental analysis of dynamic response. In particular, for a thin plate, it is due to the proximity of the fundamental bending mode and the lowest shear mode with the value of the cut-off frequency tending to zero. Based on experimentally obtained vibration spectra, and the associated displacement and stress fields for a number of coating specimens, these models appear to be useful for optimizing coating performance.

Experimental dynamic analysis of an elastic plate covered with thin viscoelastic layer was performed using the optical measuring system GOM Aramis HS equipped with two high-speed Photron Mini UX100cameras. Special attention was focused on the clamping of the plate, due to its substantial effect on the accuracy of measurements. Measuring bending modes makes the experimental visualization of the dynamic behaviour of the layered plates very useful for comparing experimental and analytical results coming from various ad hoc layered plate theories.

Keywords: layered plate, coating, bending mode, vibration spectra

Article classification: Scientific paper



Je CO₂ laserski rezalnik še konkurenčen?

Is CO₂ laser cutting machine still competitive?

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Povzetek

Na trgu, kjer deluje neusmiljena konkurenca, moramo biti vedno pripravljeni na izboljšave, napredek, biti v koraku s časom, da ne ostanemo za tekmeci. To seveda velja tudi za tehnološko opremo, s katero moramo v podjetju slediti času in konkurenci, ali še boljše, prehiteti konkurenco. Velikokrat pa nastopi težava, kakšno strojno opremo sploh uporabiti oziroma smiselnost menjave starejše tehnologije z novejšo. Pojavi se veliko vprašanj, ki so tako tehnične kot tudi ekonomske narave. Zastaviti pa si je treba ključna vprašanja, kot so: Kakšno opremo potrebujemo, Koliko sredstev imamo in Kdaj se nam bo investicija povrnila. Ko si odgovorimo na vsa splošna vprašanja, se odprejo podrobnejša, tehnična, npr. v kateri tip opreme investirati. Zato bomo v prispevku primerjali dva različna izvora na hitro razvijajočem se področju.

Prispevek obravnava primerjalno analizo dveh povsem različnih virov laserskega rezalnika, in sicer primerjavo med CO₂ laserskim virom in vlakenskim laserskim virom. Osnova analize so profesionalni stroji z uporabo v masovni proizvodnji. Analiza je razdeljena na več sklopov, ki so podrobno razčlenjeni, ter tako vir podatkov za vsakega bodočega ali že trenutnega uporabnika laserskega stroja. Raznovrstnost pridobljenih podatkov prinaša veliko možnosti izbiranja pri odločanju. Rezultate teh sklopov na koncu povzamemo z odločitvenimi metodami.

Ključne besede: analiza primerjave, CO₂-laserski izvor, izvor, laserska optika, optična vlakna, resonator, rezanje, vlakenski-diodni laserski izvor

Razvrstitev: Strokovni članek

Abstract

Where markets are ruled by fierce competition rules one always has to be prepared for improvements, progress and keeping up to date in order not to be left behind. This also applies to technological equipment in order to keep track of time or, even better, overtake the competition. There is often a problem concerning the type of mechanical equipment that should be used, or if it is logical, to replace the old equipment with a new one. A lot of questions appear, technical as well as economical. But we have to set the key questions such as what kind of equipment do we need, how many financial resources do we have and when will we see the return on investment. Once we have answered these questions some more specific, technical ones come up, such as what type of equipment should we invest in. The paper describes the comparison between two different types of laser sources that are currently prevailing on the market.

The paper deals with a comparative analysis of two completely different laser cutter sources, namely a CO₂ laser source and a fibre laser source. Professional machines used in mass production are the basis of this analysis. The analysis is divided into several parts which are broken down in detail and therefore represent a source of data to each future or current laser cutting machine user. The diversity of the data obtained helps us choose between two sources. The results are finally summarised by decision methods.

Keywords: comparative analysis, CO₂ laser cutting source, origin, laser sight, optical fibres, resonator, cutting, fibre-diode laser cutting source

Article classification: Professional paper



Razvoj koncepta sistema za geometrijsko kontrolo kakovosti EAGLE

Development of the concept of the EAGLE geometric quality control system

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Povzetek

V okviru projekta EAGLE razvijamo demonstracijski prototip naprednega 3D-senzorskega sistema, ki omogoča frekvenčno vizualno kontrolo geometrije kompleksnih kovinskih predmetov. Kontrola se izvaja z uporabo inovativnih 3D-postopkov strojnega vida. Prototip validiramo in demonstriramo v simuliranem operativnem okolju.

Na podlagi razvojnih izhodišč pri zasnovi koncepta novega merilnega sistema rešujemo izzive s svetlobnimi odsevi indirektno osvetljenih delov predmetov zaradi odbojev svetlobe ter težave z računsko zahtevnostjo in posledično visoko kompleksnostjo merilnih postopkov. Posebno pozornost posvečamo detekciji detajlov na merjencu, ponovljivosti vpenjanja merjencev ter ustreznim postopkom osvetljevanja opazovanega področja za zagotavljanje pravilnega zajema slikovnih podatkov. Raziskujemo priložnosti za vključitev sistema EAGLE ter razvitih merilnih postopkov v koncept pametne tovarne.

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. C3330-18-952007 (EAGLE).

Ključne besede: 3D slikovni senzor, kontrola kakovosti, avtomatizacija proizvodnje, industrija 4.0, tovarne prihodnosti

Razvrstitev: Strokovni članek

Oblika predstavitve: Poster

Abstract

As part of the EAGLE project, we are developing a demonstration prototype of an advanced 3D sensor system that enables frequency visual control of the geometry of complex metal objects. The control is performed using innovative 3D machine vision procedures. The prototype is validated and demonstrated in a simulated operating environment.

Based on the development starting points in the design of the concept of the new measuring system, we solve challenges with light reflections of indirectly illuminated parts of objects due to light reflections and problems with computational complexity and consequently high complexity of measuring procedures. We pay special attention to the detection of details on the subject, the repeatability of the clamping of the objects and the appropriate procedures for illuminating the observed area to ensure the correct capture of image data. We are exploring opportunities to integrate the EAGLE system and developed measurement procedures into the smart factory concept.

Acknowledgement: 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. C3330-18-952007 (EAGLE).

Keywords: 3D image sensor, quality control, industrial automation, Industry 4.0, factories of the future

Article classification: Professional paper

Type of presentation: Poster



Izdelava lopatic modelne vetrne turbine

Manufacturing of model size wind turbine blades

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Povzetek

V prispevku je predstavljena izdelava lopatic vetrne turbine modelne velikosti za testiranje v vetrovniku. Lopatice so bile izdelane s postopkom 3D-tiskanja. Cilj je bil izdelati lopatice v velikosti trikratnika maksimalne višine tiskanja, zato so bile lopatice sestavljene iz treh segmentov, ki so bili ustrezno spojeni. V prispevku so predstavljeni problemi in omejitve pri izbiri različnih filamentov ter kasnejšem spajanju segmentov. Uspešnost izdelave je bila testirana z izvajanjem porušnih preizkusov z namenom zagotavljanja varnosti pri kasnejšem izvajanju meritev karakteristike modela vetrne turbine v vetrovniku.

Ključne besede: lopatice vetrne turbine, izdelava, 3D-tiskanje, vetrovnik

Razvrstitev: Znanstveni članek

Abstract

This paper presents the manufacturing of a model-sized wind turbine blades for wind tunnel testing. The blades were made by 3D printing. Since the goal was to make the blades three times larger than the maximum print height, the blades were built of three joint segments. Problems and limitations in the selection of different filaments and subsequent joining of segments are presented. The manufactured blades were tested by performing destructive tests to ensure safety in the subsequent measurements of the wind turbine characteristic in the wind tunnel.

Keywords: wind turbine blades, manufacturing, 3D printing, wind tunnel

Article classification: Scientific paper



Simulacija skladišč s tehnikami navidezne resničnosti na spletu

Warehouse simulations with web virtual reality techniques

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Povzetek

Logistika in simulacije v navidezni resničnosti sta dve področji, katerih povezovanje, delujoče na spletu, izkazuje izredno moč integracije dveh sistemov. V kontekstu industrije 4.0 in upravljanja skladišč so virtualna skladišča intuitiven način prikaza in napovedovanja procesov in dejavnosti v skladišču. Za razumevanje dinamičnega obnašanja sistemov in preverjanja procesov je potrebna uporaba simulacij. Čeprav sta količina podatkov in potreben čas za izvedbo tovrstnih simulacij precejšna, 3D-vizualizacija sistema omogoča boljše razumevanje obnašanja in načrtovanja sistema. Članek opisuje uporabo 3D-simulacije za vizualizacijo delovnih tokov v skladišču z uporabo standardnih tehnik za prikazovanje v spletnih brskalnikih. Uspeh 3D-aplikacij na spletu je odvisen od kakovosti prikaza in stopnje interakcije. XML uporabljamo kot vmesnik med realnimi podatki in definicijo parametrov, ki določajo obnašanje simulacije. Avtomatizirano generiranje vozlišč in generiranje kode omogočajo izvedbo v standardnem X3D-formatu. Aplikacija omogoča uporabo X3D kot standardnega označevalnega jezika za modeliranje, vizualizacijo in spreminjanje parametrov za optimiranje delovanja skladišča. Podatki iz simulacij v virtualnem skladišču se lahko neposredno uporabljajo za optimizacijo zmogljivosti in nadaljnje operativno načrtovanje v skladišču.

