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SUPERVISORY EXPERT CONTROL FOR VIBROISOLATION SYSTEM

B. Sapinski, M. Sibielak, J. Kowal

University of Mining and Metallurgy, Al. Mickiewicza 30, 30-059, Cracow, Poland

Email: deep@uci.agh.edu.pl

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ABSTRACT
The paper presents the idea of fuzzy logic application to active vibroisolation system. This idea concerns the structure of supervisory expert control system that consists of supervisory fuzzy logic controller, PID controller and electropneumatic actuator with throttling control which action depends on vibration disturbance. parameters. Results of simulation experiments that illustrate operation of active vibroisolation system are finally given.

1 - INTRODUCTION
The improvement of active vibroisolation systems properties may be achieved by using different methods that usually lead to structural or parametric modifications of vibration systems with additional power source. The problem of contradictory system requirements such as performance of vibration suppression in the range of low frequencies, wide spectrum of disturbance vibrations, dynamic stability and stiffness may be solved by introduction of automatic control. Such ideas have become possible in recent years thanks to development of microprocessor technology and actuators construction improvement. On the one hand, it allows to employ complex control algorithms (adaptive, fuzzy logic, neural networks); and on the other hand, it introduces modern hydraulic, pneumatic or electric actuators which compensate vibration exciting force. The force generator is controlled by the controller on the basis of plant state data coming from measurement system that uses acceleration, velocity or displacement transducers.
The considered active vibroisolation system uses the idea of supervisory expert control system (SECS) with knowledge based controller that plays the role an expert in PID controller autotuning. The base of knowledge was created in simulation experiments carried out for the assumed range of disturbance parameters. Each rule of this base refers to the concreate disturbance parameters and determines polyoptimal PID settings by different criteria of control system quality.

2 - STRUCTURE OF VIBROISOLATION SYSTEM
One of the basic problems in control system synthesis is the choice of appropriate criteria for control quality estimation. The criteria that are usually used for vibroisolation systems are coefficient of vibration transmission and integral of squared acceleration squared. In addition, the constructional restrictions of actuator have to be taken into considerations in the control algorithm. For further considerations, the vibration damping system with electropneumatic actuator, the diagram of which is presented in Fig. 1, is assumed.
Due to nonlinearities taking place in both actuator and vibroisolation plant, optimal controller settings (by the chosen quality coefficient) depend on disturbance parameters. Following the mentioned above, the structure of control system as shown in Fig. 2, was assumed for vibroisolation system. SECS, that is used in the assumed structure, takes place out of feedback loop. It operates as an expert for conventional controller (CC). The role of SECS is the extension of CC acting via introducing explicit representation of knowledge base.
CC is responsible for current control rules realization and SECS makes a decision how and when current rules should be changed. In this case, the assumed structure of control system allows to adjust CC acting in the dependency of disturbance parameters (using analyser). In other situations it may be useful in

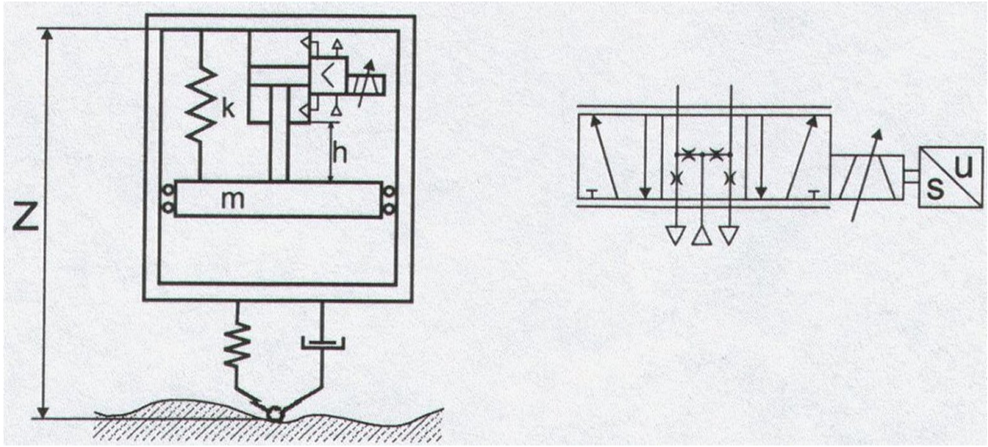

Figure 1: Diagram of vibration damping system with electropneumatic actuator.

