Design and Fabrication of Bladeless Wind Mill

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ABSTRACT

Today, India is top amongst the list of developing countries in terms of economic development. Hence the energy requirement is increasing rapidly. To meet these energy requirements non- renewable energy sources are used excessively but due to limited storage of this sources there is a need for generation of clean energy through renewable energy sources. India is having fifth largest installed wind power capacity in the world. As the region of high speed wind is limited and also the area required for installation of conventional windmill is high, bladeless windmill based on vortex induced vibrations can provide the solution for these disadvantages of the conventional windmill. Bladeless windmill basically works on the vortex shedding effect. The device is composed of a single structural component, and given its morphological simplicity, its manufacturing, transport, storage and installation has clear advantages. The new wind turbine design has no bearings, gears, so the maintenance requirements could be drastically reduced and their lifespan is expected to be higher than traditional wind turbines. Generally structures are designed to avoid vortex induced vibrations in order to minimize the mechanical failures. But here, we try to increase the vibrations to increase the generation of electricity.

Keyword: - *Bladeless Windmill, Vortex Induced, Vibrations, spring*.

1. INTRODUCTION

In the process of wind power generation there are mainly two methods are considered, Rotational wind harvesting and Oscillation wind harvesting. Though both allow the transfer of mechanical energy to electric energy there is major difference in the mechanical system of transmission of energy from one form to another.

Rotational wind harvesting is the basic principle used in the conventional windmill. In this type the spinning turbine blades are connected along a center shaft to gearbox. This gearbox transmits the mechanical energy obtained from the rotation of the blades by the flowing wind to the generator which intern translates the mechanical energy of rotation of blades into usable form of electricity

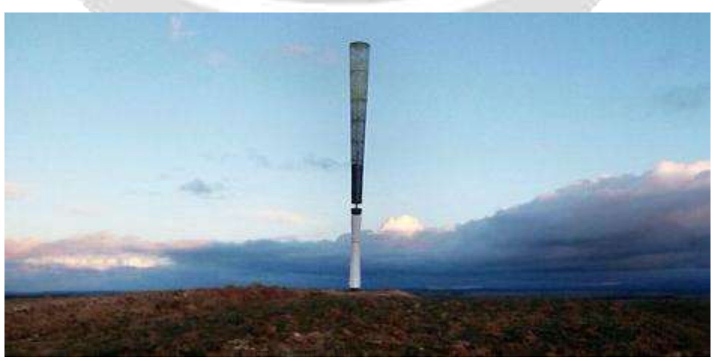


Figure 1: Vortex windmill

Oscillation wind harvesting is the less common method used amongst the both methods. To understand the reason behind it we have to understand the working of it. This device works on the vortex induced vibrations (VIV). VIV are the motions induced on the body due to the interaction with the external fluid flow, produced by periodic irregularities in the flow. Basically VIV is the vibration in the perpendicular direction induced when a fluid is passed over an object. In the oscillation wind harvesting the most geometrically appropriate airfoil shape is cylindrical.
The Cylinder optimizes the effects of VIV because of its symmetry along its center axis. As a fluid flows past a cylinder placed vertically it starts to oscillate in the horizontal direction proportionate to air speed suspended by a spring. This oscillation can be compared to the rotation of turbine blades in the sense that both are Mechanical motions caused by wind flow that must then be transferred to electrical energy. In the case of the oscillation wind harvesting device, the transformation is most commonly done through the use of a magnetic field. As the cylinder oscillates up and down, coils attached to either end move in tandem around magnets. The motion of the coils through the magnetic field generates current, causing voltage, which is then harnessed as electrical energy. This process varies greatly in efficiency based on device scale, spring tension, and the strength of the magnetic field being used to generate electricity.