Gljučne besede: virtualizacija, 3D-simulacije, industrija 4.0

Razvrstitev: Znanstveni članek

Abstract

Logistics and virtual reality simulations are two areas whose integration, working online, demonstrates the extraordinary power of integrating two systems. In the context of Industry 4.0 and warehouse management, virtual warehouses are an intuitive way to display and predict processes and activities in a warehouse. The use of simulations is required to understand the dynamic behavior of systems and to check processes. Although the amount of data and the time required to perform such simulations is considerable, 3D visualization of the system allows for a better understanding of the system behaviour and design. The article describes the use of 3D simulation to visualize warehouse workflows using standard rendering techniques in web browsers. The success of 3D applications online depends on the quality of the display and the degree of interaction. XML is used as an interface between real data and the definition of parameters that determine the behaviour of the simulation. Automated node generation and code generation allow execution in the standard X3D format. The application allows the use of X3D, as a standard markup language, for modelling, visualization and changing of parameters to optimize the warehouse performance. Data from simulations in the virtual warehouse can be used directly to optimize performance and further operational planning in the warehouse.

Keywords: virtualization, 3D simulations, Industry 4.0

Article classification: Scientific paper



Primerjava simulacij med različnimi CFD-sistemi

Comparison of simulations in different CFD systems

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Povzetek

Trend na področju računske dinamike fluidov nakazuje na vedno več programskih rešitev za simulacije, za katere ni potrebno veliko specialističnega znanja s področja numeričnih simulacij fluidov. Nekatere programske rešitve so vključene v obstoječe programske sisteme za obvladovanje geometrije ali kot dodatki k specializiranim programskim sistemom za simulacije dinamike fluidov. V članku predstavljamo izvedene simulacije z različnimi programskimi paketi na enakih geometrijskih primerih ob enakih robnih in začetnih pogojih. Primerjamo kakovost in primernost različnih programskih sistemov v različnih fazah razvoja izdelka tako po pristopu kot rezultatih. Primerjava izkazuje veliko razliko med rezultati, pridobljenimi s programskimi paketi Ansys, Ansys Discovery Live in SolidWorks Flow Simulations.

Ključne besede: simulacije, računska dinamika fluidov, ANSYS Discovery LIVE, SolidWorks Flow Simulation

Razvrstitev: Strokovni članek

Abstract

The trend in the field of computational fluid dynamics indicates an increasing number of software solutions for simulations, which do not require much specialist knowledge in the field of numerical fluid simulations. Some software solutions are integrated into existing software systems for managing geometry or as additions to specialized fluids dynamics simulation software systems. In this paper, we present simulations with different software packages on equal geometry examples, under the same boundary and initial conditions. We compare the quality and suitability of different software systems at different stages of product development, both by approach and results. The comparison shows a big difference between the results obtained by the Ansys, Ansys Discovery Live and SolidWorks Flow Simulations software packages.

Keywords: simulations, computational fluid dynamics, ANSYS Discovery LIVE, SolidWorks Flow Simulation

Article classification: Professional paper



Low-frequency dynamics of a pre-stressed fluid loaded layer

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Abstract

Dynamic problems in fluid structure interactions are investigated in great detail for relatively stiff elastic plates and shells motivated by numerous technical applications, e.g. see [1]. Much less attention is given to fluid loaded membranes, e.g. see [2]. Implementation of modern soft materials motivates modelling of pre-stressed elastic structures interacting with fluid. Low-frequency asymptotic analysis of thin pre-stressed layer results in the leading order approximation, given by a wave equation for membrane vibrations. We study dynamics of a pre-stressed layer resting on a fluid half-space starting from the membrane approximation. Various asymptotic limits are analysed depending on the relation between the wave speeds in the membrane and fluid.

References:

- [1] Junger, M. C., & Feit, D. (1986). Sound, structures, and their interaction (Vol. 225). Cambridge, MA: MIT press.
- [2] Crighton, D. G. (1983). The Green function of an infinite, fluid loaded membrane. *Journal of Sound and Vibration*, 86(3), 411-433.

Keywords: fluid loaded layer, wave propagation

Article classification: Scientific paper



Rayleigh-type wave on an elastic half-space with an added mass distributed along the surface

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Abstract

This paper deals with surface waves propagating in a linearly isotropic, elastic half-space, with a focus on the effects of added mass distributed along the surface. The dispersion relation for the associated surface elastic wave is derived, with the terms arising due to the inertial effects pointed out. The asymptotic procedure for a thin layer attached to a half-space is established, justifying the original formulation for the added distributed mass. Then, an explicit asymptotic model capturing the contribution of the studied surface wave to the overall dynamic behaviour is constructed, extending further the methodology of hyperbolic-elliptic models in [1], with the inertial effects providing dispersive perturbative terms in the wave equation on the surface. The results may be useful for various engineering applications, including analysis of vibrations in underground structures.

Reference:

[1]. J. Kaplunov, D.A. Prikazchikov. "Asymptotic theory for Rayleigh and Rayleigh-type waves." *Advances in Applied Mechanics*. Vol. 50. Elsevier, 2017. 1-106.

Keywords: elastic, surface wave, dispersion, inertial, asymptotic

Article classification: Scientific paper



Trajnostne tehnologije
Sustainable technologies



Correlation between adhesion strength and phase transition behaviour in Au- and SiO₂-supported lipid membranes

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Abstract

Profound understanding of lipid vesicle adhesion, especially in the size range below 200 nm, is of major importance for biological processes. When being in contact with solid surfaces, vesicles can form either supported vesicle layers or rapture into supported lipid bilayers. Quartz-crystal microbalance with heat dissipation (QCM-D) is an acoustic, label-free, versatile method for the detection and characterization of phase transitions in solid-supported lipid vesicles and membranes.

In this paper, the correlation between vesicle deformation and membrane rapture, as well as the respective phase transitions, have been experimentally researched by means of QCM-D [1]. Vesicles of dipamitoylphosphatidylcholine have been synthesized and extruded at 100 nm and 30 nm. Two types of substrates have been used with different adhesion levels, namely, Au and SiO₂. The correlation between surface adhesion strength and membrane phase transitions has been researched as a function of the vesicle size (extruded at 100 nm and 30 nm) and adsorption temperature (above and below melting). The experimental results are complemented by numerical simulations.

Reference:

[1] K. Bibissidis, K. Betlem, G. Cordoyiannis, F. Prista-von Bonhorst, J. Goole, J. Raval, M. Daniel, W. Goźdź, A. Iglič and P. Losada-Pérez, "Correlation between adhesion strength and phase behaviour in solid-supported lipid membranes", *J. Mol. Liq.* 320: 114492 (2020).

Keywords: lipid vesicles, solid-supported lipid bilayers, phase transitions, adhesion strength, quartz-crystal microbalance with heat dissipation.

Article classification: Scientific paper

Type of presentation: Poster



Napovedovanje porabe električne energije z umetno inteligenco

Prediction of electricity consumption with artificial intelligence

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Povzetek

V predavanju bomo predstavili rezultate raziskave, katere cilj je bil razvoj in preizkušanje novih algoritmov umetne inteligence za napovedovanje bodoče porabe električne energije posameznih končnih uporabnikov. Delo pri tej raziskavi je bilo sestavljeno iz treh sklopov: analiza vplivnih faktorjev, analiza profiliranja končnih uporabnikov ter razvoj algoritmov za napovedovanje bodoče porabe končnih uporabnikov. Na realnih zgodovinskih podatkih za 2500 končnih uporabnikov smo razvili tri algoritme, ki temeljijo na klasterški analizi, slučajnih drevesih, posplošenih linearnih modelih in nevronskih mrežah.

Pri analizi vplivnih faktorjev smo ugotovili, da imajo največji vpliv izbrani vremenski in koledarski faktorji ter njihove izpeljanke. Pri profiliranju končnih uporabnikov smo ugotovili, da ima cca. 40 % uporabnikov skupaj manj kot 1 % celotne porabe, zato smo jih združili.

Algoritme smo ovrednotili po metodi deljenja podatkov v učno množico, ki zajema vse podatke od prvega dne do do izbranega četrta, v testno množico pa podatke od sobote po izbranem četrtku do naslednjega petka. Z izračunom MAPE (mean absolute percentage error) smo ugotavljali kvaliteto dobljenih napovedi. Dobljeni rezultati kažejo, da so vsi trije algoritmi dobri, v povprečju pa se najbolje obnaša model, ki temelji na posplošenih linearnih modelih.

