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Annual scientific awards of the Division IV Technical Sciences of the Polish Academy of Sciences in 2006

For many years it has been a great tradition of the Division IV of Technical Sciences of the Polish Academy of Sciences to recognize the outstanding achievements of young scientists with several Awards related to various fields of technology. The awarded candidates have to satisfy the requirements specified in suitable Regulations. In 2006 the Scientific Award Fund of the Division IV was supported by the well known international Siemens company which significantly augmented the status of the Awards. The list of Awarded Winners and the brief description of their achievements prepared by the authors are as follows.

In the field of Materials Mechanics:

Wacław Olszak Prize

Compensation systems for low temperature applications

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The Award of the Division IV of the Polish Academy of Science in the field of Materials Mechanics has been granted for the monograph "Compensation systems for low temperature applications". The monograph is dedicated to three distinct problems: mechanics of continuum at low temperatures (including the temperatures close to absolute zero), stability of axi-symmetric thin-walled corrugated shells and parametric optimisation of compensation systems designed to work at cryogenic temperatures. Taking into account that the publications related to material issues combined with the structural analysis and optimisation for low temperature applications are very rare, the present monograph constitutes an attempt to fill the vacancy.

The significant part of the monograph is focused on the analysis of phenomena related to plastic yielding of metals at low temperatures. The following phenomena are discussed: phase transformations, discontinuous yielding and evolution of micro-damage. The thermodynamics of processes that occur in the "frozen" metal lattice is explained. Special attention is focused on the phonon mechanisms of heat transport in the investigated temperature range. The second part of the monograph deals with stability of thin-walled shells at cryogenic temperatures. One of the interesting issues developed in the work is the fatigue induced structural instability of shells represented by corrugated bellows. The reliability oriented parametric optimum design of cryogenic systems containing the corrugated bellows constitutes the third part of the book. The last chapter contains the applications of the previously derived equations and algorithms to design modern instruments of high energy physics – particle accelerators and cryogenic systems.

In the field of Electronics:

Investgation of micro and nanostructure using scanning probe microscopy

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The awarded work presents the experiments carried out in the Laboratory of Scanning Probe Microscopy, Nanostructure and Nanometrology at the Faculty of Microsystem Electronics and Photonics of the Wroclaw University of Technology. In these investigations the nearfield based methods and techniques in the quantitative measurements of thermal, mechanical and electrical surface properties in the nanometer scale were utilized. In this publication the design and characterization of the nearfield microsensors, which were utilized during experiments, are also presented.

In the field of Electrical Engineering:

Three-phase PFC unidirectional energy flow rectifier systems

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The award of the Technical Sciences Division of Polish Academy of Science was granted for the series of papers devoted to three-phase Power Factor Correction unidirectional energy flow rectifier systems. Rectifier systems are one of the most popular converters widely utilised in industry, office and home electronic applications. Electrical power quality is a common and important question, especially the problem of current harmonics that are drawn from the electric power utility and high power factor value have priority meaning. Low harmonic content of currents absorbed by electrical power receivers and high power factor ratio is essential for more effective use of electric power

utility. Classical rectifier structures are one of the electric systems with large input non-linearity. They draw out current from the mains at low power factor value and high total harmonic distortion ratio. For these reasons, constructions of rectifier systems that are able to fulfil these requirements and guarantee robust and safe operation are still developed. The standard bipolar, bi-directional energy flow, PWM converter is two voltage level system. It causes relatively high level of current ripples and electromagnetic noise. Voltage stresses of the transistors are relatively high. For these reasons, multilevel rectifier systems are developed. Most of the applications, except high dynamic electric drives and tanks of electric energy that are applied for electric system stability, do not need energy recuperation. In these cases rectifiers with unidirectional energy flow and three or higher voltage levels may be good solutions. Two structures of rectifier systems have been discussed in these papers: modified diode bridge rectifier and Vienna Rectifier I. Presented structures may be considered as a development of a standard three-phase six diode bridge rectifier. The first construction is devoted to low frequency, high but near constant power applications. The second is applied for a high power factor, a low current distortion rectifier for high voltage supply (about 700V to 1000V) of electronic equipment.

