

Polyvinylidene Fluoride for Piezoelectric Energy Harvesting

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Abstract

The creation of a new framework has been prompted by recent developments in the field of distributed sensors/actuators. The current technology makes use of the thermal mechanical properties of piezoelectric materials, which exhibit unique properties under stress and when exposed to electricity. Vibrations are the primary cause of structural cyclic failure. This mechanical device will help to mitigate this. The aim of this research is to determine the damping characteristics of piezoelectric members as well as the degree of reduction. This damping is made of various materials since it is directly proportional to the system's natural frequency. As a consequence, the obtained governing equations become a multi-physics problem involving mechanical stress-strain combined with piezoelectric electromagnetic properties.

Keywords: - Electricity, Power system, ANSYS, Electromagnetic properties

INTRODUCTION

A basic understanding of mechanics and electrostatics is needed for the creation of models for smart material systems. The thermal mechanical properties of certain materials that show certain special properties during stresses and by electrical application are used in current technology. Vibrations are the primary cause of structural cyclic failure. These special devices may help to minimise this. The

aim of this research is to determine the damping characteristics of piezoelectric members as well as the degree of reduction. This damping is made of various materials since it is directly proportional to the system's natural frequency. The damping characteristic of the material used here, as well as its properties, are tabulated alongside the PVDF material.

Properties

Table 1: Properties of beam materials

Properties	Aluminium	Steel
E11(Young's Modulus)	72Gpa	276Gpa
Density(kg/m ³)	2700	7800
Poison's ratio)	.277	.32

Dimensional Plot

- Rectangular Plate
- Length = 0.4m
- Height = 0.05m
- Thickness of plate = 0.005m
- PVDF thickness = 0.0005m

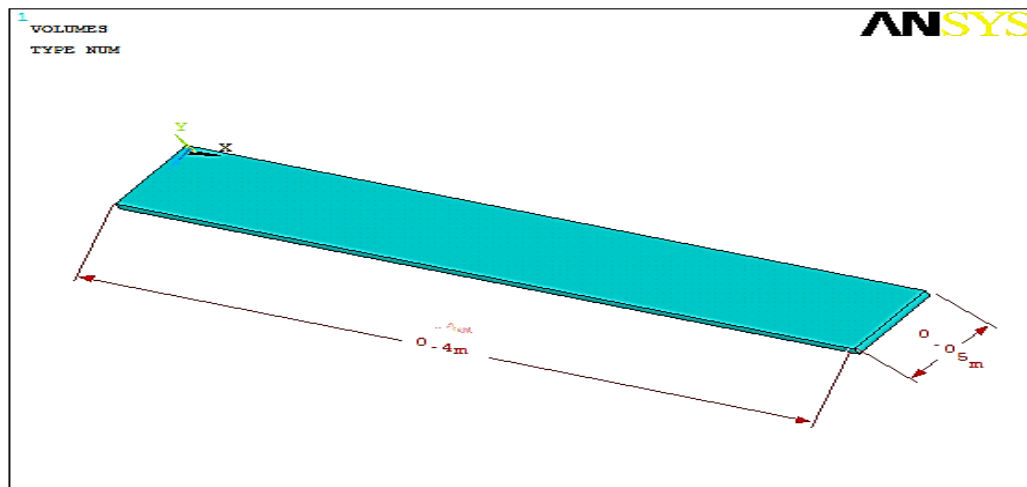


Figure 1: Showing the dimensional plot for aluminium cantilever beam.

