Acta Mechatronica - International Scientific Journal about Mechatronics
Volume: 7 2022 Issue: 4 Pages: 25-29 ISSN 2453-7306



*doi:10.22306/am.v7i4.87*

*Received: 23 Nov. 2022*
*Revised: 03 Dec. 2022*
*Accepted: 19 Dec. 2022*

# Testing LAD1 of harvesting electric roads

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***Keywords:*** piezoelectric effect, energy harvesting, testing PZT.
***Abstract:*** Alternative power sources for roadway accessories have been brought to light through energy harvesting technologies. Several types of nanogenerators can harvest energy from rotating automobile tires by using the piezoelectric effect to generate electricity from these roads. As the wheel is pressed against the piezoceramic disks, energy is harvested by embedding them within a protective package. In this paper, we demonstrate the testing of several types of electric vehicles and how they are tested for electric performance and determine the output voltage and current.

## 1 Introduction

A growing interest among researchers has been generated by energy harvesting technology. Various types of energy harvesters can convert ambient energy to electricity, including thermoelectric, electromagnetic, photovoltaic, and piezoelectric [1-5]. The most productive method is piezoelectric energy harvesting, especially on roads under wheel cars. It is coming in second after photovoltaic [6-9]. We have before sits of designing piezoelectric as follows:

- Type, Design characteristics,
- LAD1 (Figure 1), It contains up to six piezoceramic disks.

*Figure 1 LAD1 (layout of the assembly design) of HER*

## 2 Testing LAD1 designing of piezoelectric

Before starting to explain the testing, we need to test the disk piezoelectric which is protected by Teflon.

*Figure 2 The types of disks piezoelectric*

<u>1- tests the stack of piezoceramic-disk:</u>

We prepared three specimens as single-layer stacks, double-layer stacks, and four-layer stacks, and these specimens were made by Zibo Yuhai Electronic Ceramic Co., Ltd. figure 2. Show the three types of discs of piezoelectric PZT-51.

An illustration of the setup of the testing frame can be found below. To determine the force applied to the paradigm, a load resistance is attached to it and a force meter is placed above it there.

The paradigm is set upon an electric shaker supported by a steel stabilizer. Lab Master software connects one computer to the meters and collects testing data. Different loading resistances are applied to each specimen to obtain voltage output data. Based on the output voltage, the following formula can be used to calculate the power/force ratio, and also depending on 1.21V of voltage can give approximately 91 N of stress. so, we write (1):

$$\frac{P}{F} = \frac{\int V^2}{R \cdot \int F} \tag{1}$$

P/F: it is the Power/force ratio.
V: it is the output voltage.
R: it is loading resistance.

A piezoceramic disk with a parallel connection generates a different loading resistance when at maximum power output. The single-piece generator should have the highest R of the double generators, while the four-piece generator should have the lowest R. Also, in general, generators should have the lowest power-to-force ratio possible, while four pieces of piezoelectric generators should have the highest.

As shown in figure 3, the plots of (P/F) versus Loading Resistance are shown.

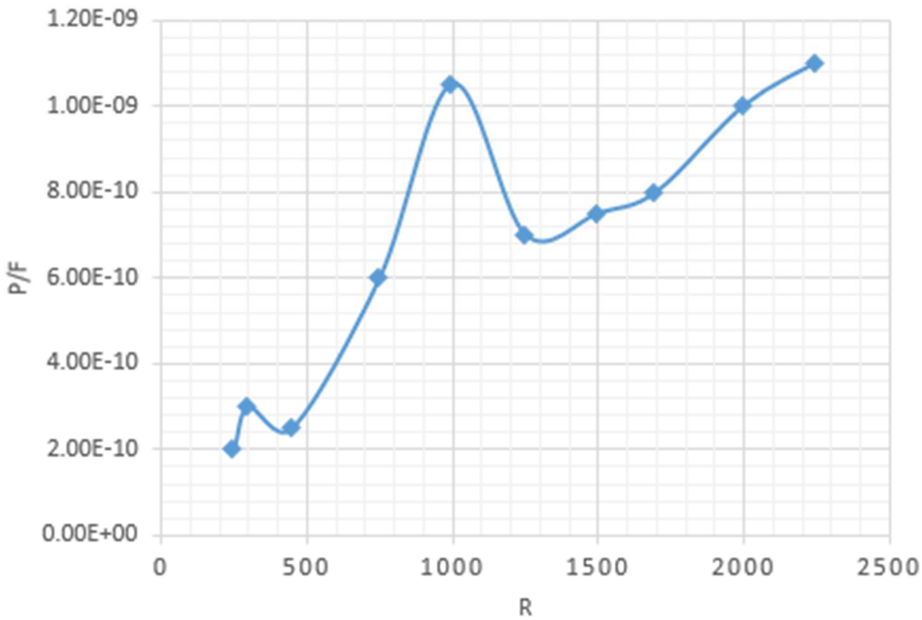


*Figure 3 the graph of the single-layer generator between P/f & R*

We found here that when R equals about 2250 kΩ the p/f will be more than about 1.14 $x10^{-9}$watts/N, now we need to check with a double layer as figure 4.

