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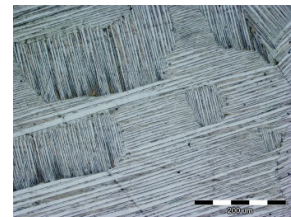
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19. MEĐUNARODNO SAVJETOVANJE LJEVAČA

Ljudi – Vrijedan resurs za razvoj ljevarske industrije

19th INTERNATIONAL FOUNDRYMEN CONFERENCE

Humans - Valuable Resource for Foundry Industry Development



Split, 16.-18. lipnja 2021. / Split, June 16th-18th, 2021

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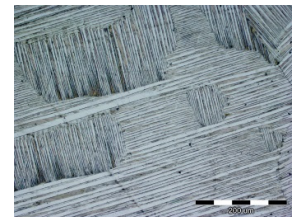
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19. MEĐUNARODNO SAVJETOVANJE LJEVAČA: Ljudi – Vrijedan resurs za razvoj ljevarske industrije

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PREDGOVOR

Znanje postaje sve važniji resurs gospodarskog razvoja. Republika Hrvatska suočena je s izazovima svjetskog gospodarstva prema kojima, između ostalog, mora ispuniti određene zahtjeve u oblikovanju obrazovnog sustava. Osiguranje jamstva kvalitete obrazovnog sustava samo je jedan od zahtjeva koje Sveučilište u Zagrebu Metalurški fakultet kao i ostali suorganizatori iz visokog obrazovanja imaju postavljeno kao kontinuiranu misiju. Kako stupanj obrazovanja stanovništva utječe na napredak gospodarstva, za Republiku Hrvatsku iznimno je važno povećati udio visokoobrazovanih stručnjaka.

Metalna industrija kao temeljna grana gospodarstva predstavlja važan čimbenik koji doprinosi ekonomskom potencijalu svake zemlje. Trenutni razvoj tržišta, kao i tehnički i ekonomski cilj, proizvodnja visokokvalitetnog, jeftinog i ekološki prihvatljivog odljevka zahtijeva primjenu najnovijih i naprednih materijala, kao i proizvodnih tehnologija, praćenih i podržanih razumijevanjem proizvodnog procesa. Metalna industrija prepoznata je kao "pokretačka poddjelatnost" gospodarskog razvoja.

Ovo je prilika za susret gospodarstva i mladih stručnjaka te zapošljavanje kao glavni potencijal za razvoj poslovanja. Suživot znanosti o materijalima i održive tehnologije u gospodarskom rastu predstavljaju prijenos znanja između malih i srednjih poduzeća (MSP), industrije i visokoškolskih ustanova. Visoko obrazovanje na Metalurškom fakultetu (HEI), zamišljeno kroz program i ishode učenja, temelji se, između ostalog, na promicanju znanstvenog i istraživačkog rada studenata na primijenjenim temama, omogućavajući ambicioznim i kreativnim mladim ljudima da postanu neovisni rješavači problema, razvijanje i podržavanje njihove znatiželje, analitike i komunikacije: **Diplomci u skladu s tržištem rada!**

Predsjednica Organizacijskog odbora

Prof.dr.sc. Zdenka Zovko Brodarac



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PREFACE

Knowledge is becoming an increasingly important resource for economic development. The Republic of Croatia is facing the challenges of the world economy, with the aim to meet certain requirements in shaping the education system. Ensuring the quality assurance of the education system is just one of the requirements that the University of Zagreb Faculty of Metallurgy as well as other co-organizers from the high-education have set up as a continuous mission. In recent years, the ratio of the highly educated population of the Republic of Croatia has been growing, but in comparison with Europe, Croatia is still lagging behind. In order to increase the share of highly educated people, it is necessary to invest in the quality of education, both in higher education and in secondary and primary education. This would increase awareness of the importance of education, which would ultimately result in an increase in the share of **highly educated and competent professionals**.