Vse sklope raziskave smo implementirali v okolju Python in R, podatke pa hranimo v MongoDB bazi. Vizualizacija napovedi je narejena z orodjem Grafana.

Ključne besede: umetna inteligenca, napovedovanje porabe električne energije, profiliranje uporabnikov, vplivni faktorji

Razvrstitev: Znanstveni članek

Abstract

In the talk, we will present the results of research aimed at developing and testing new artificial intelligence algorithms for predicting the future electricity consumption of individual end users. The work consisted of three phases: analysis of influencing factors, analysis of end-user profiling, and development of algorithms for predicting future electricity consumption of end-users. Based on real historical data for 2,500 end-users, we developed three algorithms based on cluster analysis, random trees, generalized linear models, and neural networks.

In the analysis of influencing factors, it was found that the selected weather and calendar factors and features extracted from them have the greatest influence. When profiling the end users, it was found that approximately 40% of consumers together had less than 1% of total consumption, so we merged them.

The algorithms were evaluated according to the method of splitting the data into a training set, which includes all data from the first day to the selected Thursday, and the test data set, consisting of the data from the Saturday after the selected Thursday to the following Friday. By calculating the MAPE (meaning absolute percentage error), we determined the quality of the obtained forecasts. The obtained results show that all three algorithms are good, and on average the model based on generalized linear models behaves best.

All parts of the research were implemented in the Python and R environment, and the data is stored in the MongoDB database. Visualization of the forecasts is made with the Grafana tool.

Keywords: artificial intelligence, electricity consumption forecasting, consumer profiling, influencing factors

Article classification: Scientific paper



Ugotavljanje obodne togosti plastomerne cevi s programsko opremo Zwick Roell TestXpert III

Determination of ring stiffness of thermoplastic pipes with Zwick Roell TestXpert III software

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Povzetek

V prispevku smo ugotavljali mehanske lastnosti gladke in narebričene plastomerne cevi različnega nominalnega premera po standardu SIST EN ISO 9969:2016. Pri izvedbi preiskave smo uporabili Univerzalni preizkuševalni stroj Zwick Z150 in programsko opremo Zwick Roell Testxpert III. Za izvedbo naloge je bila potrebna priprava testnega programa v okolju TestXpert III tako, da programski paket po izdelavi serije testov izračuna povprečno obodno togost obroča plastomerne cevi. Predstavljena je eksperimentalna metoda, ki obsega zahteve glede starosti vzorcev za preiskavo, zahteve glede hrambe, princip označevanja cevi, določanje dolžine testnih vzorcev in postopek merjenja dimenzij. Posebno pozornost smo namenili testni proceduri v delu, ki se nanaša na hitrosti obremenjevanja cevi po obodu, meritvam sil, meritvam deformacij in izračunu togosti obroča v programskem okolju TestXpert III. Povprečno togost cevi iz preizkusa smo primerjali z danim zahtevami in ugotovili, da cevi ustrezajo specifikacijam proizvajalca po SIST EN ISO 9969:2016.

Ključne besede: univerzalni preizkuševalni stroj, Zwick Roell TestXpert III, plastomerne cevi, SIST EN ISO 9969:2016, izračun obodne togosti obroča

Razvrstitev: Strokovni članek

Abstract

In this paper, the determination of mechanical properties of smooth and ribbed thermoplastic pipes of different nominal diameters according to the SIST EN ISO 9969:2016 standard is described. The universal Zwick Z150 testing machine together with Zwick Roell Testxpert III software was used to perform the investigation. To adequately perform the task, a special test procedure was prepared to calculate the average circumferential stiffness of the thermoplastic pipe ring. An experimental method is presented, which includes requirements regarding the age of samples for examination, storage requirements, the principle of pipe marking, the determination of the length of test samples, and the procedure for measuring dimensions. Special attention was paid to the test procedure in the part related to a load speed of the pipe around the circumference, force measurements, deformation measurements, and the calculation of the stiffness in the TestXpert III software environment. The average experimentally determined stiffness of the pipes was compared with the given requirements and it was found out that the pipes meet the manufacturer's specifications according to SIST EN ISO 9969:2016.

Keywords: universal testing machine, Zwick Roell TestXpert III, thermoplastic pipes, SIST EN ISO 9969:2016, determination of ring stiffness

Article classification: Professional paper



Vpliv usmerjenosti tiska na mehanske lastnosti miniaturnih preizkušancev, natisnjenih s Polyjet tehnologijo aditivnega tiska

The influence of print orientation on mechanical properties of miniature test specimens printed with Polyjet additive manufacturing technology

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Povzetek

3D-tiskanje je relativno nova tehnologija, ki nam omogoča nov način izdelave izdelkov. Tehnologija tiskanja izdelkov temelji na postopku nalaganja materiala v naprej določeni obliki. Zaradi načina izdelave izdelkov je proces 3D-tiska anizotropni proces, kar hipotetično pomeni, da so tudi mehanske lastnosti tiskanega materiala anizotropne. Namen članka je predstaviti način preizkušanja mehanskih lastnosti na miniaturnih preizkušancih, natisnjenih s polyjet tehnologijo, ter analitični in grafični prikaz pridobljenih rezultatov. Glavni cilj preučevanja polyjet tehnologije je odkriti, kakšen vpliv ima različna usmerjenost med tiskanjem na končne mehanske lastnosti preizkušancev. Za preizkus mehanskih lastnosti smo s pomočjo polyjet tehnologije natisnili miniaturne vzorce za natezni preizkus in preizkus nanoindentacije. Preizkušance smo natisnili v miniaturnih dimenzijah, saj pričakujemo, da bo tako razlika v doseganju mehanskih lastnosti med posamezno usmeritvijo preizkušancev večja. Po opravljenih preizkusih so pri nateznem preizkusu v povprečju preizkušanci, natisnjeni v usmerjenosti tiska XYZ, dosegali 58,4 % višji modul elastičnosti in 48,15 % višjo maksimalno napetost v primerjavi z YXZ-natisnjenimi preizkušanci. Podoben odziv materiala smo pridobili tudi pri preizkusu nanoindentacije, kjer je Berkovich indenter pri enaki vtiskovalni sili pri preizkušancih v usmerjenosti tiska ZXY v povprečju dosegel za 50 % večjo globino vtiska. Iz pridobljenih podatkov smo preračunali tudi modul elastičnosti, ki se med različno usmerjenimi preizkušanci, na katerih smo izvajali preizkus nanoindentacije, razlikuje za 28,9 %. Pri obeh načinih preizkušanja so najboljše mehanske lastnosti dosegli preizkušanci, natisnjeni v ležeči usmerjenosti, in najslabše preizkušanci v pokončni usmerjenosti. To dokazuje, da najboljše mehanske lastnosti dosegajo preizkušanci, ki imajo največjo površino tiskane plasti.

Ključne besede: miniaturni vzorci, nanoindentacija, natezni preizkus, polyjet tehnologija, površina tiskanja, usmerjenost preizkušancev

Razvrstitev: Znanstveni članek

Abstract

3D printing technology is based on the process of loading the material layer by layer in a predetermined form. Due to the way the products are manufactured, the 3D printing process is an anisotropic process, which means that the mechanical properties of the printed material could be anisotropic as well. The main goal of the article is to determine the influence of different print orientations on the mechanical properties of test specimen. To test the mechanical properties, we used PolyJet technology to print miniature specimens, on which we performed a tensile and a nanoindentation test. The miniature test specimens were designed in order to show the difference in the mechanical properties between the individual orientation of the test specimens. After the tensile tests, the test specimens printed in XYZ print orientation achieve on average a 58.4% higher modulus of elasticity and a 48.15% ultimate stress compared to YXZ printed specimens. A similar material response was obtained in the nanoindentation test, where the Berkovich indenter achieved an average of 50% greater depth of impression at the same injection force in the specimens in the XYZ than in the ZXY print orientation. From the obtained nanoindentation data, we calculated the modulus of elasticity, which differs by 28.9% among the differently oriented test specimens on which the nanoindentation test was performed. These results indicate that the best mechanical properties are achieved in the specimens that have the largest surface area of the printed layer.

Keywords: miniature specimens, nanoindentation, tensile test, PolyJet technology, printing surface, orientation of specimens

Article classification: Scientific paper



Implementacija končnih super pretvornikov v jezikovni model govornih pogonov

Implementation of finite state super transducers into language models of speech engines

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Povzetek

V zadnjih letih se velik poudarek posveča predvsem raziskavam učinkovitega prenosa govornih tehnologij na vgrajene sisteme mobilnih terminalov. Pri tem igra uspešnost učinkovite predstavitve jezikovnih virov, ki so pogosto zelo obsežni, še zlasti za pregibno bogate jezike, eno izmed ključnih vlog. Kljub dejstvu da obstaja precej raziskav in literature na temo računalniške predstavitve leksikalnih jezikovnih virov, njihova implementacija v celovitih sistemih za prepoznavanje ali sintezo govora na vgrajenih platformah, še zlasti za jezike z bogato pregibno paradigmo, predstavlja netrivialen problem.