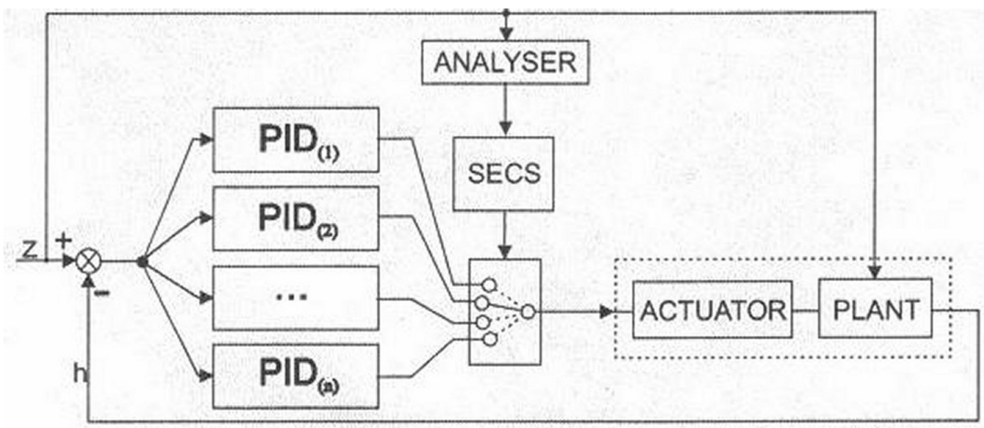

Figure 2: Control structure of vibroisolation system.

emergency states or by plant parameters changes. For the purpose of control system synthesis both actuator and plant are concerned together in one system.
For further considerations, PID algorithm in CC and fuzzy logic controller based on Mamdani type rules [1] in SECS are used respectively (Fig. 2).

3 - METHOD OF KNOWLEDGE BASE CREATION FOR SECS

The task for SECS is to choose PID controller that acts directly in feedback loop using disturbance parameters data such as frequency and amplitude. In order to create knowledge base, mathematical model of electropneumatic actuator was used [2]. This model was concerned as a system of pneumatic resistances. It concerns dynamics of control valve, nonlinear character of air flow and frictional forces, alterations of air in chambers of pneumatic actuator and valve leakage. The model was implemented in Matlab-Simulink. The PID settings for disturbance parameters are chosen by expert via simulation experiments. The usage of expert (a man) knowledge enabled to consider different quality coefficients in the procedure of rules base creation. The algorithm of knowledge base creation for SECS is shown in Fig. 3.
Input parameters are here: chosen frequencies $\omega_1, \ldots, \omega_n$, appropriate amplitudes $A_1, \ldots, A_n$ of disturbance and initial PID settings $K^{(0)}, T_d^{(0)}, T_i^{(0)}$. The choice of current disturbance parameters (A, ω) and initial settings $K^{(j)}, T_d^{(j)}, T_i^{(j)}$ of j PID controller take place in main loop. Next, using the algorithm for parameters adjustment, polyoptimal controller settings for chosen disturbance parameters are determined and PID settings adjustment is evaluated in iterative procedure.

4 - RESULTS OF SIMULATION EXPERIMENTS

Simulation experiments of vibroisolation system were carried out using mathematical model of electropneumatic actuator that was employed for knowledge base creation of supervisory controller. For the

