Design and simulation of piezotyres Using Comsol multiphysics 4.3b software

T.Madhuranath*, R.praharsha and Dr.K.Srinivasa Rao
Department of Electronics an instrumentation Engineering
Lakireddy Bali Reddy College of Engineering, Mylavaram-521230, A.P, India
*The Corresponding author address:madhuranath.tumuluri@hotmail.com

Abstract: This paper proposes a new design of a vibration-based piezoelectric generator, utilizing mechanical energy within a rolling tyre. A thin piezoelectric ring is placed in the inner layers of the rubber tyre, so the stress is varying on the piezoelectric ring at the road and tyre interface. As a result we can get electric current. It can be used for charging batteries in vehicles.
In this paper, we have reported the design and simulation of Piezotyres by COMSOL Multiphysics.

Keywords: Tensile stress, Tyres, Vibrations, Compressive stress, Mechanical energy, Power generation, Power supplies, piezoelectric devices, Sensors.

1. Introduction

As electricity is playing a vital role in present day world we have to utilize every chance in generating electricity apart from major power generation techniques like Thermal, hydel, nuclear, solar, wind, fuel cell, tidal. Here every chance guides to new energy generating technique.
In small scale energy can be collected from devices or components that convert the given physical input to electrical output for example piezo electric devices i.e. they convert the mechanical force (stress, strain, pressure, magnetic strength) to electric voltage. Piezotyres are the tyres lined with piezoelectric materials that utilizes the mechanical stress (between tyre and road) during motion and provides electrical output which in turn used for battery charging or live utilization.

1.1 Piezoelectric effect:

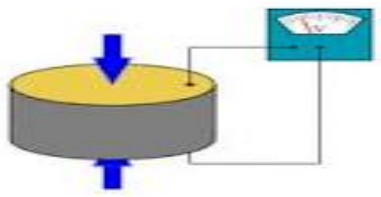

Figure:-Piezoelectric effect.

A. The production of electricity or electric polarity by applying a mechanical stress to certain crystals.
B. The converse effect in which stress is produced in a crystal as a result of an applied potential difference piezoelectrically.The generation of an electric charge in certain non-conducting materials, such as quartz crystals and ceramics, when they are subjected to mechanical stress (such as pressure or vibration), or the generation of vibrations in such materials when they are subjected to an electric field. Piezoelectric materials exposed to a fairly constant electric field tend to vibrate at a precise frequency with very little variation, making them useful as time-keeping devices in electronic clocks, as used in wristwatches and computers.

2. Working:-

At the point of road and tyre interface stress is exerted on the piezoelectric material inside the tyre.

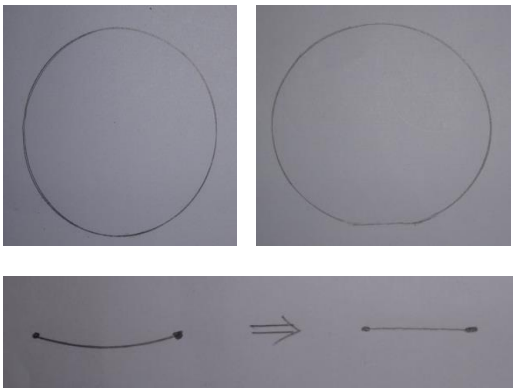

Figure: Showing the deformation of piezo layer at the interface of road and tyre.

As piezo layer undergoes deformation there is an output voltage, so when the tyre is moving electric potential is produced continuously.

3. Designing:-

Our project piezotyres is designed using Comsol multiphysics 4.3b. For this structural mechanics> solid mechanics and piezo electric devices are selected and the designing is as follows.

A steel rim with geometry (1*0.7) m is builted.

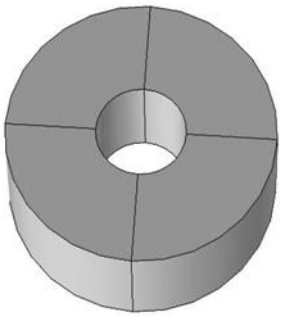

Figure: Steel Rim

For the steel rim rubber tyre is attached around it.

