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Exprimental Modal Analysis of a Rectangular Plate with Embedded Piezoelectric Actuators and Sensors

Miroslav M. Jovanović[1,a,*], Ardeshir Guran[2,b], Aleksandar M. Simonović[3,c], Nemanja D. Zorić[3,d], Nebojša S. Lukić[1,e], Slobodan S. Ilić[1,f]

[1]Serbian Armed Forces, Technical Test Center, Vojvode Stepe 445, 11000 Belgrade, Serbia

[2]Institute of Structronics, Montreal, Quebec, Canada

[3]University of Belgrade, Faculty of Mechanical Engineering,
Kraljice Marije 16, 11120 Belgrade, Serbia

[a]mjovano@sbb.rs, [b]ardeshir.guran@gmail.com, [c]asimonovic@mas.bg.ac.rs,
[d]nzoric@mas.bg.ac.rs, [e]nesaluca@ptt.rs, [f]slobodan.ilic@vs.rs

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Abstract: This paper present experimental modal analysis of rectangular thin plates with embedded Piezoelectric Actuators and Sensors. This study gives the difference in natural frequencies of the rectangular plate without and with integrated PZT actuator and PVDF sensors with the aim to define the structural changes before the development of active control vibration system.

Introduction

Integration of actuators and sensors on structure area have changed its modal parameters. The optimization of sizing and location of actuators and sensors for active vibration control of flexible structures has been shown as the one of the most important issues in the design of active structures since these parameters have a major influence on the performance of the control system.

Modes (or resonances) are inherent properties of a structure. Resonances are determined by the material properties (mass, stiffness, and damping properties), and boundary conditions of the structure. Each mode is defined by a natural (modal or resonant) frequency, modal damping, and a mode shape. If either the material properties or the boundary conditions of a structure change, its modes will change. For instance, if piezoelectrical actuator is embedded on structure, the modes of structures will be changed.

Experimental set-up and modal analysis of rectangular plate

Aluminum rectangular plate was used for experimental determination of first three natural frequencies. The experimental set-up was in CFFF configuration and excited at opposite side of clamped side. The response acceleration are measured with two piezo film sensors. PVDF sensors are integrated on clamped side of the plate as shown in Figure 1.

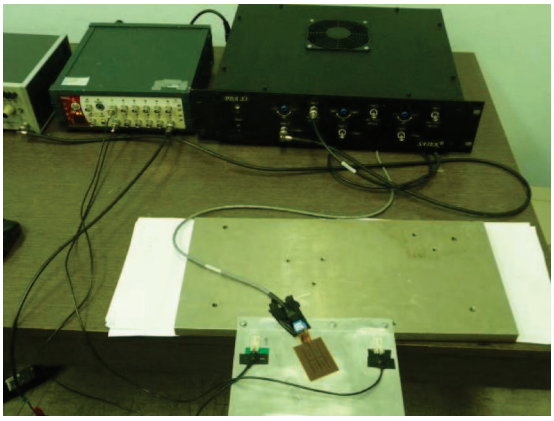

Fig. 1: Plate with integrated PZT actuator and PVDF sensors

The response measurements were acquired, using the multi-channel signal analyzer NetdB 12, and its matched software dBFA Suite, with sampling rate of 12800 Hz.

Table 1 shows Experimental results of the first three natural frequencies for plate without the PZT actuator.

Table 1: Experimental results for plate without the PZT actuator

Modes	Modes	
	Frequency [Hz]	Phase [φ]
1	10.8367	4.64
2	39.9698	179.40
3	70.2782	3.31

The experimental results of the first three natural frequencies for rectangular plate after mounting the piezoelectric actuator are given in Table 2.

Table 2: Experimental results of plate with the PZT actuator

Modes	Modes	
	Frequency [Hz]	Phase [φ]
1	10.5769	1.37
2	39.7837	174.77
3	67.6411	1.13

Natural frequencies of the thin rectangular plate before and after embedded piezoelectric actuators, which are evaluated from experimental methods given in this study are not in compliance.

Local increase of the plate stiffness, with mounted actuator, is given the increase in natural frequencies of whole plate. The mass of the actuator has a lower effect on natural frequencies than its stiffness.

In experiment, the local increase of stiffness from mounted actuator and sensors has a lower effect on natural frequencies in relation of added mass. The added mass is overall mass of glue (epoxy, etc.) and connection cables (sensors and actuator). The experimental result shows that the increase in total mass of the system decreases the frequencies of the first three modes.

Conclusion

In this paper, the first three natural frequencies of a thin rectangular plate before and after integration of the piezoelectric actuator are determined by experiment.

Based on experimental result it is concluded that the consequences in changes of natural frequencies in the process of integration of the sensors and actuators on real structure can approach the system to the working frequencies of external forces, and to reinforce the vibration of the structure.

References

[1] M.M. Jovanović, A. Guran, A.M. Simonović, N.D. Zorić, N.S. Lukić, S.S. Ilić, Estimation the Changes in Modal Parameters of a Rectangular Plate with Embedded Piezoelectric Actuators and Sensors, Proceeding of 12th International Symposium on Stability, Vibration, and Control of Systems (SVCS 2015), Prague, Czech Republic, 2015.

[2] R.C. Fuller, J.S. Elliott, A.P. Nelson, Active Control of Vibration, Academic Press, New York, 1996.