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Fakulteta za industrijski inženiring
Faculty of Industrial Engineering

5. MEDNARODNA KONFERENCA O RAZVOJU INDUSTRIJSKEGA INŽENIRINGA:

Priložnosti, potenciali, izzivi

5th INTERNATIONAL CONFERENCE ON THE DEVELOPMENT OF INDUSTRIAL ENGINEERING:

Opportunities, Potentials, Challenges

Zbornik povzetkov

Book of Abstracts

Zbornik povzetkov | Book of Abstracts

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Kazalo | Table of Contents

Predgovor

Pred vami je zbornik povzetkov 5. Mednarodne znanstvene konference o razvoju industrijskega inženiringa, s podnaslovom: Priložnosti, potenciali in izzivi, ki ga tradicionalno organizira Fakulteta za industrijski inženiring Novo mesto. Vabilu k sodelovanju se je odzvalo veliko število avtorjev s skupaj 30 prijavljenimi povzetki. Za Fakulteto, ki je nosilka razvoja posameznih ved o industrijskem inženiringu, je tak odziv potrditev pravilne usmerjenosti in trdega dela v preteklih letih in dobra popotnica tudi za letošnjo jubilejno konferenco.

V tokratnem zborniku so povzetki avtorjev razvrščeni v osem tematskih sklopov. Vsebina posameznih povzetkov je raznolika in obravnava sodobne metode in posamezne inovativne rešitve problemov na področju industrijskega inženiringa. Uvodoma se seznanimo z dodajalnimi tehnologijami na področju medicinskih vsadkov, ki jih v vabljenem plenarnem predavanju predstavlja priznan češki strokovnjak Matej Daniel. V drugem sklopu štirih prispevkov s področja biomehanike spoznamo urejenost membran in njihova funkcionalnost, lipidne membrane, uporabo mikroskopa na atomsko silo ter modeliranje obnašanja možganskega tkiva. Tretji in četrti sklop zajemata štiri prispevke, ki predstavijo dejavnike konkurenčnosti ter zdravo bivalno in delovno okolje skozi posodabljanje vhoda materialov, testiranje uporabljivosti izdelka, merjenje zalog izdelkov ter razvrščanje in označevanje farmacevtskih učinkovin. V petem sklopu se dotaknemo vedno aktualne teme Industrija 4.0, kjer v treh prispevkih spoznamo uporabo IoT za merjenje odjemnih mest vodovodnega omrežja ter klasifikacijo zvočnih signalov in uporabo načel programskega inženiringa pri strojnem učenju. Sledi šesti sklop petih prispevkov s področja materialov in tehnologij, kjer se srečamo z izzivi pri konstruiranju kompozitnih tlačnih posod in nastavljivih stopalk motocikla, vplivi preoblikovanja in spajanja na zdržljivost izdelkov, vplivi načina litja na lastnosti aluminijeve zlitine ter MKE analizami z nateznim preizkusom pri nerjavnem jeklu. V sedmem sklopu so skozi šest prispevkov predstavljene dosedanje raziskave v okviru projekta EAGLE pri razvoju demonstracijskega prototipa naprednega 3D senzorskega sistema, ki bo omogočal frekvenčno vizualno kontrolo geometrije kompleksnih predmetov. Zbornik zaključuje sklop sedmih prispevkov, ki zajemajo temeljne in aplikativne raziskave disperzije elastičnih valov v homogenih in simetričnih trislojnih ploščah, večkriterijsko optimizacijo območij stabilnosti vibracij zobniških gonil, asimptotsko analizo robnega upogibnega vala na trdni plošči, večparametrično dinamično modeliranje plastovitih močno nehomogenih elastičnih struktur, eksperimentalno in numerično določitev integralne karakteristike modelne vetrne turbine, večparametrično dinamično analizo »lightweight« laminatov ter ne nazadnje numerično napoved gladinskega stanja v območju sotočja dveh rek.

Kot avtorji ali soavtorji posameznih povzetkov so se k sodelovanju na konferenci odzvali mednarodno uveljavljeni raziskovalci in eminentni visokošolski učitelji tako iz Slovenije kot tudi iz tujine, med njimi iz Anglije, Belgije, Češke in Nemčije, katerih prispevek v programskem odboru še posebno cenimo.

Dr. Tomaž Savšek
Predsednik programskega odbora

Preface

Proceedings Abstracts of the 5th International Scientific Conference on the Development of Industrial Engineering, with the subtitle: Opportunities, Potentials, Challenges, traditionally organized by the Faculty of Industrial Engineering Novo mesto, are presented. A large number of authors with a total of 30 submitted abstracts responded to our invitation. For the Faculty, which is involved in the development of individual industrial engineering sciences, this response is a confirmation of the correct orientation and hard work over the years, and a great impetus for this year's anniversary conference.

In this volume, conference abstracts are grouped into six thematic sections. The contents of each individual abstract are very diverse and treat the modern methods as well as innovative solutions of problems of industrial engineering. Introductory abstract presents add-on technologies in the field of medical implants, which are presented in the invited plenary lecture by renowned Czech expert Matej Daniel. The second set of four papers in the field of biomechanics deals with the membranes' in-plane phase ordering and their functionality, lipid membranes, the use of an atomic force microscopy, and the modelling of brain tissue behaviour.

The third and fourth sections consist of four papers presenting competitive advantage factors and a healthy living and working environment through technological modernisation of the input of materials, assessment of tee product usability, stock metering, and classification and labelling pharmaceutical ingredients. In the fifth section we touch on the always current topic Industry 4.0, where in three papers we learn something new about the use of IoT for measuring water supply points, the classification of sound signals, and the application of principles of software engineering in machine learning. The following is the sixth set of five contributions in the field of materials and technologies, where we face challenges of designing complex composite pressure vessels and adjustable motorcycle pedals, effects of forming and joining technologies on product durability and effects of casting on the properties of aluminium alloys and FEM analyses with tensile test of stainless steel. In the seventh set, six papers present the research to date in the EAGLE project, to develop a demonstration prototype of an advanced 3D sensor system which will enable frequency visual control of geometrically complex products. Proceedings conclude a set of seven papers covering fundamental and applied research of dispersion of elastic waves in homogeneous and symmetric three-layered plates, multi-objective optimization of stability domains of gear drive vibrations, asymptotic analysis of the edge bending wave on a stiffened plate, multi-parametric dynamic modelling of layered strongly inhomogeneous elastic structures, experimental measurement and numerical prediction of integral characteristic of a model-size wind turbine, MULTI-parametric dynamic analysis of »lightweight« laminates, and numerical prediction of water surface levels in the confluence of two rivers.

Dr. Tomaž Savšek
Chairman of the Program Committee

Plenarno predavanje

Plenary Lecture

5th International Conference on the Development of Industrial Engineering
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Otočec pri Novem mestu, Slovenia

Additive manufacturing and implantable medical devices

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Abstract

The medical industry is already one of the largest users of additive manufacturing also denoted as 3D printing. New additive manufacturing methods allow engineers to create more anatomically-accurate devices requiring designs that are difficult to produce with traditional subtractive methods. The aim of the lecture is to explain basics of additive manufacturing and focus on current state-of-art and limitations of the technology. Direct metal laser sintering will be presented as a method for orthopaedic device production from biocompatible titanium alloys. New techniques significantly reduce product development timelines and allow creating implants that closely mimic shape of natural bone. Furthermore, the implants can be made with complex porous designs that fuse more easily with other bone structures.

Keywords: additive manufacturing, implants, medical industry

Biomehanika

Biomechanics

5th International Conference on the Development of Industrial Engineering
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Membranes' in-plane phase ordering and their functionality

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Abstract

Biological membranes present an essential constituent of living cells. Their main role is to separate the interior of a cell from its surrounding, however allowing the selective transfer of specific material through it. Configuration changes of membranes are often correlated with important biological processes. For example, they might trigger divisions of cells, adaptation of red blood cells to temporal conditions during their transport to different parts of biological tissues, they might be involved in cancerous and cell death processes... Membrane structures are in general extremely complex, but their key properties are often dominated by geometry. This was first illustrated by Helfrich who constructed a minimal model of membranes introducing curvature fields. In the lecture we will present our originally developed Helfrich-type mesoscopic modelling, which considers presence of in-plane ordering in membranes. From our model it emerges that membranes could exhibit extreme susceptibility, signal trasport efficiency, and efficient structural reconfiguration capabilities if their phase exhibiting in-plane ordering exists close to the corresponding structural phase transition.

Keywords: membranes, topology, topological charge, curvature, defects

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Supported lipid membranes on Au substrates: effects of composition, size and temperature

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Abstract

The cell membrane, consisting of a two-dimensional phospholipid bilayer hosting proteins and glycolipids, is associated with variable cell functionalities as well as with neural signalling. Solid supported lipid vesicles (SLVs) and solid supported lipid bilayers (SLBs) resemble the cell membrane to a great extent, albeit with a smaller complexity. Thus, they offer an experimental testing ground for the study of phase transitions, structure, self-assembly and mechanical properties of biological membranes.

In this contribution, different approaches for creating SLBs and the role of initial conditions are discussed [1]. Recent experimental results, obtained on SLVs and SLBs by means of quartz crystal microbalance with dissipation, are presented. The focus is on the effects of composition, size and temperature on lipid phase transitions.

Reference:
[1] K. Betlem, G. Cordoyiannis, P. Losada-Pérez, “Supported lipid membranes at the Au-buffer interface by solvent exchange: the effect of initial solvent concentration”, Phys. Status Solidi A, in press (2019).

Keywords: solid supported lipid vesicles, solid supported lipid bilayers, phase transitions

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April 21, 2020
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Atomic force microscopy of neural cells

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Abstract

Atomic force microscopy is a powerful technique for surface analyses allowing three-dimensional topography imaging. It has been used in many scientific-analytical works as well and it is opening its way to industry usage, particularly with the improved speed of analysis and especially in the field of semiconductors and electronics industry[1]. Its speciality is detecting surface damages that can appear during the production. This technique provides an important piece of information about the surface properties and composition on a nano-level scale.

