PhD research topics

ANTAL KERPELY DOCTORAL SCHOOL OF MATERIALS SCIENCE & TECHNOLOGY

University of Miskolc
Faculty of Materials Science and Engineering
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1. Chemical Metallurgy

Chemical metallurgy basically deals with the extraction of metals - in the suitable form for a specific utilization – from the primary and secondary resources. The scope of this field includes the preparation of raw materials, their processing by pyro- hydro- and electrometallurgical methods, the refining and chemical processing of raw metals and the examination and possible development of the relevant technologies. A special focus is also devoted to the surface modification of metals by various coating techniques and the preparation of metallic, compound or composite surface layers.
The understanding and modelling of the processes taking place under high-temperature conditions or in aqueous solutions allow the production of metals, alloys and special metal containing (semiconducting, magnetic, etc.) materials by novel metallurgical technologies. The subject field also covers the utilization of critical waste materials which may cause difficulties in deposition with regard to environmental protection.
The purpose of this program is to provide further scientific and technical training after the former university level studies in modern mathematical, chemical, physical and materials related fields, enabling the examination of metallurgical processes and the development of systems for metals extraction, purification and chemical processing.

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2. Foundry Engineering

Foundry engineering is one of the most ancient technology of metal object manufacturing which includes the filling and solidification of metals and the treatment of the casted objects.
Casting is the best practice for creating complex shape objects.
Earlier casting production was only based on experiments which was often unsuccessful because of the high number of determinants. These operations today are simulated by computer processes. Simulation algorithms are coequal to Computer Aided Technology tools and rapid prototyping is an effective tool for the fast feedback.
The high standard of the customer requirements can be fulfilled by automatization, process- and device control improvement and by the material and technology development.
New materials and new technologies create new applications for casting parts by continuous development.
Foundry engineering is a modern, up-to-date technology which is safe and environmental friendly.
Foundry industry is essential in technology based societies for creating high end products.
The whole foundry technology is a computer based manufacturing process from tooling to surface treatment and this industry sector is ready to fulfil the requirements of the customers, the environment and the government. Castings are produced by observing design and process requirements.
Target of the program: Scientific postgraduate program based on the university degree. Based on scientific knowledge, theoretical and experimental research&development projects are implemented in the casting-mould-environment system to analyse the relationship between casting shape, moulding material, casting technology and casting part properties. Latest engineering tools, such as computer simulation, CAD-CAM tools, 3D printing, analysis methods are adapted to develop the casting technology and discover new areas of production methods and material applications.

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3. Interfacial phenomena and nanotechnology

The Interfacial phenomena and technologies research field could be classically handled as a subfield for other topics (such as material science or chemical metallurgy), but today, interfacial phenomena and technology based on these phenomena are devoted to world-wide attention.
This structure is also reflected in the progressive educational and research, so we are already presenting as a self-contained topic group under the Doctoral School of Materials Science and Technologies.
The research field can be divided into the following three levels.
Interfacial characterization and modeling of two- and three-phase systems of different material quality.
Creating a link between the interface characteristics (composition, structure and energies) detailed in the previous paragraph and the phenomena that play a decisive role in the various interfacing technologies, with the aim of optimizing the material technology parameters from an interfacial perspective, including the conscious engineering change in the composition / structure of the interface. The aim is to determine experimental and theoretical determination of interfacial energies (and their composition, structure, and temperature) by determining the direction of the interfacial technologies, determining the direction and speed of the processes that are taking place.
The examined phases, on the interface of which the topic group provides knowledge and research possibilities in a list (and not in order of importance) are as follows:
(a) solid phases: solid metal, solid ceramic solid polymer;
b) liquid phases: molten metal, salt melt, melted slag,
polymeric melt, aqueous solutions, organic solutions;
(c) vapor-phase phases of different composition, from air to various reactive gases vapors to inert gases.