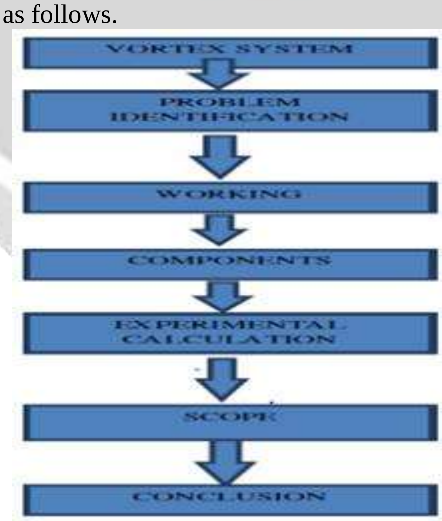
2. PROBLEM IDENTIFICATION

The rate of wind power developed founds costly when compared to an existing wind mill. For these several investigations need to be found out. Some of identifications are as follows:

1. Higher capital expenditure in observed in erection and commissioning of a wind mill. Conventional windmill requires places where wind speed is more. Such places are limited.
   Hence windmills working on lesser wind speeds are need of the hour.
2. The cost of manufacturing different parts of windmill is very high. A typical windmill will cost $3000-$8000 per kilowatt.
3. So also the transportation of such huge parts is very costly and risky. If during transportation components get damaged then again cost increases.
4. Area of installation is 60 acres per megawatt of capacity of wind farms.
5. Also they prove fatal to birds.
6. They produce low frequency sound which is not good for human health.

3. METHODOLOGY

Methodology is the basic requirement for a project, because it defines the proper start and end condition of the works to be done. Proper planning and execution of the workflow decides the successful completion of the project. The methodology of this project is as follows.



4. WORKING PRINCIPLE

The energy conversion happens in the mast, in which the wind strikes the column mast to vibrate. This vibration is converted into mechanical energy and then to electrical energy. When the wind impinges on the projected surface area of the mast from one specified direction, stream lines of the wind tend to depart and get sheared off. Further passage results into the formation of wind currents called vortices or eddies. When they are strong enough to overcome the internal resistance offered by the mechanism (crank shaft or direct linear alternator), the mast vibrates due to spring connected at outside surface of the mast. Then spring is connected to the foundation seat. The connecting rod is bound to transmit this vibration to the crank. The crank shaft can be connected to a generator further. We can also connect the lower end of the mast with the linear alternator directly.

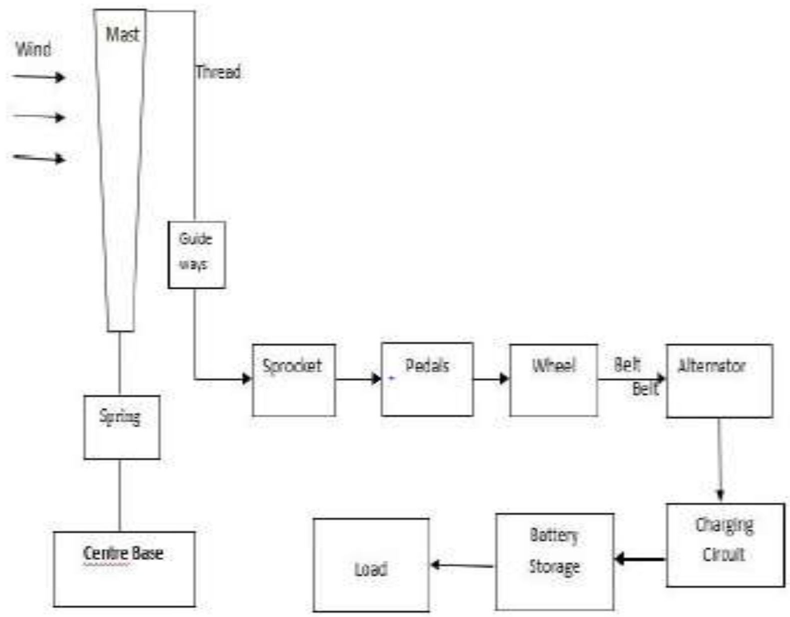


Figure 2: Flow chart of the model

Obviously, we can use a rectifier circuit to transform this A.C. current to D.C. current and charge a battery or connect it the load.

