Applications of contemporary software systems for piezoelectric beams investigations

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Abstract: *This paper presents investigations of vibrations of cantilever beams with piezoelectric layers. The paper discusses the contemporary engineering and scientific software systems in order to select the appropriate for the study of mechanical and electrical dynamic behavior of piezoelectric beams.The system COMSOL has been chosen and a study with it has been stated with a static analysis and an eigenvalue analysis. Conclusions are made and a frequency response and time dependent investigations are planned to be done.*
Keywords*: PIEZOELECTRIC BEAM, CANTILEVER BEAM, VIBRATIONS, MODELING, SIMULATION, SOFTWARE*

1. Introduction

The aim of this paper is to discuss the contemporary engineering and scientific software systems and to chouse the appropriate for investigating the mechanical and electrical dynamical behavior of piezoelectric beams.

The development of extremely low power electronics and wireless systems has led to a strong interest in the fields of energy harvesting and development of miniature generators. Typically, these devices are used to power sensors and wireless communication systems, enabling standalone wireless sensors that are cheap to deploy.

In the area of the mechanical structure vibrations investigations and the multiphysics simulations, four software systems have the lead positions. These are: *ABAQUS*, *COMSOL*, SOLIDWORKS, and *MATLAB*. The software system *MATLAB* is a system for "computer aided mathematics" and "matrix laboratory", but in fact this software system is often used from scientist and engineers to solve mathematical models that describes problems in the area of the mechanical structure vibrations and the multiphysics simulations.

The major components of the energy harvester are: a piezoelectric bimorph, a proof mass and, a supporting structure. The piezoelectric bimorph usually consists from a ground electrode embedded within it (coincident with the neutral plane of the beam) and two electrodes on the exterior surfaces of the cantilever beam – Fig. 1 [6].

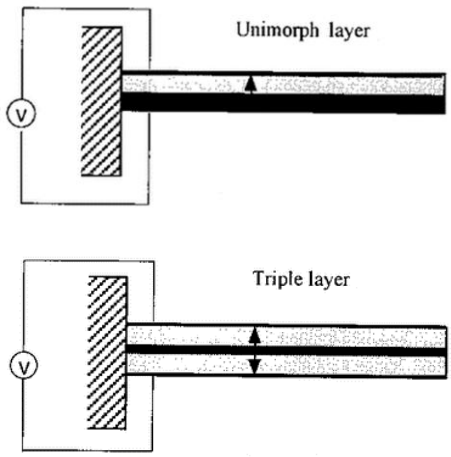

Fig. 1. *Kinds of bimorph layers*

As it is of utmost importance to enable users to apply developed numerical tools in modeling and simulation, the investigation presented in [2] addresses ABAQUS implementation of the recently developed piezoelectric 3-node shell element. Similar works were already reported in available literature [1, 3, 4]. In what follows, the most important aspects of the element development are briefly presented together with the results of several test cases computed by using the element implemented in Abaqus.

In [5], a simple cantilever piezoelectric beam is modeled trough *MATLAB* ang *Partial Deferential Equation Toolbox* – Fig. 2. Then, the free vibrations are studied.

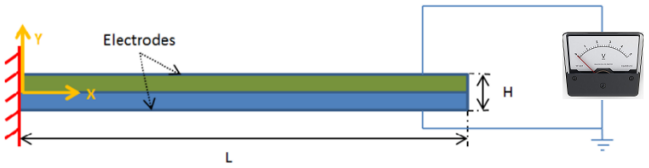

Fig. 2. *Simple piezo beam in MATLAB*

2. Basic piezo beam in COMSOL

The *COMSOL* Multiphysics software enables the simulation of designs involving coupled physics (mechanics, electromechanics, acoustics, fluid flow, heat transfer, chemical reactions, etc.) and the creation of easy-to-use apps. *COMSOL* Multiphysics and *SOLIDWORKS* software interface via *LiveLink* for *SOLIDWORKS* – Fig. 3.

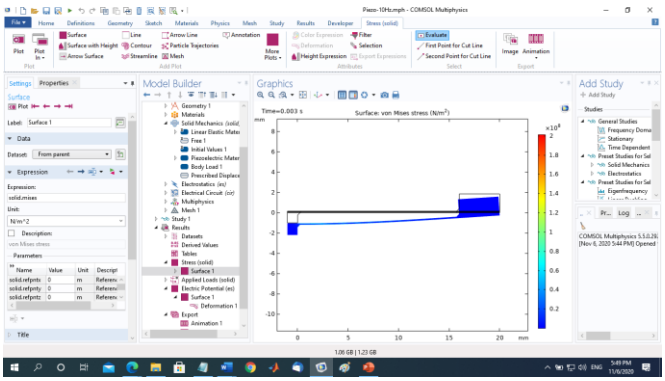

Fig. 3. *The beam investigated in the COMSOL Multiphysics software*

Also, *COMSOL Multiphysics* is a simulation platform that encompasses all of the steps in the modeling workflow - from defining geometries, material properties, and the physics that describe specific phenomena to solving and postprocessing models for producing accurate and trustworthy results. These are the reasons why COSMOL was chosen for this study. Two supporting schemes are used – Fig. 4.