Metal industry as a base branch represents an important factor contributing to the economic potential of each country. Current market development as well as technical and economic objective, the production of high-quality, low-cost and environmentally friendly casting, requires application of recent and advanced materials, as well as production technologies, followed and supported by understanding of production process. The metal industry has been recognized as a “driving subdivision” of economy development.

This is an opportunity for industry to meet and recruit human resources as a main potential for business development. Coexistence of material science and sustainable technology in economic growth represent a knowledge transfer between small and medium enterprises’ (SMEs’), industry and higher education institutions. Higher education at the Faculty of Metallurgy (HEI), conceived through the program and the learning outcomes, is based, inter alia, on promoting students’ scientific and research work on applied topics, enabling ambitious and creative young people to become independent problem solvers, developing and supporting their curiosity, analytics and communication: **Graduates like the labour market need!**

President of Organizing Board



Prof. Zdenka Zovko Brodarac, PhD



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PLAZMA ZAVARIVANJE NEHRĐAJUĆIH ČELIKA

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U radu je obrađeno plazma zavarivanje nehrđajućih čelika. Opisan je postupak plazma zavarivanja korištenjem automata za plazma zavarivanje šavnih cijevi od nehrđajućeg čelika. Prikazana je oprema korištena u eksperimentu te su navedeni parametri zavarivanja. Kako ovakav tip proizvoda zahtjeva i naknadnu toplinsku obradu nakon zavarivanja ista je također prikazana u radu. Prikazana su ispitivanja zavarenog spoja i konačnog proizvoda. U konačnici je donesen zaključak o korištenim parametrima i dobivenim rezultatima.

Ključne riječi: nehrđajući čelik, šavno zavarene cijevi, plazma zavarivanje

PLASMA ARC WELDING OF STAINLESS STEELS

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This paper describes plasma arc welding of stainless steels. Plasma arc welding of seam welded stainless steel pipes using automated plasma welding machine has been described. Utilized equipment in this experiment has been presented along with the welding parameters. As this type of the product requires post welding heat treatment the specified procedure has been presented. Testing of welded joints and final product examination has been presented. In conclusion selected parameters have been discussed and resulted product has been commented.

Keywords: stainless steel, seam welded pipes, plasma arc welding



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UTJECAJ ATMOSFERE PEĆI KOD TOPLINSKE OBRADJE KALJENJA ČELIKA C45E NA MIKROSTRUKTURU, TVRDOĆU I ŽILAVOST

Zvonimir Dadić, Zrinka Magazinović, Igor Ćulum

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Istraživanjem je definiran utjecaj atmosfere peći na čelik C45E. Provedena je toplinska obrada kaljenja u standardnoj atmosferi zraka i dušikovoj atmosferi zbog proučavanja štetnih pojava razugljčavanja i oksidacije. Parametri atmosfere peći kontrolirani su senzorima za postotak kisika, temperature, tlaka i relativne vlažnosti. Početno stanje uzoraka je u normaliziranom stanju. Usporedbom rezultata uzoraka uočena je razlika u tvrdoći i žilavosti. Uzorak zagrijavan u atmosferi dušika postigao je veću tvrdoću i manju žilavost od onog zagrijavanog u standardnoj atmosferi zraka. Metalografska analiza oba uzorka ukazuje na velik udio martenzitne mikrostrukture uz malu količinu nepretvorenog austenita. Istraživanjem je pokazano da pravilan odabir zaštitne atmosfere tokom toplinske obrade utječe na razugljčavanje i oksidaciju.

