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WIND ENERGY INTEGRATION BY BLADELESS WINDMILL

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Abstract: In recent years, the Non-Renewable energy sources are dwindling day by day, so we are in such a position to produce energy by using renewable energy by utilizing renewable energy sources. The conventional blade wind turbines are used to produce energy but its cost is very high and it has many disadvantages such as capital cost, running cost, friction loss and it is also dangerous to birds and is noisy as well. Hence, there is a need to produce a low-priced and safe replacement for conventional windmills. The concept of bladeless windmill works on the principle of vortex shedding effect. Vortex bladeless windmills are a wind powered generator that generates electricity with minimum moving parts. It generates the electric current by using the oscillation or vibrations produced due to the wind. It works on the principle of Vortex induced vibrations (VIV). Hence, the electricity is generated by using linear alternator or piezoelectric material. Usually, structures are designed to minimize vortex induced vibrations in order to minimize mechanical failures. But here, we try to increase and capture the vortex induced vibrations (VIV) with maximum deflection of bladeless windmills which is used to produce electricity with experimental and geometrical approach. Utilizing piezoelectric technology as a clean energy which conserves the environment and reduces greenhouse gas emissions produced from the fossil fuel combustion. This low cost power production assists in reducing electricity bills for the retail consumers. Piezoelectric power production has been applied in limited projects and it has a greater potential growth in the modern world.

Keywords: **Bladeless windmills, deflection, renewable energy source, Vortex shedding, Vortex induced vibration, piezoelectric transducer.**

INTRODUCTION :

Energy harvesting is defined as capturing minute amounts of energy from one or more of the surrounding energy sources. Human beings have already started to use energy harvesting technology in the form of solar, hydroelectric, geothermal and wind energy. This energy production is possible by utilizing natural sources, termed as renewable sources of energy. Renewable energy harvesting plants generate kW or MW level power; it is called macro energy harvesting technology. Moreover, micro energy also can be produced from those natural sources that are called micro energy harvesting. Micro energy harvesting technology is based on mechanical vibration [3], mechanical stress and strain, thermal energy from furnaces, heaters and friction sources, sunlight or room light, human body, chemical or biological sources, which can generate mW or μW level power. Micro power supply needs are increasing greatly with time as our technology is moving to the micro and Nano fabrication levels. Our discussion on this is based on generating micro energy from vibration and pressure using piezoelectric material.

A windmill is a device which converts the kinetic energy (flow) of wind into electrical energy. There are two types of windmill based upon operating phenomena, they are rotational windmills and oscillation based windmills. The Rotational windmills are nothing but the conventional windmill. In this type, the rotating turbine blades are mounted on the shaft coupled with a gearbox at the nacelle. This gearbox converts the rotational energy of blades into mechanical energy. A generator is used to convert mechanical energy from the gearbox into electrical energy in suitable form. Rotational windmills are effectively used in commercial applications because of their effectiveness and efficiency at larger scale operations. The Oscillation based windmills are used to produce less amount of electrical energy that's why it is not used in commercial applications. Its main advantage is that it has less moving parts, less space is required for installation, light in weight and cost is low because of absence of blades and gearbox. This type of windmill is based on the theory of vortex induced vibrations (VIV)[4-7]. **Vortex shedding** is a phenomenon, when the wind blows across a structural member, **vortices** are **shed** alternately from one side to the other, and where alternating low-pressure zones are generated on the downwind side of the structure giving rise to a fluctuating force acting at right angles to the wind direction.

In the oscillation type windmills, the most suitable geometrically airfoil shape is cylindrical. The cylinder produces the effect of VIV because of its symmetry along its center line. As some velocity of air is passing on a cylinder which is placed vertically, it starts to oscillate in the horizontal direction due to air force or velocity of air and which is hanging by a spring or any supporting

element like light rod. These oscillations are nothing but the mechanical motions due to the velocity wind flow that must be transferred into electrical energy. The oscillating windmills generate electricity with the application of VIV principle, we are required to convert linear mechanical motion into voltage. Oscillation type windmills are more suitable for small-scale windmills.

