J. Medved, T. Balaško, A. Šalej Lah in M. Vončina
Univerza v Ljubljani, Naravoslovnotehniška fakulteta, Oddelek za materiale in metalurgijo (SI) /
University of Ljubljana, Faculty of Natural Sciences and Engineering, Department of Materials and Metallurgy (SI)

# Poslanstvo visokošolskega izobraževanja pri usposabljanju strokovnjakov in prenosu znanja v industrijo

# The Role of Higher Education in the Training of Professionals and the Transfer of Knowledge to Industry

**Povzetek**

Visokošolsko usposabljanje je proces, ki študentom omogoča pridobivanje naprednega znanja, veščin in kompetenc, potrebnih za uspešno kariero v izbranem strokovnem področju in je ključnega pomena za razvoj in napredek v industriji ter raziskavah. Temeljni cilj visokošolskega izobraževanja na področju materialov in metalurgije je usposobiti strokovnjaka, ki bo pridobil poglobljena in usmerjena znanja in veščine iz temeljnih področij metalurgije in materialov in so bistvena za številne industrijske panoge. Študij na Oddelku za materiale in metalurgijo, Naravoslovnotehniške fakultete, Univerze v Ljubljani, poteka na vseh nivojih visokošolskega izobraževanja in ima najdaljšo tradicijo izobraževanja v Sloveniji na tem področju. V okviru študija poteka neposredno sodelovanje z industrijsko prakso preko seminarskih del, praktičnega usposabljanja in zaključnih del. Večina zaključnih del študentov (diplomskih, magistrskih in doktorskih disertacij) poteka preko neposrednega sodelovanja z industrijo, industrijskih in aplikativnih projektov. Tako je omogočeno zelo usmerjeno izobraževanje in usposabljanje novih strokovnjakov ter prenos znanja v industrijo. V članku bodo predstavljeni primeri dobrih praks prenosa znanja iz univerze v industrijo v okviru zaključnih del študentov.

**Ključne besede:** visokošolsko izobraževanje, študij materialov in metalurgije, prenos znanja v industrijo

**Abstract**

Higher education is a process that enables students to acquire advanced knowledge, skills, and competencies required for a successful career in a chosen professional field and is crucial for development and progress in industry and research. The fundamental goal of higher education in materials and metallurgy is to train an expert who acquires in-depth and focused knowledge and skills in the fundamental areas of metallurgy and materials that are essential to many industries. The study programs at the Department of Materials and Metallurgy of the Faculty of Natural Science and Engineering at the University of Ljubljana take place at all levels of higher education and have the longest tradition of education in this field in Slovenia. As part of the study, there is direct cooperation with industrial practice through seminar papers, practical training, and final theses. Most of the student's final theses (bachelor's, master's, and doctoral dissertations) are carried out in direct cooperation with industry, industrial, and application projects. This enables, highly focussed training and further education of new experts and the transfer of knowledge to industry. The article presents examples of best practice in knowledge transfer from university to industry in the context of students' theses.

**Keywords:** higher education, study of materials and metallurgy, transfer of knowledge to industry

## 1 Uvod

Študij materialov je ključna znanstvena panoga, ki ima velik vpliv na številna področja znanosti in tehnologije. Razumevanje lastnosti, strukture in obnašanja različnih materialov je temelj za razvoj novih tehnologij in izboljšanje obstoječih. Z razvojem novih materialov lahko povečamo učinkovitost energetskih sistemov. Na področju obnovljivih virov energije, kot so solarni paneli in baterije, so napredki v materialih ključni za izboljšanje zmogljivosti in zmanjšanje stroškov. Spoznanja na področju materialov tako neposredno vplivajo na zmanjšanje odvisnosti od fosilnih goriv in spodbujanje čiste energije. V mnogih industrijah, od gradbeništva do avtomobilske industrije, je pomembno, da materiali izpolnjujejo visoke standarde varnosti in zanesljivosti. Razumevanje lastnosti materialov in njihovih odzivov na različne obremenitve je ključno za preprečevanje napak in nesreč, kar neposredno vpliva na življenja ljudi. Z naraščajočo skrbjo za okolje postaja študij materialov še pomembnejši. Raziskave usmerjajo razvoj trajnostnih materialov, ki zmanjšujejo odpadke in porabo virov. Materiali, ki so biorazgradljivi ali reciklirani, lahko znatno zmanjšajo okoljski odtis in pripomorejo k trajnostnemu razvoju.