Ključne riječi: kaljenje, dušikova atmosfera, tvrdoća, žilavost, C45E

THE IMPACT OF FURNACE ATMOSPHERE DURING QUENCHING OF C45E STEEL ON MICROSTRUCTURE, HARDNESS AND IMPACT TOUGHNESS

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This research has shown the effect of furnace atmosphere on C45E steel. Quenching heat treatment was carried out in a standard air atmosphere and in a nitrogen atmosphere to study the harmful phenomena of decarburization and oxidation. Furnace atmosphere parameters were controlled by sensors for oxygen content, temperature, pressure and relative humidity. Normalized state was taken as the initial state of the samples. Comparison of the results has shown a disparity in hardness and impact toughness. The sample heated in nitrogen atmosphere achieved a higher hardness and lower impact toughness than the other heated in standard air atmosphere. Metallographic analysis of both samples indicated a mostly martensitic microstructure with a small amount of retained austenite. The study shows the importance of proper atmosphere selection during heat treatment on reducing the amount of decarburization and oxidation.

Keywords: quenching, nitrogen atmosphere, hardness, impact toughness testing, C45E steel



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BINDER AS BASIC FACTOR IN CORES PRODUCED BY COLD BOX ON SURFACE QUALITY OF CASTING

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The cold-box core production process is a high-performance and highly productive method of core production, which is used mainly in large-scale production of castings and is characterized by high reliability and productivity of the process. A characteristic feature of this process is its high reactivity, which allows short production cycles. One of the interesting factors influencing the surface quality of castings is the type of binder used and its quantity. Both components of the binder system, together with sand, are components of the core mixture from which the core is made by shot into the core mold and then purged with amine-based catalyst. In this work, different core mixtures were produced to evaluate the effect of various binders level on the quality of castings in specific conditions of the largest Slovak foundry. The strength and hardness of the cores were measured by flexural strength measuring device and by hardener and the surface quality of the test castings was monitoring by visual inspection. A total of 90 test bars were produced and 25 test castings were cast.

Keywords: cold-box, cores, binder



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ELEKTROKEMIJSKA ISPITIVANJA KOROZIJSKOG PONAŠANJA SIVOG I NODULARNOG LIJEVA U MEDIJU UMJETNE MORSKE VODE

Vjeran Furlan, Anita Begić Hadžipašić

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U ovom radu provedena su elektrokemijska ispitivanja sivog i nodularnog lijeva u mediju obične vode i umjetne morske vode u cilju preporuke koji od navedenih materijala je prikladniji za upotrebu u morskoj vodi. Rezultati dobiveni potenciodinamičkom polarizacijom ukazuju na sličnu korozivnu otpornost sivog i nodularnog lijeva u običnoj vodi, za razliku od medija umjetne morske vode, gdje je manju brzinu korozije pokazao nodularni ljev. Metalografska analiza ispitanih ljevova nakon korozije u umjetnoj morskoj vodi ukazuje na činjenicu da kloridni ioni iz otopine selektivno nagriza listiće grafita kod sivog lijeva, za razliku od nodularnog lijeva kod kojeg kloridni ioni selektivno napadaju metalnu osnovu/perlit. S obzirom na dobivene rezultate može se zaključiti da je uzorak ispitnog nodularnog lijeva korozivno otporniji u mediju umjetne morske vode od ispitnog uzorka sivog lijeva. Međutim, s obzirom na dobivene iznose brzine korozije, ispitani ljevovi se ne preporučuju za primjenu u morskoj vodi.

Ključne riječi: sivi ljev, nodularni ljev, brzina korozije, umjetna morska voda, mikrostruktura



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ELECTROCHEMICAL INVESTIGATIONS OF CORROSION BEHAVIOR OF GRAY AND NODULAR CAST IRON IN THE MEDIUM OF ARTIFICIAL SEAWATER

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In this paper, electrochemical investigations of gray and nodular cast iron in the medium of tap water and artificial seawater were carried out in order to recommend which of these materials is more suitable for use in seawater. The results obtained by potentiodynamic polarization indicate a similar corrosion resistance of gray and nodular cast iron in tap water, unlike artificial seawater media, where nodular cast iron showed a lower corrosion rate. Metallographic analysis of the investigated casts after corrosion in artificial seawater indicates that the chloride ions from the solution selectively erode graphite leaves in the gray cast iron, as opposed to the nodular cast iron where the chloride ions selectively attack the metal base/perlite. Considering the obtained results, it can be concluded that the sample of the tested nodular cast iron is more corrosion resistant in the medium of artificial seawater than the tested sample of gray cast iron. However, given the corrosion rate values obtained, the examined casts are not recommended for use in seawater.

