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APPLICATION OF PIEZOELECTRIC PLATES IN PAVEMENTS

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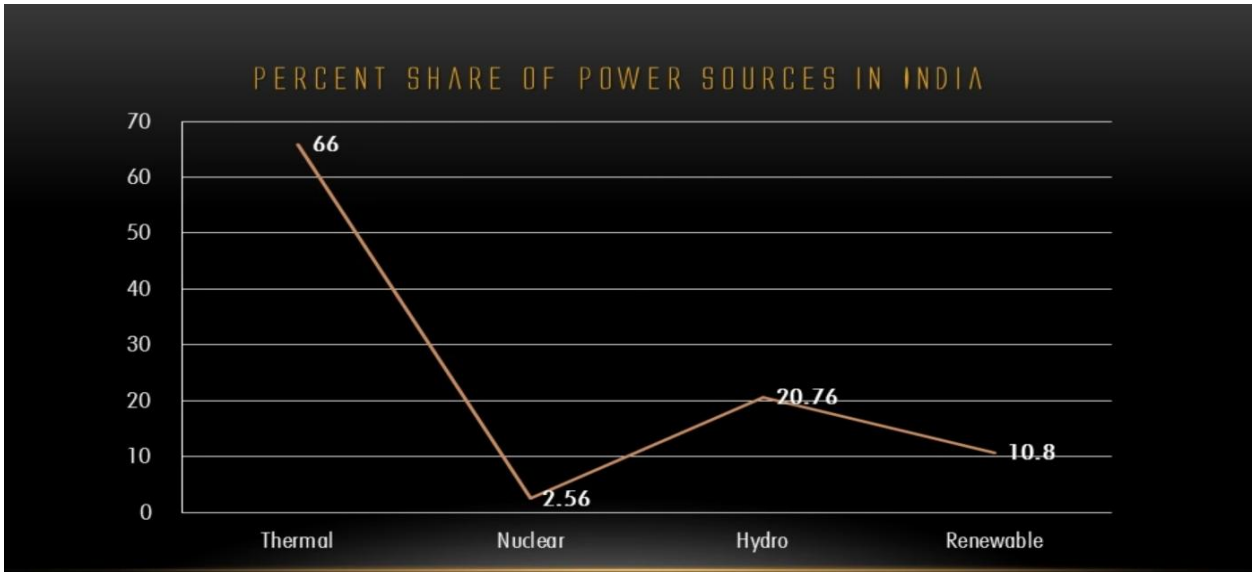
Abstract- *The environmental effects of transport itself are enormous as vehicular emission causes air pollution, noise pollution etc that erodes the natural resources and pollutes the environment in big way. Also with increase in energy consumption due to growth in number of electric devices there is need to bring advancement in transit system by equipping them with alternate energy which is generated by piezoelectric plate and using them in kinetic ramp and footfall. Electricity is produced by harnessing Kinetic energy generated by automobiles and commuter passing over it and converting it into electrical energy by transducer. This electricity hence generated would be renewable and sufficient enough to run nearby street lights, stops or terminals and fare collection stations, making mode of transit self-sustaining. This is completely green energy process.*

Keywords- *Sustainable, Kinetic energy, Alternative energy, Kinetic ramp, Footfall, Piezoelectric plates*

1. Introduction

With the electronic devices becoming integral part of day to day life both in personal and industrial environments the demand for energy is tremendously increasing across the globe. As the demand of fossil fuel is enormously increasing over time, the future of generating power using non-renewable energy will come to a halt. This over consumption and risks associated is pressuring the environment and economy as well. In 2004, the global energy consumption level of non-renewable energy has risen to 80% and it goes on increasing. This increase of energy demand will cause a price increase on fossil fuel contributing to tax policies and thus higher electricity bills. The major issue is that fossil fuels used to supply energy to feed recent generation are exhaustible. On other hand, if energy consumption continues growing than meeting future energy demands is challenging. Thus efforts are made to find alternatives source of energy such as solar hydro wind etc. Also the energy produce by piezoelectric plates proves to be cheapest of them. This device helps in using wasted mechanical energy produced by pressure of vehicles and transform it into electrical energy. Every moving object causes vibration and vibration will be directly converted to voltage with no need of additional components. Thus our main objective is to design a system that decreases energy crisis in world by utilizing the vehicles kinetic energy.