Strateški dokumenti EU obravnavajo materiale kot ključni del evropske industrijske, okoljske in tehnološke politike. Poudarek je na kritičnih surovinah, krožnem gospodarstvu in trajnostnih materialih, ki podpirajo digitalni in zeleni prehod. Vzpostavljena je STEP platforma (2024) strateških tehnologij za Evropo. Z njo želimo okrepiti strateško avtonomijo v zeleni in digitalni dobi in si povrniti vodilni položaj v prebojnih tehnologijah. Seznam kritičnih surovin (EU Critical Raw Materials Act, 2023) določa ključne surovine za

## 1 Introduction

The study of materials is an important scientific field that has an impact on many areas of science and technology. Understanding properties, structure, and behaviour of different materials is the basis for developing new technologies and improving existing ones. By developing new materials, we can increase the efficiency of energy systems. In the field of renewable energy sources, such as solar cells and batteries, advances in materials are crucial to improving performance and reducing costs. Knowledge in the field of materials has a direct impact on reducing dependence on fossil fuels and promoting clean energy. In many industries, from construction to automotive, materials must meet high safety and reliability standards. Understanding the properties of materials and how they respond to different stresses is crucial to preventing failures and accidents that directly affect people's lives. With increasing concern for the environment, the study of materials is becoming even more important. Research is aimed at developing sustainable materials that use less waste and resources. Biodegradable or recycled materials can significantly reduce the ecological footprint and contribute to sustainable development.

The EU strategy documents deal with materials as a central component of European industrial, environmental, and technology policy. The focus is on critical raw materials, the circular economy, and sustainable materials that support the digital and green transitions. The STEP Platform (2024) of strategic technologies for Europe has been established. With it, we want to strengthen strategic autonomy in the green and digital age and regain a leading position in breakthrough technologies. The list of critical raw materials (EU evropsko industrijo (litij, kobalt, redke zemlje ipd.). Cilj dokumenta je zmanjšati odvisnost od uvoza in zagotoviti varne dobavne verige. Industrijska strategija EU (EU Industrial Strategy, 2021) poudarja inovacije pri novih materialih in zmanjšanje ogljičnega odtisa ter izpostavlja ključna področja: zelena tehnologija, baterije in polprevodniki.

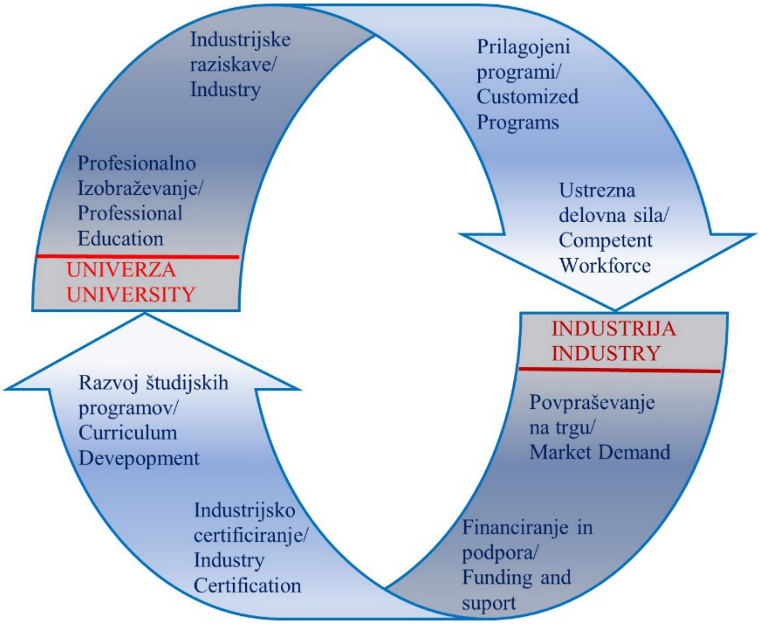
V tem članku je prikazano, zakaj je študij materialov tako pomemben in kako prispeva k napredku človeštva. Visokošolsko usposabljanje je proces, ki študentom omogoča pridobivanje naprednega znanja, veščin in kompetenc, potrebnih za uspešno kariero v izbranem strokovnem področju in je ključnega pomena za razvoj in napredek v industriji in raziskavah. Temeljni cilj visokošolskega izobraževanja na področju materialov in metalurgije je usposobiti strokovnjaka, ki bo pridobil poglobljena in usmerjena znanja in veščine iz temeljnih področij metalurgije in materialov. Ta znanja so bistvena za številne industrijske panoge kot so: metalurška, kovinsko predelovalna, avtomobilska, letalska, gradbena in druga. Strokovnjaki, ki materiale (kovinske, polimerne, keramične in sestavljene oz. kompozitne materiale) razvijajo, sočasno načrtujejo tudi tehnologije za njihovo izdelavo.