Keywords: gray cast iron, nodular cast iron, corrosion rate, artificial seawater, microstructure



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ALGE – BUDUĆNOST ANTIKOROZIVNE ZAŠTITE?

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Široka primjena konstrukcijskih materijala često rezultira njihovim oštećenjima za koja je najzaduženija korozija. Kako bi se ista spriječila, podliježe se metodama zaštite i to sve više upotrebom zelenih inhibitora. More predstavlja izvor brojnih vrsta s potencijalnim antikorozivnim djelovanjem budući da iste obiluju čitavom lepezom organskih spojeva. Ispitano je djelovanje vodenog ekstrakta smeđe alge *Padina pavonica* (u volumnim koncentracijama 0,2 % i 0,8 %) na inhibiciju korozije bakra, AISI 304 nehrđajućeg čelika te aluminija tehničke čistoće u 0,5 mol dm⁻³ otopini NaCl. Izvršena je ekstrakcija fenolnih spojeva te je određen sadržaj ukupnih fenola. Daljnja su ispitivanja provedena elektrokemijskim metodama, dok je površina ispitivanih materijala analizirana optičkim mikroskopom. Na temelju dobivenih rezultata, vodeni ekstrakt *P. pavonica* moguće je klasificirati kao djelotvorni inhibitor korozije u ispitivanim uvjetima za sva tri metala, a posebno za aluminij, dok 0,8 %-tni ekstrakt ima prednost jer je ustanovljen porast djelotvornosti inhibicije porastom koncentracije inhibitora.

Ključne riječi: smeđe alge, inhibitor korozije, bakar, nehrđajući čelik, tehnički aluminij



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ALGAE – THE FUTURE OF CORROSION PROTECTION?

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Wide usage of construction materials often results in their damage, mainly caused by corrosion. As a mean to prevent it, materials are introduced to methods of protection, increasingly by using green inhibitors. The sea is a source of numerous species with potential anti-corrosive properties which are adorned with countless organic compounds. The aim was to study the inhibition effect of aqueous extract of brown alga *Padina pavonica* (in 0.2 % and 0.8 % (v/v) concentration) on corrosion of copper, AISI 304 stainless steel and technical aluminium in the 0.5 mol dm⁻³ NaCl solution. Total phenolic compounds were isolated and determined, the following experiments were conducted using electrochemical methods, while the surface of the samples was analysed using an optical microscope. Results revealed that examined extract can be classified as an efficient corrosion inhibitor for all three metals, especially for aluminium, and 0.8 % extract proved to be the more effective one.

Keywords: brown algae, corrosion inhibitor, copper, stainless steel, technical aluminium



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ELEKTROKEMIJSKO PONAŠANJE LEGURE CuAlMnZn U NaCl OTOPINI

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Elektrokemijsko ponašanje legure CuAlMnZn u 0,1, 0,5, 0,9 i 1,5 % NaCl otopini provedeno je mjerenjem potencijala otvorenog strujnog kruga, metodama linearne i potenciodinamičke polarizacije kao i metodom cikličke polarizacije. Utjecaj temperature elektrolita na koroziju CuAlMnZn legure ispitan je u 0,1 % NaCl otopini pri temperaturama elektrolita od 20, 30 i 40 °C. Povećanje koncentracije kloridnih iona kao i povišenje temperature elektrolita dovodi do negativiranja potencijala otvorenog strujnog kruga legure, povećanja gustoće korozijske struje i smanjenja vrijednosti polarizacijskog otpora. Korodirane površine elektroda nakon polarizacijskih mjerenja, ispitane su optičkim mikroskopom.

