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DESIGN AND DEVELOPMENT OF PZT MATERIAL AS ENERGY HARVESTER WHICH CONVERTS VIBRATION ENERGY INTO ELECTRICAL ENERGY

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ABSTRACT

The design and development of vibration energy is So important and the study of it is rapidly increasing since few years as the vibration energy contains mechanical energy which is going to waste in this paper the aim is to achieve The wasted mechanical energy with help of pzt material. The piezoelectric material has the property of converting mechanical energy into electrical energy. Recently, much work has been done on the topic of the harvesting of mechanical vibration energy

KEYWORDS: vibrational energy,pzt material, aluminum beam.

I. INTRODUCTION

"Piezo" is a Greek word it means "to squeeze." Piezoelectricity, also called the piezoelectric effect, is the ability of certain materials to generate an AC (alternating current) when subjected to mechanical stress or vibration, or to vibrate when subjected to an AC voltage, or both. The most common piezoelectric material is quartz. Certain ceramics, Rochelle salts, and various other solids also exhibit this effect. When the piezoelectric elements are strained by an external force, displaced electrical charge accumulates on opposing surfaces. The piezoelectric effect is a reversible process In this the internal generation of electrical charge is resulting from an applied mechanical force and the reverse piezoelectric effect is that internal generation of a mechanical strain resulting from an applied electrical field.

II. LITERATURE REVIEW

Mechanical vibrations can be converted into electrical energy by electromagnetic, electrostatic and piezoelectric energy harvesting. Piezoelectric energy harvesting has received the most attention among the aforementioned methods because of its structural simplicity, high-voltage generation, and potential to operate without additional electrical power sources as many researchers done work on that.

D. P. D'Souza [1] used the COMSOL Metaphysics finite element package to study the direct piezoelec¬tric effect when an external load is applied at the free end of a piezoelectric composite beam. He studied the pri¬mary output parameters such as electric potential and electric field as a function of the input strain and stress as well he done the modeling for the relatively new single crystal lead magnesium niobate-lead titanate (PMN32) and three different lead zirconate titanate ceramics (PZT-5A, PZT-5H, and PZT-4). Material performance was assessed by using a common geometry and identical excitation conditions for the different piezoelectric materials

Hong-yan WANG, Xiao-biao SHAN and Tao XIE [2] in year 2012 studied a piezoelectric material combined with cantilever beam subjected to SDOF. The main function of the additional SDOF elastic system is to magnify vibration displacement of the piezoelectric cantilever to improve the power output. He developed a mathematical model of the energy harvester based on Hamilton's principle and Rayleigh-Ritz method. Furthermore, the effects of the structural parameters of the SDOF elastic system on the electromechanical outputs of the energy harvester are analyzed numerically.

Jiyuan Wang [3] considers composite thin plate excited by PZT actuators in this work. To describe the dynamic response of the quadrate plate clamped at its boundaries, commercial package FEMLAB3.1 is used to build and simulate a mathematical model. The model is a set of nonlinear partial differential equations (PDEs) with spatial discontinuous coefficients, which is developed on the basis of the Kirchhoff–Love plate theory, Von-Karman nonlinear strain-displacement relationship, and the macroscopic and quasi-static piezoelectric polarization.

Ming Li [4] presents an energy harvester employing a cantilever beam and a magnetostrictive/piezoelectric (ME) laminate transducer to transform rotation energy into electrical energy. The harvester has a magnetic circuit attached to the free end of the beam, and the ME transducer is placed in the air gap of the magnetic circuit. He summarized as the harvester should be designed to achieve the second-order super-harmonic resonance at the target rotation frequency if possible.

III.EXPERIMENTAL ANALYSIS

From literature review it is found than the cantilever system generates maximum voltage and I found one research paper of HONG YAN WANG in that he stated we can obtain the maximum energy when cantilever beam subjected to additional SDOF system is used.

Experimentation is one of the scientific research methods, perhaps the most recognizable; In order to find out voltage rate generated by PZT5A patch with cantilever beam subjected to SDOF elastic system following instrumentation is required.

The Excitation Equipment

In order to give harmonic excitation to the system an EXCITER is used.

Matlab interfaced device for voltage measurement

Pizzo input is the input signal of the system.

The Sensing Equipment

An accelerometer is a sensing element that measures acceleration Accelerometers have developed from a simple water tube with an air bubble that showed the direction of the acceleration to an integrated circuit that can be placed on a circuit board. Accelerometers can measure: vibrations, shocks, tilt, impacts and motion of an object.

Data Acquisition and Processing Equipment

A Fast Fourier Transform (FFT) is an algorithm to compute the Discrete Fourier Transform (DFT) and its inverse. A Fourier transform converts time (or space) to frequency and vice versa; an FFT rapidly computes such transformations by factorizing the DFT matrix into a product of sparse (mostly zero) factors. Before the mathematical FFT process can be applied, a certain amount of data representing the waveform has to be stored in memory as a so-called "time record". The minimum duration of this time record is the period of the lowest frequency to be processed. The time this takes is called collection time. Then the whole waveform is analyzed in one go and mathematically converted into a series of sine waves of different amplitudes, frequencies and phases. The result is an analysis of the whole spectrum part at a certain point in time.

Experimentation

1. The aluminium plate of size - 300X50X3mm is taken as beam and at the tip of the beam the PZT5A patch of size 100X50X2mm is fixed with help of araldite.

