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Energy Efficient Lighting For Railway Tunnels In India

Yogesh Popat*, Shruti Sharma, Hitesh kishnani, Govinda Sachdev

ABSTRACT

This paper depicts the concept for production of energy as well as the conservation of energy with the help of piezoelectric effect. As the technological age is quickly revolutionizing the way and actions are increasingly being handled in automatic manner so this paper depicts the automatic method of generating electrical potential by mechanical work. Day by Day the energy requirement is increasing very rapidly but there is lack of supply. In this paper the main stress is given to the energy production and conservation by piezoelectric effect in Eco friendly manner.

Keywords – Energy conservation, Piezoelectric effect , Revolutionizing , Technological age.

1. INTRODUCTION

Energy is the basic need for existence of human life & its development. At present the question arises that why the energy conservation or renewable source of energy is needed? The peoples of present age are using the fossil fuels very rapidly for electricity generation and for domestic purpose. If with the same rate the fossil fuel is in use then in next 35 to 40 years they are going to be extinct and we are in a deep trouble. The rationale behind this concept is to produce the electrical potential with help of mechanical work.

At present, lights of railway tunnels are glowing permanently which is not necessary but by this concept, lights are allowed to glow at the time when it is required. since there is a large number of railway tunnels in India so by applying this concept large amount of electrical energy can be saved which is generated by non renewable sources energy like coal.

2. SCIENTIFIC PRICIPLE INVOLVED

The scientific principle involved is piezoelectric effect which is nothing but the phenomena in which when the mechanical stress or pressure is applied on the special types of materials called piezoelectric materials, then electrical potential is induced on the certain surfaces of piezoelectric crystals this effect is called piezoelectric effect. Piezoelectric materials are good converter of mechanical energy to electrical energy. They are very sensitive to the applied pressure and can convert the pressure of sound waves into voltage. Piezoelectric materials also show the reverse effect. When the electrical potential is applied on the certain surfaces of crystal the deformation of crystal takes place i.e, The dimension of crystal changes this effect is called electrostriction effect. Piezoelectric effect is observed in materials such as Quartz, Rochelle Salt, barium titnate, lithium sulphate, Ammonium Dihydrogen phosphate. Piezoelectric materials are of two types one is natural type another is synthetic type. Quartz and Tourmaline falls under the category of natural type. Barium titnate and lithium sulphate falls under the category of synthetic type. Figure 1 shows the piezoelectric effect and Table 1 shows the properties of some piezoelectric materials. In following table G denotes the voltage sensitivity in volt meter per newton and K is the charge sensitivity in coloumb per newton.

Table 1: Some example of piezoelectric materials

S.N	MATERIALS	TYPE	G (Vm/N)	K(PC/N)
1	Barium titnate	Synthetic	0.00012	150
2	Quartz	Natural	0.00050	02
3	Dipotassium Tartrate	Synthetic	0.00060	155

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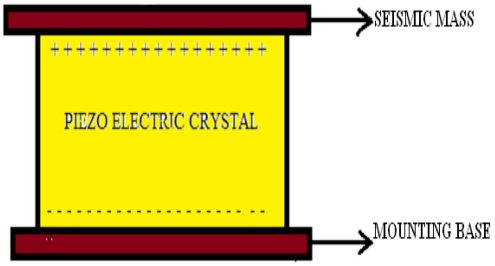
In all the piezoelectric material quartz is the most stable material which is unaffected by humidity and has the temperature range of the order of 550 degree centigrade.