Povezanost med univerzo in industrijo (slika 1) je ključna za inovacije, konkurenčnost in razvoj znanja. Gre za sodelovanje, pri katerem akademske institucije prispevajo raziskave, strokovno znanje in izobraževanje, industrija pa ponuja praktične izkušnje, vire in možnosti za prenos znanja v prakso. Sodelovanje poteka tako na študijskem, kot tudi na raziskovalnem področju.

Critical Raw Materials Act, 2023) defines the most important raw materials for the European industry (lithium, cobalt, rare earths, etc.). The document aims to reduce import dependency and ensure secure supply chains. The EU Industrial Strategy (2021) focuses on innovation in new materials and reducing the carbon footprint and highlights the following key areas: green technology, batteries, and semiconductors.

This article shows why the study of materials is so important and how it contributes to the progress of humanity. Higher education is a process that enables students to acquire advanced knowledge, skills and competencies necessary for a successful career in their chosen professional field and is crucial for development and progress in industry and research. The fundamental goal of higher education in materials and metallurgy is to train an expert who acquires in-depth and focused knowledge and skills in the fundamental areas of metallurgy and materials that are essential to many industries such as metallurgy, metal processing, automotive, aerospace, construction and others. Professionals who develop materials (metallic, polymeric, ceramic and composite) also design the technologies for their production.

The connection between university and industry (Figure 1) is the key to innovation, competitiveness, and knowledge development. It is a collaboration in which academic institutions contribute research, expertise, and education, while industry provides practical experience, resources, and opportunities for the transfer of knowledge into practice. Collaboration takes place in both the academic and research fields.




**Slika 1.** Povezava univerzitetnega izobraževanja in raziskovanja z industrijsko prakso.

**Figure 1.** Connection of university education and research with industrial practice.

## 2 Formalne oblike študija materialov

Materiali igrajo ključno vlogo pri razvoju novih tehnologij. Z napredkom v študiju materialov, kot so napredni kovinski materiali, nanomateriali, keramika in kompoziti, se odpirajo nove možnosti za izdelavo lažjih, močnejših in bolj učinkovitih izdelkov. Izobraževanje s področja materialov in metalurgije obsega osnovna in nadaljevalna znanja. Osnovni cilj visokošolskega izobraževanja na področju materialov in metalurgije je podati:

- osnovna naravoslovna in tehnična znanja vključno z digitalizacijo
- mehke veščine (komunikacija, vodenje, računalništvo, itd.)
- osnovna strokovna znanja (Termodinamika materialov, Fizikalna metalurgija)

## 2 Formal Forms of Materials Study

Materials play a crucial role in the development of new technologies. Advances in the study of materials such as advanced metallic materials, nanomaterials, ceramics, and composites are opening new possibilities for the manufacture of lighter, stronger, and more efficient products. Education in the field of materials and metallurgy includes basic and advanced knowledge. The basic aim of higher education in the field of materials and metallurgy is to introduce:

- basic natural science and technical knowledge including digitalization
- soft skills (communication, management, computer science, etc.)
- basic professional knowledge (Thermodynamics of materials,

- strokovna znanja: Materiali (kovine in zlitine, keramika, polimeri, kompoziti (MMC), itd.) in tehnologije (proizvodnja kovin, toplotna in površinska obdelava, livarstvo, preoblikovanje kovin, varjenje, aditivne tehnologije, itd.).

Praktične veščine so pomemben del izobraževanja (laboratorijski, industrijski, projektni, diplomski, itd.) v povezavi z industrijo ter integracijo in povezovanjem pedagoškega procesa z znanstvenoraziskovalnim delom.

**Študij na Oddelku za materiale in metalurgijo** ima najdaljšo tradicijo v Sloveniji na področju tovrstnega študija. Vsako leto razpisuje univerzitetna študijska programa Inženirstvo materialov (1. stopnja) in Materiali in metalurgija (2. stopnja) ter visokošolski strokovni program Metalurške tehnologije (1. stopnja) ter doktorski program Znanost in inženirstvo materialov (slika 2). Študenti med študijem sodelujejo tudi pri raziskovalnih projektih, povezanih z gospodarstvom. V okviru programa Erasmus+ pa lahko en letnik ali semester opravijo tudi na eni izmed partnerskih tujih

Physical metallurgy, etc.)

- Professional knowledge: Materials (metals and alloys, ceramic, polymers, composites (MMC), etc. and Technologies (metal production, heat and surface treatment, foundry, metal forming, welding, additive technologies, etc.).

Practical skills are an important part of education (laboratory, industry, projects, thesis, etc.) in connection with industry and the integration and connection of the pedagogical process with scientific research work.

