

BOOK OF ABSTRACTS

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IN-SITU Al-AIN METAL MATRIX COMPOSITES FABRICATED INDUSTRIALLY AT A LARGE SCALE

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Conference abstract / Kongresno priopćenje

Abstract

This study introduces *in-situ* aluminum Al-AIN metal matrix composites (MMCs) manufactured by a powder metallurgy (PM) cost-effective approach realized at a large industrial scale. The Al-AIN MMCs were targeted for structural load-bearing applications with an expected service at elevated temperatures not normally associated with a use of conventional Al-based alloys and MMCs. Commercial Al, Mg, and Sn powders were processed by readily available PM techniques of blending, cold isostatic pressing (CIP), a solid-state nitridation in a static gaseous nitrogen, and a hot direct extrusion. Two sound voids free Al + 8.8 and 14.7 vol.% AIN MMCs were reproducibly fabricated in a form of the long-extruded bars with the cross-section of 80 x 15 mm. The microstructure of nitrided and extruded MMCs was presented in details. A typical yolk-shell-like microstructure of Al metallic core and nitrided layer was formed homogeneously in a volume of the CIP bulky (~25 kg) billets upon nitridation. The microstructure of extruded Al-AIN MMCs consisted of Al grains elongated into the extrusion direction. The Al grain structure was embedded with the evenly distributed micrometric regions formed by a high density AIN nanocrystals in Al matrix. A stability of the tensile mechanical properties of as-extruded Al-AIN MMCs was pursued in transversal and longitudinal directions after the annealings performed at 300–600 °C for 24 h. Owing to an effective stabilization by the stable and fine AIN dispersoids by Zener pinning action no major changes to the mechanical properties took place after annealing up to 500 °C. The mechanical, thermal and creep properties, active strengthening mechanisms, and microstructure-property relations of Al-AIN MMC annealed at 500 °C for 24 h, which were examined in a broad temperature range of 22–500 °C, are discussed in details. In addition to increased Young's modulus Al-AIN MMC showed high tensile strengths determined at 300 °C, which were superior to any conventional Al alloy, accompanied with reasonably high ductility. At the same time Al-AIN MMC preserved excellent creep performance, which was superior to the heat resistant reference alloys, reduced coefficient of thermal expansion, and reasonable thermal conductivity and fatigue endurance. The results confirmed that reported thermally stable Al-AIN MMC may be considered a promising material with an appealing set of the properties directed for load-bearing structural applications with an expected service at elevated temperatures.

Key words: aluminum (Al); aluminum nitride (AIN); extrusion; *in-situ*; metal matrix composites (MMC); powder metallurgy (PM).

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DEVELOPMENT OF BIACOM[®] DENTAL IMPLANTS

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Original scientific paper / Izvorni znanstveni rad

Abstract

This paper concisely reviews the development of a dental implant manufactured from the novel TiMg bioactive composite material named BIACOM[®]. BIACOM[®] enables reduction of the stress-shielding effect and it leads to better biocompatibility compared with that of the traditional Ti and Ti alloys used in dentistry. BIACOM[®] was fabricated by cold consolidation of atomised TiGr1 and Mg powder blend. BIACOM[®] comprises bioabsorbable Mg component in the form of interconnected filaments, elongated along the direction of extrusion, which are embedded within a permanent, bioinert ultrafine-grained Ti matrix. The Ti component provides the mechanical properties, required for a function of the implant during its service. As the Mg content increases, the discrete filaments become interconnected with each other and form a continuous spatial network. The Mg component with low Young's modulus (E), homogeneously dispersed within the Ti matrix, reduces E of BIACOM[®]. Moreover, Mg gradually dilutes at a controlled rate from the implant's surface in contact with a corrosive environment after implantation. As a result, the pores gradually form at prior Mg sites, composite's E decreases further down, and the stress-shielding phenomenon is reduced. Also, Mg promotes the osseointegration process and a bonding strength increases at the interface between the bone and implant, eventually. In the current paper we report the development of the dental implant, which was manufactured from the optimized BIACOM[®] composite by an efficient hydro-extrusion (HE) consolidation process. The implant was designed in a way to reflect the properties and peculiarities of this novel Ti17Mg composite material. Two different implants designs were pursued. Static mechanical performance was assessed by the finite element analysis (FEA) and experimentally in compliance with the standard for the fatigue testing of endosseous dental implants. The corrosion of Mg from the surface of the implants was evaluated by H₂ evolution volumetric method. *In-vitro* cytotoxicity biological response was assessed by the indirect contact MTT assay using DMEM extracts of the implants.

Keywords: *bioactive; composite; dental implant; in-vitro; magnesium; powder metallurgy; titanium.*

HEAT TREATMENT OF MARAGING STEEL OBTAINED BY ADDITIVE MANUFACTURING

TOPLINSKA OBRADA MARAGING ČELIKA DOBIVENOG ADITIVNIM POSTUPKOM

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Conference abstract / Kongresno priopćenje

Abstract

MARAGING steel is a type of high-strength, low-alloy steel that is commonly used in applications requiring excellent mechanical properties, such as aerospace, defence, and medical industries. With the emergence of additive manufacturing, it is now possible to produce MARAGING steel components with complex geometries and customized properties. Selective laser melting (SLM) is a popular additive manufacturing technology for producing high-performance metal parts with complex geometries. MARAGING steel is an attractive material for SLM due to its high strength and toughness, as well as its ability to produce parts with customized properties. In the experimental part, MARAGING steel samples were produced using SLM technology and subjected to aging heat treatment. Variation of heat treatments parameters were defined by a review of the literature, and the hardness of the samples was measured using the Vickers method on a reference hardness ethanol in the Laboratory of Mechanical Properties Testing (LIMS) using different loads. The uniformity of hardness across the surface of the processed samples and the appearance of the microstructure were monitored. Finally, the results were analysed, and certain conclusions were drawn.

***Keywords:** MARAGING steel, SLM, heat treatment*

Sažetak

MARAGING čelik je vrsta čelika visoke čvrstoće i niskog udijela legirnih elemenata koji se često koristi u primjenama koje zahtijevaju izvrsna mehanička svojstva, kao što su zrakoplovstvo, obrana i medicinska industrija. S pojavom aditivne proizvodnje, sada je moguće proizvesti komponente MARAGING čelika sa složenim geometrijama i prilagođenim svojstvima. Selektivno lasersko taljenje (SLM) popularna je aditivna tehnologija proizvodnje visokoučinkovitih metalnih dijelova složenih geometrija. MARAGING čelik je atraktivan material za SLM zbog visoke čvrstoće i žilavosti te sposobnosti proizvodnje dijelova s prilagođenim svojstvima. U eksperimentalnom dijelu izrađeni su uzorci MARAGING čelika upotrebom SLM tehnologije na kojima je vršena toplinska obrada dozrijevanja. Varijacija parametara toplinske obrade definirana je pregledom literature, te je na uzorcima provedeno mjerenje tvrdoće po metodi Vickers na referentnom etanolu tvrdoće u Laboratoriju za ispitivanje mehaničkih svojstava (LIMS) primjenom različitih opterećenja. Praćena je jednolikost tvrdoće po površini obrađenih uzoraka te izgled mikrostrukture. Na kraju je provede analiza rezultata i doneseni određeni zaključci.

***Ključne riječi:** MARAGING čelik, SLM, toplinska obrada*

EUROPEAN METROLOGICAL INFRASTRUCTURE EUROPSKA INFRASTRUKTURA MJERITELJSTVA

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Review paper / Pregledni rad

Abstract

The European metrological infrastructure is a comprehensive network of organizations that ensure the accurate measurements in science, technology, and trade to strengthen the competitive position of European enterprises in the global marketplace. This infrastructure comprises several organizations, including the Bureau International des Poids et Mesures (BIPM), European Association of National Metrology Institutes (EURAMET), National Metrology Institutes (NMIs) in EURAMET, and the European Metrology Network (EMN). EURAMET is a network of 37 NMIs across Europe, aiming to promote the coordination of metrology research and development. NMIs are responsible for ensuring traceability and accuracy of measurements within their respective countries. The EMN analyses the European and global metrology needs and address these needs in a coordinated manner. Together, these organizations play a crucial role in ensuring the accuracy and reliability of measurements in various fields and promote scientific progress, fair trade, and consumer protection.

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Keywords: *European metrology infrastructure, BIPM, EURAMET, NMIs, EMN*

Sažetak

Europsku mjeriteljsku infrastrukturu čine sastavnice koje osiguravaju točna mjerenja u znanosti, tehnologiji i trgovini kako bi se ojačala konkurentna pozicija europskih poduzeća na globalnom tržištu. Ta infrastruktura obuhvaća nekoliko organizacija, uključujući Međunarodni ured za utege i mjere (BIPM), Europsko udruženje nacionalnih mjeriteljskih instituta (EURAMET), nacionalne mjeriteljske institute (NMI) EURAMET-a te Europsku mrežu za mjeriteljstvo (EMN). EURAMET je mreža od 37 NMI-ova diljem Europe, čija je svrha promicanje koordinacije istraživanja i razvoja u području mjeriteljstva. NMI-ovi su odgovorni za osiguravanje sljedivosti i točnosti mjerenja unutar svojih zemalja. EMN analizira europske i globalne potrebe mjeriteljstva s ciljem koordiniranog rješavanja. Ove organizacije zajedno igraju ključnu ulogu u osiguravanju točnosti i pouzdanosti mjerenja u različitim područjima te promoviraju znanstveni napredak, pošteno tržišno natjecanje i zaštitu potrošača.

Ključne riječi: *Europska mjeriteljska infrastruktura, BIPM, EURAMET, NMIs, EMN*

THE USE OF NON-WOOD CELLULOSE FIBERS IN THE COMPOSITION OF PAPER FOR THE FINAL GRAPHIC PRODUCT

UPOTREBA NEDRVNIH CELULOZNIH VLAKANACA U SASTAVU PAPIRA ZA FINALNI GRAFIČKI PROIZVOD

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Invited lecture / Pozvano predavanje

Abstract

Natural resources such as minerals, forests, water, oil, wind, and fertile land are materials or substances that are created without human intervention, are essential for human survival, and their potential for economic development. Forests are one of the greatest natural resources that we exploit. Humanity must ask itself how much we are consuming and whether we have enough of every resource on the earth's surface that we are recklessly using. Forest resources are of significant value in the production of a number of raw materials for the pulp and paper industry. Also, by reducing the consumption of synthetic materials, which are environmentally unacceptable, the consumption of natural sources, i.e. lignocellulosic materials, is rapidly increasing in the pulp and paper industry. Wood remains the world's most widely used raw material for the production of pulp and paper, but due to the unreasonable long-term exploitation of this natural resource, its availability has drastically decreased. Considering the reduction of forest areas and the decrease in available wood raw materials, along with the increase in the growth rate of the world's population and its standard of living, the search for new sources of primary cellulose fibers is of great importance for the paper and graphic industry. Prior to the Industrial Revolution, non-woody cellulose fibers were the main raw material for pulp and paper production. The modern phase of paper production beginning in the 18th century with Jakob Christian Schaeffer, who proved that wood could be used as a raw material for paper production. Over the past 40 years, global demand for paper has grown by an average of 4.7% per year. In the future, it is expected that even a possible reduction to 2 to 3% through recycling will not be enough to meet the growing demand for paper, especially in Eastern Europe and the Asia-Pacific region. Therefore, it is of great importance to consider the use of non-wood cellulose fibers in the development of paper printing materials for the final graphic product to cover the possible deficit in pulp and paper production. The use of non-wood fibers in the printing substrates enables the creation of additional values for the resulting graphic products such as packaging, labels, stickers, which are produced using modern and conventional printing techniques.

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Keywords: *graphic product, non-wood cellulose fibers, production of paper*

Sažetak

Prirodni resursi kao što su minerali, šume, voda, nafta, vjetar i plodna zemlja su materijali ili tvari koj su stvorene bez ljudskog doprinosa, neophodne su za ljudski opstanak i njihov potencijal za ekonomski razvoj. Šumski pokrivač je jedna od najvećih prirodnih bogatstava koje iskorištavamo. Čovječanstvo se mora zapitati koliko trošimo i imamo li dovoljno svakog resursa na zemljinoj površini koji nesmotreno koristimo. Šumski resursi imaju značajnu vrijednost za proizvodnju niza različitih sirovina za industriju celuloze i papira. Također, smanjivanjem potrošnje sintetskih materijala koji su ekološki neprihvatljiviji, u industriji celuloze i papira rapidno raste potrošnja prirodnih izvora odnosno lignoceluloznih materijala. Drvo je i dalje najkorištenija svjetska sirovina za proizvodnju celuloze i papira, no zbog neracionalne dugogodišnje eksploatacije tog prirodnog bogatstva, njegova dostupnost drastično se smanjila. S obzirom da je smanjenjem šumskih površina dostupne drvene sirovine sve manje, uz porast stope rasta svjetske populacije i njihovog životnog standarda, potreba za novim izvorama primarnih celuloznih vlakana od ključne važnosti za papirnu i grafičku industriju. Prije industrijske revolucije, nedrvna celuloznih vlakana bila su glavna sirovina za proizvodnju celuloze i papira. Moderna faza proizvodnje papira počinje u 18. stoljeću s Jakobom Christianom Schäfferom koji je dokazao da se drvo može koristiti kao sirovina za proizvodnju papira. Tijekom proteklih 40 godina globalna potražnja za papirom rasla je u prosjeku za 4,7% godišnje. U budućnosti se očekuje da čak ni moguće smanjenje na 2 do 3% kroz recikliranje neće biti dovoljno za zadovoljenje rastuće potražnje za papirom, posebno u istočnoj Europi i azijsko-pacifičkoj regiji. Stoga je od velike važnosti razmotriti primjenu nedrvenih celuloznih vlakana u razvoju papirnatih tiskovnih materijala za finalni grafički proizvod, kako bi se pokrio mogući deficit za proizvodnju celuloze i papira. Primjena nedrvenih vlakana unutar tiskovnih podloga omogućit će stvaranje dodatnih vrijednosti za grafičke proizvode kao što su ambalaža, etiketa, naljepnice koje su nastale modernim i konvencionalnim tehnikama tiska.

Ključne riječi: grafički proizvod, nedrvna celulozna vlakanca, proizvodnja papira.

INFLUENCE OF THE VISCOSITY OF GRAVURE PRINTING INKS ON THE QUALITY OF PRINTED PACKAGING

UTJECAJ VISKOZNOSTI BAKROTISKARSKIH BOJA NA KVALITETU OTISNUTE AMBALAŽE

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Original scientific paper / Izvorni znanstveni rad

Abstract

Viscosity is the property of gases and liquids to resist the flow or relative motion of adjacent layers. Viscosity is a form of internal fluid friction that occurs when fluid molecules move their layers during flow under the influence of appropriate stress. Ink viscosity affect the ink transfer and is therefore a very important parameter for the overall quality of the print and is defined by the printing technique. If the viscosity of the ink is not properly adjusted, the quality of the print will deteriorate, i.e., when the fluidity of the ink changes, the thickness of the ink layer will also vary. The quality of the gravure printing process depends on many chemical and physical properties of the materials and components involved in the process itself. In this study, the influence of the viscosity of conventional and UV curable gravure inks was observed in comparison with visual quality control and undertone parameter. The printing substrates prepared for this research were made by mixing recycled wood pulp with wheat, barley, or triticale pulp in a ratio 7:3 which gave insight into their potential use as packaging intended for printing.

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Keywords: *gravure printing, ink viscosity, printing substrate, undertone*

Sažetak

Viskoznost je svojstvo plinova i tekućina da se opiru protoku ili relativnom gibanju susjednih slojeva. Viskoznost je oblik unutarnjeg trenja tekućine koji nastaje kada molekule tekućine pomiču svoje slojeve tijekom strujanja pod utjecajem odgovarajućeg naprezanja. Viskoznost boje definirana je tehnikom tiska jer utječe na njezin prijenos tijekom otiskivanja i stoga je vrlo važan parametar za ukupnu kvalitetu otiska. Ako viskoznost boje nije pravilno definirana, kvaliteta otiska će se pogoršati, tj. kada se fluidnost boje promijeni, debljina sloja boje će također varirati. Kvaliteta procesa dubokog tiska ovisi o mnogim kemijskim i fizikalnim svojstvima materijala i komponenti uključenih u sam proces tiska. U ovom istraživanju promatran je utjecaj viskoznosti konvencionalnih i UV sušućih bakrotiskarskih boja te je uspoređivan s vizualnom kontrolom kvalitete i parametrom podtona. Tiskarske podloge pripremljena za ovo istraživanje izrađene su miješanjem reciklirane drvene pulpe s pulpom pšenice, ječma ili pšenoraži u omjeru 7:3, što je dalo uvid u njihovu potencijalnu upotrebu kao ambalaže namijenjene tisku.

Ključne riječi: *bakrotisak, podton, tiskarska podloga, viskoznost*

VACUUM VERTICAL CENTRIFUGAL CASTING OF STAINLESS STEEL TUBES

VAKUUMSKO VERTIKALNO CENTRIFUGALNO LIJEVANJE CIJEVI OD NEHRĐAJUĆEG ČELIKA

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Original scientific paper / Izvorni znanstveni rad

Abstract

Vertical centrifugal casting process is used to produce tubes. Permanent mould has cylindrical shape. Laboratory prototype of the vacuum vertical machine for centrifugal casting was developed in cooperation with FRIPOL d.o.o. company from Ljubešćica, Croatia. Based on simulation results, casting parameters of EN 1.4301 stainless steel were defined. Experimental casting was done. After visual inspection, chemical composition was examined, a metallographic analysis was made and mechanical properties of the casting were tested. On scanning electron microscope, material was characterized by secondary and backscattered electrons. By visual inspection, shrinkage porosity was observed on inner side of the casting, at the place of last solidification, which is in accordance with simulation results. This cannot be avoided, but it can be reduced by choosing right casting parameters. During melting in a coated graphite crucible and a hybrid graphite/SiC crucible, carburization of the melt occurred and an increased appearance of carbides in the casting, which could lower the corrosion resistance of the casting. By switching to ceramic Al₂O₃ crucibles, problem was solved, with additional modifications when mounting the crucible into the inductor. It can be concluded that the machine is applicable for industrial use.