Cilj projekta OptiLEX je bil povezati jezikovne vire v slovar izgovarjav ter raziskati postopke optimizacije računalniške predstavitve leksikalnih jezikovnih virov za pregibno bogate jezike, ki jih je možno uporabiti pri prepoznavanju in sintezi govora na vgrajenih platformah. Postopke smo implementirali in preizkusili na strojni opremi vgrajenega prenosnega terminala.

Poiskali smo učinkovite postopke za zmanjševanje odvečnosti pri predstavitvi in računalniškem zapisu jezikovnih virov za pregibno bogate jezikovne skupine v obliki končnih super pretvornikov, ki omogočajo hitro, pomnilniško čim manj zahtevno ter visokokakovostno pretvorbo grafemskega zapisa besed v fonetični prepis in obratno. Uspešnost zmanjševanja odvečnosti pri predstavitvi jezikovnih virov smo ovrednotili na slovarskih jezikovnih virih.

Zahvala: Raziskovalno delo je sofinancirala Javna agencija za raziskovalno dejavnost Republike Slovenije v sklopu aplikativnega raziskovalnega projekta OptiLEX (L7-9406).

Ključne besede: govorne tehnologije, jezikovni viri, sinteza govora, prepoznavanje govora, vgrajeni sistemi, pametna mesta in skupnosti

Razvrstitev: Znanstveni članek

Oblika predstavitve: Poster

Abstract

In recent years, great emphasis has been placed on research into the efficient transfer of voice technologies to embedded mobile terminal systems. In doing so, the success of the effective presentation of language resources, which are often very extensive, especially for inflectionally rich languages, plays one of the key roles. Despite the fact that there is a lot of research and literature on the topic of computer presentation of lexical language resources, their implementation in comprehensive speech recognition or synthesis systems on embedded platforms, especially for languages with a rich inflectional paradigm, represents a non-trivial problem.

The aim of the OptiLEX project was to link language resources into a pronunciation dictionary and to explore procedures for optimizing the computer representation of lexical language resources for inflectionally rich languages that can be used in speech recognition and synthesis on embedded platforms. The procedures were implemented and tested on the hardware of the built-in portable terminal.

In using finite state super transducers, we have found effective procedures to reduce redundancy in the presentation and computer notation of language resources for language groups with a rich inflectional paradigm, which enable



fast, low-memory and high-quality conversion of grapheme scripts into phonetic transcription and vice versa. The success of reducing redundancy in the presentation of language resources has been evaluated using lexical resources developed in the scope of the project.

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Keywords: speech technologies, language resources, speech synthesis, speech recognition, embedded systems, smart cities and communities

Article classification: Scientific paper

Type of presentation: Poster



Discovery of a FeCoNiPdCu high-entropy alloy with excellent magnetic softness

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Abstract

The author reports on the discovery of a magnetically soft high-entropy alloy of a FeCoNiPdCu composition, which performs comparably to the best commercial soft magnets for static and low-frequency applications. Properly heat-treated FeCoNiPdCu develops nanostructure that can be viewed as a two-phase bulk nanocomposite of randomly intermixed FeCoNi magnetic domains and PdCu nonmagnetic “spacers”, both of 2–5 nm cross dimensions. Due to the nanometric size, the FeCoNi domains are magnetically single-domain particles, and since the particles are exchange-coupled across the boundaries, exchange averaging of magnetic anisotropy takes place, resulting in an almost vanishing coercive field and excellent magnetic softness. The formation of a two-phase nanostructure favourable for the exchange averaging of magnetic anisotropy is a consequence of specific values of the binary mixing enthalpies for the chosen elements. Though high-entropy alloys are generally considered to be random solid solutions of multiple elements on a topologically ordered crystal lattice, clustering of the atoms into preferential chemical environments on a nanoscale essentially determines their magnetic properties. Experimentally, the magnetic properties of the FeCoNiPdCu high-entropy alloy are compared to the commercial, magnetically soft non-oriented silicon electrical steel [1].

Reference:

[1] P. Koželj, S. Vrtnik, A. Jelen, M. Krnel, D. Gačnik, A. Meden, M. Wencka, J. Leskovec, S. Maiti, W. Steuer, J. Dolinšek: Discovery of a FeCoNiPdCu high-entropy alloy with excellent magnetic softness, *Advanced Engineering Materials* 2019: 1801055.

Keywords: high-entropy alloy, bulk nanocomposite, magnetism, magnetic softness

Article classification: Scientific paper



Optimiranje oblike platine za izboljššan proces vleka pločevine z ozirom na manjšo porabo materiala

Optimization of blank for better sheet metal drawing process with regard to lower material consumption

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Povzetek

Pri snovanju metodnega plana orodja za preoblikovanje pločevine za izdelavo kompleksnega kosa iz visoko trdne jeklene pločevine se je zasnovalo večfazno orodje za preoblikovanje pločevine, v katerem je tudi operacija vleka za izdelavo grobe oblike vlečenca. Za validacijo in optimizacijo zasnovanega metodnega plana se je izvajalo simulacije preoblikovanja pločevine v programski opremi AutoForm. Zaradi kompleksne oblike kosa je bil izziv zasnovati operacijo vleka s še sprejemljivim tanjšanjem in gubanjem. Slednje se je reševalo z obliko preoblikovalnih površin, konceptom orodja in izhodiščno obliko platine. V tem članku je predstavljen izziv iz sklopa raziskav projekta TPV4LIGHT, ki zajema optimizacijo gubanja z izhodiščno obliko platine. Izhodišče je bila oblika platine, definirana in preverjena v fazi izdelave prototipov, ki je v procesu vleka pločevine podala sprejemljive rezultate gubanja. V raziskavi se je podrobneje v ozir vzelo bruto porabo materiala, ki jo je bilo cilj zmanjšati, vendar pri tem ne poslabšati rezultata procesa in vlečenca. S pomočjo simulacij preoblikovanja smo optimirali obliko platine, da se je zmanjšalo gubanje in tudi bruto poraba materiala pločevine. Predstavljen je tudi vpliv zmanjšanja bruto porabe materiala na emisije CO₂.

Gljučne besede: preoblikovanje pločevine, platina, gubanje, poraba materiala, vlečenec

Razvrstitev: Strokovni članek

Abstract

When designing the method plan for a stamping tool for production of a complex part of high strength sheet metal, a multistage tool for sheet metal forming was designed. It also included a drawing operation for producing a rough shape of the drawn part. For validation and optimization of the designed method plan, forming simulations were performed with the AutoForm software. Because of the complex shape of the part, it was a challenge to design the drawing operation with still acceptable thinning and wrinkling. The latter was solved with the shape of the forming surfaces, the concept of the tool and with the initial shape of the blank. In this paper, one of the challenges from the set of researches of the TPV4LIGHT project, which includes the optimization of wrinkling with the initial blank shape, is presented. The starting point was the shape of blank defined and checked in the phase of prototype production. In the process of sheet metal drawing this yielded acceptable results of wrinkling. In the research, the gross material consumption was considered more closely, as the aim was to lower it; however not to worsen the result of the process and the drawn part. With the help of forming simulations, the shape of the blank was optimized in order to obtain lower wrinkling and gross material consumption of sheet metal. Also, the impact of gross material consumption reduction on CO₂ emissions is presented.

Keywords: sheet metal forming, blank, wrinkling, material consumption, drawn part

Article classification: Professional paper



Optimalna izbira orodij za frezanje krivih površin

Optimal selection of tools used for milling of curved surfaces

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Povzetek

Pri oblikovanju izdelkov se uporabljajo različni modelirni programi. Ti omogočajo oblikovanje modelov natančno določenih ukrivljenih ploskev, kar smo uporabili tudi pri frezanju v naši raziskavi. Tako smo na podlagi podatkov iz literature določili geometrijsko obliko frezala. V raziskavi smo preiskovali vpliv mehanske obdelave na krogelna frezala in kakovost obdelovancev po frezanju. Površina frezala je bila polirana ali prevlečena s trdimi prevlekami.

Preizkuse smo izvedli na treh različnih materialih: aluminiju, lesu in kerrocku. Vsak material smo obdelovali z orodji treh različnih dobaviteljev. Po obdelavi smo pregledali obrabo rezalnega roba frezala z orodnim mikroskopom in ugotavljali kakovost obdelovanca z merjenjem hrapavosti.

Ugotovili smo, da sta od treh dobaviteljev frezal dva proizvajalca dobavila frezali s prevleko, ki sta se kot najprimernejši izkazali v obdelavi lesa in aluminija, frezalo tretjega dobavitelja pa je bilo polirano in se je najbolje obneslo pri obdelavi kerrocka.