**Studies at the Department of Materials and Metallurgy** have the longest tradition in this field of study in Slovenia. Every year, it announces the university study programs Materials Engineering (1st level) and Materials and Metallurgy (2nd level) as well as the higher education program Metallurgical Technologies (1st level) and PhD: Materials Science and Engineering are offered (Figure 2). During their studies, students also take part in research projects related to industry. As part of the Erasmus+ program, they can also spend a year or a semester at one of the partner universities. This program allows students to gain international experience, improve their language skills, and broaden their academic and cultural horizons. At the same time, it promotes personal development and independence and improves employability in the job market.


**Slika 2.** Študij materialov na Oddelku za materiale in metalurgijo

**Figure 2.** Study of materials at the Department of Materials and Metallurgy

univerz. Ta program študentom omogoča pridobivanje mednarodnih izkušenj, izboljšanje jezikovnih spretnosti ter širjenje akademskih in kulturnih obzorij. Hkrati pa spodbuja osebni razvoj, samostojnost in povečuje zaposljivost na trgu dela.

## 3 Potencial za sodelovanje med izobraževalnimi ustanovami in industrijo

Potencial sodelovanja med izobraževalnimi institucijami in industrijo je velik in koristen za obe strani. Strokovnjaki iz industrije lahko obogatijo izobraževalni proces z deljenjem spoznanj iz resničnega sveta in praktičnih izkušenj (slika 3), s čimer premostijo vrzel med teorijo in aplikacijo. Skupne seminarske naloge ponujajo študentom priložnost, da se soočijo z izzivi iz resničnega sveta v sodelovanju s strokovnjaki iz industrije, spodbujajo veščine reševanja problemov in praktično znanje. Sodelovanje pri laboratorijskih vajah skupaj z izkušenimi tehniki omogoča praktično učenje s standardno industrijsko opremo. Prakse v industriji zagotavljajo intenzivne izkušnje, ki študentom omogočajo, da svoje znanje uporabijo v poklicnem okolju in zgradijo dragocene mreže (slika 4). Raziskovanje in razvoj diplomskih nalog študentom omogočata, da prispevajo k inovativnim projektom, hkrati pa pridobivajo dragocene raziskovalne izkušnje. Skupni projekti, ki vključujejo študente iz različnih strok in industrijske partnerje, spodbujajo sodelovanje in inovacije, ki odražajo dinamiko sodobnega delovnega sveta. Nazadnje, skupna prizadevanja za posodobitev raziskovalne opreme in učnih pripomočkov študentom zagotavljajo dostop do najnovejših tehnologij, ki jih pripravijo na zahteve hitro razvijajočega se industrijskega okolja. Te združene pobude

## 3 The potential for Collaboration Between Educational Institutions and Industry

The potential for cooperation between educational institutions and industry is great and beneficial for both sides. Industry experts can enrich the educational process by sharing real-world insights and practical experience (Figure 3), bridging the gap between theory and application. Joint seminar papers offer students the opportunity to engage with real-world challenges in collaboration with industry professionals, fostering problem-solving skills and practical knowledge. Participation in laboratory practicals alongside experienced technicians enables hands-on learning with industry-standard equipment. Industrial placements provide intensive experiences that allow students to apply their knowledge in a professional environment and build valuable networks (Figure 4). Thesis research and development allow students to contribute to innovative projects while gaining valuable research experience. Joint projects involving students from different disciplines and industry partners encourage collaboration and innovation, reflecting the dynamic nature of the modern working world. Finally, joint efforts to modernize research equipment and study aids ensure that students have access to the latest technologies to prepare them for the demands of a rapidly evolving industrial landscape. These combined initiatives create a dynamic ecosystem where education and industry are intertwined, fostering a pipeline of skilled and experienced graduates ready to contribute to innovation and economic growth. Cooperation in the field of study programs and industry also takes place through the SRIP MATPRO partnership.

Below are two examples of good practice in cooperation between industry ustvarjajo dinamičen ekosistem, v katerem se izobraževanje in industrija prepletata ter spodbujajo nabor usposobljenih in izkušenih diplomantov, ki so pripravljeni prispevati k inovacijam ter gospodarski rasti. Sodelovanje na področju študijskih programov in industrije poteka tudi preko partnerstva SRIP MATPRO.

and educational institutions, i.e. Faculty of Natural Sciences and Engineering, Department of Materials and Metallurgy.