The basic theory of functionality has been described. Original voltage space vector control method is proposed for Vienna Rectifier I. Simulative and partial experimental investigation results are placed. Advantages and disadvantages of the presented structures are given in detail.

In the field of Materials Engineering:
Bohdan Ciszewski Prize

Unconventional methods of forming structure and properties of FeAl-based intermetallic alloys

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The awarded dissertation summarizes recent progress in research on structural FeAl intermetallic alloys. Considered FeAl intermetallics possess attractive mechanical properties for structural applications at elevated temperatures in hostile environments. However, they exhibit poor ductility and brittle fracture at room temperature as well as poor strength and creep above 6000C. Recent studies have led to recognizing both intrinsic (materials) and extrinsic (technological) factors governing the fracture behaviour of FeAl intermetallics. Moisture-induced hydrogen embrittlement and vacancy hardening have been identified as a major cause for brittle fracture and low tensile ductility. The addition of boron has been found to improve the ductility of FeAl alloys at room temperature. The FeAl intermetallics exhibit anomalous temperature dependence on yield stress. A grain refinement which is very beneficial for the improvement of mechanical properties of metal alloys is conventionally achieved by successive cold-work and recrystallization. However, conventional cold-work routs such as rolling, forging. etc. are difficult to be carried out for FeAl intermetallics which are inherently brittle. Therefore, this dissertation is an overview describing the results of studies on the processing of FeAl intermetallics by two unconventional methods resulting in a heavy cold-deformation: shock-wave (explosive) deformation and controlled mechanical (ball) milling. The structural and microstructural evolution, long-range order changes, and Vickers microhardness brought about by shock-wave loading and ball-milling as well as subsequent annealing are presented and discussed in this dissertation.

In the field of Metalurgy:

Hydro-jet surface treatment

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The hydro-jet surface treatment method belongs to the group of newest technologies that uses high-pressure waterjet energy and admixtures carrying by the jet. The main stream of experimental and technical development of hydro-jet machining is directed to cutting different materials. While surface treatment, after its initial development from before 30 years, as a principal stream progress in water-jetting, since last six years has been again in prosperity, mainly thanks to usage of ice particle jet.

High-pressure water-jetting consist of two technological groups, connected with high-pressure pure water jet and water jet including different solid particles admixtures. All above are analyzed in this awarded scientific work.

After reviewing approximately 3 thousands publications in that scope, devoted to different methods of high-pressure water jetting and derivative jets, there are presented a short reviews of most important problems. Problems of surface treatment using high-pressure water jet and its specific character of pipeline inside cleaning, also high-pressure abrasive-water and ice-water jets, are admitted as most important for presented subject area.

Basing on theoretical analysis results and experimental research, it was worked out a total problem showing out basis of surface treatment using high-pressure water jet, a problem of outer surface treatment and inside pipelines cleaning method, also surface treatment using high-pressure abrasive-water, ice-water and hybrid jets. Detailed conclusions, presented chronologically, describes each analyzed matter, separated in individual chapters.

Finally, there are presented the most important generalizations, that results form realized theoretical analysis and experimental research presented in individual chapters. Such form of generalized conclusions, based on comprehensive considerations, that are presented in, can be a

kind of summary of author's literary output in presented scope of theoretical and experimental basis of hydro-jet surface treatment.

In the field of Informatics:

Feedback control of acoustic noise at desired locations

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Sound is a common part of everyday life. It enables spoken communication, provides enjoyable experience, permits to make quality evaluations and diagnoses, alerts or warns. However, sometimes sound is unpleasant or unwanted an then it is called noise. Noise increases together with development of industry and transport. In addition to loss of concentration and annoyance many people suffer from severe hearing damage due to high-level ambient noise in their working environment. Commonly used passive barriers are practically unfeasible for low-frequency noise, e.g., industrial or road noise. They are also not applicable if the listener needs to move over a noisy environment. Therefore, active solutions gain considerable interest in recent years.

In active noise control secondary sound sources are used to reduce acoustic noise from the original primary sources by generating appropriate secondary sounds. The theory, although formally very simple, is difficult to be directly applied in practice. There are many problems related to physical aspects of the cancellation phenomenon as well as related to control.

