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Faculty of Mechanical Engineering and Robotics

Department of Process Control

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08-11 June 2015

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Preface

Ladies and Gentlemen,

Following the 20 years' tradition, we are meeting again at the Conference on Active Noise and Vibration Control Methods. Our main aim is to present the results of recent research work, to exchange ideas and to share experience with representatives from research centres foreign and Polish.

The control of low frequency noise and vibration has always proved to be a difficult task and in many cases not feasible at all due to the long acoustic wavelength involved. If passive techniques only were considered, noise control would require large mufflers (silencers) and heavy enclosures and very soft (flexible) isolation systemsor perhaps extensive structural damping treatment would be needed for vibration control. Active noise and vibration control methods involve the use active systems to reducethe transmission of vibration from one plant or structure to another.

The Conference organized by the Department of Process Control AGH University of Science and Technology is held every two years. The major research areas include: active and semi-active methods of vibration control, active noise control, applications of smart materials and structures and control of noise and vibration parameters.

The "School" held for the first time in 1993 was transformed into a Conference in 2003 and was named: Conference on Active Noise and Vibration Control Methods. The papers submitted by those taking part will be published not only in conference materials but in acknowledged academic journals. Following the decision of the reviewers, the papers will be published in the quarterlies "Mechanics and Control" and "Low Frequency Noise, Vibration and Active Control".

The first "School" was held in Rabka - Zaryte. The idea was put forward in Janowice, by Professor Igor Ballo, Professor Zbigniew Engel and Professor Józef Nizioł. Active vibration and noise control was already developing rapidly in the world and the academic community in Cracow, were the first to begin the research in this field in Poland.

Though from the very beginning the School was organized as a local conference, the Program Committee also included academics from research centres abroad.

This year the 12th Conference on Active Noise and Vibration Control Methods is organised offering scientific sessions with presentations of contributing papers and posters.

We are pleased to give the readers electronic versions of 38 papers selected by Program Committee and divided in 5 sections:

- Active Vibration Control,
- Semi-active Vibration Control,
- Active Noise Control,
- Structural Control,
- Smart Structures,

I would like to thank the Program Committee for reviewing the papers and the publishers who agreed to publish them. I would like to express my gratitude to research workers from the Department of Process Control who have shown a great sense of commitment.

As the Chairman of the Organizing Committee let me express my hope that the conference will be a good opportunity for the exchange of ideas and for presentation the results of research work. I am convinced you will find the presented topics most interesting, instructive and useful in practical applications. Let me wish you then, on behalf of the Organizing Committee and Program Committee, a pleasant sojourn in Krynica Zdroj.

Janusz Kowal

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Extended Abstracts

Active Noise and Vibration Control Methods
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Design and Modelling of a vibration exciter based on electro-hydraulic servo-actuator

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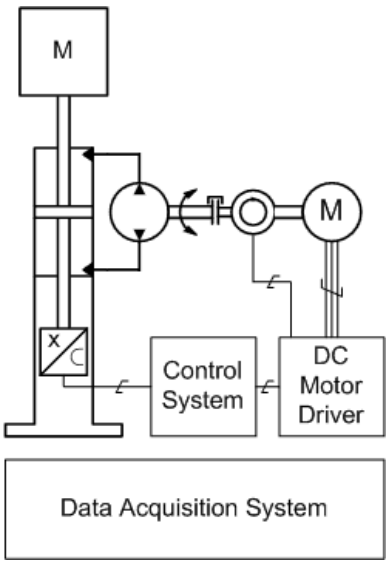
Keywords: electro-hydraulic servo-actuator, hydraulic pump, exciter.

Abstract. The purpose of investigation an electro-hydraulic servo-actuator is to find out their usefulness as an exciter with ability to control of a frequency, amplitude and a shape of the generated vibrations. Proposed solution of an electro-hydraulic servo-actuator consists of fixed displacement hydraulic pump driven by DC servomotor that directly supplies a hydraulic cylinder described among the other in [1]. Main feature of this solution is their simplicity, width range of stroke, high available forces and ability to continuous control a speed, position and direction of a cylinder motion as well as low power losses comparing traditional electro-hydraulic servo-drives. In the paper proposed mathematical model has been described that refers to the idea of vibration exciter based on electro-hydraulic servo-actuator. Simulations show the principle of an exciter work with strong emphasis to the bandwidth of generated vibrations related to amplitude. Results of simulations show as well influence of a load applied to the exciter and ability to trace different type of harmonic signals determined by a control system.



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Simulation Studies of the Active Control of Smart Rotors with Gyroscopic Effects

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Keywords: rotor-dynamics, FEM, active control, piezoelectric.

Abstract. The work is focused on the modelling of a rotor with significant gyroscopic effects, equipped with piezoelectric sensors and actuators bonded on its surface, so that it can be controlled. Since the analysis of such a structure has important limitations in most FEM software, caused by inadequate rotor-dynamics models provided, it cannot be reliably simulated in commercial finite element codes. The authors develop a method of solving these limitations by combining the FEM and Matlab software. By importing the FEM matrices into Matlab and appropriately transforming them, it is possible to supplement the FEM model with the necessary additional expressions in the equations of motion.

In their earlier works the authors have examined the possibilities and limitations of the FEM software Ansys in the area of rotor-dynamics. In Ansys the analysis in the rotating reference frame is not fully satisfactory since it does not account for the gyroscopic effects and the capacity to model damping is limited. On the other hand, the proposed active structure needs to be analyzed in this reference frame, since the piezoelectric elements are bonded to the surface of the rotor and rotate with it (if the analysis were performed in a non-rotating reference frame, piezoelectric elements would act in the stationary directions).

In the first step the correctness of the proposed modelling of gyroscopic effects will be verified for a rotor without piezoelectric elements through comparison with the results obtained from an analytical 4 DOF model of a rotor, as well as with the results using the stationary reference frame in Ansys. In the next step piezoelectric elements will be taken into account and control algorithm will be implemented in the models imported from Ansys into Matlab. The influence of gyroscopic effects on the performance of a control algorithm that allows to influence the effective damping of the rotor will be checked. The analysis in our previous studies indicates that the internal damping of rotors with a geometry in which the gyroscopic effects are negligible can be affected by applying a direct velocity feedback control algorithm. The aim of the present analysis is to study numerically the influence of the gyroscopic effects on the operation of such a control algorithm in a rotor with a significant gyroscopic matrix.

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Adaptive control for robot manipulator

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Keywords: Robot manipulator, mathematical model, control algorithms, nonlinear object, simulation tests.

Abstract. This paper is concerned with minimizing vibration two degree of freedom robot manipulator intended for the rehabilitation process. The vibrations of mechanical systems, this system is a robot manipulator, defined as the oscillating movement around the position of the quasi-static equilibrium. By the vibrations of the robot manipulator should be understood as additional movement, accompanying of specified movements robot elements when performing define tasks in the manipulation workspace. Causes vibrations thus defined, should be seen as a time-varying robot motion speeds, accelerations and "jerks". Where the jerk is the third derivative of the generalized coordinate describing the movement of elements of its structure. Furthermore in the accompanying effectors configuration changes (ie. the orientation and position) and change the value of mass moments of inertia relative to the axis of rotation of individual members. Important for the vibration level observed in the robots systems are also the external forces manipulator.

Robot manipulators vibration level directly influence the obtainable precision and repeatability of positioning during manipulation tasks. Particularly important is the elimination of vibrations during the rehabilitation process. The vibrations are in fact transferred to the rehabilitated person. Therefore, it is proposed to position control the adaptive control algorithm. First, a robot manipulator mathematical model was developed.

The dynamic equations were used to build a model in MATLAB. During this research, the main problem was suitable control quality. It is very important because control quality is connected with a rehabilitation process. The control algorithms enable movement realization and obtain a set position given by the physiotherapist. The results of simulation tests include comparisons between a traditional PID controller and adaptive algorithms.

