

# How “Practice Makes Perfect” on the Faculty of Materials Engineering and Metallurgy?

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**Abstract** — *Main areas of research conducted on the faculty of Materials Engineering and Metallurgy are strictly connected with the didactic process realised on particular specialisations. Measurable effects of Faculty's activity are about 300 publications a year, including the ones in publishing houses and conference materials of international range (more than 150), about 30 elaborations of new research methods, technologies, devices, patents of first utility models. For the last few years, a lot of students have been successfully taking part in the abovementioned research works. The experiment with the involvement of students in research projects has been successfully realised on the Faculty of Materials Engineering and Metallurgy, it has been recognised and is appreciated among the students of the Faculty. The achievements of the Faculty within the co-operation with students in the years 2007-2010 are presented in the paper.*

**Index Terms** — *the involvement of students in research projects, practical knowledge*

## INTRODUCTION

The current program of studies on the Faculty of Materials Engineering and Metallurgy of Silesian University of Technology in its main outline is subjected to mutual dependences between microstructure, properties and technology of materials. The graduates of the Faculty of Materials Engineering should have broad stabilised knowledge concerning the structure of materials, the relations of materials with their structure as well as sufficient knowledge of physical chemistry, thermodynamics and kinetics of processes in order to understand the bases of technologies of production and treatment of various materials. For the graduates of the Faculty of Metallurgy the most important is the well-rounded knowledge and understanding of the bases of technologies of production and treatment of materials and further on the bases of knowledge concerning the structure and relations of material properties with their structure. At the same in each of the cases the students should know the general methods of material research, their structure, chemical composition and properties. Such knowledge should be enough in the field of assessment of possibilities and limitations of particular methods in order to be able to conduct independently some research and critical assessment of expertise research. The special features of such studies are their interdisciplinarity and universality. These are huge advantages because the graduates of the Faculty easily adjust to various working conditions.

In recent years, an interesting trend among students can be observed. The trend is not only to gain broad theoretical knowledge but also to gain a lot of practical skills. The theoretical knowledge can be broadened independently in our modern world with the use of the Internet whereas the practical knowledge of the profession of an engineer can be gained in the necessary practice. The most precious practical knowledge can be gained during practical training in various enterprises and companies. The students also demand as many “practical classes” during studies as possible, want to conduct real research on their own, see their usefulness and follow a difficult path leading to experimental success. On the Faculty of Materials Engineering and Metallurgy, an experiment of active involvement of students in the realisation of research projects conducted by academic teachers has been going on for the last 4 years. The precursor of such actions on the Faculty was the Department of Materials Science.

In this publication the involvement of students of Faculty of Materials Engineering and Metallurgy in scientific research is presented together with the range of their research types and the effects of such co-operation.

## THE BEGINNINGS OF THE EXPERIMENT “HOW PRACTICE MAKES PERFECT?”

At the beginning the offer of involvement in research projects was presented to the students of the third year of Materials Engineering specialisation. The employees of the Department of Materials Science were mainly involved in those activities. At present the students of all specialisations on the Faculty of both first and second stage of studies take part in such projects starting from their second year of studying. Initially, the initiative was supported by the science club “Millennium II” which has been operating on the Faculty since 1998. After the consolidation of all five Science Clubs operating on the faculty in 2009 - EURO, Fryszernia, Informer, MediTech and Millennium II – one common Science Club - MaterTech - appeared and has been working up till now. The members of the Science Club are still the

organisation body of the whole project although many students who take part in the research works are not necessarily members of it.

The experiment, which has been conducted for the last 4 years, is connected with direct involvement of students in the scientific activities of the employees of the Faculty. The projects realised on the Faculty are financed from the national budget or by the European Union. The possibilities in this field on the Faculty of Materials Science and Metallurgy are huge, in the last 4 years numerous have been realised. At present, on the Faculty, there are 28 scientific projects in progress, including scientific research type – 12, ordered – 4, development type – 7, 3 target projects, one key project and one strategic project (table 1).

