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Bladeless Wind Turbine

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Abstract: A wind turbine is a device that converts kinetic energy of wind into electrical energy. Wind turbines are manufactured in a broad range of vertical axis and horizontal axis. The smaller turbines are used for applications like battery charging for auxiliary power for boats or to power traffic signs. Large turbines are used to generate domestic power supply. This paper will illustrate a new conception of bladeless wind-turbine. Its design and basic analysis will provide a better understanding about this system. This paper will also talk about the efficiency calculation of bladeless wind turbine. Turbines that would provide a quiet, safe, uncomplicated and efficient substitute to our apparently sophisticated bladed turbine. This new turbine poses to be the ideal replacement for the conventional turbines. The design of such an unconventional turbine was conceived bearing in mind the catastrophic effects that conventional turbines may have on the machines they are integrated.
Keywords: Vortex phenomenon, bladeless wind turbine, energy, renewable, source, analysis.

I. INTRODUCTION

As non-renewable sources turn down, the necessity for renewable sources increases. Efficient renewable sources of energy are vital as non-renewable sources, such as fossil fuels are declining, substitute methods of generating electrical energy are becoming more popular. One existing equipment is already providing an alternative method, that is wind turbine. Current wind turbines take advantage of a naturally stirring, renewable system to produce electricity.

Conventional turbines suffer a main drawback in many applications because of their low efficiencies. Their efficiency is lowered by the use of moving blades to generate shaft power. Consequences of failure of a single blade is thus an insufficient expansion, which directly affects the overall efficiency of the turbine. On the contrary, bladeless turbine shakes back and forth from the vortices created by the movement of air around the structure. Once the construction begins to vibrate, an alternator located in the base of the device converts the mechanical movement into electricity. The concept of bladeless windmill is inexpensive and also has less maintenance cost. It has fewer moving parts compared to blade windmill. It requires less space and also is safe for the birds.


Fig 1: Prototype of Bladeless wind turbine


Fig 2: Traditional wind turbine

II. METHODOLOGY

In this phenomenon, when the cylinder body is placed in the flowing fluid there is a low alternate pressure created at the side of the cylinder, the body begins to displace in the perpendicular direction of the flowing fluid. Figure.3 shows a cylinder placed in the flowing fluid. One end of cylinder is hinged & the other end is placed freely in the fluid. Primarily the fluid is at rest. The cylinder is in the vertical direction. When the fluid starts flowing, assume that a low pressure is created in the left direction, due to this the cylinder's free end shifts to left side. Fig. 4 shows the fluid in motion. In this, low pressure is created on the right. The cylinder starts to displace in the right direction as shown in Fig .4. In this way there is a perpendicular angular movement in the fluid. This results in fluctuating pressure differential which produces lift force perpendicular to the direction of the flow. The oscillating motion on the body is due to alternating lift forces.

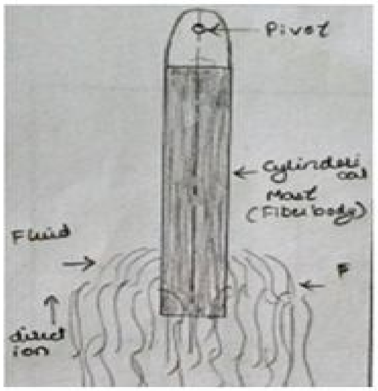

Fig 3: Fluid at rest

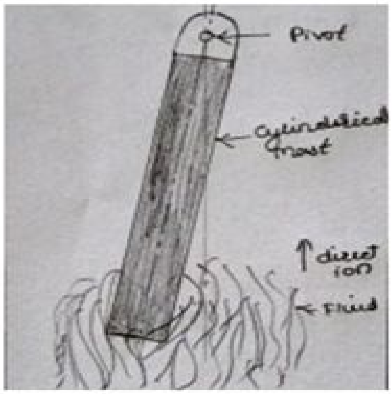

Fig 4 : Fluid in motion

A. Method & Calculation of Vortex Shedding Frequency

The parameters of the cylinder body are important to know so as to understand the dynamic condition of vortex shedding phenomenon.

Reynolds number is used to distinguish the fluid, being laminar or turbulent. For this phenomenon Reynolds number is targeted between 300< Re< 3*10^5 for better frequency of vibration.

1) Reynolds Number:

Re =U*D/v ------------------- (1)

Where,

U – Free stream velocity (wind velocity)

D- Diameter of cylinder

v – kinematic viscosity (m^2/s)

Reynolds number has a relation with Strouhal number.

When Reynolds number is between (300 < Re < 3* 10^5) the value of Strouhal number is 0.2. [3]

2) Strouhal Number: It is a non-dimensional parameter used to describe the vortex shedding frequency.

St = Fs * D/ U --------------- (2)

Where,

Fs – Vortex shedding frequency (unknown)

Diameter (D) = 0.2 m

Strouhal No. = 0.2

Velocity of fluid (U) =2.8 m/s.