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Balance Maintaining by Human

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Keywords: balance, low-frequency, sway, analysis.

Abstract. Harmonious cooperation of the skeletal, muscular and nervous systems, forming a human motion organ, is responsible for all undertaken movement activities. Motion organ in the illustrated embodiment responsible not only for two basic motion activities, locomotion and manipulation, but also for maintaining the posture of the human body. Standing posture control makes a particular dimension of physical activity, because correct, stable posture determines the ability to perform most human movements. In the case of a man to maintain a balance in a standing position seems to be something obvious and does not require much effort, but with the advent of lesions or aging we begin to see how complex it is the process of balance control. The changes lead to impaired balance control which in turn can lead to the appearance of postural instability and in extreme circumstances, even to collapse. Maintaining a stable posture it is primarily associated with motor control provided by the human nervous system. The nervous system acts as an posture control system and most of all giving to a body well-defined silhouette. This control relies heavily on the integration of information from the human receptor system. Muscle, joint, tendon and skin receptors communicate first to the brain information about the movement and position of individual body parts and then feedback these signals to the muscles, causing reflex reactions allowing for correction of posture and thus return the center of gravity to a position that maintaining equilibrium. Subdivide those human body into segments linked closely with the system osteoarthritis limbs and trunk can create a system of interconnected pendulums with many degrees of freedom. In the case of standing it will be largely complicated inverted pendulums system by which activities phenomena associated with maintaining balance and locomotion can be modeled. If additionally in an upright position, taking into account the natural motion restrictions movements in all joints except the ankles will be blocked, the body will be a close approximation behave like a rigid body. So we can assume that for supporting the human body at the ankle, it will behave like an inverted pendulum. The article presents the ways of describing the equilibrium of man as an inverted pendulum.

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Discrete Preisach Model of a Shape Memory Alloy Actuator

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Keywords: actuator, shape memory alloy, model.

Abstract. Shape Memory Alloy is a material used to designing actuators. These actuators have many advantages. They are light, strong and silent [1]. They are building in laboratory and tested because beside advantages they have disadvantages too [2,3]. SMA actuators have nonlinear characteristics with hysteresis loop.

In the first part of the paper Shape Memory Alloys are shortly described. Next mathematical model was formulated. In the paper the Preisach model was developed [4]. Discrete form of the model was considered and implemented. After parameter identification model was implemented in LabView. Tests of the model were conducted and results were worked. Obtained characteristics of the SMA actuator are shown in the paper. At the end of the paper the conclusions were formulated.

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Optimal controller for active vehicle suspension disturbed by sinusoidal signals

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Keywords: Optimal control, sinusoidal disturbance, vibration reduction, frequency response shaping, active vehicle suspension

Abstract
The problem of optimal control of systems disturbed by sinusoidal signals for infinite control time is considered in the paper. The control laws described in [1] is base of a modified mean-square performance index with an infinite control time. The performance index was formulated in such a way that each sinusoidal component corresponds to a separate weight matrix. This allows energy constraints on the control signals to be differentiated based on frequency. An optimal solution to the optimization problem was found. In the paper the problem of the impact of time on the identification of sinusoidal disturbance on vibration isolation system frequency characteristic.The controller was synthesized for slow-active vehicle suspension [2,3]. The model of suspension, synthesis of the controller and implementation of the system was described. The results of simulations of the designed vehicle active suspension system are presented.

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Employment of double-panel casing for active reduction of device noise

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Keywords: active casing; double panel; active noise control; active vibration control; active structural acoustic control; adaptive control.

Abstract. The idea of active casing is an approach to reduce device and machinery noise by controlling vibration of casing walls. The sound insulation efficiency of this technique for a single-plate casing was confirmed by the authors in previous publications. However, under specific circumstances, a dedicated double-panel structure can yield even higher noise reduction.
The aim of this paper is to propose and evaluate by means of laboratory experiments the performance of a double-panel casing in comparison with a single-panel casing. An adaptive control strategy based on the Least Mean Square (LMS) algorithm is used to update control filter parameters. A low-frequency noise in the range up to 250 Hz is considered. Obtained results are reported, discussed, and conclusions for future research are drawn.
Experimental results and conclusions. Active structural acoustic control of multiple walls of a device casing has been performed for both single- and double-panel structures. To control vibrations of the casing walls, inertial exciters NXT EX-1 have been used. Depending on the particular configuration, the error signal is obtained by microphones placed in front of each casing wall in the distance of 500 mm (outer microphones), microphones placed in the cavity between the plates of double panels (cavity microphones), or by accelerometers. Significant levels of global noise reduction have been achieved, confirming high potential of the active casing approach to reduce excessive device noise. The configuration employing outer microphones for control purposes performed better in case of single panels than in case of double panels. This is due to the fact that actuators have been placed on the incident panel. However, the double panel-structure introduces higher passive noise attenuation, and hence the noise is reduced more in total. The configuration with cavity microphones performed definitely better. Its performance was more reliable and noise enhancement or convergence problems never occurred. Moreover, such configuration is more feasible for practical implementation. Usually, users cannot agree to keep error microphones around the casing. Additionally, cavity microphones can operate with a lower gain, than outer microphones. Hence they are less vulnerable to external disturbances. Therefore, for double-panel structures cavity microphones are more recommended as error sensors than the outer microphones. Employment of accelerometers as error sensors is inferior to using microphones. It is efficient in reducing vibrations. However, it does not necessarily imply that the noise is reduced most efficiently. The research has been supported by the National Science Centre, decision no. DEC-2012/07/B/ST7/01408.

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Identification of kinematic excitation function by the modal coordinates estimation of the system's dynamics

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Keywords: dynamics, finite element method, fatigue life, modal analysis

Abstract. The paper presents a method of the kinematic excitation courses' identification in excitation points, based on the car road test acceleration at different measurement points. For the purpose of the laboratory fatigue life investigation of contemporary complex structures (e.g. cars bodies) and components of these structures (i.e. cars roofs), only a few first vibration modes are usually taken into account. During real life tests (i.e. road tests), accelerations at the selected points and along the defined directions are recorded and preprocessed appropriately. The FIR low pass filter was applied to analysis of the recorded accelerations at cut off frequency set to 30 Hz. This allowed correct identification of the first twelve modal accelerations of the subsystem with unknown motion. Subsequently, appropriate information about the measured acceleration allows us to identify such kinematic excitation function on the laboratory stand, whose result is the same as during the real road test (Fig. 1).

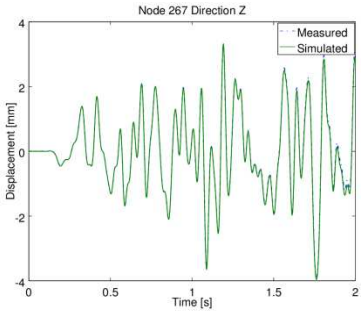

Fig. 1. Exemplary time displacements of the structure for node 267, green line – simulated plot, blue dotted line – measured plot.

Thanks to the proposed approach, further experiments towards determination of the fatigue endurance can be performed, instead of time-consuming and costly investigations of vehicles on roads, on the especially arranged laboratory stand.

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Topology optimization of a bounded space for a vibroacoustical problem in a low frequency

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Keywords: vibroacoustics, modal analysis, optimization, genetic algorithms.

