Fabrication Of Energy Harvesting Using Piezo-Electric Materials In Vehicle Suspension System

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***Abstract*: Energy harvesting (EH) is the most upcoming technology which is defined as a process where the environmental energy sources such as load, mechanical vibrations, temperature changes, light energy, wind energy etc. are captured and transformed to acquire quite small levels of power with in the of range of Nano Watts – Milliwatts. This method is used to power an installed system by accumulating energy from ambient sources such as solar, wind, thermal and radio frequency waves and It is also called Energy Scavenging. The purpose of energy harvesting is to power electronic devices where there are no conventional power sources. The energy harvesting device has design goals and the three main elements are energy Source, Energy harvesting IC, Energy storage. In particular the energy harvesting used in charging of rechargeable batteries on site, low power electronic devices like traditional and super capacitors. Common energy harvesting systems include a lot of applications in many remote locations, distant locations, undersea where batteries and conventional power are not in used practically .In this project primarily we analyse the vibrations occurs in two wheelers & four wheelers vehicle suspension system later these vibrations are converted into voltage by piezo electric materials attached to the vehicles in a form of layer the primary objective of our project is that voltage is harvested by a micro energy harvester and stored by suitable circuitry. Also, this paper presents a systematic design of proposed circuit that allows us to harvest energy under both ideal and realistic constraints**

***Keywords*: Vehicle suspension system, Piezo-electric materials, battery.**

I.INTRODUCTION

1.1 *IntroductioN*:

Energy harvesting is approaching an interesting technological juncture wherein the power requirements for electronic devices have been reduced while at the same time the efficiency of energy harvesting devices has increased. Out of various possible energy harvesting technologies, piezoelectric vibration energy harvesting has emerged as a method of choice for powering meso-to-micro scale devices.1,2,3,4 Piezoelectric materials and transducers can be designed to handle a wide range of input frequencies and forces allowing for energy harvesting to occur.

Piezoelectric energy harvesting is a very convenient mechanism for capturing ambient mechanical energy and converting it into electric power

1.2 *Working principle of piezoelectric materials:*

In piezoelectricity the term" piezo" stands for pressure or stress. Thus piezoelectricity is defined as "Electricity generated by application of mechanical stress or tension" and the materials that exhibit this property comes under the category of piezo-electric materials

A piezoelectric crystal is placed between two metal plates. At this point the material is in perfect balance and does not conduct an electric current.

Mechanical pressure is then applied to the material by the metal plates, which forces the electric charges within the crystal out of balance.

Piezoelectric effect is extensively used to convert the electric energy into mechanical energy and vice-versa i.e. the piezoelectric substances are used as electromechanical transducers as shown in figure.1.