2. Electric sector in India



From the graph we infer, that India as a nation is dependent extravagantly on non-renewable sources of energy such as thermal and nuclear energy to provide electricity for its natives.

3. Sources of Energy

Non-renewable sources of energy:

Thermal power plants:

- Changes the surrounding ecosystem
- Huge raw material requirement
- Exploitation of fossil fuels.
- Huge impacts on health and environment.

Hydro power plants:

- Huge methane and carbon dioxide emissions.
- Disturbance of habitats.
- Fish killing and agriculture.
- Divert natural waterways.

Nuclear power plants:

- Rare raw material
- Nuclear waste radioactive
- Extremely high cost
- Major impact on human life

Thus it is crystal clear that non-renewable sources of energy definitely do not support sustainable environment. So what will? Renewable sources?

Solar energy:

- Only harnessed when sun is out.
- Large area of open land required.
- High maintenance cost.

Hydro power:

- Releases large amount of CO2 and methane.
- Area near dams is degraded.
- Disturbs ecological balance near dams.

Biomass gas:

- Inefficient energy output.
- Ethanol used in hazardous to machines.
- Methane gas evolved degrades environment.

Geo thermal:

- Emits poisonous gases,
- Excessively high initial cost .
- Heavy dependence of water.

4. The Solution

Piezoelectricity.

- 33% of India population use public transport.
- 40% of India population use private transport.

But how does this wasteful mode of transportation helps to produce the electricity?

Methods to harvest kinetic energy:

1. **Piezoelectric**: A piezoelectric element like PZT, PVDF, etc., acts as a transducer means to convert the kinetic energy into electric energy upon stepping on the floor tile. Deformation of piezoelectric elements caused by the load acting the tile induce charges. The piezoelectric_effect converts mechanical strain into electric current or voltage. This strain can come from many different sources. Human motion, low-frequency seismic vibrations, acoustic noise, pressure energy etc. piezoelectric electricity sources produce power on the order of miliwatts which can be multiplied by increasing numbers. Piezoelectric crystal generate a small voltage whenever they are mechanically deformed.

2. **Magnetic**: Magnets moving on a cantilever are sensitive to even small vibrations and generate microcurrents by moving relative to conductors due to Faraday's law of induction. Transducer means consists of a magnetic element and a conductive element, wherein one of the elements is movably coupled to the floor surface.

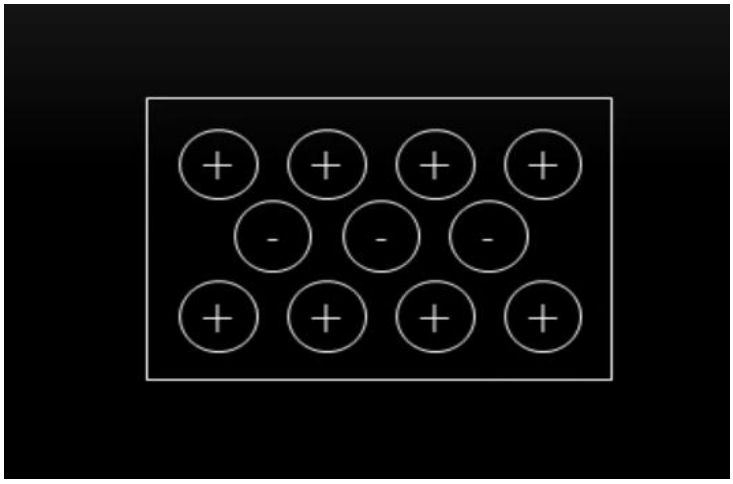
3. **Generator:** Generator is a device that converts motive power (mechanical energy) into electrical power for use in an external circuit. Sources of mechanical energy includes steam turbines, gas turbines, water turbines, internal combustion engines and even hand cranks. Generators provide nearly all of the power for

4. **Photovoltaics** : Photovoltaics is a method of generating electrical power by converting solar radiation (both indoors and outdoors) into direct current electricity using semiconductors that exhibit the photovoltaic effect.