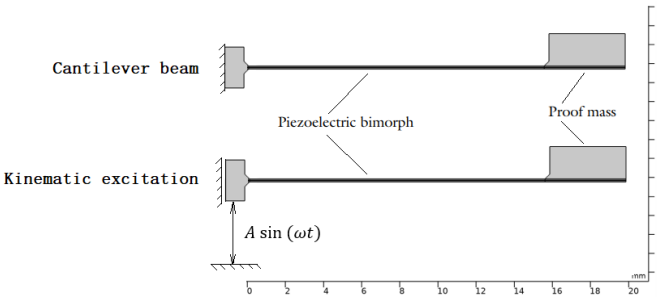

Fig. 4. *Simple piezo beam*

Firstly, a static study is conducted and the beam deflection is obtained. Also, the proof mass displacement is calculated – Fig. 5 and Fig. 6.

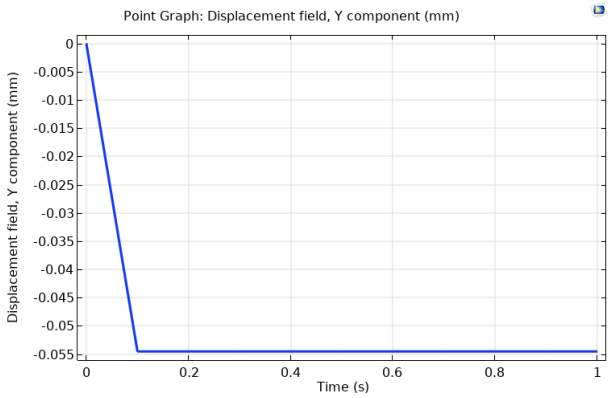

Fig. 5. *The proof mass static displacement plot*

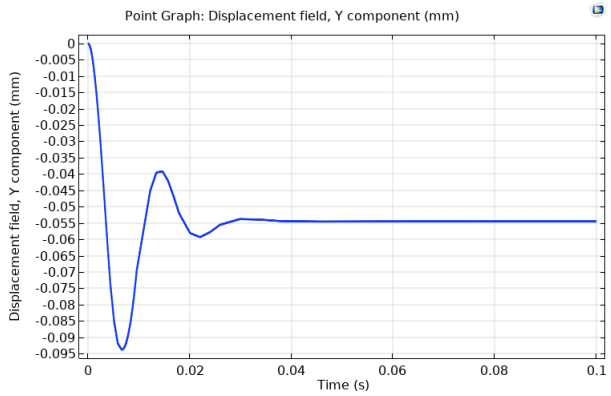

Fig. 6. *The proof mass dynamic displacement plot*

An eigenvalue study is performed and the natural frequencies and shapes are obtained – Fig. 7 and Fig. 8. One can see that the first natural frequency has a value of 80.6 Hz and the corresponding natural shape has one node. The second natural frequency is 903.8 Hz and their natural shape has two nodes.

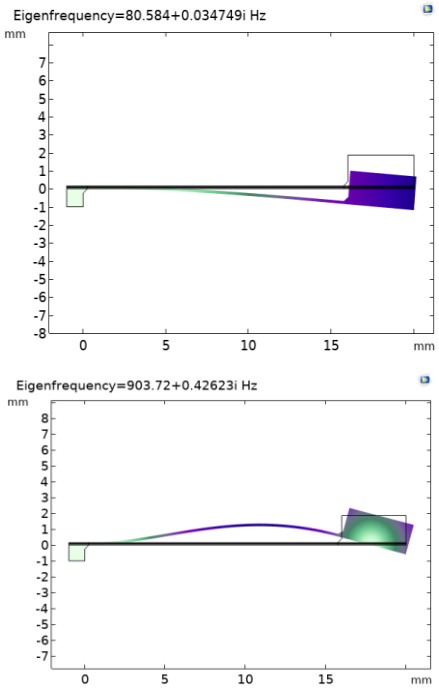

Fig. 7. *The firs and second natural shapes of incestigated piezo beam*

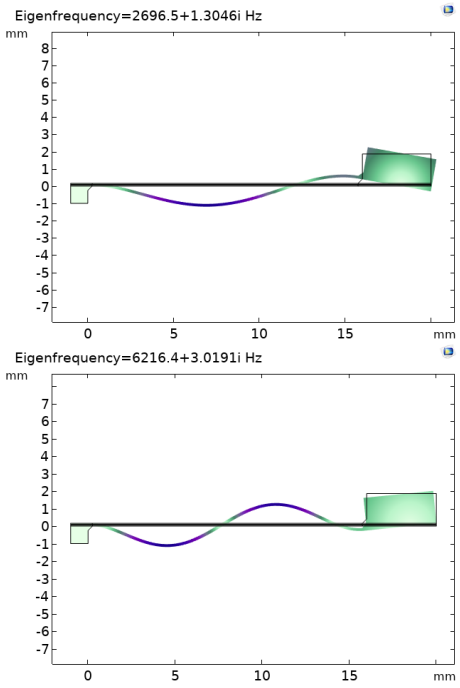

Fig. 8. *The third and four natural shapes of incestigated piezo beam*

3. Conclusions

A simple piezoelectric beam is modelled in *COMSOL Multiphysics* software and a static study is conducted. After that, an eigenvalue analysis is performed and the first four natural frequencies and shapes are obtained.

It is planed the investigation to be continued with a frequency response analysis and a time dependent analysis. They will provide information about the mechanical and electrical vibration behavior of the beam.

3. References

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