Table 2: Modal frequency of aluminium

Set No	Mode Frequency(Hz)
1	25.893
2	162.13
3	253.46
4	394.52
5	452.08

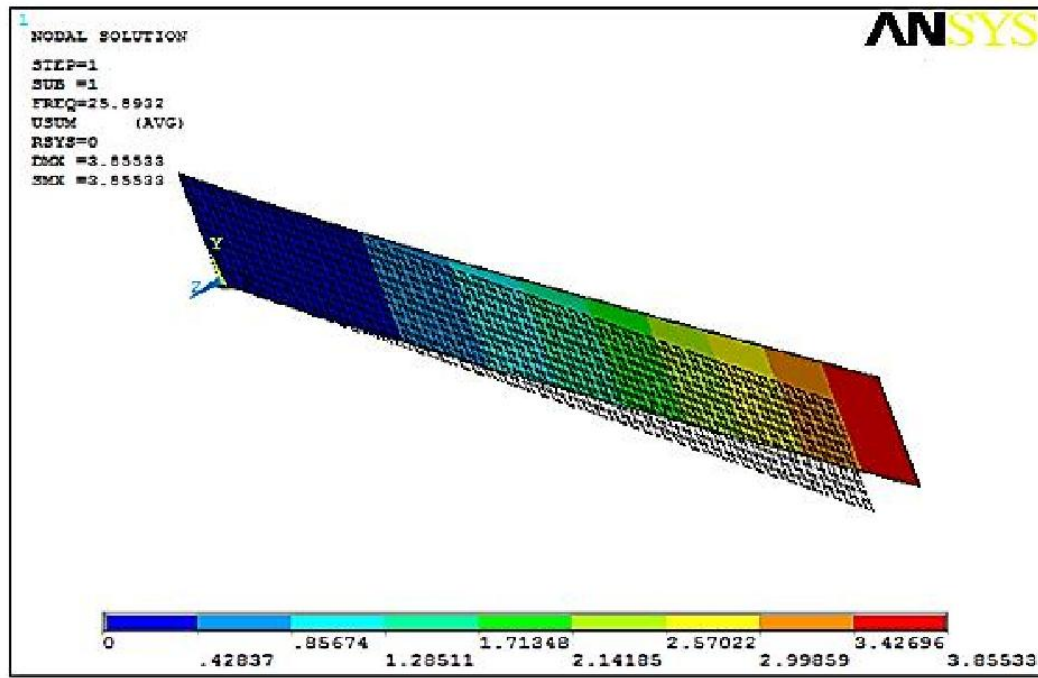


*Figure 2: Deformed and undeformed shape of aluminium beam without PVDF sensor
undamped response of aluminium beam.*

MODAL ANALYSIS OF BEAM WITH PIEZO MATERIAL

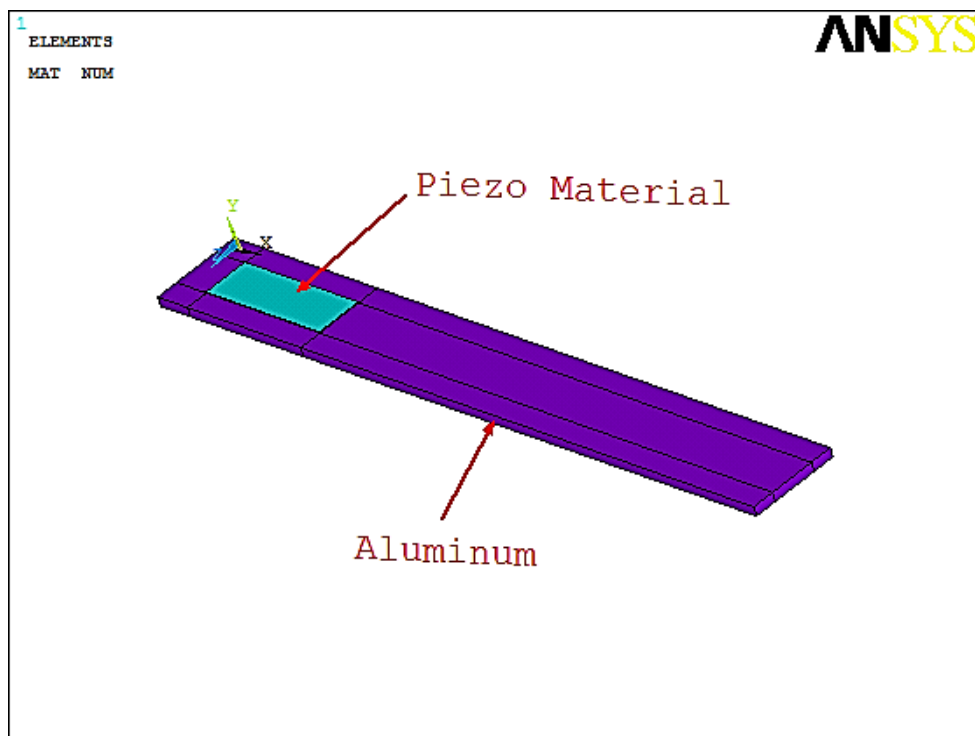


Figure 3: Aluminium material with a piezo patch.