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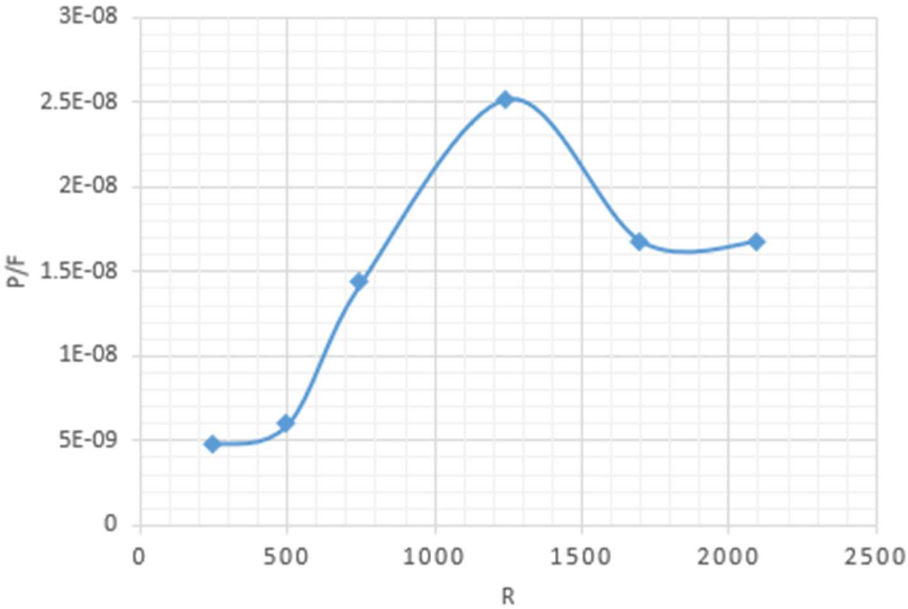



*Figure 4 the graph of the double-layer generator between P/f & R*

Our results here show that for R around 1360 kΩ the p/f will be more and equal to about $2.51x10^{-8}$ watts/N. According to figure 5. Referring to R as 1120 kΩ the power/force is equal to about $1.01x10^{-7}$ watts/N.

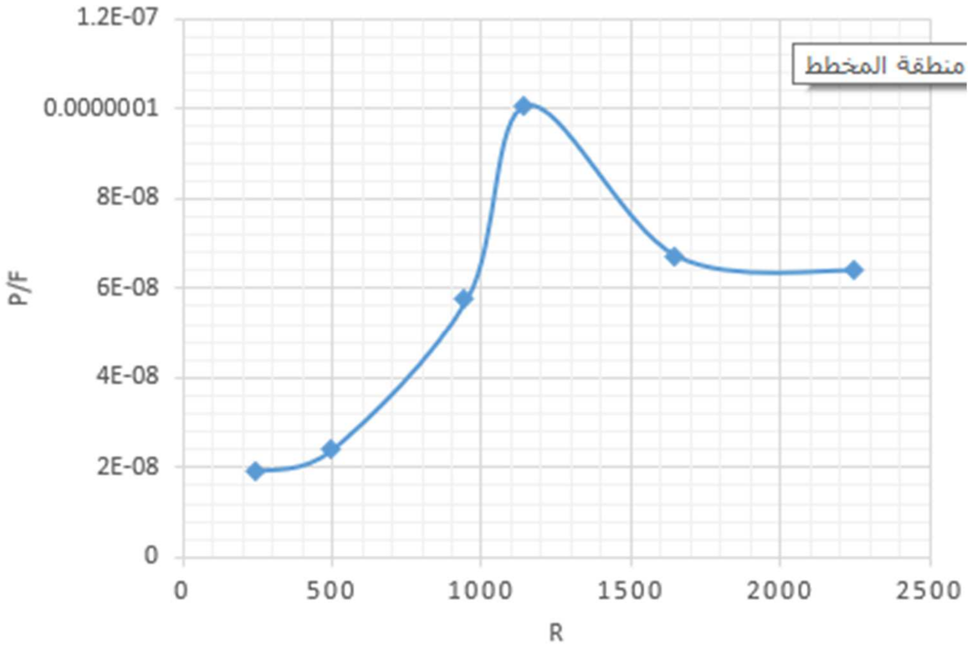



*Figure 5 the graph of the four-layer generator between P/f & R*

Double and four layers from all schemes for every single layer show that the four-piece generators will provide the best performance.

