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Piezo-Electricity: A Future Energy Alternative

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Abstract: ***Electricity is the most used form of energy and has a very high demand.It can be produced from hydroelectric power plants, thermal energy power plants, nuclear power plants, etc. But these resources are either polluting or depleting or unreliable at times, etc. So we have been shifting to alternative ways of generating electricity to generate clean and from renewable resources e.g. - solar energy, wind energy, etc. But one of the solutions to the generating clean, FREE and a renewable source is 'Piezoelectricity', which uses simple mechanical pressure to generate electricity.So if these piezoelectric materials are installed in places where there are frequent forces acting on surfaces like a foot path, shoes, hammers etc., electricity can be generated to serve some dedicated purposes. thus, saving the remaining resources and generating free and clean energy on which we may rely. It is also a very good way of utilizing wasted mechanical energy to do some useful work. Thus, we have presented how piezoelectricity works and have designed three applications where we can use piezoelectricity.***
Keywords: piezoelectricity, free and clean energy, mechanical forces, compressive forces, impact

I. INTRODUCTION

A. *The Piezoelectric Effect*

Certain materials generate electricity due to the application of mechanical forces, this effect is called as the piezoelectric effect.
It was discovered by Pierre Curie and Jacques Curie in 1880. They found that the quartz crystal produced electric charges on the application of pressure. This phenomenon is observed in crystalline materials that lack inversion symmetry. They demonstrated the effect in tourmaline, topaz and quartz crystals by predicting the behavior of crystals by combining the concepts of pyro-electricity and crystal structures. Quartz and Rochelle salt exhibit the most piezoelectricity.

B. *Working*

The positive and negative charges are distributed symmetrically in a crystal. Piezoelectric ceramic materials need to be made piezoelectric by aligning the random ferroelectric domains by a process known as poling. Poling subsists of inducing a DC voltage across the material. A negative charge is induced on the expanded side, when there is some pressure applied to an object and a positive charge is induced on the compressed side. Then, an electrical current flows across the material once the pressure is released. The output voltage of single piezoelectric crystal is in milli-volts and the wattage is in micro-watt range. In order to achieve higher voltages and current, the piezoelectric crystals can be arranged in mergers of series and parallel.

II. APPLICATIONS

A. *Piezoelectric Cricket Bat*

1) *Aim:* The aim of this application is to use to the impact energy of bat hitting the ball in cricket to generate electricity and store it in a battery.
2) *Principle:* When the ball comes in contact with the bat with a high velocity, the piezoelectric material embedded inside the bat will experience a compressive force. This will help to some amount of induce electricity.
3) *Construction*

a) The cricket bat will have a cuboidal cavity in it in which the piezoelectric material along with its base metal plate and the charging circuit will be embedded.
b) The piezoelectric material will be linked to the front face of the bat from the inside of the cavity and the base metal plate will be connected to it on the other side which will be rigidly fixed to the other end of the cavity.
c) This arrangement will be present from a little above the half portion through the height of the bat to the toe end of the bat as it is the most used part of the bat while hitting.
d) The charging circuit will be placed in the empty top portion of the cavity and the battery will also be placed there. There should also be an opening at the back end to load and unload the battery.

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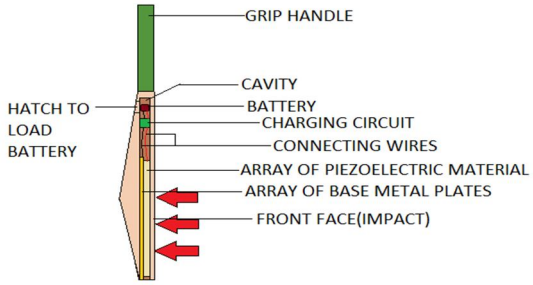

Fig.1. Piezoelectric Cricket Bat (image by YashAshtekar)

4) Working

a) When the ball is hit, the impact of the bat and the ball will always have compressive forces acting on the piezoelectric material.
b) This will help in inducing electricity in the piezoelectric material.
c) This generated power will be stored in a battery by means of a charging circuit.
d) This battery can be then used to run different small scale applications.