Displacement with piezo-voltage 25V

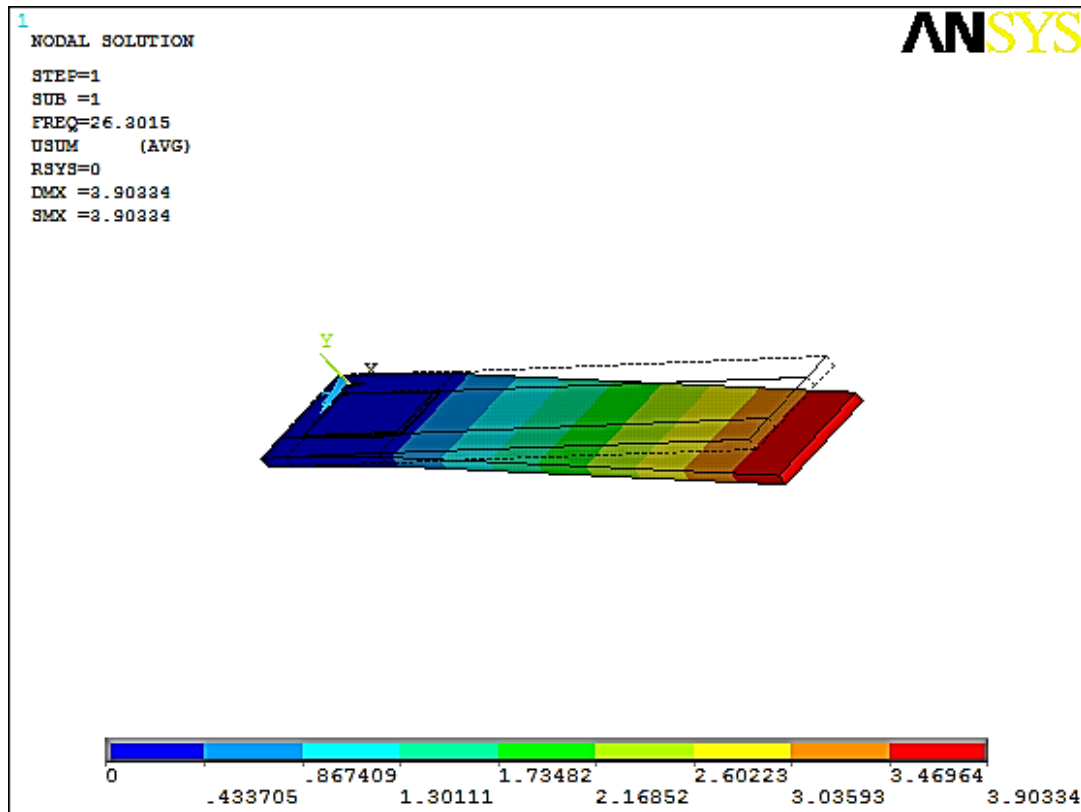


Figure 4: Deformed and undeformed shape with PVDF voltage 25 V.

