

Conversion of Sound to Electric Energy

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Abstract— This paper presents the work done on the conversion techniques and methodologies of converting sound energy to its electrical counterpart. It focuses on the feasibility and the ground zero application of the same. The prediction of the future development of these kind of sources of energy is emphasized other than commonly known ones such as solar energy, biogas, wind energy and so on. So one can imagine if we were able to convert the sound energy to electricity then we can charge our mobile phone just by talking to our friends on mobile itself.

Index Terms— Sound energy; Phonons; Piezo-electric generators; Transducers; Diaphragm; Thermodynamics; Electromagnetic induction.

1 INTRODUCTION

THE “law of conservation of energy” states that energy cannot be created nor be destroyed. Under the consideration of this law the technological giants have discovered numerous sources to extract energy from them and use it as a source of power for conventional use.

There are various so called eco-friendly sources of energy that we have discovered till the present artificial era. Some of them are implemented to great extent under the suitable circumstances to overcome the short run of the energy due to technological boom that has led the energy needs to its apex. 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. There are various other sources of renewable energy which includes harassing energy form 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 sources to harass energy for our conventional uses.

To add to the list there is an emerging scenario which leads us to a new renewable energy source known to us since long and that is the sound. The sound or noise in other terms is present all around us. So why not use it to satisfy our needs of energy. In our basic applications we see sound be converted in the electrical signals to travel over the media for communication purposes. For example the sound energy is converted into electrical signals using diaphragm present in the microphone and these signals then reach to the speakers and then converted back to sound. The electrical current generated by a microphone is very small and referred to as MIC-level; this signal is typically measured in millivolts. Before it can be used for anything serious the signal needs to be amplified, usually to line level (typically 0.5 -2V). Application of sound energy as the source of electricity can be much beneficial for the human existence as compared to other sources. This is because the sound is present in the environment as a noise which forms an essential part of the environmental pollution. The concentration of noise to use it for power generation can lead to discovery of another hidden source of energy which can act as a boon to non-renewable sources such as coal, crude oil etc. which are on line of extinction.

2 INTRODUCTION TO SOUND ENERGY

Sound or popularly known to us as noise is one of the widely available energy sources which have its range extending almost to infinity. The noise is considered to be a great contributor in the increasing pollution which is studied under the category of noise pollution.

Let us first understand the basic definition of sound. Sound basically is mechanical wave that is an oscillation of pressure transmitted through some medium (like air or water), composed of frequencies which are within the range of hearing. Thus, considering sound as the wave we can imagine it as the flow of energy from one point to another with the help of a medium as air. The sound waves can be longitudinal as well as transverse as per direction of vibration of the sound particles called phonons.

Sound that is perceptible by humans has frequencies from about 20 Hz to 20,000 Hz. In air at standard temperature and pressure, the corresponding wavelengths of sound waves range from 17 m to 17 mm.

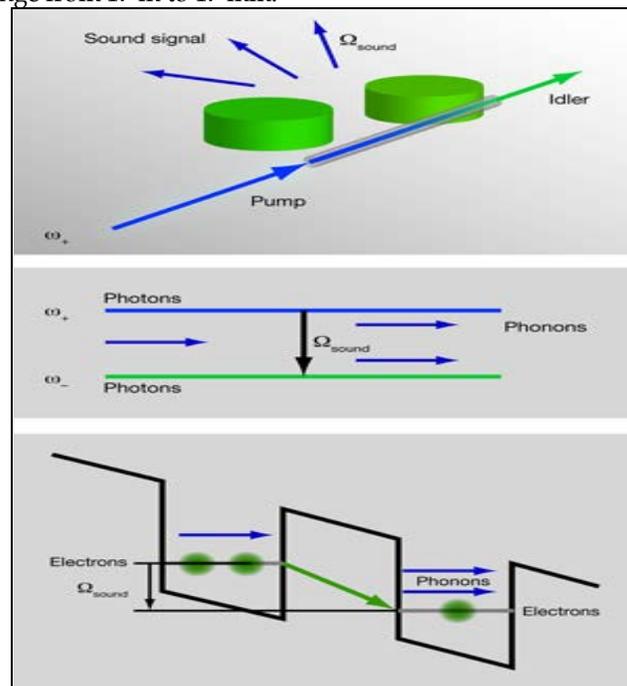


Fig 1 Propagation of Phonons in sound

But have we ever imagined sound as source of electricity? No, is the answer. This is because it was stone which was left unturned by the researchers up till now but this hidden source is now emerging as the a new era in the world of renewable sources of energy. This could be easily understood by the "law of thermodynamics" which states that the mechanical energy can be converted to electrical energy.