<b>ORDERED RESEARCH PROJECTS</b>		
No.	Symbol of the work	Title of the activity (research topic)
1.	<u>PBZ-2/RM-7/2007</u> PW-004/ITE/04/2006/6/ UW-2007	Elaboration of production technology of wear-resistant nanostructural composite Fe-Cr-Mo coatings by thermal spraying.
2.	<u>PBZ-11/RM-7/2007</u> PBZ-MNiSW-03/I/2007	Elaboration of production technology of constructional elements of hot part of aircraft engines by direct solidification method, task No 4: Elaboration of methods for characterization of nano- micro- and macrostructure of alloys and physicochemical studies of metals and ceramics surfaces.
3.	<u>PBZ-13/RM-7/2007</u> PBZ-MNiSW-01/I/2007 nr 1B-1	Elaboration the basis of production technology of diffusive heat-resistant coatings and interlayers for ceramic coatings on Ni-based alloys for aircraft applications by gas method.
4.	<u>PBZ-15/RM-7/2007</u> PBZ-MNiSW-01/I/2007 nr 1B-2	Elaboration the basis of production technology and characterization of properties of thermal barrier coatings (TBC) by thermal spraying using new ceramic materials.
<b>PURPOSEFUL RESEARCH PROJECTS</b>		
1.	<u>PC-2/RM-7/2007</u> 6 ZR9 2006C/06813	Elaboration and introduction of regeneration technology of surface layer of aircraft engine elements covered by diffusion alumine coatings and thermal barrier coatings TBC
2.	<u>PC-4/RM-7/2007</u> 6 ZR7 2007C/06860	Optimisation of construction and technology of power systems of ceramic forms for precision casting of aircraft parts
3.	<u>PC-3/RM3/2010</u> 6 ZR7 2009 C/07235	Elaboration and introduction of anti-corrosion protection technology of alternative non-cadmium coatings for stationary and rotational elements of compressor of engine PZL-10W and PZL-10S.
<b>DEVELOPMENTAL RESEARCH PROJECTS</b>		
1.	<u>PBR-5/RM7/2007</u> R15 002 02	Material conditioning of technology development for casting of new generation magnesium alloys into sand moulds.
2.	<u>PBR-8/RM7/2007</u> R07 018 02	Elaboration of technology basis for plastic shaping of construction elements from multi-component alloys on inter-metallic phase matrix of Fe-Al type.
3.	<u>PBR-14/RM7/2007</u> R15 013 03	Development of technology of hydroxylapatite coatings creation with the use of thermal spraying method on titanium alloys designed for medicine.
4.	<u>PBR-6/RM-7/2008</u> N R15 0017 04/2008	Development of technology bases for production (in our local conditions) of conventional titanium alloys and alloys with modernised properties caused by the presence of carbon.
5.	<u>PBR-7/RM-7/2008</u> N R15 0015 04/2008	Phenomena occurring during crystallisation of magnesium cast alloys deciding on the high-temperature brittleness
6.	<u>PBR-4/RM3/2009</u> N R15 0012 06/2009	High-resistance steel Mn-Al used for construction elements of mechanical vehicles.
7.	<u>PBR-9/RM3/2009</u> O R00 0051 08	Structure shaping and properties testing of protection coatings created on directionally crystallised nickel alloys used as elements of turbines of military and civilian aircraft engines.
<b>INDIVIDUAL AND SUPERVISOR RESEARCH PROJECTS</b>		
1.	<u>PBU-25/RM-7/2007</u> N507 118 32/3470	The influence of structural factors on the mechanism and kinetics of zinc type "Galfan" coating corrosion.
2.	<u>PBU-58/RM-7/2007</u> N N507 3617 33	The influence of lead halides PbX <sub>2</sub> (X=F, Cl, Br, I) and heat treatment on the obtaining and properties of mixed oxide-halide glass and materials of glass-ceramics type which include lanthanide ions.