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Keywords: *Centrifugal Casting, Vacuum, Stainless Steel, Casting Parameters*

Sažetak

Proces vertikalnog centrifugalnog lijevanja koristi se za proizvodnju cijevi koje su relativno velikog promjera i male duljine. Kalup je kokila cilindričnog oblika. Laboratorijski prototip vakuumskeg vertikalnog stroja za centrifugalno lijevanje razvijen je u suradnji s Fripol d.o.o. tvrtkom iz Ljubešćice, Hrvatska. Na temelju rezultata simulacije definirani su parametri lijevanja nehrđajućeg čelika EN 1.4301. Napravljeno je eksperimentalno lijevanje. Nakon vizualne kontrole, ispitan je kemijski sastav, napravljena je metalografska analiza i ispitivanje mehaničkih svojstava odljevka. Na pretražnom elektronskom mikroskopu, materijal je karakteriziran preko sekundarnih elektrona i povratno raspršenih elektrona. Vizualnom kontrolom uočene su usahline na unutarnjoj strani odljevka, na mjestu posljednjeg skrućivanja, što je u skladu s rezultatima simulacije. Ta pojava se ne može izbjeći, ali se izborom parametara lijevanja može smanjiti. Prilikom taljenja u premazanom grafitnom loncu i hibridnom grafit/SiC loncu došlo je do naugličenja taline i povećane pojave karbida u odljevku, što je dovelo u pitanje korozivnu postojanost odljevka. Prelaskom na keramičke Al₂O₃ lonce taj je problem riješen, uz dodatne preinake prilikom montaže lonca u induktor. Na temelju provedenih ispitivanja može se zaključiti da je stroj primjenjiv za industrijsku upotrebu.

Ključne riječi: *centrifugalno lijevanje, vakuum, nehrđajući čelik, parametri lijevanja*

MECHANICAL PROPERTIES OF MEDICAL-GRADE POLY(LACTIC ACID)- BASED SCAFFOLD DURING *IN VITRO* DEGRADATION

MEHANIČKA SVOJSTVA OKOSNICA NA TEMELJU POLIMLIJEČNE KISELINE VISOKE ČISTOĆE TIJEKOM *IN VITRO* RAZGRADNJE

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Conference abstract / Kongresno priopćenje

Abstract

Tissue engineering and regenerative medicine represent an alternative approach for bone defect treatment by using biodegradable and biocompatible scaffolds as temporary supports for cell adhesion, proliferation and tissue regeneration. More importantly, such scaffolds should degrade at controlled rate *in vivo* leaving space for neotissue growth. Poly(lactic acid), PLA, is one of the most used biodegradable polymers for additive manufacturing of bone scaffolds due to its low melting temperature for melt extrusion. However, biomaterials with a strictly defined composition and high purity are required in clinical practices. The compositional difference between technical-grade and medical-grade biodegradable polymers leads to different material behaviour *in vitro* and *in vivo*. In this work, we investigated the mechanical behaviour of 3D-printed medical-grade PLA-based scaffolds during *in vitro* degradation. The initial 3D-printed PLA scaffolds were modified by chitosan-hydroxyapatite hydrogel to enhance the bioactivity of potential bone scaffold. Modified PLA scaffolds were incubated in enzymatic medium and simulated body fluid (Hanks' balanced salt solution) for 8 weeks at 37°C to test compressive strength of scaffolds under *in vitro* conditions. The compression tests showed no significant difference in Young's modulus and compressive strength indicating that modified PLA scaffolds maintained mechanical stability during prolonged incubation period. Furthermore, there was no significant difference in mechanical properties of the scaffolds incubated in different buffer solutions.

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Keywords: *poly(lactic-acid), chitosan, hydroxyapatite, additive manufacturing, scaffold.*

Sažetak

Tkivno inženjerstvo i regenerativna medicina predstavljaju alternativni pristup liječenju koštanih oštećenja primjenom biorazgradljivih i biokompatibilnih okosnica kao privremenih potpora za staničnu adheziju, proliferaciju i obnovu tkiva. Također, takve okosnice bi se trebale razgraditi kontroliranom brzinom *in vivo* ostavljajući prostor za rast novog tkiva. Polimljična kiselina, PLA, jedan je od najčešće korištenih biorazgradljivih polimera za aditivnu proizvodnju koštanih okosnica zbog svoje niske temperature taljenja. Međutim, u kliničkoj praksi potrebni su biomaterijali strogo definiranog sastava i visoke čistoće. Razlika u sastavu između biorazgradljivih polimera tehničke i visoke čistoće rezultira različitim ponašanjem materijala *in vitro* i *in vivo*. U ovom radu istražili smo mehanička svojstva 3D ispisanih okosnica na temelju PLA visoke čistoće tijekom razgradnje *in vitro*. 3D ispisane PLA okosnice modificirane su hidrogelom na temelju kitozana i hidroksiapatita kako bi se poboljšala bioaktivnost potencijalne koštane okosnice. Modificirane PLA okosnice inkubirane su u enzimskom mediju i simuliranoj tjelesnoj tekućini (Hanksovoj uravnoteženoj otopini soli) tijekom 8 tjedana pri 37°C u svrhu testiranja tlačne čvrstoće okosnica pod *in vitro* uvjetima. Ispitivanja pod tlakom pokazala su slične vrijednosti Youngovog modula i tlačne čvrstoće modificiranih PLA okosnice što ukazuje na zadržavanje mehaničke stabilnosti tijekom produljenog perioda inkubacije. Nadalje, okosnice inkubirane u različitim puferskim otopinama nisu pokazale značajne razlike u mehaničkim svojstvima.

Ključne riječi: polimljična kiselina, kitozan, hidroksiapatit, aditivna proizvodnja, okosnica.

MARVELOUS DESIGNER – SUSTAV ZA 3D DIZAJN I VIZUALIZACIJU DIGITALNIH TKANINA

MARVELOUS DESIGNER - 3D VISUALIZATION SYSTEM FOR DESIGN AND DIGITAL TEXTILES

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Review paper / Pregledni rad

Abstract

The main focus of this paper is to get acquainted with the program for creating, visualizing and simulating 3D fabrics and materials bearing the name Marvelous Designer. Article begins with a description of the tools and methods as well as the features of the program and the advantages of the 3D applications that have been used to make. The user interface is analyzed and the paper shows the functionality and speed of operation. Examples have been made, and it is shown how the obtained results can be incorporated into the present way of working. The emphasis is placed on making the detail as well as the options that this program makes very simple and intuitive to use. The main feature of the program is simulation of physical properties of materials, ie fabrics.

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Keywords: *Marvelous Designer, Fabric Simulation, 3D Design*

Sažetak

Tema rada je upoznavanje s programom za izradu, vizualizaciju i simulaciju 3D tkanina i materijala koji nosi naziv Marvelous Designer. Rad započinje opisom alata i metoda kao i značajkama programa te prednostima u odnosu na do sada poznate 3D programe koji su korišteni za izradu tkanina. Daje se prikaz korisničkog sučelja te se pokazuje funkcionalnost i jednostavnost korištenja alata za potrebe kreiranja materijala i provođenja simulacije nad istim. Napravljeni su primjeri, te se prikazuje kako se dobiveni rezultati mogu ukomponirati u dosadašnji način rada. Stavlja se naglasak na izradu detalja kao i na opcije koje ovaj program čine vrlo jednostavnim i intuitivnim za korištenje. Glavna značajka programa je simulacija fizičkih svojstava materijala, tj. tkanine.

Ključne riječi: *MarvelousDesigner, simulacijatkanine, 3D dizajn.*

ANALYSIS OF DAMAGE TO THE CHAINSAW SPROCKET

ANALIZA OŠTEĆENJA LANČANIKA MOTORNE PILE

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Conference abstract / Kongresno priopćenje

Abstract

Chainsaw sprockets can be damaged in many ways, such as by the chain hitting rocks or other hard objects, improper storage, or simply wear and tear from prolonged use. The analysis of damage to the chainsaw involves identifying and examining the specific type of damage sustained, assessing the severity of the damage, and finally determining the root cause of the damage. This can assist in halting additional sprocket degradation as well as identifying potential safety hazards for the operator. The analysis techniques used vary from visual inspection and dimensional analysis to various analytical techniques such as metallography, hardness testing, and Glow Discharge Optical Emission Spectroscopy (GDOES). Metallography includes examining the microstructure of the sprocket through the use of microscopes, which can reveal the type and extent of damage. Hardness testing can determine the strength and hardness of the material, which in turn helps identify areas of weakness or damage that may not be directly visible. GDOES is a surface analysis technique that provides detailed information on the chemical composition of the surface, including impurities and surface contaminants, which can help identify the root cause of damage. This paper compares the wear between two chainsaw sprockets.

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Keywords: sprocket, GDOES, metallography, hardness testing

Sažetak

Lančanici motornih pila mogu biti oštećeni na mnogo načina, kao što su udarci lanca o kamenje ili druge tvrde predmete, neodgovarajuće skladištenje ili jednostavno trošenje uslijed dugotrajne uporabe. Analiza oštećenja lančanika uključuje identifikaciju i pregled specifičnog tipa oštećenja, procjenu težine oštećenja te konačno određivanje korijenskog uzroka oštećenja. To može pomoći u zaustavljanju daljnjeg propadanja lančanika, kao i u identifikaciji potencijalnih sigurnosnih opasnosti za operatera. Tehnike analize koje se koriste variraju od vizualne inspekcije i dimenzijske analize do različitih analitičkih tehnika poput metalografije, ispitivanja tvrdoće i spektroskopije optičke emisije sjaja (GDOES). Metalografija uključuje pregled mikrostrukture lančanika kroz uporabu mikroskopa, što može otkriti vrstu i opseg oštećenja. Ispitivanje tvrdoće može odrediti čvrstoću i tvrdoću materijala, što zauzvrat pomaže u identifikaciji područja slabosti ili oštećenja koja možda nisu izravno vidljiva. GDOES je tehnika analize površine koja pruža detaljne informacije o kemijskom sastavu površine, uključujući nečistoće i onečišćenja koja se nalaze na površini, što može pomoći u identifikaciji korijenskog uzroka oštećenja. Ovaj rad uspoređuje trošenje između dva lančanika motornih pila.

Ključne riječi: lančanik, GDOES, metalografija, ispitivanje tvrdoće

HYDROTHERMAL SYNTHESIS AND CHARACTERIZATION OF NANOSTRUCTURED ZnO

HIDROTERMALNA SINTEZA I KARAKTERIZACIJA NANOSTRUKTURIRANOG ZnO

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Original scientific paper / Izvorni znanstveni rad

Abstract

Due to its properties, nano-sized ZnO finds multiple applications in biomedical and cosmetic industries, paint industry, electronics, solar cell development, etc. Also, quick synthesis in an environmentally friendly and economical way increases the use of zinc in various fields. The research in this work is focused on the synthesis of nanostructured ZnO particles by a hydrothermal method and their characterization. Zinc acetate dihydrate, $Zn(CH_3COO)_2 \cdot 2H_2O$, was used as a source of Zn^{2+} ions and absolute ethanol with addition of NaOH as a solvent. The surfactant triethanolamine (TEA) was used to control crystal growth and crystal shape. Syntheses were carried out at a temperature of $T=55\text{ }^\circ\text{C}$ for up to 2 hours. The resulting milky-white solutions were centrifuged, decanted and washed with ultrapure water or absolute ethanol. The samples were characterized by X-ray diffraction on polycrystalline samples (PXRD) and scanning electron microscopy (SEM). The results show that despite minor differences in the synthesis process, morphologically different reaction products are formed, which are mutually isostructural. The synthesized nanostructured ZnO rod samples have hexagonal wurtzite structure. Heating the sample to 820°C leads to an increase in the size of the unit cell, which is reversible and results in a decrease in the dimensions of the crystallites after cooling compared to the initial value.

Keywords: nanostructured ZnO, hydrothermal method, XRD, SEM

Sažetak

Zbog svojih svojstava ZnO u nano veličini pronalazi mjesto u različitim primjenama u medicini i kozmetičkoj industriji, u industriji boja, elektronici, razvoju solarnih ćelija itd. Također, mogućnost brze sinteze, na ekološki prihvatljiv i ekonomski isplativ način povećava upotrebu cinka u raznim područjima. Istraživanja u ovom radu usmjerena su na sintezu nanostrukturiranih ZnO čestica hidrotermalnom metodom i njihovu karakterizaciju. Kao izvor iona Zn^{2+} korišten je cink acetat dihidrat, $Zn(CH_3COO)_2 \cdot 2H_2O$, a kao otapalo apsolutni etanol uz dodatak NaOH. Surfaktant trietanolamin (TEA) korišten je za kontrolu rasta i oblika kristala. Sinteze su provedene pri temperaturi od $T=55\text{ }^\circ\text{C}$ u trajanju do 2 sata. Dobivene mliječno-bijele otopine su centrifugirane, dekantirane i isprane ultra čistom vodom ili apsolutnim etanolom. Uzorci su karakterizirani difrakcijom X-zraka na polikristalnim uzorcima (PXRD), pretražnom elektronskom mikroskopijom (SEM). Rezultati pokazuju da iako je riječ o malim razlikama u postupku sinteze nastaju morfološki različiti reakcijski produkti koji su međusobno izostrukturalni. Sintetizirani nanostrukturirani štapićasti uzorci ZnO imaju heksagonalnu wurtzitnu strukturu. Grijanjem uzorka do 820°C dolazi do porasta dimenzije jednične ćelije koja je reverzibilna uz snižavanje dimenzija kristalita nakon hlađenja u odnosu na početnu vrijednost.

Ključne riječi: nanostrukturirani ZnO, hidrotermalna metoda, XRD, SEM

ANALYSIS OF EROSION WEAR RESISTANCE OF NANOSTRUCTURED WC-Co MODIFIED WITH TiBN COATING

ANALIZA OTPORNOSTI NA EROZIJSKO TROŠENJE NANOSTRUKTURIRANOG WC-Co MODIFICIRANOG TiBN PREVLAKOM

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Abstract

In recent years, coated cemented carbides have often been the first choice for a wide variety of tool inserts and applications. In this study, a multi-layered gradient coating, deposited on nanostructured cemented carbides by plasma-assisted chemical vapor deposition (PACVD) was investigated with emphasis on its wear properties. TiBN coating was deposited on nanostructured cemented carbide samples with 5 wt% Co, 10 wt% Co and 15 wt% Co. Complex architecture built of TiN and TiB₂ gradient multilayer sequence block was deposited on each type of substrate. Wear resistance of the obtained samples was determined by erosion wear testing. The conducted tests show excellent wear properties of the newly developed TiBN coating under chosen conditions. The optimum substrate/coating system that showed the best erosion wear resistance was the coated WC-Co material with 10 - 15 wt.% Co.

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Keywords: WC-Co, Cemented carbide, TiBN, PACVD, Erosion wear.

Sažetak U novije vrijeme prevučeni tvrdi metali često su prvi izbor za široku paletu alatnih umetaka i primjena. U ovom radu je istraživana višeslojna gradijentna prevlaka, nanosena na nanostrukturne tvrde metale plazmom potpomognutim kemijskim prevlačenjem iz parne faze (PACVD) s naglaskom na njezina svojstva trošenja. Prevlaka TiBN nanosena je na uzorke nanostrukturiranog tvrdog metala s 5 mas.% Co, 10 mas.% Co i 15 mas.% Co. Kompleksna arhitektura gradijentne višeslojne prevlake sastavljene od naizmjenično poredanih TiN i TiB₂ slojeva nanosena je na svaki tip podloge. Otpornost na tošenje dobivenih uzoraka određena je ispitivanjem erozijom. Provedena ispitivanja pokazuju izvrsna svojstva novorazvijene TiBN prevlake u odabranim uvjetima. Optimalni sustav podloga/prevlaka koji je pokazao najbolju otpornost erozijskom trošenju bio je prevučeni WC-Co materijal s 10 - 15 mas.% Co.

Ključne riječi: WC-Co, Tvrđi metal, TiBN, PACVD, Erozijsko trošenje.

INFLUENCE OF HYDROXYAPATITE CONTENT ON PHYSICAL AND RHEOLOGICAL PROPERTIES OF CHITOSAN-BASED SCAFFOLD

UTJECAJ UDJELA HIDROKSIAPATITA NA FIZIKALNA I REOLOŠKA SVOJSTVA KITOZANSKIH NOSAČA

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Original scientific paper / Izvorni znanstveni rad

Abstract

Chitosan-based scaffolds offer significant potential in tissue engineering and regenerative medicine. Whilst exhibiting great bio-regenerative and biocompatible properties, their mechanical properties remain quite low. The presented research is focused on the modification of microporous chitosan scaffolds with various amounts of bioactive ceramics (hydroxyapatite) and its influence on physical and rheological properties of the composite scaffold. Chitosan/hydroxyapatite composite scaffolds with a highly porous microstructure have been prepared by suspending hydroxyapatite (HAp) particles into the chitosan matrix. According to SEM imaging, homogeneous dispersion of inorganic phase in chemically-crosslinked chitosan matrix had been achieved. The obtained composite scaffolds exhibited lower swelling capacity with respect to pure chitosan after 24 h of incubation in Hanks' balanced salt solution. Rheological measurements show an increase in storage and loss modulus indicating an improvement in mechanical properties under shear stress. Furthermore, no significant change in loss factor ($\tan\delta$) was observed indicating no change in composite viscoelastic properties with an increase in HAp content.