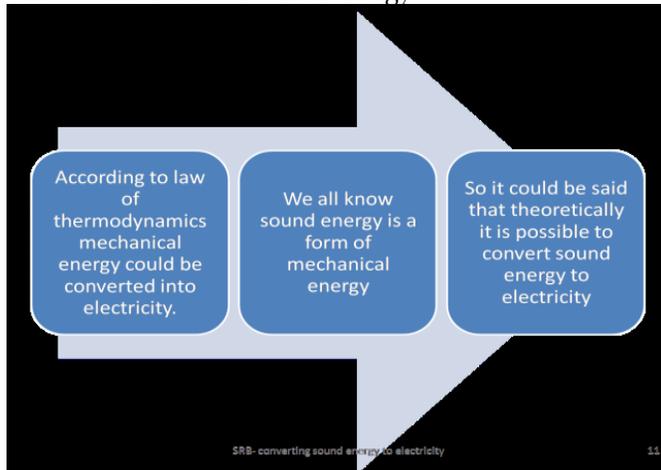


Fig 2 Transformation of energy

2.1 Practical Methods of Conversion

In our day to day life we actually come across various devices that serve the same purpose that is they convert the sound to electrical signals. For example a microphone is an example of a transducer, a device that changes information from one form to another. Sound information exists as patterns of air pressure; the microphone changes this information into patterns of electric current. The recording engineer is interested in the accuracy of this transformation, a concept he thinks of as fidelity.

The basic idea is that sound is mechanical wave. When sound travels through any medium then it disturbs the particles of that particular medium and these disturbances caused by the sound can be used to produce electricity.

The efficiency of the transducers and several such devices is quiet low and cannot be utilized for practical applications. Thus the major arena to focus is how we can increase the efficiency of the electricity produced by conversion of sound energy. Let us now see various methods by which we can make a system to convert sound to electrical energy. The basic parameters that determine the energy characteristics of noise are oscillation frequency and sound pressure.

Oscillation frequency is represented in Hertz (Hz) and the sound pressure level is represented by decibels (dB). Such electrical properties include Voltage (V), Current (I), resistance (R) and power (P). These quantities are related to each other as,

$$I=V/R,$$

$$P=V^2/R \quad (1)$$

2.1.1 METHOD 1

The first method illustrates the use of the "faradays law of electromagnetic induction" which states that the induced electromotive force (ϵ) in any closed circuit is equal to the negative of the time rate of change of the magnetic flux (Φ) through the circuit.

$$\epsilon=-d\Phi B/dt \quad (2)$$

In this method we will place a very thin layer of diaphragm which will be fluctuated by the pressure created by the sound waves. Now we can attach a conductor to the diaphragm which will be placed between the magnetic poles. So when the diaphragm oscillates then the conductor will have magnetic flux around it change and as per the faradays law the emf is induced in the conductor causing the current to flow to conductor.

Generated voltage (emf) = (Velocity of Conductor) X (Magnetic Field) X (Length of Conductor)

As the frequency of the sound waves is high thus oscillations will be fast and considerable amount of electricity could be produced. But only limitation is that we require sound of very high decibels to generate usable quantity of electric power.