**Example 1: A good example of cooperation between industry and the Faculty of Natural Sciences and Engineering certainly is the cooperation**

**Slika 3.** Sodelovanje strokovnjakov iz industrije v študijskem procesu

**Figure 3.** Participation of industry experts in the study process

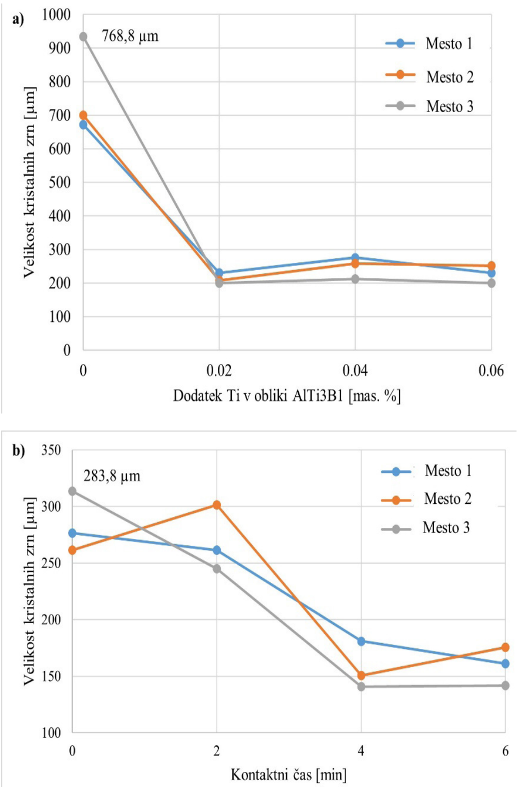
**Slika 4.** Študentje bogatijo študijski proces s strokovnimi ekskurzijami v industriji

**Figure 4.** Students enrich their study process with professional excursions in industry

V nadaljevanju sta prikazana dva primera dobre prakse sodelovanja med gospodarstvom in izobraževalnimi institucijami, to je Naravoslovnotehniška fakulteta, Oddelek za materiale in metalurgijo.

**Primer 1: Dober primer sodelovanja med gospodarstvom in Naravoslovnotehniško fakulteto je zagotovo sodelovanje s podjetjem IMPOL. Naslov magistrskega dela je bil DOLOČEVANJE USTREZNEGA DODATKA UDROBNJEVALCA GLEDE NA STANJE TALINE ZLITINE EN AW-6110A.**

Livarne običajno izboljšajo zrnato strukturo tako kovanih kot litih aluminijevih




**Slika 5.** Vpliv dodatka Ti kot AlTi3B1 (a) in kontaktnega časa (b) na velikost kristalnih zrn[9]

**with the company IMPOL. The Master thesis title was DETERMINING THE PROPER ADDITTIVE OF THE GRAIN REFINER ACCORDING TO THE STATE OF ALLOY EN AW-6110A MELT.**

Foundries usually refine the grain structure of both wrought and cast aluminium alloys to improve the material properties. This is usually achieved by adding master alloys or by processes such as ultrasonic machining or electromagnetic stirring.

While the addition of master alloys is usually standardised, this thesis investigated how the amount of grain refiner can be adapted to the state of the melt of the alloy EN AW-6110A. Thermal analysis and cooling curves were used to measure undercooling

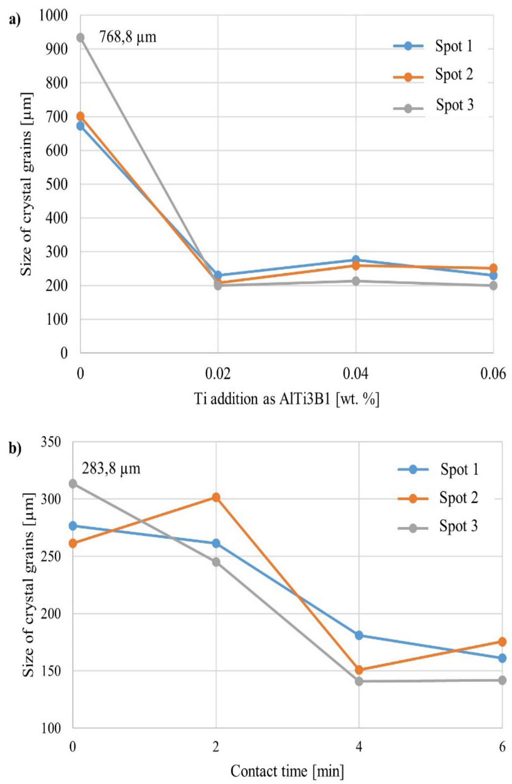
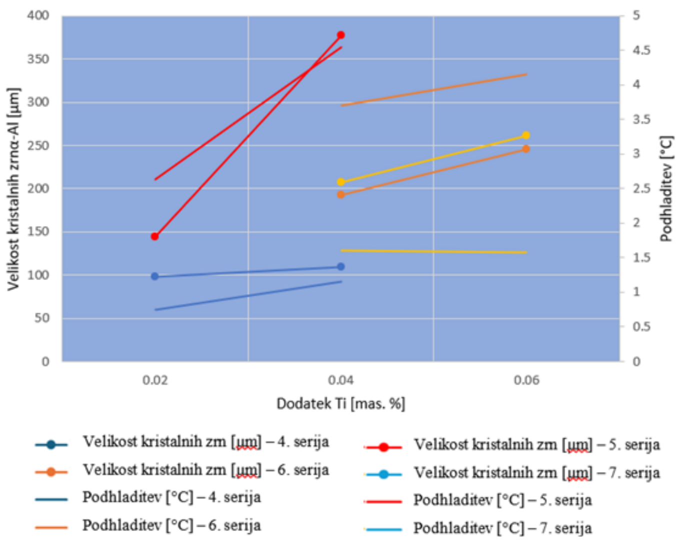