PRINCIPLE OF OPERATION :

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In vortex-induced vibrations (VIV)(figure 1), the motions carried by the body due to an external fluid flow start to oscillate. For example, A cylinder which is placed in a wind of definite velocity as the air strikes in the perpendicular direction to the center axis of a cylinder the vortex induced vibrations are produced. Hence the fluids always have some viscosity, when the flow comes in contact with the cylinder then will be slowed down and forming the boundary layer. Because of the curvature of the body, the boundary layer will be separated at some point. Vortices are then formed changing the pressure distribution along the surface. When the body is not formed symmetrically around to its midplane then due to this reason different lift forces are developed on each side of the body, hence it tends to convert motion transverse to the flow. This motion changes the nature of the vortex formation in such a way as to lead to limited motion amplitude.

The function of VIV airfoils is to the production of lift forces in two directions which is perpendicular to airflow. Due to this, the airfoil must be symmetrical with the vertical cross-section for the analysis purpose as shown in figure 1.

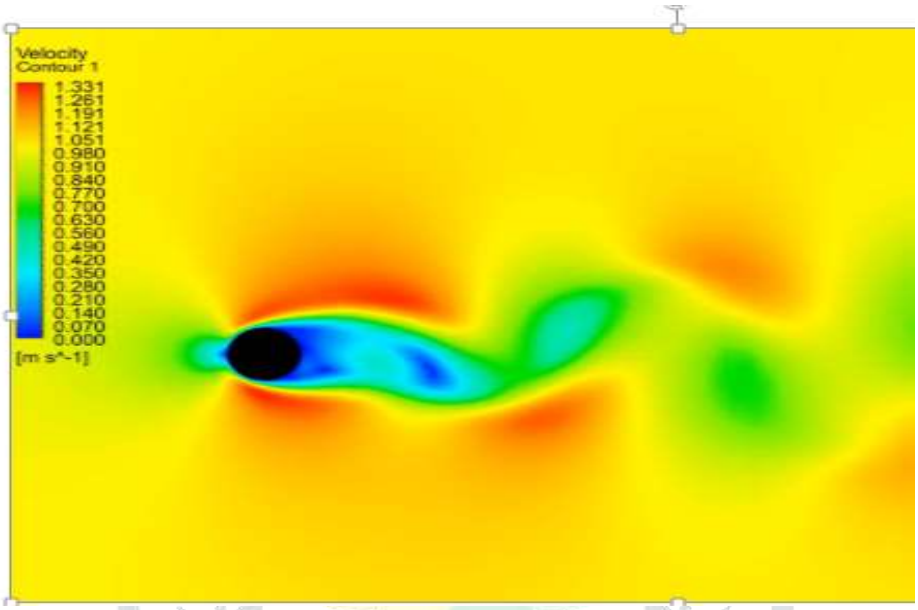


Figure 1 - Vortex Induced Oscillation

The transducer converts one of energy into the other form of energy. Here, piezoelectric transducers (figure 2) are implemented to convert mechanical energy into electric energy. A piezoelectric transducer is a device that uses the piezoelectric effect to measure changes in pressure, acceleration, temperature, strain, or force by converting them to an electrical charge. Piezoelectric material has a crystalline structure. When we give mechanical strain it will convert it into electrical energy. Due to piezoelectric material it will be converted into electrical energy in the form of AC. The obtained AC is not in steady state so a bridge rectifier is used to convert variable AC to constant DC and stored in the battery.

The main factors that affect piezoelectric technology usage are output power per oscillation, battery storage, cost, consumption facility. Proposal was supported by using different case studies to clarify the sequence and the reliability of the proposal. Aim of this Project is reaching a guide as a tool for architecture designers to facilitate embedding this technology in their designs as a part of the demanded low energy consumption in the buildings.

