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Bladeless Windmill Power Generation: A Review

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Abstract: Bladeless windmills use a radically new approach to capture wind energy. The working principle of this device is, when wind bypasses a fixed structure, its flow changes and generates a cyclical pattern of vortices. Once these forces are strong enough, the fixed structure starts oscillating. Consequently, these aerodynamic instabilities can be utilized for power generation. A uni-directional gear mechanism for converting the oscillatory motion into uni-directional rotation of the gear mechanism is used for this device. A slight oscillation in clockwise and anti clockwise directions can give many number of rotations in single direction at the generator. The design of this device is completely different from traditional windmills. Instead of usual tower and blades, this device uses an oscillating mast, and a gear mechanism for getting the output.
Keywords: Bladeless, vortex, oscillation, unidirectional, power.

I. INTRODUCTION

Windmills are contributing significantly in the world's energy budget. But if we have a look at it, we come to know that, they even pose many problems such as high space requirement, high maintenance cost, danger to bird's habitat, high noise during operation. Bladeless windmills can resolve these issues and could represent a more efficient method of power generation.

The Vortex Street effect was first described and mathematically formalized by Theodore von Karman, the genius of aeronautics, in 1911. This effect is produced by lateral forces of the wind on any fixed object immersed in a laminar flow. The wind flow bypasses the object, generating a cyclical pattern of vortices, which can become an engineering challenge for any vertical cylindrical structures, such as towers, masts and chimneys. The issue is that they may start vibrating, enter into resonance with the lateral forces of the wind, and ultimately collapse. One such example is the collapse of three cooling towers of the Ferrybridge power station just about two miles west north-west of Knottingly, Yorks in 1965 [4]. However, it is possible that the same forces can be captured to produce energy - the idea behind Vortex. When a semi-rigid structure enters into a horizontal laminar air flow, it begins to vibrate under the influence of the lateral forces generated by the vortex street. When the frequency of vortex occurrence in the atmosphere matches the natural frequency of the structure, it enters into resonance, maximizing the amplitude of vibration and coincidentally the power generation capability we are interested in. The natural frequency of any object is limited and would only enter resonance, vibrate at certain wind speeds. It may start oscillating, may enter into resonance with the lateral forces of the wind, and even collapse. There is a classic academic example of the Tacoma Narrows Bridge, which collapsed three months after its inauguration because of the Vortex shedding effect as well as effects of flattering and galloping [5]. Instead of avoiding these aerodynamic instabilities the new approach maximizes the resulting oscillation and captures that energy. Naturally, the design of this device is completely different from a traditional turbine. Instead of the usual tower, nacelle and blades, this device makes use of a mast which is hollow, lightweight and semi-rigid fiberglass cylinder.

Bladeless Turbines use a radically new approach to capturing wind energy. It captures the energy of vorticity, an aerodynamic effect that has plagued structural engineers and architects for ages (vortex shedding effect). As the wind bypasses a fixed structure, its flow changes and generates a cyclical pattern of vortices. Once these forces are strong enough, the fixed structure starts oscillating. Consequently, these aerodynamic instabilities can be utilized for power generation [3].

II. OBJECTIVES

A. To generate the electricity at low maintenance and operating costs.
B. To reduce the space required for its installation.
C. To make it environment friendly.

III. METHODOLOGY AND WORKING

A. Principle of Operation

The main principle of working of this device is, 'The bladeless windmills captures the energy from the wind by a phenomenon produced by an aerodynamic effect called vortex shedding, i.e. When wind bypasses a fixed structure, its flow changes and generates a cyclical pattern of vortices. Once these forces are strong enough, the fixed structure starts oscillating. Consequently, these aerodynamic instabilities can be utilized for power generation' [1].

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B. Methodology and Detail Operation

Here in this bladeless wind generator the linear oscillation of the mast is converted to rotational motion of gears in one direction. As the mast is subjected to wind energy, it tends to oscillate due to the vortices formed around the structure of the mast, which can be converted to rotational force to generate electricity.