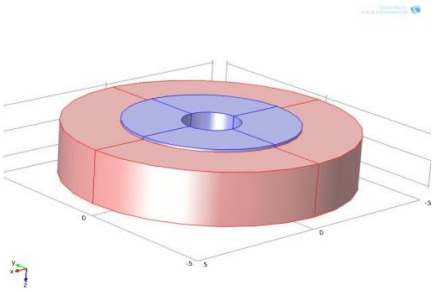

Figure: General rubber tyre

Insertion of piezo material:

A thin layer of piezoelectric material with thickness 0.05m is attached around the tyre as shown in figure.

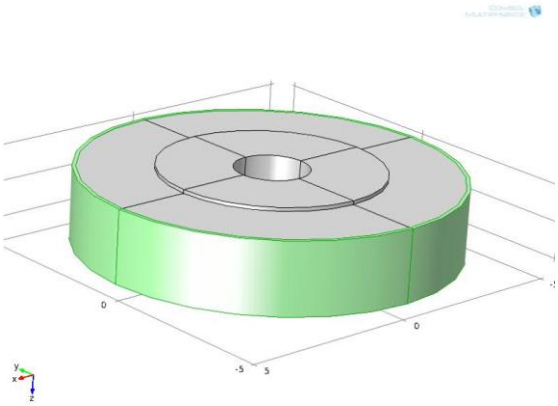

Figure: Tyre with piezo layer

Now again attach rubber layer around piezoelectric material .Thus piezo tyre is completed.

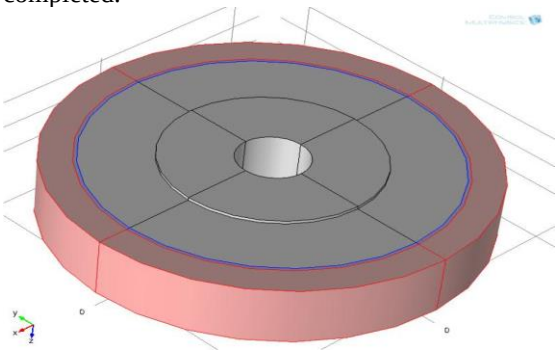

Figure: piezo tyre

The transparent view of the tyre is as follows.

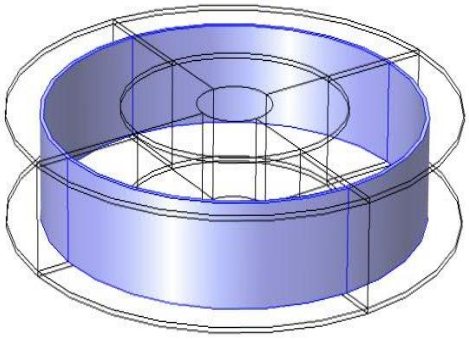

Figure: Transparent view

4. Meshing:-

Discretizing of the model into small and simple pieces is called the meshing. For discretization purpose we are using the different shapes and sizes. In this module we are using the FREETETRAHEDRAL, and then distributed to the total module through distribution technique. For applying the meshing we follow the following steps.

Free triangle:-

In the Model Builder window, right-click Model 1>Mesh 1 and choose More Operations>Free Tetrahedral.

Distribution:-

Click the Build Selected button. Total meshed structure is as shown in the following figure.

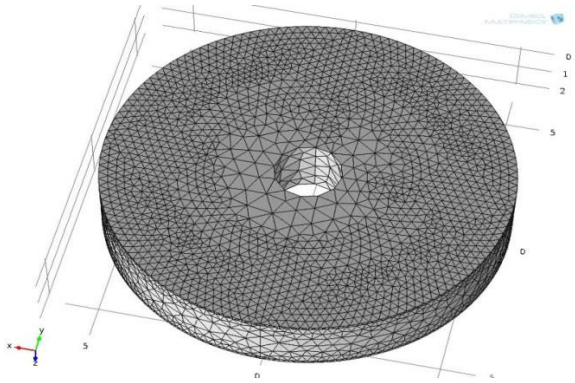

Figure:- Mesh

5. Results

For view the output of the device we are using the 3D plot groups.