2. These configuration is fixed on the lumped mass with help of bolts as seen in image of experimental setup.

3. For SDOF system the steel rod working as spring and damping element. This steel rod is fixed at the bottom of lumped mass with help of stud.

4. Above three steps gives the actual model preparation. This model is fixed on the exciter of 100N capacity by preparing threads in the steel rod. After assembly of apparatus in vibration analyzer, measurement scheme has to be made, in analyzer proper selection of sensors and their channel is made. Measurement parameters are defined i.e. measurement of displacement amplitude vs. time with channel 1 and channel 2, to which accelerometers are to be connected. To trig/tacho channel digital stroboscope is to be set.

5. All sensors should be attached to vibration analyzer when it is in power off mode. Proper connections of all sensors are made. Various sensors used are accelerometers and digital stroboscope.

6. The accelerometers are attached to system as shown in Figure 3.5 to give the constant input amplitude of 20μm by adjusting the input current.

7. The system is connected to the microcontroller based circuit to measure the voltage generated in the system and it is MATL AB interfaced.

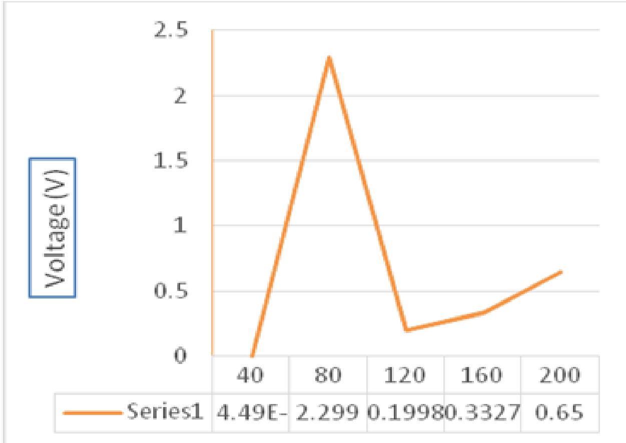
8. By changing the input frequencies from 40HZ, 80HZ, 120HZ,160HZ and 200HZ and by setting the operating amplitude to 20μm by fine adjustment of input current from amplifier the voltage measurement is started with the help of MATLAB interfaced circuit.

IV. RESULTS

Frequency Voltage readings

X axis Frequency (Hz)	Y axis Voltage (V)
40	4.49E-03
80	2.299
120	0.1998
160	0.3327
200	0.65

Graph



V. CONCLUSION FOR EXPERIMENT

In this Experimentation we study of Finite element modeling of a cantilever beam bonded by piezoelectric material PZT5A and a single degree of freedom elastic system subjected to harmonic excitation is carried out. For experimental analysis setup of cantilever beam with PZT5A and SDOF is developed. Experimental result shows maximum voltage 2.29 volt is generated at its first natural frequency 80HZ and it drop at next excitation frequency and increased for the second natural frequency of 160HZ.

FINITE ELEMENT ANALYSIS

The finite element analysis of cantilever beam with PZTA material subjected to SDOF elastic system is carried out by using ANSYS software.

Preprocessor input data

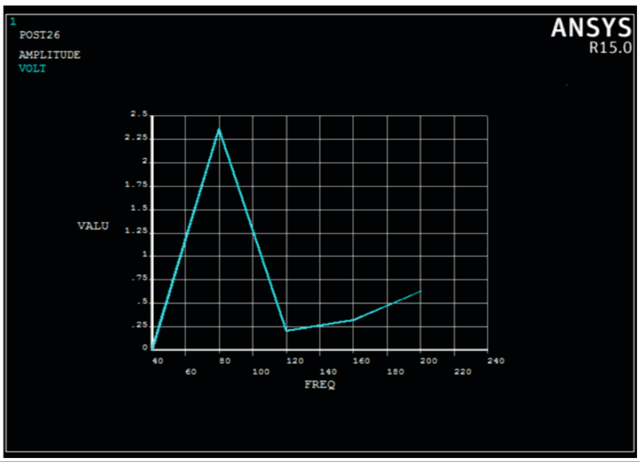
- Size of the substrate (AL) plate- 300x50x3mm
- Size of Piezoelectric Plate-100x50x2mm
- Aluminum: Density= 2700 kg/m3.
E= 0.70 e11Pa.
μ=0.35.
- PZT5A: Density= 7750 kg/m3
- Elements used

For 'Al': Solid – brick 8node 185

For 'PZT': Coupled field Brick 20 node 226

I am working on very important assumption that the contact surface between beam and PZT5A material is perfectly rigid. In FEA we used contact pair between them.

VI. FEA RESULT



VII. CONCLUSION

In this FEA study of a cantilever beam bonded by piezoelectric material PZT5A and a single degree of freedom elastic system subjected to harmonic excitation is carried out. For finite element analysis ANSYS software is used and the SOFTWARE result shows maximum voltage 2.35 volt is generated at its first natural frequency 80HZ and it drop at next excitation frequency and increased for the second natural frequency of 160HZ.

VIII. VALIDATION & RESULT DISCUSSION

Sr. no.	Experimental analysis		Finite element analysis		Percentage error.
	Frequency (HZ)	Voltage (V)	Frequency (HZ)	Voltage (V)	
1	80	2.29	80	2.35	2.55
2	120	0.1998	120	0.21	4.85
3	160	0.3327	160	0.35	4.94
4	200	0.65	200	0.68	4.41
Average					4.18

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