Ključne besede: frezanje, hrapavost površine, karbidna trdina, orodni mikroskop, obraba

Razvrstitev: Strokovni članek

Abstract

In product design different modelling programs are used. They enable the design of models with precisely defined curved surfaces. This was also used for milling in this research. Based on information from the literature a precise geometric shape of a milling cutter was determined. The research examined the effect of mechanical shaping on ball milling cutters and the quality of products after milling. The milling surface was polished and coated with hard coatings.

Tests were carried out on three different materials: aluminium, wood and kerrock. Each material was shaped with tools made by different manufacturers. After use the wear of the milling cutter edge was examined using a tool microscope. Also, product quality was established by measuring the roughness.

It was established that two out of three suppliers supplied milling cutters with coating which proved to be most appropriate for wood and aluminium processing. The milling cutter from the third supplier was polished and proved to be most appropriate for kerrock processing.

Keywords: milling, surface roughness, carbide hardness, tool microscope, wear

Article classification: Professional paper



Kompleksnost upravljanja *Managing complexity*



Impact of light conditions on optical inspection of surface defects

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Abstract

Optical inspection is a contactless, non-destructive method used widely in automotive and aerospace industry. It is worth noting that the industrial environment exhibits more complex conditions compared to a standard research laboratory; these include variations in light, temperature, humidity and vibrations. The light conditions have impact on the captured image quality and, in particular, on distinguishing surface defects. This impact has been investigated by means of a simple in-house-built setup. Images of surface defects have been obtained in dark or ambient light, under light-emitting diode illumination of variable brightness, as well as by changing the angle of the light source with respect to the object. Metallic objects were either of simple cylindrical or more complex geometry, whereas their surfaces were either of black color or non-painted.

Keywords: optical inspection, light conditions, light-emitting diode illumination, surface defects.

Article classification: Professional paper



Avtomatizacija stavbe v sistemu WiFi Direct

WiFi Direct building automation

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Povzetek

WiFi direct je protokol, ki ga uporabljajo za povezavo na WiFi-usmerjevalnik številne cenovno dostopne IoT-naprave, a jih težko povežemo v enoten sistem, zato že pri izvedbi enostavnih nalog trčimo v zid. Skupni imenovalec WiFi direct naprav je njihov nadzor z največkrat mobilnimi aplikacijami proizvajalcev naprav prek oblčnih storitev, kar preprečuje njihovo interakcijo in uporabo v enotni standardizirani platformi in vodi zgolj v otočne rešitve. Hkrati takšno upravljanje z napravami predstavlja grožnjo za informacijski sistem za požarno steno. Po drugi strani je ogromno IoT-naprav zasnovanih na mikrokontrolniku ESP8266 wifi. Če na ESP8266 naložimo novo programsko opremo Tasmota, lahko IoT-naprave različnih proizvajalcev povežemo v enoten sistem, v katerem lahko z napravami upravljamo s spletno aplikacijo, MQTT- ali HTTP-protokolom. Tasmota je izredno močna programska oprema, ki vključuje številne gonilnike za podporo senzorjev in aktuatorjev, ki jih najdemo v popularnih in poceni napravah s police za avtomatizacijo domov. Omogoča vključevanje naprav v spletno aplikacijo Home Assistant, s katero upravljamo z inštalacijo v pametni stavbi. V prispevku bo prikazan vzorčni sistem za avtomatizacijo osnovnih bivanjskih parametrov v stavbah.

Gljučne besede: avtomatizacija stavb, Tasmota, WiFi direct, Home Assistant

Razvrstitev: Strokovni članek

Abstract

WiFi Direct is a protocol used to connect to a WiFi router by many affordable IoT devices, but it is difficult to connect them to a single platform, so we run into a wall already when performing simple tasks. WiFi Direct devices are commonly controlled with mobile applications of device manufacturers via cloud services, which prevents their interaction and use in a single standardized platform and leads only to island solutions. At the same time, such device management poses a threat to the information system protected by the firewall. On the other hand, there is a huge number of IoT devices based on the ESP8266 WiFi microcontroller. If we load the new Tasmota firmware on the ESP8266, IoT devices from various manufacturers can be connected to a single system in which the devices can be managed using a web application, MQTT or HTTP protocol. Tasmota is an extremely powerful software that includes a number of drivers to support sensors and actuators found in popular and inexpensive devices from home automation shelves. It allows one to integrate devices into the Home Assistant web application, which manages the installation in a smart building. The paper presents a sample system for the automation of basic housing parameters in buildings.

Keywords: Home Assistant/building automation, Tasmota, WiFi Direct, home assistant

Article classification: Professional paper



Sistem strojnega vida v robotski celici RoBIN

Vision system for the RoBIN bin picking robot cell

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Povzetek

V projektu RoBIN smo razvili napredni slikovni senzorski sistem, ki je sposoben pobiranja in orientiranja več vrst kosov raznovrstnih oblik, ki so v vhodnih zabojnikih v raztresenem stanju. Ta sistem strojnega vida je vključen v robotsko celico RoBIN, ki omogoča identifikacijo in manipulacijo teh kosov v okviru proizvodne linije. Prototip smo validirali in demonstrirali v operativnem okolju v okviru serijske industrijske proizvodnje.

Pri razvoju smo uporabili inovativen koncepta sistema za strojni vid, ki vključuje kombinacijo 3D-analize opazovanega prizora ter sekundarno verifikacijo orientacije predmeta z 2D-slikovno analizo. Za zaznavanje predmetov znotraj zaboja in izbiro najboljšega kandidata med zaznanimi predmeti smo razvili sistem računalniškega vida, ki temelji na laserskem trirazsežnem skeniranju prostora, ter verifikacijo in korekcijo prijetega predmeta s pomočjo sekundarnega 2D-optičnega skeniranja. Rezultat skeniranja je točkovni oblak, ki ga sistem primerja s CAD-modelom predmetov, ki so v zaboju.

Po identifikaciji vseh vidnih oz. dostopnih predmetov sledi izbira kandidata, ki je najbolj primeren za naslednjo operacijo zajemanja z robotsko roko, ter preslikava prostorske lege izbranega kandidata v koordinatni sistem robota. Robotska roka prime prednostno izbrani predmet ter ga prestavi pred sekundarno kamero, s katero lahko preverimo pravilnost prve operacije in izboljšamo natančnost pozicioniranja predmeta. Nato odloži predmet v predvideno odlagališče.

Razpoložljivi sistemi za robotski bin picking se soočajo s težavo, da večjega števila kosov, tudi do 15 %, niso sposobni pobrati iz embalažne enote. V okviru projekta RoBIN smo razvili inovativne rešitve, ki omogočajo izpraznitev 98 % kosov iz embalažne enote. Nepobrani kosi so samodejno premeščeni v novo embalažno enoto. Visoko učinkovitost robotske celice RoBIN smo dosegli s kombinacijo inovativnih postopkov strojnega vida in pretresanja embalažne enote.

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. C2130-19-09675 (RoBIN).

Ključne besede: strojni vid, 3D-slikovni senzor, pobiranje kosov iz zabojev, avtomatizacija proizvodnje, industrija 4.0. tovarne prihodnosti

Razvrstitev: Znanstveni članek

Oblika predstavitve: Poster

Abstract

In the RoBIN project, we have developed an advanced image sensor system that is capable of picking up and orienting several types of pieces of various shapes that are placed in the input bins in a scattered state. This machine vision system has been integrated into the RoBIN robotic cell, which allows the identification and manipulation of the pieces within the production line. The prototype has been validated and demonstrated in an operational environment as part of serial industrial production.

In the development, we used an innovative concept of a machine vision system, which includes a combination of a 3D analysis of the observed scene and a secondary verification of the object orientation with a 2D image analysis. To detect objects inside the box and select the best candidate among the detected objects, we designed a computer vision system based on laser three-dimensional space scanning, and verification and correction of the captured



object using secondary 2D optical scanning. The result of the scan is a point cloud, which the system compares to a CAD model of objects that had been placed in the input bin.

After identifying all visible or available objects the selection of the most suitable candidate for the next capture operation with a robotic arm is performed. This is followed by the mapping of the spatial position of the selected candidate into the coordinate system of the robot. The robotic arm grabs the preferentially selected object and moves it in front of the secondary camera, with which we can check the correctness of the first operation and improve the positioning accuracy of the object. The object is finally deposited at the designated place and position.

The available robotic bin picking systems face the problem that a large number of pieces, even up to 15%, are not able to be picked up from the bins. As part of the RoBIN project, we have developed innovative solutions that enable the emptying of 98% of pieces from the bins. Uncollected pieces are automatically transferred to new bins. The high efficiency of the RoBIN robotic cell was achieved by a combination of innovative machine vision procedures and bin shaking of the packaging unit.

Acknowledgement: 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. C2130-19-09675 (RoBIN).