In general, the samples can be analysed in air or in a liquid environment. For biological samples, it is wary important for them to be measured in the liquid and at its normal conditions (temperature, pH, etc.). In our research, we are observing self-propagating neuron cells, which need to be in buffer solution at 37 °C. The aim of our investigation is to measure the change in morphology during the nerve pulse propagation through the axon. First, it is important to scan the surface of the cell to get a topology in 3 dimensions. This allows finding the exact position of interest and investigation of the changes with the tip on a small spot. This technique can give information about the elasticity of the membrane on a very small scale. In the case of the neuron cell, it can also show the changes in movement and visco-elastic properties during the axon firing. Based on this information we simulate the pulse propagation and increase our understanding of how brain works.

[1]Atomic Force Microscopy Market (AFM) by Offering (AFM, Probes, Software), Grade (Industrial Grade, Research Grade), Applications (Materials Science, Life Sciences, Semiconductor & Electronics, Academics), and Region - Global Forecast to 2024

Keywords: membrane properties, elastic modulus, neural cell, pulse propagation, atomic force microscopy

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April 21, 2020
Otočec pri Novem mestu, Slovenia

Viskoelastično modeliranje mehanskega obnašanja možganskega tkiva

Viscoelastic modelling of brain tissue mechanical behaviour

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Povzetek

Pri modeliranju mehanike možganskega tkiva ali vzpostavljanju eksperimentalnih protokolov za karakterizacijo naletimo na številne težave, ki so povezane s kompleksnostjo mehanskega obnašanja le-tega. Kljub temu pa je poznavanje pravih materialnih lastnosti možganskega tkiva in uporaba ustreznih analitičnih in numeričnih orodij za izračune odzivov ključnega pomena; na primer za čim natančnejšo identifikacijo razlik med zdravim in bolnim tkivom, ali na primer pri razvoju naprednih simulacijskih sistemov za kirurška usposabljanja.

Glede na navedbe v literaturi možgansko tkivo izkazuje nelinearne viskoelastične karakteristike. Obstoječi modeli običajno zahtevajo eksperimentalne podatke iz večjih različnih eksperimentov, da je s tem na voljo dovolj vhodnih parametrov za popis nelinearne viskoelastičnosti. Klub temu pa ni zagotovila, da bodo napovedi vzpostavljenih modelov veljavne tudi izven eksperimentalnih območij uporabljenih vhodnih podatkov.

Na osnovi teh izhodišč v prispevku predstavljamo fizikalno podprto metodologijo s potencialom širše uporabnosti, ki za napoved frekvenčno odvisnih modulov in odzivov pri konstantni hitrosti obremenitve kot vhodni podatek potrebuje le znane eksperimentalne podatke o relaksaciji napetosti. Relaksacijska sumarna krivulja je zgrajena s premikanjem segmentov ob upoštevanju principa časovno-deformacijske superpozicije. Dobljena sumarna krivulja nato služi kot vhod za napoved frekvenčno odvisnega obnašanja z uporabo konstitutivnih viskoelastičnih zvez ter kot vhod za napoved odziva na obremenitev s konstantno hitrostjo deformacije z uporabo nelinearnega viskoelastičnega modela, ki temelji na uvedbi notranjega časa materiala.

Rezultati kažejo, da je uporabljeni pristop primeren za napovedovanje tovrstnih mehanskih odzivov, hkrati pa daje jasnejši vpogled v fenomenologijo mehanskega dogajanja v možganskem tkivu ter s tem povezano konstitutivno modeliranje.

Ključne besede: možgansko tkivo, viskoelastičnost, časovna in frekvenčna odvisnost viskoelastičnih lastnosti, časovno-deformacijska superpozicija, viskoelastična interkonverzija

Abstract

Modelling mechanics of brain or establishing experimental protocol to capture its mechanical response may cause several difficulties due to the mechanical behaviour complexity. Nevertheless, it is of great importance to know the real material properties of brain, and to apply the most proper analytical and numerical tools for adequate computational characterization. This is, for example, necessary for precise identification of the differences between healthy and sick tissue mechanics or development of advanced simulation systems for surgical training.

According to the literature, brain tissue exhibits nonlinear viscoelastic characteristics. State-of-the-art models usually require experimental data from several different experiments in order to provide input parameters for modelling of nonlinear viscoelasticity. However, there is no guarantee for the validity of established models outside the experimental ranges of the input data.

Based on this starting point, we present physically supported methodology with potential to be applied broadly, that only requires experimentally known stress relaxation data to predict the frequency-dependent moduli and the constant strain rate response of brain tissue. Relaxation master curve is built via shifting of the relaxation segments with the aid of the time-strain superposition principle. The obtained master curve serves as an input for prediction of the frequency-dependent behaviour and the constant strain rate response by applying constitutive viscoelastic laws and the nonlinear internal-clock viscoelastic model, respectively.

Results indicate that the proposed approach serves well for prediction of the investigated brain mechanical responses, and give an insight in the phenomenology of brain tissue mechanics and its constitutive modelling.

Keywords: brain tissue, viscoelasticity, time and frequency dependence of viscoelastic properties, time-strain superposition, viscoelastic interconversion

Dejavniki konkurenčnosti

Competitive Advantage Factors

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Otočec pri Novem mestu, Slovenia

Tehnološko posodabljanje vhoda materialov v industriji

Technological modernization of the input of materials in the industry

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Povzetek

Logistika že ima svoj prostor v industriji, gospodarstvu, javni upravi in drugje, kjer je potrebna določena priprava dela, izpeljava procesov ali določenih faz dela, ki omogočajo proizvodnjo, prodajo, oskrbo in podobno. V konkretnem primeru gre za iskanje rešitev glede vhodnih materialov, ki v industriji predstavljajo nujno sredstvo, obenem pa veliko izgubo časa in breme. Skozi posamezne vidike obvladovanja vhoda materialov za industrijsko proizvodnjo, smo želeli tehnično posodobiti nekatere postopke sprejema, priprave in dostave materialov neposredno na proizvodni trak. Namen je bil razbremeniti zaposlene, uporabiti sodobno tehnologijo in obenem uvesti ustrezen številčni nadzor nad potekom vhoda in izhoda materialov v industrijski proizvodnji. Proučevali smo posamezne postopke vhoda materialov ter skozi faze iskali možnosti uporabe sodobne tehnologije, ki enakovredno ali boljše izvaja posamezne naloge. Cilj je usmerjen k odpravi izgube časa, razbremenitvi delavcev in vključevanje novodobne tehnologije. Gre za znanstven pristop proučevanja posameznih faz dela v industriji ter za pridobivanje novega znanja za izboljšanje posameznih postopkov. Metoda temelji na zbiranju opazljivih, empiričnih in merljivih podatkov, ki so podvrženi določenim merilom razmišljanja in se lahko odražajo v izboljšanju procesov, časovni ali cenovni enoti. Razvoj industrije išče možnosti uvajanja sodobne tehnologije, posodabljanje posameznih postopkov ter uvajanje tistih oblik in načinov dela, ki bodo zagotovili prihranek. Gre za nadaljevanje raziskave preteklih posodobitev, ki izkazujejo, da je z uvajanjem nove tehnologije v faze vhodnih materialov mogoče odpraviti izgube časa, razbremeniti zaposlene ter stroške prepoloviti.

Ključne besede: čas, industrija, prihranki, sodobna tehnologija, vhodni materiali

Abstract

Logistics already has its own space in industry, economy, public administration and elsewhere, where certain preparation of work, derivation of processes or certain phases of work that allow production, sales, care and the like. In this particular case, there is a solution for the input materials that represent an essential asset in the industry, while a significant loss of time and burden. Through individual aspects of the management of input materials for industrial production, we wanted to technically update certain procedures of acceptance, preparation and delivery of materials directly to the production strip. The purpose was to relieve employees, use modern technology, and at the same time introduce adequate numerical control over the course of input and output of materials in industrial production. We have studied individual material input procedures and searched through the stages of the use of modern technology, which is an equivalent or better exercise of individual tasks. The aim is to eliminate the loss of time, relieve workers and integrate new technologies. It is a scientific approach to examining individual phases of work in the industry and to acquire new knowledge to improve individual procedures. The method is based on the collection of observable, empirical and measurable data, which are subject to certain criteria of reflection and can be reflected in the improvement of processes, time or price unit. The development of the industry is looking for the possibility of introducing modern technology, updating individual processes and introducing those forms and methods of work to ensure savings. It is a continuation of the survey of past updates, which show that the introduction of a new technology in the phases of input materials can eliminate the loss of time, relieve employees and cost halving.

Keywords: time, industry, savings, modern technology, input materials

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April 21, 2020
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Preverjanje ustreznosti lastne metodologije testiranja uporabljivosti izdelka

Assessment of the validity of a method for testing usability of a product

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Povzetek

Projekt je bil namenjen preverjanju ustreznosti lastne metodologije testiranja uporabljivosti izdelka. Danes so številni izdelki zasnovani tako, da jih je predvidoma enostavno uporabljati, zato je poleg uporabnosti izjemnega pomena tudi uporabljivost izdelka. Uporabljivost pomeni preprosto uporabo ali preprosto učenje uporabe orodja ali naprave. V okviru projekta smo preverjali ustreznost lastne metodologije testiranja uporabljivosti programske opreme - spletne učne platforme.

Ključne besede: metoda, uporabljivost, emocije, Sakai, BigBlueButton

Abstract

The purpose of the project was to assess the validity of a method for testing usability of a product. Today, many products are designed to be reasonably easy to use and, in addition to usefulness, product usability is of high importance. Usability means simply using or simply learning how to use a tool or device. As part of the project we assessed the validity of our own methodology for testing the usability of software - online learning platform.

Keywords: Method, Usability, Emotions, Sakai, BigBlueButton

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Merjenje zaloge izdelkov v prodajnih avtomatih

Stock metering in vending machines

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Povzetek

Prodajne avtomate je potrebno redno polniti z izdelki, da se zagotovi zadostna zaloga za prodajo med zaporednimi polnjenji. Za lažje upravljanje z mrežo prodajih avtomatov, optimizacijo zaloge, polnjenje naprav ob ravno pravem času, preverjanje količin polnjenja in kontrolo izdaje je zaželeno, da se zaloga po neki merilni metodi izmeri in po potrebi pošlje prek širokopasovnih telekomunikacijskih povezav do nadzorne programske opreme. S pomočjo sprotnega merjenja operater upravlja s prodajno mrežo, torej prodajnimi avtomati, izvaja statistične analize za optimizacijo svojega poslovanja in lažje rešuje reklamacijske zahtevke.