Abstract. The article deals with the problem of a space with vibroacoustical source generating inside specific conditions, which form a field of some values. All applies to an acoustic field in particular, characterized by an acoustic pressure or field of displacements in vibration problems. In general the field is described by specific dependent variable *w(t)* in all points of space, whose location are defined by coordinates r. The first aspect of this work relates to the modeling of an induced field, which can be alternative to finite element method (FEM) or boundary element method (BEM) in a low range of frequency. According to modal assumption the solution describes the vibroacoustical field is in the form of sum of time components *w(t)* and eigenfuntions Ψ(r): $p(r,t) = \sum_{m=0}^{\infty} w_m(t)\Psi_m(r)$.
In order to get Ψ the eigenvalue problem has to be solved and time components are simple and easy to obtain especially in case of harmonic source. If the assumption of the highest values of acoustical or mechanical impedance of the space boundaries (damping properties of boundaries) is made, the modal coupling can be neglected. Such approach results in the vibroacoustical model being faster than alternative FEM or BEM models and suitable for the optimization. The second aspect is connected with minimization of some significant factor level related to dependent variable w(t) and subsequently to control field inside bounded space in order to get required state. Thereafter, the topology optimization problem is formulated, where the influence of boundaries, represented by their impedance and the shape of space, represented by eigenfunctions are considered as the design variables. The genetic algorithm method is applied in order to find a minimum of objective function. In this case the function returns some functional value. As the result of the optimization a topology of the investigated space is obtained in the form of its shape and simultaneously configuration of damping properties of the space's boundaries. The results show that a combination of boundary conditions and simultaneously the space shape modification have the effect of field values reduction more powerful than their separate influence. In this paper the example 2D arbitrary bounded space is considered and optimized. The optimal space shape and impedance values are plotted and compared to same possible shapes, which could be found and considered.

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Virtual microphone control for an active noise-cancelling casing

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Keywords: active noise control, active vibration control, adaptive control, virtual microphone control, active casing

Abstract. An active noise-canceling casing is very attractive for reduction of sound generated by devices. Such casing can provide good noise reduction for low frequencies, where a passive barrier would be too thick for practical use. The classical active noise control approach, where the goal is to minimize the sound pressure level around multiple microphones outside the casing can be used. However, it requires placing external microphones, what makes the overall technical solution not accepted for many applications. The active vibration control, where the goal is to minimize vibrations of all plates, requires only sensors on the plates. However, in this solution, in turn, noise reduction results are worse. This paper presents employment of the idea of the virtual microphone-based approach to improve results from the system based on vibration sensors only, which are used to estimate acoustic pressure at specific locations in the acoustic field. By using a two-stage structure, the system is tuned to reconstruct the same vibrations of the plates,
which were present when the acoustic pressure were minimized directly in the square sense. A laboratory active noise-canceling casing used for experiments is made of 5 actively controlled aluminum plates mounted on a steel frame. It is passively isolated from the floor. On each plate, three electrodynamical actuators are installed. The control system is experimentally verified and obtained results are reported.
Conclusions. The proposed VMC system provides much better results in terms of noise reduction, than the AVC system using the same sensors, and they, moreover, are comparable to results of the ANC system requiring external microphones. For the VMC system such microphones are only needed for the tuning stage, which can be performed during assembly or instalation of the casing on site.
Acknowledgements. The research reported in this paper has been supported by the National Science Centre, decision no. DEC-2012/07/B/ST7/01408, and by the Ministry of Science and Higher Education, Poland. The calculations in this study were carried out using GeCONiI grant infrastructure (POIG.02.03.01-24-099/13).

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Influence of Reduction Methods of Structure Models on the Stability of Vibration Control System

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Keywords: smart beam, orthogonal methods, Ritz decomposition, optimal controller

Abstract: To design vibration control system for flexible structures their model should be reduced. In the paper we consider the influence of the model reduction on the dynamics of the real closed-loop system. A simply cantilever beam is an object of consideration since we are able to formulate the exact analytical model of such structure. Many of the reduction methods are presented in the literature [1,2,3]. As a result of reduction the model with low frequency resonances is usually separated from the high frequency dynamics because high frequency part of the model is naturally strong damped. In order to estimate dynamical system for control purposes in the paper we applied a few orthogonal methods such as: modal, Rayleigh-Ritz and Schur decompositions. As it is shown all methods well calculate resonances frequencies but generate different anti-resonances frequencies. In the vibration control systems the anti-resonances play essential role [4,5]. They influence on the stability and dynamics of the closed-loop systems. The optimal controllers designed for different reduced models were applied to real full plant. Dynamics behavior of the closed-loop systems with such controllers were analyzed and compared. In conclusion we should carefully choose model reduction methods in the design process of the vibration control system.

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The System for Active Control of Sound Transmission Through a Window Panel – The Concept and Simulation Results

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Keywords: List the keywords covered in your paper(at least three).

Abstract. High acoustic insulation windows are common mean to decrease sound transmission to closed spaces. Hence, the improvement of sound insulation of windows is very important research issue. In this paper partial results of research project aimed at synthesis of the window panel with actively controlled sound transmission are presented. Recent stage of the project is focused on the development of multichannel Active Structural Acoustic Control algorithm. High amplitude excitation produces nonlinear vibration effects. Using feedforward control strategy it is convenient to control not only the reference signal spectrum, but also additional frequencies generated as the cause of nonlinearity. Therefore neural network based algorithm is considered. To lower the computational burden of the algorithm, round robin based error backpropagation learning is employed. round robin provides relevant time periods to each process not taking into account any priorities. In the proposed concept of the active noise control algorithm, the round robin algorithm is used to divide the neural network adaptation process into stages. In each sampling period, coefficients of a selected sections of neural network are adapted. The round robin algorithm determines sections of the neural network to be adapted and the order in which the adaptation process for each section is performed. In order to investigate the properties of the active noise control system with an round robin algorithm, the algorithm was implemented in Matlab/Simulink environment. Primary and secondary signal paths were modelled with finite impulse response filters of 16th and 3rd order accordingly. The sampling frequency was set to 8 kHz. Filtered Gaussian noise was used as the reference signal during the simulations to render real-world conditions, i.e. to simulate a machine or device. In all cases, the final value of the error signal level was close to 16 dB, with the initial value of 26 dB, which means the effectiveness of the active noise control of up to 10 dB. The noise compensation occurs over a wide frequency range. Within the scope of the numerical simulation, an active noise control system with full error backpropagation learning has also been investigated. i.e. with a simultaneous adaptation of all the neural network coefficients. The main conclusion of presented part of the research is that the algorithm is capable of controlling a wide-band noise efficiently. Reduction of the computational complexity leads to increased convergence time, not influencing the final value of mean square error.

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Active Casing Controlled with a Partial-Update Neural Network

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Keywords: neural network, adaptive control, active noise control, vibrating plate, active casing, partial update

Abstract. An active casing made of appropriately controlled vibrating plates can be used to reduce noise propagating from the mechanism enclosed in the casing. Since a practical vibrating casing can behave in a nonlinear way, the performance quality strongly depends on the ability of control filters to compensate for the nonlinearity. The classical approach to nonlinear active control, e.g. based on the Volterra filters, can deal with harmonics generated by the nonlinearity. However, when a complex structure is considered, neural networks have a higher potential. Although, they are much more computationally demanding, for some cases they can be simplified and still provide acceptable performance. In this paper, results of control obtained for a real casing with multiple actuators exciting each wall are presented and discussed.

Conclusions.

This paper focuses on the complexity of nonlinear ANN filters. The computationally simplified approach, namely Partial-Update filtered-x backpropagation, is presented and verified. The algorithms have been based on real data acquired from the active casing, where multiple walls are controlled at the same time to reduce noise generated by device or machinery enclosed in the casing. Such approach has been proven by Pawelczyk and co-authors to have high potential for a number of practical applications, both in industry and households. Two update scenarios have been considered: layer-wise and neuron-wise. Both of them result in the same reduction level. However there is a large difference in their convergence rate. The layer-wise update version is in general as fast as the full-update version. In turn, the neuron-wise algorithm is much slower. The update scheme should be carefully adjusted as a trade-off between computational complexity and desired convergence rate. The optimal update plan should take into consideration also the hardware capabilities, including hardware support for parallel filtering (multiplications and subtractions). There is a group of applications, including the active casings for stationary noise, where the convergence rate is not crucial, and then the most computationally effective version can successfully be applied.

