ANALYSIS OF CONVERSION OF NOISE TO ELECTRICAL ENERGY IN A STADIUM

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Abstract- The constant increase in the population and development has a direct effect on the energy consumption. An energy crisis has been created due to the increased demand which can be regarded as a significant bottleneck that affects the economy. The acme of electricity demand being reached, the global energy demand is estimated to double by 2030. Despite the investment in renewable sources, integration with power grid still faces challenges. With the increase in energy demand, depletion of existing fuels and intermittency of renewable sources, efforts must be made to find alternate sources of energy. Sound energy is one such potential source. Noise when efficiently harvested can be converted into consumable electrical energy.

Index Terms- Noise, Piezoelectric, Stadium, Transducer

I. INTRODUCTION

As the world's energy demand grows, the range of energy sources continues to expand - solar, wind, biomass, and fuel cells. However, despite their growth, it will be years before they comprise of a significant percentage of our energy supply. It is likely that even after decades, the world would still depend on fossil fuels for majority of its energy demands [1]. For example, the transportation sector—the fastest area of growth for energy demand—is faced with limited, near to mid-term practical alternatives to crude oil - based fuels. In many cases, oil and natural gas also continue to provide the most readily available and cost-effective source of energy to the electric power, industrial, commercial and residential sectors, and they continue to be essential feedstock for a wide range of industrial and consumer goods. India's energy consumption is set to grow by 4.2% by 2035 [2], while becoming the largest consumer of fossil fuels. Although fossil fuels are being formed via natural processes, they are considered to be non-renewable resources and they take millions of years to form and the known usable reserves are being depleted much faster than new ones are being made. Energy conservation refers to the reducing of energy consumption through using less of an energy service. A great deal of energy is consumed for the production, refining and transportation of oil. Reducing the usage of fossil fuels will invariably reduce the energy consumption. Any stadium consists of a lot of equipments that work on electricity - flood lights and sound systems. During an event, these equipments end up consuming megawatts of electricity. A stadium is generally powered by generators so that any interruption in the grid will not affect the event taking place. A generator converts mechanical energy to electrical energy. The input mechanical energy to the generator is produced by an engine. Generator engines operate on a variety of fuels such as diesel, natural gas, or gasoline. With the rapid depletion of fossil fuels already underway, conservation of these resources is the need of the hour. A stadium is a venue where a great deal of energy of impactful noise is generated. This momentarily generated noise when channelized to make a piezoelectric transducer vibrate can generate continuous electricity. The electricity thus produced can help take some load off the generators, which in turn will contribute to the saving of resources produced from fossil fuels. This paper sheds light on the analysis of conversion of noise to electrical energy in a stadium, with the help of a piezoelectric transducer.

In this context, a sensitive analysis - considering Chinnaswamy Stadium, Bengaluru - was conducted in order to represent the relation between noise generated and electricity produced.

II. LITERATURE SURVEY

According to thermodynamics, the law of conservation of energy states that the total energy of an isolated system remains constant - it is said to be conserved over time. Energy can neither be created nor destroyed; it can be transformed from one form to another. Thusly it is possible to convert sound energy to electrical energy. Sound is produced by vibrations in a medium. It is a form of mechanical energy and requires a material medium for its propagation - longitudinal or transverse waves depending on the medium. Noise ranges from a few Hz to a thousand Hz. The average range of human hearing is from 20Hz to 20kHz.

We have come across a device which converts sound to electrical energy on a day to day basis - microphone. Every microphone has a diaphragm attached to it which moves back and forth when the sound waves are

bombarded onto it. There is a coil that is attached to the diaphragm that moves to and fro. A permanent magnet produces a magnetic field that cuts through the coil. As the coil moves to and fro through the magnetic field, an electric current flow through it. This is how sound can be converted to electrical energy using a microphone [3]. The strength of the electrical signal thus produced is given by:

Generated voltage = (Velocity of Conductor) x (Magnetic Field) x (Length of Conductor) [4].

