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DIRECT AND INVERSE PIEZOELECTRIC EFFECT OF PZT-5H DISC BENDERS

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ABSTRACT

In this paper presented a direct and inverse piezoelectric calculations of lead zirconate titanate(PZT) disc at different resonance frequencies such as frequency constant, capacitance, static displacement and static voltages under variable forces. These are the basics for analytical studies and the design of a energy harvesters by using ambient vibrations. The static displacement is very small for PZT-5H when the voltage is applied. It comes under inverse piezoelectric effect. If the applied voltage is 10 V for the disc of 32 mm diameter and 2 mm thickness the change in displacement is 3.47 x 10^{-6} mm. And also concluded with the effect of voltage constant(g33) in generating the static voltage which plays very important key role. Simulation work is done in COMSOL5.0.

KEYWORDS: PZT; frequency constant; capacitance; static voltage.

INTRODUCTION

The process of acquiring the energy surrounding a system and converting it into usable electrical energy is termed power harvesting. At present, next-generation energy technology is a technology to harvest electrical energy using piezoelectric ceramics based on piezoelectric effect. Piezoelectric effect is the phenomenon where electrical energy is obtained when mechanical energy is applied to piezoelectric ceramic. Technologies are developed because of a shortage of energy in the world. One of the next-generation energy technologies is piezoelectric energy harvesting technology. Piezoelectric energy harvesting technology is very eco-friendly and useful because of the use of discarded physical energy around our living atmosphere. For example, electrical energy is harvested from a vibration of a road when people and cars pass the road. For this method, the piezoelectric energy harvesting technology needs proper piezoelectric generator. The world energy production sector is in transition and is nowadays called to face great challenges in a context in which the fossil fuel reserves are running out, while the energy demand steadily increases. On the other hand, the rising cost and the related environmental issues make the use of conventional energy resources more and more difficult. The increment of the world energy demand, mainly fulfilled by fossil fuels has brought to an increment in greenhouse gas emissions with serious consequences on our environment.Energy harvesting allows the recovery of the mechanical energy from environmental vibrations and is obtained through the piezoelectric materials according to the direct piezoelectric effect. More in detail, it implies the generation of an electric field across the material corresponding to a mechanical strain. Since past this technology found interesting applications in the framework of wireless sensor systems in order to make the transmission and acquisition units self-powered.

LITERATURE REVIEW

This review only shows the devices which are made by the past researchers in the area of energy harvesting by using ambient vibrations but the output of those devices are only in micro watts because not availing the tools which are available at present such as Matlab , Catia , Ansys etc. Authors are focusing on Piezo electric generation by man powered and impact coupled devices. Power may be recovered passively from body heat, breathing, blood pressure, arm motion, typing, and walking or actively through user actions such as winding or pedalling. John Kymissis examined three different devices that can be built into a shoe, and used for generating electrical power "parasitically" while walking. One of these is piezoelectric in nature: a unimorph strip made from Piezo ceramic composite material. The second is a shoe-mounted rotary magnetic generator [1]. Later in 2012 Jose Luis Gonzalez shown how it is feasible to use the energy harvested from human body to power wearable units incorporating computing, communication and audio functions. Existing shoe mounted rotary electromechanical generators can provide enough power from walking to supply these devices. The generators based on piezoelectric effect are or will be also capable of powering wearable units. However more investigation and development is necessary to raise the electrical output power for the existing prototypes to the power level that can be obtained theoretically [2]. Spring-comprised Piezoelectric Energy Generator (SPEG) for random vibration is modelled and analyzed in this work. The work basically focuses a novel spring comprised piezoelectric energy harvester with hitting masses, which is capable of harvesting energy from the ambient vibration. By properly designing the parameters, such as the length, diameter and mass of the shell and hitting masses, we can increase energy generated. For finding these parameters we carried out parametric analysis in SIMULINK. The main aim of the project is to get maximum voltage & power. Analysis is carried out by varying the geometry, mass of a shell & stiffness of spring. Ki Hwan described a method for efficient piezoelectric energy harvesting from impacts using an array of piezoelectric modules. He showed that rectifying the output of each module separately affords higher output voltage and faster charging than the use of a single rectifier. In addition, an increase in the rate of impacts produces an increase in output voltage and charging rate. However, under real conditions, it may not be practical to increase the rate of impacts. Instead, it is more practical to include a phase difference. The inclusion of a phase difference between impacts on individual modules in the array has the same effect as an increase in the rate of impacts increase in the charging rate. Another advantage of including a phase difference is that the forces are distributed temporally. These methods can be used to realize more efficient piezoelectric energy harvesting [3].Later Kumar discussed the simulation studies on a vibration based energy harvesting system to convert the undesirable mechanical vibration to useful green power. The design consists of a resonating proof mass and a spring system enclosed in housing and fixed on the source of vibration. He proposed that by using an array of such devices tuned to slightly different frequencies, a wide bandwidth response can be obtained [4]. Shashank presented a patent as "energy harvesting with plurality of piezoelectric elements". The invention pertain generally to a mechanism for capturing mechanical energy and converting it to electrical, and is particularly useful for continually charging or providing emergency power to mobile, battery powered devices that are handheld or carried by persons. The mechanism comprises a plurality of elongated piezoelectric elements for generating electric energy from mechanical energy [5].

