

## **Pregled stanja in vpogled v prihodnost svetovne proizvodnje ulitkov. Vloga fakultete za livarstvo pri izobraževanju inženirjev za livarsko industrijo**

### **The State of art and Foresight of World Casting Production. The Role of the Faculty of Foundry Engineering In Educating Engineers for Casting Industry**

#### **Izvleček**

Proizvodnja ulitkov velja za enega glavnih dejavnikov, ki vpliva na razvoj svetovnega gospodarstva. Ta članek obravnava pregled stanja in vpogled v prihodnost svetovne proizvodnje ulitkov na podlagi najnovejših statističnih podatkov. Napredek v zadnjih nekaj letih na področju livarstva je prikazan kot možnost dodatnega razvoja livarske tehnologije. Zadnje desetletje je prineslo pomembne spremembe na področju največjih proizvajalcev ulitkov. Globalizacija in preoblikovanje gospodarskih sistemov se odražata v spreminjanju proizvodnje livarn v različnih državah, pri čemer globalizacija gospodarstva ne pomeni zgolj priložnosti, pač pa predstavlja tudi nevarnost za poljske in evropske livarne [1–5].

V drugem delu te predstavitev je prikazan razvoj livarn in metalurških znanosti na Univerzi za znanost in tehnologijo AGH v Krakovu na Poljskem od ustanovitve Fakultete za obdelavo železa in jekla leta 1922 do danes. Raziskava predstavlja zgodovino izgradnje znanstvenega, didaktičnega in organizacijskega profila Fakultete za livarski inženiring, ki so jo ustanovili najuglednejši člani raziskovalne ekipe na univerzi AGH, kjer se ukvarjajo z disciplinami, vezanimi na livarsko industrijo z železnimi in neželeznimi kovinami v najširšem smislu.

Podan je kratek opis didaktičnih dejavnosti fakultete, raziskovalnih področij in sodelovanja z industrijo. Poudarjena je vloga, ki jo ima fakulteta pri rasti poljske livarske industrije.

**Ključne besede:** livarna, litje, proizvodnja, razvoj, izobraževanje

#### **Abstract**

The casting production is considered as one of the main factors influencing the development of world economy. The state of art and foresight of world's casting production is discussed in the paper on the basis of the latest statistical data. The progress gained during the last few years in foundry engineering is shown as a way to further development of foundry technology. The last decade brought significant changes in the world map of the greatest casting producers. Globalization and transformation of economic systems is reflected by variations of foundry production in different countries, more over the globalization of economy is regarded not only as a chance but also as a menace for the Polish and European foundries [1-5].

The second part of the presentation presents the development of foundry and metallurgical sciences at the AGH University of Science and Technology in Krakow, Poland, since the time when a Faculty of Iron and Steel Practice was established in 1922 until the present day. The study outlines the history of creating a scientific, didactic and organization profile of the Faculty of Foundry Engineering, founded by the most eminent members of AGH research staff who practice the disciplines related with iron steel and non ferrous metals casting industry in a widely understood meaning of this word.

A short characteristic of the didactic activities of the faculty was given, and the areas of research and cooperation with industry were described. The role, which the faculty plays in the growth of the Polish casting industry, was emphasized.

**Key words: foundry, casting, production, development, education**

### **Svetovna proizvodnja ulitkov**

Proizvodnja ulitkov velja za enega glavnih dejavnikov, ki vpliva na razvoj svetovnega gospodarstva. Dejanska zmogljivost svetovne proizvodnje ulitkov se močno razlikuje. Zadnje desetletje je prineslo pomembne spremembe na področju največjih proizvajalcev ulitkov. Globalizacija in preoblikovanje gospodarskih sistemov se odražata v spreminjanju proizvodnje livarn v različnih državah, pri čemer globalizacija gospodarstva ne pomeni zgolj priložnosti, pač pa tudi nevarnost za evropske livarne [1].

### **Trenutno stanje v svetovni proizvodnji ulitkov**

Proizvodnja ulitkov v zadnjih letih raste. To dokazuje dejstvo, da je v obdobju od leta 2009 do 2015 svetovna proizvodnja ulitkov narasla za 29,6 %. Skupna proizvodnja ulitkov, ki je v letu 2016 znašala 104,1 milijona ton, je bila rekordna [5].

Izmed 35 držav največjih proizvajalk ulitkov na svetu je bila proizvodnja ulitkov v letu 2015 v primerjavi z letom 2014 nižja v samo 14 država (tj. Norveška, Švica, Japonska, ZDA). Proizvodnja v Mehiki je

### **World Casting Production**

The casting production is considered by the main factors influencing the development of the world economy. Actual capacity of the world's casting production is strongly diversified. The last decade brought significant changes in the map of the world by the greatest casting producers. Globalization and transformation of economic systems is reflected by variations of foundry production in different countries, moreover the globalization of economy is regarded not only as a chance<sup>1</sup> but also as a menace for the European foundries [1].