V tem članku je opisan razvoj metode za merjenje zaloge v prodajnih avtomatih, od iskanja novih idej, raziskovanja različnih principov merjenja, preverjanja možnih metod merjenja, primerjanja različnih rešitev in optimalne izbire ene izmed njih, do izdelave delujočega prototipa.

Na začetku je opisan spiralni mehanizem za izmet produktov iz prodajnih avtomatov. Predstavljeno je, kako so izvedeni sedanji avtomati s spiralnimi mehanizmi in česa nimajo. Nato so opredeljene izhodiščne zahteve in kriteriji raziskovanja, ki so bili določeni zato, da bi kar najbolje izbrali končno rešitev. Opisane so različne možnosti merjenja, ki so bile raziskane glede na princip merjenja in možnosti za izvedbo. Pri vsaki merilni metodi so podane prednosti in slabosti ter navedeni razlogi, zakaj bi bila metoda merjenja primerna ali ne. Raziskanih je bilo le nekaj kontaktnih in brezkontaktnih metod za merjenje zaloge izdelkov. Po predstavitvi metod je izbrana najboljša in opravljena utemeljitev izbire. Za izbrano merilno metodo je bil izdelan prototip, v katerem so vgrajeni izbrani senzorji za merjenje razdalje na optičnem principu, s katerimi je pozneje, ob ustrezni programski podpori, izvedeno uspešno merjenje stanja zaloge in pošiljanje stanja preko GSM modula v obliki SMS sporočil. Podani so rezultati preizkušanja in utemeljene prednosti izbrane metode merjenja.

Ključne besede: avtomat, merjenje, prodaja, telemetrija, zaloga

Abstract

Vending machines need to be filled regularly to ensure sufficient product stock to be sold between consecutive refills. In order to optimise the management of the vending machine network, automate inventory, organise just in time filling, check filling quantity and monitor product ejection, it is desirable to measure the stock online and, if necessary, send it via broadband telecommunication network to supervisory and data acquisition software. By using this data, operator manages vending machines on the field, performs statistical analyses to optimize his business and resolves claims of customers.

This article describes the development of a method for measuring product stock in vending machines. Several ideas how to approach the measurement are discussed. Different measurement principles are explored and possible measurement methods are sought. Finally, one of them considered optimal is selected, and built into a working prototype.

A spiral mechanism for ejecting products from vending machines is described. We present how machines with spiral mechanisms operate and state what they lack. System requirements and the search criteria for suitable measurement method are stated. Several different methods are considered and arguments why a method would be appropriate or not are given and discussed for them. After presenting the methods, the optimal one is chosen and implemented in a prototype. The proposed method is based on optical distance meter, which subsequently, with appropriate software support, can be used to successfully measure the stock and report it in SMS messages to data centre. Test results and advantages of the selected method are given.

Keywords: sales, vending machine, stock, measurement, telemetry

Zdravo bivalno in delovno okolje

Healthy Living and Working Environment

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Primerjava razvrščanja in označevanja nekaterih farmacevtskih učinkovin

Evaluation of classification and labeling of some active pharmaceutical ingredients

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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 zahteva od proizvajalcev in uvoznikov nevarnih kemikalij, 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. Na primeru nekaj farmacevtskih učinkovin smo analizirali kakšne razvrstitve nevarnosti so zavezanci prijavili v popis in jih poskušali ovrednotiti glede na javno objavljene toksikološke in ekotoksikološke podatke.

Pravilna interpretacija toksikoloških in ekotoksikoloških podatkov je namreč ključna za pravilno razvrščanje, označevanje in pakiranje farmacevtskih učinkovin kot potencialno nevarnih snovi in je osnova za zaščito okolja, predvsem pa zaščito zaposlenih v industriji.

Ključne besede: CLP, GHS, ECHA, farmacevtske učinkovine, nevarne kemikalje

Abstract

The European Union is implemented the so-called Globally Harmonised System of classification and labelling of hazardous chemicals (GHS) by regulation CLP (1272/2008/EC) as an important contribution to the sustainable development of the Member States. The regulation requires from manufacturers and importers of hazardous chemicals to carry out the classification and labelling of them. In addition the CLP requires from manufacturers and importers to notify the classification and labelling of chemicals to the inventory of classification and labelling of hazardous chemicals maintained by European Chemicals Agency. On the sample of a few active pharmaceutical ingredients notified in the inventory by manufacturers and importers were analysed the hazard classifications reported and tried to evaluate them according to the published toxicological and ecotoxicological data.

Correct interpretation of toxicological and ecotoxicological data is namely a key for the proper classification, labeling and packaging of pharmaceutical ingredients as potentially hazardous substances and is a basis for environmental protection, and above all for the protection of employees in the industry.

Keywords: CLP, GHS, ECHA, hazardous chemicals, active pharmaceutical ingredients

Industrija 4.0 in pametne specializacije

Industry 4.0 and Smart Specializations

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Uporaba IoT za merjenje manjših odjemnih mest vodovodnega omrežja v podjetju Luka Koper

Use of IoT for measuring small water supply points in Port of Koper

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Povzetek

Eden od pomembnejših današnjih tehnoloških trendov je tudi razvoj interneta stvari. Ta predstavlja povezljivost naprav po različnih topologijah in uporabo različnih komunikacijskih standardov z namenom zajemanja podatkov in upravljanja tehnoloških procesov. V članku bomo predstavili rešitev z uporabo interneta stvari na primeru prenove vodovodnega omrežja v podjetju Luka Koper s poudarkom po priklopu manjših odjemnih mest na primarno omrežje za oskrbo s pitno vodo. Ker so odjemna mesta večinoma na območjih, kjer ni klasične infrastrukture, je bilo potrebno poiskati ustrezno rešitev za prenos manjše količine podatkov z nizko porabo energije, dolgo avtonomijo in prenosom na večje razdalje.

V članku se bomo osredotočili na LoRaWAN komunikacijski standard, ki se je izkazal kot najprimernejši za predstavljeno rešitev v podjetju Luka Koper. Ta vključuje postavljeno LoRaWAN omrežje z perifernimi enotami, bazno postajo in spletnim strežnikom. Opravili smo tudi meritve LoRa radijskega signala na ključnih mestih po celotnem območju podjetja. Meritve smo izvajali na vseh lokacijah predvidenih za postavitev vodnih števcev, nato pa še na za radijski signal najbolj nedostopnih mestih. Za meritve smo uporabili dva Adeunisova ročna analizatorja, nastavljena na različne faktorje razširjanja signala. S tem smo hkrati dobili po dva rezultata meritev izvedena pod različnimi pogoji. Izmerjene vrednosti in lokacije meritev smo nato zbrali v tabeli. Rezultati meritev so presegli pričakovani odziv sistema in s tem potrdili upravičenost izbranega komunikacijskega standarda.

Ključne besede: energija, faktor razširjanja, modulacija, avtonomija, infrastruktura, LAN, LoRaWAN

Abstract

One of today's major technological trends is the development of the Internet of Things. It represents the connectivity of devices across different topologies and the use of different communication standards to capture data and manage technological processes. In the article, we will present a solution using the Internet of Things in the case of the renewal of the water supply network at Port of Koper, with emphasis on connecting smaller outlets to the primary drinking water supply network. As collection points are mostly located in areas where there is no conventional infrastructure, it was necessary to find a suitable solution for the transmission of small amounts of data with low energy consumption, long autonomy and long-distance transmission.

The article will focus on the LoRaWAN communication standard, which has proven to be the most appropriate for the presented solution in Port of Koper. This includes a set up LoRaWAN network with peripherals, a gateway and a web server. We also performed LoRa radio signal measurements at key locations throughout the company. Measurements were carried out at all locations intended for the installation of water meters, and then at the most inaccessible locations for the radio signal. We used two Adeunis handheld analyzers tuned to different signal spread factors. With this we simultaneously obtained two results of measurements carried out under different conditions. The measured values and locations of the measurements were then collected in a table. The measurement results exceeded the expected response of the system and thus confirmed the validity of the chosen communication standard.

Keywords: energy, spread factor, modulation, autonomy, infrastructure, LAN, LoRaWAN

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Klasifikacija kratkotrajnih zvočnih signalov z uporabo strojnega učenja

Short audio signal classification with machine learning

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Povzetek

V industrijskem okolju je potrebno pri montaži določenih sklopov sistema zagotavljati 100% in-line kontrolo prileganja, saj lahko pomanjkljivo prileganje sklopa povzroči nedelovanje ali slabše delovanje celotnega sistema. V prispevku smo reševali problem strojne zaznave pravilnega prileganja sklopov žarometa v podjetju Hella Saturnus Slovenija. Pri reševanju problema smo bili omejeni s stroškovne, kot tudi s kakovostne plati, kajti rešitev je morala učinkovito zaznavati pravilne spoje v industrijskem okolju in biti pri tem tudi stroškovno sprejemljiva. Zaradi podanih omejitev smo se odločili za zvočno zaznavanje pravilnosti montažnega procesa s klasifikacijo zvočnih signalov z uporabo nadzorovanega strojnega učenja. Pri tem smo izdelali lastne algoritme za pripravo signalov in označevanje. Uporabili smo značilke iz časovne in frekvenčne domene, ter značilke s področja signalov, kot sta entropija in energija signala. Klasifikacijske modele smo pridobivali z različnimi algoritmi strojnega učenja, kot sta metoda podpornih vektorjev in nevronske mreže. V najboljših primerih smo dosegli 100% pravilno klasifikacijo dogodkov na podlagi uporabe naključnih 50 % vzorcev za učenje. Razvita aplikacija, ki teče na industrijskem računalniku, deluje tako hitro, da se proizvodni proces z uporabo aplikacije ne upočasni.

Ključne besede: nadzorovano strojno učenje, ekstrakcija značilk, nevronske mreže, strukturni zvok, kratkotrajni zvočni signali

Abstract

In an industrial environment, 100% in-line fitting control must be ensured when mating certain assemblies of the system, as a faulty fitting of the assembly may cause malfunction or poor performance of the entire system. The article addresses the problem of detecting the correct fitting of headlamp assemblies at Hella Saturnus Slovenia. We were limited in terms of cost as well as quality in solving the problem because the solution had to effectively detect the correct assembly fit in an industrial environment while being cost-effective. Due to the given limitations, we decided to acoustically detect the correctness of the assembly process, with the classification of acoustic signals using supervised machine learning. We have developed our algorithms for signal preparation and marking. Time and frequency domain features as well as signal features such as entropy and signal energy ware used. We obtained classification models using various machine learning algorithms, such as the support vector method and neural networks. In the best cases, we achieved 100% correct event classification based on the use of random 50% learning patterns. A developed application running on an industrial computer runs fast enough to enable on-line detection without slowing down the manufacturing process.

