SELECTED ENGINEERING PROBLEMS
NUMBER 4
INSTITUTE OF ENGINEERING PROCESSES AUTOMATION
AND INTEGRATED MANUFACTURING SYSTEMS

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COMPUTER AIDED MODAL ANALYSIS OF A VIBRATING SYSTEM WITH PIEZOELECTRIC COMPOSITE TRANSDUCER

Abstract: Paper presents a computer aided simulation of one-dimensional vibrating system with piezoelectric transducer used as vibration actuators. The algorithm of modelling and analysis of such kind of systems was presented in details in other author's works [2,3]. Here results obtained using computer aided methods are presented. The work is an introduction to comparison of results obtained analytical methods and computer simulations. The considered system with MFC transducer used as vibration actuator was modelled using a NX 8.0 software.

1. Introduction

Modelling of systems with piezoelectric transducers is very complex and time-consuming while testing of prototypes in order to verify if the dynamic characteristic of the system is in agreement with requirements is expensive. Knowing of this characteristic is very important for the system's operating at the same time. This is why it is important to find a method to verify dynamic parameters of designed system during the designing phase that will be precise and allows to choose the parameters (geometric and material) of the system that will be optimal taking into account its requirements. The mathematical algorithm of modelling and analysis of such kind of systems was presented in previous publication [2,3]. Discrete-continuous and continuous mathematical models of systems with piezoelectric transducers used as vibration dampers or actuators were presented. An approximate Galerkin method was proposed to calculate required characteristics of analysed systems. Now, the computer aided methods are proposed.

Application of the approximate Galerkin method to the analysis of vibrating mechanical and mechatronic systems was presented in previous author's publications [2,3]. It was used to designate characteristics of considered systems. Its exactness was verified on the basis of a cantilever beam analysis and it was proved that it can be used to the analysis of mechatronic systems. The optimal (taking into account maximal precision and minimal complication of required calculations) mathematical model of considered mechatronic systems was identified. Obtained results are an introduction to the synthesis task of simply and complex mechatronic systems. The aim of the future works will be to develop a mathematical algorithm useful to design such kind of systems with desired values of natural frequencies and required dynamic

characteristics. Presented work is a part of this research projects concerning with analysis and synthesis of mechanical and mechatronic systems [1-4].

2. Modelling and analysis of the system

Using the NX software a CAD model of the beam with the MFC transducer bonded to its surface was prepared. It is presented in Fig. 1*a*. In the next step the CAE model was created in order to realize modal simulation using Finite Element Method (see Fig. 1*b*).

a) *b)*

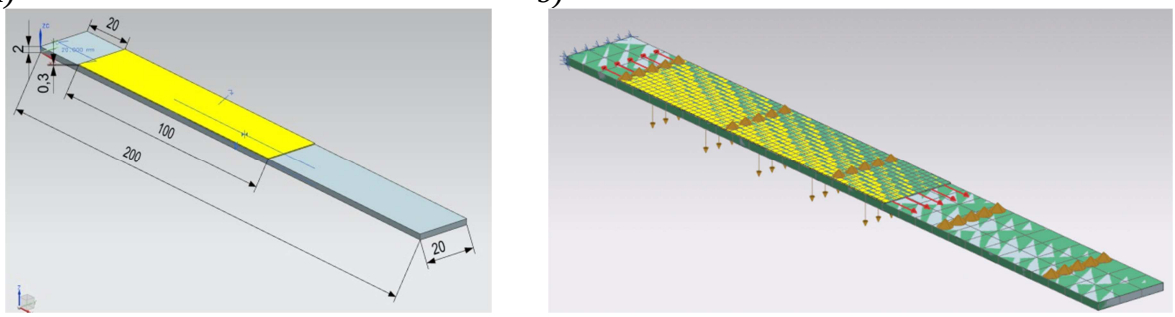

Fig.1. The CAD model (a) and the CAE model (b) of the considered system

Values of the natural frequencies a mechanical subsystem (the beam without the piezoelectric transducer) were calculated and it was analysed using a Fourier method of separation of variables [2,3]. Values of natural frequencies and its forms of vibrations were also obtained using the NX software and its CAE model. Values of natural frequencies and forms of vibration of the system with piezoelectric MFC transducer bonded to the beam's surface were calculated only using the NX software and Finite Element Method. Obtained results are presented in table 1 (values of first three natural frequencies) and in Fig. 2 and 3 (first three vibrations forms) respectively for the mechanical subsystem and for the system with MFC transducer.

Tab. 1. Values of the first three natural frequencies of vibration

n	Mechanical subsystem [Hz]		System with MFC transducer [Hz]
	Analytical method	Computer aided simulation	
1	41,78	41.80	42.65
2	261,81	261.8	259.4
3	733,07	733	725.1

As it can be observed obtained results are very similar and transducer bonded to the surface of the mechanical system has only a slight effect on the value of natural frequencies and it does not change the forms of vibrations.