Deformation:

When default stress is applied on the tyre, the piezo layer of tyre undergoes a maximum deformation of 45x10^-21 as shown in figure below. (The bulging part shows deformation)

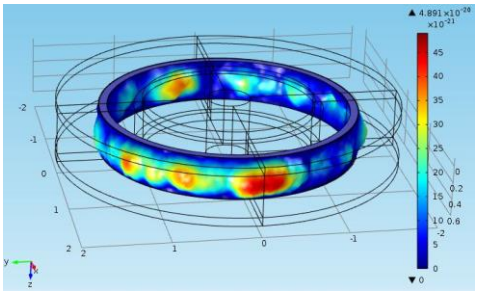

Figure:-3D plot group1

Output:

The obtained deformation derives an output of 8v. In the figure 3D- plot group2 the thin slices shows the voltage distribution at the stressed part of tyre.

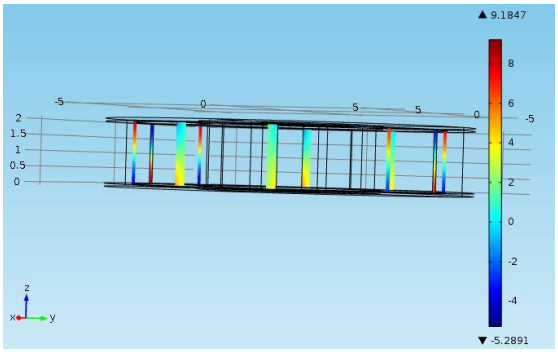

Figure: -3D plot group2

5. Simulation:-

After simulation we got better results by reducing the radius of tyre as follows.

Deformation after simulation:

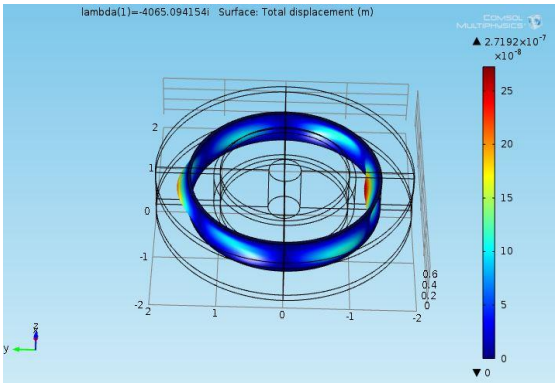

Figure: 3D plot group3

3D plot group3 shows that after simulation there is a deformation of 25x10^-8.

Output after simulation:

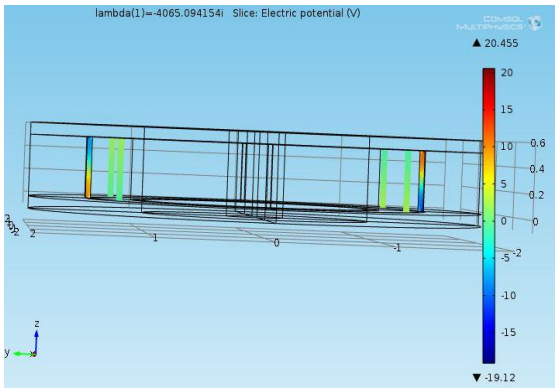

Figure: 3D plot group4

The 3D plot group4 shows output after simulation i.e. 20v.

6. Results and Discussions: -

The design of piezotyres was made by using COMSOL Multiphysics software version 4.3b. In which by using, electric potential produced in these tyres is used to charge the batteries in auto mobiles. By reducing the radius of the tyre and thickness of piezo layer best results are obtained.

7. Conclusions

As electricity is very scarce today we should not waste even a small source of power. This piezotyres provide the space for utilizing the mechanical stress to electrical voltage in automobiles (in motion).

8. Acknowledgements

I have done this job in MEMS lab of
LAKIREDDY BALI REDDY COLLEGE OF ENGINEERING
Under the guidance of
Dr. K.srinivasa rao
I was privileged to experience a sustained enthusiastic and involved interest from his side.