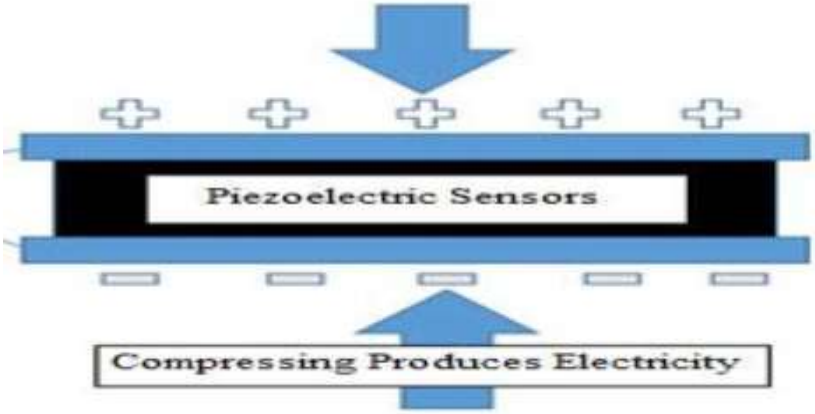
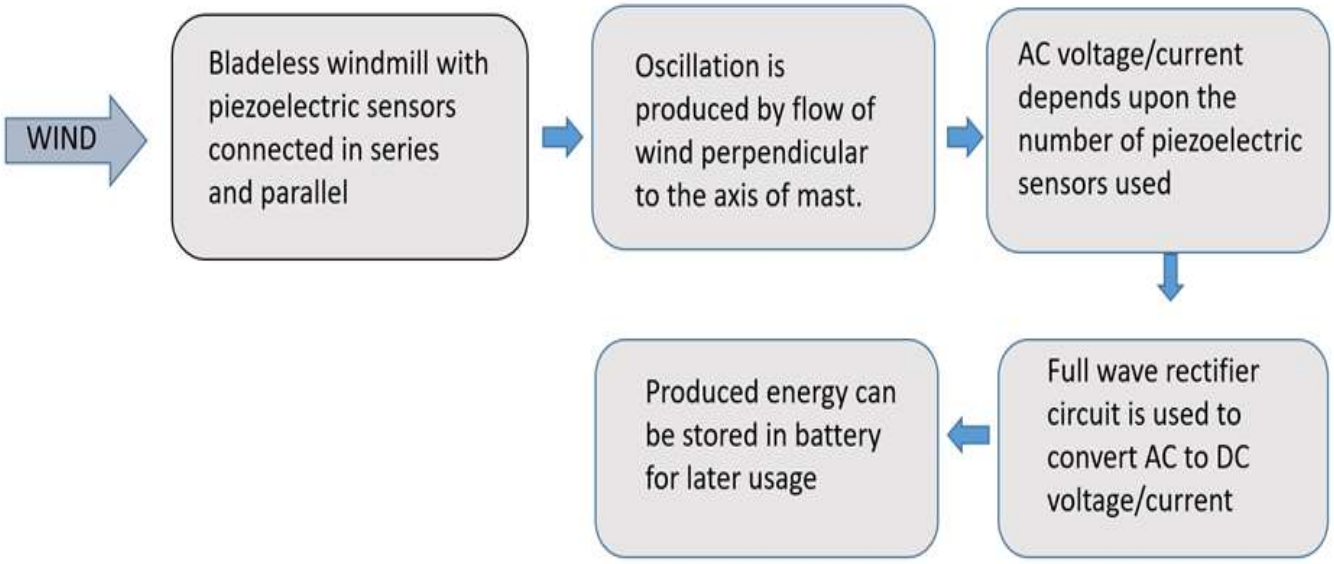


Figure 2 - Piezoelectric Power Generation

COMPONENTS AND DESCRIPTION :

S.NO	COMPONENTS	DESCRIPTION
1	Polyvinyl Chloride (PVC) pipe	Rigid structure on the top which obstructs the wind flow creating vortices.
2	Spring	Used as a support and balances the mast during oscillation.
3	Piezoelectric transducer	Converts mechanical strain into AC voltage.
4	Multi meter	Used to measure voltage produced.
5	Full wave Rectifier	Converts the AC voltage into DC voltage.
6	Mild steel rods	Used as a main frame to the setup.
7	Connecting Wires	Used to connect the circuit components.

METHODOLOGY :



DESIGN AND CALCULATION :