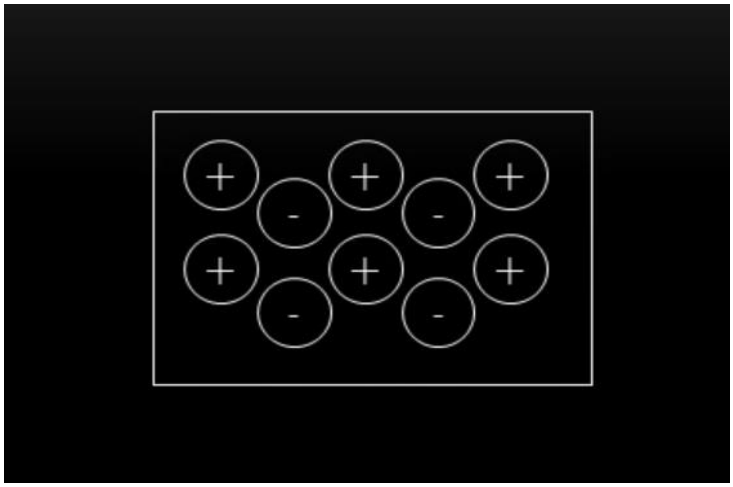
5. Piezoelectric plates (transducer)

- A transducer can be anything which converts one form of energy to another.
- We squeeze this material or we apply force or pressure on this material it converts it into electric voltage and voltage is function of force and pressure applied to it.
- The material which behaves in such a way is called piezoelectric sensor.

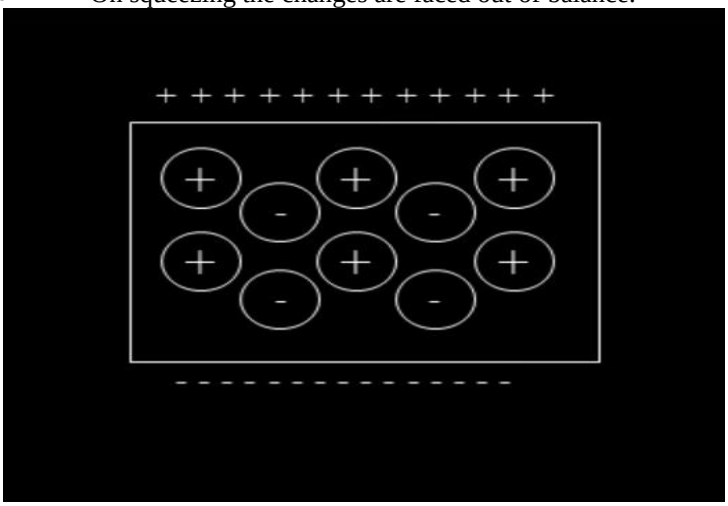
6. Working principle of Piezoelectric plates (transducers):



- The changes are exactly balanced.
- Electric dipole moments cancel each other out.



- On squeezing the changes are faced out of balance.

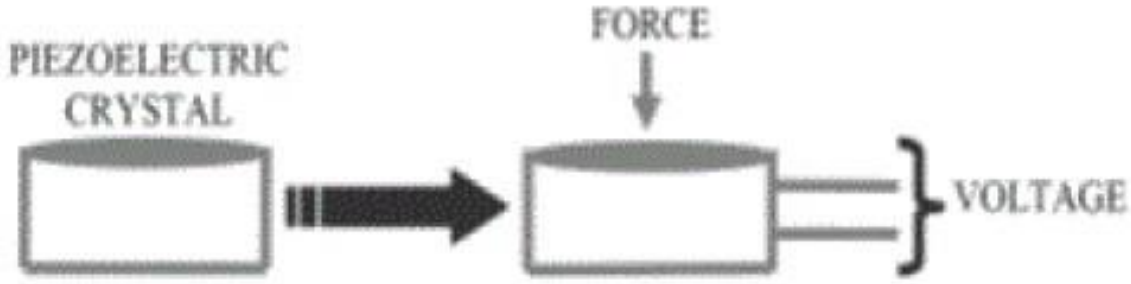


This shift from equilibrium state, leads to accumulation of changes on opposite ends and hence produces a voltage between the negative and the positive plate.