3.	<u>PBU-67/RM-7/2007</u> N N507 4689 33	Analysis of interface influence of alloy magnesium-carbon in the aspect of new construction materials production.
4.	<u>PBU-83/RM-7/2007</u> N N507 3805 33	Modelling of structure changes of chosen metal alloys during hot plastic deformation with the use of cellular automaton method.
5.	<u>PBU-16/RM-7/2008</u> N N507 451334	Structural stability of Mg-RE-Zr magnesium alloys in artificial exploitation conditions.
6.	<u>PBU-30/RM-7/2008</u> N N507 439634	Application of ceramics technologies in the process of recycling and waste utilisation.
7.	<u>PBU-52/RM-7/2008</u> N N507 373335	Nanostructural ceramics on the basis of silicon nitride.
8.	<u>PBU-55/RM-7/2008</u> N N507 373435	The influence of big plastic deformations on structure and properties changes in Cu and Al.
9.	<u>PBU-43/RM3/2009</u> N N507 316436	Pulling of glass-ceramics fibres from pre-forms on the basis of SiO <sub>2</sub> -Al <sub>2</sub> O <sub>3</sub> -PbO-PbF <sub>2</sub> with the addition of thulium ions, erbium ions and ytterbium ions for the use in active optical fibres and determining their transmission and emission properties.
10.	<u>PBU-49/RM3/2009</u> N N507 270436	Analysis of dependences between the deformation processes structure reconstruction in alloys on alloys on inter-metallic phase matrix of Fe-Al type.
11.	<u>PBU-80/RM3/2009</u> N N507 462337	Microstructure shaping and properties of the outer coating of titanium alloys with the use of hydrogen treatment in conditions of glow discharge.
12.	<u>PBU-107/RM3/2009</u> N N507 467737	The obtaining and the properties of YAG (Yttrium Aluminium Garnet) with addition of nitrogen and cerium.
<b>TECHNOLOGICAL INITIATIVE I</b>		
1.	<u>IT-1/RM-7/2008:</u> KB/57/13592/IT1-B/U/08	Development of production technology of protection coat on energetic blades of steam turbines with the use of laser sintering method.
<b>STRATEGIC RESEARCH PROJECT</b>		
1.	<u>FSB-71/RM3/2010</u> POIG.01.01.02-00-015/09-00	Advanced materials and technologies of their manufacturing.

**TABLE 1**

EXAMPLE LIST OF RESEARCH PROJECTS REALISED IN DEPARTMENT OF MATERIALS SCIENCE FROM 01.01.2007 TO 31.05.2010.

The students got more interested in participation in scientific research works conducted on the Faculty after organisation of a trip for second and third year students involved in research to the enterprise WSK PZL Rzeszów and to Rzeszów University of Technology where they could visit the modern Research and Development Laboratory for Aerospace Materials and Aviation Training Centre in Jasionka. Modern technologies used in aviation on the world's highest level caused that the door to the Faculty remained open until very late at night and laboratories almost exploded due to enormous interest of students. Such huge interest continues, in and out, in all the laboratories of Department of Materials Science.

#### RANGE AND EFFECTS OF THE STUDENTS' INVOLVEMENT IN RESEARCH PROJECTS

The offers of participation in projects are presented to the students directly by the project manager during a specially organised meeting of science club, open to all the interested students. Students who have chosen and discussed the topic of co-operation type with the project manager gather in groups and learn the basis of the scientific workshops and conduct the tasks which they are to complete within that research. The form of such co-operation differs and is adjusted to the time limitations and students' abilities as well as the range of research in a given project. Students are particularly willing to participate in the experimental parts of research, for example – they prepare metallographic specimens individually, observe the microstructures on light and scanning microscopes, conduct heat treatments, test the hardness and the corrosion processes etc.

Practical approach and created opportunities for individual work for students are appreciated by the students and they participate in the projects actively and with devotion to work. The benefits of co-operation are clear for both sides. The project managers find a lot of enthusiasm and huge practical help in the students and the students not only broaden their knowledge but also realise research for their own final theses. The list of research projects in cooperation with students on the Faculty of Materials Engineering and Metallurgy in 2010 only in the Department of Materials Science is presented in Table 2.