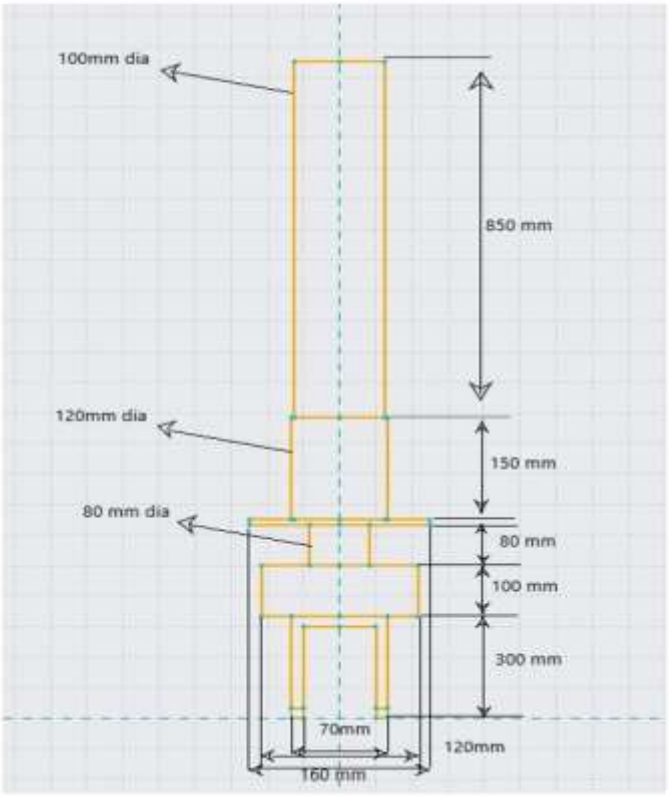


Figure 3 - 2D diagram

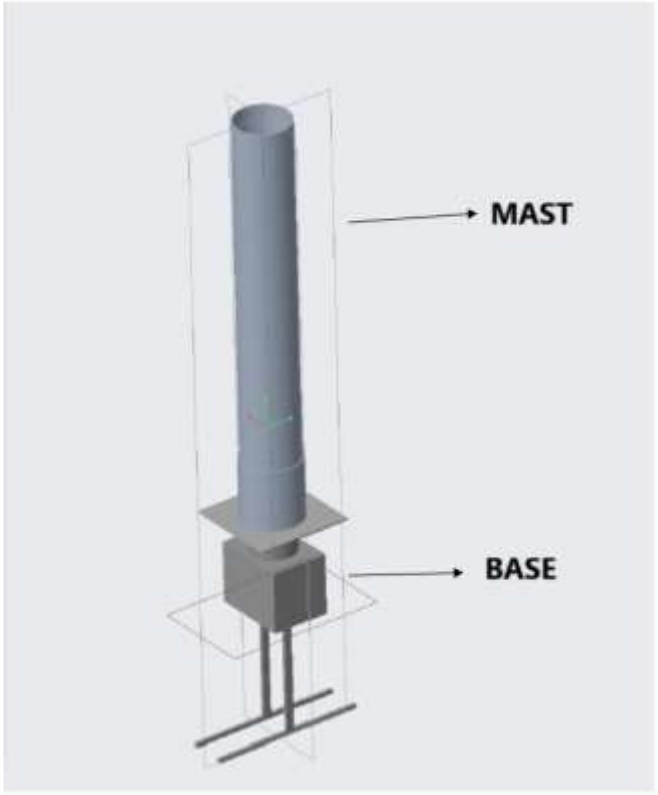


Figure 4 - 3D Design

Power produced in piezoelectric transducer,

Output voltage of piezoelectric crystal can be calculated by using formula;

$$V = P \times g \times t$$

Where,

P is the pressure applied in N/(sq.m)

g is the sensitivity of the material (40pc/N)

t is the thickness of the material

V is output voltage

Surface area of mast exposed to wind,

Diameter of the Mast, D = 100 mm

Length of the Mast, L = 1000 mm

S = (1/2)*3.14*D*L

= (1/2)*3.14*100*1000

= 157000 sq.mm

Force of the wind on the projected area,

$$F = \rho \times A \times v$$

Where,

P is the air density(1.225kg/cu.m)

A is the surface area of mast exposed to wind

V is the velocity of wind

Voltage Generated,

When a force is applied on piezo material, a charge is generated across it. Thus, it can be assumed to be an ideal capacitor. Thus, all equations governing capacitors can be applied to it. In this project,, we connect 2 piezo in series.2 such series connections are connected in parallel. Thus when 2 piezoelectric discs are connected in series, its equivalent capacitance becomes:

$$1/Ceq = 1/C1 + 1/C2$$

We know that, Q = C * V , therefore C = Q/V

Hence, Veq /Q = V1/Q + V2/Q

Thus, Veq = V1 + V2

Hence, the net voltage generated in series connection is the sum of individual voltages generated across each piezoelectric disc. Output voltage from 1 piezo disc is 4V.

Veq = 4 + 4 = 8V

RESULT AND ANALYSIS :

The samples of the Vortex bladeless windmill were tested in an open environment at 10 ft. height of building to check the maximum deflection. Firstly the windmill was mounted on the rigid fixture; it was observed that on application of air velocity the windmill began to deflect with 7-30 mm.