Acknowledgements

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A Higher Order Spectra Based Method of On-line Secondary Path Model Identification for Active Noise Control Systems

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Keywords: System identification, active noise control, nonlinear systems, non-Gaussian excitations, higher order spectra.

Abstract. Electroacoustic paths models are of great importance for designing effective active noise control systems. Though there exist active noise control systems working without these models, their applications are limited only for reduction of single tone noises. They are ineffective in reduction of random noises. To reduce such noises, active noise control systems using models of secondary and acoustic feedback paths should be used. These paths may change significantly during operation of active noise control system, therefore, in many situations, they should be also identified on-line under operation of active noise control system. This paper is devoted to such case of secondary path model identification with active adaptation algorithm. In contrary to the literature of the subject, nonlinearity of the secondary path is taken into account. Proposed approach to on-line secondary path model identification is based on ideas of closed-loop system identification with integrated higher-order spectra (bispectra or trispectra) and low-power higher-order non-Gaussian discrete-time multisine random process as external excitation. Variance of the external excitation must be chosen carefully so as not to decrease noise attenuation obtained by the operating adaptive active noise control system too much. Hence, it is the problem of identification in low signal-to-noise ratio conditions. Moreover, it implies that nonlinearity of control signal generation as well as data acquisition subsystems should be taken into account during secondary path model identification and it is assumed in the paper that the secondary path exhibits nonlinear behaviour. Identification experiment with the external excitation is designed in a special way. During this experiment a realization of the external excitation is periodically repeated. Data acquisition starts after all transients implied by inputting the external excitation into active noise control system have decayed. Acquired signals are initially processed for the purpose of signal-to-noise ratio increase and they are used to identify the corresponding secondary path frequency response model using method based on integrated bispectra or trispectra. This action is repeated for a number of different realizations of the external excitation and obtained secondary path models are averaged. Result of frequency responses averaging is recalculated into a parametric model and used in active noise control system. This allows to reduce an influence of the secondary path nonlinearities on the corresponding identified model quality and, consequently, on the operation of the analysed active noise control systems. Effectiveness of the proposed approach to on-line secondary path model identification is proved by the corresponding adaptive feedforward and feedback active noise control simulations. It is also worth to mention that the acoustic feedback path model may be identified in the same way.

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Extended Kalman filter in 2S1 tracked vehicle system with hybrid control

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Keywords: Extended Kalman filter, MIMO model, semi-active suspension system, simulation

Abstract. The essence of the article is the problem of estimation of state vector in the tested, dynamic model of 2S1 tracked vehicle suspension system through the use of extended Kalman filter. The use of non-linear filter has become necessary due to the magnetorheological damper located at suspension system, which has been described by hyperbolic model. Application of the damper caused the tested suspension system has become a semi-active structure in which the hybrid control was applied. The choice of hybrid control algorithm stems from the fact that in the case of tracked combat vehicles in addition to the advantageous conditions of work of vehicle crew also cornering stability and the possibility of sudden acceleration or braking is important. Hybrid Control allows to determine a compromise between ride comfort and stability of 2S1 platform.

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Deep neural network in acoustical signal analysis

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Keywords: neural networks signal analysis, signal processing.

Abstract. The paper presents selected aspects of research concerning a new concept in application of computer technology to the analysis of acoustic signal. Processing, analysis, classification and speech signal recognition methods are seemingly known from many years, because it is easy to find a variety of literature listings that refers to those ideas and present results of either basic research or application papers. However, above mentioned classical methods in the main omit problem of speech signal valuation, especially in term of obtaining estimates needed in diagnostic supporting process, therapy optimization and rehabilitation monitoring. In presented paper the effort of estimation artificial intelligence methods and learning systems fitness for valuation the degree of acoustical signal deformation had been taken. Traditionally used artificial neural networks contain an input layer, hidden layer and output layer. For such networks developed effective learning algorithms. However, decades ago we defined "deep" neural networks (Deep Neural Networks , DNN), defined as a network consisting of multiple hidden layers. The depth of the network shall be understood as the number of neurons in the path from input to output network. The need for the use of deep architectures arises from the fact that, in the classification problems needed are better than previously representations can move from the most elementary data provided at input (pixels , the amplitude of the time samples , the amplitudes of the bands of the spectrum) to the more general terms. Deep architecture further assumptions correspond to the characteristics of lower level (for example, it is estimated that the brains of mammals have five to ten levels of processing). DNN networks can be used in case of: pathological speech recognition means, diseases based on the classification of the speech deformed, prediction based on the development of the pathology generated in their early stage of information hidden in speech deformed .
In the case of pathological speech has no strict evidence to fully algorithmic representation of the speech signal on the numerical, which is a measure of the degree of psycho acceptability. It is therefore necessary to find such a model form processing and analysis of this signal, in which the process for preparing the respective rules and the new signal transformation methods can largely be automated to make the process. The paper presents therefore based on collected and verified data models for the analysis and classification of speech deformed using as a basic tool for artificial neural networks and proposes to use for this purpose the Deep Neural Networks.

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Analysis of selected pressure signal descriptors used to control combustion engine

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Keywords: signal descriptors, engines, control, combustion.

Abstract. This paper analyses the option of using pressure signal new descriptors for controlling a selected object. Pressure signal deviations from the pressure mean values were selected to be the example descriptors. A compression ignition combustion engine fuelled with mineral- and bio-fuels was chosen to be the reference object. The pressure signal was recorded during the combustion process in the cylinder.

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Piezoelectric generators in the energy harvesting systems

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Keywords: piezoelectric materials, piezoelectric generator, wireless monitoring

Abstract. Piezoelectric generator is a device used to convert mechanical energy into electrical energy. The basic element of the generator is made from piezoelectric material in which electrical energy is created as a result of deformations caused by reactions of mechanical structure of the generator. The amount of obtained electrical energy depends mainly on the piezoelectric material used, construction of the generator as well as a type of the source of mechanical energy. Construction of the generator is adjusted to the type of the source of mechanical energy. In order to obtain electrical energy from mechanical vibrations, the most frequent solution is beam structure. The subject of recent examinations and practical applications are beam generators, constructed from basic material which does not indicate piezoelectric characteristics as well as from piezoelectric composite made from piezoelectric ceramics and polymer warp. The system comprising a metal plate with pasted piezoelement, forced by the movement of pendulum fastened perpendicularly to the plate, was first used in high buildings situated in high seismic activity areas. The number of publications on obtaining electricity from mechanical vibration has been growing since early 21st century, with a focus on increasing the effectiveness of energy conversion due to relatively low efficiency of piezoelectric systems. Among the significant scientific works were papers by Sodano and Inman in which particular emphasis was placed on using the piezoelectric generators as a source of power. The results of testing of a rectangular cross-section beam generator with the PZT-4H ceramic element pasted onto it were presented for instance in the paper by Roundy in 2004. In successive years, the development of piezoelectric generators has taken place in two main areas: optimization of the beam structure to increase strain in the piezoelectric material and using new or modified piezoceramic materials with composite structure which ensure greater flexibility and resistance to brittle cracking in comparison with classical piezoceramic materials. The optimization of the energy generation structure is implemented by a suitable choice of the generator beam shape and by introducing additional components with geometry adapted to the source of mechanical vibration. Effective electric energy generation by the piezoelectric generators depends on the following main factors: piezoelectric material used, generator structure, electronic system of the control and storage of energy, and the generator size. Generated by piezoelectric generators electric energy, can be used to power of miniaturized electronic devices with low power supply demand. The goal may be monitoring of the structure or industrial processes in hardly accessible places or/and in systems requiring the use of a big number of sensors. It will make cutting the operating costs possible and allow to create the eco-friendly technology (no waste discharged batteries).