<u>2- tests of LAD1 harvester:</u>
It is tested by a model mobile loading simulator from the company PAVETESTING; it consists of a small wheel rotating on the top of the piezoelectric layer as shown in figure 6. A wheel's speed can range from (0 – 15) km/h and for frequency between (0 to 48Hz). Under real traffic conditions, this simulates very closely the loading conditions on real pavements.

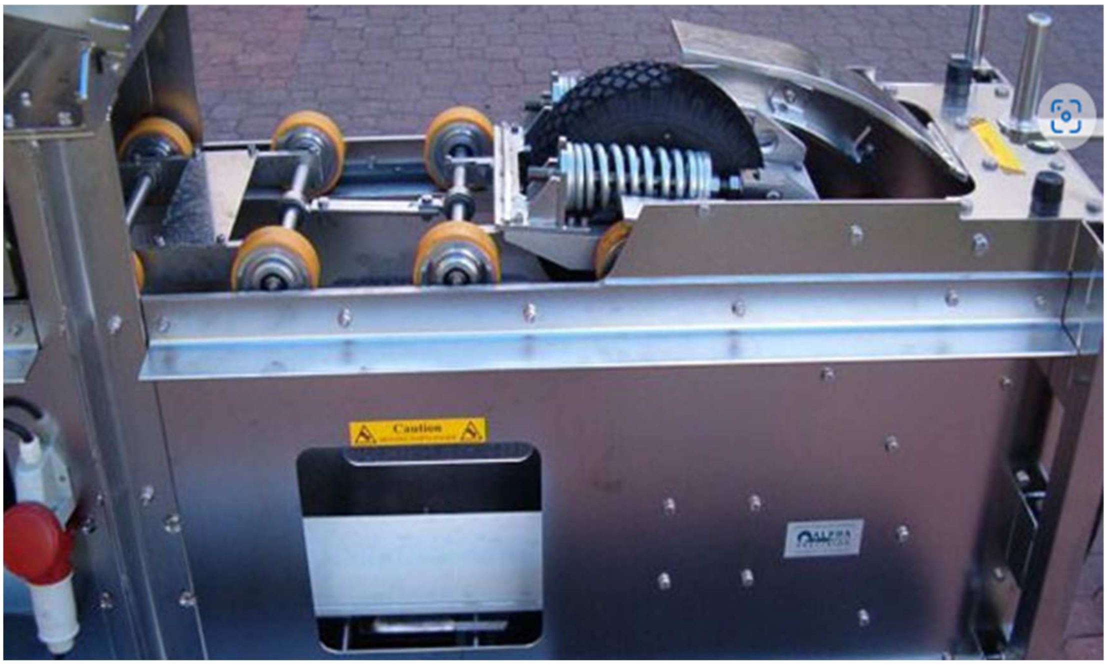
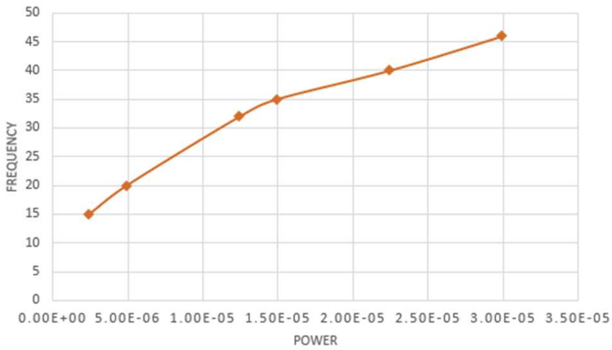


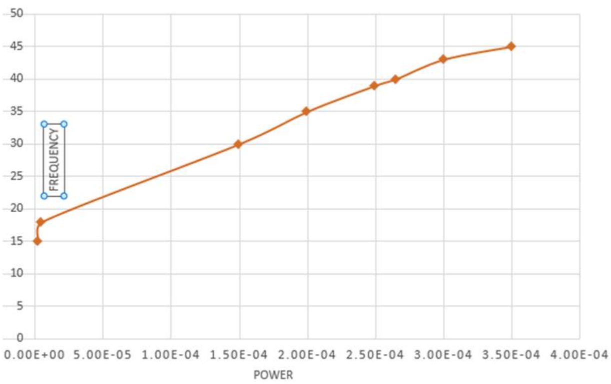

*Figure 6 Model Mobile Loading Simulator*

The LAD1 harvester was tested at different wheel speeds and with different resistors (335 kΩ, 565 kΩ). With an increase in electrical resistance and a speed increase in testing, power output is increased. In the region where equivalent resistance of the harvester and load equals, maximum power output should occur.

For 335 kΩ we found:




For 565 kΩ we found:




## 3 Conclusions

We demonstrate in our previous demo how to test for electric performance and voltage output. We have fabricated and tested many piezoelectric energy harvesters according to the proposed design, and all previous calculations indicate that the power will be greater with higher voltage.

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**Review process**

Single-blind peer review process.