Keywords: supervised machine learning, features extraction, neural networks, structural sound, short audio signals

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Using Software Engineering Principles for Machine Learning

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Abstract

In the recent years, machine learning (ML) has enjoyed a continuously rising popularity due to the astonishing results in the field. With modern frameworks it is surprisingly easy to build an ML system for even the most complex tasks. But what quickly gets overlooked are the numerous challenges that come with maintaining a model in production, such as the effort of versioning and monitoring large data volumes. A variety of principles and best practices from the discipline of Software Engineering helped create robust and maintainable software over the last decades. Programs expressible in symbolic logic, without dependencies to external data, have been studied quite well. Programming with data as it is done in ML is comparably less understood. Due to the complexity of machine learning software, and it's young history in comparison, the field is lacking best practices for a systematic, disciplined and quantifiable approach.

This paper will first introduce the topic by outlining some practices that have been proven successful in software engineering. The subsequent sections describe what challenges arise when operating an ML system in production, and how software engineering principles are applied to machine learning.

Keywords: machine learning, software, engineering, system design

Materiali in tehnologije

Materials and Technologies

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Izzivi pri konstruiranju in izdelavi zahtevnih kompozitnih tlačnih posod

Challenges in designing and manufacturing complex composite pressure vessels

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Povzetek

Članek na kratko predstavi prevladujoča konstrukcijska standarda za kompozitne tlačne posode. Prvi je standard ASME-X, ki izvira iz ZDA in ima za seboj pol stoletja zgodovine. Drugi je evropski standard EN 13121, ki je v uporabi eno desetletje. Konstrukcijska standarda sta obsežna in glavnina njune vsebine je uporabna pri konstruiranju in izdelavi večine kompozitnih izdelkov ojačanih z dolgimi vlakni. Posledično standarda predstavljata dragoceni vir informacij za proizvajalce, pri čemer so informacije naravnane doseganju učinkovite konstrukcije in proizvodnje kompozitnih izdelkov.

Obravnavane vsebine iz standardov temeljijo na sodobnem in zanesljivem znanju o kompozitih, ki se je gradilo skozi dolgoletne raziskave, razvoj ter izkušnje pri eksploataciji kompozitnih izdelkov. Standarda nazorno obravnava anizotropne lastnosti kompozitnih materialov in nam prikažeta kako te upoštevati v konstrukcijskih izračunih, testiranju in evaluaciji rezultatov. Kljub podobnemu namenu standardov in prekrivanju njunih vsebin, standarda temeljita na drugačnem pristopu konstruiranja kompozitnih izdelkov. V članku sta oba pristopa predstavljena in primerjana z namenom, da prepoznamo prednosti in slabosti obeh pristopov.

Čeprav standarda vodita proizvajalce kompozitnih tlačnih posod skozi korake konstruiranja in proizvodnje, oba standarda vsebujeta pomanjkljivosti, ki izvirajo iz zapletenega popisovanja obnašanja kompozitnih materialov. Pomanjkljivosti, ki se lahko pripišejo k nenatančnosti konstrukcijskim izračunom in izdelavi so sprejemljive v kolikor je varnostni faktor izdelka ustrezno povečan. Zaskrbljujoče pa so pomanjkljivosti, ki lahko privedejo do zavrnitve izdelka in s tem do velikega stroška proizvajalcu, čeprav je izdelek mehansko ustrezen namenjeni aplikaciji.

Ključne besede: kompozit, material, konstrukcijski standard, anizotropnost, tlačna posoda

Abstract

The paper briefly presents the prevailing construction standards for composite pressure vessels. The first is the ASME-X standard, which originates in the US and has half a century of history. The second is the European standard EN 13121, which has been in use for a decade. The construction standards are extensive, and the majority of their content is useful in the design and manufacturing of composite products reinforced with long fibers. As a result, the standards represent a valuable source of information for manufacturers, and the information is tailored towards achieving an effective construction and production of composite products.

The contents discussed from the standards are based on modern and reliable knowledge on composites, which has been developed through years of research, development and experience from exploitation of composite products. The standards clearly illustrate the anisotropic properties of composite materials and show us how to take these into account in structural calculations, testing and evaluation of results. Despite the similar purpose of the two standards and their overlapping contents, the standards are based on a different approach to designing composite products. In the paper both approaches are presented and compared in order to identify the advantages and disadvantages of each approach.

Although the standards guide manufacturers of composite pressure vessels through the design and production steps, both standards have deficiencies that arise from modeling the complex behavior of composite materials. Deficiencies that can be attributed to the inaccuracy of design calculations and manufacturing are acceptable, if the safety factor of the product is adequately increased. However, of great concern are the deficiencies that can lead to the rejection of the product, and thus to a high cost to the manufacturer, even if the product is mechanically adequate for the intended application.

Keywords: composite, material, construction standard, anisotropic, pressure vessel

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Kombinirani vpliv preoblikovanja in spajanja na zdržljivost izdelkov

Combined Influence of Forming and Joining Technologies on Product Durability

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Povzetek

Zaradi povečanja varnosti, dodajanja novih funkcij in vse hujših regulativ postajajo nosilne komponente avtomobilskega podvozja in karoserije vse bolj kompleksnih oblik. V kolikor želimo, da naši izdelki ohranijo konkurenčnost, morajo biti narejeni hitro, kvalitetno in poceni. Z namenom izpolnjevanja vseh omenjenih zahtev so dandanes končni izdelki dejansko sestavi več kompleksno preoblikovanih pločevin, spojenih s postopkom varjenja. Iz ene v drugo operacijo se ne prenaša samo spremenjena geometrija izdelka, temveč tudi vpliv vseh predhodnih obdelav, ki se kažejo tudi kot zaostale napetosti. Zaostale napetosti predstavljajo eno izmed večjih neznank v vsakodnevni inženirski praksi, saj jih je bilo v preteklosti praktično nemogoče ovrednotiti ter predvideti njihov vpliv na vedenje izdelka med obratovanjem, zaradi česar so bili izdelki mnogokrat močno predimenzionirani. Z vse večjo zahtevo po lahki gradnji in zaradi vse zmogljivejših računalniških orodij lahko danes zaostale napetosti, kot posledico izdelovalnega procesa, predvidimo. Še vedno pa se nam poraja vprašanje kako upoštevati zaostale napetosti, ki nastanejo med posamezno operacijo, ter kako le-te medsebojno vplivajo na preostale operacije izdelovalnega procesa in na stanje končnega izdelka. Poleg tega so komponente avtomobilskega podvozja podvržene dinamičnim obremenitvam, ki prav prav tako zahtevajo posebno vrednotenje. V tem prispevku je narejen pregled teorije zaostalih napetosti. Pregledali smo metode merjenja zaostalih napetosti, zaostale napetosti kot posledico varjenja, kombiniran vpliv zaostalih napetosti kot posledico različnih izdelovalnimi procesov, metode modeliranja zaostalih napetosti, ki nastanejo med varjenjem, in njihov vpliv na dobo trajanja dinamično obremenjenih izdelkov.

Ključne besede: zaostale napetosti, lahka gradnja, preoblikovanje, numerične simulacije, varjenje, zdržljivost izdelkov

Abstract

High safety requirements, new functionalities and enhanced regulations are some of the main reasons for the complex shape of car chassis components. In order to maintain competitiveness of our components, they must be developed fast, in compliance with the required quality level and they must be reasonably priced. The only way to achieve all of these requirements is to form the chassis components into complex shapes and then weld them together into a final complex shape assembly. It is important to consider that not only the changed shape of the product is transferred from one production stage to another, but also the influence from all of the previous manufacturing processes that results in occurrence of residual stresses. In the past, residual stresses and their effects on component behaviour during operation were almost impossible to evaluate, which resulted in oversized products. With a development of Computer Aided Design (CAD) methods and more advanced computer software, it was possible to translate influence of production process from one step to another, which helps us in designing lightweight products. The question that remains open is how residual stresses, which are caused by preceding production steps, affect the remaining steps and the final product. Furthermore, the components of the car chassis are loaded with dynamic loads, which require special analysis. The residual stress theory is presented in this paper. It covers residual stress measurement techniques, residual stresses as consequence of the welding process, combined influence of residual stresses caused by different production processes as well as methods of numerical modelling of residual stresses caused by welding and their influence on the durability of dynamically loaded products.

Keywords: Residual stresses, lightweight design, forming, FE simulations, welding, product durability

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Konstruiranje nastavljivih stopalk motocikla

Design of adjustable motorcycle pedals

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Povzetek

Članek opisuje razvoj in konstruiranje nastavljivih stopalk za motocikel. Proizvajalci motociklov se zaradi čim boljše prodaje in dobičkonosnosti osredotočijo na voznike povprečne višine in teže, saj s tem s čim nižjimi stroški dosežejo najširši krog kupcev. Na motocikel zato pritrdijo fiksne stopalke, kar pa za mnoge posameznike ni optimalna rešitev.

V prispevku je podana možna rešitev problema fiksnih stopalk z nastavljivimi. Opisan je celoten postopek razvoja in konstruiranja s časovnim načrtom. Predstavljene so ideja, koncept, računalniško modeliranje CAD, analiza trdnosti izdelka CAE, izdelava tehnične dokumentacije ter proces tehnologije strojne obdelave CNC in CAM. Opravljene so bile tudi različne meritve za verifikacijo izdelka.

Prilagodljivost kupcu je ključna za uspešno prodajo izdelkov. Prispevek je primer kako inženirsko znanje in računalniška orodja CAD, CAE in CAM uporabimo v praksi za razvoj in konstruiranje inovativnih izdelkov.

Ključne besede: Stopalke motocikla, razvoj izdelka, konstruiranje, CAD, CAM, CAE

Abstract

The paper describes the development and mechanical design of adjustable motorcycle pedals. To maximize sales and profitability, motorcycle manufacturers focus on drivers of average height and weight, reaching the widest possible range of customers at the lowest possible cost. They therefore attach fixed pedals to the motorcycle, which is not an optimal solution for many individuals.

The paper gives a possible solution to the problem of fixed pedals with adjustable pedals. The whole process of development and construction with a timeline is described. The idea, concept, computer CAD modeling, CAE product strength analysis, technical documentation preparation and CNC and CAM machining technology are presented. Various measurements were also made to verify the product.