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Effectiveness of the sliding mode control in a two coupled discontinuous dynamical systems with dry friction

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Keywords: Friction, sliding mode control, compensation, numerical modeling.

Abstract. Numerical modeling and a tracking control of angular velocity of a rotor measured in the assumed sliding contact bearing subject to a discontinuous dynamical loading has been performed in this contribution. A contact interface in the direct current motor's sleeve bearing has been treated as a dynamical system with dry friction, including a few sources of the stick-slip and creep-slip effects. The object of control is subject to an irregularly changing torque generated by another discontinuous dynamical system with friction. The loading comes from a block-on-belt model of a conveyer system with intensification of friction force, which has been elastically coupled with the direct current rotor's shaft by means of the transmission belt. Therefore, the dynamic loading of the DC motor changes because of time-varying linear velocity of two belts. If such additional torque oscillates while the rotational velocity of the motor's shaft is small due to a requirement, then it significantly affects the entire system's dynamics producing stronger nonlinear response of the motor's speed. In present study we are concerned on a continuation of our previous work [1] devoted to the low-speed voltage-input tracking control of a DC motor. Effectiveness of the sliding mode control in the two elastically coupled discontinuous systems investigated in this work has been taken into consideration. With regard to many nonlinear effects caused by dry friction, there have been observed slowly damped oscillations around the tracked path of the controlled variable. It is very interesting result, because the phenomenon is caused by the self-sustained vibrations of the block moving on the conveyer belt, and its higher frequency creep-slip oscillations are propagated on the motor's rotor via the conveyer belt and vice versa Comparing to the unloaded motor analyzed in the work [1], which was extended here, the source of high frequency creep-slip oscillations has significantly affected the effectiveness of the introduced there sliding mode control supported with a PD.
Acknowledgements. This work has been supported by the Polish National Science Centre, MAESTRO 2, No. 2012/04/A/ST8/00738.

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STUDY OF FLOW-INDUCED VIBRATION PHENOMENA IN AUTOMOTIVE SHOCK ABSORBERS

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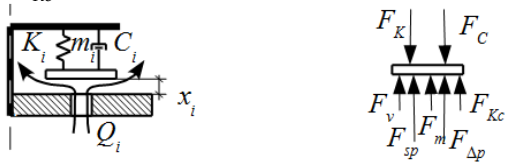
Keywords: automotive, double-tube shock absorber, vibration, lumped parameter model

Abstract. The purpose of this study was to develop a model of the dynamic behavior of an automotive double-tube shock absorber. The model accounts for the effects of compressibility, viscosity, inertia, etc. and can be suitable for use in the analyses on flow-induced pressure fluctuations in the device. The valve model is shown in fig.1. Each discs stack is characterized by the mass m_i, the stiffness K_i and the damping C_i. The model includes also the stiction force F_v, the geometric preload force F_{sp}, the force related to the fluid momentum change F_m, the force generated by the pressure difference across the disc $F_{\Delta p}$ and the contact force F_{Kc}.



a) b)

Fig. 1. Valve model, a) Valve lumped parameter model b) Forces acting on the disc stack

In the paper the author highlights all major variables to influence the output of the shock absorber, and then proceeds by performing a series of simulations using the developed model. The model is demonstrated to operate in the large amplitude and low frequency range as well as the small amplitude and high frequency excitation operation regimes. The results are presented in the form of time histories. Fast Fourier Transform (FFT) graphs are presented, too, in order to identify major components of the pressure fluctuation phenomena in frequency domain.

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Evaluation of the Characteristics of Shock Absorbers on the Basis of Diagnostic Vibrational Symptoms

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Keywords: shock absorbers, vibration measurements, quality control, frequency analysis

Abstract. A quality control of operating parameters of components manufactured in industrial factories has become essential step in each production process. Meeting the requirements of the ISO/TS 16949 standard, involves implementation of advanced preventive maintenance techniques and the management models oriented on the quality and production improvement. The article presents the identification of the operational characteristics of automotive shock absorbers in the frequency range 0÷10 kHz, allowing evaluation of executive components in the frequency and time domains. The author defines the suitability of obtained results for use in case of the quality control assessment and determines further steps leading to the development of a complete diagnostic system working in automatic or semi-automatic modes.

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Rock bolts health monitoring using self-excited phenomenon

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Keywords: non-destructive testing, self-excited system, rock bolts

Abstract. Health monitoring of rock bolts can indirectly indicate the state of rock which is crucial for mining safety. This paper presents an innovative application of the Self-excited Acoustical System SAS for stress change measurement in rock bolts which are used to secure roofs and walls in mines and tunnels. The method gives information on the change of rock stress in the immediate area next to the bolt. It can be used also to determine the necessity of the exploited bolt replacement.

The laboratory tests were conducted on a hydraulic tensile testing machine presented in Figure 1.

The mining bolt was placed in the machine and then stretched. Different types of clamping rings which connected the measurement system to a bolt were examined. The changes of the resonance frequency caused by the increase of the tensile strength were observed during the research. A mathematical model of the system to set out the basic parameters which affect the system's sensitivity was also presented.

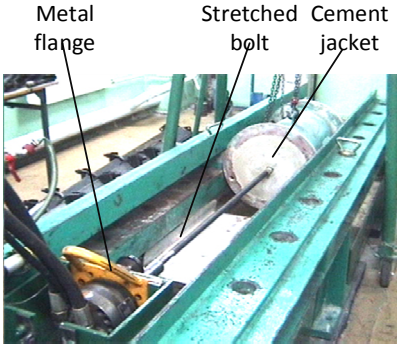

Fig. 1. Hydraulic tensile testing machine used during testing rock bolts

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The application of XPC Target platform for a circular plate vibration control

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Keywords: circular plate, vibration control, XPC Target, MFC elements, off-line identification.

Abstract. The goal of this work is to describe a control procedure that simplifies the implementation and improves the performance of feedback active control on a planar structure. The article presents a design, development and experimental verification of an active feedback vibration control system of circular plate with the application of XPC Target platform. Vibrations of the plate are measured using MFC sensors. The control input is applied to the plate by a MFC disk, attached to the plate in its center. The plate vibrations were e**x**cited by a loudspeaker or by a second MFC actuator placed at a certain distance from the center of the disc.

The basic philosophy is the off-line identification of the best model for the controlled process[1] and the subsequent synthesis of the controller. There are many classical strategies that can be used when a mathematical model is available, for instance poles allocation or optimal control (LQR), used also by the authors [2, 3]. This article proposes an approach to design an effective controller for vibration suppression of a circular plate with with the use the pole placement method. For the considered system a linear discrete model obtained by parametric identification method for the data measured in a separate experiment has been designated. This model was used to develop the 6-th order digital controller which was implemented on XPC Target platform. Before implementation of the chosen control law design on real plant the simulations in Simulink/Matlab were performed.

In order to investigate the influence of the implemented controller on the plate vibrations suppression the 3D scanning vibrometer has been used. The obtained simulation and experimental results, corresponding to the developed active vibration control system have been presented, compared and analysed.