Keywords: *Chitosan, hydroxyapatite, scaffold, rheological properties.*

Sažetak

Okosnice na temelju kitozana pokazuju veliki potencijal za primjene u inženjerstvu tkiva i regenerativnoj medicini. Iako pokazuju izvrsna bioregenerativna i biokompatibilna svojstva, njihova mehanička svojstva su prilično loša. U ovom radu provedena je modifikacija mikroporoznih kitozanskih okosnica različitim udjelom bioaktivne keramike (hidroksiapatita) te je istražen utjecaj biokeramike na fizikalna i reološka svojstva kompozitnih okosnica. Kompozitne kitozan/hidroksiapatit okosnice s visoko poroznom mikrostrukturom pripremljene su suspendiranjem čestica hidroksiapatita (HAp) u matrici kitozana. SEM analiza pokazala je homogeno dispergiranje čestica anorganske faze u kemijski umreženoj matrici kitozana. Dobivene kompozitne okosnice pokazale su niži kapacitet bubrenja u odnosu na čisti kitozan nakon 24 sata inkubacije u Hanksovoj ravnotežnoj otopini soli. Reološka mjerenja pokazala su porast modula pohrane i gubitka kompozitnih okosnica što ukazuje na poboljšanje mehaničkih svojstava pod smičnim naprezanjem. Nadalje, dodatak hidroksiapatita nije uzrokovao promjenu u viskoelastičnosti kompozitnih okosnica što je vidljivo iz sličnih vrijednosti faktora gubitka ($\tan\delta$).

Ključne riječi: *kitozan, hidroksiapatit, okosnica, reološka svojstva*

THE INFLUENCE OF PRESENTATION TECHNOLOGY ON THE EMOTIONAL EXPERIENCE OF PHOTOGRAPHIC ILLUSTRATION

UTJECAJ TEHNOLOGIJE PRIKAZA NA EMOCIONALNI DOŽIVLJAJ FOTOGRAFSKE ILUSTRACIJE

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Original scientific paper / Izvorni znanstveni rad

Abstract

The research of presentation technology (print in newspaper press, laptop computer screen, calibrated professional screen, smartphone screen) was carried out in the paper depending on the experience and emotional reactions of respondents to different photographic illustrations. Respondents rated from 1 to 5 the emotional reaction caused by the observed photographic illustration according to the offered emotional and experiential reactions: happiness, love, hope, sexual attraction, pride, sadness, hatred, anger, envy, fear, disgust, shame... Research results indicate that depending on the age of the respondents, previous media habits and, above all, on the experience of viewing photographic illustrations, there are considerable differences in the experience of photographic illustrations depending on the presentation technology.

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Keywords: *photographic illustration, emotion, experience, screen, newsprint.*

Sažetak

U radu je provedeno istraživanje doživljaja i emocionalne reakcije ispitanika na različite fotografske ilustracije u ovisnosti o medijima prikaza (kalibrirani profesionalni zaslon, otisak u novinskom tisku, zaslon laptop računala, zaslon pametnog telefona, tablet). Ispitanici su od 0 do 5 ocijenili emocionalnu reakciju koju kod njih izaziva promatrana fotografska ilustracija prema ponuđenim reakcijama: sreća, ljubav, nada, seksualna privlačnost, ponos, tuga, mržnja, ljutnja, zavist, strah, gađenje, sram. Rezultati istraživanja ukazuju da ovisno o dobi ispitanika, prethodnim medijskim navikama, a najviše o iskustvu promatranja fotografskih ilustracija postoje znatne razlike u doživljaju fotografskih ilustracija ovisno o mediju prikaza.

Cljučne riječi: *fotografska ilustracija, emocija, doživljaj, zaslon, novinski tisak.*

THERMAL ANALYSIS OF THE BIODEGRADABLE POLYMER PVA/PEO BLENDS

TOPLINSKA ANALIZA BIORAZGRADLJIVIH POLIMERNIH MJEŠAVINA PVA/PEO

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Original scientific paper / Izvorni znanstveni rad

Abstract

Poly(vinyl alcohol) (PVA) and poly(ethylene) oxide (PEO) are widely used water-soluble and biodegradable polymers that possesses high biocompatibility. In this work PVA/PEO blends were prepared via solution casting method, where the solvent was water. After drying, samples were characterized by differential scanning calorimetry (DSC) and thermogravimetric analysis (TG). Based on the results of the DSC analysis, the specific thermal transitions were determined. Since the possible intermolecular interaction between PVA and PEO could not be confirmed by DSC, infrared spectroscopy with Fourier transform (FT-IR) was utilized. Finally, the TG analysis revealed a three-stage degradation pattern in the case of all PVA/PEO blends, similar as neat PVA. On the other hand, neat PEO exhibited only a single stage degradation pattern confirming its superior thermal stability to PVA.

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Keywords: *polyvinyl alcohol, polyethylene oxide, polymer blends, thermal analysis.*

Sažetak

Poli(vinil-alkohol) (PVA) i poli(etilen-oksidi) (PEO) su široko primjenjivi vodotopljivi i biorazgradljivi polimeri koji pokazuju iznimnu biokompatibilnost. U ovom radu mješavine PVA/PEO pripremljene su metodom lijevanja filma iz otopine, pri čemu je otapalo bila voda. Nakon sušenja, uzorci su karakterizirani diferencijalnom pretražnom kalorimetrijom (DSC) i termogravimetrijskom analizom (TG). Temeljem rezultata DSC analize određeni su specifični toplinski prijelazi. Budući da možebitne intermolekulske interakcije PVA i PEO nije bilo moguće potvrditi primjenom DSC-a, primjenjena je infracrvena spektroskopija s Fourierovom transformacijom (FT-IR). Konačno, TG analiza je pokazala da se toplinska razgradnja uzoraka svih mješavina PVA/PEO odvija kroz tri stupnja razgradnje, istovjetno kao i čistog PVA. S druge strane, čisti PEO se toplinski razgrađuje u samo jednom stupnju, potvrđujući svoju superiorniju toplinsku stabilnost u odnosu na čisti PVA.

Ključne riječi: *poli(vinil-alkohol), poli(etilen-oksidi), polimerne mješavine, toplinska analiza.*

MICROSTRUCTURE CHARACTERIZATION AND ABRASION RESISTANCE OF ALUMINUM BRONZE OVERLAY

KARAKTERIZACIJA MIKROSTRUKTURE I ABRAZIJSKA OTPORNOST NAVARA OD ALUMINIJEVE BRONCE

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Professional paper / Stručni rad

In the paper, a comparison of the resistance to abrasion wear of overlay made of aluminium bronze CuAl8Ni2Fe2Mn2, on the base material CuAl10Fe5Ni5, was carried out. The microstructure was analysed and the microhardness HV0.2 was measured on both materials. The microstructure of the base material consists of primary α -phase, κ -phase, and eutectoid. The overlay has a typical foundry, dendritic microstructure, and the heat affected zone is very narrow. The base material and the overlay metal have similar abrasion resistance, which increases slightly from the surface of the overlay to the base material. The measured microhardness values range from 152.5 HV0.2 to 312.3 HV0.2. The highest microhardness was measured in the HAZ due to more secreted hard intermetallic compounds, but this was not reflected in the increase in abrasion resistance due to the small width of the HAZ. There is a large positive linear correlation between the microhardness of the overlay and the distance from the surface ($R=0.78$).

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Keywords: *abrasion wear, microhardness, overlay, aluminium bronze*

Sažetak

U radu je uspoređena otpornost na abrazijsko trošenje navara od aluminijske bronce oznake CuAl8Ni2Fe2Mn2 i osnovnog materijala oznake CuAl10Fe5Ni5. Analizirana je mikrostruktura te izmjerena mikrotvrdoća HV0,2 na oba materijala. Mikrostruktura osnovnog materijala sastoji se od primarne α -faze, κ -faze i eutektoida. Navareni sloj ima tipičnu ljevačku, dendritnu mikrostrukturu, a zona utjecaja topline je vrlo uska. Osnovni materijal i metal navara imaju sličnu abrazijsku otpornost koja se blago povećava od površine navara prema osnovnom materijalu. Izmjerene vrijednosti mikrotvrdoće su u rasponu od 152,5 HV0,2 do 312,3 HV0,2. Najviša mikrotvrdoća izmjerena je u ZUT-u zbog više izlučenih tvrdih intermetalnih spojeva, no to se nije odrazilo na povećanje abrazijske otpornosti zbog male širine ZUT-a. Između mikrotvrdoće navara i udaljenosti od površine postoji velika pozitivna linearna korelacija ($R=0,78$).

Ključne riječi: *abrazijsko trošenje, mikrotvrdoća, navar, aluminijska bronca*

INFLUENCE OF PULSE PARAMETERS ON GEOMETRY CHARACTERISTICS OF TIG WELDED AISI 304 STEEL

UTJECAJ PARAMETARA IMPULSA NA GEOMETRIJSKE ZNAČAJKE PRI TIG ZAVARIVANJU ČELIKA AISI 304

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Expert paper / Stručni rad

Abstract

The use of impulse current during TIG welding enables the ignition and extinguishing of the electric arc at the minimum and maximum energy level, i.e. the basic and peak current of the impulse. In this way, it is possible to achieve greater penetration and control of the weld pool when welding out of position. Also, there are less deformations due to lower heat input, and it is easier to weld materials of different thicknesses, especially thinner materials. In the conducted experiment, 12 samples were made for the purpose of quantifying the influence of individual pulse parameters (frequency, balance of peak and base current, strength of peak current and strength of base current) on process stability, productivity and geometric features of the weld. Based on the analysis of the obtained results, a recommendation was given for the optimal values of the pulse current when welding AISI 304 steel with a thickness of 10 mm.

Keywords: *TIG pulse welding, AISI 304, weld geometry, productivity.*

Sažetak

Korištenje impulsne struje pri TIG zavarivanju omogućava uspostavu i prekid električnog luka na minimalnoj i maksimalnoj energetske razini tj. osnovnoj i vršnoj struji impulsa. Na taj način moguće je postići veću penetraciju i kontrolu taline kada se zavaruje u prisilnom položaju, manje su deformacije zbog manjeg unosa topline, te se lako zavaruju materijali različitih debljina, a pogotovo tanji materijali. U provedenom eksperimentu izrađeno je 12 uzoraka u svrhu kvantificiranja utjecaja pojedinih parametara impulsa (frekvencija, balans vršne i osnovne struje, jakost vršne struje te jakost osnovne struje) na stabilnost procesa, produktivnost i geometrijske značajke navara. Analizom dobivenih rezultata dana je preporuka za optimalne vrijednosti impulsne struje pri zavarivanju čelika AISI 304 debljine 10 mm.

Ključne riječi: *TIG impulsno zavarivanje, AISI 304, geometrija zavara, produktivnost.*

DETERMINATION OF THE SELECTIVITY OF NATURAL ZEOLITE CLINOPTILOLITE COATED WITH IRON SULFIDES SPECIES TOWARDS Hg(II) IN RELATION TO OTHER DIVALENT HEAVY METAL CATIONS

ODREĐIVANJE SELEKTIVNOSTI PRIRODNOG ZEOLITA KLINOPTILOLITA OBLOŽENOG ŽELJEZO SULFIDNIM SPECIJAMA PREMA Hg (II) U ODNOSU NA OSTALE DVOVALENTNE KATIONE TEŠKIH METALA

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Original scientific paper / Izvorni znanstveni rad

Abstract

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In this paper, the selectivity of the prepared natural zeolite clinoptilolite coated with iron sulfides species (FeSZ) towards divalent cations of heavy metals (Hg, Pb, Cu, Cd, Zn, Co, Ni, Mn) from mono-, two- and multi-component equimolar aqueous solutions was examined. The results demonstrate the following sequence of selectivity in all, mono-, two- and multi-component systems: Hg > Pb > Cu > Cd > Zn > Co > Ni > Mn. The presence of Hg in two- and multi-component systems significantly diminished the removal efficiency of other heavy metals. Finally, the results indicate that FeSZ has a superior sorption ability for Hg over other tested divalent heavy metal cations, making it desirable material in remediation of mercury-contaminated sites.

Keywords: natural zeolite, modified zeolite, heavy metals, selectivity.

Sažetak

U ovom radu ispitana je selektivnost pripremljenog prirodnog zeolita klinoptilolita obloženog željezovim sulfidnim specijama (FeSZ) prema dvovalentnim kationima teških metala (Hg, Pb, Cu, Cd, Zn, Co, Ni, Mn) iz jednokomponentnih, dvokomponentnih i višekomponentnih ekvimolarnih vodenih otopina. Rezultati su pokazali sljedeći slijed selektivnosti u svim, jednokomponentnim, dvokomponentnim i višekomponentnim sustavima: Hg > Pb > Cu > Cd > Zn > Co > Ni > Mn. Prisutnost Hg u dvokomponentnim i višekomponentnim sustavima značajno smanjuje učinkovitost uklanjanja drugih teških metala. U konačnici, rezultati su pokazali da FeSZ ima bolju sposobnost sorpcije Hg u odnosu na druge ispitane katione dvovalentnih teških metala, što ga čini poželjnim materijalom za remedijaciju živom onečišćenih područja.

Ključne riječi: prirodni zeolit, modificirani zeolit, teški metali, selektivnost.

INFLUENCE OF CENTRIFUGAL CASTING PARAMETERS ON SOLIDIFICATION TIME OF AUSTENITIC STAINLESS STEEL TUBE

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Original scientific paper / Izvorni znanstveni rad

Abstract

This paper describes the vertical centrifugal casting process of austenitic stainless steel tube. The factors analysed were mould rotation speed, mould preheating temperature, and pouring temperature. The design of experiment was conducted using Design Expert software. For optimization, Fractional Two – Level Factorial Design 2³ was made, which resulted in eight runs. Solidification time was observed as the response. Results were obtained through computer simulations using the ProCAST software. The statistical significance of all factors was established through the analysis of variance (ANOVA), and the resulting model exhibited excellent statistical properties, ensuring its reliability in predicting future results for austenitic stainless steel tubes. This presented analysis provides valuable foundations for future planning and conducting further research in the production of castings using vertical centrifugal casting technology.

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Keywords: *vertical centrifugal casting, austenitic stainless steel, two-level factorial design, solidification time, numerical simulation, ProCAST*

Sažetak

Ovaj rad opisuje postupak vertikalnog centrifugalnog lijevanja cijevi od austenitnog nehrđajućeg čelika. Analizirani faktori bili su broj okretaja kalupa, temperatura predgrijavanja kalupa i temperatura ulijevanja. Za provedbu eksperimenta korišten je softver Design Expert. Kako bih se optimizirao proces, napravljen je faktorski plan s dvije varijable na dvije razine, što je u konačnici rezultiralo s osam eksperimenata. Odzivna varijabla koja je praćena u ovom istraživanju bilo je vrijeme skrućivanja. Rezultati su dobiveni putem računalnih simulacija korištenjem softvera ProCAST. Statistička značajnost svih faktora utvrđena je analizom varijance (ANOVA), a dobiveni model pokazivao je dobra statistička svojstva, čineći ga pouzdanim za predviđanje budućih rezultata pri dobivanju cijevi od austenitnog nehrđajućeg čelika. Ova analiza pruža vrijedne temelje za buduće planiranje i za provođenje daljnjih istraživanja u proizvodnji odljevaka tehnologijom vertikalnog centrifugalnog lijevanja.

Ključne riječi: *vertikalno centrifugalno lijevanje, austenitni nehrđajući čelik, faktorski plan pokusa, vrijeme skrućivanja, numeričke simulacije, ProCAST*

DESINING A VISUAL IDENTITY USING SUSTAINABLE DESIGN

OBLIKOVANJE VIZUALNOG IDENTITETA UZ ODRŽIVI DIZAJN

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Original scientific paper / Izvorni znanstveni rad

Abstract

The graphic designer aesthetically neatly, clearly, functionally, and efficiently transmits information to the client and the recipient of the message, the user. When designing, measures can be introduced to reduce the possible negative impact on the environment by introducing common methods and means. Such measures are procedures for avoiding printing, using eco-materials and others. When creating a visual identity, it is necessary to convey the desired message to the public. When, in addition to the aforementioned, desire to respect sustainability during creating graphic products, the process of creating a visual identity becomes more demanding for the graphic designer. The successful creation of a design and the delivery of an ecological message to the recipients is considered to be the simplicity of recognizing the client's message and leading the recipient of the message to responsible sustainable behaviour. The aesthetics of the image play a very important role in the transmission of the mentioned messages. Due to the desire to convey the message to the widest possible audience, the design must be based on the use of basic aesthetic principles that are known and approachable to the public. Respecting all the guidelines mentioned earlier in this research was designed a visual identity for an ecological association.

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Keywords: *sustainable design, visual identity, associations*

Sažetak

Grafički dizajner estetski uredno, jasno, funkcionalno i efikasno prenosi informaciju klijentu i primatelju poruke, korisniku. Pri dizajniranju mogu se uvesti mjere kako bi se smanjio mogući negativni utjecaj na okoliš uvođenjem uobičajenih metode i sredstva. Takve mjere su postupci izbjegavanja otiskivanja, korištenja eko materijala i drugo. Kod kreiranja vizualnog identiteta potrebno je željanu poruku prenjeti od široke javnosti. Kada se uz spomenuto želi poštivati održivost pri izradi grafičkih proizvoda, proces osmišljavanja vizualnog identiteta postaje zahtjevniji za grafičkog dizajnera. Uspješnim osmišljavanjem dizajna i donošenjem ekološke poruke primateljima smatra se, jednostavnost prepoznavanja poruke naručitelja te navođenje primatelja poruke na odgovorno održivo ponašanje. Vrlo bitnu ulogu u prijenosu spomenutih poruka igra estetika slike. Zbog želje za prijenosom poruke što široj publici, dizajn se mora temeljiti na korištenju osnovnih estetskih načela koja su poznata i pristupačna široj javnosti. Uvažavajući sve smjernice ranije spomenute u ovom istraživanju osmišljen je vizualni identitet za ekološku udruhu.

Ključne riječi: *održivi dizajn, vizualni identitet, udruge*

TENSIOGRAPHY AND LIQUID DROP METROLOGY

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Professional paper / Stručni rad

Abstract

This research focused on drop metrology and the use of camera technology and vibration analysis influence on theoretical and practical tensiography. Drop shape and Tensiography are explained and how they relate to each other. Studies shows a relationship between vibration frequency and surface tension of liquids. However they also reveal the need for a theoretical understanding of the vibration tensiotrace of drops. Camera studies on large diameter dropheads used in tensiography are explored. Various image analysis methods were investigated for determining drop shape from camera images. Examination of the digital image reveals measurement issues. High speed camera images reveal new details of the drop separation process. An examination of drop modelling methods from camera images and the principles of such modelling were undertaken. Camera studies were developed which enabled the practical investigation of edge-detection. The theory developed links the drop shape with the tensiotrace of drops examined.