Customer flexibility is key to successful product sales. This article is an example of how engineering knowledge and computer tools CAD, CAE and CAM are put into practice to develop and design innovative products.

Keywords: Motorcycle pedals, product development, mechanical design, CAD, CAM, CAE

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Primerjava MKE analiz z nateznim preizkusom pri nerjavnem jeklu

Comparison of FEM analyzes with tensile test of stainless steel

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Povzetek

Rdeča nit prispevka je primerjava realnosti z računalniškimi simulacijami. Inženir je med snovanjem oz. konstruiranjem večino časa razpet med dvema poloma. Na eni strani sozahteve po čim cenejši oz. čim lažji zasnovi, medtem ko mora konstrukcija zdržati vse obremenitve, ne da bi se kritično deformirala ali še huje – porušila. Pri sklepanju čim boljšega kompromisa so inženirju v veliko pomoč računalniške analize, kot je na primer metoda končnih elementov. Problem nastane, ko ne vemo, v kolikšni meri se lahko nanje opremo. Ugotoviti, kako točni so rezultati MKE-simulacij v praksi, je bil namen in cilj raziskovanja.

Primerjali smo obnašanje 1.4301 nerjavnega jekla pri natezni enoosni obremenitvi v naravnem in računalniškem okolju. Preizkušance smo vpeli v stroj za natezni preizkus in jih obremenjevali do porušitve. Ugotovili smo, pri kakšni sili se pojavi meja tečenja, kjer se začne plastična deformacija. Da bi zagotovili linearnost računalniških simulacij, smo preizkušance v obliki 3D-modelov virtualno obremenili s silo, ki še ni povzročala plastične deformacije, saj je bila napetost pod mejo tečenja. To smo storili s pomočjo MKE-analiz v različnih CAE programskih opremah, katerih rezultate smo primerjali z rezultati realnega nateznega preizkusa.

Ključne besede: nerjavno jeklo, natezni preizkus, meja plastičnosti, metoda končnih elementov – MKE, računalniške simulacije – CAE

Abstract

The red thread of the thesis is the comparison between real and computer aided simulation. An engineer is frequently torn between the two sides at the design phase. On one hand there are requirements to make as low cost or/and light construction as possible while the structure must withstand all loads without critical deformations or even worse - failing. In making of the best compromise computer analysis such as the Finite Element Method is very helpful to the engineer. The problem arises when we do not know how strong we can rely on them. The exact purpose and goal of this research is to determine how accurate the results of FEM simulations are.

We compared the behaviour of 1.4301 (AISI 304) stainless steel under axial tensile loading in both natural and computational environments. Specimens were inserted into a tensile test machine and loaded to the point of failure. Experimentally we found out where yield point occurs at which material begins to deform plastically. At that point material stops to deform elastically (when tension is released it returns to initial state) but plastically. To ensure the linearity of computer simulations the test subjects in the form of 3D-models were virtually loaded with force that didn't cause any plastic deformation because stress was still under yield point. Different CAE (Computer Aided Engineering) software were used to run FEM analysis of which results were compared to the real tensile test results.

Keywords: stainless steel, tensile test, yield stress, Finite element method – FEM, Computer aided engineering – CAE

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Vpliv načina litja na lastnosti aluminijeve zlitine

The influence of casting method on the properties of aluminium alloy

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Povzetek

V raziskavi smo preiskovali vpliv nizkofrekvenčnega elektromagnetnega litja na mehanske lastnosti aluminijeve zlitine AA 6182. Za preiskavo smo odlili dve vrsti drogov, iz katerih smo pripravili preizkušance za metalografski in mehanski preizkus.

Rezultati mikroskopske preiskave so pokazali, da imajo izdelki odliti po klasičnem postopku večja kristalna zrna kot preizkušanci izdelani po postopku nizkofrekvenčnega elektromagnetnega litja. Posledica spremenjenega načina litja je zmanjšanje količine dodanega modifikatorja, znižanje temperature ter časa homogenizacijskega žarjenja. Površina litih drogov ima manjšo hrapavost. Tako ni potrebe po struženju pred razrezom na okroglice.

Ključne besede: aluminijeve zlitine, litje, klasično, nizkofrekvenčno elektromagnetno, mehanske lastnosti, mikrostruktura

Abstract

The subject of our research was influence of low frequency electromagnetic casting on mechanical properties of aluminium alloys AA 6182. In research we have casted two types of bars from which we prepared test products for metallographic and mechanical testing.

The results of microscopic research showed us that the products casted according to the classical procedure have bigger crystal grains than the test products made by low frequency electromagnetic casting. Due to the changed casting method there is reducing in amount of added modifier, lowering the temperature and reducing the time of homogenization annealing. Hardened bars have lower roughness. Thus, there is no need for turning before cutting into rounds.

Keywords: aluminium alloys, casting, classic, low-frequency electromagnetic, mechanical properties, microstructure

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Nekateri pristopi in rešitve pri razvoju adaptivnih in inteligentnih pogonov

Some approaches and solutions in development of adaptive and intelligent drives

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Povzetek

V sistemih ogrevanja in hlajenja prihaja pogosto do nihanj temperature in tlakov, ki so posledica neustreznih nastavitev regulacijskih parametrov, nelinearnosti sistema, neprimernega načrtovanja sistema ter spremenljivih pogojev delovanja sistema čez leto (zimski, prehodni in letni režim delovanja). Zaradi nihanj prihaja do neželenih izgub energije, krajše delovne dobe komponent ter slabše kakovosti bivanja. Da bi ublažili naštete težave, smo v zadnjem desetletju razvijali tako strojne kot tudi programske rešitve za različne družine pogonov ventilov v podjetju Danfoss Trata, d.o.o. Med drugim smo razvili pogone, ki so sposobni samodejno zmanjšati ali odpraviti temperaturne, tlačne in mehanske oscilacije v sistemih daljinskega ogrevanja ter v HVAC sistemih. V prispevku bomo predstavili nekatere vgrajene programske rešitve s področja adaptacije, razpoznavanja vzorcev in mehke logike, kot tudi rezultate iz prakse.

Ključne besede: adaptivno vodenje, nelinearnost procesa, oscilacije, inteligentni pogoni, HVAC sistemi, ventili

Abstract

Temperature and pressure oscillations are common in HVAC systems. The oscillations appear due to unsuitable controller parameter tuning, system non-linearity, inappropriate system design, and fluctuating operating conditions throughout the year (winter, transitional and summer operating modes). The oscillations lead to energy losses, shorter life-span of the components and poorer living quality. In the last decade, in order to alleviate the mentioned problems, we have developed hardware and software solutions for different valve actuator families at Danfoss Trata, d.o.o. Among other solutions, the actuators capable of automatic reduction or elimination of temperature, pressure and mechanical oscillations in district heating systems and HVAC systems have been developed. The paper will present some of the developed embedded software solutions in the field of adaptation, pattern recognition and fuzzy logic as well as results in practice.

Keywords: adaptive control, process non-linearity, oscillations, intelligent drives, HVAC systems, valves

Raziskave na projektu EAGLE

Research on the EAGLE Project

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Napredni senzorski sistem EAGLE za 3D kontrolo geometrije kompleksnih predmetov v tovarnah prihodnosti

Advanced Sensor System EAGLE for 3D Geometry Control of Complex Objects in Factories of the Future

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Povzetek

V okviru projekta EAGLE bomo razvili demonstracijski prototip naprednega 3D senzorskega sistema, ki bo omogočal frekvenčno vizualno kontrolo geometrije kompleksnih predmetov. Kontrola se bo izvajala z uporabo inovativnih 3D postopkov strojnega vida, ki jih bomo razvili in nadgradili na podlagi lastnih patentiranih rešitev ter preizkusili v okviru projekta. Prototip bomo validirali in demonstrirali v simuliranem operativnem okolju.

Predstavljamo razvojna izhodišča pri zasnovi koncepta novega merilnega sistema ter opisujemo s tem povezane razvojne izzive. V okviru projekta bomo reševali težave s svetlobnimi odsevi indirektno osvetljenih delov predmetov zaradi odbojev svetlobe ter težave z računsko zahtevnostjo in posledično visoko latenco merilnih postopkov. Posebno pozornost bomo posvetili detekciji detajlov na merjencu,

ponovljivosti vpenjanja merjencev ter ustreznim postopkom osvetljevanja opazovanega področja za zagotavljanje pravilnega zajema slikovnih podatkov. Raziskali bomo 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: strojni vid, 3D slikovni senzor, kontrola kakovosti, avtomatizacija proizvodnje, industrija 4.0, tovarne prihodnosti

Abstract

Within the EAGLE project, we will develop a demonstration prototype of an advanced 3D sensor system which will enable frequency visual control of geometrically complex products. The prototype will be validated and demonstrated in a simulated operational environment. The quality control will be performed by using innovative 3D machine vision procedures, which will be developed and upgraded based on our own patent solutions and tested within the project.

We present the research premises for the EAGLE System Concept Design and discuss the associated research challenges. We will address problems related to reflection issues i.e. indirectly illuminated parts of the measured objects due to light reflection, as well as problems related to high computational costs of measurement procedures which in turn yield high latencies of measurement results that are not acceptable in production environments. Special attention will be paid to the automatic detection of relevant details on the measured objects and their fastening imprecisions, as well as to relevant methods for scene illumination in order to secure correct image acquisition. Finally, we will analyse the opportunities for EAGLE system integration into broader smart factory concepts.

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

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Razvojna izhodišča za zasnovo koncepta sistema strojnega vida za geometrijsko kontrolo kakovosti EAGLE

Research Premises for 3D Vision System Concept Design in EAGLE Geometry Quality Control

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Povzetek

V okviru projekta EAGLE bomo razvili demonstracijski prototip naprednega 3D senzorskega sistema, ki bo omogočal frekvenčno vizualno kontrolo geometrije kompleksnih predmetov. Kontrola se bo izvajala z uporabo inovativnih 3D postopkov strojnega vida, ki jih bomo razvili in nadgradili na podlagi lastnih patentiranih rešitev ter preizkusili v okviru projekta. Prototip bomo validirali in demonstrirali v simuliranem operativnem okolju.