The mast is made up of a very light material, but should have enough strength to withstand the wind forces. It is designed in such a way that the top portion diameter is big, while the bottom portion has a smaller diameter. The outer conical portion of the mast is designed to be substantially rigid and has the ability to oscillate, remaining anchored to the bottom rod. (Refer Fig-4). This mast is fixed on the top of the semi-circular big gear as shown in the figure-2 below. This gear is further connected to the uni-directional gear mechanism with the help of a small gear.

When the wind strikes the mast, it starts to oscillate due to the vortices formed around the structure and suspension springs placed on either sides of the mast at the bottom. These springs hold the mast at the center. When the wind strikes the mast, it tilts on one side allowing the spring to operate and pull it back. Due to this action of spring the mast may tilt on the other side allowing the spring to operate and pull it back further. This action will drive the uni-directional gear mechanism, (Refer Fig-3) which is coupled to the drive pulley, which in turn will rotate the driven pulley mounted on the generator to produce electricity.

The energy generated is stored in the battery which is used when required. The output of the energy generated can be stored in the battery and used to glow LED bulbs, charging a mobile through regulator IC, glowing an LED tube light, etc.

In the design shown below, when the mast is tilted to 30 to 40 degrees towards one side, approximately 18 teeth of the big gear will get engaged with the driven spur gear having 10 teeth, hence the ratio here will be 18/10 = 1.8. Next the rotations from the driven spur gear are converted into same direction by the uni-directional mechanism which comprises two spur gears and two ratchet mechanism free wheels that are being coupled to each other and mounted on two set of axles. Further a pulley of 90 mm diameter drives the small pulley of size 12 mm connected to the generator. The ratio obtained here will be 90/12 = 7.5.

Thus the total final ratio of gears and pulley obtained will be = 1.8 x 7.5 = 13.5 rotations. For each oscillation of mast towards one direction, 13.5 rotations are obtained at the generator and the opposite direction another 13.5 rotations. Therefore the total number of rotations will be 13.5x2= 27 rotations. Hence the generator will be continuously working.

The generated energy is stored in the battery which is used when required. Here we are showing the output by glowing high watt LEDs during oscillation and from stored energy from battery we are charging a mobile through regulator IC, glowing an LED tube light

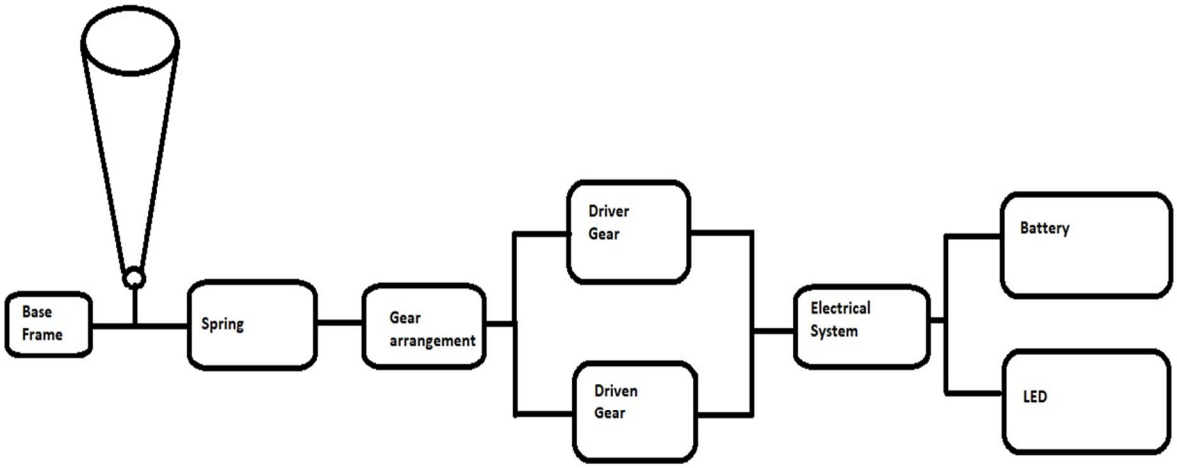

Fig:-1 Block Diagram showing components of Bladeless windmills.