The ray tracing method of the modelling of drop shape would have to be consolidated by establishing a definitive relationship between drop shape and the tensiotrace. This lead to acquiring photo images of real drops to get the profile of its edge or the drop shape.

Various methods are used and assumptions are made in finding the edge of a drop from a photo image, in particular to the measurement of length, radii and angles.

Keywords: *Tensiography, Liquid Drop analysis, Ray tracing.*

HARDNESS CHANGES CAUSED BY IN-CRYSTAL DISLOCATION BEHAVIOUR IN THE CASE OF EQUAL CHANNEL ANGULAR PRESSING (ECAP)

PROMJENA TVRDOĆE UZROKOVANA KRETANJEM DISLOKACIJA UNUTAR ZRNA POD UTJECAJEM PROCESA KUTNE EKSTRUZIJE

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Invited lecture / Pozvano predavanje

Abstract

Mechanical properties of crystalline solids are highly conditioned by the presence and number of dislocations. Equal Channel Angular Pressing (ECAP) belongs to severe plastic deformation (SPD) processes which cause significant multiplication and localized accumulation of dislocations. One of the materials that are commonly used in ECAP processes is aluminium. Improvement of its mechanical properties presents a great challenge and expands the area of its use in the aviation and space industry. In this area of application, its low mass brings significant savings in fuel consumption, which means not only economic gain, but is also environmentally friendly. As representative enough, and the simplest way to observe changes in mechanical properties is possible to choose hardness measurement. When the results of hardness measurements are related to changes in position and density of dislocations, a broader picture is obtained about the interdependence of dislocations motion and mechanical properties of materials. These changes should also be viewed in the context of the size and shape of the crystal grain. As a confirmation of SPD influence dislocation monitoring is enabled using the light and electron microscopy and AFM (Atomic Force Micro-scope) device. The representative area of the most severe deformation is determined by a numerical simulation of the Equal Channel Angular Pressing process using the ABAQUS software package.

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Keywords: *Equal Channel Angular Pressing (ECAP), Aluminium (Al), Severe Plastic Deformation (SPD), Atomic Force Microscope (AFM), Hardness.*

Sažetak

Mehanička svojstva krutih kristalnih tvari visoko su uvjetovana prisutnošću i brojem dislokacija. Istosmjerna kutna ekstruzija (ECAP - Equal Channel Angular Pressing) spada u postupke značajne plastične deformacije (SPD - Severe Plastic Deformation) koji uzrokuju značajno umnožavanje i lokalizirano nakupljanje dislokacija. Jedan od materijala koji se obično koristi u ECAP procesima je aluminij. Poboljšanje njegovih mehaničkih svojstava predstavlja veliki izazov i proširuje područje njegove uporabe u zrakoplovnoj i svemirskoj industriji. U ovom području primjene njegova niska masa donosi značajne uštede u potrošnji goriva, što znači ne samo financijsku dobit, već je i ekološko unaprjeđenje. Kao dovoljno reprezentativan, a najjednostavniji način promatranja promjena mehaničkih svojstava moguće je odabrati mjerenje tvrdoće. Kada su rezultati mjerenja tvrdoće povezani s promjenama položaja i gustoće dislokacija, dobiva se šira slika o međuovisnosti gibanja dislokacija i mehaničkih svojstava materijala. Te promjene također treba promatrati u kontekstu veličine i oblika zrna. Kao potvrda utjecaja značajne plastične deformacije praćeno je ponašanja dislokacija korištenjem AFM (Atomic Force Micro-scope) uređaja. Reprezentativni presjek, koji trpi najveće deformacije, određen je numeričkom simulacijom procesa kutne ekstruzije pomoću softverskog paketa ABAQUS.

Ključne riječi: kutna ekstruzija, aluminij, značajna plastična deformacije, AFM (atomic force microscope), tvrdoća.

INCREASE RESISTANCE OF BUILDING CONSTRUCTIONS AT LOW CYCLE FATIGUE OF CONCRETE

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Preliminary notice / Prethodno priopćenje

Abstract

Structural adaptation of materials provides stability in maintaining the initial properties of concrete despite changing stress. This is mainly influenced by the alteration of parameters concerning technological cracks and internal surfaces, which act as active components of the structure, capable of responding promptly to external influences. The material's properties are preserved at the predetermined level through self-organization of the structure. The poly-structure of concretes implies a mutual influence and interaction of structural levels throughout their life cycle. By modifying the initial conditions for structure formation in individual subsystems, known as levels of structural heterogeneities, there are new possibilities for deliberately organizing the complex and dynamic open system of concrete. By varying compositions, one can control the kinetics of the structure's organization at specific levels, ultimately achieving the desired structure of the concrete product. The microstructure of concrete can be organized through internal, external, and complex activation processes. The formation of the macrostructure can be influenced by changing the ratio of adhesion and cohesion forces at the surface of the interface between the matrix material and the fillers. Concretes with a structure formed by selective adhesion of the cement matrix to the fillers exhibit enhanced quality parameters and better adaptation to low-cycle fatigue stress.

Keywords: *concrete, expanded clay concrete, structure, self-organization, active elements, deformations, damage, low cycle fatigue.*

THE MECHANICAL PROPERTIES AND CREEP BEHAVIOR OF THERMALLY STABLE ULTRAFINE-GRAINED AL STABILIZED BY NANOTHICK Al_2O_3 NETWORK DETERMINED AT ELEVATED TEMPERATURES BY SMALL PUNCH TESTING

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Original scientific paper / Izvorni znanstveni rad

Abstract

The mechanical properties and creep behavior of thermally stable ultrafine-grained Al composite strengthened and stabilized by continuous nano-metric in-situ Al_2O_3 network (named HITEMAL[®]) fabricated by powder metallurgy were tested by small punch testing (SPT) in temperature range from room temperature up to 400 °C. The microstructure of HITEMAL and fracture surfaces were characterized by scanning and transmission electron microscopy. The SPT results were compared and correlated with the results obtained by the conventional tensile testing. The mutual correlation of yield strength obtained from static tensile test and static SPT with the temperature dependency was proposed. The creep behavior of HITEMAL is characterized by the presence of the threshold stress and high stress exponent. In low stress regime at temperature of 300-350°C, the detachment controlled diffusional creep is the main deformation mechanism, in the temperature range of 350-400 °C Nabarro-Herring creep becomes presumably dominant creep mechanism. The creep deformation of HITEMAL is highly localized in small volume of SPT disc. The fracture surface of crept SPT disc tested at 350 and 400°C showed unusual presence of thin and long Al fibers.

Keywords: *small punch testing, mechanical properties, powder metallurgy, ultrafine-grained Al composite*

EVALUATION OF CORROSION RESISTANCE OF DIFFERENTLY DRIED TOPCOATS USING ELECTROCHEMICAL IMPEDANCE SPECTROSCOPY

PROCJENA KOROZIJSKE OTPORNOSTI RAZLIČITO SUŠENIH ZAVRŠNIH PREMAZA ELEKTROKEMIJSKOM IMPEDANCIJSKOM SPEKTROSKOPIJOM

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Original scientific paper / Izvorni znanstveni rad

Abstract

Metal corrosion causes significant costs for the industrial sector. Therefore, manufacturers of metal structures often protect their products with organic coatings. In order to be able to put as many products on the market as possible in the shortest possible time, the industry is turning to accelerated drying using infrared radiation. The aim of this work is to demonstrate the acceleration of drying of organic topcoats using IR radiation, to examine the adhesion of differently dried coatings and to examine the influence of accelerated drying on the corrosion resistance of topcoats using the electrochemical impedance spectroscopy method. It has been shown that IR radiation accelerates drying several times and improves adhesive property of the coating, while it has a divided effect on corrosion resistance.

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Keywords: *Organic topcoats, IR radiation, drying time, EIS, corrosion resistance.*

Sažetak

Korozija metala uzrokuje značajne troškove za industrijski sektor. Proizvođači metalnih konstrukcija zbog toga često svoje proizvode štite organskim premazima. Kako bi što više proizvoda mogla u što kraćem vremenu izbaciti na tržište, industrija se okreće ubrzanom sušenju pomoću infracrvenog zračenja. Cilj ovog rada je pokazati ubrzanje sušenja organskih završnih premaza primjenom IC zračenja, ispitati adheziju različito sušenih premaza te metodom elektrokemijske impedancijske spektroskopije ispitati utjecaj ubrzanog sušenja na korozijsku otpornost završnih premaza. Pokazalo se da IC zračenje višestruko ubrzava sušenje i poboljšava adhezijska svojstva premaza, dok na korozijsku otpornost ima podijeljeno djelovanje.

Ključne riječi: *organski završni premazi, IC zračenje, vrijeme sušenja, EIS, korozijska otpornost.*

HOW TO DEFINE PARAMETERS FOR 3D PRINTING

KAKO ODREDITI PARAMETRE ZA 3D PRINTANJE

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Professional paper / Stručni rad

Abstract

3D printing is still a relatively new technology that has a lot of potential for further development and progress. The application of this technology today covers a wide range of applications such as the automotive industry, architecture, medicine and many others. The goal of this research is to show the differences in the properties of 3D printed objects with regard to 3D modeling of the object, types of materials and settings in the slicing software. The research results showed that every step from modeling to preparation can have a significant impact on the printed object. The quality of printed objects is also affected by the printing method, the material used and the filling.

***Keywords:** 3D printing, material, strength.*

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Sažetak

3D printanje je još uvijek relativno nova tehnologija koja ima puno potencijala za daljnje razvijanje i napredak. Primjena ove tehnologije danas obuhvaća široko područje primjene kao što su automobilska industrija, arhitektura, medicina i mnoge druge. Cilj ovog istraživanja je prikazati razlike u svojstvima 3D printanih objekata s obzirom na 3D modeliranje objekta, vrsta materijala i postavkama u slicing softwaru. Rezultati istraživanja pokazali su da svaki korak od modeliranja do pripreme može imati značajan utjecaj na printani objekt. Na kvalitetu printanih objekata utječe i način printanja, materijal koji se koristi kao i ispuna.

***Ključne riječi:** 3D printanje, materijal, čvrstoća*

IMPROVING THE CONTRAST OF TARGET IMAGES TO ENHANCE THE DETECTION CAPABILITIES OF THE AUGMENTED REALITY SYSTEM IN THE NATIONAL MUSEUM OF MODERN ART

POBOŠLJANJE KONTRASTA TARGET IMAGES ZA DETEKCIJU U PROŠIRENOJ STVARNOSTI U NMMU

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Original scientific paper / Izvorni znanstveni rad

Abstract

Augmented reality (AR) is a technology that enables the perceptual integration of digital content into the image of real world, which makes it a valuable tool in many fields, including education and entertainment. Target image detection is a critical component of augmented reality, and successful target image detection is key to integrating digital content and augmenting the experience of reality. Changing image contrast is one of key techniques for improving target image detection in AR engines. This paper investigates a histogram equalization technique for image contrast enhancement in service of improving target image detection in augmented reality systems, including image processing, camera settings, lighting conditions, and the use of contrast enhancement techniques.

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***Keywords:** augmented reality, computer vision, target images, contrast, histogram equalization.*

Sažetak

Proširena stvarnost (*augmented reality* AR) je tehnologija koja omogućuje prikaz digitalnog sadržaja u stvarnom svijetu, što ju čini vrijednim alatom u mnogim područjima koja uključuju i obrazovanje i zabavu. Otkrivanje ciljne slike (*target image-a*) kritična je komponenta proširene stvarnosti, a uspješna detekcija *target image-a* je ključna za prikaz digitalnog sadržaja i uspješno iskustvo doživljaja proširene stvarnosti. Promjena kontrasta slike jedna je od ključnih tehnika za poboljšanje detekcije *target image* u AR stvarnosti. U ovom radu istražuje se tehnika izjednačavanja histograma za poboljšanje kontrasta slike za detekciju *target image-a* u proširenoj stvarnosti, uključujući obradu slike, postavke kamere, uvjete osvjetljenja i korištenje tehnika poboljšanja kontrasta.

***Ključne riječi:** proširena stvarnost, računalni vid, ciljna slika, kontrast, izjednačavanje histograma.*

ARTIFICIAL INTELLIGENCE: A NOVEL APPROACH FOR CREATING ANIMATION

UMJETNA INTELIGENCIJA: NOVI PRISTUP STVARANJU ANIMACIJE

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Conference abstract / Kongresno priopćenje

Abstract

The field of animation has seen significant progress in recent years, with the integration of artificial intelligence (AI) playing a key role in optimizing the animation process and improving the quality of the result. This paper presents a new approach to creating animation using artificial intelligence, the goal of which is to speed up the creation of animation using different artificial intelligence techniques. AI combines state-of-the-art machine learning algorithms with advanced models to generate realistic and visually appealing animations. The proposed method solves the challenges of traditional animation techniques, such as the intensity of manual work, time-consuming processes, and difficulties in achieving natural movement and fluidity. The paper presents a comprehensive overview of the AI framework, detailing its key components and the underlying principles that govern its operation. It also explores how it can be implemented in various animation scenarios, including character animation, facial animation, and environmental effects, demonstrating its versatility and adaptability.

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Keywords: *AI, animation, Stable Diffusion.*

Sažetak

Područje animacije doživjelo je značajan napredak posljednjih godina, s integracijom umjetne inteligencije (UI) koja igra ključnu ulogu u optimizaciji procesa animacije i poboljšanju kvalitete konačnog rezultata. U ovom radu prikazan je novi pristup izradi animacije pomoću umjetne inteligencije, čiji je cilj ubrzati stvaranje animacije korištenjem različitih tehnika umjetne inteligencije. UI kombinira najsuvremenije algoritme strojnog učenja, s naprednim modelima za generiranje realističnih i vizualno privlačnih animacija. Predložena metoda rješava izazove tradicionalnih tehnika animacije, kao što su intenzitet ručnog rada, dugotrajni procesi i teškoće u postizanju prirodnog kretanja i fluidnosti. Rad predstavlja sveobuhvatan pregled UI okvira, s detaljima njegovih ključnih komponenti i temeljnih načela koja upravljaju njegovim radom. Također istražuje se način implementacije u različitim scenarijima animacije, uključujući animaciju likova, animaciju lica i učinke na okoliš, pokazujući njegovu svestranost i prilagodljivost.

Ključne riječi: *UI, animacija, Stable Diffusion.*

NON-LINEAR STATIC STRESS SIMULATION FOR 3D PRINTED PART WITH PLA MATERIAL

NELINEARNA STATIČKA SIMULACIJA NAPREZANJA ZA 3D TISAK S PLA MATERIJALOM

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Original scientific paper / Izvorni znanstveni rad

Abstract

Additive manufacturing technologies are a popular way of prototyping and manufacturing complex and unique parts from different materials. The mechanical properties of parts made by the process of 3D printing fused filament fabrication (FFF) are often influenced by the parameters of the process itself, such as the thickness of the layer, the density of the filling and the orientation of the object. A 3D model of a printing form for a book printing press was created for testing. In this research, a nonlinear static stress simulation was performed on a 3D printed part made of polylactic acid (PLA), a biodegradable thermoplastic material that is often used in additive manufacturing technologies, the FFF process. The aim of the work is to examine the possibility of using PLA material to produce printing forms for use in a book printing press. The obtained results show the distribution of stress and deformation to optimize the design and process of additive manufacturing of the printing form for the book printing machine.

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Keywords: *polyacril acid (PLA), Non-linear static stress simulation, 3D printing.*

Sažetak

Aditivne tehnologije proizvodnje su popularan način prototipiranja i proizvodnje složenih i jedinstvenih dijelova od različitih materijala. Mehanička svojstva dijelova izrađena postupkom 3D tiska *fused filament fabrication* (FFF) često su pod utjecajem parametara samog postupka, kao što su debljina sloja, gustoća ispune i orijentacija objekta. Za ispitivanje je izrađen 3D model tiskovne forme za knjigo-tiskarski zaklopni stroj. U ovom istraživanju provedena je nelinearna simulacija statičkog naprezanja na 3D tiskanom dijelu izrađenom od polilaktične kiseline (PLA), biorazgradivog termoplastičnog materijala koji se često koristi u aditivnim tehnologijama proizvodnje, postupku FFF. Cilj rada je ispitati mogućnost korištenja PLA materijala za izradu tiskovnih formi za upotrebu u knjigo-tiskarskom zaklopnom stroju. Dobivenim rezultatima prikazuje se distribucija naprezanja i deformacije kako bi se optimizirao dizajn i postupak aditivne proizvodnje tiskovne forme za knjigo-tiskarski stroj.

Ključne riječi: *polilaktična kiselina (PLA), nelinearna simulacija statičkog naprezanja, 3D tisk.*

OPTIMIZATION OF SYNTHESIS OF STOICHIOMETRIC HYDROXYAPATITE FOR BONE TISSUE ENGINEERING APPLICATION

OPTIMIZACIJA SINTEZE STEHIOMETRIJSKOG HIDROKSIAPATITA ZA PRIMJENU U INŽENJERSTVU KOŠTANOG TKIVA

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Conference abstract / Kongresno priopćenje

Abstract

Diseases and fractures of natural bone tissues represent a global issue in medicine. One of the approaches to treat bone defects is bone tissue engineering which aims at development and application of materials for replacing and restoring functions of damaged tissues. An ideal bone graft substitute follows the biomimetic approach for bone regeneration applications. Therefore, calcium phosphates (CaP) were mostly used biomaterials due to their chemical similarity to the mineral part of bone. In this research, wet precipitation method was used to synthesize stoichiometric hydroxyapatite (HAp). The aim was to optimize reaction conditions including precursor type of calcium and phosphorus ions, temperature and reaction time. First, different phosphorous precursors were used, namely ammonium dihydrogen phosphate, urea phosphate and phosphoric acid in the reaction with calcite during 48 h. Then, the effect of calcium precursor (calcite and calcium acetate) on the composition of calcium phosphate was investigated during 48 h. XRD analysis and FTIR spectroscopy indicated the formation of different calcium phosphate phases, especially when different calcium precursor was used. The formation of brushite was detected during the first 6 h of the reaction with calcium acetate, while synthesis with calcite resulted in the formation of octacalcium phosphate pentahydrate during the first 24 h. After 48 h of reaction, hydroxyapatite as the only calcium phosphate phase was detected in all syntheses, indicating the transformation of initially precipitated CaP phases into thermodynamically stable HAp. The morphology of obtained powders was investigated by SEM analysis, while the thermal stability was analyzed by thermogravimetric analysis.

