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REVIEW PAPER ON BLADELESS WIND TURBINE

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***Abstract*:-** As World is focused upon achieving sustainable goals and enriching its environmental conditions, it is necessary to exploit the renewable sources of energy for fulfilling energy requirements. This paper focuses on a innovative concept of harnessing wind energy. Bladeless Wind Turbine is basically a rod like structure which vibrates due to the flow of wind and it converts the vibrations into the energy. The phenomenon it uses is vortex induced vibration due to resonation of the structure. This paper shows the components used in bladeless wind turbine and the work principle of it. The progress of bladeless wind turbine and various researches going on to commercialized this technology is also discussed in this paper.

Index Terms - ***Vortex Induced vibration, Bladeless Wind Turbine, Mast, Vortex shedding.***

I. INTRODUCTION

Non-renewable energy is depleting at a very fast pace and this is a sign of worry for countries to meet its energy requirements. To deal with future shortage of non-renewable energy we have started exploring different ways to harness renewable energy for our requirements and it's proving the best choice as it creates very minimal or no harm to the environment and it gives clean energy. Wind energy is the most suitable aspect for meeting energy demand after solar energy. Wind energy is harnessed by using the wind turbines. The traditional horizontal wind turbine is mostly used but it has certain drawbacks like it requires lot of space for installation, high maintenance and high capital cost which result in finding new way of harnessing wind new i.e. Bladeless Wind Turbine. Bladeless Wind Turbine is a vertical wind turbine which is having a mast made up of fibre glass or carbon fibre which vibrates to create energy which is to be converted to electricity. It is a unique concept which have no blades, no gearbox and requires minimal space for installation.

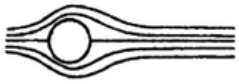
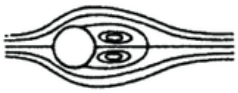
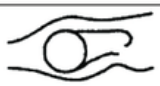
II. LITERATURE REVIEW

Bladeless Wind Turbine works on the principle of Vortex induced Vibration. Paper (1) shows the vortex shedding on bluff bodies due to wind. The oscillation of the body makes the boundary layer on the surface of the body. Similarly (2) and (3) shows unsteady separation of flow due to swirling vortices which makes the oscillation to resonate frequently and when it matches with structural frequency it starts vibrating known as Vortex induced vibration (VIV). Likewise other paper shows the formation of structure of Bladeless wind turbine i.e.Mast, base and support, tuningsystem, and devices for converting mechanical energy into electricity and working of Bladeless wind turbine with the help of VIV to energy conversion. The energy produced by Bladeless wind turbine is a green energy and requires less cost than horizontal turbine.

III. WORKING PHENOMENON

Bladeless Wind Turbine consist of a big mast of cylindrical shape or conical shape. When air passes through the body at certain speed depending on its size and shape it starts oscillating and simultaneously vortices are created at the back of the body. It forms a boundary layer on the surface of the body. Von Karman is the scientist who studied repeating pattern of swirling vortices caused by unsteady separation of flow over bluff bodies. It shows the natural instabilities in transition from laminar to turbulent flow conditions [1]. The Von Karman effects occurs on certain range of Reynolds numbers. Different Reynolds number will effect the function of vortex shedding over bluff bodies.

Table 1:- Flow regimes at a circular cylinder based on Reynolds number [3]

Reynolds number regime	Flow regime	Flow form	Flow characteristic
$Re \to 0$	Creeping flow		Steady, no wake
$3-4 < Re < 30-40$	Vortex pairs in wake		Steady, symmetric separation
$\begin{matrix}30\\40\end{matrix} < Re < \begin{matrix}80\\90\end{matrix}$	Onset of Karman vortex street		Laminar, unstable wake
$\begin{matrix}80\\90\end{matrix} < Re < \begin{matrix}150\\300\end{matrix}$	Pure Karman vortex street		Karman vortex street
$\begin{matrix}150\\300\end{matrix} < Re < \begin{matrix}10^5\\1.3\cdot10^5\end{matrix}$	Subcritical regime		Laminar, with vortex street instabilities
$\begin{matrix}10^5\\1.3\cdot10^5\end{matrix} < Re < 3.5\cdot10^6$	Critical regime		Laminar separation Turbulent reattachment Turbulent separation Turbulent wake
$3.5\cdot10^6 < Re$	Supercritical regime (transcritical)		Turbulent separation