Requirements:

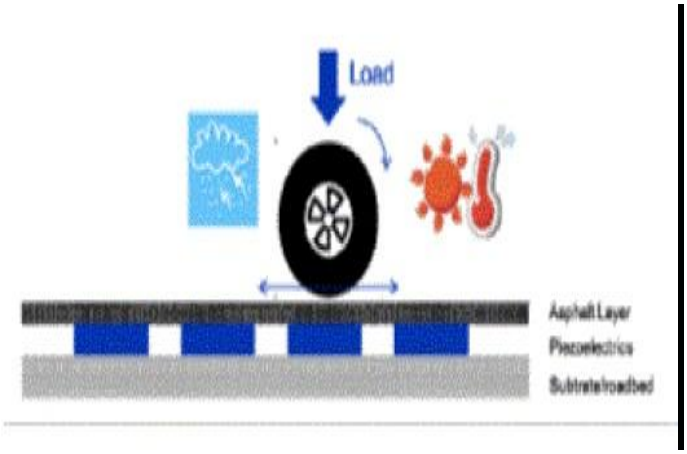
1. Capacitor
2. Piezo plates
3. Conducting wires
4. AC to DC rectifiers
5. Multimeter
6. Wooden/cardboard base
7. Probes
8. cork

The principle of piezoelectricity lies behind the crystals is shown in figure below. When crystalline material subjected to external pressure or strain then electric voltage is generated. The efficiency of piezoelectric devices is influence by the type of crystals due to varieties of properties. However, PZT crystals i.e lead zirconate titanate are being used widely because of high piezoelectric effect, ease of fabrication, long life service, high material strength, resistance against humidity and heat temperature over 100ºC.