Project manager and the title of the project	Students who co-operate
<p><b>Prof. dr hab. inż. Jan Cwajna</b>  <b>1. PBZ-MNiSW-03/I/2007:</b> Development of manufacturing technology of construction elements of hot parts of engines with the use directional crystallisation method.  <b>2. POIG.0101.02-00-015/08</b> in Operational Program Innovative Economy (POIG). Project is co-financed by the European Union and from the funds of European Regional Development Fund. "Modern material technologies applied in aviation industry", Task 12: Precision casting of Ni alloys for critical parts of aviation engines.</p>	<ul style="list-style-type: none"> <li>- Eliza Budna</li> <li>- Patrycja Pluta</li> <li>- Lucja Klajnert</li>   <li>- Barbara Kościelniak</li> <li>- Izabela Pikos</li> <li>- Marcin Czekaj</li> </ul>
<p><b>dr hab. inż. Lucjan Swadźba, prof. w Pol.Śl.</b>  <b>1. FSB -34/RM2/2009:</b> Modern material technologies used in aviation industry: modern barrier coating on the critical elements of aviation engine.  <b>2. Structure shaping and testing the properties of the protecting coatings created on directionally crystallised Ni alloys in military and civilian aviation engines.</b></p>	<ul style="list-style-type: none"> <li>- Rozmysłowska Aleksandra</li> <li>- Szewczyk Michał</li> <li>- Swadźba Radosław</li> </ul>
<p><b>dr inż. Janusz Adamiec:</b>  <b>MNiSW Nr 0438/R/T02/2008/04 (N R15 0015 04):</b> Phenomena occurring during crystallisation of magnesium cast alloys deciding on high-temperature brittleness.</p>	<ul style="list-style-type: none"> <li>- Kierzek Agata</li> <li>- Ścibisz Bartłomiej</li> <li>- Mucha Sebastian</li> <li>- Chabko Tomasz</li> <li>- Guguła Krzysztof</li> <li>- Laskowski Artur</li> <li>- Saternus Małgorzata</li> <li>- Woźniak Piotr</li> <li>- Młodzieniak Mateusz</li> </ul>
<p><b>dr hab. inż. Anita Olszówka-Myalska, prof. w Pol. Śl.</b>  <b>N507 4689 33:</b> Analysis of interface surfaces influence of magnesium-carbon alloy in the aspect of new construction materials manufacturing.</p>	<ul style="list-style-type: none"> <li>- Anna Urbańczyk</li> <li>- Monika Misiowiec</li> <li>- Jakub Ziemiński</li> <li>- Piotr Wrona</li> <li>- Izabela Szczerba</li> </ul>
<p><b>dr hab. inż. Maria Sozańska, prof. w Pol. Śl.</b>  <b>N N507 462337:</b> Microstructure shaping and properties of surface coating of titanium alloy through hydrogen treatment in conditions of glow discharge.</p>	<ul style="list-style-type: none"> <li>- Bartłomiej Dybowski</li> <li>- Przemysław Polechoński</li> <li>- Tadeusz Herman</li> <li>- Justyna Sudol</li> </ul>
<p><b>dr inż. Magdalena Jabłońska:</b>  <b>N R15 0012 06/2009:</b> High-resistance steel Mn-Al used for construction elements of mechanical vehicles.</p>	<ul style="list-style-type: none"> <li>- Karolina Psikusa</li> <li>- Jakub Zander</li> <li>- Mateusz Matuszczak</li> </ul>
<p><b>dr inż. Tomasz Rzychoń:</b>  <b>FSB - 71/RM-3/2010:</b> Advanced materials and technologies of their manufacturing. Gravitation casting of modern Mg alloy with the addition of alkaline earth metals.</p>	<ul style="list-style-type: none"> <li>- Michał Stopyra</li> <li>- Paweł Jankowski</li> </ul>
<p><b>dr inż. Grzegorz Moskal:</b>  <b>1. MNiSW nr 01/I/2007:</b> Technology of modification of outer coating of advanced construction materials, task 1B-2: Development of technology basis for creation of thermal barrier coatings TBC with the use of thermal spraying and application of new ceramics materials and characteristics of their properties.  <b>2. POIG.01.01.02-00-015/09:</b> Advanced materials and technologies of their manufacturing, priority 1: Research and development of modern technologies, Action 1.1. – Support for scientific research for creation of economy based on knowledge, Sub-action 1.1.2 – strategic programs of scientific research and development works, Area I, task I.2.: Characteristics of chemical, technological properties and usefulness of powders and layers of nano-crystals resistant to abrasion and erosion.</p>	<ul style="list-style-type: none"> <li>- Aleksandra Rozmysłowska</li> <li>- Wojciech Kroker</li> <li>- Radosław Swadźba</li> <li>- Grzegorz Harwat</li> <li>- Sebastian Theda</li>   <li>- Aleksandra Rozmysłowska</li> <li>- Radosław Swadźba</li> <li>- Sebastian Theda</li> </ul>
<p><b>Dr inż. Aleksander Iwaniak:</b>  <b>1. PW-004/ITE/04/2007:</b> research task: technology development of manufacturing the abrasion resistant nanostructural composite thermally sprayed layers of Fe-Cr-Mo</p>	<ul style="list-style-type: none"> <li>- Grzegorz Baran</li> <li>- Michał Hołda</li> </ul>