Ključne riječi: CuAlMnZn legura, korozija, elektrokemijske metode, optička mikroskopija

ELECTROCHEMICAL BEHAVIOUR OF CuAlMnZn ALLOY IN NaCl SOLUTION

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The electrochemical behaviour of CuAlMnZn alloy in 0.1, 0.5, 0.9 and 1.5 % NaCl solution was performed by measuring the open circuit potential, linear and potentiodynamic polarization methods as well as cyclic polarization method. The influence of electrolyte temperature on the corrosion of CuAlMnZn alloy was investigated in 0.1 % NaCl solution at electrolyte temperatures of 20, 30 and 40 °C. An increase in the concentration of chloride ions, as well as an increase in the electrolyte temperature, leads to a lowering open circuit potential value, an increase in the corrosion current density and a decrease in the value of the polarization resistance. After polarization measurements corroded electrode surfaces were examined with an optical microscope.

Keywords: CuAlMnZn alloy, corrosion, electrochemical methods, optical microscopy



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UTJECAJ BRZINE HLAĐENJE NA MIKROSTRUKTURU I TVRDOĆU ČELIKA 42CrMo4

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Čelik 42CrMo4 je niskolegirani ugljični čelik, legiran sa kromom i molibdenom. To je čelik namjenjen za poboljšanje. Čelici za poboljšanje su oni konstrukcijski čelici koji su na osnovu svog kemijskog sastava, posebno sadržaja ugljika, pogodni za kaljenje i naknadno popuštanje. U poboljšanom stanju ovi čelici imaju visoku žilavost i povećano naprezanje tečenja. Ovi čelici su našli svoju primjenu za statički i dinamički opterećene konstrukcijske dijelove motora i strojeva. U ovom radu su prikazani rezultati ispitivanja utjecaja brzine hlađenja na mikrostrukturu i tvrdoću čelika 42CrMo4. Za analizu mikrostrukture koristio se optički mikroskop Olympus s maksimalnim povećanjem 1000 x, a ispitivanje tvrdoće provedeno je u skladu sa standardom BAS EN ISO 6507-1:2018. Uzorci su zagrijavani u austenitno područje, a zatim hlađeni u peći, vodi, ulju i na zraku. Rezultati ispitivanja su pokazali da se s povećanjem brzine hlađenja povećava tvrdoća čelika zbog dobivanja neravnotežne mikrostrukture. Međutim, i pri malim brzinama hlađenja kao što je hlađenje na zraku može se dobiti neravnotežna mikrostruktura u ovisnosti od dimenzija komada i kemijskog sastava.

Ključne riječi: toplinska obrada, brzina hlađenja, mikrostruktura, tvrdoća



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EFFECT OF COOLING RATE AT MICROSTRUCTURE AND HARDNESS OF STEEL 42CrMo4

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Steel 42CrMo4 is a low-alloy carbon steel, alloyed with chromium and molybdenum. It is a steel intended for quenching and tempering. Steels for quenching and tempering are structural steels which are suitable for quenching and tempering on the basis of their chemical composition, in particular the carbon content. In this heat treated state, these steels have high toughness and increased yield strength. These steels have found their application for statically and dynamically loaded structural parts of engines and machines. This paper presents the results of testing the influence of cooling rate on the microstructure and hardness of 42CrMo4 steel. The Olympus optical microscope with a maximum magnification of 1000 x was used for the analysis of the microstructure, and the hardness test was done in accordance with the standard BAS EN ISO 6507-1:2018. The samples were heated to the austenitic temperature and then cooled in an oven, water, oil and air. The results showed that with increasing cooling rate, the hardness of steel increases due to obtaining a metastable microstructure. However, even at low cooling rates such as air cooling, a metastable microstructure can be obtained depending on the dimensions of the sample and the chemical composition.

