Energy Harvesting from Tire by using piezo-electric Material

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Abstract— Energy harvesting which is also known as power harvesting or energy scavenging. This is the process by which energy is derived from external sources like Solar, thermal, wind energy and kinetic energy etc, captured, and stored for small, wireless autonomous devices, like those used in wearable electronics and wireless networks. Energy harvesting is process in which powering an embedded system by harvesting energy from the environment. In this case, the vibrational or strain energy generated in the automobile tires is gone wasted. This energy is can be converted to an electrical form using the oryof piezoelectricity and can be stored efficiently for its effective utilization. The mechanical stress or force applied to some solid material produces electric charge that accumulates in that material is Piezoelectricity. The word piezoelectricity means electricity obtained from pressure variation. The piezoelectric effect is attributed to the electromechanical interaction between the mechanical and the electrical state in crystalline materials. The piezoelectric effect can also be reversed.

Keywords: **Piezoelectric, Energy harvesting, tire pressure monitoring system, TPMS**

I. INTRODUCTION

Appearance of aelectric field in certain non- conducting crystals and as a result of the application of mechanical pressure. Due to Pressure the positive and negative charge in some crystals gets separated and polarization of crystals takes place and potential difference is developed and electric field is formed. The reverse effect also occurs an applied electric field produces mechanical deformation in the crystal. Using this effect, a high-frequency alternating electric current can be converted to an ultrasonic wave of the same frequency while a mechanical vibration can be converted into a corresponding electrical signal. Piezoelectricity can be used in microphones, phonograph pickups and telephone communications systems.
Energy harvesting from wasted or unused power has been atopic of discussion in recent times. Unused or wasted power exists in various forms such as industrial machines, human activity, vehicles, structures and environment sources. Among all of these, some of the promising sources for recovering energy areperiodic vibrations generated by rotating machinery orengines. Table1giveslist some of the energy sources available in the surrounding which can be used for generating electricity. Primarily, the selection of the energy harvester as compared to other alternatives such as battery dependson two main factors cost effectiveness and reliability. In recent years, several energy harvesting approaches have been proposed using solar, thermoelectric, electromagnetic, piezoelectric material.

II. REVIEW

The piezoelectric effect is a reversible process in that materials exhibiting the direct piezoelectric effect means the internal generation of electrical charge resulting from an applied mechanical forcewhich exhibit the reverse piezoelectric effect,the internal generation of a mechanical strain resulting from an applied electrical field. Viz., lead zirconatetitanate crystals will generate measurable piezoelectricity when their static structure is deformed by about 0.2% of the original dimension. Vice-versa, those same crystals will change about 0.2% of their static dimension when an external electric field is applied to the material. The inverse piezoelectric effect is used in ultrasonic sound waves generation.

Generation of electric potential due to change in temperature is called as pyro electric effect, which was studied by Carl Linnaeus and Franz Aepinus in the mid-18th century. Drawing on this knowledge, both René Just Haüy and Antoine César Becquerel posited a relationship between mechanical stress and electric charge but their proves were inconclusive.

Human Body	***Vehicles***	***Structures***	***Industrial***	***Environment***
Breathing,blood pressure, body heat	***Trains, UAV, helicopter, automobile***	***Bridges, roads***	***Motors, compressor, chillers***	***Wind,solar, temperature gradient***
Walking, arm motion, finger motion	***Tires, tracks, brakes, shock absorbers***	***Ducts, control switches, cleaners***	***Conveyers, vibrating machines***	***Ocean currents, acoustics waves,EM waves***

Table: Sources of Energy available in surrounding

The first demonstration of the direct piezoelectric effect was conducted in 1880 by the brothers Pierre Curie and Jacques Curie. They combined their knowledge about pyro electricity with their understanding of the underlying crystal structures which leads us to generation of branch of pyro electricity which predict crystal behavior, and also demonstrated the effect using crystals of tourmaline, quartz, topaz, cane sugar, and Rochelle salt. Rochelle salt sodium, potassium tartrate tetra hydrate. Highest piezoelectricity is exhibited by Quartz and Rochelle salt.