Keywords: machine vision, 3D image sensor, bin picking, industrial automation, Industry 4.0, factories of the future

Article classification: Scientific paper

Type of presentation: Poster



Samodejno optično preverjanje dimenzij kovinskih odpreškov s sistemom strojnega vida EAGLE

Automatic optical geometry control of metal parts using the EAGLE machine vision system

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Povzetek

Pomemben del industrijskih procesov je nenehno preverjanje izdelkov in zagotavljanje ustrezne kvalitete. Pri proizvodnji kovinskih odpreškov je uveljavljen postopek periodičnega preverjanja dimenzij izdelkov s posebnimi mehanskimi merilnimi pripravami. Slabost te metode je časovno zamudna in draga izdelava posebnih merilnih priprav, potreba po periodičnem preverjanju obrabe teh merilnih priprav ter relativno dolgo trajanje preverjanja posameznega izdelka.

Sodobnejši pristop preverjanju dimenzij izdelkov predstavljajo optične merilne metode. V projektu EAGLE smo raziskali uporabnost optičnih merilnih metod za preverjanje dimenzij kovinskih odpreškov. Ena izmed merilnih metod, preizkušenih v projektu, je merjenje dimenzij izdelka s paralelno projekcijo slike izdelka na slikovno ravnino kamere. Takšno projekcijo dosežemo z uporabo sistema telecentričnih leč in transmisivne osvetlitve z vzporednimi svetlobnimi žarki. Kamera zajame izredno natančno sliko projekcije izdelka v različnih položajih. Računalnik analizira posnetke, določi značilne točke na izdelku, izmeri vnaprej določene tolerančne razdalje ter določi, ali je izdelek znotraj tolerančnega območja. Da bi lahko posneli ustrezne projekcije predmeta, moramo postaviti predmet v točno določene položaje glede na optični sistem za zajem slike. Hitra in natančna postavitev predmeta v predvidene položaje je rešena z uporabo robota.

Postopek omogoča natančnosti meritve razdalje reda velikosti 20 μm . Priprava postopka za novi izdelek traja manj kot 1 uro in ne zahteva namenske opreme. Preverjanje izdelka je opravljeno v času reda velikosti 10 sekund in vključuje shranjevanje meritev za poznejšo statistično analizo in poročanje. Postopek ne vpliva na preverjeni izdelek in ne vsebuje elementov, ki se obrabljajo in zahtevajo pogosto vzdrževanje ali recalibracijo. Slabost postopka je nezmožnost preverjanja dimenzij, ki niso vidne na paralelnih projekcijah izdelka. Te dimenzije lahko preverjamo z dodatnimi optičnimi merilnimi postopki, ki so nekoliko počasnejši in manj natančni, vendar pa posnamejo celoten 3D-model izdelka.

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. C3330-18-952007 (EAGLE).

Ključne besede: strojni vid, 3D-slikovni senzor, kontrola kakovosti, avtomatizacija proizvodnje, industrija 4.0, tovarne prihodnosti

Razvrstitev: Znanstveni članek

Oblika predstavitve: Poster

Abstract

An important part of industrial processes is the constant inspection of products and ensuring adequate quality. In the production of metal parts, the procedure of periodic verification of product dimensions with special mechanical measuring devices is being used. The disadvantage of this method is the time-consuming and expensive production of special measuring devices, the need to periodically check the wear of these measuring devices and the relatively long duration of checking an individual product.

Optical measurement methods represent a modern approach to product dimension control. In the EAGLE project, we investigated the applicability of optical measurement methods for checking the dimensions of metal parts. One



of the measurement methods tested in the project is to measure the dimensions of the product by parallel projection of the product image on the camera image plane. Such a projection is achieved by using a system of telecentric lenses and transmissive illumination with parallel light rays. The camera captures an extremely accurate image of the product projection in various positions. The computer analyzes the images, determines the characteristic points on the product, measures predetermined tolerance distances, and determines whether the product is within the tolerance range. In order to be able to capture the appropriate projections of the object, we need to place the object in specific positions relative to the optical image capture system. For rapid and accurate placement of the object in the intended positions a robot arm has been used.

The procedure allows the accuracy of measuring a distance of the order of 20 μm . The preparation process for a new product takes less than one hour and does not require dedicated equipment. The verification of the product is performed in the order of 10 seconds and includes the storage of measurements for later statistical analysis and reporting. The procedure does not affect the tested product and does not contain elements that wear out and require frequent maintenance or recalibration. The disadvantage of the procedure is the inability to check the dimensions that are not visible on the parallel projections of the product. These dimensions can be verified with additional optical measurement procedures that are slightly slower and less accurate, but capture the entire 3D model of the product.

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Keywords: machine vision, 3D image sensor, quality control, industrial automation, Industry 4.0, factories of the future

Article classification: Scientific paper

Type of presentation: Poster



Metoda hitre estimacije rotacijske hitrosti na osnovi ponavljajočih se vzorcev

Method of rapid estimation of the rotational speed based on repeated patterns

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Povzetek

Pri regulaciji delovanja električnih rotacijskih strojev je natančnost merjenja rotacijske hitrosti zelo pomembna. V primeru, če se meritev položaja in s tem tudi meritev hitrosti izvaja večkrat znotraj enega obrata motorja, lahko v primeru nenatančne nastavitve senzorjev pride do znatnih odstopanj izmerjene do dejanske hitrosti motorja. Tovrstna odstopanja ustvarjajo šum meritve hitrosti, ki vodi do šuma na izhodu iz regulatorja in posledično do neenakomernega navora motorja med delovanjem. Le-to lahko povzroči vibracije v regulacijskem sistemu in s tem hitrejšo odpoved krmilnika motorja, motorja ali sistema, gnanega z električnim motorjem. Omenjen šum pri meritvi običajno rešujemo s filtriranjem signalov rotacijske hitrosti, vendar s tem tudi upočasnimo zaprtostančno regulacijo hitrosti in posledično tudi zmanjšamo učinkovitost vodenja. V prispevku je prikazan algoritem (postopek) hitre in samodejne estimacije rotacijske hitrosti v primeru neidealne postavitve senzorjev položaja. Predlagan postopek je preizkušen tudi v praksi, rezultati potrjujejo učinkovitost predlagane rešitve.

Ključne besede: električni motorji, merjenje rotacijske hitrosti, regulacija hitrosti, senzorji položaja

Razvrstitev: Znanstveni članek

Abstract

The accuracy of the measured speed is very important in the control of electric rotary machines. If the position and hence the speed measurement is made more than once within one motor revolution, considerable deviations from the actual speed may occur if the sensor is placed incorrectly. Such deviations create noise in the speed measurement, which results in noise in the controller output and consequently uneven motor torque during operation. This can cause oscillations in the controlled system, leading to faster failure of the actuator, motor, or the entire system driven by the motor. This noise is usually attenuated by filtering the speed signal, but this reduces the control speed and thus the control efficiency. In this paper, an algorithm (method) for fast and automatic estimation of speed in case of imperfect placement of position sensors is presented. The proposed method is also tested in practice and the results confirm the effectiveness of the proposed solution.

Keywords: electric motors, rotational speed measurement, speed control, positional sensors

Article classification: Scientific paper



Kompensacija neželenih fizikalnih vplivov na dimenzijske meritve velikega in vitkega Al zvarjenca

Compensation of unwanted physical influences on dimensional measurements of large and slender Al welded part

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Povzetek

Za zagotavljanje geometrijske ustreznosti izdelka je potrebno izvajati različne kontrolne meritve geometrije, pri tem pa upoštevati primerljivo stanje izdelka, kot je predvideno pri vgradnji v vozilo. Kombiniran vpliv fizikalnih omejitev, kot so vitkost, velikost in teža izdelka ter omejitev proizvodnega procesa, ki zaradi velike količine vnesene toplote v kombinaciji z vplivom materiala povzroči velike temperaturne deformacije še vročega kosa na merilni postaji, je privedel do problematike 3D-meritev geometrije aluminijastega zvarjenca nosilca baterije. Geometrijska kontrola se izvaja na dveh ločenih neodvisnih postajah. Prva avtomatska kontrolna priprava izvaja 100 % kontrolo izdelkov v avtomatizirani liniji sestave takoj po tem, ko so le-ti zavarjeni. Kombinacija vplivov materiala in procesa varjenja privedeta do velikega vnosa toplote v končni izdelek. Slednji je tako potrjen temperaturnim deformacijam in ne izkazuje realnega stanja geometrije. Druga, 3D CNC-merilna postaja pa izvaja frekventno geometrijsko kontrolo ohlajenega izdelka na koncu proizvodnega procesa. Ta zaradi prostorske in tehnične omejitve linije ter izdelka ne more zagotavljati meritve izdelka v prisilnem vpetem stanju, ki bi odražalo vgradno stanje vozila, zatoj meritev takega izdelka zopet ne odraža dejanskega stanja slednjega. Ker gre za novost na tržišču elektro mobilnosti in specifično problematiko merilnega sistema, na tržišču ne obstaja univerzalna metoda ali produkt, ki bi bil zmožen ponuditi rešitev za omenjeno problematiko. V ta namen smo v podjetju TPV AUTOMOTIVE v sodelovanju s partnerjem KNT d. o. o. razvili lasten kompenzacijski algoritem za temperaturno kompenzacijo 100 % meritev vročih izdelkov v liniji, ter algoritem za virtualno prisilno vpetje izdelka na frekventni kontroli na 3D CNC-merilnem stroju.