Therefore shedding frequency is 2.8 Hz.[2]

B. Method & Calculation of Natural Frequency of Cylindrical Body:

The natural frequency of the body is calculated by using torque method.

$$wn = \frac{\sqrt{(K L^2 - 2Mc \times g L)/4}}{\sqrt{I}} \quad \text{-------------(3)}$$

$$fn = \frac{1}{2\pi} * \frac{\sqrt{(K L^2 - 2Mc \times g L)/4}}{\sqrt{I}} \quad \text{----------(4)}$$

Where,

I –Moment of inertia of the cylindrical body about its perpendicular axis

$$I = \frac{M_c \times L^2}{3} \text{------------------(5)}$$

K – Spring stiffness

L - Length of cylindrical body
M_c – Center of mass of cylindrical Body = 1.5 Kg
g - acceleration due to gravity.

C. *Resonance Condition*

When the natural frequency of cylindrical body is in match with vortex shedding frequency then this is a maximum possible condition of vibration which takes place at a very high amplitude .This condition is known as resonance. For designing a spring to sustain the high stress developed in the resonance condition, it is necessary to calculate the value of spring stiffness under resonance.

$$fn = fs \text{----------------------------(6)}$$

$$\frac{1}{2\pi} * \frac{\sqrt{(K L^2 - 2Mc \times g L)/4}}{\sqrt{I}} = fs \text{--------(7)}$$

$$K = \frac{4\, I\, fs^2 \times 2\pi + 2\, M_c \times gL}{L^2} \quad \text{N/m-------- (8)}$$

K = 215.57 N/m

Lift force developed at the upper end of the cylinder and coefficient of lift force C is assumed to be 0.6 based on previous study.

$$F = 0.5\, \rho\, U^3\, D\, L\, C \text{-------- (9)}$$

Density of fluid ( ) =1.145 Kg/m3
Diameter of cylinder (D) = 0.2 m
Velocity of fluid (U) = 2.8 m/s
Length of cylinder (L) =1.8 m
Therefore, Lift force F is 2.714 N [2]

The oscillation produced by the vortex shedding is converted into rotary motion that is then converted into power.

$$P = \frac{2\pi N}{60} \text{---------(10)}$$

For converting oscillatory motion into rotary motion we used slider crank mechanism. There are two gears meshing which have a module of 6. The number of teeth on larger gear is 40 and smaller gear is 10. The torque transmitted at the smaller gear is 3.81 N-m and at the speed of 480 rpm. Therefore power developed is 191.5 watts.

Sr No:	Length (L) m	Frequency(Fn) Hz	Torque(T) Nm	Speed(N) rpm	Power (P) watt
1	1.8	2.8	3.81	480	191.5
2	4	3.1	12.2	620	792.1
3	6	3.6	27.8	730	2125.7
4	10	3.9	39.9	890	3718.70

Table 1: Power generated for varying parameters

III. ANALYSIS

Bladeless turbine is a new concept, which has an advantage of an aerodynamic effect called vorticity. Bladeless turbines take advantage of this effect. When wind lashes against the turbine the wind flows downwards in a circular motion called a vortex. This generates areas of low and high pressures adjacent to the turbine which causes it to oscillate. When the wind is sluggish and steady, it lashes against the turbine. Making the vortices homogeneous and the oscillations caused by them are homogeneous too. However, as the wind speed increases, the vortices that are formed become unpredictable and uneven. Hence the frequency at which the turbine is oscillating is in a state of flux. Studies on the turbines show that when they are positioned close by they can feed off each other. The vortices given off by the first turbine networks with the next turbine which helps form oscillations(fig5). The size of the turbine also affects the consistency of the vortices created. Wind speed, and hence pressure, varies with altitude. If a huge turbine is made, wind of changeable velocities would be acting on it. This will give rise to oscillations in the turbine of various frequencies. Given that wind is a high entropy system, and that this turbine's efficiency is reliant on the regularity and stability of the parameters of the system, this will deeply affect its efficiency.

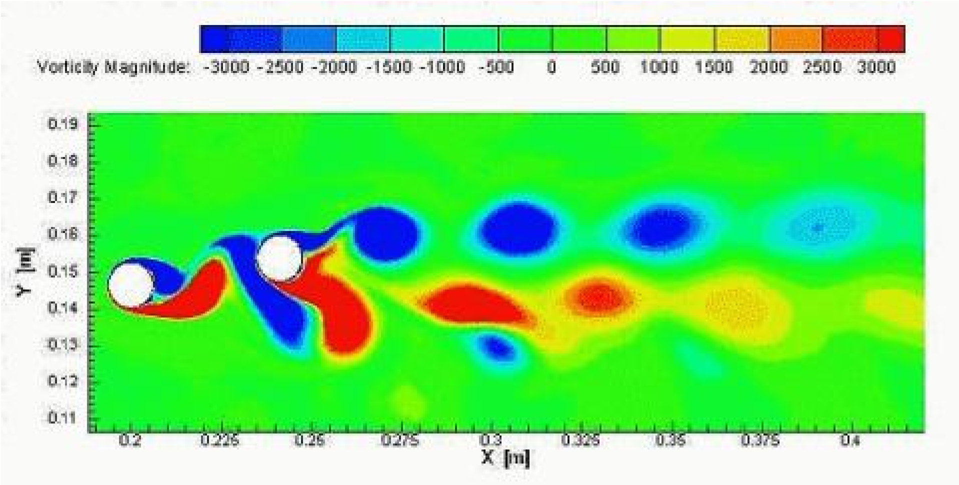

Fig 5: Beneficial vorticity effect on two cylinders

A. Mathematical Analysis

The shaking motion of a bladeless turbine can be directly related to simple harmonics as seen in