**Figure 5.** Influence of Ti addition as AlTi3B1 (a) and contact time (b) on size of crystal grains[9]

zlitin, da bi izboljšale lastnosti materiala. To se običajno doseže z dodajanjem predzlitin ali pa s postopki, kot sta ultrazvočna obdelava ali elektromagnetno mešanje.

Medtem ko je dodajanje osnovnih zlitin običajno standardizirano, smo v tem diplomskem delu raziskali, kako je mogoče količino udrobnilnega sredstva za udrobnjevanje prilagoditi stanju taline

and recalescence. These measurements, together with thermodynamic calculations, differential scanning calorimetry, and microscopy with EDS analysis, contributed to the determination of characteristic temperatures and precipitates. The study had two objectives. First, the influence of undercooling and recalescence on α-Al grain size was investigated, with grain




**Slika 6.** Velikost kristalnih zrn α-Al in podhladitev vzorcev vlitih v jeklene merilne celice z različnimi dodatki titana[9]

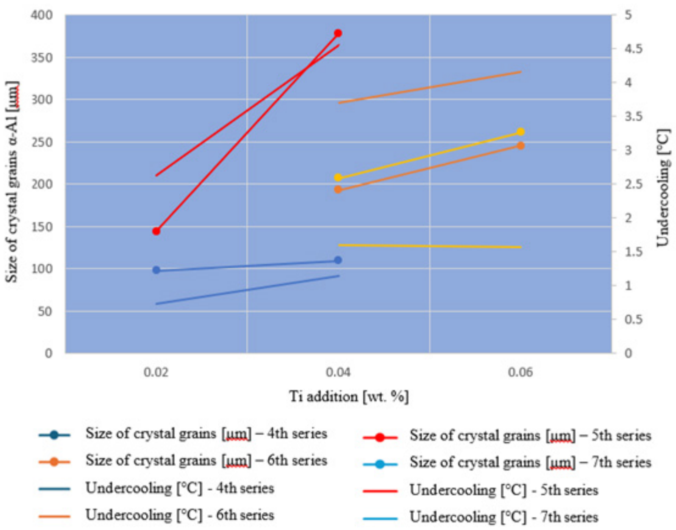



**Figure 6.** α-Al crystal grain size and undercooling of samples cast into steel measuring cells with different titanium additions[9]

zlitine EN AW-6110A. Termična analiza in ohlajevalne krivulje so bile uporabljene za merjenje podhladitve in rekalescence. Te meritve so skupaj s termodinamičnimi izračuni, diferenčno vrstično kalorimetrijo in mikroskopijo z analizo EDS prispevale k določitvi značilnih temperatur in izločanja. Študija je imela dva cilja. Najprej je bil raziskan vpliv podhladitve in ponovne rekalescence na velikost zrn α-Al, pri čemer je bila velikost zrn optično izmerjena v skladu s standardi ASTM. Ugotovljeno je bilo, da je podhladitev dober napovednik velikosti zrn, zato je bil razvit regresijski model, ki je pokazal močnejšo korelacijo v udrobnjenih vzorcih (slika 5). V nadaljevanju smo raziskali, ali bi manjši dodatki sredstev za udrobnitev zrn lahko dosegli podobne ali manjše velikosti zrn kot večji dodatki, pri čemer se je spet zanašala na podatke o podhladitve in rekalescenci. Rezultati so pokazali, da večji dodatki ne zagotavljajo manjših zrn; kritična dejavnika sta podhladitev in rekalescenca, ki odražata število aktivnih nukleusov. Končno je bilo analizirano razmerje med velikostjo zrn α-Al in parametrom omejitve rasti Q.

Študija je pokazala, da ima nukleacija pomembnejšo vlogo kot omejitev rasti in da lahko preveč titana povzroči aglomeracijo delcev $TiB_2$, kar povzroči večja zrna α-Al (slika 6).[9]

**Primer 2: Drug primer sodelovanja med gospodarstvom in Naravoslovnotehniško fakulteto je sodelovanje s podjetjem HIDRIA. Naslov magistrskega dela je bil VPLIV SPECIFIČNE POVRŠINE IN DELEŽA SEKUNDARNEGA ALUMINIJA NA KAKOVOST ZLITINE AlSi10Mg(Fe).**

Aluminij, lahka neželezna kovina, se zaradi ugodnih mehanskih lastnosti pogosto uporablja takoj za jeklom. Zlitina za ulivanje AlSi10Mg je priljubljena v avtomobilskem

size measured optically according to ASTM standards. Undercooling was found to be a good predictor of grain size, and a regression model was developed that showed a stronger correlation in refined samples (Figure 5).