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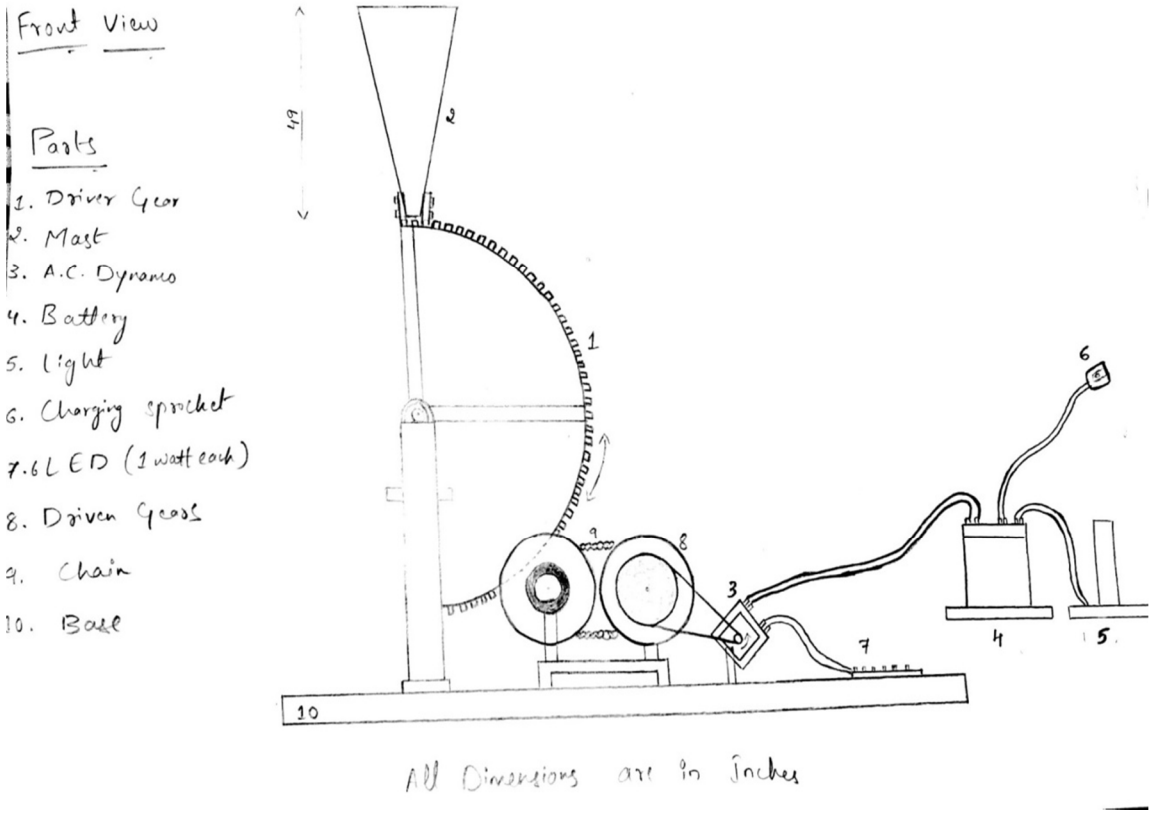

Fig:-2 Sketch showing components of Bladeless windmills.

Fig:-3 Uni directional Gear Mechanism used in the design

Fig:-4 Mast

IV. ADVANTAGES

A. This device works at low wind pressures also.
B. It improves the efficiency of wind power generation.
C. It produces clean energy.
D. It is very helpful in rural areas for electrification purpose.
E. The cost of the device is reduced since the use of blades is avoided, instead a mast is used.
F. It produces less noise during operation.
G. The design eliminates most of the mechanical elements that can suffer wear and tear from friction, leading to an estimated 50% reduction in the maintenance costs compared to traditional wind turbine.
H. It occupies less space as compared to conventional wind turbine.
I. Environmental effects on human, birds and other flying animals are almost zero.