### **Current Situation in the World's Casting Production**

A casting production in the last years has had an increasing tendency. It is shown by the fact, that the world casting production increased by 29,6 % from 2009 to 2015. The total casting production being 104,1 million tons in 2016 is the highest ever [5].

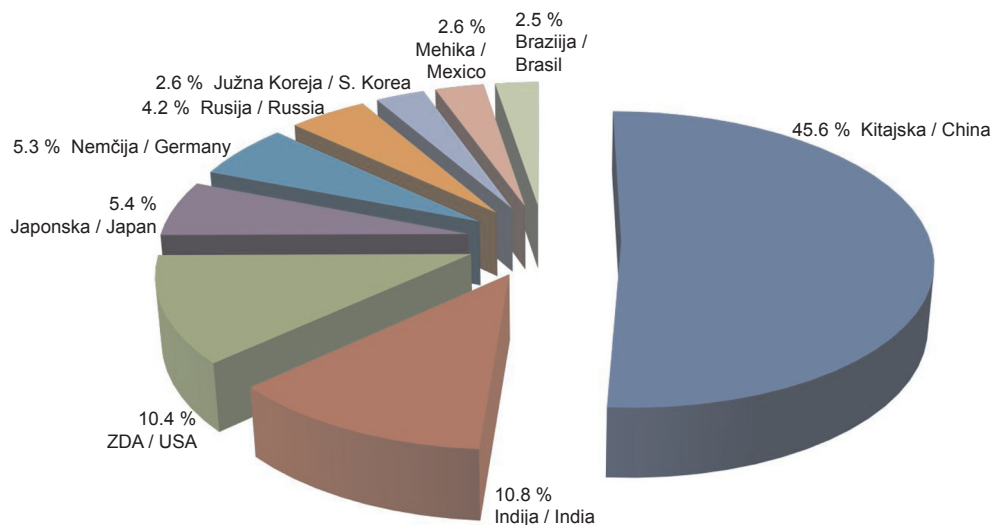
Out of 35 countries, main casting producers in the world, in 14 countries only the casting production in 2015 was lower than in 2014 (ie. Norway, Switzerland, Japan, US.). Whereas Mexico had the

doživela največji porast v tem obdobju, in sicer 55 %.

10 držav največjih proizvajalk ulitkov je v letu 2015 proizvedlo približno 87 % ulitkov, njihova udeležba v svetovni proizvodnji je ostala enaka letu 2014. Največje proizvajalke ulitkov v letu 2015 so bile: Kitajska, ZDA, Indija, Nemčija, Japonska, Rusija, Brazilija,

highest production increase in this period, being 55 %.

Ten countries, the largest casting producers in the world produced in 2015 approximately 87 % of casting, having the same participation in the global production as in 2014. The largest casting producers in the year 2015 were: China, USA, India,