type.	
2. <b>R15 013 03:</b> Development of technology of manufacturing hydroxylapatite coatings creation with the use of plasma spraying method on titanium alloys designed for medicine.	- Katarzyna Mania - Grzegorz Lubos - Jolanta Mzyk
3. <b>KB/57/13592/IT1-B/U/08:</b> Development of production technology of protection coat on energetic blades of steam turbines with the use of laser sintering method.	- Ewa Śloska - Grzegorz Lubos - Jolanta Mzyk - Adrian Mościcki

**TABLE 2**  
**PARTICIPATION OF STUDENTS IN RESEARCH PROJECTS ON THE FACULTY OF MATERIAL ENGINEERING AND METALLURGY IN 2010**

In 2010, the first group of students, both from the first and second stage of studies, defended their diploma theses realised in the form of co-operation (as described in this paper). The diploma theses were on a very high level and the knowledge level of the students presented by them in their theses, both theoretical and practical, was excellent. Some of the students, as a result of this co-operation could also present, together with the employees of the Faculty, their publications and papers. Their papers were presented by them not only during students' sessions but also during national and international conferences as well as during presentations of so called Philadelphia list (table 3). Each year the place where the students present the achieved results of their own research is their international students' session on the Faculty called "**Materials and technologies of the 21st century**" with edited conference materials. In 2010 the session was organised for the 12th time. Example list of students' publications taking part in projects on the Faculty in 2009 is presented in table 4.

Year	Number of presented papers and publications			
	International Students' Scientific Session „Materials and technologies of 21st century”, Katowice	International Students' Day of Metallurgy-Germany, Austria, The Czech Republic	School of Materials Engineering, AGH	Other
2010	6	declared 10	-	6
2009	10	9 (Ostrava)	9	11
2008	11	9 (Freiberg)	6	12
2007	4	4 (Aachen)	4	7

**TABLE 3**  
**PUBLICATIONS OF STUDENTS TAKING PART IN SCIENTIFIC RESEARCH PROJECTS IN THE DEPARTAMENTS IN THE YEARS 2007-2010**

Place of publication	Data concerning publication
<b>International Students' Scientific Session „Materials and technologies of 21st century”, Katowice 14.V.2009</b>	<ol style="list-style-type: none"> <li>1. Tomasz Chabko – Repair Technology of casts from AZ91 alloy,</li> <li>2. Agata Kierzek – Assessment of possibilities of joining the magnesium cast alloys ZRE1,</li> <li>3. Wojciech Kroker – Influence of chemical composition of heat diffusion of magnesium-aluminium alloys,</li> <li>4. Piotr Krzyżowski – Influence of hydrogen on the microstructure of Ti-6Al-4V alloy,</li> <li>5. Monika Misiowiec – Thermal analysis of the Mg-Ti powder mixture,</li> <li>6. Tomasz Kukielka – Microstructure and hardness studies of ingot MSR-B,</li> <li>7. Jolanta Mzyk, Ewa Śloska – Influence of parameters of anode passivation on the structure of titanium surface,</li> <li>8. Anna Urbańczyk, The influence of temperature and time of pressing on the density and porosity of composite Mg-Si,</li> <li>9. Misiowiec M., Botor-Probierz A., Urbańczyk A.: Thermal analysis of the Mg-Ti powder mixture,</li> <li>10. Urbańczyk A. Botor-Probierz A., Misiowiec M.: The influence of temperature and time of pressing on the density and porosity of composite Mg-Si.</li> </ol>
<b>16 th International Students' Day of Metallurgy- Ostrava,</b>	<ol style="list-style-type: none"> <li>1. Botor-Probierz Agnieszka - Characteristic of chromium coating formed on carbon fibres by physical vapour deposition,</li> <li>2. Chabko Tomasz - The structures and properties of repairing welds of the AZ91-magnesium</li> </ol>