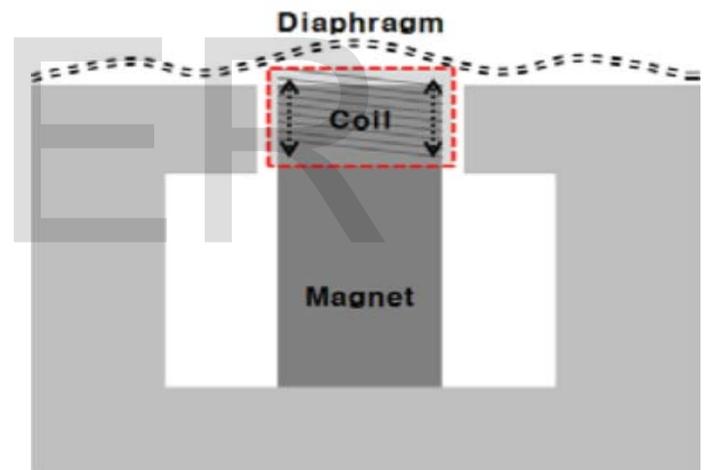


Fig 3. Noise Energy Generating Device

2.1.2 METHOD 2

The second method of converting the sound to electricity is with the use of piezoelectric materials Lead zirconium titanate, Barrium titanate, Zinc oxide.

Electricity can be generated directly from sound energy by piezoelectric effect.

The way it works is that the mechanical energy of sound is applied directly to a crystal (or possibly a ceramic) with strong piezoelectric characteristics, and the crystal will generate a small amount of voltage in response to the application of that mechanical energy (sound). What we are doing is "squeezing" the crystal. A squeeze will generate a small voltage for the duration of the squeeze. When the crystal is released, another small voltage will be generated in the opposite polarity.