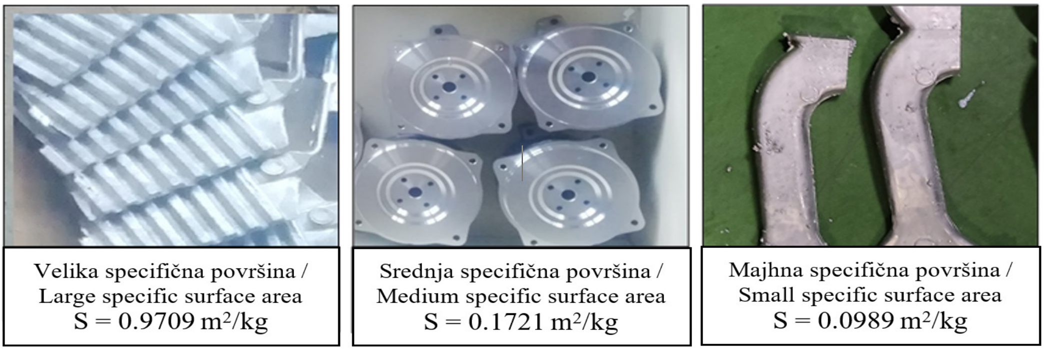
Secondly, the study investigated whether smaller additions of grain refining agents could achieve similar or finer grain sizes than larger additions, again relying on undercooling and recalescence data. The results showed that larger additions do not guarantee smaller grains; undercooling and recalescence, which reflect the number of active nuclei, are critical factors. Finally, the relationship between α-Al grain size and the growth restriction parameter Q was analysed.

The study concluded that nucleation plays a more important role than growth restriction, and that too much titanium can cause agglomeration of $TiB_2$ particles, resulting in larger α-Al grains (Figure 6).[9]

**Example 2: Another example of cooperation between industry and the Faculty of Natural Sciences and Engineering is the collaboration with the company HIDRIA. Master thesis title was INFLUENCE OF SPECIFIC SURFACE AND AMOUNT OF RECYCLING ALUMINIUM ON AlSi10Mg(Fe) ALLOY QUALITY.**

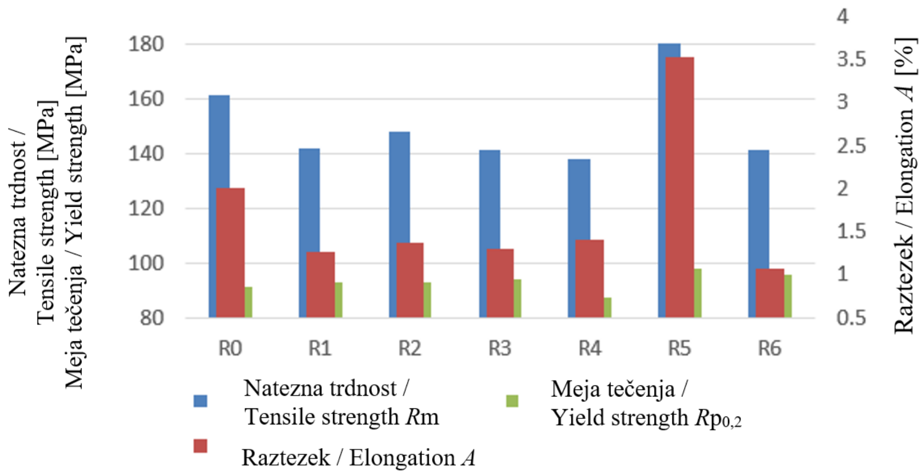
Aluminium, a light non-ferrous metal, is widely used after steel due to its favourable mechanical properties. The casting alloy AlSi10Mg is popular in the automotive sector due to its high temperature resistance and is often produced using the die casting process.

