



Conversion of Automotive Vibrations and Noise Pollution into Electrical Energy

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Abstract- This paper presents the conversion techniques and methodologies of converting automotive vibrations and noise pollution to its electrical counterpart. We all know everywhere there is huge scarcity of electrical energy to carry out daily work. It's really very difficult to imagine our life without electricity. Automotive Vibrations (mechanical energy) that is generated by vehicle movement on the road and Noise pollution (sound energy) by vehicles, railways, airways, etc., are converted into electric energy by piezoelectric effect. The aim of this work is to make power generation more sustainable, economic and ecological by utilizing the advancement in the technology.

Key words; Vibration energy, Sound energy, Piezoelectric effect, Sustainable power.

1. Introduction

The "law of conservation of energy" states that energy neither be created nor be destroyed. Under the consideration of this law many technologists have discovered numerous sources to extract energy from them and use it as a source of power for conventional use.

There are various sources so called eco-friendly sources of energy that we have discovered till the present days. Some of them are implemented to great extent under the suitable circumstances. Solar energy is one in the list that came up with the wide range of applications such as solar heaters, solar cookers and it gained success due to its easy implementation and suitable circumstances. There are various other sources of renewable energy which includes energy in the form of wind, Biomass, water etc. But the efficiency of the energy sources discussed above is the major issue over which the scientists are working since long. The efficiency of the solar cell is 20% only under the practical conditions. This is not the only problem with present sources it further extends to high cost involved in production process. Thus the researchers now are feeling the need of other kinds of energy sources for our conventional uses.

To add to the above list there is an emerging scenario which leads us to a new renewable energies known to us since long and that is the Automotive Vibrations (mechanical energy) and Noise pollution (sound energy).

2. Source and their Effects

Moving automobiles produce vibrations due to transfer of energy (loss) from the rotating parts to the body of the vehicle. These vibrations are generated either when the vehicle is at stable (engine is in on condition) or when the vehicle is at running condition. These vibrations are maximum when the body of vehicle is in resonance with the rotating parts and the vibrations are more in parts of vehicles which are not mechanically fitted. The generation of vibrations in automobiles is due to many reasons such as moment of inertia of rotating parts, uneven road surfaces and load on the system. So in order to retrieve this waste going energy (mechanical energy)

into useful by piezoelectric materials for energy conversions.

Due to the noise pollution (sound energy) such as vehicles, railways, airways, etc. are also to be consider as a loss of energy which occurs in the environment. Sound which is in the mechanical form of energy which travel in the form of wave, mechanical wave that is an oscillation of pressure this pressure created by the sound could be used to convert it into electric energy or other form of energy. Transducer is also used to convert Mechanical energy to electric energy i.e.it can convert sound energy to electric energy the simple e.g. of use of transducer to convert sound to electric and vice versa is in speakers, headset, also it could be converted into electric energy by piezoelectric materials for energy conversions.

The concentration of noise to use it for power generation can lead to discovery of another hidden source of energies which can act as a boon to non-renewable sources such as coal, crude oil etc. which are in the stage of extinction.

3. Practical Conversion Techniques

According to law of thermodynamics mechanical energy could be converted into electricity. Piezo material converts mechanical strain into electric energy, this property of piezo material could be used to make a device which would be able to sustainably convert the sound energy to electric energy as piezo material convert sound energy to electric energy.

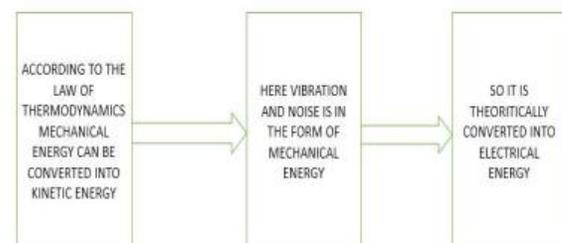


Fig 1. Energy Transformations

3.1. Vibrational conversion

Since the vibrations produced by moving vehicles are continuous and this vibrational energy is wasted continuously. In order to utilize this energy efficiently we need to develop a system which converts these vibrations into useful electrical energy, which is stored in rechargeable batteries used for other purposes. The conversion system consist of a spring mass system used as interconnection for applying vibrations produced, to piezo electric crystal (PZT material). When the vibrations occurs due to moment of inertia of rotating parts or uneven road surfaces and load on the vehicles, these vibrations are occurred through an spring mass system which can efficiently observes these mechanically produced vibrations. PZT materials are placed on the outer side of spring mass system. When the vehicle moves on plane surface the amount of vibrations produced are less. When the vehicle is moving on a irregular surface or during acceleration of the vehicle or when brakes are applied. The change in property of the PZT material tends to charge in PZT material which is stored in storage devices (Batteries).The energy generated will be continuous as long as the vehicle keeps moving and the conversion is more efficient, as a result maximum amount of energy is obtained.