Wind Speed (m/s)	Deflection (mm)	Current (mA)	Voltage (V)
8	7.891	2.798	0.7
10	8.254	3.125	1.2
12	12.568	4.758	2.76
15	18.257	8.114	4.123
18	24.66	11.234	6.587
20	29.233	14.5487	8.159

Table 1- Comparison Of Various Parameters of Bladeless windmill

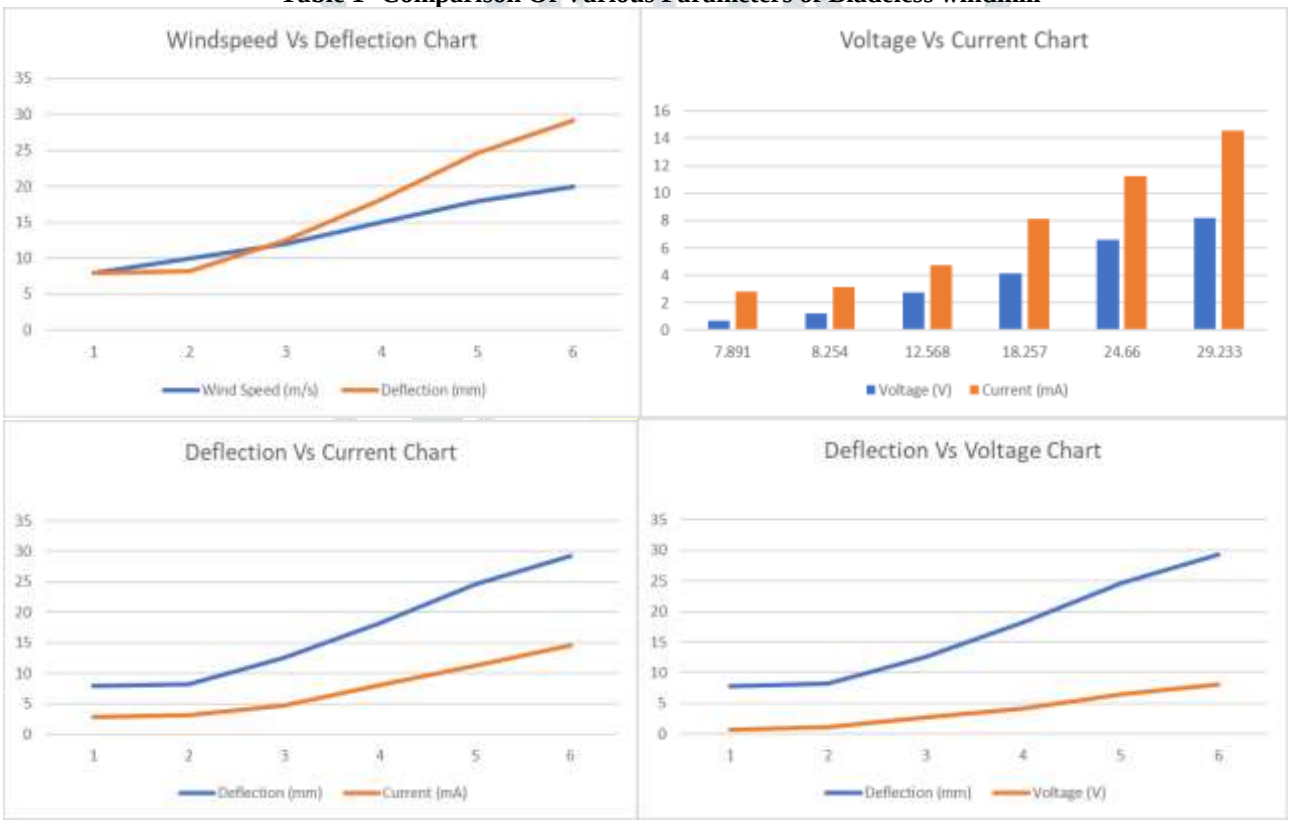


Figure 5 - Various performance curves of Bladeless windmill

CONCLUSION :

Vortex bladeless windmill is mostly used in small applications where less amount of electricity is required. It is the most preferable solution as compared to conventional windmills due to it being simple in construction, easy to design, easy to manufacture and less space required. The main advantage is that it requires low maintenance cost because of less moving parts. The overall project consumes little space. The purpose of this paper is to provide some fundamental results on the bladeless wind system and serve as stepping stones for the future development of bladeless wind power generating systems. The Forces that are beneficial or useful to generate power in bladeless are different from those in conventional horizontal axial wind turbines. For future use of this project work, we can use this type of windmill for home appliances or where less amount of electricity is required. This project will satisfy the need for continuous generation of electricity.

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