

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 9, Issue 2, February 2020

Piezoelectric Energy Harvesting from Vehicle Wheel

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ABSTRACT: In our project piezoelectric energy power generation from vehicle tyres. The main reason of electricity for not becoming a practical fuel for automobiles is the fact that it is not practical as fossil fuel. Piezoelectric materials have gained the popularity in this energy harvesting solutions. The aim of this research work is to make power generation more sustainable, economical and ecological by utilizing the advancement in the technology. The piezoelectric materials is placed on the tyres. When the vehicle moves on the road there is pressure created in the piezoelectric material. A mechanical energy generated by the vehicle's wheel due to the tyre contact on the road and pressure is generated in the piezoelectric and converted into electric energy.

KEY WORDS: piezoelectric materials, electric energy, mechanical stress. Energy harvesting.

I. INTRODUCTION

As piezoelectric energy harvesting has been investigated only since the late 1990's. Electricity is the great alternative for fossil fuels, so in order to increase the practicality of electricity so that the popularity of electricity as fuel in automobile should increase. Piezo electricity was discovered in 1880 by French physicists Jacques and Pierre Curie. The piezoelectric effect is understood as the linear electromechanical interaction between the mechanical and electrical state in crystalline materials with no inversion symmetry. Piezoelectricity stands for the electricity generated from applied pressure. It is the ability of certain materials (notably crystals and certain ceramics) to generate an electrical potential in response to an applied mechanical stress. The phenomenon that produces an electric charge when a force is applied to a piezoelectric material is known as the piezoelectric effect. This phenomenon was discovered by the Curie brothers in 1880, they have discovered a relation between electricity and pressure in certain materials. After several experiments they discovered that some materials such as quartz, ceramic and potassium sodium tartrate, when subjected into mechanical stresses, the natural formation of charges breaks up therefore an electric voltage will be produced.

II. OBJECTIVES

The purpose of this paper is to provide a solid explanation for the generation of reliable amount of power by using the conversion of mechanical energy into electrical energy using piezoelectric materials. The aim is to find a suitable and efficient source of electrical energy by using our surrounding. I've used the mechanical energy produced from tyre in order to produce sufficient and reliable amount of energy. Piezoelectricity is a property for some materials which lies in generating electrical voltage when mechanical force is subjected into it.

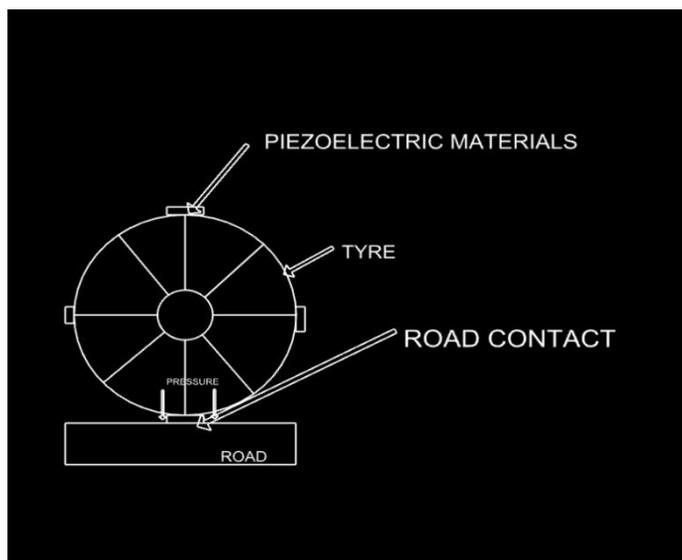
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III. WORKING PRINCIPLE



In our project we are using a piezo electric power generation system. We are using piezoelectric patches which has the piezoelectric materials in it. These piezo electric patches are fixed on the tyre. When moves on the road there is a pressure act in piezoelectric materials. Due to the mechanical force applied on the piezo electric material the piezo electric starts generating electricity. Then the electricity generated from the piezo electric material is stored in battery. The conversion of mechanical energy into electrical energy can be done by the use of piezoelectric materials. Some of the natural piezoelectric materials already in use is quartz. Some artificial piezoelectric materials like BaTiO₃, Lead Zirconium Titanate etc. Vehicle tires are subjected to normal and shear loads under static and dynamic conditions. The load can be used as a source of mechanical stress for the piezoelectric crystals.

IV. MATERIALS USED

| SL.NO | MATERIALS | QUANTITY |
|-------|------------------------|-------------|
| 1. | Piezoelectric material | As required |
| 2. | Block Bearings | 1 nos |
| 3. | Battery(12 v) | 1 nos |
| 4. | Cycle | 1 nos |
| 5. | Connecting wires | As required |

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V. CALCULATION

For calculations of the output voltage certain data indicated in Table is required. The mechanical stress source is basically from the load on the tire which is predominantly the vertical load

| Parameters | Values |
|---|-------------------------------|
| Weight of the vehicle(2 passenger,2 wheels) | 150kg |
| Weight distribution | 30:30 |
| Wheel Radius | 305mm |
| Wheel width | 50mm |
| Tire air pressure | 25psi |
| Dimension of PZT-5A module | Diameter-28mm; Thickness- 2mm |
| Electromechanical Coupling coefficient | 0.69 |

Since, the vehicle is weighing 150kg and 30:30 weight distributed, the load on each tire is calculated out to be 150 kg(150x9.81=1471.5N). The modules are to be arranged such that 2mm gap is maintained between two successive modules. Therefore,

Number of modules mounted on each wheel=

Circumferenceofthewheel/Diameterofeachmodule+gapbetweentwomodules

$$= \pi \times 305 / (28\text{mm} + 2\text{mm}) = 31.93 = 32 \text{ (approx.)}$$

Therefore, the total number of modules on each wheel is 32.

The contact patch area

= ***Loadonthewheel/Airpressureinthetire***

$$= 150 \times 9.81 / 0.1724 \text{ N/mm}^2 = 8535.38 \text{ mm}^2.$$

Assuming that the load is distributed uniformly in the contact patch area, the mechanical stress induced in each module will be:

= ***ForceonemoduleAreaofapplicationoftheload***

$$= 150 \times 9.81 \times 4 / 3 \times \pi \times 0.028^2$$

$$= 785327.69 \text{ N/m}^2$$

Open Circuit Voltage (OCV) = $\sigma \times t$

where,

σ = induced mechanical stress in the module

t = thickness of the module

Therefore, O.C.V = 785327.69×0.002

$$= 8 \text{ volt}$$

VI. ADVANTAGES

- piezoelectric material cost is low
- Sustainable and reliable energy source
- This system is able to provide uninterrupted power even when the power has cut off from main grid.
- It is quite suitable for low power consuming application.
- It does not compromise in environmental safety and stability.
- It is green technology.
- It is continuous power generation technology.
- By using this technique there will be significant reduction in cost of energy harvester.

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VII. APPLICATIONS

- piezoelectric elements are also used in the detection and generation of sonar waves
- piezoelectric materials are used single axis and dual axis tilt sensing
- it can be used in auto motive engine management system
- piezo electric transducer is also used in fuel injection system
- it used in tyres and suspensions to generate electric power

VIII. CONCLUSION

Piezoelectric materials have the ability to transform mechanical strain energy into electrical charge. The amount of energy generated depends on the speed of the vehicle and the number of piezoelectric elements on the tires. In this paper a theoretical model for energy harvesting system using piezoelectric materials have been presented. With the increase of popularity of non-conventional energy sources among the researchers all over the world, the possibilities of energy harvesting by the use of piezoelectric materials paves its way towards major green technology designs. The Piezo Electric Power Generation from Tyres is working with satisfactory conditions

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