Ključne besede: 3D-meritve, geometrija izdelkov, elektro mobilnost, avtomobilska industrija, kompenzacijski algoritem, numerične analize, prisilno vpetje, vplivi proizvodnih procesov

Razvrstitev: Strokovni članek

Abstract

To ensure the geometric suitability of a product, it is necessary to perform various geometry measurements with the comparable condition of the product, as provided for installation in the vehicle. The combined influence of physical constraints, such as slenderness, size and weight of the product, as well as limitations of the weld process combined with the influence of material, lead to high temperature. Geometry measurement is performed at two separate stations. The first station performs a 100% control of hot products in automated assembly immediately after they are welded. The combination of the material and welding process leads to a large heat input into the product, subjecting it to temperature deformations at the measuring station. The 3D CNC measuring station performs frequent geometric control of the cooled product at the end of the production process. Due to spatial and technical limitations of the line and the product, the station itself cannot ensure the measurement of the product in the forced clamping state, which would reflect the installation condition of the vehicle. Therefore, the measurement of such a product again does not reflect the actual condition of the mounted part. For this purpose, TPV AUTOMOTIVE in partnership with KNT d.o.o. developed their own algorithm for temperature compensation for a 100% measurement of hot products, and an algorithm for virtual forced clamping of a product at the frequent control on the 3D CNC measuring machine.

Keywords: 3D measurements, geometry of parts, e-mobility, automotive industry, compensation algorithm, numerical analysis, forced clamping, influences of production process.

Article classification: Professional paper



Regulacija položaja DC motorja s pomočjo metode momentov

Control of DC motor position based on method of moments

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Povzetek

DC motorje uporabljamo v različnih vejah industrije: v beli tehniki, zabavni elektroniki in robotiki. Za učinkovito uporabo DC-motorjev potrebujemo ustrezno zaprtično vodenje hitrosti ali položaja (zasuka) motorja. Hitrost in s tem tudi zasuk motorja po navadi uravnavamo z napajalno napetostjo motorja. Ker je zasuk motorja časovni integral njegove kotne hitrosti, ima prenosna funkcija med vhodno napetostjo in zasukom motorja integrirni značaj. Integrirni procesi z omejenim obsegom vhodnega signala (DC-motorji imajo omejeno napetost napajanja) so načeloma kompleksnejši za vodenje, zato v praksi po navadi uporabljamo kaskadno regulacijo, kjer v notranji zanki nastavlamo hitrost motorja, v zunanji pa položaj motorja. V prispevku je prikazana metoda nastavljanja parametrov notranjega (PID) in zunanjega (P) regulatorja na osnovi metode momentov. Prednost omenjene metode je analitičen izračun parametrov regulatorjev na osnovi a) parametrov DC-motorja oziroma prenosne funkcije motorja ali b) časovnih odzivov motorja pri spremembi vhodne napetosti. Oba načina izračuna parametrov regulatorjev sta ekvivalentna. Dodatna prednost predlagane metode je implicitna zaščita pred integralnim pobegom regulatorja s spremembo strukture PID-regulatorja na osnovi metode prilagajanja stanj.

Ključne besede: električni motorji, regulacija hitrosti, regulacija položaja, kaskadna regulacija, zaščita pred integralnim pobegom

Razvrstitev: Strokovni članek

Abstract

DC motors are used in various industries, home appliances, consumer electronics and robotics. For efficient use of DC motors, appropriate control of the speed or position (rotation) of the motor is required. The speed and hence the rotation of the motor is usually controlled by the motor supply voltage. Since the motor rotation is a time integral of its angular velocity, the transfer function between the input voltage and the motor rotation has an integrating character. Integrating processes with a limited input signal range (DC motors have a limited supply voltage) are in principle more complex to control. Therefore, cascade control is usually used in practice, where the inner loop controls the motor speed and the outer loop controls the motor position. In this paper, a method for tuning the internal (PID) and external (P) controller parameters based on the method of moments is presented. The advantage of this method is the analytical calculation of the controller parameters based on a) the physical parameters of the DC motor or the transfer function of the motor or b) the time responses of the motor when the input voltage changes. Both methods of calculation are equivalent. An additional advantage of the proposed method is the implicit protection against integral windup based on the conditioning technique achieved by the modified PID controller structure.

Keywords: electric motors, rotational speed control, position control, cascade control,

Article classification: Professional paper



***Delovno, socialno in kulturno okolje
v novi dobi***

***Working, social and cultural
environment in a new era***



Dejavniki motivacije v večkulturnem timu

Motivation factors in a multicultural team

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Povzetek

Živimo v času globalizacije, kar pomeni, da vse več podjetij širi svoja poslovanja čez meje svoje države. Posledično je to povzročilo pošiljanje zaposlenih v tujino, zaposlovanje in izobraževanje kadrov tako doma kot v tujini. Na ta način pridejo zaposleni v stik z drugimi kulturami, kar prinese veliko izzivov in če jih podjetja uspešno prestajajo, so v konkurenčni prednosti. Uspešno premagovanje kulturnih ovir je eden glavnih korakov k uspešnim rezultatom delovanja podjetja.

V članek je zajeto multinacionalno podjetje z več tisoč zaposlenimi, ki so razporejeni po več regijah. Namen raziskave je pregled trenutnega motivacijskega stanja, kaj dejansko vpliva na samo motiviranost v podjetju, preučitev vloge medkulturne komunikacije znotraj podjetja ter primerjava stanja motiviranosti med kulturami. Podrobnejšo analizo bomo posvetili primerjavi rezultatov treh najbolj zastopanih držav, in sicer Slovenije, Srbije in Poljske. Poiskati želimo predvsem skupne motivacijske faktorje in prepoznati tiste moteče dejavnike, ki zavirajo uspešno delovanje večkulturnih timov.

Ključne besede: komunikacija, medkulturno izobraževanje, motivacija, multinacionalno podjetje, nagrajevanje, učinek motivacije

Razvrstitev: Strokovni članek

Abstract

We live in a globalized world. This means that more and more companies are expanding their businesses beyond the borders of their country. As a result, these companies send their employees abroad, employ and train staff both at home and abroad. In this way employees come in contact with other cultures, which brings a lot of challenges and if companies overcome them, they gain an advantage over the competition. So, overcoming cultural barriers is one of the main steps for a company's successful results.

In this paper we present a multinational company with thousands of employees all over the world. The purpose of this research is to review the current motivational state, to point out what actually affects the motivation levels in the company, study the role of intercultural communication within the company and respectively the state of motivation between cultures. A detailed analysis is undertaken of the survey results of the three most represented countries - Slovenia, Serbia and Poland. Our aim is above all to identify common motivating factors and identify those disruptive factors that hinder the successful work of multicultural teams.

Keywords: communication, intercultural education, motivation, multinational enterprise, rewarding, effect of motivation

Article classification: Professional paper



Medkulturne razlike z vidika aspektov pogajanj v evropskih državah

Intercultural differences in terms of negotiation aspects in European countries

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Povzetek

Živimo v dobi globalizacije, kjer smo za konkurenčnost na trgu prisiljeni poslovati s tujimi trgi. Za uspešnost mednarodnega poslovanja je poleg dobre ponudbe pomembno tudi poznavanje kulture, navad, bontona in etike tujega poslovnega partnerja. Bistvenega pomena je, da s poslovnim partnerjem na poslovnem srečanju oz. pogajanju ustvarimo sinergijo. To ustvarimo s poznavanjem, razumevanjem, asimiliranjem ter apliciranjem omenjenih elementov v faze pred, med in po pogajanjih. Vsaka kultura ima svoje specifične, na katere se mora pogajalec znati prilagoditi. Pri tem si lahko pomagamo z medkulturnim vzorcem pogajanj. Weiss-Strippova matrika je eden izmed pripomočkov, ki pogajalcu omogoča predvidevati in pojasniti ravnanja poslovnega partnerja, ga pripraviti na pogajanja in k sprejemanju ustreznih odločitev v vseh fazah pogajanj. Gre za dinamičen model, kar pomeni, da pogajalec v matriko po potrebi lahko vključi nove spremenljivke. Obenem ima možnost beležiti odklone in svoja opazovanja. To mu omogoča razumeti potrebe, pričakovanja, motivacijo ter poglede poslovnega partnerja.

Namen prispevka je prikazati medkulturne razlike evropskih držav z vidika aspektov pogajanj po Weiss-Strippovi matriki. Oblikovali bomo vzorec vprašanj, ki bo omogočil ovrednotiti pomembnost posameznega aspekta pogajanj v določenih evropskih državah in jih medsebojno primerjati. Prikazali bomo, katerim segmentom pogajanj dajejo posamezne evropske države prednost oz. so za njih manj pomembni.