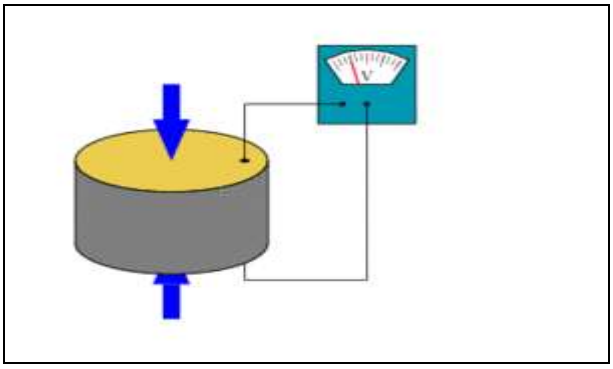

Figure 2.1:Pizoelectric Effect

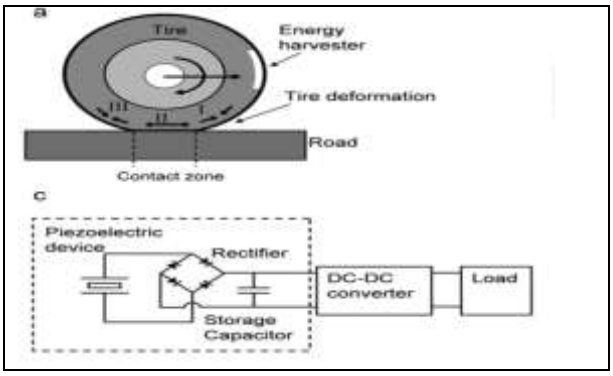

Fig 2.2: Basic Electric Circuit Used In the Setup.

III. MECHANISM

The nature of the piezoelectric effect shows resemblance is closely related to the occurrence of electric dipole moments in solids. The latter may either be induced for ions on crystal lattice sites with asymmetric charge surroundings asfound in $BaTiO_3$ and PZTs or may directly be carried by molecular groups as seen in cane sugar. The dipole density or polarization whose dimensionality is [Cm/m^3] may easily be calculated for crystals by adding up the dipole moments per volume of the crystallographic unit cell. As we know every dipole is a vector and the dipole density *P*is vector field. Dipoles near each other tend to be aligned in regions called as Weiss domains. The domains are generally randomly oriented, but they can be aligned using the process ofpoling**.** Not same as magnetic poling. Polling is a process by which a strong electric field is applied across the material. It is done usually at higher temperatures. All piezoelectric materials can notpoled.

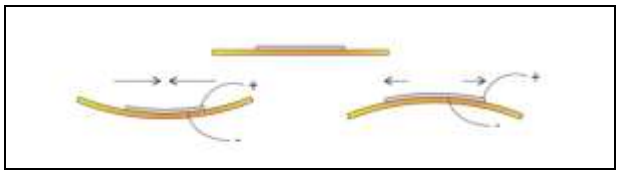

Figure 3: Working of piezoelectric material

Decisive importance for the piezoelectric effect is the change of polarization noted as *P* while applying a mechanical stress. This might either be caused by a re-configuration of the dipole-inducing surrounding or by re-orientation of molecular dipole moments under the influence of the external stress. Piezoelectricity may then manifest in a variation of the polarization strength, its direction or both, with the details depending on

1. The orientation of P within the crystal
2. Crystal symmetry and
3. The applied mechanical stress.

The change in *P* generates a variation of surface charge density upon the crystal faces, therefore as a variation of the electric field extending between the faces caused by a change in dipole density in the bulk.

For example,

A 1 cm^3 cube of quartz with 2 kNof correctly applied force can produce a voltage of 12500 V.

Piezoelectric materials also show the reverse effect known as converse piezoelectric effect in which the application of an electrical field creates mechanical deformation in the crystal.

Usual nomenclature used is as follows:

NOMENCLATURE
F : force, N
t : time, second
P : tire inner pressure, N/m2
r : tire radius, m
b : tire contact patch width, m
v : longitudinal speed, m/s
ε :strain
θ : rotational angle, radian
B : bias matrix of neural network model
W:weight matrix of neural network model

Significant problem in Definition

The significant problem with electric cars is that they need continuous recharging. Like, the Tesla Roadster gets the most miles per charge at 245 mpc, whereas on the other handmost of current electric cars get only about half of that amount. Our efforts are to increase the potential miles per charge by converting the unused kinetic energy into electric energy. our efforts are to increase overall efficiency of the machine. In non-electric cars also, regenerative braking systems (RBS) recovers only 15-20% of total energy. Conventionally, alternators have been used in cars to recover some of the energy lost by using their mechanical motion but none of these methods have been successful in actually recovering a high fraction of the lost energy. For regenerative shock absorbers, around 20-70% of energy is lost in suspension and one of the biggest challenges in automation industry is to increase the percentages of recovered energy or to increase overall efficiency. Another significant challenge for this project is to integrate all mechanisms of battery charging for an optimum performance.

Solution

Tire intelligence is crucial in the improvement of the safety and well being of vehicles because the tire connects the car body and the contact point between the vehicle and the road. To create an intelligent tire, sensors must be installed which measures the behavior and conditions of the tire. However, it is quite difficult to apply a wired sensor system on the wheel of the tire. Hence, it is necessary to install a self-powered, wireless system like a type of energy harvesting system which can beinstalled inside the tire. The purpose of this study and research is to convert the strain energy caused by deformation of the tire while rotation of wheel into useful electrical energy to supply the sensor system. A flexible piezofiber is utilized for the energy conversion. The variation in strain, due to changes in speed, load, and the internal pressure of the tire, was measured along two axial directions to evaluate the amount of available strain energy.