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Keywords: *calcium phosphates, hydroxyapatite, bone tissue engineering*

Sažetak

Prijelomi, oštećenja i bolesti prirodnog koštanog tkiva predstavljaju značajan problem u medicini. Jedan od pristupa liječenju je inženjerstvo koštanog tkiva, koje ima za cilj razviti i primijeniti materijale za obnovu i povećanje funkcije oštećenog tkiva. Idealne okosnice za koštanu obnovu temelje se na biomimetičkom pristupu, stoga su kalcijevi fosfati (CaP) najčešće korišteni biomaterijali zbog svoje kemijske sličnosti mineralnoj fazi koštanog tkiva. U ovom radu, stehiometrijski hidroksiapatit (HAp) sintetiziran je metodom precipitacije. Cilj je optimizacija reakcijskih uvjeta uključujući tip prekursora kalcijevih i fosfatnih iona, temperaturu i vrijeme reakcije. Prvotno su ispitivani različiti prekursori fosfatnih iona; amonijev dihidrogenfosfat, ureafosfat i fosfatna kiselina, u reakciji s kalcitom tijekom 48 h. Zatim je ispitan utjecaj prekursora kalcija (kalcit i kalcijev acetat) na sastav nastalih kalcijevih fosfata tijekom 48 h. XRD analizom i FTIR spektrometrijom je utvrđeno da korištenjem različitih prekursora kalcija nastaju različite kalcij-fosfatne faze. Tijekom prvih 6 h reakcije s kalcijevim acetatom nastaje brušit, dok tijekom 24 h reakcije s kalcitom nastaje oktakalcij fosfat pentahidrat. Nakon 48 h, hidroksiapatit je prisutan kao jedina CaP faza pri svim reakcijskim uvjetima, što upućuje na faznu transformaciju prvotno nastalih kalcijevih fosfata u termodinamički stabilniji HAp. Morfologija praškastih uzoraka analizirana je SEM mikroskopijom, dok je termogravimetrijska analiza korištena za ispitivanje toplinske stabilnosti pripremljenih uzoraka.

Ključne riječi: kalcijevi fosfati, hidroksiapatit, tkivno inženjerstvo

REVIEW OF ENGINEERING METAL FILAMENTS IN FDM ADDITIVE PRODUCTION

PREGLED INŽENJERIJSKIH METALNIH FILAMENATA U FDM ADITIVNOJ PROIZVODNJI

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Professional paper / Stručni rad

Abstract

FDM is the simplest and cheapest additive manufacturing technology, which is mostly based on polymer materials. An offer expand is tried with the development of metal filaments. It's about unique filaments where metal particles are mixed with pure plastic. After printing, the plastic is removed by the debind process and strengthened by the sintering process. Metal filaments enable the production of less demanding metal components with complex geometry on a cheap 3D printer at an affordable price. The aim of this paper is to analyze the market of metal filaments for FDM additive technology, categorize the material offer and objectively compare the available materials with those offered by renowned manufacturers of materials for classic FDM printers. Special emphasis is on filaments with a high metal content, the quality and scope of technical specifications of FDM metal filaments, which is essential for their professional use.

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***Keywords:** additive manufacturing, FDM, metal filament, metal content, price analysis*

Sažetak

FDM je najjednostavnija i najjeftinija tehnologija aditivne proizvodnje. Većinom je bazirana na polimerne materijale. Razvojem metalnih filamenata pokušava se proširiti ponuda. To su jedinstveni filamenti gdje su čestice metala pomiješane s čistom plastikom. Plastika se nakon tiskanja uklanjaju debind postupkom i učvršćuju procesom sinteriranja. Metalni filamenti omogućavaju izradu manje zahtjevnih metalnih komponenti sa složenom geometrijom na jeftinom 3D pisaču po pristupačnoj cijeni. Cilj ovog rada je analizirati tržište metalnih filamenata za FDM aditivnu tehnologiju, kategorizirati ponudu materijala i objektivno usporediti dostupne materijale s onima koje nude renomirani proizvođači materijala za klasične FDM pisače. Poseban naglasak stavljen je na filamente s visokim udjelom metala kvalitetu i opseg tehničkih specifikacija FDM metalnih filamenata, što je ključno za njihovu profesionalnu upotrebu.

***Ključne riječi:** aditivna proizvodnja, FDM, metalni filament, udio metala, analiza cijena*

STUDY OF EFFECTS OF NATURAL POROUS FILLERS AND POLYMER MODIFIERS ON STRENGTH PROPERTIES OF DRY MIXED MORTARS

ISTRAŽIVANJE UTJECAJA PRIRODNIH POROZNIH PUNILA I POLIMERNIH MODIFIKATORA NA SVOJSTVA ČVRSTOĆE SUHIH MJEŠAVINA ŽBUKA

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Original scientific paper / Izvorni znanstveni rad

Abstract

Dry mix mortars are becoming more and more popular in the world's building materials market. Therefore, the issue of increasing the technological and mechanical properties of stucco mixes is relevant. The aim of the paper is modification of lightweight dry stucco mixes with fine limestone and perlite as well as with hydroxyethyl methyl cellulose and dispersible polymer. In order to investigate the different mixes, an 18-point experiment was designed. Density, compressive strengths and crack resistance of dry plaster mixes were studied using requirements of standard. Mathematical models were obtained for the compositions as a result of processing the experimental data. The regularities of the fillers' and additives' influence on the properties of the mixes were established, depending on their amount and combination. It was observed that methyl hydroxyethyl cellulose improves the crack resistance and compression strength, and contributes to a slight decrease in density. The crack resistance of plaster mortars changes more than 1,5 times, the most crack-resistant compositions have an average amount of porous fillers.

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Keywords: *Dry mix mortar, Cellulose ether, Dispersible polymer, Crack resistance, Compression strength.*

Sažetak

Suhe mješavine žbuke svake godine postaju sve popularnije na svjetskom tržištu građevinskih materijala. Stoga je pitanje povećanja tehnoloških i mehaničkih svojstava suhe žbuke relevantno. Cilj rada je modifikacija lakih suhih mješavina žbuke finim vapnencem i perlitom te hydroxyethyl methyl cellulose i disperzibilnim polimerom. Za istraživanje različitih mješavina prihvaćen je eksperiment od 18 točaka. Primjenom zahtjeva standarda ispitivana je gustoća, tlačna čvrstoća i otpornost na pukotine suhih mješavina žbuke. Kao rezultat obrade eksperimentalnih podataka dobiveni su matematički modeli za sastave. Utvrđene su zakonitosti utjecaja punila i aditiva na svojstva mješavina ovisno o njihovoj količini i kombinaciji. Uočeno je da je metil hidroksietil celuloza poboljšala otpornost na pukotine i čvrstoću na pritisak, te pridonosi blagom smanjenju gustoće. Otpornost žbuke na pukotine mijenja se više od 1,5 puta, sastavi koji su najotporniji na pukotine imaju prosječnu količinu poroznih punila.

Ključne riječi: *suhe mješavine žbuke, celulozni eter, disperzibilni polimer, otpornost na pukotine, tlačna čvrstoća.*

GRAPHIC TECHNOLOGIES AND COMMUNICATIONS IN THE DIGITAL AGE: MATERIALS, TRIBOLOGY, AND MULTIMEDIA PAPER TITLE

GRAFIČKE TEHNOLOGIJE I KOMUNIKACIJE U DIGITALNOM DOBU: MATERIJALI, TRIBOLOGIJA I MULTIMEDIJA

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Conference abstract / Kongresno priopćenje

Abstract

The paper explores the connection between graphic technology, communication, and digital technologies in today's digital age. Key elements such as materials, tribology, and multimedia reveal how these factors complement each other and influence the creation of visual content and communication. The application of graphic technology in design, illustration, and photography is considered, taking into account various materials used for creating and reproducing printed and digital materials. The role of tribology in print quality and the durability of graphic products is also investigated. Multimedia receives special emphasis as a crucial factor for interactivity and rich user experience, enabling the combination of text, images, sound, video, and animation. This paper provides insight into the complex network of connections between graphic technology, communication, materials, tribology, and multimedia, highlighting their significance in the contemporary digital environment.

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Keywords: *graphic technology, communication, digital age, materials, tribology.*

Sažetak

U radu se istražuje veza između grafičke, komunikacije i digitalnih tehnologija u današnjem digitalnom dobu. Ključni elementi kao što su materijali, tribologija i multimedija, otkrivaju kako se ovi faktori međusobno nadopunjuju i utječu na tehnologije stvaranje vizualnih sadržaja i komunikaciju. Razmatra se primjena grafičke tehnologije u dizajnu, ilustraciji i fotografiji, uzimajući u obzir različite materijale koji se koriste za stvaranje i reprodukciju tiskanih i digitalnih materijala. Istražuje se i uloga tribologije u kvaliteti otiska i trajnosti grafičkih proizvoda. Multimedija ima poseban naglasak kao ključni čimbenik za interaktivnost i bogato korisničko iskustvo što omogućava kombinaciju teksta, slika, zvuka, videozapisa i animacije. Ovaj rad pruža uvid u složenu mrežu veza između grafičke tehnologije, komunikacije, materijala, tribologije i multimedije, ističući njihovu važnost u suvremenom digitalnom okruženju.

Ključne riječi: *grafičke tehnologije, komunikacije, digitalno doba, materijali, tribologija.*

SOLIDIFICATION PROCESSES OF Mg-Al ALLOYS

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Conference abstract / Kongresno priopćenje

Abstract

The solidification of the mostly used Mg-alloys could be considered after the Mg-Al phase diagram. The equilibrium solubility of Al in Mg at the eutectic temperature of 437°C is 12.6 mass.%. According to the solvus line of the Mg-Al phase diagram the intermetallic compound of Mg₁₇Al₁₂ is precipitating on the boundaries of the primary Mg grains after the completed solidification. Solidification of the binary magnesium aluminium alloys has been investigated with a new three thermal analysis at three different cooling rates at the same time. Investigation of solidification was done by evaluation of the cooling curves in connection with metallographic examinations, simultaneous thermal analyses (STA) and thermodynamic calculations. Characteristic temperatures determined from cooling curves and STA curves were: liquidus T_L, solidus T_S and eutectic T_E. At cooling rates smaller than 5 K/s non equilibrium eutectic (αMg + Mg₁₇Al₁₂) was observed in alloys with concentration higher than 4 mass.% Al which is precipitating on the boundaries of the primary α_{Mg} grains. It is caused by the local Al - microsegregations. This effect was not observed in the case of commercial MgAl5Mn alloy, due to formation of Al₄Mn intermetallic compound phase. The consequence was decreased concentration of dissolved Al in Mg-Al liquid solution.

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Keywords: Mg-Alloys, Thermodynamics, Thermal Analyses

INFLUENCE OF THERMAL AND MECHANICAL LOADING ON TOOTH WITH FILLING

UTJECAJ TOPLINSKOG I MEHANIČKOG OPTEREĆENJA NA ZUB SA ISPUNOM

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Preliminary notice / Prethodno priopćenje

Abstract

The scope of this study is to evaluate biomechanical behaviour of healthy and restored tooth during normal daily activity to understand how much tooth filling impacts on stress distribution in hard dental tissues. To describe influence of thermal loading as well as mechanical loading on healthy tooth and on restored tooth finite element method is used. Thermal and mechanical loading are simulating different everyday oral condition. Mechanical loading is uniform biting force of 100 N applied vertically and at 45° degrees. Thermal loading of 50°C and 5°C respectively is used to simulate effects of cold and hot beverage. Both loading are natural changes appearing daily in oral cavity. Different restorative material, amalgam, equia forte and composite resin as the most common restorative material are used for numerical analysis of tooth filling.

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Keywords: *healthy tooth, restored tooth, finite element method, stress distribution.*

Sažetak

Cilj ovog istraživanja je prikazati biomehaničko ponašanje zdravog zuba i restauriranog zuba tijekom svakodnevnih aktivnosti da bi se vidjelo koliko ispuna zuba utječe na raspodjelu naprezanja u tvrdom dentalnom tkivu. Da bi se opisao utjecaj toplinskog opterećenja kao i mehaničkog na zdrav zub te na restaurirani zub korištena je metoda konačnih elemenata. Toplinsko i mehaničko opterećenje simulira različita svakodnevna stanja u usnoj šupljini. Mehaničko opterećenje zamjenjuje uniformnu žvačnu silu u iznosu od 100 N apliciranu vertikalno te pod kutom od 45°. Toplinsko opterećenje u iznosu od 50°C i 5°C prikazuje utjecaj toplog i hladnog pića. Oba opterećenja su prirodne promjene koja se svakodnevno događaju u usnoj šupljini. Različiti materijali za restauraciju, kao što su amalgam, equia forte i kompozitna smola, koji su najčešće u upotrebi su korišteni za numeričku analizu zuba sa ispunom.

Ključne riječi: *zdravu zub, restaurirani zub, metoda konačnih elemenata, raspodjela naprezanja.*

ADDITIVE MANUFACTURING OF METALS USING FUSED DEPOSITION MODELING

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Conference abstract / Kongresno priopćenje

Abstract

Additive manufacturing has the ability to create structures that can be light, stable, and at the same time have properties with a high degree of functionality. The constant development of production techniques and design in the future will be even more cost-effective and the use of additively produced industrial metals and ceramics will continue to grow. With the combination of AM, highly filled polymer or paste material systems with metal particles are extruded from a nozzle and are gradually layered according to a 3D model. After the polymer binder removal, the additive-manufactured object is further heat-treated to form a dense structure. Our research in this field is focused on metal and composite materials (Al, CuSn, 316L, Al/Al₂O₃). To achieve high-quality and reproducible, print optimization of parameters (temperature, nozzle size, layer height) of fused deposit modeling (FDM) and direct ink writing (DIW) is needed. The macro and microstructure of the 3D printed material before and after binder removal is studied using scanning electron microscopy.

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Keywords: *additive manufacturing, metal powder, aluminium, 316L, fused deposit modeling*

Acknowledgement:

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DETERMINING THE MATERIAL PROPERTIES OF SPRUCE WOOD USING THREE-POINT BENDING TESTS: AN INVERSE APPROACH

ODREĐIVANJE SVOJSTAVA MATERIJALA DRVA SMREKE POMOĆU TESTOVA SAVIJANJA U TRI TOČKE: INVERZNI PRISTUP

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Original scientific paper / Izvorni znanstveni rad

Abstract

The objective of this paper is to present an experimental investigation of a three-point bending test for radial and tangential-orientated spruce wood fibres. Furthermore, a numerical model of the three-point bending test is proposed. The main goal of the performed research work is the inverse determination of the material parameters of the orthotropic material model of spruce wood. Finally, validation of the numerical model, based on a comparison of experimental and numerical responses, is analysed. The presented numerical model will further serve to determine the fatigue life of specimens made of spruce wood.

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Keywords: *Spruce Wood, Experimental Setup, Numerical Model*

Sažetak

Cilj ovog rada je prikaz eksperimentalnog ispitivanja uporabom savijanja u tri točke za radijalno i tangencijalno orijentirana drvena vlakna smreke. Nadalje, predložen je numerički model ispitivanja savijanja u tri točke. Glavni cilj izvedenog istraživanja je inverzno određivanje materijalnih parametara ortotropnog materijalnog modela drva smreke. Na kraju se analizira validacija numeričkog modela temeljena na usporedbi eksperimentalnog i numeričkog odziva. Prikazani numerički model nadalje će poslužiti za određivanje vijeka trajanja zamora uzoraka izrađenih od drva smreke.

Ključne riječi: *drvo smreke, eksperimentalna postavka, numerički modeli*

ESTIMATION OF EASY AVAILABLE MATERIALS AS LOW-COST SORBENTS IN SINGLE AND MULTI-STAGE TREATMENT OF MANGANESE-CONTAMINATED WATER

PROCJENA LAKO DOSTUPNIH MATERIJALA KAO JEFTINIHI SORBENASA U JEDNOSTUPANJSKOJ I VIŠESTUPANJSKOJ OBRADI VODE ONEČIŠĆENE MANGANOM

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Original scientific paper / Izvorni znanstveni rad

Abstract

Manganese (Mn) occurs naturally in aquatic ecosystems, since is one of the most widespread elements in the Earth's crust, although higher Mn concentrations originate from anthropogenic activities. Since elevated Mn concentrations in water cause a number of aesthetic and technical problems and are health concern, it is necessary to keep its level under control. In this paper, the removal of Mn from an aqueous solution containing ≈ 20 mg Mn/L was examined by a combination of several low-cost treatment methods: oxidation (aeration) with alkalisation using milk of lime, filtration, and finally sorption on different easy available materials: natural zeolite and industrial food processing waste – olive, cherry and sour cherry pits. It was found that oxidation of Mn(II) must be performed at $\text{pH} > 9.0$, leading to the much lower residual Mn concentration and better overall removal efficiency. Among all tested sorbents, almost complete ($> 99\%$) Mn removal was obtained for sodium form of natural zeolite, while pits showed satisfying removal up to $\approx 64\%$. Finding a useful purpose for such waste is highly desirable, contributing to better management of solid waste and more favourable water treatment.