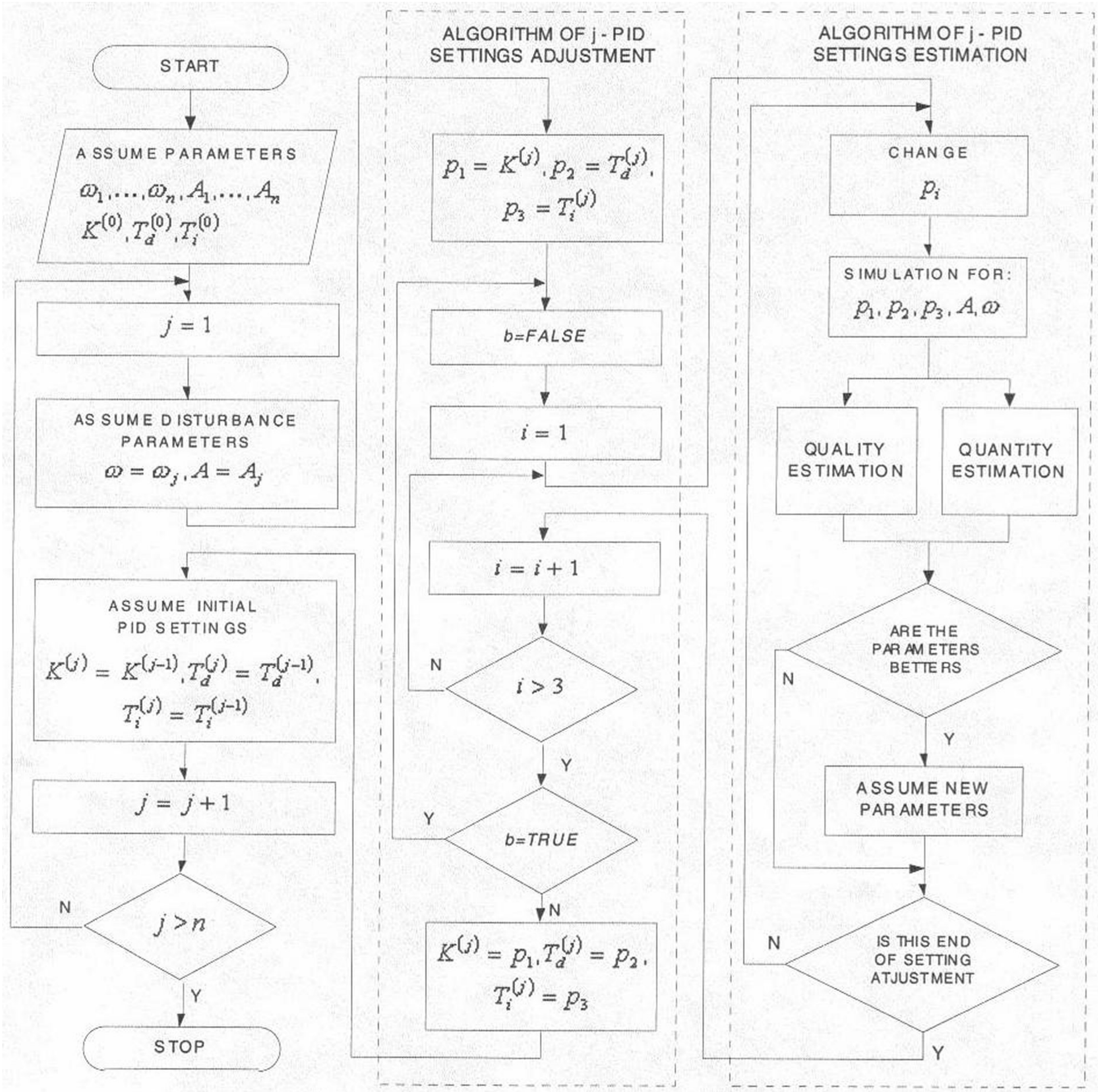

Figure 3: Algorithm of knowledge basis creation for SECS.

purpose of exhibition of autotuning mechanism effectiveness by the assumed SECS control structure, the results of vibroisolation system operation were referred to the system that operates only with only PID controller. Exemplary results of simulation experiments are shown in Fig. 4.
In both cases of variable disturbance parameters (A, ω) the improvement of vibroisolation system operation by the assumed SECS structure may be observed.