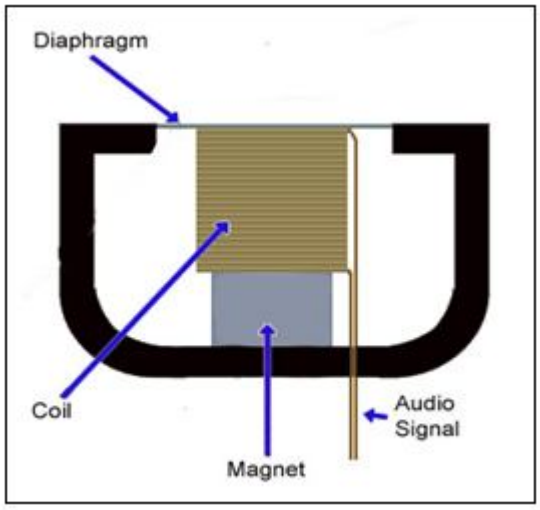


Figure 2.1 Structure of a microphone

But the efficiency of such a transducer will not suffice practically. Hence new methodologies have to be developed in order to produce electricity using sound. One such method is using piezoelectric transducers. Piezoelectric materials are used for flex, touch, vibration and shock measurement. Piezoelectric materials can take the form of a transducer or a sensor, but they all operate as a result of some degree of physical pressure placed upon them. In simple words, whenever a structure moves, it experiences acceleration. Most piezoelectric devices are piezoelectric or piezoresistive in nature [5]. The most common piezoelectric material currently in use is the man-made ceramic lead zirconate titanate, known as PZT.

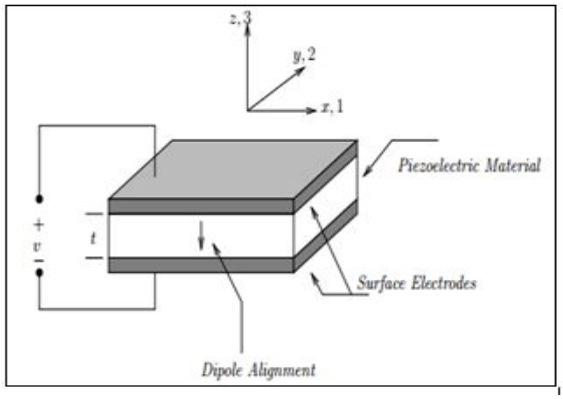


Figure2.3 Structure of piezoelectric material

Piezoelectric materials have a wide frequency range from 0.001Hz to 10^9 Hz. The impedance offered by the materials to sound is very less. These transducers are highly elastic and they can be fabricated into unusual designs. They've high mechanical strength and impact resistance [6]. The output voltage generated is really high – ten times of piezoelectric polymers.

A stadium is a place where large crowd gathering events are held. The structure is designed to accommodate spectators in large numbers to sit/stand and view the event. A tremendous amount of noise is generated by these spectators during such events.

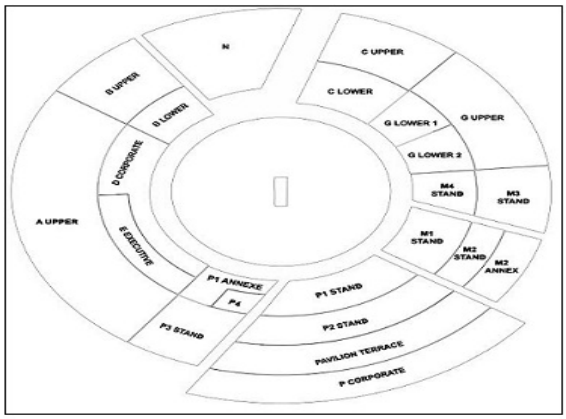


Figure 2.2 Chinnaswamy Stadium layout, (Karnataka State Cricket Association)

The relation between size of the crowd and sound power level can be written as

$K_N \alpha 10\log(N)$ (where N is the number of spectators)