**Slika 1.** Proizvodnja ulitkov 10 največjih svetovnih proizvajalk (v mio. ton) [5]

**Figure 1.** Casting production in top 10 world casting producers (in million tons) [5]

**Tabela 1.** Proizvodnja ulitkov največjih proizvajalk ulitkov (v tisoč tonah) [5]

**Table 1.** The production of castings in world largest casting producers (in thousands tons) [5]

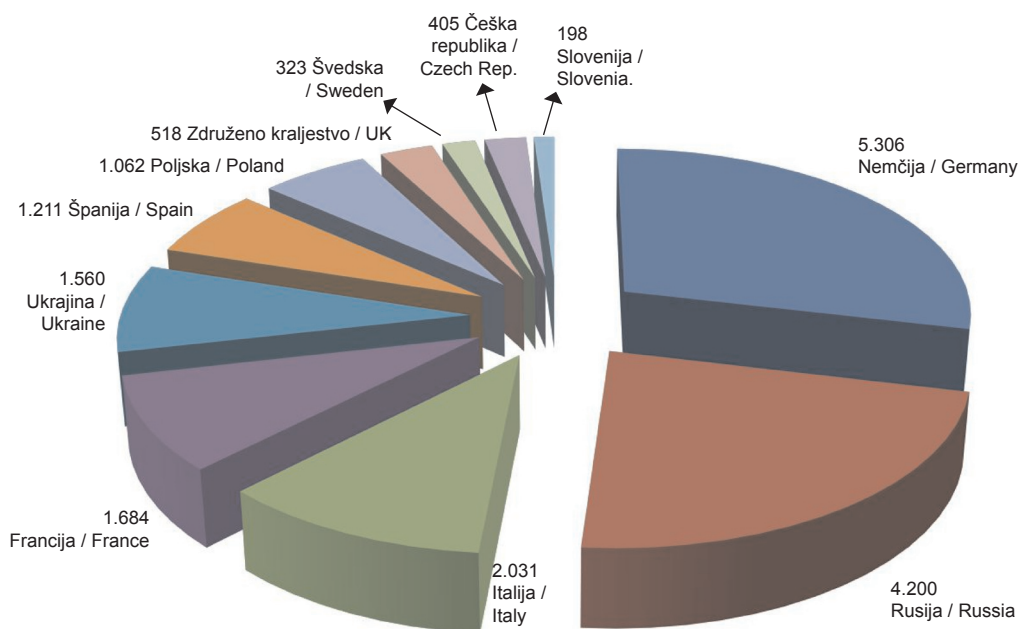
| Država / Country     | Siva litina / Grey Iron | Nodularna litina / Ductile Iron | Jeklo / Steel | Aluminij / Aluminum | Drugo / Other | SKUPAJ / TOTAL |
|----------------------|-------------------------|---------------------------------|---------------|---------------------|---------------|----------------|
| Kitajska / China     | 20.200                  | 12.600                          | 5.100         | 6.100               | 7.700         | 45.600         |
| Indija / India       | 7.410                   | 1.180                           | 880           | 1.250               | 1.300         | 10.770         |
| ZDA / USA            | 3.328                   | 3.115                           | 1.493         | 1.622               | 2.452         | 10.388         |
| Japonska / Japan     | 2.022                   | 1.703                           | 157           | 418                 | 1.522         | 5.404          |
| Nemčija / Germany    | 2.337                   | 1.520                           | 196           | 1.071               | 1.253         | 5.306          |
| Rusija / Russia      | 2.982                   |                                 | 756           | 462                 | 462           | 4.200          |
| J. Koreja / S. Korea | 1.082                   | 708                             | 164           | 623                 | 669           | 2.623          |
| Mehika / Mexico      | 815                     | 375                             | 330           | 735                 | 1.040         | 2.560          |
| Brazilijska / Brasil | 1.342                   | 548                             | 243           | 154                 | 182           | 2.315          |
| Italija / Italy      | 694                     | 374                             | 62            | 760                 | 901           | 2.031          |

Južna Koreja, Italija in Francija (Slika 1, Tabela 1).

Proizvodnja ulitkov največjih evropskih proizvajalk v letu 2015 je prikazana na Sliki 2.

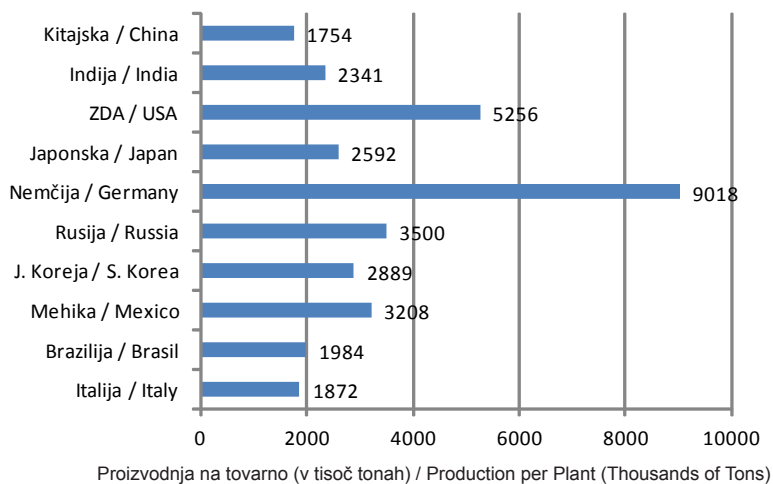
Germany, Japan, Russia, Brazil, South Korea, Italy and France (Figure 1, Table 1).

Casting production in the top European countries in 2015 is shown in Figure 2.