5 - SUMMARY

Fuzzy logic introduction to vibroisolation systems enable to consider on the one hand nonlinear effects caused by actuators (e.g. electropneumatic actuator) and on the other hand, changes of disturbance parameters (e.g. using SECS, that aids CC action). For the considered example, the value of transmission vibration coefficient was decreased with about 70% in comparison to the system without autotuning mechanism. The results obtained in simulation will be verified in experimental setup tests.

ACKNOWLEDGEMENTS

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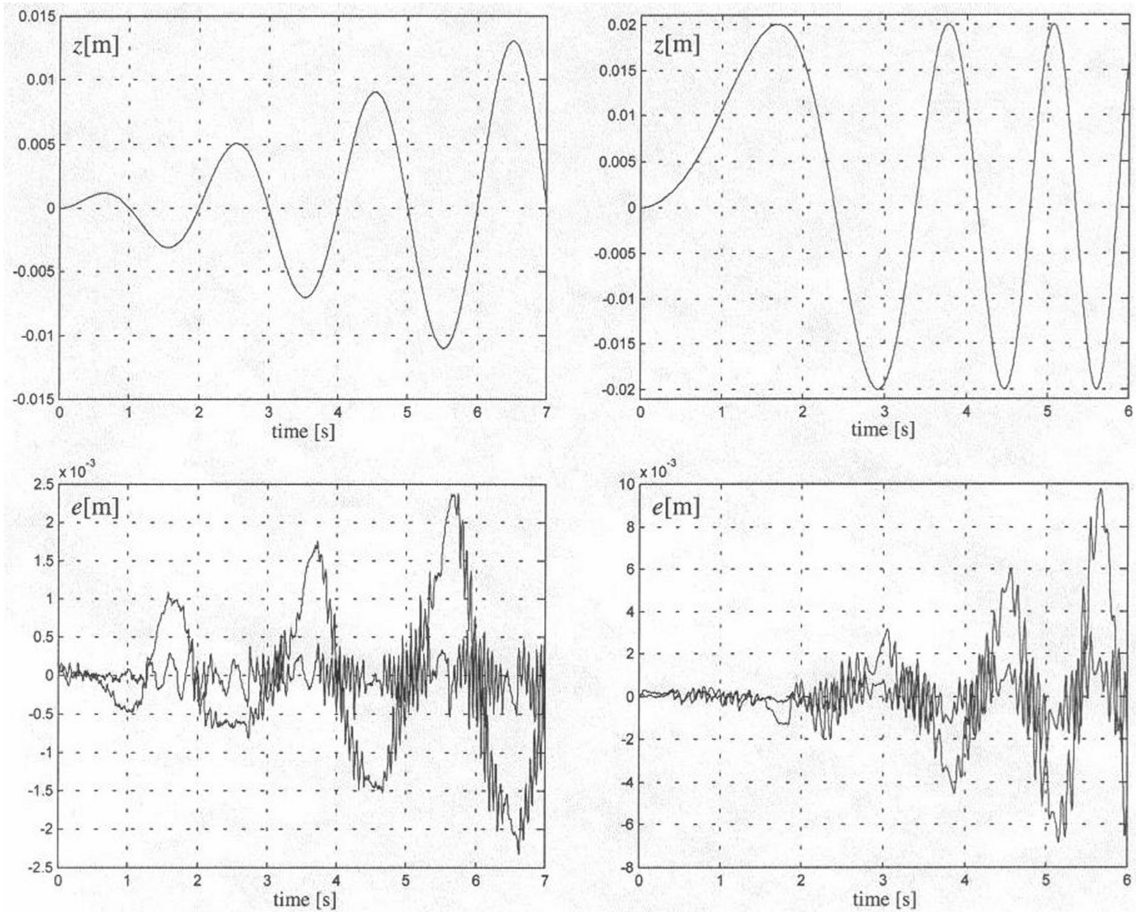

Figure 4: Disturbance signal, control error for vibroisolation system: a) A=var with the range of $(0 - 13)$ [mm], $\omega = \pi$ [rad/s], $\omega = 0.5$ [Hz] b) ω=var with the range of $(0 - 2\ \pi)$ [rad/s], $(0 - 1)$ [Hz], A=20 [mm].

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