7. Application of piezoelectric plates in kinetic ramps:

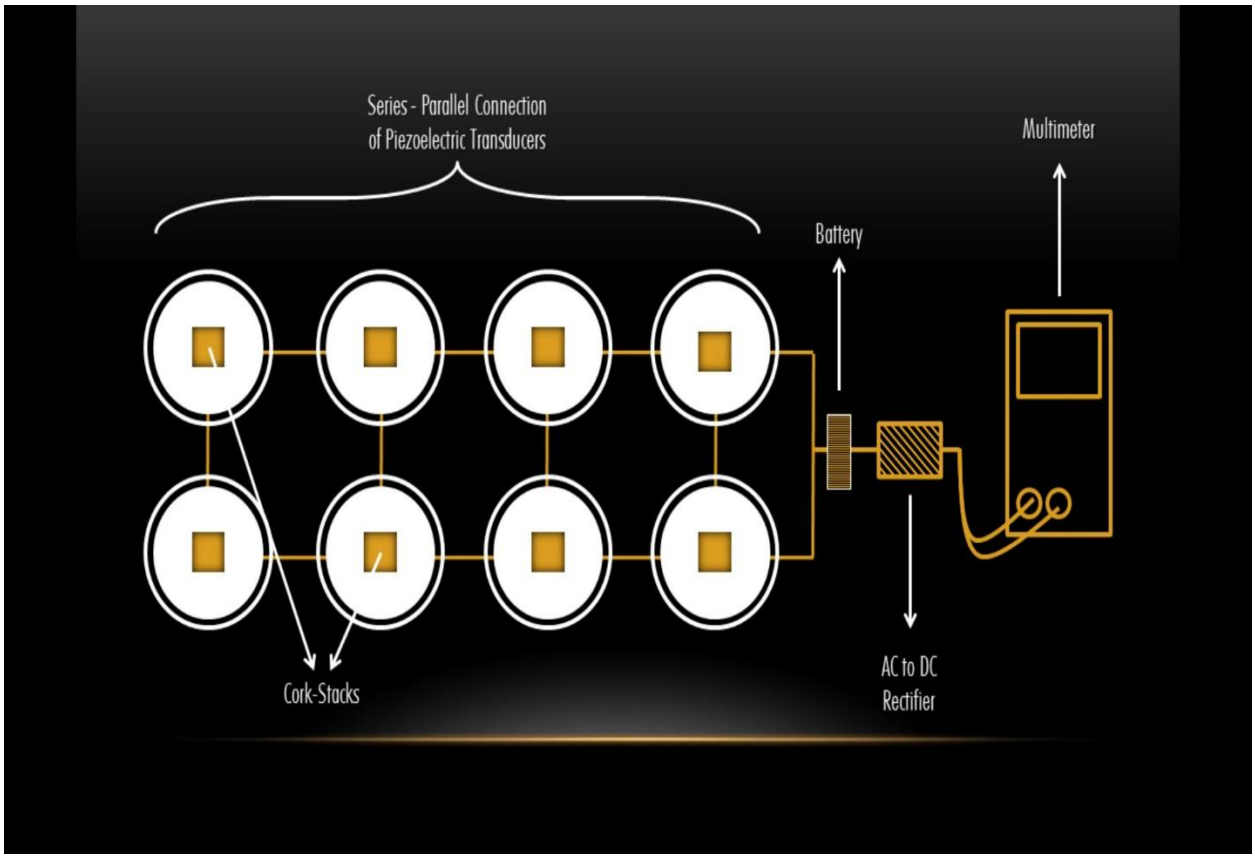
Piezoelectric crystals can be embedded under the asphalt layer to use it for generation of energy due to vehicle motion. When the vehicle passes over kinetic ramp the wheels exerts the force or pressure on the crystals of piezo plates and thus they gets deformed. This deformation will absorb the force and under goes the process of power generation. Only AC voltage is generated by piezo crystals. The generated voltage is then adjusted and converted in to DC voltage through transformers. The generated energy is stored in batteries or capacitors for electric application purposes. On city roads the stored energy can be used for street lightening, while on highway it is used to light up toll plaza. In addition to this, kinetic ramps on BRTS routes can be used to light up bus stations.



8. Factors affecting piezoelectric road efficiency:

1. **Vehicle speed**: Vehicles moving slowly will generate slightly more energy than faster moving vehicles. More suitable speed will be 35 to 45 kmph.
2. **Vehicle weight**: Heavier the vehicle more deformation of crystals will happen which will generate more energy. For instance, a truck will generate more energy than light vehicle like motorcycles.
3. **Traffic flow capacity**: This technology will provide less energy if power asphalts are design in areas where there is less traffic. It is suggested to apply piezo plates on busy roads where a reasonable number of vehicle capacity flow.
4. **Thickness of plates**: More energy is produced with thinner material.
5. **Geometry**: The most efficient form to produce more energy is tapered shape.