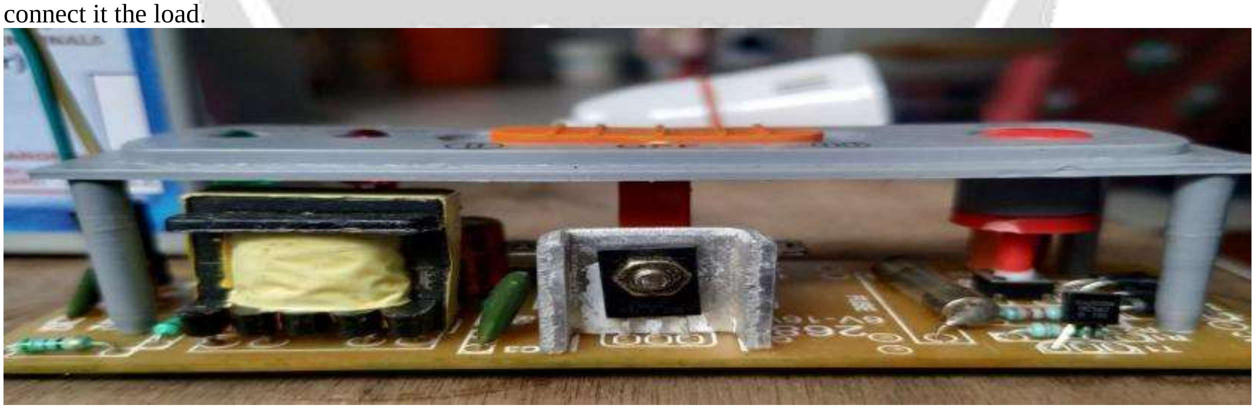


Figure 3: Inverter circuit

5. COMPONENT SELECTION

The bladeless windmill consists of the following components to fulfil the requirements of completing the operation of the machine.

5.1 Centre Base

Base is made up of the rigid iron angular structure. The base provides equidistant point for the position of the mast. It is capable of tolerating the mechanical stress acting on it. This provides the strong foundation to the mast and spring

Figure 4: Centre base

5.2 Spring

Spring is mounted at the center of the mast which provides the oscillation of the mast in any of the direction. Safe design consideration adopted for the spring, such that it takes the entire load of mast.

5.3 Mast

The rigid, oscillating part at the Centre which has a conical shape forms the mast. The mast is made lighter in weight to increase the oscillations and to reduce the stress due to inertia which transfers to the base.

Figure 5: MAST (poly carbonate sheet role)

5.4 Crank shaft

The crank shaft is used to perform conversion between reciprocating motion and rotating motion. It is usually connected to flywheel

5.5 Alternator

The alternator is driven by the power wheel via the belt drive. The generator is design by using a ceiling fan stator which consists of 16 set of windings.. It is made to generate to electricity by replacing the metal rotor with a wooden rotor which comprises of Neodymium magnets.

Figure 6: Alternator

5.6 Blower

Blower is used to supply the artificial air required by the mast.

6. EXPERIMENTAL CALCULATION

Larger Radius of the mast, R1= 0.125 m, Smaller Radius of the mast, R2=0.0625 m
Height of the mast, L=1 m
Lateral Surface area of the mast (open) S=π × (R1+R2) ×L = 3.14× (0.0625+0.125) ×1.00 = 0.5887 m^2
Density of the Fiber glass, ρ=1760 kg/m^3
Thickness of the FRP sheet, t=2 mm
Mass of the mast, m=ρ×S×t = 1760×05887×.002 =2.068 kg
Centre of gravity, C.G (from the bottom end) =1-{h(R1 2 +2R1R2+3R2 2)}/{4(R1 2 +R1R2+R22)}=1-0.39=0.61m
Velocity of the wind, v=40 m/s (Gujarat, India)
Projected area of the mast exposed to wind, A= (R1+R2) ×l = 0.1875 m^2
Force of the wind on the projected area, F1= ρair×A×v2 = 1.225 × 0.1875× 11.122 = 28.40 N
Radius of the mast at the point of pivot, R3
Applying theory of proportionality, R3=R1×0.39 = 0.125×0.39 = 0.048 m
Centre of gravity of frustum portion above the pivot, L1
= hypo perfusion - {hypo perfusion (R12 +2R1R3+3R32)}/ {4(R12 +R1R3+R32) =0.61-0.22198 L1=0.388
So, Centre of gravity of the frustum above the pivot from the bottom of
The whole mast=0.338+0.39=0.778
Lower end of the mast connected to the hinge = =100 mm Point of Pivot=1/3×L (from the bottom) =333 mm (experimental for maximum deflection)
Net distance of Point of hinge from point of pivot L2= 233 mm
Mechanical advantage
F1×L1 = F2 ×L2
F2= 28.40 × 0.388/0.233
F2= 47.29 N
Loss at the rolling contact hinge joint and crank shaft offset is close to 10% (Found by experiments)
Length of the connecting rod >>>> crank radius and thus, effect of arc can be neglected.
Net force on the crank shaft is = 42.56 N
Crank radius is 25mm
Net Torque at the end of the crank shaft is P =0.025×42.56N =1.06 N.