B. Piezoelectric Bicycle Pedal

1) Aim: To generate electrical energy from piezoelectric bicycle pedal & store it in battery for further use. The electricity generated can be used for mobile phones charging, torch, to provide additional acceleration whenever required etc.
2) Principle: Electricity will be generated due to cyclic loading and unloading on each piezoelectric pedal by the force applied by rider while riding bicycle.
3) Construction

a) The piezoelectric pedal will contain an array of piezoelectric crystals and a charging circuit.
b) The pedal has into 2 parts i.e. an upper arm and a lower arm.
c) The lower layer is kept fixed and the upper layer is free to move downward and back to its original position.
d) Prepare a suitable arrangement of piezoelectric crystals as per the required output.
e) This arrangement is fixed between upper and lower layers of pedal.
f) The crystal set arrangement is connected to the circuit for regulating, managing and storing the electricity generated.
g) The battery is connected to the circuit for storing energy for future use.
h) Then the output is connected with LED (torch) or motor for additional acceleration whenever required, etc.

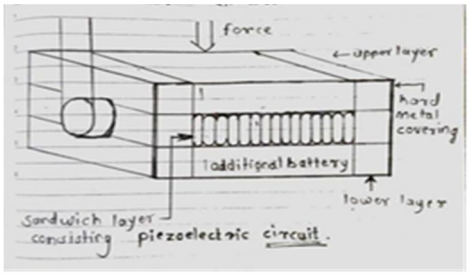

Fig.2. Design of pedal (image by ParthLadole)

4) Working

a) While cycling, rider applies force alternately on each pedal. In first half cycle force is applied on one pedal and in another half cycle force is applied on second pedal. This change in the force results in change in stress on piezoelectric crystal present in pedal.
b) Electricity will be generated by piezoelectric crystals which will be stored in battery connected to the circuit or can be directly used if required. This electrical power can be used for a particular purpose according to the requirement.
c) While riding bicycle, in each cycle, loading occurs on both pedals i.e. two times in one cycle.
d) If 'N' is the frequency of cycling in r. p. m. then the energy will be generated 2N times in a minute. If frequency increases by X then energy production will be increased by 2X.
e) Also the number times loading and unloading occurs in this application is much more than many other applications, which will help in higher energy production.

C. Piezoelectric Hammer Torch

1) Aim: The aim of this application is to use the impact energy from the hammering action is to generate electricity by using the piezoelectric effect.

2) Principle: The generated electrical energy due to the compression caused by the hammering action will be stored in a battery and be used to run an LED array torch embedded in the handle of the hammer.

3) Construction

a) The handle will have a suitable arrangement to support the head and it will have a circular hole for containing the battery and the LED array.

b) One part of the hammer head will be fixed rigidly to the handle.

c) The other part of the hammer head will be fixed on a sliding support and will be free to move back and forth linearly.

d) It will be kept in position by spring connections with the rigid part.

e) The metal plate in the piezoelectric circuit will be fixed on the rigid part of the hammer head and the piezoelectric material on it will be linked to the sliding part.

f) Thus, the piezoelectric material will be placed between the two parts of the hammer head.

g) The output will be taken out from the piezoelectric plate by means of connecting wire and be supplied to the battery inside the cavity in the hammer, by means of a charging circuit.

h) The battery will be connected to an array of LED bulbs that will be fixed at the end of the handle.

i) There will be a switch provided to switch between the piezoelectric charging circuit and the LED torch circuit.

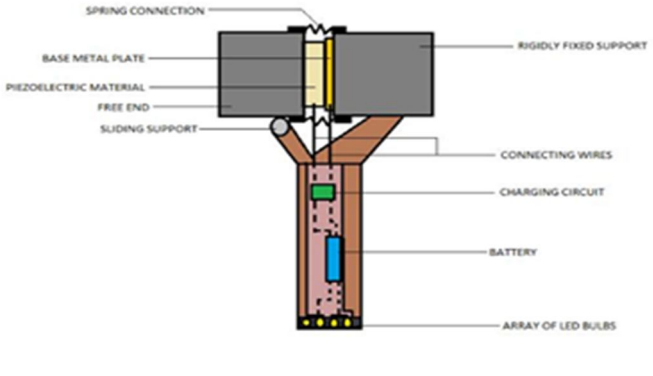

Fig.3. Piezoelectric hammer torch (image by YashAshtekar)

4) Working

a) When the hammering action is performed, it must be done using the sliding part to hit the object and the switch must complete the piezoelectric charging circuit.

b) Ater impact, the sliding part will tend to move inside thus applying compressive pressure on the piezoelectric material.

c) This will lead to the accumulation of charges and thus when the hammer is raised again; a current will flow due to the e.m.f. induced.

d) Thus after many cycles of hitting, the battery will be charged.

e) Then by switching to the torch circuit, the LED bulbs will be lighted up; thus acting as a torch.