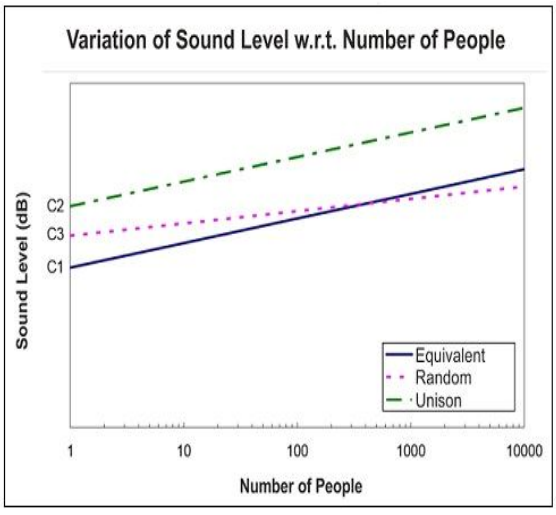


Figure 4.1 Relation between sound and number of people [7]

The average capacity of stadiums range, from 30,000 to 50,000 people. So, the noise made by these people is good enough to generate usable electricity. Considering the case of Chinnaswamy stadium (Bengaluru, India), which has a capacity of about

40,000, the above relationship holds good for the stadium since the noise made during cheering is sufficient enough to produce consumable electricity.

IMPLEMENTATION

We have come across various devices that convert sound to electrical signals. Microphone - a transducer which converts acoustical energy to electrical signals has an efficiency which is quite low and cannot be utilized for large scale practical applications. Thus, this paper focuses on the conversion of sound energy to electric energy on a large scale - stadium - using a piezoelectric transducer.

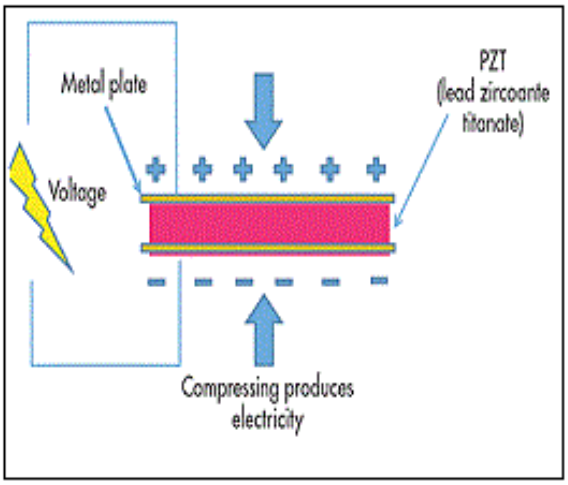


Figure 3.1 Working of a piezoelectric transducer

Piezoelectric transducers are placed around the stadium, in areas where sound is picked up easily - around the sound systems, wired mesh/pillars - near the spectators. Piezoelectric transducers are fabricated so that they can be placed on these pillars or wired mesh and also around the sound systems of the stadium.

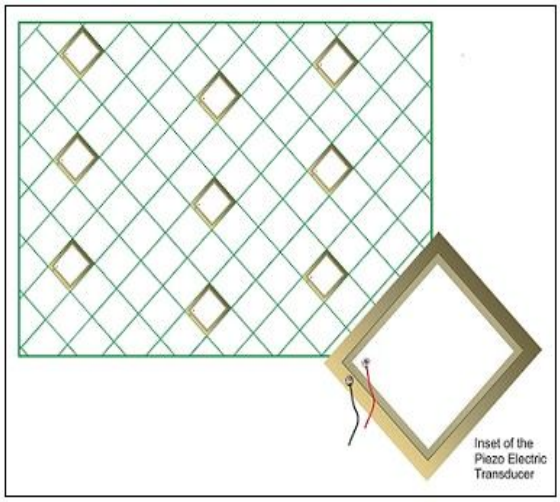
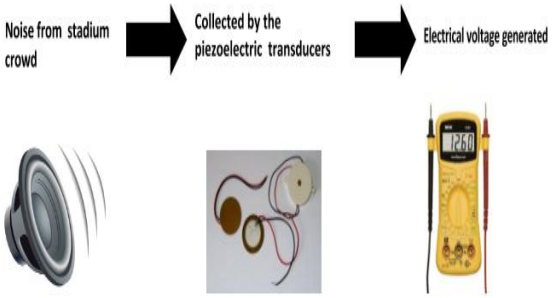


Figure 3.2 Design of the mesh

The noise generated in the stadium at different times cause the piezoelectric transducers to vibrate. The output from the transducers, drawn through the wires connected to this setup, is consumable electricity. The electricity produced can be stored in batteries - lithium ion or lead acid batteries - for future use.