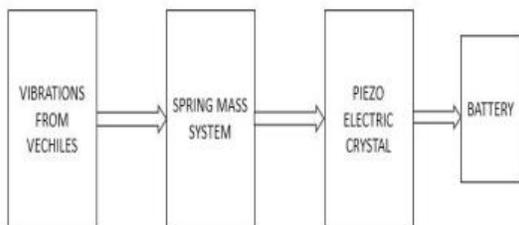


Fig 2. Block Diagram of Automotive Vibration Conversion

The vibrations that are produced by moving vehicles are efficiently used for harvesting energy by using PZT material. Output stage of piezo energy conversion system as discussed in the section 3.3

3.2. Noise conversion

In our daily use we use many products in which the conversion between sound energy and electric energy takes place. For example-mic, speaker, mobile phone, transducers. However the amount of conversion is very small and we require large amount of energy to convert it so the problem is how we could convert efficiently. As sound wave is a mechanical wave when it travels through a medium it disturbs the particle of the medium these disturbance created by sound could be used to produce electricity.

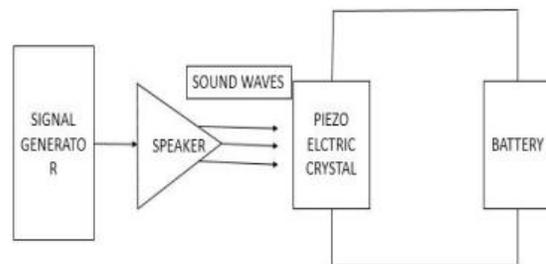


Fig 3. Block Diagram of Noise Conversion

The method of converting the sound to electricity is with the use of piezoelectric materials such as Lead zirconium titanate, Barium titanate, and Zinc oxide. Electricity can be generated directly from sound energy by piezoelectric effect. The way it works is that the mechanical energy in the form of sound is applied directly to a crystal with strong piezoelectric characteristics, and the crystal will generate a small amount of voltage in response to the application of that sound (mechanical) energy. What we are doing is pressing the crystal. A press will generate (deformation) a small voltage for the duration of the deformation. When the crystal is released, another small voltage will be generated in the opposite polarity. Output stage of piezo energy conversion system as discussed below.

3.3. Output stage of piezo energy conversion system

The output power of the piezoelectric material is alternating in nature which is not suitable for storage in batteries. So in order to store the electrical energy into energy storage devices it is first converted from bipolar to unipolar direction. A full wave rectifier is used for converting Alternating current output to Direct current. But the output Direct current waveform is not smooth. It again contains pulses which is not efficient for storage in batteries. So in order to smooth the output waveform a capacitor in parallel with load is placed. But the value of capacitor is chosen such that the value of load capacitance is equal to source capacitance (i.e. internal capacitance of unstressed piezoelectric material).

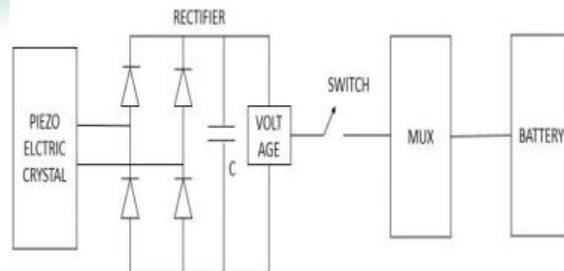


Fig 4. Circuit diagram of output stage of energy conversion

4. Piezoelectric materials

In physics, the piezoelectric materials can be described

as the link between electrostatics and mechanics. The piezoelectric effect describes the relation between a mechanical stress and an electrical voltage in solids. It is reversible, an applied mechanical stress will generate a voltage and an applied voltage will change the shape of the solid by a small amount (up to a 4% change in volume). Piezoelectric materials exhibit intrinsic (spontaneous) polarisation. Most of the piezoelectric materials are ceramic in nature and some of them are discussed below.

The largest material group for piezoelectric device is piezo-crystal and piezo-polymer due to its low weight and small size. Piezoelectric crystals are now used in buzzer, solar system also.

Examples of such crystalline structures (piezoelectric materials) are formed naturally Quartz, Bone, DNA, whereas artificially Rochelle salt, Topaz, Tourmaline, Cane sugar, Berlinite (AlPO₄), Bone, Tendon, Silk, Enamel, Dentin, Barium Titanate (BaTiO₃), Lead Titanate (PbTiO₃), Potassium Niobate (KNbO₃), Lithium Niobate (LiNbO₃), Lead Zirconium Titanate (PZT) etc.