**Slika 2.** Proizvodnja ulitkov največjih evropskih proizvajalk [5]

**Figure 2.** Casting production in top European countries [5]



**Slika 3.** Letna proizvodnja ulitkov na livarno [5]

**Figure 3.** Year casting production per plant [5]

Proizvodnja na tovarno (v tisoč tonah) / Production per Plant (Thousands of Tons)

Kitajska, ki je v letu 2015 proizvedla 43,8 % ulitkov, na področju proizvodnje ulitkov prednjači že vrsto let. Drugo mesto s štirikrat manjšim obsegom proizvodnje od Kitajske pripada Indiji, katere delež znaša 10,3 % zaradi 44,7-% dviga glede na leto 2009. Bistveno zvečanje proizvodnje (40,2 % v primerjavi z letom 2009) so dosegle tudi Združene države Amerike. Države EU imajo nespremenjen delež proizvodnje ulitkov, ki znaša pribl. 28 % [2–4].

V letu 2015 je skupno obstajalo približno 47.000 livarn, število se je glede na leto 2010 zmanjšalo za 1.164. To kaže, da se livarstvo krepi in postaja učinkovitejše (Slika 3).

### **Izobraževanje inženirjev za livarsko industrijo**

Poljsko terciarno izobraževanje in visokošolski (akademski) sistemi so bili kodificirani ter zajemajo tri stopnje izobrazbe: diplomant (dodiplomski študij oz. licencjat), magister (magistrski študij oz. magister) in doktor (doktorski študij oz. PhD). Proces uvedbe nove tristopenjske strukture namesto dvostopenjske (magister in doktor), ki se na številnih univerzah še vedno izvaja, vztrajno napreduje.

V poljskih akademskih krogih je Bolonjska deklaracija dobro poznana in se izvaja vsaj delno. Zato se želimo v navedbah v naslovu tega članka navezati na najpomembnejšo težavo v zvezi s to deklaracijo, ki zajema šest osnovnih ukrepov, vezanih na akademske kroge, hkrati pa določa cilje nalog in obveznosti državam, ki so jo podpisale. Naloge in obveznosti bi bilo treba uvesti v praksi do leta 2010. Te naloge so:

- uvedba primerljivega in preprostega sistema prepoznavanja akademskih

The leader in the casting production from many years is China, which produced 43,8 % of castings in 2015. The second place, however with the production 4-times smaller than China, belongs to India, which share is 10,3 %, due to 44,7 % increase in relation to 2009. A significant production increase (40,2 % as compared with 2009) obtained also the United States of America. The EU countries share in the casting production equaled approximately 28 % [2–4].

The total number of casting facilities in 2015 was about 47000 and it decreased from 2010 by 1164. This fact indicates that metalcasting business is consolidating and becomes more efficient Figure 3).

### **Education of Engineers for Casting Industry**

The Polish tertiary education and academic systems have been codified including three levels of degrees: Bachelor (licencjat), Master (magister) and Doctor (PhD). The process of implementing a new, three-degree structure instead of the two-degree one (Master and PhD), which is still operative in many universities, is progressing steadily.

In Polish academic circles the Bologna Declaration is a document quite well known and verified practically in part at least. Therefore my remarks indicated in the title of this paper I would like to refer to the most important issues covered by this Declaration, which involves 6 basic actions addressed to the academic circles, and at the same time assigns the scope of tasks and duties to the states who have signed the Declaration. The tasks and duties should be put in practical implementation by year 2010. They are as follows:

- adopting a comparable and easy to read system of academic grades (professional

ocen (strokovnih in znanstvenih) – tudi z uvedbo Dodatka k diplomu;

- uvedba dvostopenjskega študijskega sistema – dodiplomski (ki zajema vsaj tri leta izobraževanja) in magistrski/doktorski (razen prava, medicine in psihologije);
- uvedba Evropskega sistema prenašanja kreditnih točk (ECTS) – kot sredstvo za spodbujanje mobilnosti. Takšne kreditne točke bi se lahko pridobile tudi zunaj višjega izobraževalnega sistema (npr. med usposabljanjem v industrijskem okolju);
- promoviranje in podpiranje mobilnosti študentov, učiteljev in administrativnega osebja, ki dovoljuje različna obdobja v smislu izobraževanja, usposabljanja in izvajanja raziskav;
- spodbujanje evropskega sodelovanja glede zagotavljanja kakovosti;
- promoviranje nepogrešljivega evropskega obsega visokošolske izobrazbe, zlasti v zvezi z načrti mobilnosti in medinstitucionalnim sodelovanjem, pa tudi z integriranimi programi izobraževanja, usposabljanja in izvajanja raziskav.