Keywords: heat treatment, cooling rate, microstructure, hardness



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ISPITIVANJE MEHANIČKIH SVOJSTAVA BRODOGRAĐEVNOG ČELIKA POVIŠENE ČVRSTOĆE OZNAKE LR-AH36 PRI RAZLIČITIM TEMPERATURAMA

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U radu su prikazani rezultati ispitivanja mehaničkih svojstava brodograđevnog čelika povišene čvrstoće oznake LR-AH36 pri različitim temperaturama. Mjerenja su provedena statičkim vlačnim pokusom na kidalici MAN 60 koja je povezana s računalom, na kojoj se vlačnom silom djeluje na ispitni uzorak sve do pojave loma. Dio epruveta neposredno prije ispitivanja podvrgnut je pothlađivanju do temperature od -30 °C, a dio zagrijavanju do temperature od 650 °C. Dobiveni dijagrami pothlađenih epruveta jasno prikazuju točku granice razvlačenja dok je kod epruveta koje su bile izložene povišenim temperaturama ona slabije izražena. Iz rezultata se može zaključiti da granica razvlačenja i vlačna čvrstoća rastu snižavanjem temperature, a izduženje se smanjuje. Kod epruveta 8 i 11 uočena su manja odstupanja od navedenog zaključka.

Ključne riječi: čelik, mehanička svojstva, kidalica, granica razvlačenja, vlačna čvrstoća



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INVESTIGATION OF MECHANICAL PROPERTIES OF HIGH STRENGTH SHIPBUILDING STEEL LR-AH36 AT DIFFERENT TEMPERATURES

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Results of mechanical properties investigation of the increased strength shipbuilding steel, marked as LR-AH36, at different temperatures are presented in this paper. Measurements were performed by static tensile test on a MAN 60 tensile testing machine connected to a computer, on which the tensile force acts on the test specimen until fracture occurs. Before testing, one group of testing samples were subcooled at -30 °C and the other group were heated up to 650 °C. The obtained diagrams of subcooled samples clearly show the point of the yield strength, while in the case of samples exposed to elevated temperatures it is less pronounced. From the results it can be concluded that the yield strength and tensile strength increase with decreasing temperature, and the elongation decreases. In the case of two test tubes, 8 and 11, minor deviations from the stated conclusion were observed.

Keywords: steel, mechanical properties, tensile testing machine, yield strength, tensile strength



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UTJECAJ MODIFIKACIJE I DEBLJINE STIJENKE NA SVOJSTVA AISi12 LEGURE

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U ovom radu analiziran je utjecaj modifikacije dodatkom natrija i stroncija te debljine stijenke na slijed skrućivanja, mikrostrukturu te mehanička svojstva AISi12 legure eutektičkog sastava. Modifikacija eutektika ($\alpha_{Al} + \beta_{Si}$) rezultira transformacijom morfologije eutektičke β_{Si} faze iz grube pločaste u finu vlaknastu s ciljem poboljšanja mehaničkih svojstava odljevaka. Legure su sintetizirane u indukcijskoj peći pretaljivanjem AISi12 bloka uz korekciju kemijskog sastava dodatkom AISi50 %, AlTi10 te AlMn predlegura. Nakon cijepjenja dodatkom AlTiB predlegure, taline su modificirane natrijem pri temperaturi od 720 °C, odnosno AlSr10 predlegurom pri temperaturi od 780 °C. Nakon obrade cijepljenjem te modifikacijom, taline su odlivene u stepenastu probu s debljinama stijenke od 15, 20, 25 i 30 mm uz praćenje promjene temperature s vremenom jednostavnom toplinskom analizom (STA). Povezivanjem rezultata STA, metalografske analize te statičnog vlačnog pokusa uočena je razlika u karakterističnim temperaturama faznih transformacija te pojava različitih morfologija eutektika koja direktno utječe na vrijednosti vlačne čvrstoće odljevaka.