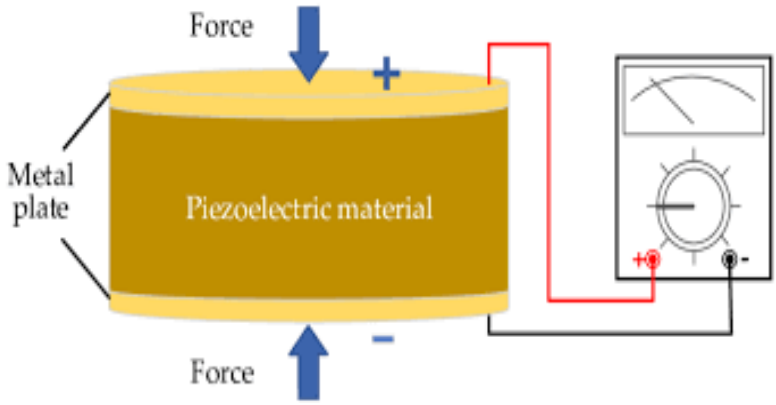

Fig.1: Working Of piezo electric material

II.LITERATURE REVIEW

Pranjal Ghormare et.al [1] : discuss Conventional energy resources are depleting at a rapid rate and there exists a possibility that the future generations will suffer from the lack of these resources. In a similar vein, this study makes an effort to harness the energy from vehicle vibrations, which is currently being wasted. When the vehicles move on the road, a lot of vibration occurs ,if this energy can be scavenged and stored, then it could be used in any practical application .**Saleh Alhumaid** et.al [2]:discuss Recent research has examined the possibility of recovering energy from mechanical vibration induced by a vehicle shock absorber using piezoelectric and electromagnetic transducers. In terms of automotive applications, piezoelectric vibration energy harvesting shows promise for recapturing some (even if small) amounts of vehicle vibration energy, which would otherwise be wasted through the vehicle dampers. Functional materials, such as piezoelectric materials, are capable of converting mechanical energy into useful electrical energy and vice versa. **Corina Covaci** et.al [3] **:** says The goal of this paper is to review current methods of energy harvesting, while focusing on piezoelectric energy harvesting. The piezoelectric energy harvesting technique is based on the materials' property of generating an electric field when a mechanical force is applied. This phenomenon is known as the direct piezoelectric effect. Piezoelectric transducers can be of different shapes and materials, making them suitable for a multitude of applications.**E. L .Pradeesh** et.al [4**] :** says In this digital race, electronic equipment has been integrated into human beings as a part of their body. Some electronic equipment is connected by wires, while some are self- powered by batteries. Today the ultra low power smart electronic gadgets and smart wireless sensor devices need an unlimited battery for enhancing the performance. In a remote area such as forests and hill areas, conventional charging methods of batteries by wire is not possible. **Dr.G. Ramakrishna Prabu** et.al [5] : discuss In the method proposed technique, the energy crisis caused by renewable resources as energy sources. As the population grows and the daily energy resources increase, we need a solution to solve this problem. Renewable unconventional energy source using piezoelectric technology. High-speed breakers are one of the most popular tools to slow down oncoming vehicles. In this way, we will describe how energy renewable energy can be collected as a source in vehicle through a high-speed breaker made of piezoelectric material. The use of speed breakers in generating energy lies in the concept of piezoelectricity, which is lost every day. **Ayan Bhattacharya** et.al [6] : discuss Humans have always being depended upon the fossil fuels as the source of energy for their daily needs. With the exponential growth in population, the dependence on these conventional sources for the daily energy requirements has led to the depletion of the same and adverse ill- effects on the environment. To lessen the burden and if possible minimize to zero, energy harvesting has become the need of the hour and the development of the different energy harvesting technologies has been the prime area of research. Piezoelectric materials have gained the popularity in this niche of energy harvesting solutions.**Zhen Zhao,** et.al [7] : discuss In this paper, a new type of piezoelectric harvester for vehicle suspension systems is designed and presented that addresses the current problems of low energy density, vibration energy dissipation, and reduced energy harvesting efficiency in current technologies. A new dual-mass, two degrees of freedom (2-DOF), suspension dynamic model for the harvester was developed for the inertial mass and the force of the energy conversion component by combining with the piezoelectric power generation model, the rotor dynamics model, and the traditional 2DOF suspension model. **Sanjana Mann** et.al [8] : discuss This paper is designed to lay emphasis on a regenerative form of power generation. A conventional leaf spring is taken and its plates are replaced with piezoelectric plates in order to convert vibrational energy obtained from unevenness and bumps on the road into electrical energy to feed the battery. The plates are replaced alternatively to ensure that the overall structural integrity of the model is not affected negatively. The model is created in Solid Works and static evaluation is carried out in ANSYS. **Khaled Mohamed** et.al [9] : discuss The piezoelectric energy harvester efficiency depends on optimizing the cantilever geometry and tuning its natural frequency with vibration source frequency. Moreover, the effect of harvester parameters on natural frequency is vital in tuning the resonance frequency. So, a COMSOL Multi-physics finite element analysis, Eigen frequency study and analytical analysis using MATLAB were constructed to calculate the resonance frequencies and to analyze the harvester parameters effect. **Chirangivee .K.R** et.al [10] : discuss The purpose of the shock absorber in a vehicle's suspension system is to reduce the vehicle's vibration by dissipating the vibrational energy. About 10 years ago, researchers began looking into recovering the vibrational energy using various magnetic devices The results of the project are encouraging and suggest that significant amount of the vertical motion energy can be recovered and stored .**Nilimamayee Samal**, et. al, [11] **:** discuss For managing the soaring power demand, various types of Energy Harvesting Systems (EHS) have been developed. The Piezoelectric energy harvesting system works on the phenomena of direct piezoelectric effect; i.e. the transducer generates electric energy when it is exposed to mechanical stress/pressure/vibration. The goal of this paper is to review the PEH (Piezoelectric Energy Harvesting) systems developed in last decade to harness energy required for small electronics. The energy harvesting from UN-utilized natural renewable sources using piezoelectric transducers is one of them. **Melodi Sila Bozkaya** et.al, [12] **:** says In this project low current and voltage producing piezoelectric crystals were connected in a parallel circuit which contained a capacitor. In In this paper discuss about the producing electricity in the in sound waves with help of piezoelectric crystals. Due tot eh existence of the capacitor the values for the current and the voltage have increased. The primary goal of producing usable energy from ambient noise has been achieved and enough energy to charge a phone that works with 1 ampere and 5 volt has been produced. effect of a piezoelectric actuator was modelled and characterized .**Chunhua Sun** et.al, [13] : says "On Piezoelectric Energy Harvesting from Human Motion" .The technology is then summarized and the direction of future development and efforts is further pointed out. Based on the different human motions, the existing technology of piezoelectric energy harvester (PEH) is firstly classified, including PEHs through heel-strike, knee-joint, arm motion, center of mass With the rapid development of low-power communication technology and microelectronics technology, wearable and portable embedded health monitoring devices, micro- sensors, and human body network positioning devices have begun to appear. For seeking reliable energy sources.**Shreyanil Kar** et.al [14**]** : says The energy generated here is very less and hence, may be used in the modern environment like baffle gates. Here, to obtain energy from this process and use it with batteries for vehicles, it is crucial to cover as much of a tire's inner surface area as possible with PZT benders. This brings us to piezoelectric materials, which have the property to generate electricity once mechanical stress has been applied on them. Benders made of PZT (lead zirconate titanate) attached to a tire have also been used but only to supply energy to pressure sensors in a tire that function