Na nizu srečanj ministrov za šolstvo, ki jih je organizirala Evropska komisija (Lizbona – 2000, Stockholm – 2001, Barcelona – 2002, Berlin – 2003), se je značaj Bolonjske deklaracije postopoma spreminjal in prešel z ukrepov izrecno prostovoljne narave na nabor obvezujočih zavez, ki jih morajo univerze upoštevati. Najpomembnejše zadeve pri teh zavezah so:

- vseživljenjsko učenje;
- študij za doktorsko izobrazbo kot tretji študijski cikel;
- sodelovanje na področju akreditacij in zagotavljanja kakovosti;
- evropski izobraževalni prostor in evropski raziskovalni prostor kot dva

and scientific) - also through adoption of a Diploma Supplement;

- adopting a two-cycle system of the studies - a bachelor (taking minimum three years of learning ) and a master/doctor (excluding law, medicine and psychology);
- adopting a European Credit Transfer System (ECTS) - as a means to promote mobility. Credits of this type might be also gained outside the higher educational system (e.g. during industrial training);
- promotion and supporting the mobility of students, teachers and administrative personnel, allowing for different periods in the context of teaching, training and research;
- promotion of European cooperation with regard to quality assurance;
- promotion of the indispensable European dimension of higher education, specially as regards the plans of mobility and interinstitutional cooperation, as well as the integrated programmes of teaching, training and research.

At the successive meetings of the ministers of education, arranged by the European Commission (Lisbon-2000, Stockholm- 2001, Barcelona-2002, Berlin-2003), the character of the Bologna Declaration was gradually changing, passing from actions of strictly voluntary nature to a set of obligatory commitments which the universities should obey. The most important of these commitments are as follows:

- lifelong learning
- studies for doctor's degree as a third cycle of the studies
- cooperation in the field of accreditation and quality assurance
- European Education Area and European Research Area as two main pillars of

glavna stebra družbe, ki je osnovana na znanju;

- stalno spremljanje bolonjskega procesa.

V nadaljevanju so kratke informacije v zvezi s Fakulteto za livarski inženiring Univerze AGH za znanost in tehnologijo v Krakovu, Poljska, ter zgoščen opis njenih dejavnosti na področju izobraževanja inženirjev za razvijanje raziskav in sodelovanja z industrijsko panogo. Fakulteta za livarski inženiring je ena izmed 16 fakultet Univerze AGH za znanost in tehnologijo.

Začetki Fakultete za livarski inženiring segajo v študijsko leto 1951/52, ko so se trije oddelki ločili od Fakultete za metalurgijo, da bi zagotavljali študij s področij livarske tehnologije in livarske mehanizacije.

Trenutni dekan fakultete je prof. Rafal Danko, poddekani pa so: prof. Marcin Górny, prof. Halina Krawiec in prof. Barbara Kalandyk.

Didaktično katedro Fakultete za livarski inženiring sestavlja 21 rednih in izrednih profesorjev, 31 doktorjev, 3 magistre inženirstva, ki so zaposleni v štirih znanstvenih in didaktičnih oddelkih:

- Oddelek za inženiring livarskih procesov,
- Oddelek za livarske zlitine in kompozite,
- Oddelek za litje materialov, tehnologije litja in litje zlitin iz neželeznih kovin,
- Oddelek za kemijo in korozijo kovin.

V nadaljevanju je navedenih nekaj tematik, ki jih fakulteta razvija v okviru znanstvenih in raziskovalnih dejavnosti:

- virtualizacija tehnoloških procesov v livarskem inženiringu Modeliranje kristalizacije in dovajanje ulitkov ter eksperimentalno preizkušanje procesov strjevanja in kristalizacije skupaj z računalniško simulacijo;

the knowledge-based society

- constant monitoring of the Bologna Process

Below you will find a short information concerning the Faculty of Foundry Engineering AGH-UST in Krakow, Poland and a concise characteristic of its activity in the field of educating engineers for developing research and cooperating with industry. The Foundry Engineering Faculty is one of 16 Faculties of the AGH-UST.

The origins of the Faculty of Foundry Engineering date back to the academic year 1951/52, when three departments were separated from the Faculty of Metallurgy to offer courses in the fields of foundry technology and foundry mechanization.

Presently the Dean of the faculty is Professor Rafal Danko, while Deputy Deans are Professors: Marcin Górny, Halina Krawiec and Barbara Kalandyk.