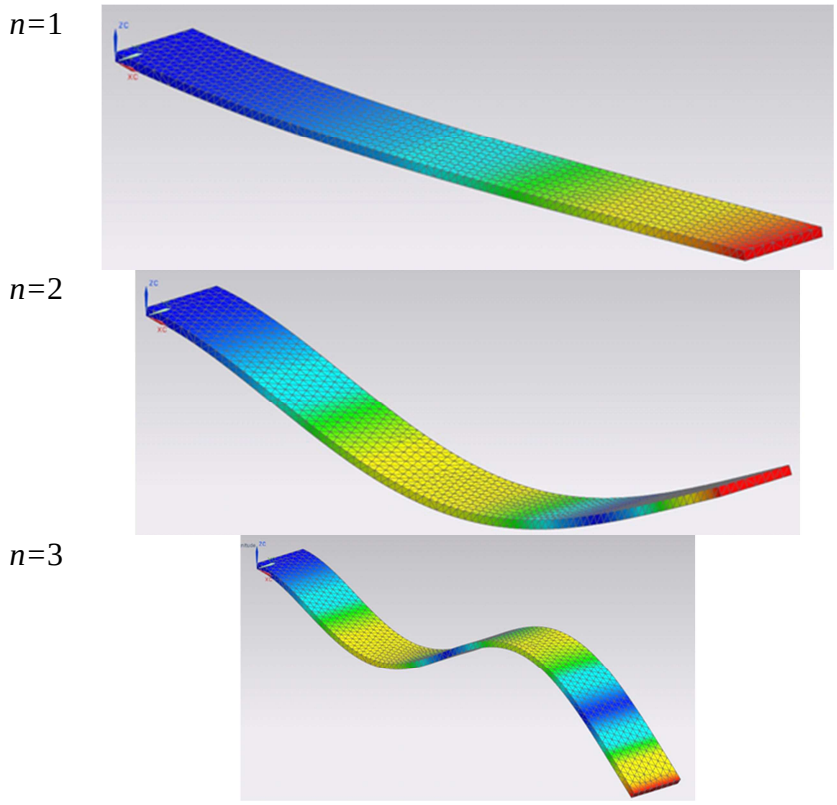

Fig.2. First three forms of vibration of the mechanical subsystem

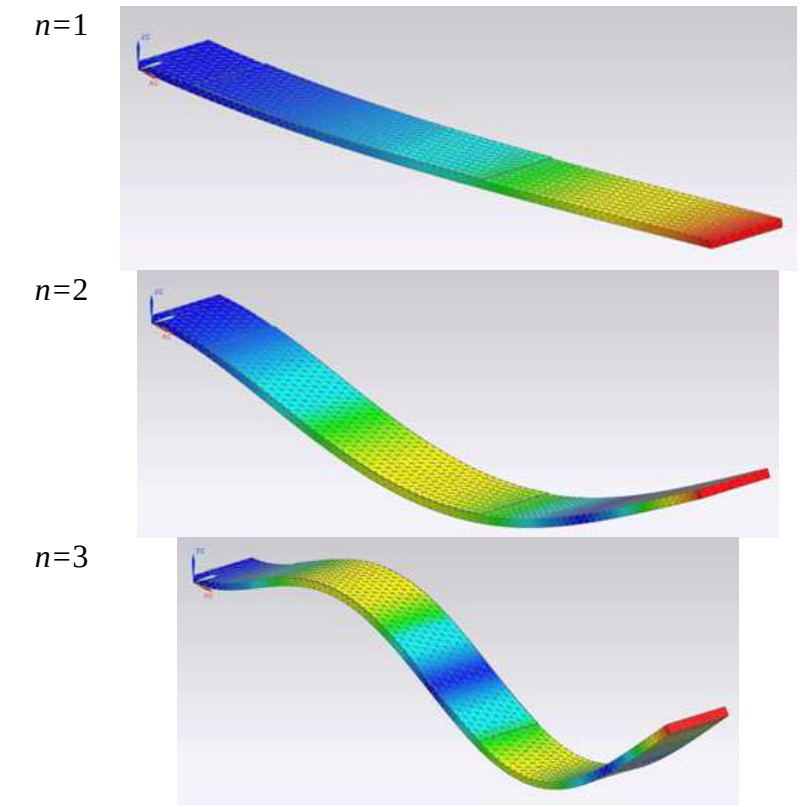

Fig.3. First three forms of vibration of the system with MFC transducer

Forms of variations are also juxtaposed in Fig. 4 as 2D graphs in order to show that the MFC transducer has negligible influence on obtained results. It should be mentioned that was used it is the M8514-P1 that thickness is only 300 μm [5].

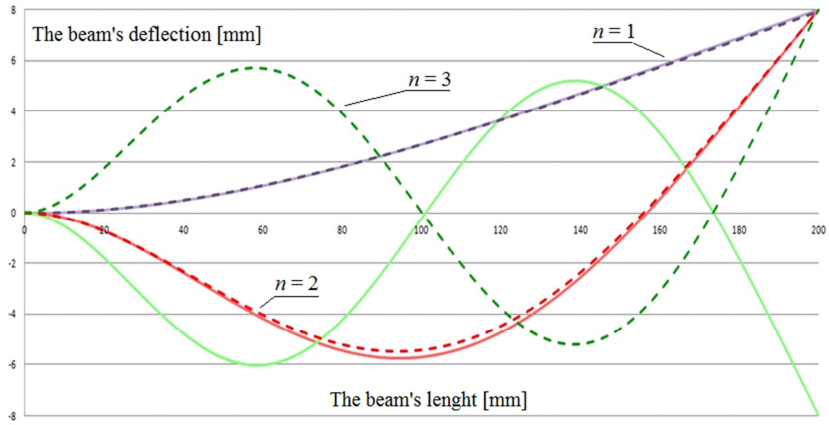

Fig.4. Juxtaposed first three forms of vibration of the system with MFC transducer

3. Conclusion

This work is an introduction to computer aided analysis of systems with piezoelectric transducers used as vibration dampers or actuators. It was also carried out to verify the influence of the MFC transducer glued to the surface of the mechanical subsystem on its natural frequencies and forms of vibrations. It was proved that its influence is negligible. In the future work the analysis of vibrating systems excited by piezoelectric actuators or whose vibration is damped using forces generated by piezoelectric transducers will be carried out. Obtained results will be juxtaposed with results obtained using mathematical models of such kind of systems and mathematical algorithm of their analysis based on the approximate method that were presented in other author's publications.

Acknowledgements

The work was carried out under the project number PBS2/A6/17/2013.

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