Proceedings of the 7th International Conference on Mechanics and Materials in Design,
Albufeira/Portugal 11-15 June 2017. Editors J.F. Silva Gomes and S.A. Meguid.
Publ. INEGI/FEUP (2017)

PAPER REF: 6539

A DESIGN OF PIEZOELECTRIC DAMPER FOR VIBRATION ATTENUATION OF FLEXIBLE STRUCTURES

Yu Su[1(*)], Wei Zhou[1], Wei-Zhong Zhang[2]
[1]Department of Mechanics, School of Aerospace Engineering, Beijing Institute of Technology, Beijing, China
[2]Key Laboratory of Dynamics and Control of Flight Vehicles, Ministry of Education, School of Aerospace Engineering, Beijing Institute of Technology, Beijing, China
[(*)]*Email:* adamyusu@bit.edu.cn

ABSTRACT

A piezoelectric energy absorber of PVDF layers was designed and applied in vibration suppression of flexible cable structure. The vibration characteristics of the structure, the output voltage, and power of the damper were studied by theoretical analysis and numerical simulation. The response of the entire system was evaluated under the condition of harmonic or impulsive excitation. The optimal thickness of the designed damper was determined by theoretical derivation and then confirmed by numerical simulation on three selected non-dimensional thickness, i.e., 0.1, 0.4 and 1.0, in frequency and time domains. It was demonstrated that the optimal non-dimensional thickness is around 0.4. On top of that, it was discovered that the optimal thickness remains almost the same value with varying radius-length ratio in the design.

Keywords: flexible structure, vibration control, piezoelectric, frequency response.

INTRODUCTION

With the rapid technological development in aerospace engineering and the increasing need for deep-space exploration, the cable-net structure exhibits a great potential in the wide application of space structures. But the microgravity environment in space brings a number of problems to the utilization of deployable flexible space structures. One of the most serious problems is the vibration of the cables in the flexible structures during the deploying process. The space conditions, ie., microgravity, nearly-zero damping, and varying thermal load, make it quite challenging to efficiently control the vibration. In order to achieve an efficient and practical solution to this problem, a piezoelectric damping structure of PVDF thin films and an electric circuit were designed. Passive vibration control can be established by distributing these piezoelectric dampers to the key positions in the flexible structure.

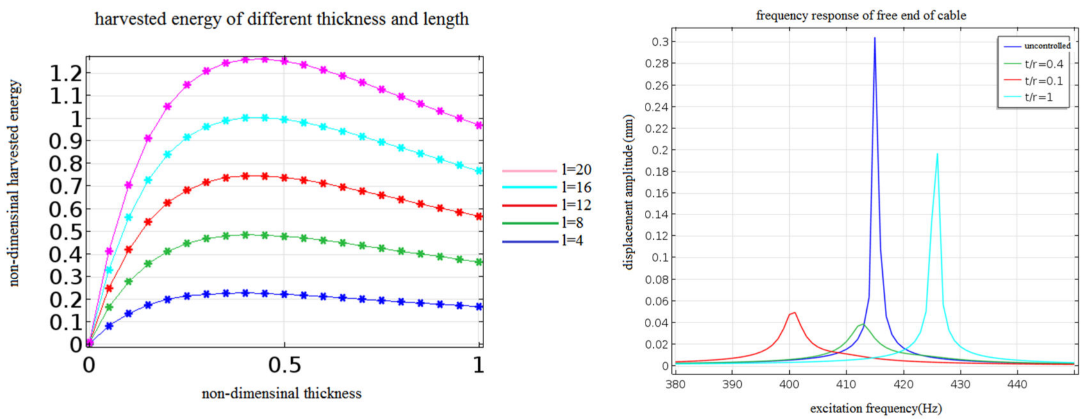
In the application of the piezoelectric damper, the PVDF thin film with t in thickness and l in length is attached to the flexible cables. The non-dimensional thickness t of the damper is a key parameter for the efficiency of the design. Its value will affect the overall effective stiffness of the structure and the capacitance of the piezoelectric damper. Therefore, it has a significant effect of the efficiency of the design. The PVDF material employed in this design has been widely used for sensors/actuators in active damping (Saravanan, 2001). Earlier study (Wasa, 2012) showed that the electrical energy output of piezoelectric cantilevers is governed by the energy transmission coefficient λ, which depends on the value of length, thickness and compliance of a cantilever beam.

RESULTS AND CONCLUSIONS

In the simulation, a single cable was fixed at one end and loaded with a constant force *F* at the other. The computed non-dimensional energy with selected values of thickness and length is plotted in Fig. 1(a).

Table 1 - Optimized design parameters for different value of thickness

Thickness	Open(Hz)	Short(Hz)	R(Ω)	L (H)
0.1	402.65	402.54	2.2287e+03	1.8648e+05
0.4	415.26	415.10	7.3289e+03	7.5137e+05
1	425.66	425.56	1.3961e+04	1.1451e+06



(a) (b)

Fig. 1 - Comparison of the design efficiency with different film-thickness: (a) the non-dimensional energy harvested; (b) the displacement amplitude in the frequency domain.

The results showed that the value of the optimal non-dimensional thickness is 0.42. Higher value of length may let it store more energy, but not change the optimal thickness value. We reached the same conclusion by observing the frequency response of the cable, as shown in Fig. 1(b).

ACKNOWLEDGMENTS

The authors gratefully acknowledge the support by National Natural Science Foundation of China (No. 11290153).

REFERENCES

[1]-C. Saravanan, N. Ganesan, V. Ramamurti. Analysis of active damping in composite laminate cylindrical shells of revolution with skewed PVDF sensors/actuators. Composite Structures, 48, 305-318 (2000).

[2]-C. Saravanan, N. Ganesan, V. Ramamurti. Thin-film piezoelectric materials for a better energy harvesting MEMS. Journal of Microelectromechanical Systems, 21, 451-457 (2012).