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4. Plastic deformation

In metallurgical processes, products produced by chemical metallurgical processes, usually in liquid or powder form, must be further processed into another shape and structure. This is mostly done by metal forming: e.g. by rolling, forging, extrusion. The resulting metallurgical products: rod, tube, plate, wire, are also partly reworked by metal forming (closed die forging, cold deformation, sheet metal forming). Metal forming is a field of science that deals with the deformation of products and the tuning of their properties. From a professional point of view, it integrates the plasticity of materials, applied materials science, tribology, process modeling, as well as the design and operation of forming machines, equipment and manufacturing tools.

The participants in the PhD program will acquire the theoretical and technological design knowledge of metal forming, considering the synergy and interactions between the workpiece, tool and forming machine system. In the course of study, we emphasize the workability of materials, modeling of forming processes, increasing the size and shape accuracy of the products, and overall improvements in product quality. The acquired knowledge is a solid foundation for developing new technologies, new materials and new products.

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5. Physical metallurgy and heat treatment

The metallic materials are indispensable in many areas of today's life. Cars, electrical industry, skyscrapers or space exploration are unthinkable without the use of metallic materials (special alloys). In the field of Physical metallurgy and heat treatment the structure and the physical, mechanical properties of these alloys are examined. The structure and thus the properties can be changed by heat treatment within wide limits. We investigate the processes undergoing heat treatment of steels, cast irons, light and non-ferrous metals, the evolving structure and the changing properties. This topic also covers the study of metal matrix composites.

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6. Materials informatics

The topic is the computational image analysis and modelling of the microstructure of the metallic and composite materials. The methods and algorithms are widely used in that places where the microstructure is investigated by microscopy. Relatively new interdisciplinary research area which importance is growing continuously from the 1970's. Nowadays it is one of the key methods in the microstructure research. The main task of the material science to discover the relations between the distribution of the microstructural elements and the properties of the materials. These relations make possible to develop and produce the best material (best set of properties) to the given application. This topic has an importance in the modelling of material properties, in the computational aided processing or in the quality control of the materials. One of the main method is the stereographic microscopy, which describe geometrically the micrographs and adopt it in the spatial description. It describes exactly the correlation between the examined parameters and the spatial values. The mathematical morphology deals with the basics of the image processing. The stereology either deals with the practice. In this field the differential geometry and statistics are applied to describe the structure of the materials with success.
The aim of the topic: Scientific education based on a master degree. The Participants meet with the modelling and image analysis of the microstructures based on modern material scientific knowledge. The Participants become able to apply the methods in innovative way and to development of new solutions.

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7. Space materials and technology

This topic covers the research of that inorganic phenomena which depends on the gravity. In the second half of the 20th century several new methods are developed to the mentioned examinations and observations. These methods for example the drop-towers, drop-pits, parabolic flight space shuttles and satellites and centrifuges. Several studies prove that normal phenomena (for example burning, solidification, heat and mass transport) takes place in a different way than in the earth under 1G. In the topic the microgravity (10-3 – 10-6 G) and the macrogravity (>1G) are distinguished. One part of this research is look at a part of space research.
There are three main parts of the topic. The first one deals with the equipment of the space research, mainly the materials of the satellites, space stations, centrifuges etc. The second one is studying the phenomena which could not be observed on the earth. For example, the flow of the fluids (heat conductivity, diffusion etc.). The third one examines the materials processing under different gravity level. Very important goal is to separate perfectly the different kind of processes in these conditions.

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8. High temperature equipment and heat energy utilization

The aim is to further develop the knowledge provided by the university degree in mass transport and heat transfer. The subject also covers the chemistry-physics, thermodynamics as well as the latest developments in the field of applied science in combustion, material science and atmospheric environmental protection. The program also includes a production of fireproof building materials, the reduction of pollution caused by combustion of energy carriers and the energy consumption optimization of individual manufacturing technologies.
The topic is based around the research and infrastructure of the faculty. Most of the existing, already produced or extracted energy is used as form of thermal energy (in industrial furnaces, chemical industry, heat treatment, households). It is important therefore, to optimize the distribution and use of thermal energy and minimize the associated air pollution.
The research topics that can be chosen as a doctoral dissertation offers an acquirement of knowledge in the field of primary and secondary energy sources, as well as the knowledge base in the field of the primary energy consumer technologies (metallurgical, electrical energy, chemical, ceramics, glass and agricultural industries). The main goal of education is to prepare scientifically-qualified practitioners in the field of thermal energy management who can:
- optimise the utilization and operation of devices and technologies,
- the innovative modernization of a given technology and creation of new technologies
- the introduction, design, operation of economical thermal energy utilization processes,
- monitoring and improving process measurements and control technologies,
- the active provision of environmental protection tasks related to the utilisation of thermal energy,
- the establishment of the safety conditions and accident prevention in the use of thermal energy,
- the rapid and professional troubleshooting and elimination of malfunctions related to thermal energy production.