Displacement with piezo – voltage 50V

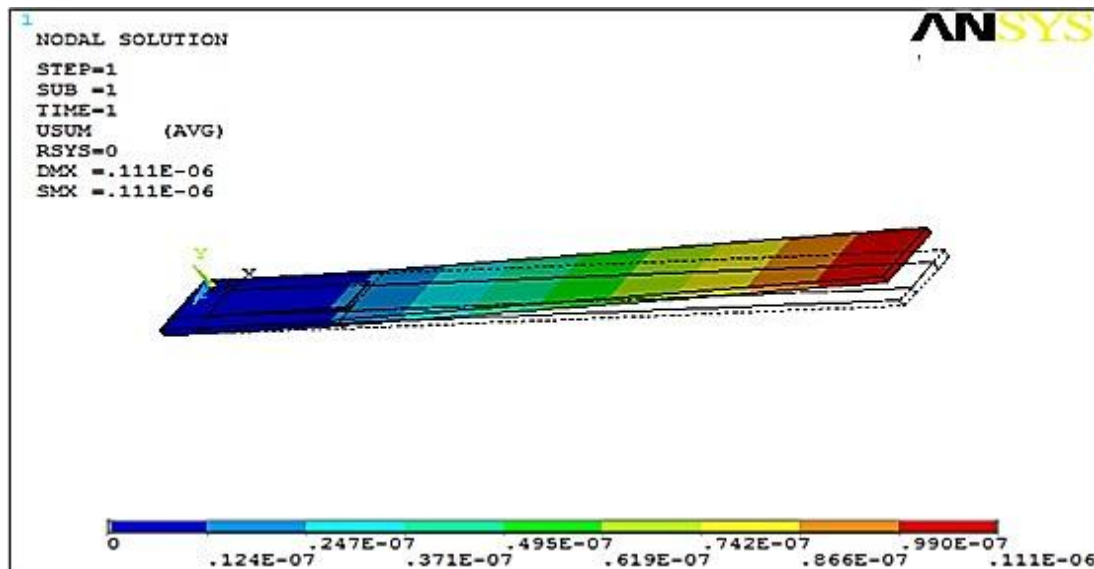


Figure 5: Deformed and undeformed shape of Al with PVDF voltage 50V.

Modal analysis – Steel plate

Table 3: Results summary for aluminium beam

Damping Ratio (10^{-4})	Beta $d(10^{-5})$	Amplitude of Vibration (microns)	% reduction
0	0	10.29	-
0.95	1.0971	9.97	3.1
1.777	2.18	9.86	4.18
2.68	3.29	9.816	4.6
3.59	4.41	9.79	4.9

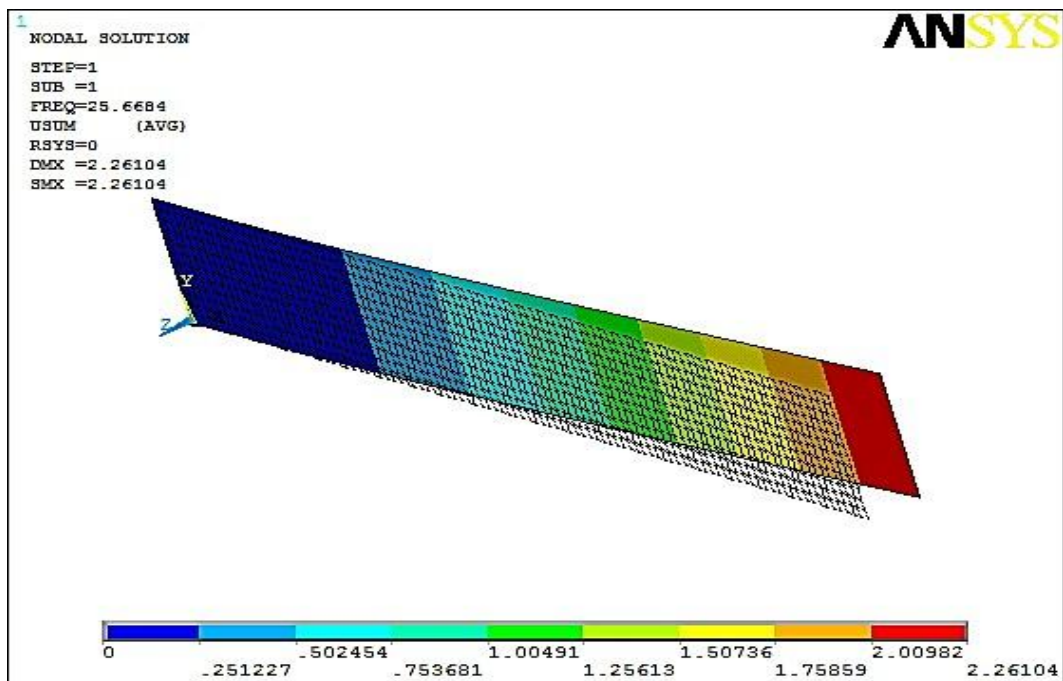


Figure 6: Deformed and undeformed shape of steel beam without PVDF sensor.