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Keywords: *Manganese, Water Treatment, Natural Zeolite, Industrial Food Processing Waste.*

Sažetak

Mangan (Mn) je prirodno prisutan u vodenim ekosustavima jer je jedan od najraširenijih elemenata u Zemljinoj kori, ali veće koncentracije ipak su posljedica antropogenih aktivnosti. Budući da povišene koncentracije Mn u vodi uzrokuju niz estetskih, tehničkih i zdravstvenih problema, potrebno je njegovu razinu držati pod kontrolom. U ovome radu ispitano je uklanjanje Mn iz vodene otopine koncentracije ≈ 20 mg/L kombinacijom nekoliko isplativih metoda obrade: oksidacijom (aeracijom) uz alkalizaciju vapnenim mlijekom, filtracijom i na posljetku sorpcijom na lako dostupnim materijalima: prirodnom zeolitu te industrijskom otpadu od prerade hrane – košticama maslina, trešanja i višanja. Utvrđeno je da se oksidacija Mn(II) treba provesti pri $\text{pH} > 9,0$ što dovodi do znatno niže koncentracije zaostalog Mn i bolje ukupne učinkovitosti uklanjanja. Od svih testiranih sorbenasa, skoro potpuno uklanjanje ($> 99\%$) Mn postignuto je na natrijevom obliku prirodnog zeolita, dok se na košticama postigla zadovoljavajuća učinkovitost do $\approx 64\%$. Pronalaženje korisne namjene ovakvim materijalima pridonosi boljem gospodarenju krutim otpadom i povoljnijem pročišćavanju vode.

Ključne riječi: *mangan, obrada vode, prirodni zeolit, industrijski otpad od prerade hrane.*

MICROSTRUCTURE CHANGES ANALYSIS IN AlMg_{4,5}Mn_{0,7} ALLOY AFTER TIG METHOD HEAT INPUT

ANALIZA MIKROSTRUKTURNIH PROMJENA U AlMg_{4,5}Mn_{0,7} LEGURI NAKON UNOSA TOPLINE TIG POSTUPKOM

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Original scientific paper / Izvorni znanstveni rad

Abstract

While designing the machine element there is great emphasis on the material selection. The selected material must meet several criteria that will make the production process as economical and simpler as possible, while maintaining its properties, from start of processing to the final product. As it often happens that the material is exposed to the heat during the processing, it is important to know the potential negative influence of heat on the properties, and respectively the microstructure of the material. In this paper, the influence of heat input by the TIG heating process, for the purpose of straightening the aluminium sheets, on the microstructure of the AlMg_{4.5}Mn_{0.7} alloy was analyzed. The analysis of the TIG tool path was performed with an optical metallographic microscope and scanning electron microscope with EDS to describe certain constituents of interest. The microhardness test was performed at the location of the heat affected zone and its vicinity. For comparison and a better understanding of the influence of heat on the microstructure, each sample was exposed to different parameters in the production process.

Keywords: AlMg_{4.5}Mn_{0.7}, microstructure, microhardness, TIG

Sažetak

U procesu konstruiranja strojnog elementa, veliki se naglasak postavlja na kvalitetan odabir materijala. Odabrani materijal mora zadovoljiti nekoliko kriterija koji će proces proizvodnje učiniti što ekonomičnijim, jednostavnijim i bržim, ali uz zadržavanje zadovoljavajućih svojstava u svakoj etapi oblikovanja sve do konačnog proizvoda. Kako u proizvodnom procesu materijal često biva izložen vanjskom utjecaju topline, važno je poznavati potencijalni negativan utjecajem topline na svojstva, odnosno mikrostrukturu materijala. U ovome radu analiziran je utjecaj topline unesene TIG postupkom zagrijavanja u svrhu ravnjanja lima, na mikrostrukturu AlMg_{4.5}Mn_{0.7} legure. Analiza poprečnog presjeka na mjestu prolaska TIG gorionika izvršena je optičkim metalografskim mikroskopom te skenirajućim elektronskim mikroskopom uz EDS za opisivanje pojedinih konstituenata od interesa. Ispitivanje mikrotvrdoće Vickersovom metodom izvršeno je u zoni utjecaja topline (ZUT) i njenoj okolini. Radi usporedbe i boljeg razumijevanja utjecaja topline na mikrostrukturu, svaki je uzorak bio izložen različitim proizvodnim parametrima.

Ključne riječi: AlMg_{4.5}Mn_{0.7}, mikrostruktura, mikrotvrdoća, TIG

STAINLESS STEEL CUTTING WITH AIR PLASMA CUTTER

PLAZMA REZANJE NEHRĐAJUĆEG ČELIKA POMOĆU KOMPRIMIRANOG ZRAKA

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Professional paper / Stručni rad

Abstract

Metal cutting processes are characterized by increasing demands for the quality of the cut surface, reducing costs and the following number of operations in production. Today's cutting technologies enable the direct application of technological operations that follow cutting or the incorporation of cut segments into the final product without the need for subsequent processing of the cut surfaces. In this paper, the influence of cutting speed and current on the achieved cut quality during plasma cutting of 5 mm thick stainless steel sheet X5CrNi18-10 (AISI 304), 5 mm thick was investigated using air plasma. After nine samples were cut with different parameters, the roughness on the cut surfaces was measured. Using computer analysis of cut surface photographs the bevel angle and distance between surface peaks was measured. The analysis found that all measured values increase with the increase in cutting speed. The optimal parameters that produced the best quality on the cutting surfaces within the settings of this experiment were also determined.

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Keywords: *plasma cutting, compressed air, stainless steel, surface quality, surface roughness*

Sažetak

Obradu rezanja metala karakteriziraju sve veći zahtjevi za kvalitetom površine na mjestu nastalog reza, smanjivanjem troškova i naknadnog broja operacija u proizvodnji. Današnje tehnologije rezanja omogućuju direktnu primjenu tehnoloških operacija koje slijede nakon rezanja ili ugradnju izrezanih segmenata u konačan proizvod bez potrebe za naknadnom obradom reznih površina. U ovom radu izvršeno je ispitivanje utjecaja brzine rezanja i jakosti struje na postignutu kvalitetu reza pri plazma rezanju lima nehrđajućeg čelika X5CrNi18-10 (AISI 304), debljine 5 mm pomoću komprimiranog zraka. Nakon što je izvršeno rezanje devet uzoraka različitim parametrima izmjerena je hrapavost na reznim površinama te je pomoću računalne analize fotografija reznih površina izmjeren kut skošenja brazdi i razmak između brazdi. Analizom je utvrđeno da se usporedno s povećanjem brzine rezanja povećavaju sve mjerene veličine. Također su određeni optimalni parametri kojima se postiže najbolja kvaliteta na reznim površinama u okviru postavki ovog eksperimenta.

Ključne riječi: *plazma rezanje, komprimirani zrak, nehrđajući čelik, kvaliteta površine, hrapavost površine*

ASSESSMENT OF QUALITY IMPAIRMENT OF PRINTED PAPER PACKAGING FROM ALTERNATIVE RAW MATERIALS IN CONTACT WITH SOYBEAN OIL

PROCJENA NARUŠENOSTI KVALITETE TISKANE PAPIRNATE AMBALAŽE OD ALTERNATIVNIH SIROVINA U KONTAKTU SA SOJINIM ULJEM

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Original scientific paper / Izvorni znanstveni rad

Abstract

Soybean is an important industrial crop grown for oil and protein production. Soybean oil is the second most widely produced edible oil. Except as edible oil, soybean is widely used in human nutrition as flour, milk, cheese and sauces, while soy lecithin is an inevitable additive in many food products. It should be emphasized that soybean has become indispensable in the production of meat and dairy substitute products as the fastest growing trend in the food industry. In addition to human and animal nutrition, soybean is also important for the pharmaceutical, textile and chemical industries and in the production of biodiesel fuel. Many of the listed soybean products also require appropriate packaging that complies with environmental regulations. Due to the global trend of increasing consumption of soybean products, within the scope of this research, the impact of soybean oil on the print quality of paper packaging from alternative raw materials was monitored. The deterioration of the original quality of the print with black UV ink applied by digital, flexographic, gravure, screen and offset printing techniques was evaluated after 24 hours of contact with soybean oil based on measured spectrophotometric values.

Keywords: *paper packaging, print quality, soybean oil*

Sažetak

Soja je značajna industrijska kultura koja se uzgaja radi dobivanja ulja i bjelančevina. Sojino ulje je drugo jestivo ulje po proizvodnji. Osim kao jestivo ulje, soja se široko koristi u ljudskoj prehrani kao brašno, mlijeko, sir te umaci, dok je sojin lecitin neizbježan dodatak mnogim prehrambenim proizvodima. Treba naglasiti kako je soja postala nezamjenjiva u proizvodnji mesnih i mliječnih zamjenskih prehrambenih proizvoda kao najbrže rastućeg trenda u prehrambenoj industriji. Osim u ljudskoj i životinjskoj ishrani, soja je značajna i u farmaceutskoj, tekstilnoj i kemijskoj industriji te u proizvodnji biodizelskog goriva. Brojni navedeni sojini proizvodi zahtijevaju i adekvatnu ambalažu koja je u skladu s ekološkim regulativama. Zbog globalnog trenda sve veće konzumacije sojinih proizvoda, u okviru ovog istraživanja pratio se utjecaj sojinog ulja na kvalitetu otiska papirnate ambalaže iz alternativnih sirovina. Narušenost početne kvalitete otiska crnom UV bojom nanešenom digitalnom, fleksografskom, bakrotiskarskom sitotiskarskom i offsetnom tehnikom tiska evaluirana je nakon 24-satnog kontakta sa sojinim uljem temeljem izmjerenih spektrofotometrijskih vrijednosti.

Ključne riječi: *papirna ambalaža, kvaliteta otiska, sojino ulje*

INFLUENCE OF HEAT TREATMENT ON MECHANICAL PROPERTIES OF AISi10Mg ALLOY PRODUCED BY SELECTIVE LASER MELTING PROCESS

UTJECAJ TOPLINSKE OBRADNE NA MEHANIČKA SVOJSTVA AISi10Mg LEGURE PROIZVEDENE SLM POSTUPKOM

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Conference abstract / Kongresno priopćenje

Abstract

Selective laser melting (SLM) is a powder bed fusion type metal additive manufacturing process and is widely accepted within the industry for fabrication of customized, complex, high-value added, near-net-shaped metallic components. Aluminium alloys, especially AISi10Mg is one of the most widely additively manufactured and commercialized alloys due to the favourable combination of material properties and its ease of fabricability by SLM. In this study, AISi10Mg specimens manufactured using SLM process in as-built state and after heat treatment were studied in order to investigate the effect of various heat treatment conditions on the mechanical properties. Metallographic analyse by optical microscope and tensile test were performed to evaluate mechanical properties while considering the specimen heat treatment. According to the obtained results it can be concluded that an AM optimized heat treatment procedure, that is 40 % shorter than conventional T6 heat treatment procedure, resulted in increased mechanical properties. Either conventional or modified T6 treatment is recommended to obtain controlled mechanical properties and lower variation in mechanical values of SLM-printed AISi10Mg alloy.

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Keywords: *heat treatment, selective laser melting, mechanical properties, AISi10Mg*

Sažetak

Selektivno lasersko taljenje (SLM) je proces aditivne proizvodnje iz metalnog praha u slojevima i široko je prihvaćen u industriji za izradu prilagođenih i geometrijski vrlo složenih metalnih dijelova visoke dodane vrijednosti. Aluminijske legure, posebice AISi10Mg, jedna je od najčešće komercijalno korištenih legura u aditivnoj proizvodnji zbog povoljne kombinacije svojstava i lakoće izrade SLM postupkom. Prikazati će se rezultati ispitivanja utjecaja parametara toplinske obrade na mehanička svojstva AISi10Mg legure proizvedene SLM procesom. Na uzorcima je napravljena metalografska analiza optičkim mikroskopom i statičko vlačno ispitivanje. Na temelju dobivenih rezultata može se zaključiti da AM optimizirani postupak toplinske obrade, koji je 40% kraći od konvencionalnih T6 postupaka toplinske obrade, rezultira poboljšanim mehaničkim svojstvima u odnosu na konvencionalnu T6 obradu. Za AISi10Mg leguru proizvedenu SLM postupkom preporuča se bilo konvencionalna ili modificirana T6 obrada kako bi se dobila kontrolirana mehanička svojstva i manje varijacije u vrijednostima mehaničkih svojstava.

Ključne riječi: *toplinska obrada, selektivno lasersko taljenje, mehanička svojstva, AISi10Mg*

PROPERTIES OF PLA/PCL/SiO₂ COMPOSITES PRODUCED BY PRESSING METHOD AND FDM ADDITIVE MANUFACTURING

SVOJSTVA PLA/PCL/SiO₂ MJEŠAVINA DOBIVENIH METODOM PREŠANJA I FDM ADITIVNOM PROIZVODNJOM

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Original scientific paper / Izvorni znanstveni rad

Abstract

The most common reasons for mixing two or more polymers are to produce polymer mixture that combine the properties of the components used and form a new material with certain improved chemical and/or physical properties. One of the most commonly used methods for mixing polymers is melt blending. It is based on the principle of mixing the components in the molten state in extruders or batch mixers. In this work, two types of biodegradable polymers were used, namely polylactic acid (PLA) and polycaprolactone (PCL). Since these two polymers are not miscible, silicon dioxide (SiO₂) was used as a nanofiller to improve the compatibility of the obtained mixture. The materials were mixed in two different types of extruders and shaped by pressing and 3D printing method. The aim of the study was to determine the mechanical and structural properties of the objects made from PLA/PCL/SiO₂ composites using different producing processes.

Keywords: PLA, PCL, SiO₂, FDM additive manufacturing, pressing method.

Sažetak

Najčešći razlozi za miješanje dvaju i više polimera nalaze se u potrebi za dobivanjem polimerne mješavine s poboljšanim određenim kemijskim i/ili fizikalnim svojstvima. Jedna od najčešćih metoda umješavanja dvaju i više polimera je preradom materijala u taljevini koja se bazira na zagrijavanju polimera, taljenju i umješavanju komponenti u ekstruderu. U ovom su radu korištena dva biorazgradiva polimerna materijala: polilaktidna kiselina (PLA) i polikaprolakton (PCL). Obzirom da su ta dva polimera zajedno nemješljiva, u takve se sustave najčešće uvode punila koja bi trebala utjecati na bolju kompatibilizaciju dobivene mješavine. U radu je korišteno punilo nanočestica silicijevog dioksida (SiO₂). Polimerne komponente i punilo su umješavani u dva ratličita ekstrudera a dobivene mješavine su formirane u kvadratne oblike metodom prešanja i 3D tiskom. Svrha rada je odrediti na koji način različite metode dobivanja formiranih oblika utječe na mehanička i strukturalna svojstva PLA/PCL/SiO₂ kompozita.

Ključne riječi: PLA, PCL, SiO₂, FDM aditivna proizvodnja, prešanje.

ATOMIC FORCE MICROSCOPY: STEP HEIGHT MEASUREMENT UNCERTAINTY EVALUATION

MIKROSKOP ATOMSKIH SILA: PROCJENA MJERNE NESIGURNOSTI DUBINE BRAZDE

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Original scientific paper / Izvorni znanstveni rad

Abstract

The atomic force microscope (AFM) enables the measurement of sample surfaces at the nanoscale. Reference standards with calibration gratings are used for the adjustment and verification of AFM measurement devices. Thus far, there are no guidelines or guides available in the field of atomic force microscopy that analyze the influence of input parameters on the quality of measurement results, nor has the measurement uncertainty of the results been estimated. Given the complex functional relationship between input and output variables, which cannot always be explicitly expressed, one of the primary challenges is how to evaluate the measurement uncertainty of the results. Measurement uncertainty is a parameter associated with the result of a measurement that describes the dispersion of the values that could reasonably be attributed to the measurand with a given probability. The measurement uncertainty of the calibration grating step height on the AFM reference standard was evaluated using the Monte Carlo simulation method. The measurements within this study were conducted using a commercial, industrial atomic force microscope.

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Keywords: *atomic force microscope, measurement uncertainty, Monte Carlo simulation*

Sažetak

Mikroskopom atomskih sila (AFM) omogućuje se mjerenje površine uzoraka na nanorazini. Za podešavanje i provjeru AFM mjernog uređaja koriste se referentni etaloni koji na sebi imaju kalibracijsku rešetku. Do sada na području mikroskopije atomskih sila ne postoje upute ili vodiči koji analiziraju utjecaj ulaznih parametara na kvalitetu rezultata mjerenja niti je procijenjena mjerna nesigurnost rezultata mjerenja. Budući da se radi o složenom funkcijskom odnosu ulaznih i izlaznih veličina koji se ne može uvijek eksplicitno iskazati, jedan od primarnih problema jest kako procijeniti mjernu nesigurnost rezultata mjerenja. Mjerna nesigurnost je parametar pridružen rezultatu mjerenja koji opisuje rasipanje vrijednosti koje bi se razumno moglo pripisati mjerenoj veličini uz određenu vjerojatnost. Primjenom metode Monte Carlo simulacija procijenjena je mjerna nesigurnost dubine brazde kalibracijske rešetke umjerenog AFM referentnog etalona. Mjerenja u okviru ovog rada provede se na komercijalnom, industrijskom mikroskopu atomskih sila.

Ključne riječi: *mikroskop atomskih sila, mjerna nesigurnost, Monte Carlo simulacije.*

USABILITY AND PRINTABILITY OF PAPER SUBSTRATES WITH NON-WOOD FIBRES FOR GRAPHIC PRODUCTS PRINTED BY FIVE PRINTING PROCESS

UPORABLJIVOST I TISKOVNOST PAPIRNIH PODLOGA S NEDRVNIM VLAKNIMA ZA GRAFIČKE PROIZVODE TISKANE POMOĆU PET TISKARSKIH TEHNIKA

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Original scientific paper / Izvorni znanstveni rad

Abstract

Customers are usually unaware of the process required to reproduce graphic products that are used on a daily basis. Manufacturers of graphic products and merchandise are aware that, regardless of the substrate they are printed, they must ensure consistent colour matching and print quality to attract attention on store shelves and ensure customer loyalty. Packaging, labels and publications are mostly printed using multicolour printing, whereby different colour shades are reproduced with the three standard process colours (cyan, magenta and yellow) in different ratios. The quality of the graphic product depends largely on the origin of the raw materials used for the printing substrate, the type of ink and the technology used for printing. The paper substrate most used for printing labels, packaging, or publications is generally made from cellulose fibres derived from wood, non-wood or non-plant sources. Nowadays, the use of non-wood lignocellulosic fibres resources plays an important role in optimizing raw materials for paper production. The aim of this research was to evaluate the usability and printability of paper substrates with the addition of non-wood fibres for graphic products printed by digital, flexographic, gravure, screen and offset printing process.