sporadically. Tao Li et.al [15] : proposedThis paper is an insight on the current research and development statusof piezoelectric materials community. After decades of research and development, piezoelectric materials have been applied in a wide range of applications, rangingfrom household appliances to industrial equipment's **Kavya Ameta** et.al [16] : says they Producing a decisive amount of electricity from a bicycle or converting the energy into electricity while travelling protracted distances, has always been a myth. In this context, we are putting forward a novel ideaof generating electricity using a hybrid bicycle. Also, this paper presents a systematic design of proposed circuit that allows us to harness energy under both ideal and realistic constraints.;**Abdul Aabid** et.al[17] : says Then a summary of previous studies based on PEH's other applications is listed, considering the technical aspects and methodologies. The piezoelectric materials have shown key characteristics for engineering applications, such as in sensors and actuators for industrial use. As a result, this review can provide a guideline for the scholars who want to use PEH's for their research. In addition, the fundamental idea about piezoelectric materials, along with their modeling for various applications, are detailed systematically. In this review article, a detailed study focused on the piezoelectric energy harvesters (PEH's)is reported. **Nabeel Ahmad** et.al, [18] **:** discuss It can also be utilized for uninterruptedly powering up a soldier's wearable electronics gadgets in military operations. Our design feasibility will be proved by the positive results obtained from the experimental prototype. This paper demonstrates the method of harvesting energy from human walk. Harvesting mechanical energy from human movement is an appropriate approach for acquiring environment-friendly electrical energy. It can also be used to track any soldier's location in remote areas. **Hao Wanga** et.al [19] **:** says In this paper discuss about the piezoelectric material in applied in the roads and bridges to produce the electricity while applied moving the vehicles. Energy harvesting technologies provide promising ways to generate clean and regenerative energy for different applications. The new technologies that have emerged within this field rely on two sources of energy; namely thermal energy (from sun or earth) and mechanical energy (from vehicle loading or wind)..**X.D. Xie et.al [20] :** discuss "Energy harvesting from a vehicle suspension system". This paper represents For energy harvesting from ambient vibrations of a vehicle suspension system subjected to the roughness of road surfaces, a dual-mass piezoelectric bar harvester is designed. The harvester is composed of two masses: a sprung mass (the body mass) and an un-spring mass (the wheel mass), which are joined by a piezoelectric bar transducer, which can be equivalently represented mathematically as a suspension spring and a damper.