RESULTS AND DISCUSSIONS

Noise generated by the spectators and the sound system together make the piezoelectric transducer vibrate because of which it creates a certain amount of voltage at the output terminals of the transducer. The graph of Sound level versus applied mechanical energy is shown in ***Figure 4.2***. This graph demonstrates the relation between mechanical energy that is applied on the piezoelectric transducer when a certain level of sound is produced in the stadium. The plot of applied mechanical energy on the piezoelectric transducer versus voltage produced is shown in ***Figure 4.3***. The graph indicates the amount of voltage obtained at the output terminals of the transducer for a particular amount of mechanical energy applied on it

NOISE GENERATED →EQUIVALENT MECHANICAL ENERGY APPLIED ON THE PIEZOELECTRIC TRANSDUCER → VOLTAGE GENERATED

The graphs clearly show that sound is a potential source of energy that plays a vital role in the generation of electrical energy.

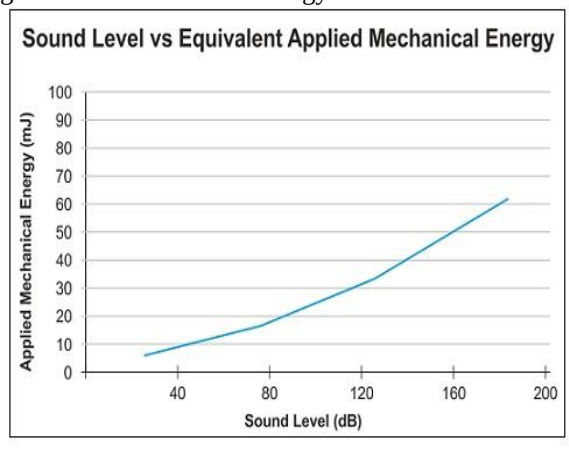


Figure4.2 Relation between sound vs mechanical energy

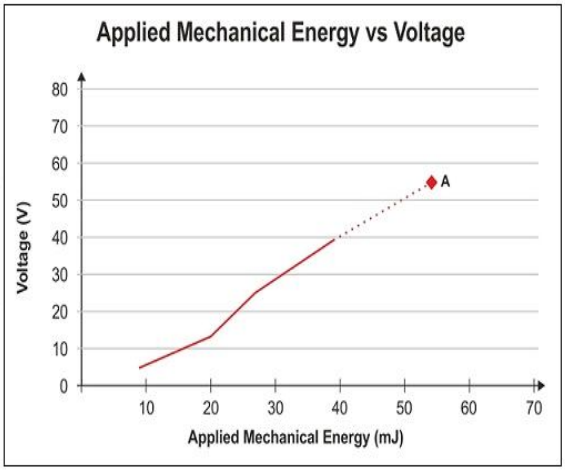


Figure4.3 Relation between mechanical energy vs voltage

The point A, in ***Figure 4.3*** refers to an arbitrary value, when the entire crowd generates noise in unison for a given amount of time that yields a peak electrical energy repetitively during the course of the event.

CONCLUSION

The paper overviews the fact that the sound energy created in a stadium can be regarded as a potential source of energy. Conversion of this sound energy into electrical energy is an unadorned measure of energy conservation. The paper has presented a discussion of factors that are to influence the electricity to be generated based on the noise emitted from the crowd in the stadium. Based upon the analysis, it has been proposed that the major factors that influence the conversion of noise to electricity involves:
1) The capacity of the stadium
2) The number of time intervals for which the maxima are obtained.

Previous studies have shown that the noise emitted in the stadium is of significance. The sound from the crowd in unison yields a greater amount of electrical energy compared to the sound created in random order.

A technique, that employs piezoelectric transducer that can be fabricated into any required design that makes the conversion possible, is presented. This technique enables the body of data to be collected that will quantify the relationship between the sound from the crowd and the electricity generated. Once this has been done, a model for every stadium for the crowd noise and electricity generated can be predicted.

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