9. Circuit Diagram:

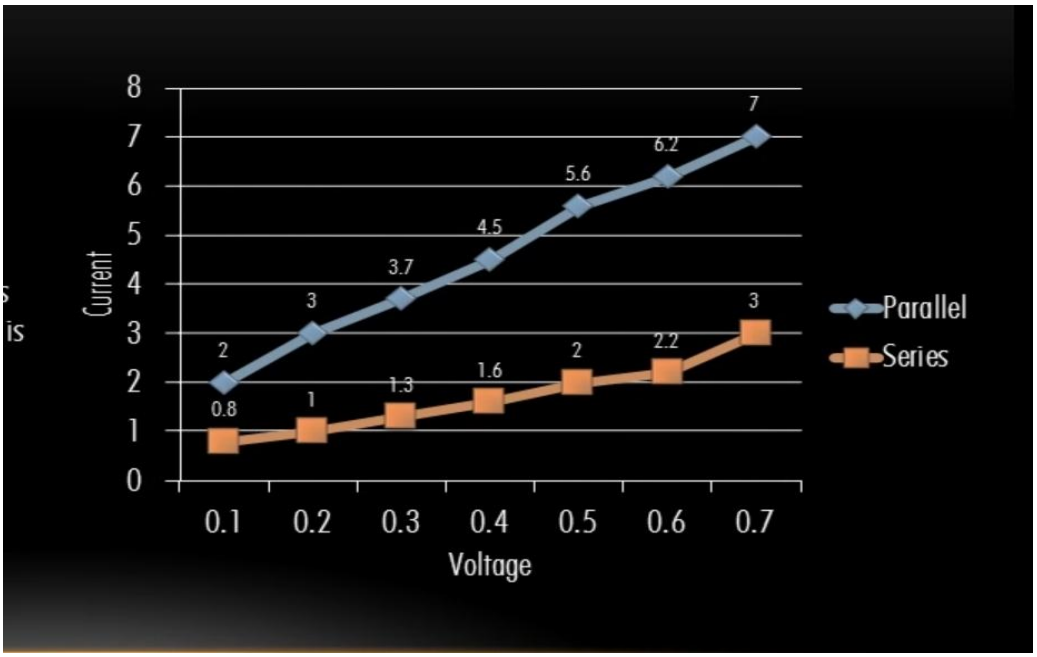


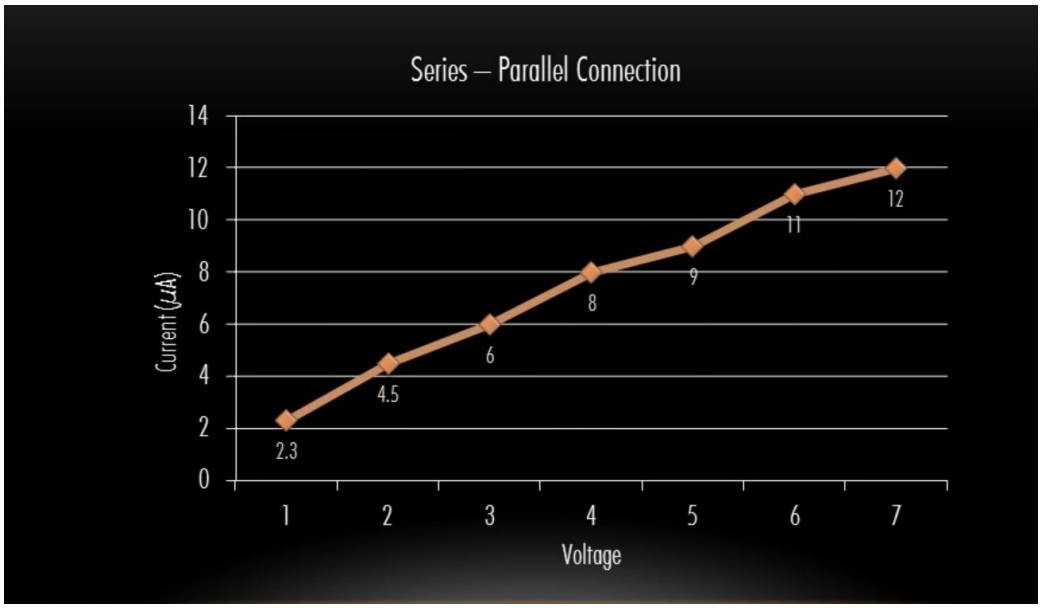
In this grouping a certain number of cells are connected in series and all such series are then connected mutually in parallel. Suppose 'n' cells are connected in series and 'm' rows of such series groups are connected in parallel.

Hence we have n=4 and m=2

- **Why are cells connected in series-parallel?**

It can be seen from graph below that the voltage from a series connection is good but the current obtained is poor, whereas the current from a parallel connection is good but voltage is poor. But this problem is rectified in a series-parallel connection where a good voltage as well as current can be obtained.





➢ **Need of rectifier?**

The current produced by piezoelectric transducers is alternating in nature and hence cannot run street lights, home appliances.