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Semi-active Method of Motion Stabilization Applied to Mechanical System with the Constant Reaction Force Vibroisolation (WoSSO) – Model Study

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Keywords: semi-active method, nonlinear WoSSO Vibroisolation, energy efficiency

Abstract. The application of the WoSSO vibration isolation system with zero frequency natural vibration for machinery and equipment in the Earth's gravity field requires stabilization of the motion because of its high susceptibility. For this purpose, an additional spring element has been introduced into the vibration isolation system with a small elastic coefficient "k" [1] and a semi-active damper "c" (t, x, v, ff) [3] connected in a parallel way with the system of the WoSSO vibroisolator. Investigations of the effect of the additional arrangement to stabilize the motion of the mechanical system have been carried out by numerical simulation of its motion. In order to do this, a physical (Fig. 1) and a mathematical model of the tested system including the spring k_1 and the introduced magneto-rheological damper (MR) have been elaborated. Based on the mathematical model the dynamics simulation program of the tested system has been developed and simulations for the sample data have been carried out to study transitional processes and their stability. The results of substantially improved stability of motion of the test system have been shown in Fig. 2. The movement stability studies have been combined also with the research of power distribution in the test system. The aim of this study was to determine the energy efficiency of the system developed, defined as the ratio of the RMS power of the exciting force to RMS power of the elastic force [2]. The achieved level of energy efficiency of the WoSSO vibroisolation is equal to 5168.

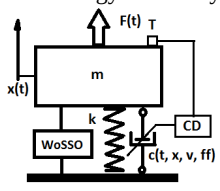

Fig. 1. Physical model of a mechanical system with WoSSO vibroisolation and semi-active stabilization

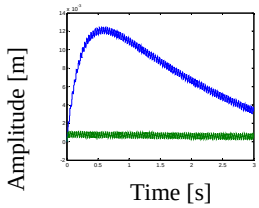

Fig. 2. Transition process of the system without and with magneto-rheological damper MR

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Hybrid simulation of tracked wehicle suspension on real-time environment

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Keywords: Hybrid simulation, tracked vehicle, hardware In the loop, real-time environment.

Abstract. The work presents simulation method of dynamic properties used as assistance in the construction process of suspension systems for high-speed tracked vehicles. Special consideration has been given to the real-time coupling of virtual models with the dynamic response of actual elastic-damping elements of the vehicles. An original design method has been proposed. The method is characterized by the fact that each of the design stages are not performed sequentially, but are parallel to each other and that at each level, mutual coupling between the tasks of the design process occurs. The proposed simulation method using the *dSpace* system is based on the integration of virtual environment such as LMS Virtual Lab or MATLAB/Simulink with the actual object such as a damper, by means of dedicated input/output devices operating in real time. The method developed in the work allowed for an extension of the classic co-simulations, that is, simulations in two coupled virtual environments, to include an actual component or, rather – its dynamic – often non-linear – characteristic, its response to excitation. The method developed in the work allowed for an extension of the classic co-simulations, that is, simulations in two coupled virtual environments, to include an actual component or, rather – its dynamic – often non-linear – characteristic, its response to excitation.

The developed test method and the computer programs have been verified by means of experimental measurements of the dynamic characteristics of the actual object during test-ground tests and in the laboratory. The obtained results of the simulations and experiments allow to confirm the validity of the assumed thesis, which has been included in the summary.

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SEMI-ACTIVE VIBRATION REDUCTION OF PERIODICALLY OSCILLATING SYSTEM

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Keywords: optimal control theory, vibration reduction, periodical vibrations

Abstract. Periodical vibrations are common phenomenon affecting a wide range of mechanical systems. Most frequently it affects machines designed to work in a steady-state conditions like: turbine, pump, rail vehicle, etc. In those kinds of machines it is always possible to decompose the system motion to basic average-speed constant component and oscillatory component. Usually the second term is treated as undesirable and various techniques are applied in order to minimize it as far as it is possible. These techniques refers to both the hardware selection – meaning the type of damping system (active, semi-active, passive) and the control method selection – meaning the damping system control method. Concerning the control methods, there are many algorithms available in literature devoted to transient systems. One of typical application is to use them in systems experiencing sudden, external force excitation. After destabilization of the system, caused by excitation, the role of the control algorithm is to restore the system stable position and additionally to reach the extreme of some additional criterion. Typical criterions are minimization of the time, of restoring the stable position, minimizing the consumed control energy, etc. On the other hand, considering the steady-state systems, especially based on semi-active damping elements, there are not so many control methods available.

This paper focuses on developing the proper methodology for deriving the optimal control strategy of semi-active damping element, to be used in periodically vibrating mechanical system. The control strategy is developed on the basis of the Optimal Control Theory. Numerical computations are involved in order to solve the optimal control problem for the considered test system. Problem solution reveals the periodical nature of optimal control function.

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Evaluation of an energy harvesting MR damper-based vibration reduction system

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Keywords: MR damper, vibration reduction system, control, energy harvesting.

Abstract. The paper presents semiactive vibration reduction system with energy harvesting magnetorheological damper (Fig.1). In typical semiactive vibration system the MR damper is supplied by external power source, in this solution electromechanical power generator supply the damper. Presented system consists of: power generator, MR damper and spring. The MR damper in contrast to the conventional damper has double piston rod. The generator is connect with MR damper by one side of the rod and placed in once housing. The generator recover part of mechanical vibration energy and changed it to electrical energy. Placing the damper and generator on common rod gives electromechanical force with is always in when force generated by MR damper. The energy can be used by MR damper when the generator coil is connected with control coil.

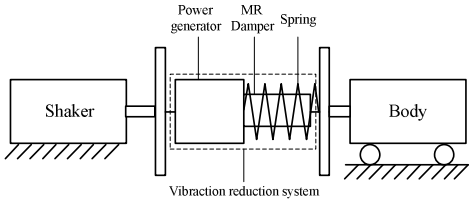

Fig. 1. Schematic diagram of the test stand

In this paper a effectiveness of vibration reduction system in one degree of freedom with energy regeneration was presented. The research work shows three strategy to MR damper control: directly connect, on-off and Sky-hook algorithm. In each of them only energy produced by power generator was used to supplied MR damper. The reduction vibration system was control by real-time system. The effective of each control strategy was compare in transmissibility vibration coefficients graph. For most important quantities time patterns characterizing operation of the system were determined.

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The shaping dynamic characteristics of military special vehicles

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Keywords: control of the dynamic characteristics, parametric modifications, military vehicles

Abstract: The article presents dynamic characteristics and methods for shaping the dynamic characteristics of military special vehicles. Based on the Journal of Laws regarding the Polish "Traffic Law Act", a definition of special vehicles has been presented and the methods of increasing the efficiency of movement made possible due to the development of intelligent structures have been reviewed. The main body of the article presents a motion dynamics model of a sample military special vehicle, two suspension control algorithms and the results of three different numerical experiments that have been conducted. The experiments concerned a sinusoidal kinematic input with a phase shift resulting from the distance between the road wheel axles and the excitement of one and two selected controlled suspension columns with harmonic functions characterized by linear modulation of frequencies at varying amplitudes. The applied measure of appraisal was the comparison of the amplitudes of displacement, speed and acceleration – both linear (in the vertical direction) and angular (in the longitudinal and transverse planes) in time.

Moreover, the article presents a detailed procedure regarding the implementation of an analogue control algorithm using the continuous Sky-hook method. The determination of damping coefficients of the semi-active vibrations reduction systems located in the suspension of the analyzed model of the vehicle has been conducted based on movement digitization. Due to the fact that the vehicle model was characterized by three degrees of freedom, an analysis of forces in the sprung mass suspension system has been conducted for the three possible movement directions: the vertical-linear movement and the angular movement in the longitudinal and transverse planes. The results of the numerical experiments have exhibited an improvement of the sprung mass stabilization when using the continuous Sky-hook control, in comparison to the passive damping. This improvement related to the vertical displacement in time as well as to the speed and acceleration. It has also been noted that the results of two-mode control, which positively influenced the minimization of displacement and had a negative impact on the acceleration values, were slightly worse. This was especially evident upon an asymmetric wheel input.