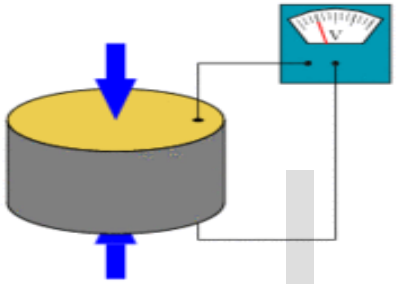


Figure 1: Piezoelectric effect

2. WORKING OF THE CONCEPT

The piezoelectric crystals are placed under the railway tracks in the area covered by the tunnel. The construction of area under consideration below the railway tracks takes place in sandwiched like structure as shown in figure 2.There are four layers in construction. Top layer is of carbon nanotube, second layer is of water proofing material (Bituminous) and third layer is of piezoelectric material crystal. the last layer is of concrete which provides a solid base. Concrete layer is acting as a mounting base and layer of carbon tube & water proof material will act as a seismic mass as shown in figure 1.When the train is passing through the tunnel area then weight of the train is transferred to the piezoelectric crystal fitted under the track due to which electrical potential is developed in the crystal and when the circuit completes the current flows through the circuit and the bulb starts glowing under the tunnel. when the train is passed out of the tunnel then weight of the train is removed from the crystal then no potential will be induced and bulb stops glowing .The complete process is shown in figure 3. As the spacing between the wheels of railway coaches & engines are fixed therefore the piezoelectric slabs must be placed properly in continuous manner other pulsed output will be obtained.

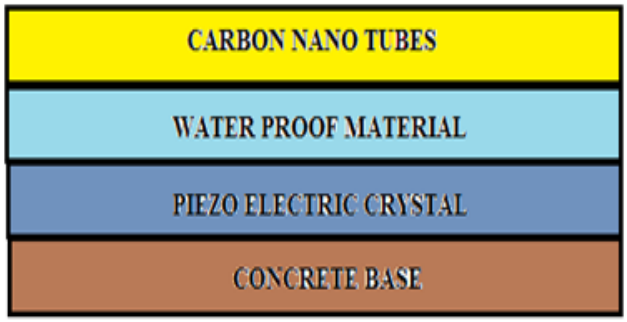


Figure 2: layers of area under implementation

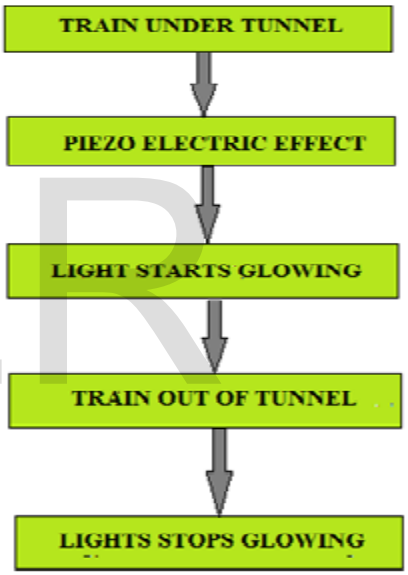


Figure 3: flow chart of working

3. MATHEMATICAL ANALYSIS

The output electrical potential of any piezoelectric material is given by the following equation

$$E = \frac{\mathrm{GFT}}{\mathrm{A}}$$

Where E is the potential developed, A is the area of the piezoelectric crystal , G is the voltage sensitivity, T is the thickness of the crystal.

Taking quartz under consideration having G = 0.050 Vm/N, T = 1 mtr, A = 1 sq. mtr. & the force applied by the train is

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300000 N putting all this values in the equation of output voltage we get E = 15000V

Taking Barium titnate into consideration having G = 0.012 Vm/N , A = 1 mtr , A = 1 mtr sq. & the force applied by the train is 300000 N putting all these values in the equation of output voltage we get E = 3600V.So by varying the parameters of the equation we are able to vary the output voltage of piezoelectric crystal.

To increase the charge sensitivity, more than one element can be used to form a transducer system and such combination are known as bimorphs or multimorphs (or piezopile),depending on whether they are of two element or more. The parallel andseriesl connected bimorphs are shown in Figure 3 and 4 respectievely. multimorphs of four element can also be used , which develops four times the charge of a single element,. It should be noted that the four element are mechanically in series but electrical in parallel and hence the net capacitance of the transducer increases correspondingly