IV. COMPONENTS USED

1] Mast: - The Mast is the main part of the structure. It is a wireframe structured covered with fibre glass. Wireframe structure helps to remain stable and strong. The mast is designed such that it maximizes the oscillation with minimum wind [4]. The Mast is made of carbon fibre or glass fibre. As [5] suggest they used fibre carbon in four different types of cross sections i.e uniform tapered hollow conical, uniform tapered plus symbol, uniform inversed tapered plus and uniform tapered rectangular cross section as seen in figure1. They found that RMS amplitude of uniform tapered rectangular cross section is 6 times larger than other three cross sections. Therefore uniform tapered rectangular cross section is more suitable for harvesting energy. Other material for mast is glass fibre. Glass fibre is used because it resist the compressive and tensile forces both. It has less weight allowing to resonate it at natural frequency of structure at lower velocities. Glass fibre is lower in cost as compared to carbon fibre [6].

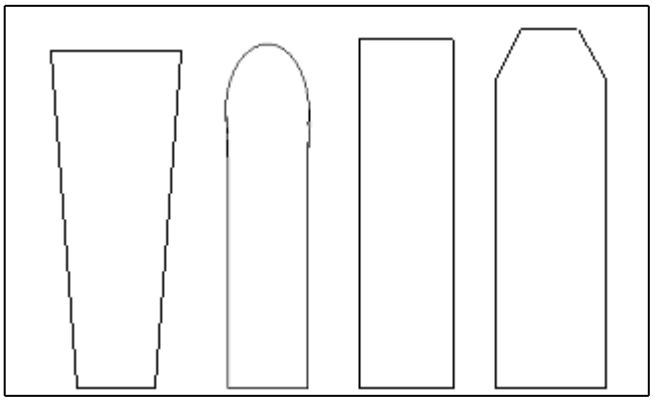


Fig.1: Different Designs of Mast

2] Base and Support: - The base of the structure should be strong and rigid so that it will not have impact of high oscillations. The base provides ground support to the mast. The base should be made up of strong material like steel. The central rod should be flexible enough to resist the fatigue due to cantilever motion of the mast. The carbon fibre rod was designed to work at maximum amplitude of 2, 7°. This implies low material's deformation. [7]

3] Tuning system and springs:- For easy functioning of structure and proper tuning with mast springs are used. Along with it two permanent magnets, one attached to oscillating mast while other fixed rod as seen in figure2. With increase in oscillation amplitude the frequency of oscillation will increase as,

$$f(x) = \frac{1}{2\pi}\sqrt{\frac{K+K'(x)}{m} - \left(\frac{c}{2m}\right)^2} \quad (1)$$

Where, f(x) is the natural frequency of the system,k + k'(x) is stiffness of the system and k'(x) is due to magnetic repulsion

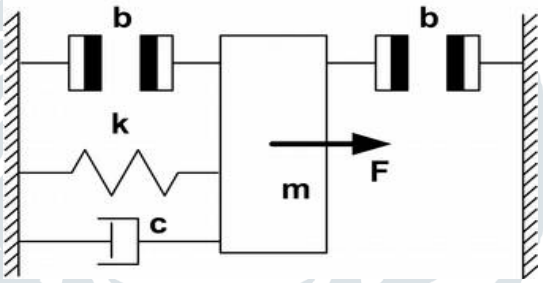


Fig.2: Tuning of magnets [7]