Ključne besede: evropske države, kultura, medkulturne razlike, pogajanja, Weiss-Strippova matrika

Razvrstitev: Strokovni članek

Abstract

We live in the era of globalization, where we are forced to do business on global markets to be competitive. Along with interesting price offer, it is also important to have knowledge of the culture, its habits, etiquette and ethics of a foreign business partner in order to succeed while doing business internationally. It is essential to create synergies with a business partner at a meeting or in negotiation. Therefore, knowing, understanding, assimilating and applying these elements to the stages before, during and after the negotiations is the key to success. Each culture has its own specifics to which the negotiator must be able to adapt. In order to understand the culture of our business partner we can use an intercultural pattern of negotiations. The Weiss-Strip matrix is one of the tools that enable the negotiator to anticipate and explain the actions of the business partner, to prepare him for negotiations and to make appropriate decisions at all stages of negotiations. It is a dynamic model, which means that the negotiator can include new variables in the matrix if necessary. At the same time, he has the opportunity to record deviations and his observations. This allows him to understand the needs, expectations, motivation and views of the business partner.

The purpose of this paper is to present the intercultural differences of European countries in terms of aspects of negotiation according to the Weiss-Strip matrix. We will create a sample of questions that will allow us to evaluate the importance of each aspect of the negotiations in some European countries and to compare them with each other. We will show which segments of negotiations individual European countries prioritize and which segments are less important to them.

Keywords: European countries, culture, intercultural differences, negotiations, Weiss-Stripp matrix

Article classification: Professional paper



Rešitve za trajnostni promet
Solutions for sustainable transport



Predelava kolesa v električno kolo

Converting a bicycle into an eBike

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Povzetek

Prispevek predstavlja projekt predelave trekking kolesa znamke KTM v kolo z električnim pogonom. Predstavljen je postopek izbire komponent (elektromotor, krmilnik, baterija) in postopek predelave, terminski načrt izbire in nabave komponent ter same predelave kolesa.

Iskali smo stroškovno učinkovit in varen pogon, zato smo izbrali elektromotor, ki deluje neposredno na os zadnjega kolesa. Izbrali smo elektromotor manjše moči 250 W, ki deluje neposredno na os zadnjega kolesa z namenom čim varnejše vožnje. Krmilnik omogoča različne stopnje (1 – 5) pomožne moči, lahko pa izberemo popolnoma električen način pogona brez poganjanja pedalov. Izbrali smo tudi cenovno ugodno baterijo napetosti 36 V s kapaciteto 13 Ah, ki omogoča domet do cca. 50 km s popolnoma napolnjeno baterijo.

Ključne besede: kolo, predelava, električen pogon, elektromotor, krmilnik, baterija

Razvrstitev: Strokovni članek

Abstract

The paper presents a project of converting a KTM trekking bike into an electric bike. The process of selecting components (electric motor, controller, battery) and the process of converting, the schedule of selection and purchase of components as well as the processing of the bike itself are presented.

We were looking for a cost-effective and safe drive, so we chose an electric motor that works directly on the rear wheel axle. We chose an electric motor with a lower power of 250 W, which acts directly on the rear wheel axle, in order to drive as safely as possible. The controller allows different levels (1 - 5) of auxiliary power, but one can choose a fully electric drive mode without pedalling. We also chose an affordable 36V battery with a capacity of 13Ah, which allows a range of up to approx. 50 km with a fully charged battery.

Keywords: bicycle, conversion, electric drive, electric motor, controller, battery

Article classification: Professional paper



Homogenizacija mehanskih napetosti v okvirju kolesa

Homogenization of mechanical stresses in a bicycle frame

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Povzetek

V zadnjem času se na trgu pojavljajo različni tipi sodobnih koles. Pri njihovem konstruiranju je tudi ljubiteljskemu kolesarju pomembno, da je masa konstrukcijsko varnega kolesa čim manjša. Konstrukcijsko varno kolo lahko zagotovimo z znanima metodama iz literature: modeliranje z računalnikom ali uporaba uporovnih lističev. Računalniška analiza razkriva notranje napetosti v obremenjenem okvirju v času projektiranja okvirja. Te napetosti so lahko lokalno zelo različne. Med oblikovanjem okvirja jih lahko spreminjamo s spreminjanjem števila in geometrije elementov okvirja. Uporovne lističe uporabljamo pri metodi merjenja dejanskih napetosti v že izdelanem okvirju. Prednost te metode je, da lahko dobimo med vožnjo z namestitvijo uporovnih lističev na kolo realne podatke o razporeditvi napetosti v okvirju. Pri tej metodi že izdelanega okvirja ni mogoče več spreminjati. Obe metodi služita odkrivanju napetosti v okvirju, nista pa namenjeni optimiziranju geometrije okvirja z namenom homogenizacije napetosti. Vsakršne opravljene spremembe zgolj naključno vplivajo na lokalne napetosti v okvirju. Sistematično rešitev omenjenega problema lokalno zelo različnih napetosti v okvirju ponuja raziskava, ki jo povzema prispevek. Na začetku je poiskana matematična rešitev profila cevi eliptičnega preseka vzdolž njene nevtralne osi. Pri iskanju profila izhajamo iz zahteve, da so napetosti na zgornji in spodnji strani plašča cevi enake. Sledi modeliranje okvirja sodobnega kolesa z numeričnim orodjem. Modelu okvirja je bil naknadno spremenjen le še vzdolžni profil cevi po poiskanem matematičnem modelu. Za oba okvirja je bila opravljena napetostna analiza. Medsebojna primerjava pokaže, da so po sistematično izboljšanjem profilu cevi okvirja napetosti bistveno bolj homogene, dokaj je zmanjšana tudi masa okvirja.

Ključne besede: okvir kolesa, konstruiranje, homogenizacija, mehanske napetosti, CAD, CAE

Razvrstitev: Znanstveni članek

Abstract

When constructing the modern bicycle frame, it is very important that the weight of a structurally safe bicycle is as low as possible. To ensure that, the literature cites two methods: computer modelling or the use of strain gauges. While modelling, computer analysis reveals von Mises stress. However, stresses can be locally different. During modelling, a different number of bicycle frame elements or their geometry can change the local stress. Strain gauges attached to the bicycle frame measure the actual stress. The advantage of this method is that we get realistic data while cycling. Unfortunately, it is not possible to modify the manufactured bicycle frame. Both mentioned methods do not explicitly help to homogenize the stresses in the bicycle frame. Any possible changes during modelling randomly effect on the local stress in the bicycle frame. This paper systematically summarizes the solution found to this problem. At the beginning, we searched for a mathematical solution for the profile of the elliptical pipe along the neutral axis. We required the same stress on the upper and the lower side of the pipes. The next step was modelling the bicycle frame by computer. For comparison, we used two bicycle frames with the same geometry. The only difference between them was that one bicycle frame had the profile of the pipes as our mathematical model predicted. In the final step, the computer calculated von Mises stress in both frames. Comparison shows that in the bicycle frame with a systematically improved profile the stresses are significantly more homogeneous and the weight of the bicycle frame is significantly reduced.

Keywords: bicycle frame, mechanical design, homogenization, stress, CAD, CAE

Article classification: Scientific paper



Blockchain backed autonomous vehicles as a part of IoT

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Abstract

On the path towards full autonomy, vehicles are becoming increasingly more connected to the Internet and hence becoming a part of the Internet of Things (IoT). Autonomous vehicles (AV) base their actions on communication with their peers and infrastructure, information that if compromised, could lead to catastrophic consequences. The Internet environment is renowned for its poor cyber-security where identity theft and other cyber-crime is a regular occurrence. Blockchain (BC) technology, commonly used for cryptocurrencies, has the attributes that could be used to enhance the cyber-security of IoT. We evaluate whether BC can enable trusted identity authentication in non-trusted environments, establish secure communication channels and improve privacy, enable secure peer-to-peer, low-fee and near-instant payments, and help create a decentralized ridesharing (RS) platform that provides secure, reliable, and more affordable rides. The information from peer-reviewed studies, journal articles, e-books, websites, and other relevant electronic sources is consolidated for the most up to date information on BC technology in AV. We find that BC-based digital identity is superior in terms of privacy and security. Communication can improve from encryption and message credibility through a BC-based reputation mechanism. It can increase safety in the autonomous intersection manager, enable a road-space priority negotiation, and in case of an accident, it reliably stores data for forensic investigation. Autonomous cryptocurrency payments are possible in some cases but need to resolve scalability and micro-payments and become more widely accepted as a payment method. BC-based RS service can benefit by leveraging all three of the popular BC attributes: privacy, communication, and payments.

Keywords: autonomous vehicle, blockchain, cryptocurrency payments, data security, identity authentication, Internet of Things, ridesharing service

Article classification: Scientific paper