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Sliding-Mode Controller for Active Vehicle Suspension

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Keywords: control, active reduction, vehicle suspension.

Abstract. The paper presents a vibration reduction system controlled by sliding-mode controller. After short introduction, reduction vibration systems used in vehicles was analyzed. One of the solution (Figure 1) of an active system was chosen to further analysis [1].

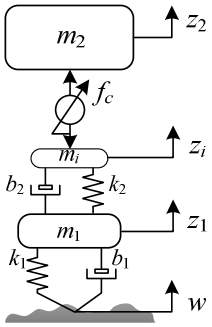

Figure 1 Slow active suspension structure.

In the first part of the paper mathematical model was formulated. After parameter identification quarter car model was implemented in numerical simulation program. Next the sliding-mode controller was synthesized for the system. The model with controller was developed, experimental tests of active vibration reduction system were conducted and the system's vibration transmissibility functions were established. At the end of the paper the conclusions were formulated.

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IDENTIFICATION OF POWER POLE CONSTRUCTION DYNAMIC PARAMETERS

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Keywords: Damping loss factor estimation, structural vibration, modal parameters

Abstract. Recently, fault detection based on tracking changes in dynamic properties or responses of considered systems has arisen great interest. The basic idea comes from the fact that dynamic properties, such as modal parameters (natural frequencies, mode shapes, damping factors) are functions of physical properties of the object (mass, energy dissipation mechanisms, stiffness). Thus, changes in physical properties result in changes in modal parameters.

Damping properties have been rarely used for fault diagnosis. However, if the presence of crack does not result in the significant change in resonant frequencies, analysis of changes in system damping may reveal nonlinear effects and dissipation phenomena. In such a situation detection of cracks on the basis of damping may provide better results than application of methods utilizing system natural frequencies and mode shapes.

The paper concerns identification of system dynamic properties on the basis of measured system responses to exploitational excitation resulting from wind acting on the structure of the tested power pole.

In the first step of analysis, the technique of extraction of step response from the registered stochastic signal was used. Then, using the Laplace wavelet, identification of dimensionless damping factor and natural frequencies in different frequency bands was carried out.

The research was carried out for the power pole 110 kV (denoted as SC185P0) that is commonly used in the in Polish electricity transmission infrastructure. Using modal superposition technique, which makes it possible to filter out unwanted natural frequencies of the response spectrum and define the dimensionless damping factor, the impulse response of selected frequency was generated. Finally, in order to identify damping factor of the considered power pole, the experimental research of industrial construction was carried out.

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Design and pre-implementation of micro-movements sensor with magnetic shape memory material

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Keywords: magnetic shape memory alloys, micro-displacement sensor.

Abstract: During the last twenty years the rapid development in smart materials, which are also known as active materials, is observed. The smart materials are sensitive to the changes of physical quantities such as light intensity, temperature, current intensity, electric and magnetic field which as a result change material properties. It provides constructors with an attractive alternative, which can lead to the simplification of device structure and possibility of using additional smart material features. Among smart materials which can undergo shape transformation, temperature-controlled shape memory alloys (SMA), electrically-controlled piezoelectric materials, magnetic field controlled magnetostrictive materials and magnetic shape memory alloy (MSMA or FSMA) can be found. The presented smart materials differ from each other by: maximum unit elongation (in relation to a sample length under controlled field), maximum values of compressing stress, reaction speed of electromechanical transducers based on given material as well as a type of crystal lattice transformation. Temperature–controlled shape memory alloys are used in many application e.g. as linear drives, active joints in air technics or in biotechnology. However, one of the main drawbacks is their strong nonlinearity, that is why they are used mainly as on-off objects with two extreme actuation positions. The hysteresis feature of SMA predisposes it to active damping vibration applications. The properties of magnetic field controlled MSMA materials draw a lot of interest and many research centres worldwide are involved. The first patents have already appeared with the focus on alloy synthesis, simple electromechanical transducer constructions or sensor's area with the help of reverse phenomenon. Undoubtedly, the touchless operating principia is its main advantage. On the other hand there are no specific industry applications. Research work on potential applications of smart materials in motion control in mechanical systems and micro-movements sensor carried out in the Department of Process Control AGH UST at the Faculty of Mechanical Engineering and Robotics resulted in a demonstrator construction of a micro-movements sensor. A simple replacement of a micro-movements sensor created with MSMA technology was performed.
In the article, the characteristics of the built MSMA micro-movements. On the basis of the experiment usefulness of the sensor construction is also discussed.

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Experimental and simulation investigations of the cantilever beam energy harvester

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Keywords: Energy harvesting, Piezoelectric, Cantilever beam, Finite Element Method

Abstract. Machines, cars suspensions, buildings steel constructions etc. usually generate vibrations, which can be the excitement signal for piezoelectric energy harvesters. The piezoelectric patches attached to the vibrating construction have ability to convert mechanical energy of harmful vibrations into electrical energy.
The goal of the study was to verify a finite element model of the piezoelectric beam energy harvester by comparing results of numerical simulations with those obtained experimentally. The stand used in the experiment consists of the cantilever beam with piezoelectric elements attached, which is excited by the base harmonic movement. The transverse displacements of the selected beam's point and the base, and also the frequency of vibrations were observed and measured using an accelerometer and a B&K Pulse platform. A portable data acquisition module was used to quantify the voltage generated by the piezoelectric layers.
The finite element model was built in ANSYS software. The beam and piezoelectric layers were modeled by twenty node elements with an additional electric degree of freedom for piezoelectric elements. A full piezoelectric matrix was used in the finite element analysis instead of a one-dimensional piezoelectric effect, which dominates in many analytical approaches. It allowed building a more accurate model of the system. The experimental tests and finite element method simulations were performed and acquired results were compared. The characteristics of voltage amplitude in the time and frequency domain were shown and discussed.

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Vibration measurements for active noise control in a HVAC system with a passive absorber

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Keywords: active noise control, passive absorber, HVAC system, acoustic duct, vibration measurement

Abstract. A hybrid active-passive noise control system for a HVAC duct combines both a physical noise absorber and an active system. Due to the presence of the passive component, requirements for the active system can be relaxed, removing the need for detecting and suppressing noise in the frequency range already covered by the passive elements. A typical noise measurement system adapted to working in airflow usually uses a microphone with a housing designed to reduce the noise generated due to local turbulent flow introduced by the housing itself. Alternatively, there are microphones specifically designed to work in the airflow. During work on the hybrid active-passive noise control system both a microphone designed for airflow and a microphone with special housing were tested. While these solutions can be used for research, both have issues making them impractical when designing a commercial product. This, along with the required narrow frequency range motivated the authors to propose a method of acoustic signal estimation based on measurements from accelerometers. To decouple those measurement from the acoustic characteristics of the whole HVAC duct the accelerometers were bonded to a metal plate with a layer of vibration dampening material between the plate and the duct. The increase in turbulent airflow due to intrusion into the duct is minimal due to placement of this plate within the passive absorber. Such a system was constructed and tested in a laboratory ventilation duct with a large cross-section with simultaneous measurements done using a microphone placed in a T-box. It was tested both with artificially injected noise and noise generated by airflow. The fundamental frequencies generated directly by the fan blades are reconstructed in the estimated signal. Further research will include using the estimated signal for the ANC system to perform a comparison of results between a microphone-driven system and an accelerometer-based one. This will give a better view of practical suitability of the method.

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A Novel Backstepping Approach for the Attenuation of Torsional Oscillations in Drill Strings

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Keywords: Torsional oscillations, Backstepping, Drill string, Stick-slip.