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9. Ceramics and their technologies

The aim of this topic is to explore and develop the microstructure and the physical, mechanical, chemical, biological, thermo-mechanical properties of ceramics; composites with ceramic matrix or reinforcement; metallic and non-metallic „ceramizable” materials. The topic also includes improving of manufacturing technologies of these materials according to the customer expectations. Research and development of clay and rock-based traditional ceramics, stone-wares, semi-porcelains and porcelains, glasses, cements, concrete and other building materials, together with modern technical ceramics (borides, nitrides, carbides, titanateschalcogenides) from selecting raw, auxiliary andadditive materials through the technological processes to the qualification of finished products are relevant as well.

Special attention is paid to development of bioceramics and the ceramizability of biomaterials originating from renewable plants and animals. Particular attention is given to the technological, mechanical, chemical and mechanochemical processes occurring during the processing operations undermentioned: shredding; grinding; homogenisation; forming; drying; firing and sintering; as well as to the factors and material properties affecting most of all these processes. Research and development of hetero-modulus, hetero-viscous and hetero-plastic complex materials and material systems, as well as hybrid materials is carried out by examining and optimizing th physical, mechanical, chemical and thermal properties.

The aim of the research theme is to provide to the engineers, physicists, chemists and biologists with MSc degree a postgraduate course which gives advanced knowledge in mathematics, physics, chemistry, mechanics and materials science. During this program, doctorands learn about the manufacturing processes of ceramics, ceramic matrix and ceramic reinforced composites, hetero-modulus, hetero-viscous and hetero-plastic complex materials and hybrid materials. Candidates will be able to create new theoretical and practical methods in researching, developing and designing ceramic based materials.

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10. Polymer technology

The aim of this topics is cover the scientific field of production, processing and application of polymers and polymer-based complex systems. It includes the examination of the properties of polymers, plastics, polymer composites and research the relationships between the structure and the properties. It deals with the definition of technical parameters of the processing; the rheology of polymer melts; and the effect to the pre-processing life.
The aim of these doctoral topic is to accomplish such a scientific training to the engineers with MSc degree when the candidates can study and learn the testing methods of polymer-based systems with several material testing equipment (DSC; DMA; FT-IR..), learn about the polymer-physics and chemistry and the special knowledge of polymer science. In additionally the importance of this program is to develop such a way of thinking that is based upon the complex properties.
The researchable themes cover many areas of application of polymers and plastics. Besides the instruments' park of the Department of Polymer Engineering it is possible to use the infrastructure of affiliated partner institutions and industrial enterprises.
Main topics: The mechanical and electronic properties of polymers; polymerblends; elastomers and rubbers; PUR-foams and elastomers; PVC-systems; polyolefins and modified polyolefins; biodegradable plastics; plastic processing.

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11. Chemical processes and technologies

This topic covers the chemistry from the molecular understanding through the colloidal systems to the chemical engineering supported by disciplines such as inorganic, organic, analytical, physical and colloid chemistry as well as macromolecular sciences. The coherent development of the fundamental research and technology empowers the chemical industry to answer the modern requirements of increasing volume, quality as well as the directives for the reduction of the environmental risks.

To meet these criteria, it is necessary to further improve the understanding of the applied chemistry and unit operation as well as the capabilities for computer aided design, modelling and process control. This improvement makes it possible to design better devices for chemical processes, to optimize chemical technologies and to achieve effective operation of the units.

The research topic can be chosen as it is focused on only one of the above mentioned chemical disciplines. Alternatively, candidate can do research on chemical.

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