Among all these materials Lead Zirconium Titanate (PZT) is used as energy converting source in vibrations from vehicles because it has high electro mechanical coupling coefficient. It represents how much electric charge in coulombs generated in material for 1 newton force applied on piezoelectric material. For PZT, electro mechanical coupling coefficient is 560(10-12Coulombs/Newton) Means that 1Newton force applied strain produces 560(10-12Coulombs/Newton) Electric charge.

5. Piezoelectricity and their properties

As piezoelectric energy harvesting has been investigated only since the late 1990's, it remains an emerging technology. Piezoelectricity is the electric charge that accumulates in certain solid materials in response to applied mechanical stress. Piezoelectricity was discovered in 1880 by French physicists Jacques and Pierre Curie. The piezoelectric effect is understood as the linear electromechanical interaction between the mechanical and the electrical state in crystalline materials with no inversion symmetry. The piezoelectric effect is a reversible process in that materials exhibiting the direct piezoelectric effect (the internal generation of electrical charge resulting from an applied mechanical force) also exhibit the reverse piezoelectric effect.

5.1. Direct and Reverse piezoelectric effect

When the crystal is mechanically strained, (here vibrations or sound energy) or when the crystal is deformed by the application of an external stress, electric charges appear on the crystal surfaces; and when the direction of the strain reverses, the polarity of the electric charge is reversed. This is called the direct piezo electric effect, and the crystals that exhibit it are classed as piezoelectric crystal.

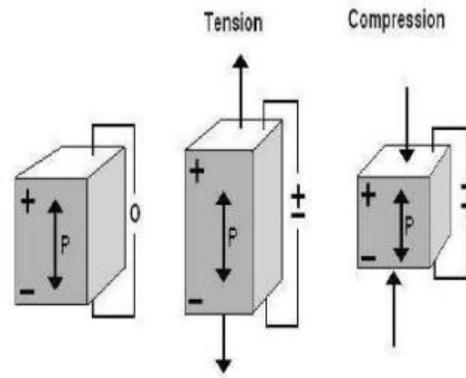


Fig 5. Direct Piezo Electric Effect

Inversely, when a piezoelectric crystal is placed in an electric field, or when charges are applied by external means to its faces, the crystal exhibits strain, i.e. the dimensions of the crystal changes. When the direction of the applied electric field is reversed, the direction of the resulting strain is reversed. This is called the inverse piezo electric effect.

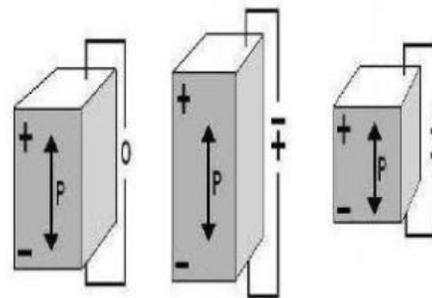


Fig 6. Inverse Piezo Electric Effect

6. Future Scope and Applications

In near future if we are able to use these kind of energy then it will cause revolution in the field of the renewable sources of energy. Due to development of new sources like sound we can overcome the deficiency of electricity that we are facing in the developing countries across the world.

- This technique can solve the problem of electricity to road lighting system, and without the need of kilometres of electrical wire which runs along the side of the road. It is more efficient operation techniques with cost effective device.
- Piezoelectric materials are capable of carrying high load and operating very high frequencies. It requires no maintenance as there are no moving parts.
- It acts as a capacitor and therefore requires very little power.



- It includes the lightening of the street lamps and traffic lights just by extracting the sound energy of the noise that is produced by the vehicles on the road. In this way we are not only able to reduce the noise pollution and but also utilize it as a source of electricity.
 - Also in the industries with the mechanical forte where very huge amount of the noise is produced as result of functioning of heavy machineries this sound can be trapped and can be used to run the low power machines used in production process.
 - If we will be able to convert sound energy to electric energy efficiently it could help us to reduce the scarcity of electrical energy globally and help in the development of mankind and reduction of CO₂ as electric energy is one of the cleanest energy.
 - The electricity produce in nuclear power station could increase as the sound produce during nuclear fission also could be used to get more electric energy.
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7. Conclusion

Piezoelectric materials have the ability to transform mechanical strain energy into electrical charge. This idea of piezoelectric energy conversion will efficiently solve the problem of charging the batteries while we are in journey and unwanted noise from the environment. This concept will help to power up any low power device even when we are travelling through some areas where there is no source of power. The sound energy is the unexplored source which has enormous potential to meet the future growing requirements of the electricity and serve as the eco-friendly and renewable source of energy.

Present scenario states that researchers are continuously trying to evolve effective methods in order to improve its efficiency. On the basis of these works it can be surely said that sound energy is the successor of the renewable and eco-friendly sources of energy. In this aspect a lot of research is to be done but on a positive note this could surely be done which could solve the energy problem of the entire world and has tremendous scope for future energy/ power solution toward sustainability.

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