Global active noise control in a large free-field area or in an entire enclosure is practically unfeasible. Therefore, generating so-called local zones of quiet, i.e., areas of high noise reduction, is of utmost interest. However, it is often impossible to place a microphone at such area due to practical inconvenience or technological difficulty. Thus, another microphone placed as close as possible should be used.

Unfortunately, the zones of quiet are of complex shape and their dimensions are small compared to the lengths of acoustic waves contributing to the noise. Hence, when generated at the microphone providing information about acoustic waves interference they may not reach the area of interest. This was experimentally confirmed when classical control systems were applied. A reasonable solution can be to shift the zones to desired locations represented by the so-called virtual microphones.

One of the examples of systems where such problem is encountered is an active headrest. In a prototype of this system used for experiments the headrest of a chair is equipped with loudspeakers generating secondary sounds for both channels, as well as microphones sensing interference effects. This system is characterised by small distances between the desired locations and corresponding available microphones, compared to the wavelengths of the acoustic noise. Other examples could be a phone or a local area in an enclosure.

If a reference signal close to the noise source is measureavailable it may be used to provide information about the primary noise in advance. Then, a feedforward control can be undertaken. However, if such signal is not available or mobile applications are considered, feedback control is the interim solution. In such approach the measurement of the acoustic waves interference constitutes the input to the control system. Such general case was dealt with. Therefore, different feedback virtual-microphone control systems were proposed.

The objective of the research was to design and analyse optimal and adaptive feedback control algorithms appropriate for attenuating acoustic noise at desired locations. Optimal control filters were derived using polynomial, frequency-domain and correlation-based approaches. However, contrary to most of the corresponding references imperfect modelling of the system was assumed. The optimal control systems were analysed in terms of performance and stability. Solutions to improve stability were recalled. Then, adaptive realisations were presented and analysed with focus on conditions for convergence of the algorithms. Overlapping problems of stability of the feedback loop and convergence of the adaptive algorithms were discussed. Methods for improving robustness were also included. First single-channel systems were considered. Then, they were extended to multichannel systems, which aimed at extending dimensions of the zones of quiet to provide higher acoustic comfort to the user.

The theoretical analysis was confirmed by means of simulation experiments as well as by experiments performed on the laboratory setup. The experiments demonstrated also practical success of the developed systems.

In the field of Machine Design and Exploitation:

Experimental analysis of strain distribution in fatigue cracking zones

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Strain and stress concentration resulting in local plastic strain zones is a cause of initiation and growth of fatigue cracks; hence relating strain and stress state to fatigue process is one of the main tasks of the fatigue structure analysis. Difficulties in modelling fatigue behaviour of structure make the experimental methods an essential tool in the effective fatigue analysis of different technical objects. With that in mind an experimental analysis was carried out which involved investigating the effect of geometrical discontinuities and material inhomogeneities

on strain distribution in fatigue cracking zones of materials and structures under fatigue load conditions. A concept was developed incorporating experimental and hybrid (experimental-and-numerical) analysis of the strain state used investigating the fatigue cracking zones in objects projecting real structures applied e.g. in aeronautics and shipbuilding. Moreover, a method was proposed to determine local fatigue properties in material inhomogeneities zones applied to local fatigue properties analysis for the laser welded joint. Based on the analysis of research results, it was shown that e.g. geometrical discontinuities and material inhomogeneities in complex structural parts can create conditions for a simultaneous initiation and growth of several fatigue cracks in a single area of strain and stress concentration; the simultaneous analysis of maximum local strains and strain gradient can be an efficient tool while predicting fatigue crack origin locations. Also the effect of local plastic strain zones on material property changes in fatigue cracking zones was shown. As a result the so-called constant material fatigue properties appear to depend on the load history. The analysis of research results for the laser welded joint showed considerable differences in material properties, both cyclic and static, in particular zones, while fatigue load significantly changed the material state, as compared to static loads. The presented research has also justified the applicability of the research.

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The suitable procedure aiming at the determination of the Award'2007 Winners has just started.