III.METHODOLOGY

Vehicle suspension system : A suspension system is a set of mechanical connections, springs, and dampers that connect the wheels to the chassis. It has traditionally performed two functions: managing the vehicle's handling and braking for safety, and keeping passengers comfortable from bumps, vibrations, and other factors. It is a mechanical system of springs or shock absorbers connecting the wheels and axles to the chassis of a wheeled vehicle.

Using multimeter: Vibration analysis is a process that monitors vibration levels and investigates the patterns in vibration signals. It is commonly conducted both on the time waveforms of the vibration signal directly, as well as on the frequency spectrum, which is obtained by applying Fourier Transform on the time waveform.

Conversion of vibrations: Conversion of vibration in electricity with help of piezo electric material. Based on vibration of is increase the voltage will also increase.

Harvesting the voltage: Harvesting the voltage it means to store the voltage in the Battery .With the help of lithium battery in 3.7V. Based on the output of voltage of the piezo electric material.

Boost up Voltage: Boost up the voltage with the help of boost converter. Its help to improve the voltage in more than 3times. Electric devices:Stored the power used in light devices. Example: Charge the mobile.

Circuit diagram: These circuit diagrams show the connections of piezoelectric material to battery in different parts of the circuit diagram Fig.3.1.

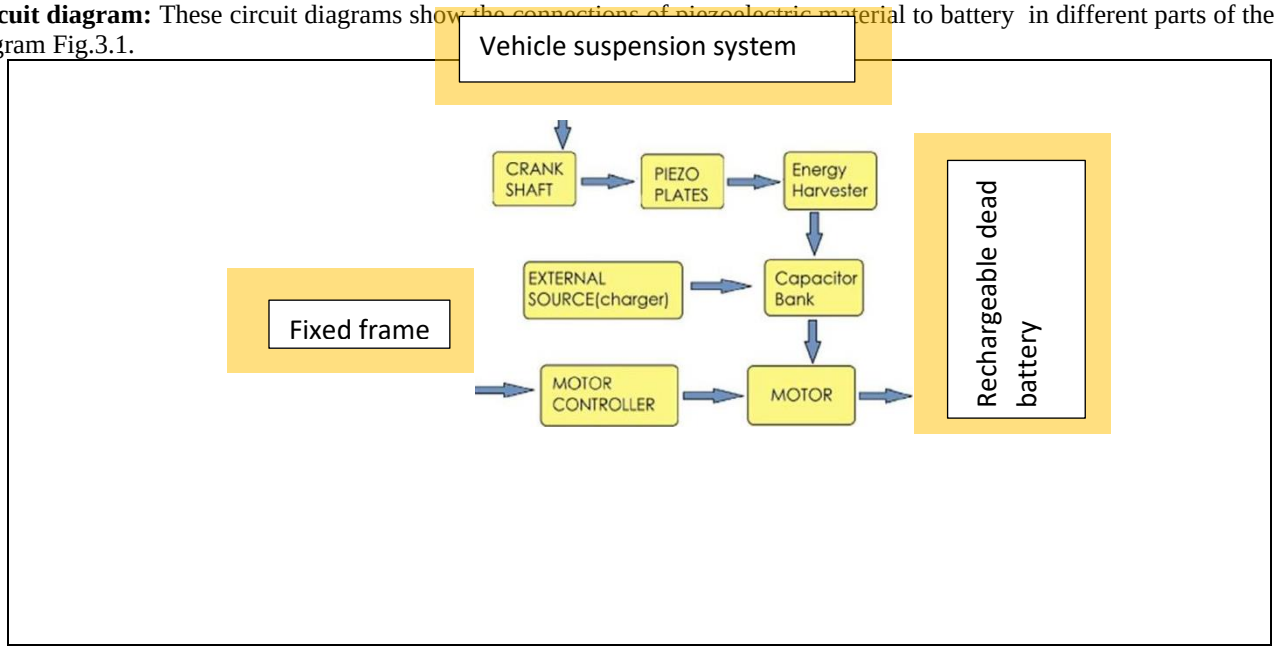

Fig.3.1: **Circuit diagram**

Construction and working :