Predstavljamo razvojna izhodišča pri zasnovi koncepta sistema za 3D strojni vid, ki temeljijo na treh patentiranih rešitvah s področja strojnega vida, ter opisujemo njihove prednosti in pomanjkljivosti. Prva rešitev se nanaša na inovativen način osvetljevanja objekta in postopek triangulacije za pridobivanje globinskih slik z nizko računsko kompleksnostjo, uporabili jo bomo za zmanjšanje računske kompleksnosti postopkov 3D strojnega vida. Druga rešitev predstavlja pripravo za samodejno optično preverjanje dimenzij cevastih objektov s posebnim načinom osvetlitve, ki omogoča večjo natančnost meritve, kar bomo uporabili kot temeljno razvojno izhodišče za nadaljnji razvoj 3D tehnologij v okviru projekta. Zadnja rešitev predstavlja sistem za pridobivanje globinskih slik s pomočjo triangulacije in modulacije svetlobnega toka, ki izloči

moteče vplive ostalih virov svetlobe, kar bomo uporabili pri zagotavljanju robustnosti postopkov strojnega vida.

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

Abstract

Within the EAGLE project, we will develop a demonstration prototype of an advanced 3D sensor system which will enable frequency visual control of geometrically complex products. The prototype will be validated and demonstrated in a simulated operational environment. The quality control will be performed by using innovative 3D machine vision procedures, which will be developed and upgraded based on our own patent solutions and tested within the project.

We present the research premises for the 3D Vision System Concept Design that are founded on three patented machine vision solutions and discuss their advantages and shortcomings. The first is a specific method for object illumination and triangulation procedure for depth imaging with a low computational complexity. By using this solution, we will seek to reduce the computational complexity of 3D machine vision processes. The second solution represents a device for automatic optical control of tubular object dimensions using a special illumination method for securing better measurement precision. It will serve as background knowledge for further development of 3D technologies within the project. The third solution reduce a system for obtaining depth imaging by means of triangulation and modulation of a luminous flux which eliminates interferences of other light sources. It will be used to boost the robustness of machine vision methods.

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

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Izzivi kakovosti in stanje tehnike pri oblikovanju razvojnih zahtev za sistem EAGLE

Quality challenges and state of the art in designing development requirements for the system EAGLE

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Povzetek

Eden od ključnih segmentov učinkovitega vodenja sistema kakovosti v avtomobilski industriji je vzpostavljen sistem kontrole izdelkov v fazi proizvodnje. Stalno spremljanje ključih parametrov izdelka je pomembno za doseganje zahtev. V proizvodnji avtomobilskih komponent so pomembni geometrijski parametri, ki jih lahko spremljamo s frekvenčno kontrolo ali s kontrolo znotraj linije.

V prispevku so predstavljeni problemi, s katerimi se srečujemo pri zagotavljanju spremljanja ključnih geometrijskih parametrov izdelka. Predstavljene so različne tehnologije in rešitve, ki jih pri tem lahko uporabljamo. 3D slikovne tehnologije postajajo z razvojem strojnega vida vse bolj primerne za kontrolo kakovosti v industrijskih okoljih, zato jim je posvečena posebna pozornost. Razumevanje problemov zagotavljanja kakovosti, poznavanje stanja tehnike in razpoložljivih rešitev je bil pomemben del pri zasnovi demonstracijskega prototipa naprednega 3D senzorskega sistema, ki bo omogočal vizualno kontrolo geometrije kompleksnih predmetov in ga bomo razvili v okviru projekta EAGLE.

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: kontrola kakovosti, 3D strojni vid, avtomatizirano merjenje geometrije

Abstract

One of the key segments of effective quality management in the automotive industry is the established product control system at the production stage. Constant monitoring of key product parameters is important for meeting requirements. In the production of automotive components, geometric parameters are important and can be monitored either by frequency control or by in-line control.

This paper presents the problems that are faced in providing monitoring of key product geometry parameters. Different technologies and solutions that we can use are represented. With the development of machine vision, 3D imaging technologies have become increasingly suitable for quality control in industrial environments, and therefore have special attention. Understanding quality assurance issues, knowing the state of the art, and available solutions was an important part in the design of a demonstration prototype of an advanced 3D sensor system that will allow visual inspection of the geometry of complex objects and will be developed within the EAGLE project.

Acknowledgements: 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: quality control, 3D machine vision, automated geometry measurement

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Metodologije nedestruktivnega testiranja industrijskih izdelkov kompleksne geometrije

Methodologies of Non-Destructive Testing of Industrial Products of Complex Geometry

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Povzetek

V kontroli kakovosti izdelkov so za industrijo velik izziv zahtevna in časovno potratna geometrijska in vizualna kontrola površin, naraščajoče zahteve standardov v kontroli kakovosti in predvsem tehnične omejitve pri kontroli kompleksne geometrije. V okviru projekta EAGLE razvijamo prototip naprednega senzorskega sistema za 3D kontrolo geometrije kompleksnih predmetov, ki bi nadziral geometrijsko pravilnost izdelkov in nemudoma opozarjal na morebitne napake. S tem bi se bistveno zmanjšal izmet, porabilo manj surovin in energije za ponovno izdelavo. S pravočasnim odkrivanjem napak bi se izognili transportu nekvalitetnih izdelkov, s tem pa neposredno prispevali k zmanjšanju števila prevozov in nastajanju toplogrednih plinov kot posledice transporta.

V prvi fazi projekta je bilo potrebno izbrati najbolj primerno merilno metodo, ki bo uporabljena za razvoj prototipnega senzorskega sistema EAGLE za robustno in precizno avtomatsko odkrivanje dimenzijskih napak na geometrijsko kompleksnih izdelkih iz pločevine. V ta namen smo izvedli temeljit pregled obstoječih tehničnih rešitev in pripadajočih temeljnih in aplikativnih raziskav na področju razvoja merilnih metod za 3D kontrolo geometrije izdelkov.

V prispevku predstavimo različne metodologije na področju nedestruktivnega testiranja industrijskih izdelkov kompleksne geometrije. Kot najbolj primerna merilna metoda v kontroli kakovosti geometrijsko

kompleksnih izdelkih iz pločevine se je izkazal sistem optičnega nadzora kvalitete izdelkov z uporabo strojnega vida.

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, kontrola kakovosti, kompleksna geometrija, nedestruktivne merilne metode, 3D optični sistem za kontrolo geometrije, strojni vid, prototip

Abstract

In the quality control of products, the industry challenges high demanding and time-consuming geometric and visual inspection of surfaces, the increasing demands of standards in quality control and, above all, the technical limitations in controlling complex geometry. Within the EAGLE project, we develop a prototype of advanced sensor system for 3D control of geometrically complex objects, to monitor the product geometry and immediately alert potential deviations in geometry. Consequently we would significantly reduce waste, consumption of raw materials and energy for reprocessing. Timely detection of defects would avoid the transport of bad products, thereby directly contributing to the reduction of transport and the production of greenhouse gases as a consequence of transport.

In the first phase of the project, it was necessary to choose the most appropriate measurement method to be used in the development of the prototype of EAGLE sensor system for robust and accurate automatic detection of dimensional errors on geometrically complex sheet metal products. For this purpose we carried out a thorough review of existing technical solutions and related basic and applied research in the field of development of measurement methods for 3D control of product geometry.

The paper presents various methodologies in the field of non-destructive testing of industrial products of complex geometry. As the most appropriate measuring method in the quality control of geometrically complex sheet metal products we identified the system of optical quality control of products using machine vision.

Acknowledgements: 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: EAGLE, quality control, complex geometry, non-destructive measuring methods, 3D optical system for geometric inspection, machine vision, prototype

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Aspects of incorporation of a three-dimensional optical inspection tool into a smart factory

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Abstract

The smart factory, the outcome of the fourth industrial revolution, embraces high-levels of automated workflow, inter-connectivity, adaptability and proactivity. In such a concept, all devices, tools and sensors connect to each other as well as to the internet of things; they exchange data in real-time or near real-time and quickly adapt to new conditions, aiming to enhance productivity and cost efficiency.

In this contribution, we present two aspects of incorporation of a three-dimensional (3D) optical inspection tool into a smart factory. Firstly, being smart factory-compatible, this tool will have a high capability of exchanging data quickly, reliably and safely with sensors and production machinery via a wireless connection protocol. This enables the implementation of real-time statistical process control (SPC). Therefore, this tool serves as a hub performing simultaneously 3D optical inspection and SPC. Secondly, the tool continuously monitors its own condition by periodically inspecting a reference component of standard and precisely known dimensions, thus, predicting when maintenance is necessary. This last feature, so-called predictive maintenance, enhances the engineering capacity of a smart factory and minimizes the planned downtime, resulting in cost-savings.

Acknowledgements: 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: smart factory; predictive maintenance; continuous condition monitoring; minimizing planned downtime; cost-savings

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Analiza različnih metod za kontrolo kakovosti izdelkov v slovenskih tehničnih podjetjih

Analysis of various methods for quality control in Slovenian technology companies

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Povzetek

Prototip Eagle predstavlja obliko naprednega 3D senzorskega sistema za kontrolo geometrije kompleksih izdelkov. Slovenska podjetja za nadzor kakovosti svojih izdelkov uporabljajo različne metode merjenja, na podlagi katerih temeljijo različni senzorski sistemi oz. senzorji detekcije geometrije kontroliranih izdelkov; proizvedeni s strani različnih proizvajalcev merilnih naprav. V nadaljevanju članka predstavljamo najpomembnejše rezultate industrijske raziskave narejene na vzorcu slovenskih podjetij in sicer rezultati predstavljajo vpogled v razširjenost posamezne metode merjenja kakovosti izdelka (senzorskega sistema oz. senzorja) ter preference in želje po bodoči implementaciji posameznega sistema v podjetju v določenem časovnem obdobju.

Ključne besede: Eagle, senzorski sistem, metode merjenja, podjetja, kakovost izdelka

Abstract

Eagle prototype is a form of advanced 3D sensor system for controlling the geometry of a product's complexity. Slovenian companies use different measuring methods to control the quality of their products, based on different sensor systems or detection sensors for geometry of controlled products; manufactured by different manufacturers of measuring devices. In the article we present the most important results of an industrial research made on the sample of Slovenian companies. The results represent an insight into the prevalence of various methods for measuring quality of a product (sensor system or sensor), as well as preferences and desires for the future implementation of a particular system in a company over a period of time.