4] Converting vibration into electricity:-

a] Alternator:- As per David Yanez [7] for converting mechanical energy into electricity the most suitable option is electromagnetic induction, by using a permanent magnets alternator. The alternator having ring shaped magnet on the mast works as a rotor and the stator on rod is independent of wind direction. The two permanent made of neodymium is placed in such a way to take vibration in all sides and give maximum efficiency. The design of alternator should maintain complete axial symmetry and behave identically independent of wind direction.

b] Gyro e generator:- Gyro-e-generator takes the vibrations from the structure. Gyro torque is infinitely variable transmission system based on the gyroscopic reaction. Gyro-Torque is capable for large speed ratios for generating electricity from wind at very less cost. Gyro torque is of kinetic type. Gyro-torque has the ability to operate at full speed range with minimal loss and higher efficiency. It can easily decoupled and control the transmission with minimum effort for maintenance and operation [8].

5] Storage: - The electricity generated in bladeless wind turbine is less as wind speed in most of the region in India varies only from 5-8 m/s, in offshore areas flow of wind is greater than 10m/s. So average wind is 6m/s that's why electricity is less generated. That amount is unable to transmit directly to the grids, so battery is used to store the electricity. Nickel metal hydride is used by A.B.D. Aballe[9]. Ni-mh battery is used because it can function even if the amount is less and it does not require any external power output. Lead acid battery is also efficient to store electricity generated by vibration.

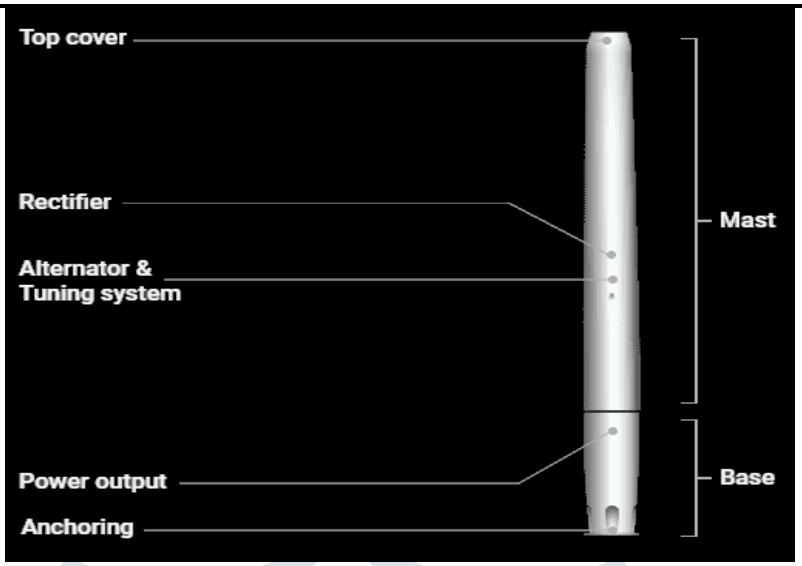


Fig.3:- Component Assembly of Vortex Bladeless (Vortex Tacoma 2.75m) [10]

V. CONCLUSION

Use of Vortex Induced Vibration for producing electricity is a new innovation in harnessing wind energy. From the study we observed that there are very few materials required for making a Bladeless Wind Turbine as compared to the traditional one. As there is no mechanical components like gearbox,shafts, bladesetc. are required there is no need of greasing and frequent maintenance of it. The size of the structure can be changed according to the output required. Study suggested that Glass fiber is best suited for mast design as it can withstand compressive and tensile forces better. The shape of mast should be tapered cylindrical or conical to give maximum oscillation in minimum wind. Two permanent magnets in disc shaped made of neodymium is used for tuning purpose and a central rod is used to support and provide stability to the structure. For converting vibrations to electricity devices like alternator, gyro-generator, and linear generator with spring mechanism are tested and study is going on to get more output. The generated electricity is stored in batteries majorly lead acid and NI-mh is used. Overall more improvements are still required to commercialize this technology but it has shown a very positive results in study.

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