1. First select & check rear suspension system of an HERO BIKE
2. And adjust the suspension springs for a required dimension to attach the piezoelectric plates in between.
3. The tools are used to lose and tightening the suspension system of back axle.
4. On the bottom of the piezoelectric disk, place the cardboard with thermocole sponze for support and squeeze piezoelectric plates.
5. We observe the vibrations in vehicle suspension system on piezoelectric plates.
6. Measure the voltage generated by the piezoelectric materials connected with wires, in multimeter save the output voltage in battery use the power electric devices as shown fig 3.2

Fig.3.2: Circuit attached to the bike

IV.RESULTS AND DISCUSSIONS

4.1: OBSERVATIONS

Case:1

Using multiple no. of plates piezo electric plates:

Based on input voltage will increase output voltage is represent the table-4.1**.**

Table-4.1: Output voltage

Input voltage (v)	Out put voltage	Time (Min)
3.91	0.62	3
5.15	1.11	3.03
7.3	1.2	3.32
11.12	1.9	1..38
14.12	2.52	5.2
19.04	3.98	2.35
19.57	4.2	1.45
25	5.08	2.43

Case:2

Based on the few plates using applying manual load on vehicle suspension to produce electricity table -4.2.

Table-4.2: Based on few plates

VOLTAGE (V)	TIME(Min)
0.25	0
0.75	2.5
0.90	5.2
1.05	7.2
2.5	10.5
3.5	15

Case: 3

Based on medium no.of plates store the power in 12 volts battery in using vehicle suspension system table-4.3

Table-4.3: Based on medium plates

VOLTAGE(V)	TIME(Min)
0.35	0
0.85	51.2
1.5	108.3
2.75	200.02
3.90	305.0
4.54	420.3

Case:4

Based on multiple no.of plates used to produce the voltage to store the power in 12V battery table-4.4

Table-4.4: Based on multiple no.of plates

VOLTAGE(V)	TIME(Min)
0.75	0
1.5	25.3
3.75	70.3
4.8	180.09
4.95	270.02
6.07	350.01

Case:5

Take different time readings using medium and multiple no.of plates table-5.5.

Table-4.5: Boost up the 12v battery

HARVEST VOLTAGE(V)	TIME(Min)	BOOSTUP VOLTAGE(V)
4.54	420.03	6.54
6.07	350.01	9.03

4.2: Formula and calculations:

Total torque applied (T) = 1177.2 N-m

Speed of rotation (N) = 5000 rpm

Power transmission (P) = 2*3.141*N*T / 60

=2*3.141*5000*1177.2 /60*1000

= 616.38 Kilo watts

Power (P) = Current(I)* Voltage(V)

Total voltage (V) = 6.07 volts

I = P/V = 616.38 / 6.07 = 101.54 Amps

Total current = 101.54Amps

4.3:Results

Graph for model 1 : Based on motor input voltage vs piezo electric material. The output voltage is represented by the Y-axis, while the X-axis is based on the motor input voltage as shown in fig-4.6. As the input voltage rises, the output voltage rises along with it, causing the vibrations to rise

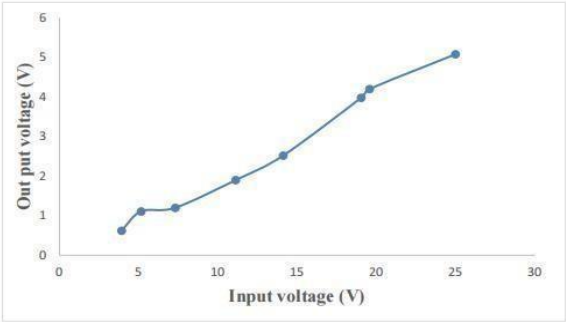

Fig-4.6 : Variation of input voltage to out put voltage

Graph for modal 2: The X-axis represents voltage(V), and the Y-axis is based on time (Min) as shown in fig-4.7. The pressure is manually applied to the plates, and in the time it takes to charge the battery, the pressure is transformed into power. It will not give higher voltage, but it will give some voltage.