V. APPLICATIONS

A. Bladeless wind energy can be used in a variety of industries and applications including marine off-grid systems, industrial applications, and mobile base station for houses, school and farms.
B. It can be used in farming, for powering electric fencing, powering water pumping, and powering lighting in fields.
C. Powering lighting in farms and farm houses.
D. Small scale bladeless wind turbine energy can be developed for household applications.

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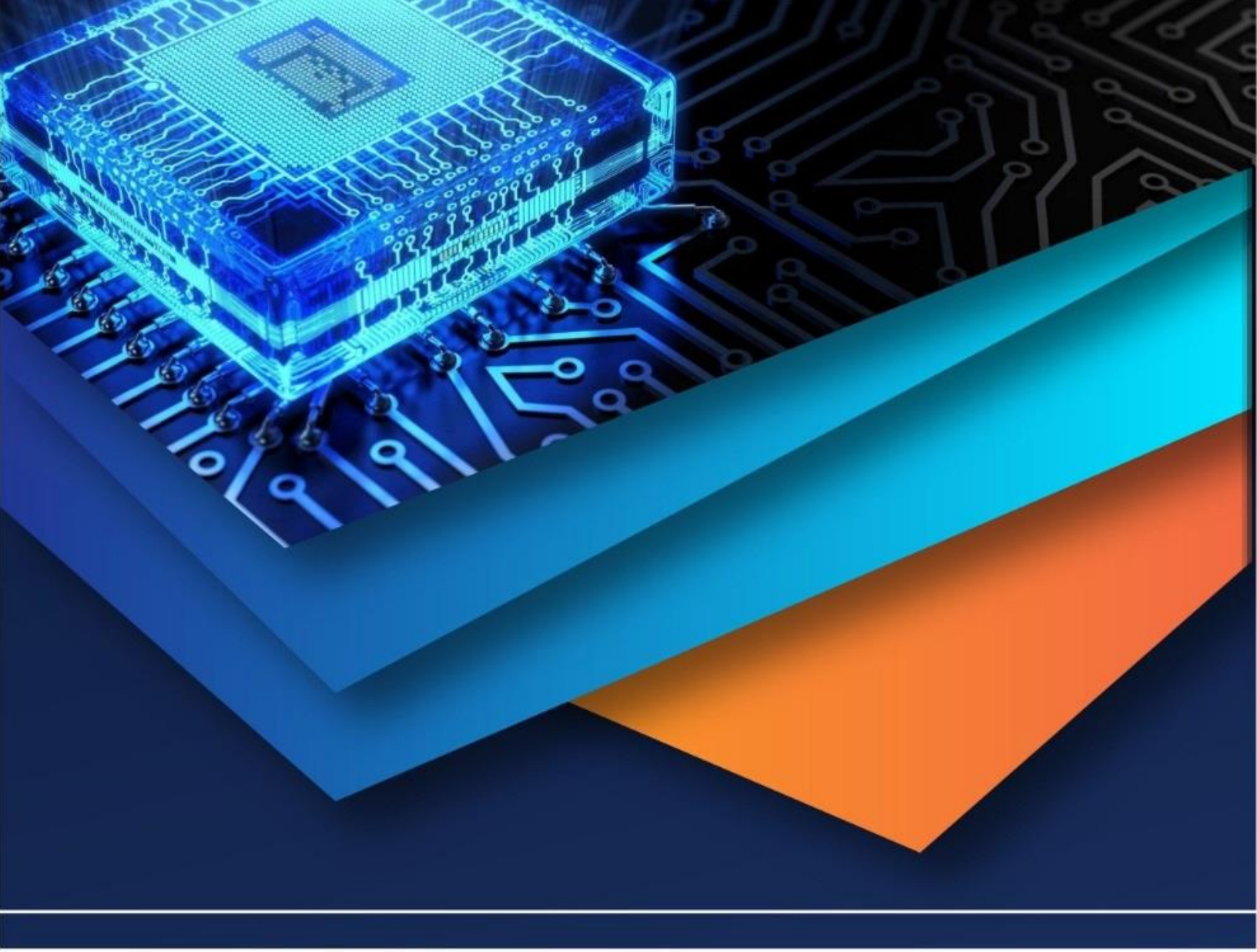

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