Keywords: *non-wood fibre, paper substrate, printability, printing process, usability*

Sažetak

Kupci obično nisu svjesni procesa koji su potrebni za reprodukciju grafičkih proizvoda koji se koriste svakodnevno. Proizvođači robe i grafičkih proizvoda svjesni su da, bez obzira na vrstu tiskovne podloge, moraju osigurati dosljednu usklađenost boja i kvalitetu otiska kako bi privukli pozornost na policama trgovina i osigurali vjernost kupaca. Ambalaža, naljepnice i publikacije uglavnom se tiskaju višebojnim tiskom, pri čemu se različite nijanse boja reproduciraju s tri standardne procesne boje (cijan, magenta i žuta) definiranim u različitim omjerima. Kvaliteta grafičkog proizvoda uvelike ovisi o podrijetlu sirovina korištenih za tiskovnu podlogu, o vrsti boje i o samom procesu otiskivanja. Papirna podloga koja se najčešće koristi za ispis naljepnica, pakiranja ili publikacija obično se izrađuje od celuloznih vlakana dobivenih iz drvnih ili nedrvnih ili nebiljnih izvora. U današnje vrijeme korištenje resursa nedrvnih lignoceluloznih vlakana igra važnu ulogu u optimizaciji sirovina za proizvodnju papira. Cilj ovog istraživanja bio je ocijeniti uporabljivost i tiskovnost papirnatih podloga s dodatkom nedrvnih vlakana za grafičke proizvode otisnute digitalnim, fleksografskim, bakrotiskarskim, sitotiskom i ofsetnim postupkom tiska.

Ključne riječi: *nedrvna vlakna, papirnata podloga, tiskovnost, tiskarski proces, uporabljivost*

MICROSTRUCTURAL CHANGES OF AlSi10Mg DEPENDING ON THE SLM PROCESS PARAMETERS

MIKROSTRUKTURNE PROMJENE AlSi10Mg U OVISNOSTI O PARAMETRIMA SLM POSTUPKA

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Preliminary notice / prethodno priopćenje

Abstract

Due to its near eutectic composition, the AlSi10Mg alloy is widely used as a casting alloy for the production of parts in the automotive and aerospace industries and for the production of heat exchanging parts. The application of the SLM additive process for the production of AlSi10Mg parts enables the production of significantly more complex products, and this alloy is today considered the most common alloy for the production of parts by the SLM additive process thanks to its narrow range of solidification. One of the disadvantages of the additive SLM process is very often a long product manufacturing time, therefore a large number of researches focuses on examining the parameters of the SLM process on the microstructure, mechanical properties and surface quality. In this paper, the influence of laser speed and power on the microstructure of the AlSi10Mg alloy for one thickness of the molten layer was examined. Characterization of the microstructure included analysis in the polished and etched state and microhardness testing. The results showed that increasing the speed with lower laser power causes a significant increase in the proportion of porosity. By increasing the laser speed with higher laser power, porosity did not result in a significant increase.

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Keywords: AlSi10Mg, SLM, microstructure characterization, microhardness, process parameters

Sažetak

AlSi10Mg legura je radi svog gotovo eutektičkog sastava vrlo zastupljena kao ljevačka legura za izradu dijelova u automobilske i zrakoplovnoj industriji te za izradu izmjenjivača topline. Primjenom SLM aditivnog postupka izrade dijelova AlSi10Mg omogućena je izrada značajno kompleksnijih proizvoda te se ova legura danas smatra najzastupljenijom legurom za izradu dijelova SLM aditivnim postupkom zahvaljujući uskom rasponu skrućivanja. Jedan od nedostataka aditivnog SLM postupka vrlo često je dugo vrijeme izrade proizvoda stoga se velik broj istraživanja fokusira na ispitivanje parametara SLM postupka na mikrostrukturu, mehanička svojstva i kvalitetu površine. U ovom radu ispitan je utjecaj brzine i snage lasera na mikrostrukturu AlSi10Mg legure za jednu debljinu taljenog sloja. Karakterizacija mikrostrukture obuhvatila je analizu u poliranom i nagrizenom stanju te ispitivanje mikrotvrdoće. Rezultati su pokazali da povećanje brzine uz manju snagu lasera uzrokuje značajno povećanje udjela poroziteta. Povećanjem brzine lasera uz veću snagu lasera nije došlo do značajnog povećanja poroznosti.

Ključne riječi: AlSi10Mg, SLM, karakterizacija mikrostrukture, mikrotvrdoća, parametri postupka

THE INFLUENCE OF DIFFERENT PREPARATIONS OF NANOCOMPOSITE COATING ON PROTECTIVE PROPERTIES

UTJECAJ RAZLIČITE PRIPREME NANOKOMPOZITNE PREVLAKE NA ZAŠTITNA SVOJSTVA

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Original scientific paper / Izvorni znanstveni rad

Abstract

Incorporating an anticorrosive component, such as nanoparticles, into organic coatings presents a challenge for researchers because nanoparticles tend to form agglomerates. The aim of this work is to improve and compare two methods of mixing nanoparticles into epoxy paints. The mixing of 1% aluminum nanoparticles was carried out by a mechanical and ultrasonic process. The surface of the nanocomposite coating was analyzed using a scanning electron microscope (SEM) and energy dispersive spectroscopy (EDS). The corrosion behavior of the epoxy coating with and without nanoparticles was examined using electrochemical impedance spectroscopy (EIS) in a 3.5% NaCl solution. Electrochemical testing of the coating was completed with the use of a scanning electrochemical microscope (SECM). Electrochemical surface analysis of the coating enables a topography of monitoring the degradation of the coating. The results show that the nanocomposite with 1% aluminium nanoparticles prepared using an ultrasonic homogenizer has better anticorrosion properties than the nanocomposite prepared by mechanical stirring.

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Keywords: *corrosion, epoxy coating, nanoparticles, electrochemical tests.*

Sažetak

Umješavanje antikoroziivne komponente, kao što su nanočestice, u organski premazi predstavlja prepreku za istraživače jer nanočestice imaju tendenciju stvaranja aglomerata. Cilj ovog rada je poboljšati i usporediti dva načina umješavanja nanočestica u epoksidne boje. Umješavanje 1% aluminijskih nanočestica provedeno je mehaničkim i ultrazvučnim postupkom. Površina nanokompozitne prevlake analizirala se pomoću skenirajućeg elektronskog mikroskopa (SEM) i energijsko-disperzijske spektroskopije (EDS). Korozivno ponašanje epoksidne prevlake s i bez nanočestica ispitana je pomoću elektrokemijske impedancijske spektroskopije (EIS) u 3.5% otopini NaCl-a. Elektrokemijsko ispitivanje prevlake upotunjeno je s primjenom skenirajućeg elektrokemijskog mikroskopa (SECM). Elektrokemijska površinska analiza prevlake omogućuje topografski prikaz praćenja degradacije prevlake. Rezultati pokazuju da nanokompozit s 1% aluminijskih nanočestica pripremljen pomoću ultrazvučnog homogenizatora imaju bolja antikorozijska svojstva nego nanokompozit koji je napravljen uz pomoć mehaničkog postupka.

Cljučne riječi: *korozija, epoksidna prevlaka, nanočestice, elektrokemijska ispitivanja.*

HYBRID BALLISTIC PROTECTION SYSTEMS

HIBRIDNI SUSTAVI BALISTIČKE ZAŠTITE

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Conference abstract / Kongresno priopćenje

Abstract

The paper describes the research and development of an integrated hybrid system of material and personal ballistic protection against kinetic penetrators and explosive devices. The purpose of this system is to protect vehicles for transporting money and valuables but also to protect people, for which the demand is increasing. The developed hybrid ballistic protection system combines primary, soft protection to absorb projectile energy and hard protection that prevents harmful deformations created in the primary protection. This was achieved through the optimized design of the composite material and the purposefully developed composition and structures of the ballistic plates, and additionally through the process of impregnating the polymer matrix with hard and solid nanoparticles. The newly developed panels were tested in an accredited laboratory in the Czech Republic and received a certificate for protection level FB4 according to EN-1522.

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Keywords: *Composite material, ballistic protection, FB4, EN-1522*

Sažetak

U radu je opisano istraživanje i razvoj integriranog hibridnog sustava materijalne i osobne balističke zaštite od kinetičkih penetratora i eksplozivnih naprava uz primjenu naprednih materijala. Namjena tog sustava je za zaštitu logističkih transportnih sredstava (vozila za prijevoz novaca i dragocjenosti) ali i za zaštitu osoba, za čime je potražnja sve veća. Razvijeni hibridni sustav balističke zaštite kombinira primarnu, mekanu zaštitu za apsorpciju energije projektila i čvrstu zaštitu koja sprječava štetne deformacije nastale u primarnoj zaštiti. To je ostvareno optimiranim dizajnom kompozitnog materijala i ciljano razvijenim sastavom i strukturama balističkih ploča, a dodatno kroz postupak impregniranja polimerne matrice s tvrdim i čvrstim nanočesticama. Novorazvijene ploče testirane su u akreditiranom laboratoriju u Češkoj te ostvarile zaštitu i dobile certifikat za stupanj zaštite FB4 prema EN-1522.

Ključne riječi: *Kompozitni materijal, balistička zaštita, FB4, EN-1522*

Acknowledgement: Istraživanje financirano projektom **Integrirana zaštita logističkih vozila, KK.01.2.1.02** Povećanje razvoja novih proizvoda i usluga koji proizlaze iz aktivnosti istraživanja i razvoja – faza II

CORRELATION BETWEEN THE PROPORTION OF LATE WOOD AND THE RESISTANCE TO ABRASION WEAR IN THE CROSS-SECTION OF BLACK LOCUST WOOD (*Robinia pseudoacacia* L.)

KORELACIJA IZMEĐU UDJELA KASNOG DRVA I OTPORNOSTI NA ABRAZIJSKO TROŠENJE U POPREČNOM PRESJEKU DRVA BAGREMA (*Robinia pseudoacacia* L.)

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Professional paper / Stručni rad

Abstract

The main aim of this work was to determine how the distance from the heartwood and the latewood percentage affect the abrasion resistance of black locust wood (*Robinia pseudoacacia*) in the cross section. The abrasion resistance test was performed on a Taber abrader. The research results showed that the proportion of latewood has a great influence on the intensity of abrasive wear. There is a strong negative linear correlation between the proportion of latewood and wear intensity with a high coefficient $R=-0.717$. The values of the measured proportions of latewood on the test samples range from 41.5 % to 86.8 %. The resistance to abrasion wear of black locust wood does not depend on the position of the samples in relation to the pith.

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Keywords: *abrasion wear resistance, black locust, latewood percentage*

Sažetak

Glavni cilj ovog rada je bio odrediti kako udaljenost od srčike i udio kasnog drva utječu na abrazijsku otpornost drva bagrema (*Robinia pseudoacacia*) na poprečnom presjeku. Ispitivanje otpornosti na abrazijsko trošenje provedeno je na uređaju Taber abrader. Rezultati istraživanja pokazali su da udio kasnog drva ima veliki utjecaj na intenzitet abrazijskog trošenja. Između udjela kasnog drva i intenziteta trošenja postoji jaka negativna linearna korelacija uz visoki koeficijent $R=-0,717$. Vrijednosti izmjerenih udjela kasnog drva na ispitnim uzorcima kreću se u rasponu od 41,5 % do 86,8 %. Otpornost na abrazijsko trošenje drva bagrema ne ovisi o poziciji uzoraka u odnosu na srčiku.

Ključne riječi: *otpornost na abrazijsko trošenje, bagrem, udio kasnog drva*

TESTING OF POLYURETHANE AND POLYSILOXAN COATINGS FOR IMPACT RESISTANCE

ISPITIVANJE POLIURETANSKIH I POLISILOKSANSKIH PREMAZA NA UDARNO DJELOVANJE

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Conference abstract / Kongresno priopćenje

Abstract

Polyurethane-based coatings and polysiloxane-based coatings have been widely applied in the protection of metal products and metal structures in a highly corrosive environment. They find their application especially in energy industry, maritime industry, production and distribution of oil and gas and civil structures. These coatings represent elastic waterproof membranes that are mainly made of highly resistant polymer material. The advantages of polyurethane and polysiloxane coatings are resistance to UV radiation, durability and ease of application and maintenance. An important characteristic in assessing the quality of the coating and the level of protection that the coating provides is its impact resistance, i.e. rapid deformation, whereby the metal substrate is plastically deformed. Therefore, in accordance with ISO 6272, samples with polyurethane coatings (Hempathane 55610, Hempathane 55210, Ching ASD 47 and Ching ADD 43) and a sample with polysiloxane coating (Hempaxane 55030) were tested and test results are presented. This study is part of the project "Smart plant for drying liquid coatings" which is co-financed within the Operational Programme Competitiveness and Cohesion from the European Regional Development Fund under reference number KK.01.2.1.02.0030.

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Keywords: *Polyurethane-based coatings, polysiloxane-based coatings, impact resistance.*

Sažetak

Premazi na bazi poliuretana i premazi na bazi polisiloksana široko su primijenjeni u zaštiti metalnih proizvoda i metalnih konstrukcija u jako korozivnom okruženju. Svoju primjenu naročito nalaze u energetici, pomorstvu, proizvodnji i distribuciji nafte i plina te građevinarstvu. Ovi premazi predstavljaju elastičnu vodonepropusnu barijeru koja je uglavnom izrađena od visoko otpornog polimernog materijala. Prednosti poliuretanskih i polisiloksanskih premaza jesu otpornost na UV zračenje, dugotrajnost te jednostavnost za primjenu i održavanje. Važna karakteristika u procjeni kvalitete premaza i razine zaštite koju premaz pruža jest njegova otpornost na udar, odnosno brzu deformaciju, pri čemu se metalna podloga plastično deformira. Stoga su, sukladno normi ISO 6272, ispitani uzorci sa poliuretanskim premazima (Hempathane 55610, Hempathane 55210, Ching ASD 47 i Ching ADD 43) te uzorak sa polisiloksanskim premazom (Hempaxane 55030) i predstavljeni su rezultati testiranja. Istraživanje je provedeno u sklopu projekta „Pametno postrojenje za sušenje tekućih premaza (Referentna oznaka: KK.01.2.1.02.) kojeg je sufinancirala Europska unija iz Europskog fonda za regionalni razvoj.

Ključne riječi: *poliuretanski premazi, polisiloksanski premazi, otpornost na udar.*

WIRE ARC ADDITIVE MANUFACTURING OF 15-5 PH PRECIPITATION HARDENING MARTENSITIC STAINLESS STEEL

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Original scientific paper / Izvorni znanstveni rad

Abstract

The research presents Wire Arc Additive Manufacturing (WAAM) of precipitation hardening martensitic stainless steel 15-5 PH, which has a wide range of applications. The deposited material was precipitation hardened by solution annealing and aging heat treatments. Parametric analysis of both heat treatments was done at different temperatures and times. Material characterization was done in as deposited, solution annealed, and precipitation hardened conditions. Studies included optical microscopy and scanning electron microscopy (SEM/EDS) microstructure analysis, hardness measurement, tensile and instrumented impact toughness testing. As deposited 15-5 PH steel microstructure was composed of martensite laths along with delta ferrite. With optimisation of solution annealing homogeneous austenite and dissolve delta ferrite was achieved in WAAM microstructure. Precipitation hardening of WAAM 15-5 PH resulted in similar hardness, tensile and impact properties compared to conventionally produced 15-5 PH steel.

Keywords: *Wire arc additive Manufacturing, stainless steel 15-5 PH, solution annealing, precipitation hardening, martensitic stainless steel*

PHYSICAL AND CHEMICAL PROPERTIES OF HIGH-TEMPERATURE COATINGS

FIZIKALNA I KEMIJSKA SVOJSTVA VISOKOTEMPERATURNIH PREMAZA

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Original scientific paper / Izvorni znanstveni rad

Abstract

High-temperature coatings play a crucial role in protecting surfaces exposed to extreme temperatures, corrosion, and other harsh environments. This paper focuses on the physical and chemical properties of high-temperature coatings, including their thermal stability, adhesion, hardness, wear resistance, and chemical resistance. The study investigates the effects of different coating parameters such as thickness, composition, and application method on the coating properties. Accordingly, tests of hardness, pull-off and cross-cut adhesion tests, salt and humid chamber tests were determined on samples. The results show that high-temperature coatings in general exhibit excellent thermal stability, high adhesion strength, and good resistance to wear and chemicals, except in the conditions of a salty atmosphere. The coating performance is affected by the thickness, composition, and application method, and optimal parameters should be selected based on the intended use and environmental conditions. This study can be useful for coating manufacturers, users, and researchers interested in understanding the physical and chemical properties of high-temperature coatings and their applications in various industries.

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Keywords: *Corrosion, high-temperature coatings, physical properties, chemical properties.*

Sažetak

Visokotemperaturni premazi igraju ključnu ulogu u zaštiti površina izloženih ekstremnim temperaturama, koroziji i drugim nepovoljnim uvjetima. Ovaj rad fokusira se na fizička i kemijska svojstva visokotemperaturnih premaza, uključujući njihovu termičku stabilnost, adheziju, tvrdoću, otpornost na trošenje i kemikalije. Studija istražuje učinke različitih parametara premaza poput debljine, sastava i metoda aplikacije na svojstva premaza. U skladu s tim, na uzorcima su provedeni su testovi tvrdoće, odvajanja i presjeka adhezije („Cross-cut“), testovi slane komore i testovi vlažne komore. Rezultati pokazuju da visokotemperaturni premazi u načelu imaju izvrsnu termičku stabilnost, visoku adhezijsku čvrstoću i dobru otpornost na trošenje i kemikalije, osim u uvjetima slane atmosfere. Na performanse premaza utječu debljina, sastav i metoda aplikacije te bi optimalni parametri trebali biti odabrani na temelju namjene i okolišnih uvjeta. Ova studija može biti korisna za proizvođače premaza, korisnike i istraživače zainteresirane za razumijevanje fizičkih i kemijskih svojstava visokotemperaturnih premaza i za njihovu primjenu u raznim industrijama.