The didactic cadre of the Foundry Engineering Faculty consists of 21 Professors and Assistant Professors, 31 PhD holders and three M.Eng employees in four main scientific and didactic Departments:

- Department of Foundry Processes Engineering
- Department of Foundry Alloys and Composites
- Department of Moulding Materials, Mould Technology and Casting of Non Ferrous Alloys
- Department of Chemistry and Corrosion of Metals

Some topics being developed in the faculty within the scientific and research activity are listed below:

- Virtualisation of technological processes in foundry engineering. Modelling of crystallization and feeding of castings as well as experimental tests of the solidification and crystallization processes joined with the computer



- optimizacija tehnologije proizvodnje in ulivanja zlitin Oblikovanje livnih struktur, preverjanje tehnoloških procesov taljenja;
- preiskovanje kovinskih kompozitov in metode njihove proizvodnje;
- preiskovanje mehanizmov vezivnih mas z glinenimi vezivi, pa tudi na osnovi snov, ki se strjujejo zaradi kemičnih procesov;
- upravljanje livarskega peska in tehnologije litja ulitkov v povezavi z varovanjem okolja;
- tvorba trdnosti pri zgradbi ulitka in instrumenti;
- pojav korozije in zaščita ulitkov pred korozijo;
- zgradba livnega stroja, mehanizacija in avtomatizacija livarn.

Zgoraj navedene tematike pokrivajo področja, ki zadevajo sodelovanje z industrijskimi podjetji, kar je mogoče realizirati z različnimi projekti, pogodbami itn.

Fakulteta ima vse akademske pravice do izobraževanja študentov na vseh ravneh izobraževanja ter podeljevanja akademskih naslov in diplom. Fakulteta svojim študentom omogoča različne vrste študijev in specializacij. Študijski program je prilagojen trenutnim potrebam sodobnega nacionalnega gospodarstva. Izobražujemo inženirje in magistre znanstvenih ved na naslednjih področjih specializacije v livarstvu: litje različnih zlitin, načrtovanje livnih strojev in njihovega delovanja, mehanizacija, avtomatizacija in načrtovanje livarskih delavnic, precizijsko in dekoracijsko litje, varovanje okolja, uporaba računalnikov pri livarski tehnologiji.

Fakulteta izobražuje študente v vseh vrstah študijev: rednih, izrednih in podiplomskih. Od študijskega leta

simulation.

- Optimisation of the technology of production and casting of alloys. Formation of casting structures, control of technological processes of melting.
- Investigations of metal composites and methods of their production.
- Investigations of mechanisms of binding masses with clay binders as well as on the basis of chemically hardened resins.
- Moulding sands management and casting mould technology in relation to environment protection.
- Strength formation of casting structures and instrumentation.
- Corrosion phenomena and protection of casting against corrosion.
- Casting machine structure, mechanisation and automation of casting houses.

The subject area - listed above - constitutes the topic range concerning the cooperation with industrial enterprises, which can be realised within the frames of various projects, contracts etc.

The faculty has full academic rights to educate students at all levels of education and to confer all academic titles and degrees. It offers to its students various types of studies and different specialisations. The study programs are adapted to the current needs of the modern national economy. We educate engineers and masters of science in the following foundry fields of specialisation: casting of various alloys, designing of foundry machines and their operation, mechanisation, automation and designing of foundry shops, precision casting and decorative casting, environment protection, application of computers in foundry technology.

The faculty educates students at all types of studies: full time, extramural and



2007/2008 naprej fakulteta izvaja tristopenjski izobraževalni sistem:

1. stopnja: (6–7 semestrov) – študentom omogoča, da svoje izobraževanje zaključijo z inženirsko diplomom;
2. stopnja: (3–4 semestri) – študentje z zaključkom te stopnje izobraževanja pridobijo magistrsko izobrazbo;
3. stopnja: (doktorski študij) – to izobraževanje doktoranda pripravi na samostojno izvajanje raziskav in didaktičnega dela ter se zaključi z doktoratom.

V svoji skoraj 55-letni dejavnosti je fakulteta izobrazila več kot 1.160 inženirjev, več kot 2.670 magistrov, 186 doktorjev in 33 izrednih profesorjev.

### **Specializacije, ki jih izvaja Fakulteta za livarski inženiring Univerze AGH za znanost in tehnologijo**

Ti študiji študente pripravijo na delo ne glede na področje v livarski industriji. Študijski program študentom v celoti omogoči obvladovanje osnov in splošnih tehničnih tematik, jim poda temelje informacijske znanosti in računalniških aplikacij, tehnično znanje in osnovne informacije o upravljanju in varovanju okolja. Študent ima prav tako priložnost, da svoje znanje širi prek samostojne izbire dodatnih predmetov, pa tudi s tematiko svojega diplomskega dela, vse skladno z lastnimi interesi in trenutnimi zahtevami trga zaposlovanja.

- Litje železa
- Litje jekla
- Litje neželeznih kovin
- Tehnologija formanja
- Mehanizacija in avtomatizacija livarn
- Livarski stroji in oprema
- Uporaba računalnikov v livarnah

post-graduate. From the academic year 2007/2008 it is introducing the three-level educational system:

- 1st level: (6-7 semesters) - this permits the students to complete their education with engineer's diploma,
- 2nd level (3-4 semesters) - the completion of this course gives the student a MSc diploma,
- 3rd level – doctoral studies –this course prepares the student to do research and didactic work on his own and ends with the doctor's degree.