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Keywords: Eagle, sensor system, measurement methods, companies, product quality

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Koncept sistema strojnega vida za pobiranje kosov iz zabojev v robotski celici RoBIN

Vision System Concept for the RoBIN Bin Picking Robot Cell

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Povzetek

V okviru projekta RoBIN bomo razvili napredni slikovni senzorski sistem, ki bo sposoben pobiranja in orientiranja več vrst kosov raznovrstnih oblik, ki so v vhodnih zabojnikih v raztresenem stanju. Ta sistem strojnega vida bo vključen v robotsko celico RoBIN, ki bo omogočila identifikacijo in manipulacijo teh kosov v okviru proizvodne linije. Prototip bomo validirali in demonstrirali v operativnem okolju.

Predstavljamo razvojna izhodišča pri zasnovi inovativnega 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 zasnovali koncept sistema 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 z 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.

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

Temeljne in aplikativne raziskave

Fundamental and Applied Research

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Disperzija elastičnih valov v homogenih in simetričnih trislojnih ploščah

Dispersion of elastic waves in homogeneous and symmetric three-layered plates

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Povzetek

Teoretično primerjamo disperzijsko relacijo, to je, zvezo med krožno frekvenco elastičnih valov in valovnim vektorjem, pri homogenih in simetričnih trislojnih ploščah. Zanima nas, kako močno tanki enaki robni plasti iz drugega, izrazito kontrastnega materiala v fizikalnih lastnostih v primerjavi z materialom v srednji plasti, vplivata na disperzijsko relacijo. Na elastične valove vplivajo naslednji materialni parametri: Youngov modul, Poissonovo število in gostota. Obravnavamo antisimetrični nihajni način. Zaradi zapletenih relacij moramo enačbe reševati numerično. Podanih je tudi nekaj praktičnih približkov iz literature.

Ključne besede: elastični valovi, disperzijska relacija, antisimetrični nihajni način, simetrične trislojne plošče, kontrastne materialne lastnosti

Abstract

We compare theoretically the dispersion relation, i.e., the relation between circular frequency of elastic waves and wavevector, in the case of homogeneous and symmetric three-layered plates. It is of interest, how strongly the thin equal edge layers made of another, markedly contrast material with regard to physical properties as compared to the material in the middle layer influence the dispersion relation. Elastic waves are influenced by the following material parameters: Young modulus, Poisson number and density. Antisymmetric oscillation mode is treated. We must solve equations numerically because of complicated relations. A few practical approximations from the literature are also given.

Keywords: elastic waves, dispersion relation, antisymmetric mode, symmetric three-layered plates, contrast material properties

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Večkriterijska optimizacija območij stabilnosti vibracij zobniških gonil

Multi-objective optimization of stability domains of gear drive vibrations

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Povzetek

V prispevku je obravnavana večkriterijska optimizacija stabilnih območij vibracij dvostopenjskega zobniškega gonila s parametričnim vzbujanjem. Amplitude vibracij zobniških gonil morajo biti čim manjše, če želimo doseči mirnejši tek in zmanjšati hrup zobniških gonil. Za doseganje tega cilja si prizadevamo zmanjšati območja nestabilnosti vibracij zobniških gonil. Izkaže se, da zmanjšanje enega območja nestabilnosti lahko vodi v povečanje ostalih območij nestabilnosti. S tem se pojavi potreba po večkriterijski optimizaciji območij nestabilnosti. V prispevku je prikazan vpliv dveh ključnih parametrov zobniškega gonila, kontaktnega razmerja in faznega premika zobniških dvojic na reševanje optimizacijskega problema. Večkriterijska optimizacija nestabilnih oziroma stabilnih območij je v prispevku prikazana pri dvostopenjskemu zobniškemu gonilu s tremi zobniškimi pari.

Ključne besede: torzijske vibracije zobniških gonil, območja nestabilnosti, večkriterijska optimizacija

Abstract

In the article, multi-objective optimization of stability domains of vibrations in two-stage gear drive with parametric excitation is treated. Vibration amplitudes of gear drives should be small to ensure calm running and noise reduction. To achieve this goal, we try to reduce domains of instabilities of vibrations. It turns out that reducing one area of instability can lead to an increase of other areas of instability. Due to this a need for multi-objective optimization of instability domains arises. In the article, the impact of two key parameters, that is of contact ratio and of phase shift on the solving of the optimization problem is shown. Multi-objective optimization of unstable and stable domains, respectively is presented in the case of two-stage gear drive involving three gear pairs.

Keywords: torsional vibrations of gear drives, instability domains, multi-objective optimization

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Eksperimentalna in numerična določitev integralne karakteristike modelne vetrne turbine

Experimental measurement and numerical prediction of integral characteristic of a model-size wind turbine

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Povzetek

V prispevku je predstavljeno modeliranje, izdelava ter meritve modelne tri lopatične turbine s profilom lopatic NREL S826. S programskim paketom SolidWorks je bil kreiran model vetrne turbine, ki smo ga nato izdelali s postopkom 3D tiskanja. V vetrovniku so bile opravljene meritve sile oziroma navora in vrtljajev vetrnice v odvisnosti od hitrosti vetra. Na podlagi meritev je bila določena karakteristika moči in koeficient moči v odvisnosti od hitrostnega števila. Primerjava rezultatov v obliki diagrama koeficienta moči v odvisnosti od hitrostnega razmerja je pokazala, da rezultati predhodnih meritev ter rezultati numeričnih simulacij ležijo v območju merilne negotovosti izmerjenih vrednosti.

Ključne besede: vetrna turbina, meritve, 3D tiskanje, vetrovnik

Abstract

The paper presents modeling, manufacturing and measurements of a three-bladed model wind turbine with an airfoil NREL S826. The turbine model was designed using SolidWorks design software. 3D printing technology was used to manufacture the model. Force and rotating speed measurements were conducted in the wind tunnel. Power characteristic curve and power coefficient in dependence of the tip speed ratio were extracted from the measured data. Experimental and numerical results were compared and numerical results lie in the range of measurement uncertainty of the measured values.

Keywords: wind turbine, measurements, 3D printing, wind tunnel

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Numerična napoved gladinskega stanja v območju sotočja dveh rek

Numerical prediction of water surface levels in the confluence of two rivers

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Povzetek

V prispevku so predstavljene numerične napovedi gladinskega stanje za območje sotočja reke Save in Krke. Simulacije so bile izvedene za dve konfiguraciji rečne struge Save, nepoglobljena in poglobljena. Za nepoglobljeno konfiguracijo rečne struge Save smo analizirali višine gladin pri pretoku Save 60 m^3/s, Krke 6 m^3/s in Save 490 m^3/s, Krke 110 m^3/s. Rezultate simulacij smo primerjali z meritvami gladin. Ugotovljeno je bilo dobro ujemanje med meritvami in numeričnimi simulacijami. Za nepoglobljeno in poglobljeno konfiguracijo smo nato opravili numerične simulacije za pretok reke Save 3750 m^3/s in Krke 510 m^3/s. Ugotovljeno je bilo, da se s poglobitvijo znižajo višine gladin v povprečju za 1 m.

Ključne besede: HEC-RAS, sotočje rek, numerične simulacije

Abstract

In this paper, numerical predictions of water surface level for the confluence of river Sava and Krka are presented. Simulations were conducted for two configurations of river Sava. In the first configuration, the riverbed is not deepened while in the second configuration the riverbed is deepened. For the configuration where the riverbed is not deepened we analysed the water surface level for the following water flows Sava 60 m^3/s, Krka 6 m^3/s and Sava 490 m^3/s, Krka 110 m^3/s. We compared the numerical results to measurements. The results show good agreement between measurements and numerical simulations. For both configurations we conducted simulations for water flow of Sava 3750 m^3/s and Krka 510 m^3/s. The results show that the water level is in average 1 m lower with the deepened configuration.

Keywords: HEC-RAS, river confluence, numerical simulations

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Večparametrična dinamična analiza „lightweight“ laminatov

Multi-parametric dynamic analysis of „lightweight“ laminates

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Povzetek

Večplastne konstrukcije z močno heterogenostjo v navpični smeri so velikega pomena za številna visokotehnološka področja v vesoljskem, avtomobilskem in civilnem inženiringu. Posebne aplikacije vključujejo zlasti fotovoltaične plošče, laminirano steklo, itd. Drug pomemben primer avtomobilske industrije je dizajn nove generacije okolju prijaznih lahkih vozil. To navdihuje modeliranje sestavljenih konstrukcijskih elementov, ki vsebujejo lahke sestavne dele.

Pri večparametrični asimptotični analizi disperzije elastičnih plošč z visokim kontrastom materialnih in geometrijskih parametrov v slojih je nujno, da je zaradi kontrasta najnižja strižna lastna nihajna oblika vzbujena v nizkem frekvenčnem območju, kar zahteva bistvene spremembe uveljavljenih teorij za tovrstne konstrukcije. Zlasti namesto klasične Kirchhoffove teorije, ki ureja temeljno lastno nihajno obliko tanke

plošče, so odkrili različne aproksimacije, ki so močno vplivale na kontrastne parametre. Slednji poleg osnovnega načina vključujejo tudi prvo nizkofrekvenčno harmoniko.

V tej predstavitvi prilagodimo večparametrično shemo ob predpostavki, da je razmerje med debelino zunanje plasti in jedra izraženo kot potenca glavnega majhnega parametra, ki je opredeljen kot relativna gostota jedra. Izpeljani so enakomerno in neenakomerno veljavni približki celotne disperzijske enačbe tipa Rayleigh-Lamb. Natančnost slednjih se primerja s točnimi rešitvami. Pridobljeni rezultati obravnavajo posebnosti nihajnih spektrov, značilnih za lahke večplastne konstrukcije.

Ključne besede: večplastne konstrukcije, lightweight, asimptotična analiza, disperzija, kontrastni parametri

Abstract

Multi-layered structures with a strong vertical heterogeneity are of major importance for numerous high-tech domains in aerospace, automotive and civil engineering. Specific applications include, in particular, photovoltaic panels, laminated glass, etc. Another important example originating from automotive industry is concerned with design of a new generation of environment-friendly lightweight vehicles. This inspires modelling of composite structural elements, containing lightweight components.

In multi-parametric asymptotic analysis of dispersion of elastic plates with high contrast in material and geometric parameters of the layers, it is essential that due to contrast the lowest shear mode may be excited over the low frequency range, requiring substantial amendments to the established structural theories. In particular, instead of the classical Kirchhoff theory governing the fundamental vibration mode of a thin plate, a variety of two-mode approximations, strongly affected by the contrast parameters were discovered. The latter, in addition to the fundamental mode, also include the first low-frequency harmonic.