7. SCOPE (COMPARISON BETWEEN WINDMILLS)

Table 1. COMPARISON OF GENERAL PARAMETERS BETWEEN CONVENTIONAL WINDMILL AND BLADELESS WINDMILL

PARAMETERS	CONVENTIONAL WINDMILL	BLADELESS WINDMILL
MODE OF OPERATION	**It generates electric power with blades**	**It generates electricity without blades**
MODE OF GENERATION	**It captures wind energy using Rotational motion of the blades**	**It captures wind energy Using "Vortices"**
STRUCTURE	**The design is sturdy & there is high wear &tear**	**The design is sturdy & there is minimal wear.**
SAFETY	**It is not safer for birds, that often suffer from collision with blades**	**It is also safer for birds, that often suffer from collision with blades**
MAINTENANCE	**It is not feasible to maintain, as it has Higher maintenance cost**	**It is easy to Maintain.**
CONSTRUCTION	**It has more moving parts**	**It has less moving parts**
EFFICIENCY	**It has high efficiency**	**It has low efficiency**

8. SUGGESTED SOLUTION

The problems that are associated with the conventional windmills are very much solved in the oscillation type wind power harvesting. Bladeless windmill is less costly and require less maintenance than the conventional windmill. The blade less windmill has fewer moving parts than the conventional windmill. It requires less area and wind speed for its area. The bladeless windmill works on a principle of vortex shedding effect. The vortex shedding is the effect which set the object in oscillations when a fluid flow is passed over an object. Instead of capturing energy through rotational moment the energy is generated through oscillations through the d c generator by the movement of crank mechanism fitted at the bottom of the bladeless wind mill.

Figure 7: bladeless wind mill

9. CONCLUSIONS

Bladeless windmills can offer promising results in near future with respect to efficiency, capacity and productivity. Is topic is a great area for research and so far the results are encouraging. Further, developments can be done in the mechanism which is converting vibrations to electricity. results above are based on 1 m prototype along with ansys analysis software outcomes. Purpose of this paper is to form some basis for the research in the field of renewable resources of energy in near future and be an encouragement for generations to come. Project has five main advantages: less space requirement, less impact on fauna, less noise, better running, multiple uses due to its portability and use in case of intermittent pulses of wind and its low cost Moreover, some disadvantages such as starting torque requirement, low extraction efficiency can be solved with optimization and changes in design. Use of rack and pinion, direct alternators and slotted link mechanisms can be done instead of crank mechanism

10. REFERENCES

[1] Design of Machine elements By V.B. Bhandari.
[2] Design of Machine structure By Sharma &Agrawal.
[3] https://www.youtube.com/watch?v=2_5K4kmn sL4 Power Generation by Bladeless Windmill Abhilash Khairkar1, Prof. Saurabh Bobde2, Prof. Saurabh Bobde3, Gaurao Gohate4, Department of Mechanical Engineering, DBACER Nagpur
[4] https://www.indiegogo.com/projects/vortexbladeless- a-wind-generator- without blades--
[5] http://ijsetr.org/wpcontent/uploads/2015/04/IJS ETR-VOL-4
[6] www.ijsrd.com/articles/IJSRDV4I31605.pdf
[7] https://en.wikipedia.org/wiki/Vortex_Bladeless
[8] IJIRST –International Journal for Innovative Research in Science & Technology| Volume 2 | Issue 11|april'16
[9] Study of Vortex Induced Vibrations for Harvesting Energy by Prof. Saurabh Bobde, Gaurao Gohate, Abhilash Khairkar, Sameer Jadhav. Paper No. (IJIRSD 2349-6010 Vol.2.Issue 11, April 2016)
[10] The influence of taper ratio on vortex-induced vibration of tapered cylinders in the cross flow direction by Banafsheh Seyed-Aghazadeh, Daniel W. Carlson, Yaha Modarres-Sadeghi. Paper No. (Journal Of Fluids And Structures, Issue 15, July 2014)
[11] Application of Vortex Induced Vibration Energy Generation Technologies to the Offshore Oil and Gas Platform: The Preliminary Study World Academy of Science, Engineering and Technology International Journal of Mechanical, Aerospace, Industrial, Mechatronic and Manufacturing Engineering.