During our, almost 55 years lasting activity, the faculty promoted the staff of over 1160 engineers, over 2670 masters of science, 186 PhDs and 33 assistant professors.

### **Specialisations offered by the Faculty of Foundry Engineering at the University of Science and Technology.**

These studies prepare students for working within the whole area of casting technology. The study programs give the student a full opportunity to master the basic and general technical subjects, the fundamentals of information science and computer applications, the technical knowledge and basic information on management and environmental protection. The student also has the opportunity to enlarge his knowledge through an individual choice of additional subjects as well as the subject of his diploma, all in accordance with his personal interests and current demands of the employment market.

- Iron casting
- Steel casting
- Casting of non-ferrous metals
- Moulding technology
- Mechanisation and automatisisation of foundries

**Specializacija: varovanje okolja v livarnah**

Študentje so pripravljeni na iskanje rešitev za težave, vezane na varovanje naravnega okolja v posebnih pogojih, ki veljajo v neodvisnih livarnah, livarskih delavnicah znotraj metalurških tovarn in drugih podjetjih kovinsko obdelovalne industrije. Diplomanti te smeri se lahko zaposlujejo v administrativnih in nadzornih službah, katerih glavna naloga je varovanje okolja. To so pretežno podjetja, ki delujejo v metalurški in livarski industriji.

**Specializacija: precizijsko in dekoracijsko litje**

Študij študente pripravi na delo v hitro razvijajoči stroki precizijskega litja zapletenih delov strojev in opreme ter na izdelavo dekoracijskih ulitkov (nekaj primerov je prikazanih spodaj). S to tehniko so izdelani bodisi originalni ulitki bodisi replike modelov (spominske plošče, spomeniki, svečniki, zvonovi, okrasni elementi). Diplomanti s tovrstno specializacijo pridobijo tudi splošno inženirsko izobrazbo o celotnem področju livarske prakse.

**Specializacija: virtualizacija livarskih tehnologij**

Ta študij diplomantom omogoči, da pridobijo znanje s področja livarskih tehnologij in trendov v razvoju, računalniško podprtega inženiringa pri livarstvu, o sodobnih sistemih upravljanja podjetij z osnovami informacijske znanosti in uporabne matematike.

Fakulteta ponuja tudi doktorske študije s področja teorije in prakse livarskih procesov. Poleg tega lahko tehnično-inženirski kader, zaposlen v livarnah, študira v podiplomskih programih in usposabljanjih za zaposodabljanje svojega znanja in izboljševanje spretnosti na izbranih področjih livarske prakse.

- Foundry machines and equipment
- Application of computers in foundries

**Specialisation: Environmental Protection in Foundries**

Students are prepared to undertake the solution of problems related to protection of the natural environment under the specific conditions of independent foundries, in-plant foundry shops operating in metallurgical plants, and other enterprises of the metal processing industry. Graduates from this specialisation can be employed in administration and control offices whose main task is the environment protection. These are mainly the enterprises of the metallurgical and foundry industry.

**Specialisation: Precision and Decorative Casting**

The studies prepare students for work in the intensively developing field of precision casting of intricate parts of machines and equipment and to make decorative castings (some examples are shown below). By means of this technique either castings from original designs or replicas of models are made, (commemorative plaques, monuments, candelabra, bells, decorative elements). Graduates from this specialisation also obtain a general engineering education within the whole area of foundry practice.

**Specialisation: Virtualisation of Foundry Technologies**

These studies enable graduates to obtain knowledge in the scope of foundry technologies and recent development tendencies, in computer-aided engineering foundry work, in modern systems of enterprise management, with fundamentals of information science and applied mathematics.

Ob koncu predstavitve naj vam še zaupam, da je edina fakulteta na Poljskem, ki študentom zagotavlja celovito izobrazbo na področju znanosti livarstva, naša Fakulteta za livarski inženiring Univerze AGH za znanost in tehnologijo v Krakovu. Na lestvici univerz s specializacijo na področju livarstva o tem, kateri diplomanti najlažje najdejo delo (so najbolj »zaposljivi«), prvo mesto zaseda prav naša Univerza AGH za znanost in tehnologijo ter njena Fakulteta za livarski inženiring. Sodelujemo z 79 % vseh livarn na Poljskem. Sledijo Šlezijška tehnična univerza v Gliwicah – pribl. 40 %, Tehnološka univerza v Varšavi – 20 %, Tehnična univerza v Lodzu – 18 % in Tehnološka univerza v Wrocławu – 10 %.