The recycling of aluminium is becoming increasingly important for environmental reasons. Recycled material, which comes from different new and old scrap with different chemical compositions, impurities




**Slika 7.** Krožni material z različnimi specifičnimi površinami: LSS – velika specifična površina, MSS – srednja specifična površina in SSS – majhna specifična površina[20]

**Figure 7.** Circular casting with different specific surfaces: LSS – Large specific surface area, MSS - Medium specific surface area and SSS – Small specific surface area20




**Slika 8.** Mehanske lastnosti preiskovanih vzorcev: R0 – 100 % primarni aluminij (PA), R1 – 70 % PA, 30 % LSS, R2 – 70 % PA, 30 % SSS, R3 – 70 % PA, 30 % MSS, R4 – 40 % PA, 60 % LSS, R5 – 40 % PA, 60 % SSS, R6 – 40 % PA, 60 % MSS20

**Figure 8.** Mechanical properties of the investigated samples: R0 – 100 % primary aluminium (PA), R1 – 70 % PA, 30 % LSS, R2 – 70 % PA, 30 % SSS, R3 – 70 % PA, 30 % MSS, R4 – 40 % PA, 60 % LSS, R5 – 40 % PA, 60 % SSS, R6 – 40 % PA, 60 % MSS20

sektorju zaradi svoje odpornosti na visoke temperature in se pogosto proizvaja s postopkom tlačnega litja.

Recikliranje aluminija postaja vse bolj pomembno zaradi okoljskih razlogov.

and surface areas, influences the properties of the resulting alloy.

This work investigates how the proportion of recycled material and its specific surface area affect the solidification, Recikliran material, ki prihaja iz različnih novih in starih odpadkov z različnimi kemičnimi sestavami, nečistočami in površinami, vpliva na lastnosti nastale zlitine.

To delo raziskuje, kako delež recikliranega materiala in njegova specifična površina vplivata na strjevanje, mikrostrukturo in mehanske lastnosti zlitine AlSi10Mg(Fe).

Pregledanih je bilo sedem vzorcev z različnimi deleži primarnega in sekundarnega materiala ter specifičnimi površinami (slika 7). Ocenili smo kakovost taline, strjevanje pa raziskali s termično analizo in diferenčno vrstično kalorimetrijo. Mikrostrukturo smo pregledali z optično mikroskopijo in Thermo-Calc. Ocenjene so bile tudi mehanske lastnosti (trdota, natezna trdnost, meja tečenja in raztezek). Rezultati so pokazali, da večja specifična površina in večji delež recikliranega materiala korelirata s slabšimi mehanskimi lastnostmi (slika 8), kar lahko pripišemo izgubi elementov pri taljenju, povečani vsebnosti nečistoč in višji vsebnosti železa.

## 4 Zaključek

Materiali in metalurgija sta ključni znanstveni panogi za tehnološki napredek in trajnostni razvoj. Raziskave na tem področju omogočajo boljše, močnejše in bolj trajnostne izdelke, ki vplivajo na gospodarstvo, okolje in kakovost življenja. Zato so dobro izobraženi strokovnjaki na področju materialov in metalurgije nujno potrebni za napredek in razvoj področja. Od inovacij v tehnologiji do trajnostnih rešitev energetskih sistemov, ta disciplina oblikuje prihodnost. Investicija v raziskave in izobraževanje na tem področju bo še naprej prinašala pomembne koristi za družbo kot celoto. S poudarkom na razvoju

microstructure, and mechanical properties of AlSi10Mg(Fe).

Seven samples with different proportions of primary and secondary material and specific surfaces were examined (Figure 7). The quality of the melt was evaluated, and solidification was investigated by thermal analysis and differential scanning calorimetry. The microstructure was examined using optical microscopy and Thermo-Calc. The mechanical properties (hardness, tensile strength, yield strength and elongation) were also evaluated. The results show that a higher specific surface area and a higher proportion of recycled material correlate with poorer mechanical properties (Figure 8), which can be attributed to the loss of elements during melting, the increased content of impurities and the higher iron content.

## 4 Conclusion

Materials and metallurgy are key scientific areas for technological progress and sustainable development. Research in this field enables better, stronger, and more sustainable products that have an impact on the economy, the environment, and the quality of life. Therefore, well-trained experts in the field of materials and metallurgy are essential for progress and development in this area. From innovations in technology to sustainable solutions for energy systems, this discipline is shaping the future. Investing in research and education in this field will continue to bring significant benefits to society as a whole. By focusing on developing new materials and improving existing ones, we can change the world and meet the challenges of modern times. To ensure a sufficient number of students and future professionals, the promotion of the profession at all levels is crucial. In novih materialov in izboljšanju obstoječih lahko preoblikujemo svet in se spopademo z izzivi, ki jih prinaša sodobna doba. Za zagotavljanje dovolj velikega števila študentov in kasnejših strokovnjakov je promocija stroke na vseh nivojih ključnega pomena. V promocijo morajo biti vključeni poleg Oddelka za materiale in metalurgijo tudi podjetja s področja materialov in metalurgije ter državne institucije.

addition to the Department of Materials and Metallurgy, companies in the materials and metallurgy sector and state institutions must also be involved in promoting the profession.

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