

# A Review- Power Generation by Piezoelectric Effect Using Wind Energy

Joyal Benjamin<sup>1</sup>, Mahendra Kanade<sup>2</sup>, Mehul Jhala<sup>3</sup>, Pratik Panchal<sup>4</sup>,  
Mr. Vishal Solanki<sup>5</sup>

<sup>1-4</sup>U.G. Student, Mechanical Engineering, Sigma Institute of Engineering, Bakrol, Gujarat, India

<sup>5</sup>Assistant Professor, Mechanical Engineering, Sigma Institute of Engineering, Bakrol, Gujarat, India

## ABSTRACT

With the ever increasing demand for electricity generation, and environmental issues, humans are forced to look for some alternative energy resources, to overcome the limitations of conventional methods for power generation. One of the alternatives available is wind energy, which is utilized to generate electricity with the help of conventionally designed wind turbines. Another alternative available is harnessing the vibration energy by using piezoelectric materials, which have ability to convert mechanical strain into electrical energy. This paper presents a concise review of power generation by using the piezoelectric materials; by the use of vibration energy generated using the wind flow.

**Keywords:** Power Generation, Piezoelectric Effect, Vorticity, Wind Energy.

## I. INTRODUCTION

The growing consumption and sound increase in the cost of non renewable sources is a major concern and has forced people to look for alternative fuels that are available abundantly and are cheap which can meet the growing demand for power generation. The different alternatives available are like solar energy, wind energy, tidal energy, geothermal energy, nuclear energy etc.

Amongst these alternatives available, one of the most commonly used methods is to utilise wind energy with the help of conventional wind turbine. It is a renewable source of energy and does not have any issue which harm the environmental as it does not produce any pollutants or emissions of any harmful gases during its operation which could damage the environment other than those required for maintenance. In the past few decades, many

efficient designs have been produced for the conventional type wind turbines which have produced increased power generation capacity of the wind turbines. Besides these improvements in design and for increasing its efficiency, there are many issues related to the windmills which are forcing us to look forward for some exceptional design for utilizing the wind energy.

One of the major issues with the conventional wind power generation is the huge size and heavy weight of the wind mills. The height is of nearly 100 meters and blade radius of around 60 meters, which requires a huge area for its operation and can weigh up to 100 tonnes. The other major problem is the transportation of its components. Due to huge size and heavy weight of its components, it requires specialized trucks and straight, wide roads, which increases transportation cost. Also the cost of installation is significantly high. Along with all these limitations, it is subjected to vibrations due to

movement of internal components as well as due to wind flow at that much height, due to which it requires strong base establishment.

One alternative energy resources is utilising waste energy of vibration. The vibration energy can then be used to convert to electricity by the use of piezoelectric materials which generate electricity when mechanically strained. Although the power generation by such method will be of smaller magnitude but it can be of great use for micro power based electronics instruments such as sensors even in remote areas. These vibrations can be produced by utilising the wind flow through the use of principle of vorticity. This kind of solution will help to overcome the limitations of wind turbines particularly reducing size, weight and ultimately the manufacturing as well as the installation cost.

## II. EXISTING TECHNOLOGIES FOR ENERGY HARVESTING

### A. Energy from sea waves

Energy harvesting from sea is not a new concept and many proposal and projects [1]-[3] have been made using wave movements. The author has presented model [4] for energy harvesting using the impact caused due to the waves. In sea areas, where there are some sensors, the problem to supply them with power arises. So in order to solve this problem a small power generating mechanism is presented. It consists of two piezoelectric disks instead of piezoelectric cantilevers. Between these disks there is a mass attached to a rod. With the sea waves the mass gets deflected and strikes the disks alternatively thus generating electricity from piezoelectric materials. The power generated is in mW only.

Micro ocean renewable energy harvesting [5] deals with the development of self electricity generating devices. The three kinetic energy harnessing technologies described are: Piezoelectric-ceramic devices, rotary magnetic generator, and linear

magnetic generator. Various advantages and disadvantages of each individual's technologies have been represented and modeling and analysis each of the technologies has been presented.

### B. Energy from rain drops impact

Energy harvesting from the raindrops impact has been a focus of many researches over recent years. One method of energy harvesting from rain drop impact [6] is with the help of piezoelectric materials. The paper [6] deals with the study of the impact of the rain drops on a piezoelectric energy harvester and checking the feasibility of the proposed method. Impacts of the raindrops were tested by varying the height to replicate the showers and detailed results were obtained.