Thus to make it a stable direct current we make it pass through a rectifier which converts AC to DC and hence provides us a usable current.

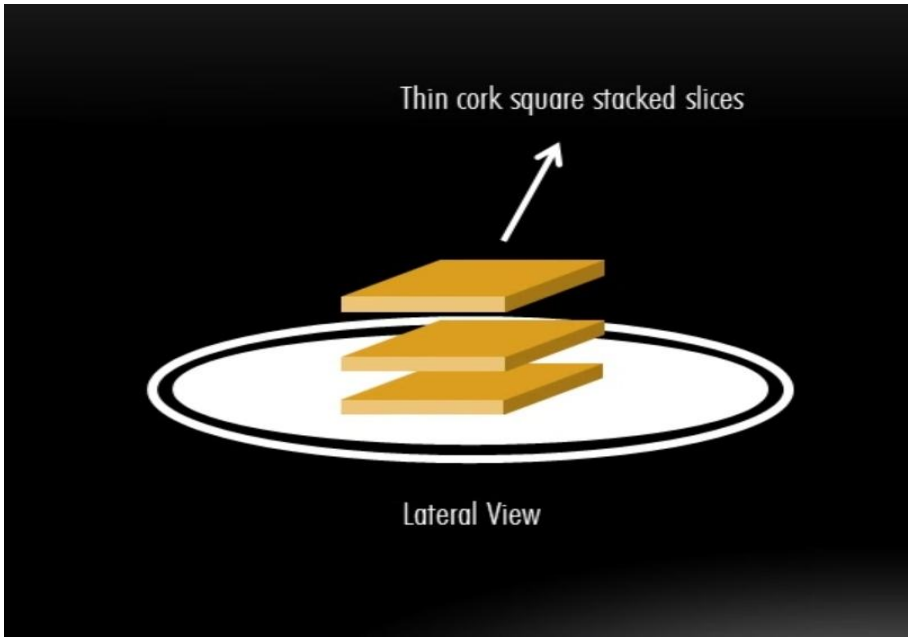
The proof of produced AC is that when the circuit is connected to a multimeter without the addition of the rectifier then the readings come up with a negative sign whereas when a rectifier is place between the readings change to positive values.

➢ **What are cork-stacks and why are they important?**

We place stacks of thin cork squares in group of three on each plate.

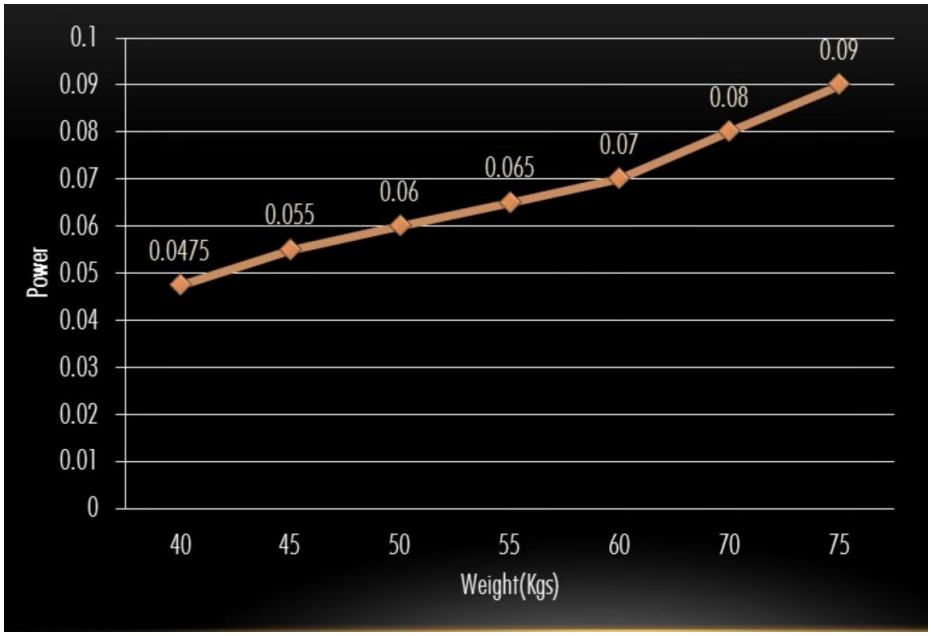
Therefore, when a vehicle pass over the board with cork stacks then the pressure applied gets concentrated on transducers causing maximum shearing and potential difference and hence produce more energy.