Upam, da sem s to kratko predstavitvijo prikazal dejavnosti Oddelka za livarski inženiring Univerze AGH v Krakovu. Na podrobnejša vprašanja o naših didaktičnih in znanstvenih dejavnostih, pa tudi naši ponudbi za izvajanje raziskav za industrijo, vam bomo z veseljem odgovorili med vašim obiskom naše fakultete.

## Povzetek

V tem orisu zgodovine metalurških znanosti na Akademiji za rudarstvo in metalurgijo lahko vidimo, kako naslednje generacije prevzemajo vodstvo na področju izobrazbe. Metalurška znanost je plod generacij profesorjev, ki so se izobraževali in svoje znanstvene nazive (pogosto v tujih državah) pridobili še pred prvo svetovno vojno. Rezultate njihovega dela so v 30. letih prejšnjega stoletja in v zgodnjem povojnem obdobju presegli tisti, ki so se izobraževali med vojno, ko se je Poljska že osamosvojila. Skupina teh znanstvenikov se je v 50. in 60. letih prejšnjega stoletja nenehno širila, kajti počasi so se jim pridruževali mladi diplomanti, ki so svoje izobraževanje

The faculty also offers doctoral studies in the field of theory and practice of foundry processes. Additionally, the technical-engineering staff employed in foundries can study at the post-graduate studies and training courses to update their knowledge and improve their skills in the selected fields of foundry practice.

At the end of my presentation it is worth to remind that the only faculty in Poland, which offers the full education in foundry science to the students, is our Faculty of Foundry Engineering at the University of Science and Technology in Krakow. In the ranking of the universities with the foundry specialisation, whose graduates can find an employment most easily (are the most „employable“), the first place occupies our University of Science and Technology and its Faculty of Foundry Engineering. We cooperate with 79% of all foundry plants in Poland. Next are the Silesian University of Technology in Gliwice - about 40%, Warsaw University of Technology - 20%, Technical University of Lodz - 18%, and Wrocław University of Technology - 10%.

I hope that this short presentation has shown the activity of the Department of Foundry Engineering, AGH Krakow. If you have any more detailed questions concerning our didactic and scientific activity as well as our investigation offer for the industry, we would gladly answer them during – planned for today - your visit in our faculty.

## Summary

In this outline of the history of the metallurgical sciences at the Academy of Mining and Metallurgy one can see how the successive generations were taking leadership in the education. Its beginnings the metallurgical science owes to the generation of professors, who had been

začeli v prvih letih po vojni. Nadaljnji razvoj v metalurški znanosti, ki ga je bilo moč opaziti, ko sta se Fakulteta za livarski inženiring in Fakulteta za neželezne kovine ločili od matične Fakultete za metalurgijo, je bil rezultat truda več generacij visoko izobraženih raziskovalnih delavcev, mnogi od njih so bili rojeni v povojnem obdobju.

Znanstvene zamisli in številni patenti raziskovalnih delavcev so se kmalu začeli praktično uporabljati v industriji, številne pomembne objave tako na domačih tleh kot v tujini so bile ključne za osebne poklicne poti mnogih mladih raziskovalcev. Mnogi diplomanti Fakultete za metalurgijo AGH so bili tako v preteklosti kot so tudi sedaj na pomembnih in odgovornih mestih v državni upravi, delujejo v vodstvenih kadrih in izvršnih odborih industrijskih podjetij, pa tudi v središčih, odgovornih za razvoj državnega gospodarstva, na univerzah ter v centrih za raziskave in razvoj tako doma kot na tujem.

educated and obtained their scientific degrees (often in foreign countries) still before the First World War. An output of their work was taken over in the thirties and in an early post-war period by those, who were educated during an inter-war period, in Poland already independent. The group of those scientists was in the fifties and sixties steadily growing as the younger graduates who started their education in the first years after the War were gradually joining them. Further development in metallurgical sciences, which was seen after the Faculties of Foundry Engineering and of Non-Ferrous Metals, had separated from the parent Faculty of Metallurgy, was an outcome of the work of several generations of the research workers fully educated and quite often also born in a post-war period.

The scientific ideas and numerous patents obtained by the research workers were soon finding their practical application in industry, and numerous valuable publications at home and abroad were the key to personal professional careers of many young research workers. Many among the graduates from the AGH Metallurgical Faculties have occupied and are still holding important and responsible posts in state administration, in managerial staff and executive boards of industrial enterprises, and in centres responsible for the development of national economy, at universities and in the R&D centres at home and abroad.

## Viri / Literature

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