IV. WORKING OF SYSTEM

We used A.C. motor to drive all system. Motor drive lower wheel of automobile is fixed on C frame only rotary motion. Upper wheel is rotating on lower wheel by surface contact of both wheels to each other. Due to this rotation pressure is applied on piezoelectric sensor, due this pressure energy generated.
We also increased pressure by adjusting screw and shift upper wheel in vertical direction.

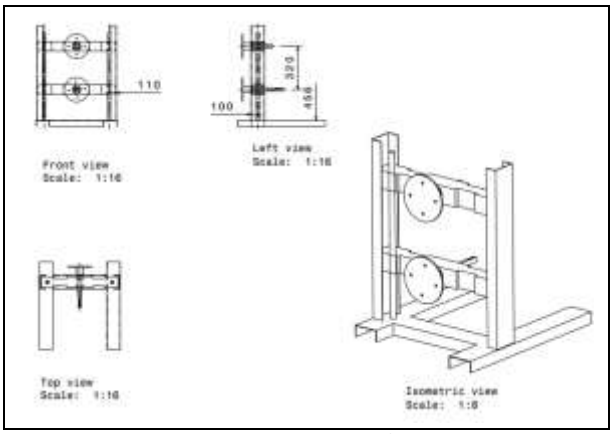

Figure 4: Working model of System

Analysis of Critical parts Moving base

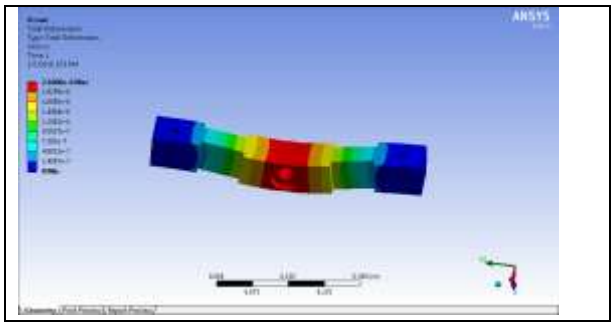

Figure 5: Total Deformation of moving base

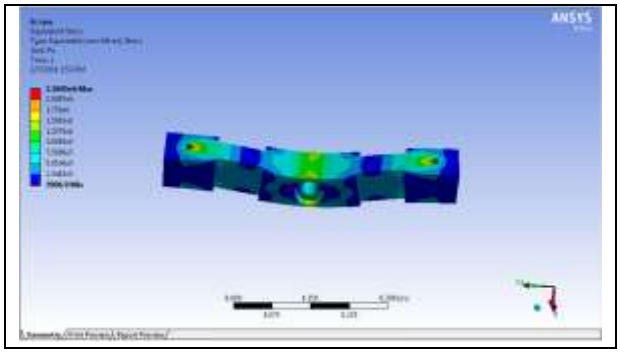

Figure 6: Equivalent stress in moving base

Wheel Support Shaft

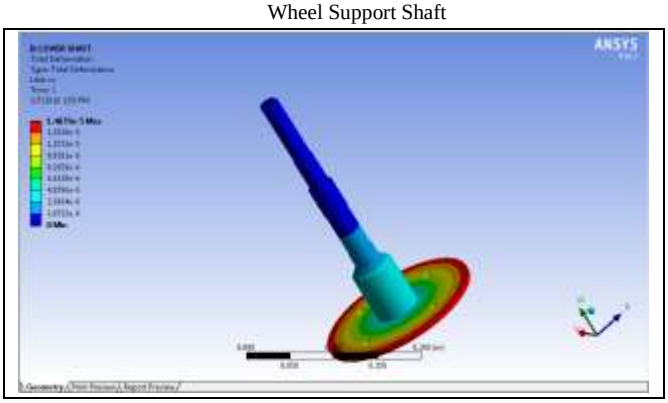

Figure 7: Total Deformation in Shaft

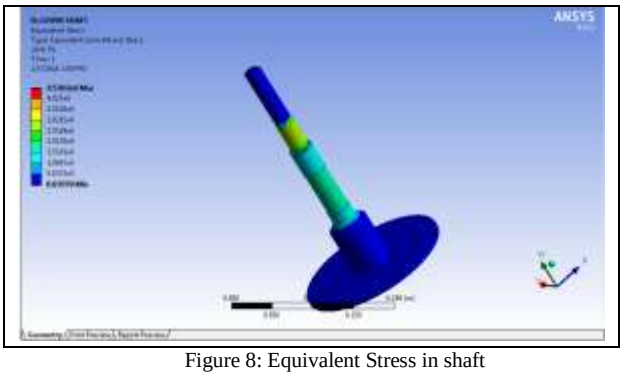

Figure 8: Equivalent Stress in shaft

V. RESULT TABLE

Sr. No.	*Part Name*	*Deformation mm*	*StressMpa*
1	*Base*	*0.002*	*22.6*
2	*Shaft*	*0.001*	*45.1*

VI. CONCLUSION

From above result we have concluded that our system for testing of piezoelectric effect and energy generation by automobile tire system is safe under the loading condition. Hence we going to manufacture it and take practical result.

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