If cork stack are not provided than applied pressure gets distributed and produce less shearing.



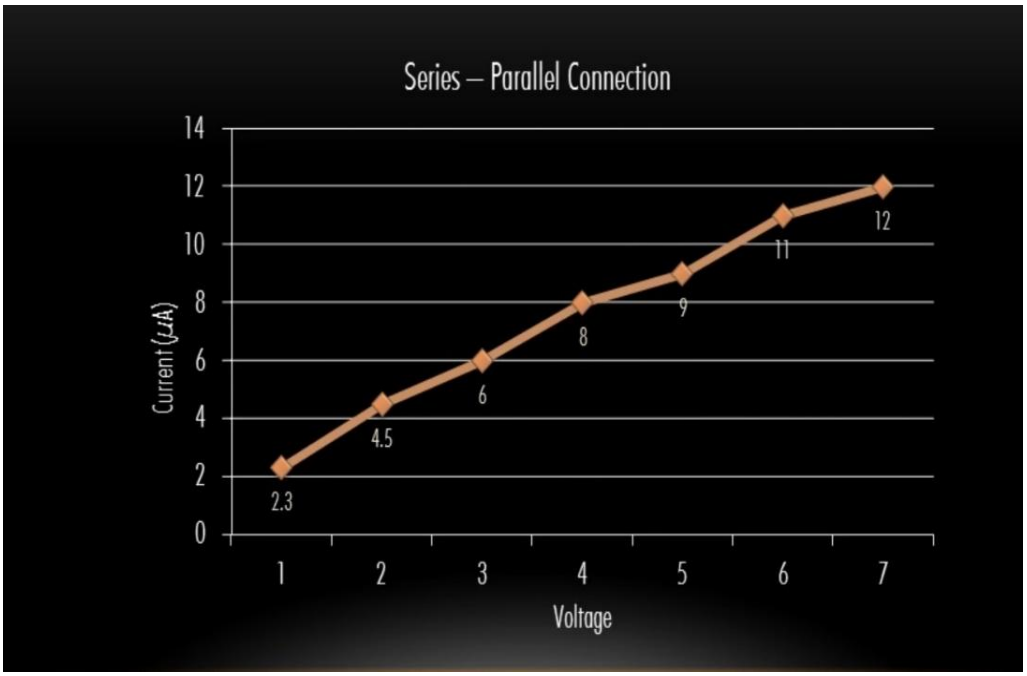
The following weights varied from 40kg to 75 kg were put on piezo plates to test voltage generating capacity of piezoplates.

The following observations were noted:



Power = voltage x current

Statically maximum voltage of 40V is generated across the piezo plate tile when a weight of 75 kg is applied on the tile. Similarly if bike of 150KG pass over it will produce 80V.



By unitary method 7V 12 microampere

1V 12/7 microampere

80V 12/7 * 80 micro ampere

137.14 microampere= 137.14x10^-6 A

Thus power produced

P = VI

= 80 x 137.14 x 10^-6

= 10971 x 10^-6 Watts

- Since the power produced by one vehicle is quite small and to keep device running we need constant power, thus a battery and capacitor is used to store power.

10. Conclusion

- Thus it can be concluded that by this project an economical, affordable energy solution to the common people is obtained.
- This can be applicable in city areas where there is shortage of power and thus by this method more power can be obtained.
- Kinetic energy which is produced by vehicles generally gets wasted thus wasted kinetic energy can turn into useful source by this project.
- Due to the low cost design of piezoelectric system it is practical product which could increase operating period of most of product.
- Energy produced by this method can be considered as alternate source of energy and it is renewable because it is produced by complete green process.

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