Table 4: Modal frequencies for steel beam without PVDF

Set No	Mode Frequency(Hz)
1	25.668
2	160.73
3	251.26
4	391.10
5	450.14

Displacement with piezo – voltage 25V

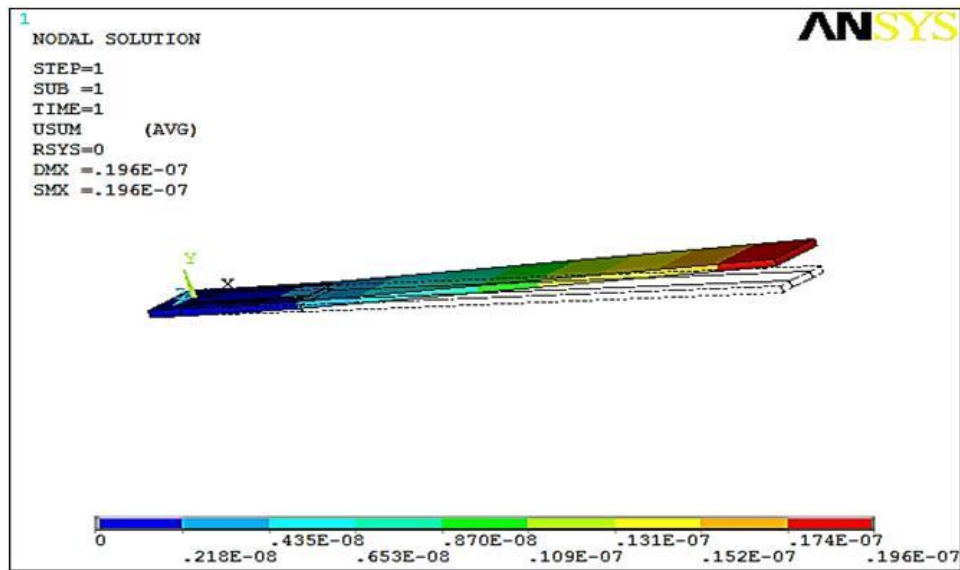


Figure 7: Deformed and undeformed shape of steel with PVDF voltage 25V.

Displacement with piezo – voltage 50V

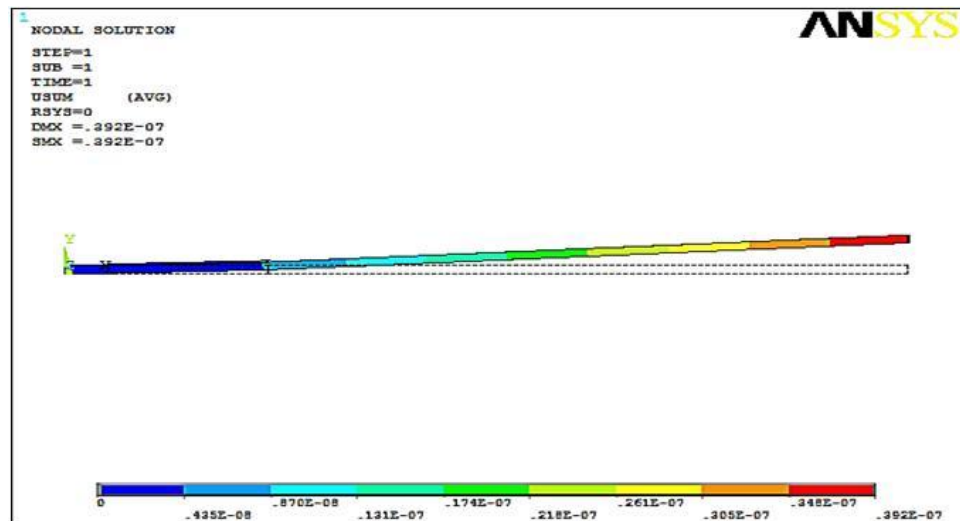


Figure 8: Deformed and undeformed shape of steel with PVDF voltage 50V.

Table 5: Damping characters of piezo material.

Damping Ratio(10^{-4})	Beta d(10^{-6})	Amplitude of Vibration (microns)	% reduction
0	0	10	-
3.122	3.803	9.8593	1.4
6.2511	7.613	9.82	1.8
9.3699	11.412	9.782	2.18
12.5108	15.237	9.74485	2.56

CONCLUSIONS

From the fixed end, the PVDF patch is surface bonded to aluminium and steel. The vibration properties of an aluminium and mild steel beam with a PVDF patch are studied by bonding the PVDF patch to a position and applying a variable voltage to the PVDF actuator. For mild steel and aluminium, the effect of a PVDF patch on the surface of the beam was investigated separately. The beam and the PVDF patch were modelled in ANSYS and were glued together and analysed for natural frequency with fixing the beam at one end. The beam and PVDF patch were modelled in ANSYS, fused together, and natural frequency analysed with the beam fixed at one end. The percentage increase in stiffness is tabulated in tables for various voltage differences, and the percentage reductions for both aluminium and steel are compared, and it is discovered that for the same voltage, aluminium has a greater reduction in vibratory amplitude and therefore has a less settling time and more stiffness.

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