### C. Energy harvesting from walking

Theoretical model for the energy generation using piezoelectric material is presented in the paper [7]. Two models are explained - one regarding the energy harvesting in food court. Second is harvesting vehicle energy in MIT campus. Several examples are present in which micro scale power is generated through walking [8]-[11]. One of them energy harvesting through shoe using the MONNIE HARVESTER [12] which is a metal ceramic composite transducer that has been developed by sandwiching a poled lead zirconate titanate (PZT) ceramic between two specially designed metal end caps. The force on the heel presses the curved plates which in turn expand the piezoelectric disk sandwiched in between the steel plate thus generating little power.

The energy harvested by the Pavegen [13] is also a technique to harvest energy from walking. This power can be used to light pedestrian light or signal lights etc. The top and bottom base surface of the flooring unit is made from 100% recycled rubber and 80% recycled materials. The system can be

simply designed or can even be established in existing floor space.

#### **D. Energy harvesting from transportation**

Innowattech [14] had developed an alternative energy system that harvests mechanical energy imparted on the roadways, railways and runways from passing vehicles, trains and pedestrian traffic and converts it into electricity. The system, is based on a new breed of piezoelectric generators, and can harvests energy that ordinarily goes in waste if not used.

Airports [15] and railways can be vital transportation hubs that could be greatly benefit from new energy technologies. Best example is the East Japan Railway Company (JR East) [16], which conducted a demonstration experiment from January 19 to March 7, 2008, at Yaesu North Gate, Tokyo Station, on a new power-generating floor. They have installed at the ticket gate area, which generates electricity from the vibrations created by passengers walking through the ticket gates.

#### **E. Energy from wind**

The bladeless turbine [17] developed by the Hampshire Company naming it as Fuller turbine. It consists of an array of closely spaced parallel thin metal, disk separated by small space. This is placed in a aerodynamically designed cavity. When wind enters through cavity opening they get into the space between disks which causes to move them. It's compact and can be used for domestic, purposes also. Also it can be used in geothermal energy generation.

In this paper [18] author has described the disadvantages of the conventional wind mills and then the advantages of the vortex blades. Various parts of the blade less turbines are described like base, spring, mast, thread, generator, battery etc. It used Gyro e generator which works on principle of

gyroscopic effect to convert the linear motion to rotary motion to generate electricity.

Wind is a prominent source that has been already in use science long back, used in large scale power generation but is less developed at smaller scale, especially by piezoelectric harvesters. The paper [19] presents several approaches to harvest wind energy for low power wind flows by using flexible piezoelectric films [20].The available power generation calculations [21] have been done theoretically and experimentally by using various piezo-film geometries.

It deals with using of the wind as an energy source for micro watt energy harvesters inspired by the trees branches moving in the winds [22]. It describes about a linear arrangement of the four cylinder attached to the piezoelectric transducers. Various measurements were taken and were found that peak power was generated using cylinders for 3.3diameter, centre to centre spacing and flow speed and relative position of the cylinders. Other parameters were studies varying the cylinders positions.

#### **F. Energy from liquid flow.**

The kinetic energy due to water flow can be a source of energy that can also be harvested by using piezoelectric harvesters [23]-[25].A new energy harvesting device based on flow induced vibration was developed. Another harvester is assembled by using macro fiber piezoelectric composite, which is fish like bimorph.

This paper deals with the design and development of energy harvester using the Fluid induced vibrations-FIV [26]. The prototype used was consisting of a cantilever piezoelectric material on top of which a cylinder was mounted, and the Cantilever was robust to the base. The cylinder causes obstruction in fluid flow causing FIV and starts vibrating, which are then converted to

electricity. Various tests were performed for turbulent and laminar flow and graphs were plotted.

The study of Vortex induced Vibration [27] for harvesting Energy is a paper for studying the scope and feasibility of the bladeless turbines. A model of bladeless turbine has been prepared which consists of a mast mounted on a base on which wind is allowed to flow normally, resulting into a vortex flow around it which sets up vibration and can be converted to electricity by proper mechanism [28]. Also calculation of power generation capacity is done by varying the mast size. Thus concluded that VIV application in generating alternative energy is a viable solution of the current energy crisis.

### III. SUMMARY

In this paper energy harvesting technologies by either use of wind energy or piezoelectric materials has been summarized. From this paper we have anticipated that piezoelectric materials have a wide range of application in day to day life and have tremendous scope in the energy generation sectors with few of the developed technologies as described in above section. The most commonly used material was PZT due to its high power density, compared to other piezoelectric material. One more important point derived from this paper is that the power generation range in piezoelectric materials is in mW, which makes its highly effective for use in micro scale power consuming devices like the electronics sensors. However by appropriate combination of piezoelectric materials in parallel connection this power density can be increased. The power density is directly proportional to the mechanical strain on the piezoelectric materials. Thus with proper mechanism for producing vibrations from wind flow and converting it to electricity by piezoelectric material is possible to a limiting power density in range of Watts.

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