In this presentation, we adapt a multi-parametric scheme assuming that the ratio of thickness of the skin and core component layers is expressed as a power of the main small parameter, defined as the relative core density. The two-mode approximations of the full Rayleigh-Lamb-type dispersion relation, both uniformly and non-uniformly valid, are derived. The accuracy of the latter are tested by comparison with the exact solution. The obtained results address peculiarities of the vibration spectra characteristic of lightweight layered structures.

Keywords: multi-layered structures, lightweight, asymptotic analysis, dispersion, contrast parameters

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Asymptotic Analysis of the Edge Bending Wave on a Stiffened Plate

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Abstract

The edge bending wave on a semi-infinite elastic plate reinforced by a strip plate along the edge is considered within the 2D classical theory for plate bending (1,2). Asymptotic analysis is performed under the assumption that a typical wave length is much greater than the thickness of a strip plate. Effective boundary conditions modelling the influence of the strip plate are derived. They are compared with the boundary conditions arising in the problem for a plate stiffened by a beam, subject both bending and torsion, Numerical results are presented, demonstrating good agreement between exact and asymptotic results. Various aspects of the edge wave localisation are discussed, including the associated cut-off frequencies.

(1) A. Alzaidi, J. Kaplunov and L. Prikazchikova (2019) Elastic bending wave on the edge of a semi-infinite plate reinforced by a strip plate. Mathematics and Mechanics of Solids, to appear. DOI: 10.1177/1081286519840687

(2) A. Alzaidi, J. Kaplunov and L. Prikazchikova (2019) The edge bending wave on a plate reinforced by a beam. JASA (146), 1061 – 1064.

Keywords: Asymptotic Analysis, Edge Bending Wave, Stiffened Plate, Cut-Off Frequencies

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Večparametrično dinamično modeliranje plastovitih močno nehomogenih elastičnih struktur

Multi-parametric dynamic modelling of layered strongly inhomogeneous elastic structures

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Povzetek

V zadnjih desetletjih je v povezavi s proizvodnjo konstrukcijskih elementov, ki temeljijo na novonastalih materialih in tehnologijah, npr. hitro rastoče področje meta-materialov itd., dinamično obnašanje plastovitih močno nehomogenih elastičnih trdnih teles postalo zelo pomembno za oblikovanje naprednih industrijskih izdelkov. Zlasti troslojne plošče in lupine, znane tudi kot sendvič konstrukcije, so zaradi svoje majhne teže in sorazmerno velike upogibne togosti predmet velikega povpraševanja za sodobno vesoljsko, avtomobilsko industrijo in nizko gradnjo.

Cilj raziskave v okviru temeljnega projekta je razvoj doslednih 2D dinamičnih modelov za plastovite močno nehomogene strukture. Tak kompleksen in zahteven problem potrebuje kombinirano poznavanje analitičnih, računskih in eksperimentalnih vidikov dinamičnega obnašanja plastovitih struktur s poudarkom na interakciji strižnih in upogibnih valov.

Na posterju so predstavljeni osnovni cilji in struktura projekta, ki je bil sprejet v sofinanciranje s strani Javne agencije Republike Slovenije (ARRS) v letu 2018. Obenem so predstavljeni glavni izsledki do sedaj doseženih rezultatov na projektu.

Ključne besede: strukturna dinamika, večparametrična analiza, plastovita plošča, kontrastne lastnosti, upogibna in strižna deformacija, Saint-Venantov princip

Abstract

Over last few decades, in connection with manufacturing of structural elements based on newly developed materials and technologies, such as the rapidly growing area of meta-materials etc., the dynamic behaviour of layered strongly inhomogeneous elastic solids became very important for design of advanced industrial products. In particular, three-layered plates and shells, also known as sandwich structures, due to their light weight combined with relatively large flexural stiffness, are in a great demand for modern aerospace, automotive, and civil engineering.

The ultimate goal of the proposed research within the project is development of consistent 2D dynamic models for layered strongly inhomogeneous structures. This complex and challenging problem assumes elucidation of analytical, computational and experimental aspects of their dynamic behaviour with the main emphasis on interaction of shear and bending waves.

The poster outlines the basic goals and structure of the project, which was approved and co-financed by the Slovenian Research Agency (ARRS) in 2018. At the same time, the main results achieved so far on the project are presented.

Keywords: structural dynamics, multi-parametric analysis, layered plate, contrast properties, bending and shear deformation, Saint-Venant principle

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Učinkovita prestavitev leksikalnih jezikovnih virov za razvoj govornih tehnologij

Compact Representation of Lexical Language Resources for Efficient Speech Technology Design

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Povzetek

Evropa danes predstavlja enega najnaprednejših trgov govornih tehnologij, ki nudijo možnost avtomatizacije obstoječih storitev in cenenega razvoja množice novih interaktivnih storitev v porajajočih se komunikacijskih omrežjih. Ponujajo tudi možnost enakopravnega vključevanja skupin oseb s posebnimi potrebami, predvsem ostarelih, slepih in slabovidnih, v sodobno informacijsko družbo.

Govorno podprti uporabniški vmesniki omogočajo uporabniško prijazno interaktivno komunikacijo, še posebej v okolju mobilnih komunikacij. Sodobni koncepti sistemov govorne komunikacije se v praksi prenašajo na majhne prenosne naprave, ki so zasnovane na vgrajenih sistemih, za katere sta značilna omejena procesorska moč ter pomnilniška zmogljivost. Za uspešen razvoj in uporabo govorno podprtih aplikacij na prenosnih terminalih je potrebno zagotoviti učinkovite in visoko kakovostne komponente sistema govornega dialoga, to je uspešnost avtomatskega razpoznavanja govora in kvalitetno, razumljivo in naravno zvenečo sintezo govora.

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.

Poleg razvoja slovarjev izgovarjav smo se v okviru aplikativnega projekta OptiLEX posvetili raziskavam in implementaciji modula za učinkovito računalniško predstavitev leksikalnih jezikovnih virov, sposobnega delovanja v govornih aplikacijah v vgrajenih sistemih. Pri tem rešujemo vrsto problemov, kot so: zahteva po delovanju v realnem času; zahteva po kompaktnem zapisu jezikovnih virov; ter zahteva po majhnem odtisu zapisa jezikovnih virov v delovnem pomnilniku.

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

Abstract

Today Europe is one of the most advanced speech technology markets, offering the automation of existing services and inexpensive development of a multitude of new services in emerging communications networks. These networks also provide an opportunity for equal inclusion of groups of people with special requirements, especially the elderly, the blind, and the visually impaired, in the modern information society.

Speech-enabled user interfaces offer user-friendly communication, especially in the mobile communications environment. In practice, modern speech communications concepts are transferred to mobile devices based on embedded systems, which are characterized by limited memory and processor power performance constraints. In order to successfully develop and use speech-enabled applications on mobile terminals and IoT devices, effective and high-quality components of the speech dialogue system must be provided: accurate automatic speech recognition and high-quality, intelligible, and natural-sounding speech synthesis.

Although there are many studies and a great deal of literature addressing computer presentations of lexical resources, their implementation in comprehensive speech recognition or synthesis systems on embedded platforms poses a substantial problem, which is further aggravated by limitations in the hardware used.

Apart from compiling a pronunciation dictionary, the OptiLEX applied project focuses on research and implementation of a module that will enable an effective presentation of lexical resources and be able to operate in speech engines on embedded platforms. A number of problems have been addressed: the need to operate in real time; the need to store language resources in a compact manner, and the need for a small language-resource footprint in random-access memory.

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

CityVOICE: zasnova novega glasu za govorne vmesnike v pametnih mestih in skupnostih

CityVOICE: Novel Voice Design for Speech User Interfaces in Smart Cities and Communities

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Povzetek

V okviru aktivnosti RRI projekta CityVOICE smo zasnovali novo govorno zbirko za potrebe sinteze slovenskega govora kot osnovo za akustično modeliranje novega ženskega glasu.

Raziskave so potekale v smeri selekcije najbolj primernih postopkov za zasnovo govorne zbirke ter izboljšav jezikovnega analizatorja in označevalnika. Sprva je bila izvedena analiza razvojnih izhodišč, ki je obsegala raziskave primerljivih rešitev s področja samodejnega tvorjenja govora na podlagi govornih zbirk. Raziskave so potekale v smeri različnih tehnologij, ki jih je možno uporabiti za tvorjenje čim bolj

naravnega govora, s poudarkom na obsegu jezikovnih virov ter zahtev po preciznosti in razčlenjenosti njihove segmentacije in anotacije. Med drugim bomo predstavili izdelani koncept postopkov za verifikacijo skladnosti govorjenih besedil z besedilnimi predlogami, vključno z metodologijo označevanja posebnih fenomenov govorjenega diskurza, kot so samokorekcije, izpusti oz. elipse, napačni začetki ter nedokončani izreki. Na podlagi nove govorne zbirke je bil s postopki strojnega učenja razvit akustični model za nov ženski glas, s katerim bomo nadgradili sintetizator govora eBralec.

Razvili smo tudi več scenarijev za vključevanje govornih tehnologij v koncept ekosistema pametnih mest in skupnosti, s poudarkom na konceptualizaciji raziskav tehnoloških osnov in infrastrukture v obliki audio točk in generatorjev vsebin ter raziskav področij uporabe glasovnih storitev v okoljih pametnih mest in skupnosti. Pri tem smo analizirali tudi potencialne pasti ter pričakovane učinke.

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Ključne besede: govorne tehnologije, sinteza govora, uporabniški vmesniki, digitalna obdelava signalov, pametna mesta in skupnosti

Abstract

Within the CityVOICE project, a novel speech corpus for Slovenian text-to-speech synthesis has been designed. The research activities were focussing on defining most suitable speech data collection and annotation methods as well as on improvements of both the linguistic analysis and the linguistic annotation engines. Using machine learning approaches an acoustic model has been trained which serves as an outline for a novel synthetic female voice that will be integrated into the eBralec speech synthesis system. Several scenarios have been developed that can be used as guidelines for integration of speech technologies into ecosystem concepts of smart cities and smart communities.

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Keywords: speech technologies, speech synthesis, user interfaces, digital signal processing, smart cities and communities

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