Abstract. A common problem in the petroleum drilling process is the torsional oscillation generated by the friction present during the cutting process. Torsional oscillations in drill string are particularly difficult to control because the drill string is an underactuated system, it has a very small diameter to length ratio and it is driven at top end with the cutting process at the other end. These factors make the drill string prone to self-excited torsional vibrations caused by the stick-slip of the cutting bit. The system is modeled as a torsional pendulum with two degrees of freedom, where the upper inertia models the top drive and also part of the drilling pipes. The bottom inertia models the bottom hole assembly (BHA). The drill is considered to be a massless torsional spring-damper. The drill string is subjected to friction, which is formulated using a dry friction model. The friction model takes into account Coulomb friction, stiction and Stribeck effect. The latter friction component is the main nonlinear phenomenon that introduces negative damping at the bit; it leads to self-enforcing stick-slip torsional oscillations.

In the approach of this work, for the attenuation of these self-excited oscillations a recursive Backstepping control strategy is used and it is carried out in continuous time. The main contribution of this work, which is different from the back stepping approaches reported in the literature, is to use a nonlinear/artificial damping as virtual control input. The stability of the system has been proven in the sense of Lyapunov. The goal of the proposed algorithm is to deal the underactuation of the system and to provide a good response for different operating points. The effectiveness and robustness of the controller has been tested in simulation.

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Active rejection of harmonic disturbances with nonstationary harmonically related frequencies using varying-sampling-time LPV control

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Keywords: Active noise control, active vibration control, disturbance rejection, gain scheduling, linear parameter-varying systems, time-varying sampling time.

Abstract. This paper presents a method for the active noise and vibration control (ANC/AVC) of harmonically related nonstationary disturbances using varying-sampling-time linear parameter-varying (LPV) controller. The frequencies are assumed to be known and varying within given range and they are multiples of one fundamental frequency.

For usual approaches of LPV control based on internal model principle, some functions of the disturbance frequencies are used as gain-scheduling parameters. In the approach presented in this paper, functions of the sampling time are chosen as the gain-scheduling parameters for harmonically related nonstationary frequencies. The sampling time is chosen in such a way that the disturbance model is time invariant, as will be explained in detail in the paper.

Polytopic LPV (pLPV) control design method is used to obtain vertex controllers by solving linear matrix inequalities (LMIs) guaranteeing quadratic stability. The controller is calculated by interpolating the vertex controllers and can reject disturbances with arbitrarily fast varying frequencies, as verified by real-time experiments on an AVC test bench.

Fig.1. Results for time-varying disturbance frequencies: Frequency variations (left) and acceleration signal (right) in open loop (gray) and closed loop (black).

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Comparison of active and semiactive sliding mode controllers used in vibration reduction system

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Keywords: vibration reduction system, sliding mode control, semiactive controller

Abstract. The paper presents an active and semiactive vibration reduction systems using siding mode control. Calculations were performed for a laboratory system of two masses that can move in vertical direction. The support of the system is connected with the moving part of the exciter. The system proposed may be a simple model of many vibroisolated objects. For example, the same structure has a quarter-car model which is very commonly used for investigating the dynamics of a car suspension. Similarly, vibrations of sprung transport platforms can be, at the first approximation, studied with the proposed model. In order to apply the control of vibrations in the suspension of the upper mass an actuator was introduced in parallel with a spring and damper.

Active and semiactive sliding mode controllers are proposed for vibration reduction system. The theoretical analysis for applying the sliding mode control in the system was performed and conditions that controllers must satisfy were derived. In general, active controller can meet all the conditions of the sliding mode control algorithm, in contrast to the semiactive controller. It is clear that semiactive controller cannot enter the power to the system. When the sliding control algorithm requires the input of energy, the semiactive controller gives the control signal equal to zero. Therefore, the use of semiactive controller is less effective.

Decouple of the system is one of properties of the sliding mode control algotithm. The actuators in active and semiactive reduction system must generate a sufficiently large force. The proposed sliding mode contolers are able to compensate bounded disturbance and uncertainties of the system. Results of simulations and experiments of which confirmed the advantages of sliding mode control used in proposed system are presented in tables and plots.

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An analysis of axial vibration in face packing seals

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Keywords: face packing seal, design, dynamics

Abstract. This paper is concerned with face packing seals. It describes their design and principle of operation and analyzes their dynamics. The seal dynamics was analyzed using two configurations of an axially flexible housing with an elastic ring made of a packing.

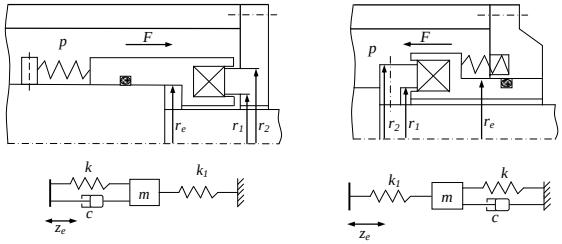

Fig.1. Calculation schemes and the dynamic models of two seal configurations of a) the axially flexible rotary housing and b) the axially flexible fixed housing of an elastic ring

The analysis involved formulating the equations of axial vibration for both configurations of the seal. It was vital to derive the relationships describing the axial free vibration and the forced vibrations of the flexible ring. The amplitude and phase-frequency characteristics were determined and represented graphically separately for the kinematic and the force excitation. This paper also describes the static and dynamic conditions of maintaining contact between the sealing rings. From the results obtained, the following general conclusions were formulated. The axial vibration of the housing with the elastic ring is mainly dependent on the amplitude of the kinematic excitation in the form of axial vibration of the shaft. The influence of the pulsation of the sealed fluid pressure is small and therefore can thus be omitted. Since the natural frequencies of the axial vibration of the housing with the flexible ring are much higher than the nominal frequencies of the rotating shaft, resonance conditions rarely occur. For the seal configuration, in which the housing with the flexible ring performs a rotary motion and the kinematic excitation acts directly on the springs, the amplitude of resonance vibration is an order of magnitude lower than that for a fixed (non-rotary) housing.

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Magnetic Shape Memory Alloys Modeling and Pneumatic Application

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Keywords: MSMA, magnetic shape memory alloy, hysteresis, generalized Prandtl Ishlinskii model, Krasnosel'skii Pokrovskii model, actuator, pneumatic valve

Abstract. Very generally material science could be divided into two groups: scientists who try to invent new materials or improve existing ones and those who work on finding the best applications for the modern materials. Among them there is group named "smart materials" or "active materials", which have ability to change theirs properties according to the external stimulation. One of the relatively most recent smart material is magnetic shape memory alloy, MSMA in abbreviation. The authors of the article focus on testing samples of this material and try to adapt them to use in fluid devices. The paper mentions about some most interesting valves' designs equipped with smart materials and summaries the previous MSMA research of the authors. It begins with literature overview of smart material applications in pneumatic or hydraulic valves. There is only one example of MSMA application in valve, therefore the overview concerns mainly the use of piezoelectric, thermal shape memory alloys and giant magnetostrictive materials. Next section describes general properties of the magnetic shape memory alloys and underlines the differences between more widely known Thermal Shape Memory Alloys and MSMA materials. One of the most important property is wide, nonsymmetrical hysteresis in static characteristics of the material, which can be seen as advantage or disadvantage, depending on the application. The material preserves its shape until perpendicular magnetic field or additional force appear. The authors mention about modeling MSMA hysteresis aspect. Three different hysteresis models were briefly described: Generalized Prandtl-Ischlinski, Preisach and Krasnosel'skii-Pokrovskii. The last section treats about the current MSMA based valve design concept. It assumes usage of two identical pieces of MSMA materials and energize them oppositely. There is flapper mounted between MSMA samples, which displacement depends on the MSMA elongations. This actuator type is called "push-push" type. Lack of the return spring result in remaining of the flapper in its final position after decreasing of the supply current. The advantage of the solution could be lowering energy consumption of the valve, when the valve setting changes relatively rare during its work. In the future, the presented hysteresis models could improve the work of such MSMA based valve.

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