Ključne riječi: *Korozija, visokotemperaturni premazi, fizička svojstva, kemijska svojstva.*

NANOINDENTATION CHARACTERIZATION OF SYNTHETIC PELVIC PROLAPSE MESH MATERIALS

NANOINDENTACIJSKA KARAKTERIZACIJA SINTETIČKIH TIPOVA MREŽICA ZA TRETIRANJE PROLAPSA ORGANA MALE ZDJELICE

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Original scientific paper / Izvorni znanstveni rad

Abstract

Pelvic organs prolapse (POP) is a common condition that affects a significant proportion of women worldwide, and surgical mesh implantation has emerged as a viable treatment option. However, the biomechanical properties of different mesh materials may vary and can influence their long-term clinical outcomes. Therefore, this study aims to evaluate the mechanical properties of various commercially available POP meshes using nanoindentation. Nanoindentation is a reliable and accurate method to determine the mechanical characteristics of small materials at the nanoscale level. Several mechanical properties, including hardness, elastic modulus, and viscoelastic properties, will be investigated. The findings of this study will provide essential information on the mechanical behavior of different POP meshes and assist clinicians in selecting the most suitable mesh for their patients. Ultimately, this research could improve the long-term efficacy and safety of surgical mesh implants for treating POP, reducing the burden of this debilitating condition for women worldwide.

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***Keywords:** pelvic proplapse mesh, nanoindentation, implant, biomechanical properties.*

Sažetak

Prolaps organa male zdjelice (POP) često se javlja kod značajnog broja žena širom svijeta, a kirurška implantacija mrežica postala je održiva opcija za liječenje ovog stanja. Međutim, biomehanička svojstva različitih materijala mrežica mogu varirati i utjecati na dugoročne kliničke ishode. Stoga je cilj ovog istraživanja procijeniti mehanička svojstva različitih komercijalno dostupnih mrežica za POP primjenom nanoindentacije. Nanoindentacija je pouzdana i točna metoda za određivanje mehaničkih karakteristika sitnostrukturiranih materijala. Istražit će se nekoliko mehaničkih svojstava, uključujući tvrdoću, elastični modul i viskoelastična svojstva. Rezultati ovog istraživanja pružit će važne informacije o mehaničkom ponašanju različitih mrežica za POP i pomoći kliničarima u odabiru najprikladnije mrežice za njihove pacijente. Konačno, ovo istraživanje bi moglo poboljšati dugoročnu učinkovitost i sigurnost kirurških implantata mrežica za liječenje POP-a, smanjujući teret ovog onesposobljavajućeg stanja za žene diljem svijeta.

***Ključne riječi:** prolaps organa zdjelice, nanoindentacija, implantat, biomehanička svojstva.*

CHALLENGES IN PREPARATION OF MWCNT/AlSi9Cu3(Fe) NANOCOMPOSITES

IZAZOVI U PRIPREMI MWCNT/AlSi9Cu3(Fe) NANOKOMPOZITA

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Invited lecture / Pozvano predavanje

Abstract

If materials of better mechanical properties are obtained by the preparation of composites and nanocomposites, the car part can be produced thinner or lighter, which ultimately leads to a reduction in car mass and fuel consumption, as well as the emission of carbon (IV) oxide (CO₂) into the atmosphere. In this work, nanocomposite materials based on AlSi9Cu3 (Fe) Aluminium alloy and Multi-Walled Carbon Nanotubes (MWCNTs) were prepared by High Pressure Die Casting. The prepared nanocomposites have significantly better mechanical properties and potential for application in the automotive industry, although the preparation process requires further research and refinement. The influence of natural and artificial aging on the new material is also examined.

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Keywords: AlSi9Cu3(Fe) alloy, MWCNT, nanocomposites, mechanical properties, HPDC

Sažetak

Ukoliko se pripremom kompozita i nanokompozita dobiju materijali boljih mehaničkih svojstava, automobilski dio može se proizvesti tanji, što u konačnici dovodi do smanjenja mase automobila te potrošnje goriva, kao i emisije ugljikovog (IV) oksida (CO₂) u atmosferu. U ovom radu pripremljeni su nanokompozitni materijali na bazi aluminijske legure AlSi9Cu3(Fe) i višestijenih ugljikovih nanocijevi (engl. *Multi-Walled Carbon Nanotubes*, MWCNT) kao ojačala postupkom visokotlačnog lijevanja. Pripremljeni nanokompoziti imaju značajno bolja mehanička svojstva i potencijal za primjenu u autoindustriji, premda postupak pripreme zahtjeva daljnja istraživanja i doradu. Ispituje se i utjecaj prirodnog i umjetnog starenja na novi materijal.

Ključne riječi: legura AlSi9Cu3(Fe), višestijene ugljikove nanocijevi, nanokompoziti, mehanička svojstva, visokotlačno lijevanje

WEAR RESISTANCE OF CASUAL MAN'S SOCKS

OTPORNOST MUŠKIH KRATKIH ČARAPA NA TROŠENJE

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Invited lecture / Pozvano predavanje

Abstract

Socks are knitted next-to-skin-type garments worn on the feet, often covering the ankle and part of the calf. They should maintain their quality throughout their lifetime and must meet high wear resistance requirements, especially a higher abrasion resistance and lower propensity to surface pilling. Abrasion, which is an unavoidable problem, usually occurs on the heel, sole and toes of the socks. In the first stage of abrasion, the small pill balls get tangled due to the loose fibres that shed from the knitted surface when worn, resulting in an undesirable appearance and unpleasant hassle. Eventually, the fibres that bind the pills to the surface break down, creating holes or thinning. Since the wear resistance of socks depends on their construction and the fibres used, it is very important to choose the yarns for their manufacture. As a rule, men's casual socks are made of a high percentage of cotton to ensure softness and comfort, and are blended with polyamide and/or Lycra to improve fit, durability and shrink resistance. Therefore, this work evaluated the wear resistance of men's socks with the highest cotton content made in full plating with yarns of different composition (polyamide 6.6, Lycra/cotton, Lycra/polyamide 6.6), as well as with polyamide 6.6 yarns of different linear density, and socks made of artificial cellulose fibres (viscose, modal or lyocell) with polyamide 6.6 yarns, which are still insufficiently researched.

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***Keywords:** socks, abrasion resistance, propensity to surface pilling, materials testing.*

Sažetak

Čarape su pleteni odjevni proizvodi namijenjeni odijevanju nogu, prekrivajući pritom stopalo, gležanj i dio potkoljenice. Moraju zadovoljiti visoke zahtjeve koji se postavljaju na njihovu uporabnu trajnost, a posebice otpornost na trošenje koja se očituje kroz veću otpornost na habanje i smanjenu sklonost pojave površinskoga pilinga. Posljedične pojave habanja najčešće se javljaju na peti, tabanskom dijelu i prstima čarape. Pritom se ponajprije na površini pletiva čarapa javljaju zamršene nakupine izvučenih vlakana rezultirajući smanjenom estetikom i neugodnim opipom, a dodatnim trošenjem materijala stanjenjem površine ili pojavom prohabavanja. Kako otpornost na trošenje ovisi o konstrukciji pletiva i sirovinskom sastavu čarapa, iznimno je važno odabrati odgovarajuće pređe za njihovu izradu. Uobičajeno se izrađuju od pamuka, koji osigurava mekoću i udobnost, u mješavini s elastičnom pređom iz poliamida i/ili elastana zbog bolje pristalosti i trajnosti. Stoga će se u ovome radu istražiti otpornost na trošenje muških čarapa izrađenih iz pamuka u mješavini s platirnom pređom različita sastava (PA 6.6, elastan/pamuk, elastan/PA 6.6) te platirnom pređom iz poliamida 6.6 različite finoće, kao i nedovoljno istraženih umjetnih celuloznih vlakana (viskoze, modala ili liocela) u mješavini s poliamidom 6.6.

***Ključne riječi:** čarape, otpornost na abraziju, sklonost površinskom pilingu, ispitivanje materijala.*

CORROSION ENHANCEMENT OF PM PROCESSED MAGNESIUM BY TURNING NATIVE OXIDE ON MG POWDERS INTO CARBONATES

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Original scientific paper / Izvorni znanstveni rad

Abstract

In addition to its use as a lightweight material, pure magnesium is a promising candidate for prospective bioimplants considering its excellent biocompatible properties. Regardless of what Mg application is used, the ultimate goal is to improve magnesium's mechanical properties and degradation behaviour. Because of the high affinity for oxygen native oxide layer of gas-atomized powders is naturally formed in contact with the atmosphere. S/TEM investigation of the native oxide of the Mg powder particles revealed a nonhomogenous nano-crystalline MgO layer. MgO is relatively soluble in water and does not provide sufficient corrosion protection. Among various surface treatment methods, conversion of the non-protective magnesium oxide to carbonate products is possible depending on the environmental conditions. This work used a simple experimental method using CO₂ and water vapour to achieve surface carbonation of Mg powders. Two carbonated samples and pure magnesium were prepared by direct extrusion. The samples after carbonation retained good mechanical properties and the layer of carbonates had a significant impact on corrosion resistance. 1 day carbonation resulted in transformation of native oxide into amorphous layer and reduction of corrosion rate. Longer carbonation (10 days) revealed layer growth and transformation of native oxide to crystalline nesquehonite structure.

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Keywords: *Magnesium powder, native oxide, surface modification, corrosion.*

THE INFLUENCE OF PROCESS PARAMETERS IN WIRE AND ARC ADDITIVE MANUFACTURING OF STAINLESS STEEL STRUCTURES

UTJECAJ PARAMETARA PROCESA PRI ADITIVNOJ PROIZVODNJI ELEKTRIČNIM LUKOM I ŽICOM STRUKTURA OD NEHRĐAJUĆIH ČELIKA

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Original scientific paper / Izvorni znanstveni rad

Abstract

Wire and arc additive manufacturing (WAAM) is an advanced manufacturing process in which electric arc melts additional material as it is in standard electric arc welding processes. By gradually adding molten material in different directions it enables efficient fabrication of components with complex geometry or components made from expensive materials. MIG welding process used for WAAM enables additive manufacturing of large-scale metal components. In this experiment MIG welding was utilized as WAAM process for production of stainless steel structures in the form of a walls. Two samples were made with different welding parameters (voltage, current, and welding speed). The surface topography, cross section structure and mechanical properties of produced structures have been analysed. Different welding parameters had an impact on measured properties of the specimens, so finally results were presented and conclusions have been drawn.

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***Keywords:** Wire and arc additive manufacturing, stainless steel, surface topography,*

Sažetak

Aditivna proizvodnja električnim lukom i žicom (engl. WAAM) napredan je proizvodni proces u kojem električni luk tali dodavani materijal jednako kao i pri elektrolučnim postupcima zavarivanja. Postupno dodavanje rastaljenog materijala u različitim smjerovima omogućuje učinkovitu izradu komponenti složene geometrije ili komponenti izrađenih od skupih materijala. MIG postupak zavarivanja koji se koristi za WAAM omogućuje aditivnu proizvodnju komponenti većih dimenzija. U ovom eksperimentu MIG zavarivanje je korišteno kao WAAM proces za proizvodnju konstrukcija iz nehrđajućeg čelika u obliku stijenki. Izrađena su dva uzorka uz primjenu različitih parametara zavarivanja (napon, struja i brzina zavarivanja). Analizirana je topografija površine, struktura presjeka i mehanička svojstva proizvedenih konstrukcija. Različiti parametri zavarivanja utjecali su na izmjerena svojstva uzoraka te su na kraju prikazani rezultati i izvedeni zaključci.

***Ključne riječi:** aditivna proizvodnja električnim lukom i žicom, nehrđajući čelik, topografija površine*

SUSTAINABLE CELLULOSE-BASED PACKAGING: OPPORTUNITIES AND CHALLENGES

ODRŽIVA AMBALAŽA NA BAZI CELULOZE: MOGUĆNOSTI I IZAZOVI

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Review paper / Pregledni rad

Abstract

Packaging plays a vital role in society by protecting products, facilitating communication with consumers, and providing product information. However, the escalating consumption rates have led to an increased demand for diverse packaging types, resulting in excessive accumulation of packaging waste within the paper recycling system. Conversely, fibers derived from paper packaging serve as valuable raw materials for producing recycled packaging paper. To ensure the desired quality of recycled fibers, ongoing research is required to explore recycling technologies, address challenges, and identify opportunities associated with packaging materials. The integration of eco-design principles into the packaging design and manufacturing process is crucial. Residual ink and impurities in recycled pulp may contain toxic compounds that raise concerns regarding the safety of food packaging. Organic recycling is proposed as a suitable method for food-contaminated packaging. Consequently, the pursuit of modifications to enhance the properties of paper packaging presents a significant challenge. There is a lack of research dealing with the impact of different additives used for paper modification on the feasibility of material and organic recycling.

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Keywords: *sustainability, packaging, cellulose, modification, challenges, opportunities*

Sažetak

Ambalaža igra vitalnu ulogu u društvu jer štiti proizvode, olakšava komunikaciju s potrošačima i pruža informacije o proizvodu. Međutim, sve veća potrošnja dovela je do povećane potražnje za različitim vrstama ambalaže, što je rezultiralo prekomjernim nakupljanjem ambalažnog otpada u sustavu recikliranja papira, što predstavlja dodatni problem. Vlakna dobivena iz papirne ambalaže služe kao vrijedne sirovine za proizvodnju recikliranog materijala. Kako bi se osigurala željena kvaliteta recikliranih vlakana, potrebna su kontinuirana istraživanja kako bi se istražile tehnologije recikliranja. Integracija načela ekološkog dizajna u dizajn ambalaže i proizvodni proces je ključna. Tiskarska boja i druge residualne nečistoće u recikliranoj pulpi mogu sadržavati otrovne spojeve koji izazivaju zabrinutost u pogledu sigurnosti pakiranja hrane. Organsko recikliranje predlaže se kao prikladna metoda za zbrinjavanje ambalaže kontaminirane hranom. Posljedično, potraga za modifikacijama za unaprjeđenje svojstava papirne ambalaže predstavlja značajan izazov. Ne postoji dovoljno istraživanja o utjecaju različitih aditiva koji se koriste za modifikaciju papira na učinkovitost materijalnog i organskog recikliranja.

Ključne riječi: *održivost, pakiranje, celuloza, modifikacija, izazovi, prilike*

THE INFLUENCE OF RUBBING ON SOLID FIBERBOARD PRINTS

UTJECAJ OTIRANJA OTISAKA NA VALOVITOJ LJEPENKI

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Preliminari notice / Prethodno priopćenje

Abstract

Materials in the graphic industry are developing exponentially, especially in the packaging sector, where solid fiberboard is one of the most important products in this sector.

Today, graphic products are made according to uniform print quality standards almost all over the world. However, in order to avoid differences in the understanding of print quality, the development of materials involves the problem of standardization of parameters that enable the production of a quality product, which refer to materials that, by their characteristics, are very problematic for printing. This is why it is very important to follow the development of materials and scientifically prove the standards that follow such development. The experimental results in this paper show the values of the dot gain of prints created on solid fiberboard before and after mechanical influences on the surface of the material.

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Keywords: *Solid Fiberboard, Printing, Quality, Graphic reproduction, Deformation of screen elements*

Sažetak

Materijali u grafičkoj industriji se eksponencijalno razvijaju, posebno u dijelu ambalaže gdje je valovita ljepenka jedan od najvažnijih proizvoda u navedenom sektoru. Grafički proizvodi se danas izrađuju po ujednačenim normama kvalitete tiska u skoro cijelom svijetu. Međutim, kako ne bi došlo do razilaženja u shvaćanju kvalitete otiska, razvoj materijala povlači za sobom i problem standardizacije parametara koji omogućuju izradu kvalitetnog proizvoda, a koji se odnose na materijale koji su po svojim karakteristikama vrlo problematični za otiskivanje. Zbog toga je vrlo važno praćenje razvoja materijala i znanstveno dokazivanje standarda koji slijede takav razvoj. Eksperimentalni rezultati u ovom radu pokazuju vrijednosti prirasta rastertonskih vrijednosti otisaka nastalih na valovitim ljepenka i to prije i nakon mehaničkih utjecaja na površinu materijala.

Ključne riječi: *Valoviti karton, Tisak, Kvaliteta, Grafička reprodukcija, Deformacija rasterskih elemenata*

BORIDE LAYER GROWTH KINETICS ON X90CrMoV-18 STEEL

KINETIKA RASTA BORIDNOG SLOJA NA ČELIKU X90CRMV-18

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Conference abstract / Kongresno priopćenje

Abstract

Boronizing is a type of thermal diffusion process with primary goal of increasing the surface hardness, wear, and corrosion resistance. Wear resistance of boronized parts depends on the type of borides that form on steel surface and their thickness. This paper focuses on evaluation of borides layers that form on martensitic stainless steel X90CrMoV-18. Pack boronizing was carried out at temperature range of 850-1000°C in duration of 1, 3 and 5 hours. After boronizing differences in surface boride layers were observed for different temperatures and time of boriding. Boriding compound depth and cross section hardness was measured. Results indicate difference in boride layer thickness and volume share of boride phases depending on temperature and time of boriding.

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Keywords: X90CrMoV-18, Arrhenius equation

Sažetak

Boriranje je vrsta toplinsko difuzijske obrade s primarnim ciljem povećanja površinske tvrdoće, otpornosti na trošenje i korozije. Otpornost na trošenje boriranih dijelova ovisi o vrsti borida koji nastaju na površini čelika i njihovoj debljini. U ovom radu ispitana je kinetika rasta boridnih slojeva na martezičnom nehrđajućem čeliku X90CrMoV-18. Boriranje je provedeno u granulatu na temperaturama od 850 do 1000°C, u trajanju od 1, 3 i 5 sati. Nakon boriranja ispitane su razlike u nastalim boridnim slojevima za različite temperature i vremena boriranja. Izmjerena je debljina boridnog sloja i tvrdoća po poprečnom presjeku uzoraka. Rezultati pokazuju razliku u debljini boridnog sloja i volumnom udjelu boridnih faza u ovisnosti o temperaturi i vremenu boriranja.

Ključne riječi: X90CrMoV-18, Arrheniusova jednadžba