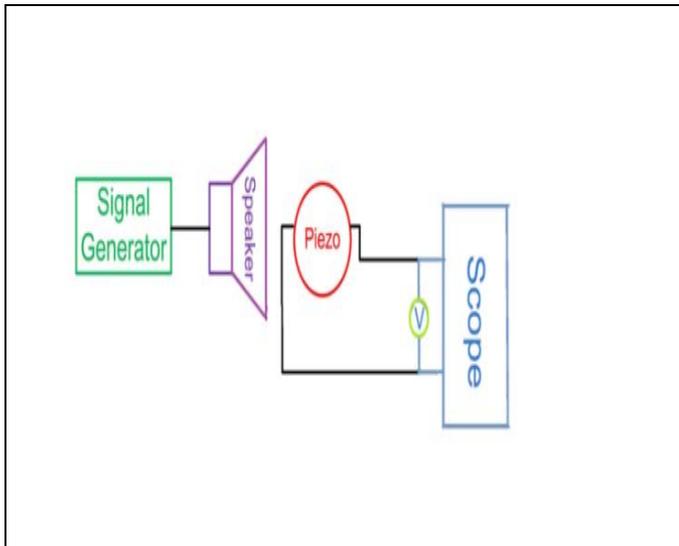


Fig 4 Energy conversion using Piezo electric material

3 PEIZOELECTRIC 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).

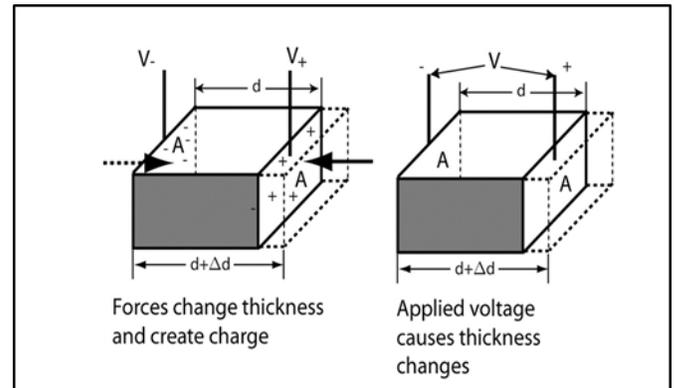


Fig 6 Peizo electric effect

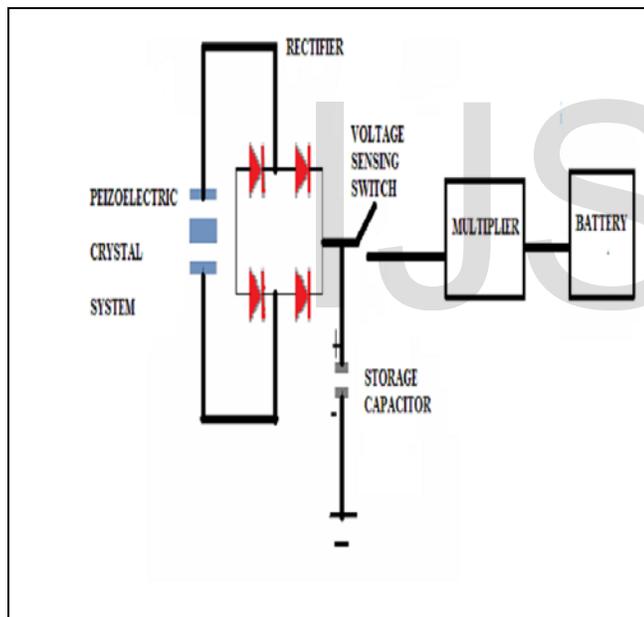


Fig 5 Circuit diagram of battery charging process

3.1 PIEZO ELECTRIC EFFECT

Piezoelectric materials exhibit intrinsic (spontaneous) polarisation. Most of the piezoelectric materials are ceramic in nature, barium titanate for example, but there are some polymeric materials that are used for specialist applications. Piezoelectric ceramics are usually polycrystalline materials that are divided up into regions of similar polarisation (domains). Once aligned, these domains produce a net polarisation. If an electric field is applied, the dipoles within the domains either contract or expand (resulting in a change in the volume). If a strain is applied, the dipoles are again forced to contract or expand, this time producing a potential difference.

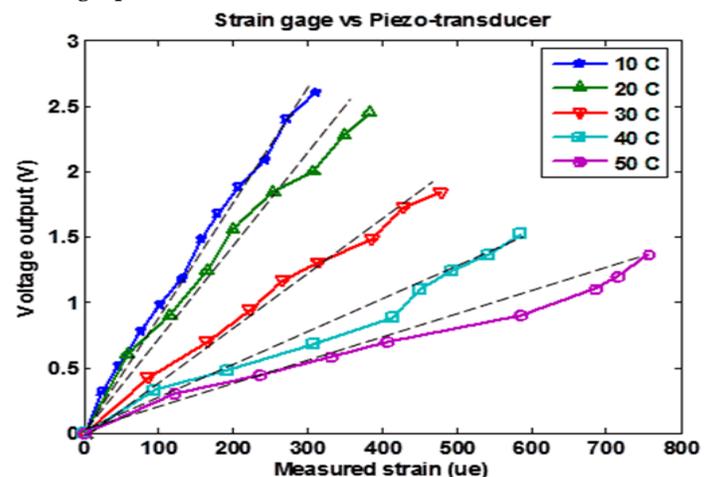


Fig 7 Relationship between strain and voltage output of piezoelectric materials at different temperatures.

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Piezoelectric materials have found applications as gas igniters, displacement transducer/accelerometers, actuators, delay lines, wave filters, and as generators of ultrasonic energy. Arrays of piezoelectric elements have been used to produce ultrasonic imaging equipment.

This link between electricity and mechanism forms the basis of the method for evolving conversion technique. The Piezo-electric materials have established a platform for mechanical energy to be utilized in novel ways such as generation of high voltages, electronic frequency generation and many other applications.

4 FUTURE SCOPE

In near future if we are able to use this 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.

With the advancement of this technology we can also imagine the charging of various battery operated devices such as our mobile phones just by making a call to a friend and talking. The mobile devices will literally satisfy their name as they will become quiet portable without much concern about their battery life.

Its other application field 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.

5 CONCLUSION

- 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.
- This technology is not practically usable up till now due to efficiency concerns but the present work on this field makes its future quiet promising.
- Phonons are the particles of sound that provide the mechanical energy as the output which could be utilized for conversion as per the laws of thermodynamics.
- There are numerous methodologies by which the sound can be converted to electricity as
 - **Method 1-** This method is based on the faradays law of electromagnetic induction and as per this method conversion of sound waves to electricity can be done using diaphragm placed between magnetic poles.
 - **Method 2-** It illustrates the use novel technology that uses Piezo-electric materials to convert mechanical energy to electrical voltage. This type of electricity is called as Piezo-electricity.

- 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 ecofriendly sources of energy.

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