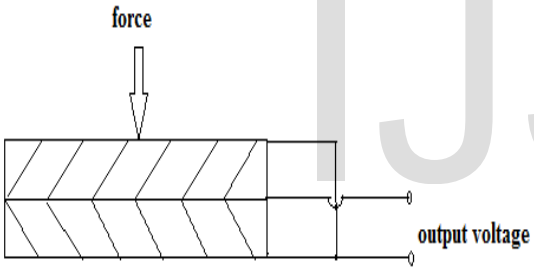

Figure 4: parallel connection

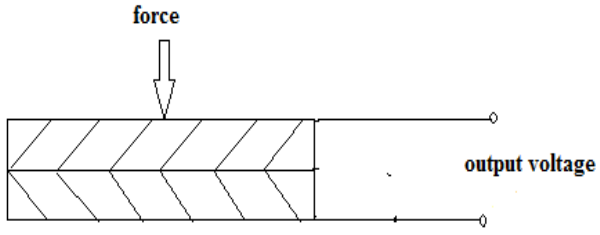

Figure 5: series connection

. The series electrical connection may as well be employed if higher voltage sensitivity is desired, provide the reduced capacitance is a satisfactory match to the signal processing circuit.

4. PROPERTIES OF SOME COMMONLY USED PIEZOELECTRIC MATERIAL

The materials exhibiting the piezoelectric phenomena is divided in to two groups: natural and synthetic.The natural group consists of quartz , Rochelle salt and tourmaline , whereas the synthetic group consists of Ammonium Dihydrogen phosphate (ADP) , Lithium sulphate (LS) and Dipotassium tartrate (DKT).

Quartz is the most stable material and artificially grown quartz is normally preferred as it is purer than natural quartz. Its d-coefficient and relative permittivity may remains unaffected by temperature. The safe stress for quartz is of the order of 98 MN/ square meter.

Rochelle salt is the material that is being produced on industrial scale for producing gramophone pick-ups and crystal microphones .It has highest relative permittivity among the natural group. For accurate measurement of force it is unsuitable due to the large effect of temperature on its relative permittivity even at room temperatures.

ADP crystals possess the lowest resistivity which is also temperature dependent. With temperature compensation , they are used in acceleration and pressure transducers. Lithium sulphate is highly sensitive when used in volume expander mode.

There are certain polycrystalline ceramic compounds which shows the property of retaining electric polarization when exposed to intense electric fields. These materials are called ferroelectric materials and after polarization there possess the properties of piezoelectric materials. Three common material which are used as piezoelectric material are Barium titnate , lead Zirconate-titnate and lead metaniobate. The crystals are kept under strong dc electric field and heated up slowly up to a temperature higher than curie temperature. Then they are allowed to cool slowly in the presence of the electric field. After cooling and removal of the electric field, posses very high values of relative permittivity and high sensitivity. The main advantage of these materials is that they are free from the limitation imposed by the crystal structure and hence they can be moulded in to any size and shape. The direction of polarization of can be set during the process of production , and depending upon the shape and size .

5. PRACTICALITY AND MATERIALS SUITED FOR THIS CONCEPT

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From the properties of piezoelectric material as explained above,In natural group quartz is the well suited material because it is the most stable material and can with stand with higher temperature range of the order of 550 degree Celsius. it can also bear a stress of the order 98 MN/ square meter which is very important characterstics because it has to bear a weight of train.

In synthetic category ferroelectric material such as Lead metaniobate or barium titnate can be used because they are also able to bear high temperature variation of the order of 400 degree Celsius and has high charge output.

Regarding the practicality of this method as the piezoelectric materials are able to sense the small amount of pressure of sound waves which is generally employed in microphones hence by using the stable material the heavy weight of the train can also be converted into electrical potential which can used to glow the bulbs of railway tunnel only when it is required.

6. CONCLUSION

In this paper we have shown Energy Efficient lighting in Railway tunnels of India. By this method the lights of railway tunnels are are allowed to glow when it is required i.e, when the train is inside the tunnel otherwise it will be off . In this way large amount of energy can be conserved.

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AUTHORS

First Author – Yogesh Popat B.E (Hons) ET & T. Lecturer in department of Electronics and Telecommunication , Rungta college of Engg. & Technology , Raipur.
E-mail- yogeshpopat28@gmail.com

Second Author – Shruti Sharma, B.E , M.M College Techonology Raipur.

Third Author – Hitesh Kishnani , B.E ECE. Lecturer in department of Electronics and Telecommunication , Rungta college of Engg. & Technology , Raipur.

Fourth Author – Govinda Sachdev, B.E , Rungta Engg. College Raipur