Ključne riječi: AISi12 legura, modifikacija, debljina stijenke, mikrostruktura, mehanička svojstva



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IMPACT OF MODIFICATION AND WALL THICKNESS ON THE PROPERTIES OF AISi12 ALLOY

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The effect of sodium and strontium modification and the wall thickness on solidification, microstructure and mechanical properties of eutectic AISi12 alloy were analysed. Modification of eutectic ($\alpha_{Al} + \beta_{Si}$) leads to transformation of eutectic β_{Si} phase morphology, from coarse lamellar to fine fibrous, in order to improve mechanical properties. The alloys were synthesized in an induction furnace by melting of AISi12 block and correction of chemical composition using AlSi50 %, AlTi10 and AlMn master alloys. After grain refinement with AlTiB, the melts were modified with sodium at 720 °C and AlSr10 at 780 °C, respectively. After treatment, melts were poured into a step casting with wall thickness of 15, 20, 25 and 30 mm. The simple thermal analysis (STA) was used to acquire temperature/time changes. Correlating STA, metallographic analysis and static tensile test results revealed differences in characteristic temperatures of phase transformations and the occurrence of different morphologies of eutectics which directly influence on tensile strength values.

Keywords: AISi12 alloy, modification, wall thickness, microstructure, mechanical properties



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UTJECAJ TOPLINSKIH OBRADA NA SVOJSTVA MARAGING ČELIKA DOBIVENOG ADITIVNIM POSTUPKOM SELEKTIVNOG LASERSKOG TALJENJA

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Selektivno lasersko taljenje ili SLM je aditivni postupak izravne proizvodnje prototipa, alata i funkcionalnih dijelova gdje se koristi laserska zraka visokog intenziteta koja tali i spaja sitne čestice metalnog praha. Tako je moguće proizvesti geometrijski vrlo zahtjevne dijelove skoro 100 %-tne gustoće čija su mehanička svojstva usporedna konvencionalno proizvedenim dijelovima. MARAGING čelici su visokočvrsti konstrukcijski čelici koji se zbog svojih izvrsnih mehaničkih i tehnoloških svojstava, prvenstveno kombinacije dobre čvrstoće i duktilnosti, koriste i za izradu alata za topli rad. U sklopu ovog ispitivanja napravljeni su uzorci od X3 NiCoMoTi 18-9-5 MARAGING čelika SLM postupkom s dvije različite debljine sloja taljenja praha. Dio uzoraka samo je podvrgnut starenju, a na dijelu uzoraka provedena je klasična toplinska obrada za MARAGING čelike, otapajuće žarenje + starenje. Toplinski obrađeni uzorci uspoređeni su s „as-built“ stanjem analizom mikrostrukture i ispitivanjem mikrotvrdoće.

Ključne riječi: aditivna proizvodnja, SLM, MARAGING čelik, toplinska obrada, karakterizacija mikrostrukture



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INFLUENCE OF HEAT TREATMENT ON THE PROPERTIES OF MARAGING STEEL PRODUCED BY ADDITIVE SELECTIVE LASER MELTING PROCESS

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Selective laser melting or SLM is an additive production process which can be used for direct production of prototypes, tools and functional parts. High intensity laser beam is used for melting and joining tiny particles of metal powder and thus it is possible to produce geometrically very complex parts of almost 100 % density whose mechanical properties are comparable to conventionally produced parts. MARAGING steels are high strength steels that are used for the manufacturing of different structural parts but also for the manufacturing of tools due to their excellent combination of mechanical and technological properties such as high strength with very good ductility. Within this research, test samples were made from X3 NiCoMoTi 18-9-5 MARAGING steel with SLM additive process. Samples were heat treated with two different set of parameters. On such treated samples microstructure was analyzed and microhardness was tested and compared with samples in as built condition.

Keywords: additive manufacturing, SLM, MARAGING steel, heat treatment, microstructure characterization

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