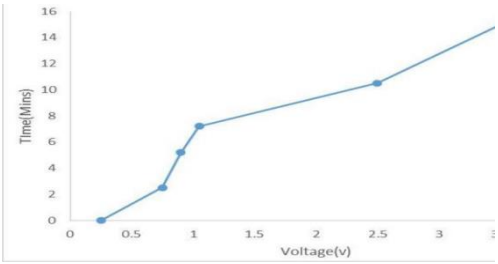

Fig-4.7: Based on few no.of plates graph

Graph for modal 3: The X-axis represents voltage(V), and the Y-axis is based on time (Min) as shown in fig-4.8. The battery is charged according to the medium no.of plates that were utilized by the mechanism over the course of time.

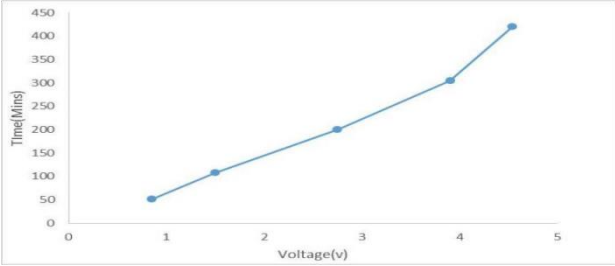

Fig-4.8: Based on medium no.of plates graph

Graph for modal 4: The X-axis represents voltage (V), and the Y-axis is based on time (Min) as shown in fig-4.9. The 12 volt battery is charged in accordance with the medium plates used by the mechanism over time.

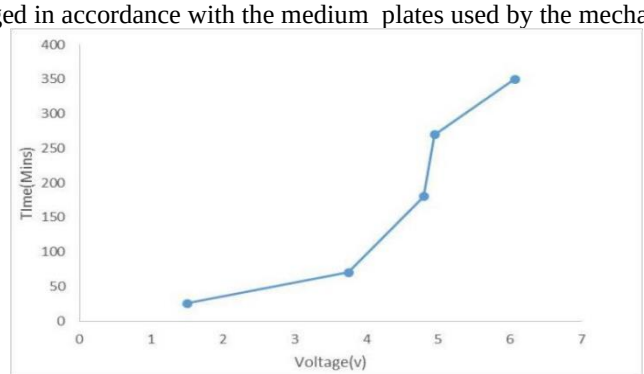

Fig-4.9: Based on multiple no.of plates graph

Graph for modal 5: Boost up the 12v battery. The X-axis represents voltage (V), and the Y-axis is based on time (Min) as shown in fig4.10 This graph depicts the boost-up of the 12V battery up to 24V, as well as the time required to charge the 12V battery. The blue colour line appears on normal voltage, while the red colour line appears on boost up the voltage.

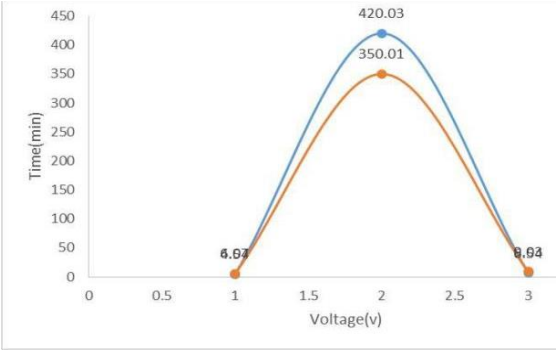

Fig-4.10: Boost up the voltage

V.CONCLUSION

In this mini project, fabrication of Energy harvesting using piezo electric materials vehicle suspension system was done and connected to the designed circuit which consists of piezo-electric materials, boost converter, capacitor, rectifier. Primarily analyses the voltage across multiple piezo-electric plates using multimeter and harvest the voltage in rechargeable dead battery for certain time period. Finally, we conclude this project by boost up voltage using boost converter which can be used for power electronic device. The main aim of our project was achieved by harvesting the vibrations to power low electrical devices.

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