23-25.IV.2009	alloy, 3. Chmiela Bartosz - Structural transformations in two-phase titanium alloys during hydrogen treatment, 4. Jarzebinski Bartosz - Corrosive tests of amalgam fillings in artificial saliva solution, 5. Kierzek Agata - Repair welding of gravity cast ZRE1 magnesium alloy, 6. Kukielka Tomasz - The influence of filling temperature on microstructure and mechanical properties of MSR-B magnesium alloy, 7. Rozmyslowska Aleksandra- Thermal diffusivity characterization of zirconate powders for TBC coating by laser flash method, 8. Swadzba Radoslaw - Structure of aluminide and Pt-Al diffusion coatings deposited on single crystal CMSX-4 alloy, 9. Szula Anna - Corrosion resistance of wires of stainless steel used in orthopaedics.
Materials Engineering School, X.2009	1. Adamiec J. Chabko T.: Weldability assessment of cast alloy AZ91, 2. Adamiec J., Mucha S: Defining the high-temperature brittleness range for magnesium alloy MSR-B, 3. Adamiec J., Kierzek A.: The influence of heat treatment on structure and properties of welds from ZRE1 alloy, 4. Adamiec J., Ścibisz B.: Susceptibility to hot cracking of welds from WE43 magnesium alloy in transvarestriant test.
Other	1. Adamiec J., Chabko T. : Problems with welding and padding of casts from AZ91D magnesium alloys, Spajanie 2/4/2009, 2009, s. 20-23. 2. Adamiec J. , Chabko T. : Structure and properties of the AZ91 magnesium alloy welds created with the use of Friction Stir Welding (FSW), Inżynieria Materiałowa nr 4/2008, s. 320-323. 3. Adamiec J. , Kierzek A. : Padding of the components of waste combustion boilers with the use of nickel alloys, Inżynieria Materiałowa nr 4/2008, 2008, s. 380-385. 4. Pawlik M.: “Errors in introduction of Just in Time in industrial enterprises”, Face to face. Zarządzanie i marketing, Politechnika Rzeszowska, 2009. 5. Czajka M.: “5S not only in times of crisis”, Face to face. Zarządzanie i marketing, Politechnika Rzeszowska, 2009. 6. Olszówka-Myalska A., Botor-Probierz A. , Swadźba L., Krzak-Roś J.: Possibilities of creating technological coatings on carbon fibres, Inżynieria Materiałowa, 2009, Nr. 3, s. 163-168. 7. Olszówka-Myalska A., Swadźba L., Botor-Probierz A., Janus T.: Application of Reactive Chemical Vapour Deposition RCVD in modification of carbon fibre surface, Kompozyty, 2009, s. 19-23. 8. Olszówka-Myalska A., Botor-Probierz A., Krzak-Roś J., Łukowiak A., Rzychoń T. : Application of process sol-gel in coating of surface of carbon fibres with SiO2 coating, Kompozyty, 2009, s. 332-336. 9. Adamiec J., Ścibisz B.: Investigation of hot cracking resistance of 2205 duplex steel, 11th EMAS 2009- modern developments and applications in micro-beam analysis, Gdańsk, Polska, 2009, s. 235. 10. Adamiec J., Mucha S.: Investigation of susceptibility to hot cracking of MSR-B alloy, 11th EMAS 2009- modern developments and applications in micro-beam analysis, Gdańsk, Polska, 2009, s. 236. 11. Iwaniak A., Augustyn E., Adamiec J. : Microstructure and properties of laser-cladded Cr-Ni coating prepared on steel, The 36th International Conference on Metallurgical Coatings and Thin Films San Diego, California, USA 2009, s. 85.

**TABLE 4**  
**PUBLICATIONS OF STUDENTS TAKING PART IN SCIENTIFIC RESEARCH PROJECTS IN THE DEPARTAMENTS IN THE YEAR 2009**

## SUMMARY

The experiment with the involvement of students in the research projects realised on the Faculty of Materials Science and Metallurgy is successful and appreciated by the students of the Faculty. The students find the involvement in the conducted research and the individual realisation of the research tasks the most practical. And that is how “practice makes perfect” on the Faculty of Materials Science and Metallurgy.