$$F = k \text{ ---------(11)}$$

F is the force of the harmonic motion (N),
k is the spring constant (N/m)
and x the displacement distance (m).
Differentiated Equation gives

$$\frac{d^2x}{dt^2} = \frac{-kx}{m} \text{ --------(12)}$$

m is the inertial mass (kg) of the oscillating body and
t is time (second)
Solving the differential equation above leads to

$$(t) = c_1 \cos(\omega t) + c_2 \sin(\omega t) = A \cos(\omega t - \varphi) \text{ -----------------------(13)}$$

c1 and c2 are constants,
A is the amplitude from the equilibrium position (m),
$\omega = 2\pi\upsilon$ is the angular frequency,
and φ is the phase.
The kinetic energy of the bladeless turbines equates to

$$KE = \frac{mv^2}{2} = \frac{kA^2 \sin^2(\omega t - \varphi)}{2} \text{ ---------------(14)}$$

and the potential energy equates to

$$PE = \frac{kx^2}{2} = \frac{kA^2 \cos^2(\omega t - \varphi)}{2} \text{ -----------------------(15)}$$

Combining the two equations for mechanical energy we get

$$E = PE + KE = kA^2 \text{ -----------(16)}$$

Which divided by time gives power (W)

$P = E/t$ -------------------(17)

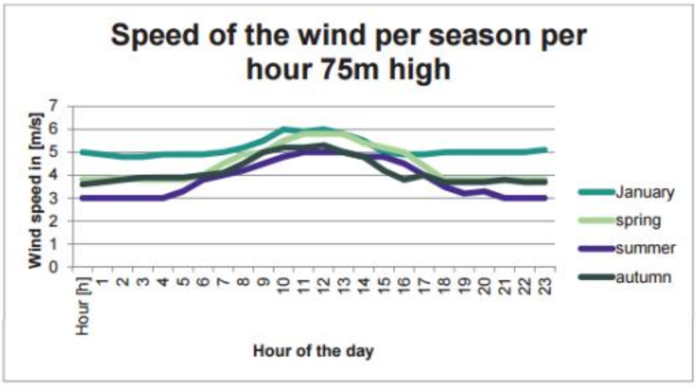

Fig 6: Wind speed analysis over seasonal days (24)

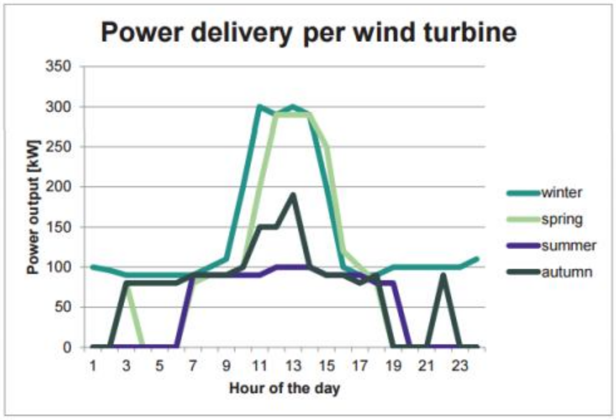

Fig 7: Power output over seasonal days (24)

IV.CONCLUSION

It is generating alternative energy that is used for wide range of applications with the help of vortex shedding phenomenon. This model extracts energy from the wind and converts it into useful energy. It is easier, simpler and an economical way of generating power. Adaptive wind turbine is more efficient in terms of operation, power produced and safety. The manufacture and instalment cost is low. This can be used widely from household purpose to larger wind farms.

REFERENCES

[1] Manwell JF, McGowan JG, Rogers AL. Introduction: Modern Wind Energy and its Origins. Wind Energy Explained: John Wiley & Sons, Ltd; 2009. p. 1-22. doi: https://doi.org/10.1002/9781119994367

[2] Encyclopædia B. Bernoulli's theorem. Available at: https://www-britannica-com.ezproxy.lib.uts.edu.au/science/Bernoullis-theorem. Accessed April, 20, 2017.

[3] A tutorial on the dynamics and control of wind turbines and wind farms. Proceedings of the American Control Conference; 2009.

[4] Turbines Info. Horizontal Axis Wind Turbine - HAWT. 2011; Available at: http://www.turbinesinfo.com/horizontal-axis-wind-turbines-hawt/. Accessed 04/24, 2017.

[5] IJSRD - International Journal for Scientific Research & Development| Vol. 4, Issue 01, 2016 | Power Generation by Bladeless Windmill, Abhilash Khairkar Prof. Saurabh Bobde Prof. Saurabh Bobde Gaurao Gohate 1,2,3,4Department of Mechanical