III. OUTCOMES

Thus, free and clean energy will be used to run various other applications like torches, charging of phones rather than charging it on electricity developed by conventional means and thus saving resources and also clean energy will be used.

Also the mechanical work produced during stamping, pedaling or hammering will be utilized to another dedicated purpose simultaneously.

IV. CONCLUSION

This study of piezoelectricity has concentrated on the design and the modeling of the applications of piezoelectricity. Three applications of piezoelectric crystals are mentioned here in this research. The next step is to instrument the circuitry and implementation. This concept has been presented, but this scheme would be implemented in the research, both in the terms of modeling and realization of actual devices.

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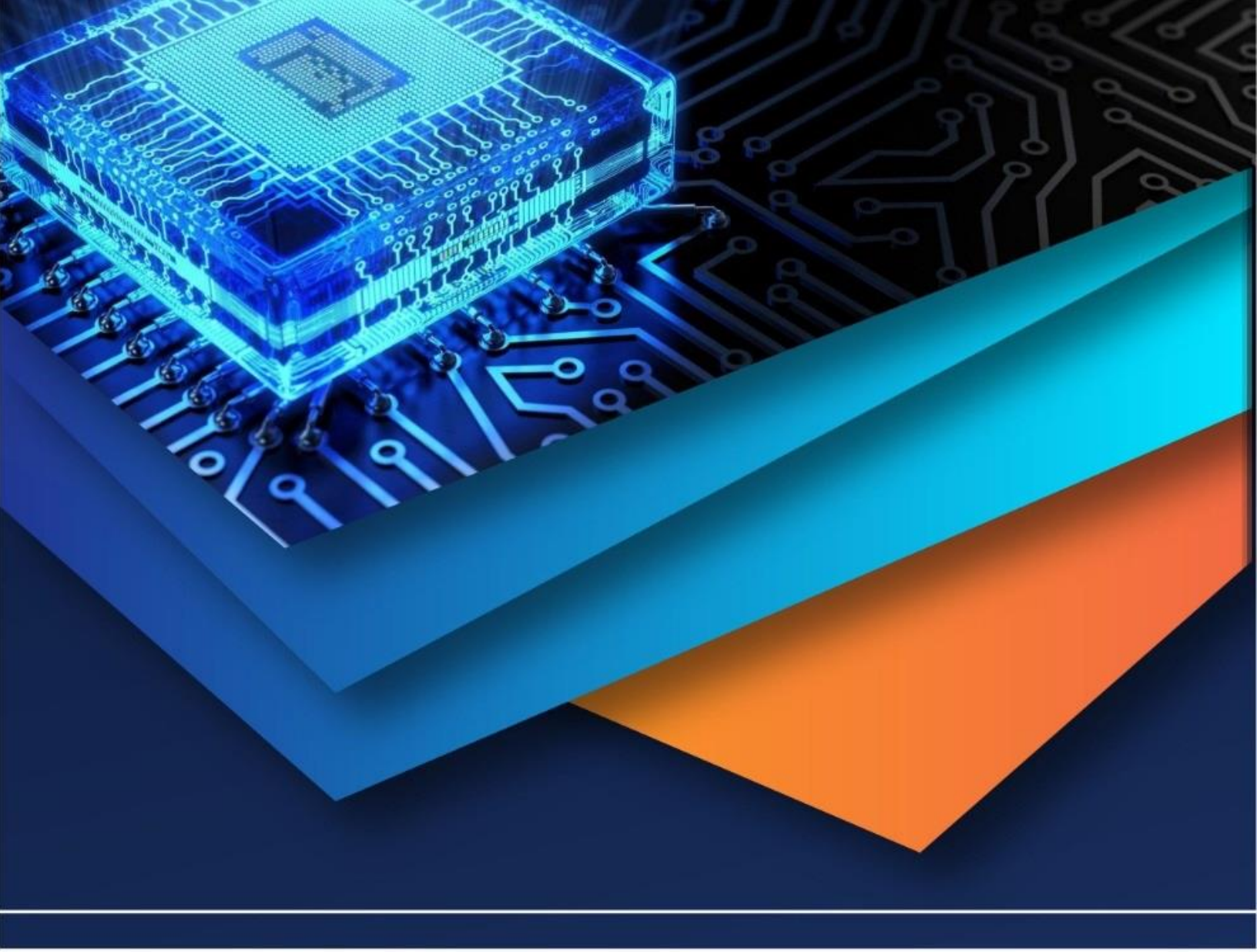

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