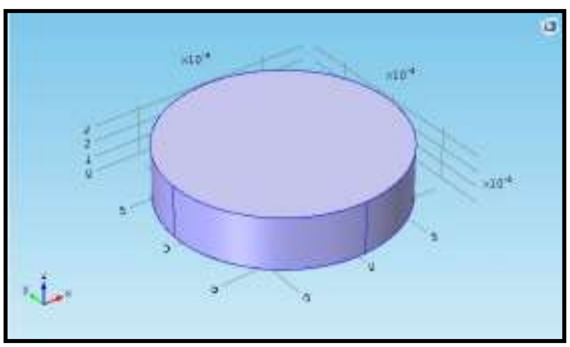

Figure .1 Model of PZT disc

RESULTS AND DISCUSSION

Figure 1 indicates the model of PZT-5H disc in simulation tool. The diameter of disc is considered as 32 mm based on the reference of IEEE standards on piezoelectricity.

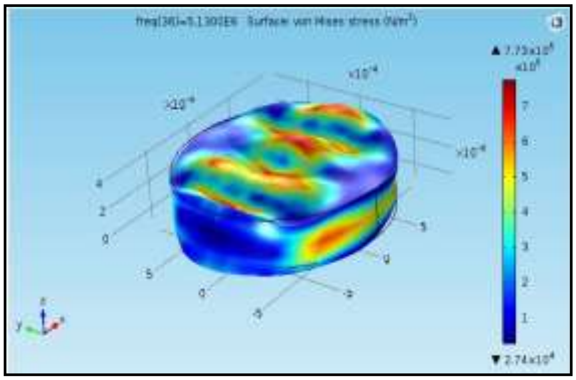

Figure .2 Stress graph at resonance

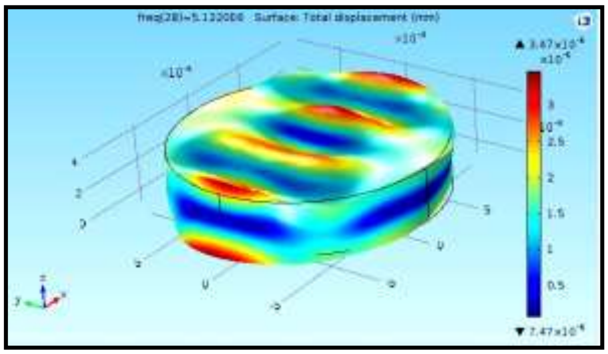

Figure .3 Voltage graph at resonance frequency

Figure 2 describes the maximum stress developed at the resonance frequency. At the resonance frequency of 5.13 MHz, the developed stress in the PZT-5H disc is 0.773Mpa . The developed displacement is 3.47 x 10-6 mm at the application of 10 V applying voltage(Figure 3).

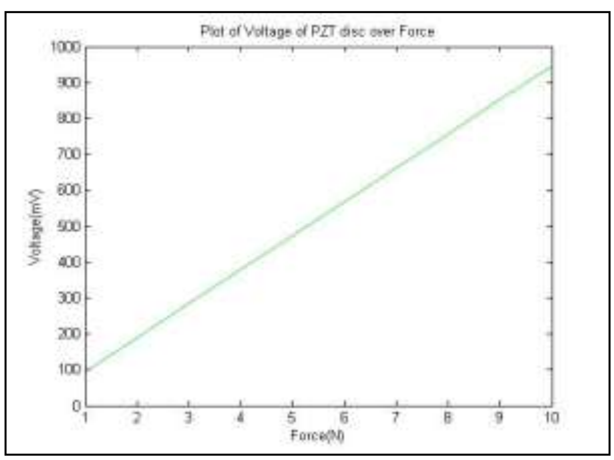

Figure 5.Voltage verses Static force

Figures 5 describes the output static voltages at different applied forces. Output static voltage of maximum 947 mV at the maximum force of 10 N is developed. For thickness mode The frequency constant , capacitance, resonance frequency, static voltage and static displacement of PZT-5H disc is recorded as 2079 m/s, 11.744n Farads, 1.0395 MHz, 94 mV and 3.47 x 10-6 mm .

CONCLUSION

In this paper presented the calculations of PZT-5H under thickness mode such as the frequency constant , capacitance, resonance frequency, static voltage and static displacement of PZT-5H disc . In the full paper radial mode calculations and its correlation with the thickness mode can be mentioned. The static displacement is very small for PZT-5H when the voltage is applied. It comes under inverse piezoelectric effect. If the applied voltage is 10 V for the disc of 32 mm diameter and 2 mm thickness the change in displacement is 3.47 x 10-6 mm .

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