Power Generation by Bladeless Windmill

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Abstract— India has fifth largest power generation capacity in the world by windmill. Due to increase in population in India. There is a need of more power in India and also in world. Early, windmill are used consist of turbine. Energy is captured from the rotation of turbine, we developed new method for generating electrical energy. Here we capture kinetic energy from the wind and produce vibration by using vortex shedding phenomenon and that vibration are converted in to electrical energy.

Key words: Bladeless Windmill, Power Generation

I. INTRODUCTION

Energy is base of the socio-economic development of any country. It's also most important for human development. India was developed 17645 MW on June 2012. It's annual growth rate is 14%.

But utilization of wind energy with the help of conventional windmill is very costly. The windmill has high production, transport and maintenance cost. They required lot much amount of space for installation of windmill. They also prove fatal to birds. Hence maintaining a windmill is so expensive. They provide low frequency sound which is not good for human health.

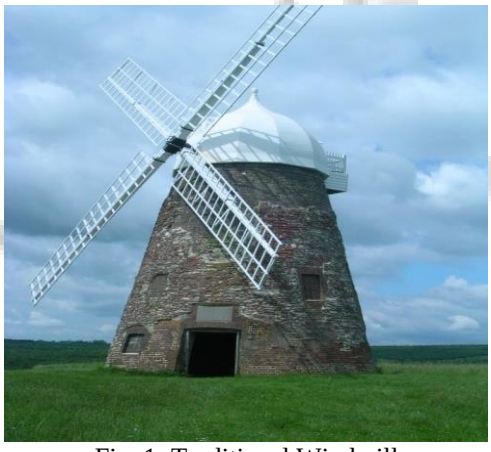

Fig. 1: Traditional Windmill

Fig. 2: Bladeless Windmill

The Bladeless windmill is 40% more efficient than conventional windmill for the given space of blade windmill. For given amount of power developed by blade windmill we developed that much amount of energy by installing 3&4 number of bladeless windmill on given space that aquiver for one blade windmill.

The concept of bladeless windmill is less costly and also have less maintaining cost. It's has lesser moving parts compared to blade windmill. It's required less space and also is safe for birds.

A. Vortex Shedding Phenomenon:

In this phenomenon, when the cylinder body is placed in the flowing fluid there is low alternate pressure create at the side of the cylinder body start displacing in perpendicular direction of the flowing fluid.

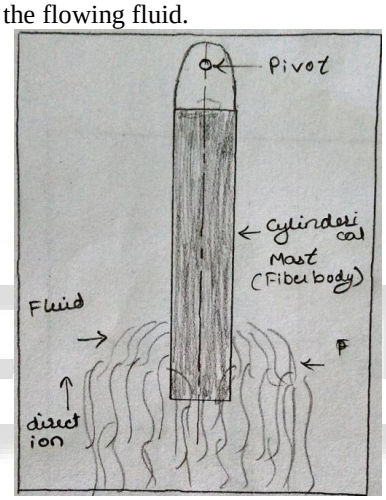

Fig. 3: When fluid at rest

Figure.3 show a cylinder is placed in flowing fluid. One end of cylinder is hinged & other end is placed is freely in the fluid. Initially the fluid is at rest condition. The cylinder in vertical direction. When the fluid start the flowing, Assume that the low pressure is created in left direction, due to this the cylinder free end goes to left side.

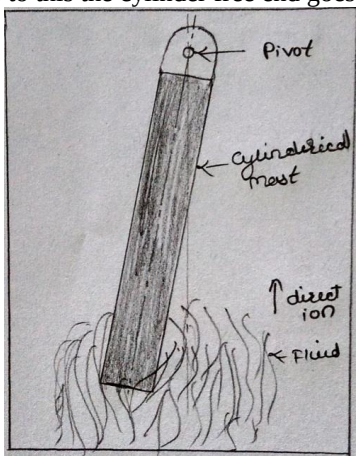

Fig. 4: When fluid in motion

After that low pressure is created at right direction. The cylinder start to displaced in right direction as shown in Fig .4. In this way there is causing of perpendicular angular

movement in the flowing fluid. Practically, vortex shedding phenomenon on vertical cone is good as compared to cylinder.[1]

B. Method & Calculation of Vortex Shedding Frequency:

The parameter of the cylinder body is important to known the dynamic condition of vortex shedding phenomenon.

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

1) Reynolds Number:

$$Re = U*D/v \quad (1)$$

Where,

U – Free stream velocity (wind velocity)

D- Diameter of cylinder

v – kinematic viscosity (m^2/s)

Reynolds number have relation with Strouhal number.

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

2) Strouhal Number:

It is a non dimensional parameter describe the vortex shedding frequency.

$$St = Fs * D/ U \quad (2)$$

Where, Fs – Vortex shedding frequency .From we find the frequency of Vortex shedding.

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]

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

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

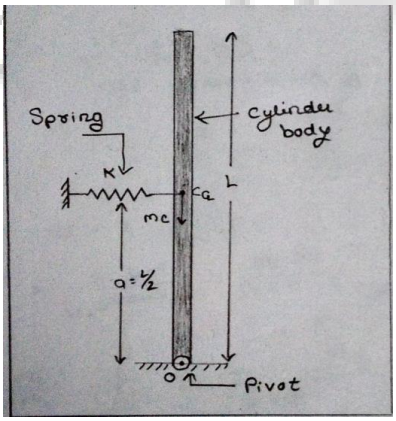

Fig. 5: Torque Method

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

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

Where,

I –Moment of inertia of cylindrical body about perpendicular axis rotating its one end.

$$I = \frac{1}{3} Mc \times L^2 \quad (5)$$

K – Spring stiffness.

L - Length of cylindrical mast.

Mc – Center of mass of cylindrical

Body = 1.5 Kg

g - acceleration due to gravity .

From this relation, we get natural frequency of cylindrical body as shown in figure(5). [4]

D. Resonance Condition:

When the natural frequency of cylindrical body is match with vortex shedding frequency then these is maximum possible condition of vibration at very high amplitude .This condition is known as resonance condition.

For designing a spring to sustain the high stress develop in resonance condition .It is necessary to calculate the value of spring stiffness under resonance condition.

$$fn = fs \quad (6)$$

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

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

K = 215.57 N/m

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

$$F = 0.5\ \rho\ U^3 D\ L\ C \quad (9)$$

Density of fluid (ρ) =1.145 Kg/m^3

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 produce by the vortex shedding is converted in to rotary motion that is converted in to power.

$$P = \frac{2\pi N T}{60} \quad (10)$$

For converting oscillatory motion into rotary motion we used slider crank mechanism. There are two gear meshing having module is 6. The number of teeth on larger gear is 40 and smaller gear is 10.[5]

The torque transmitted at the smaller gear is 3.81 N-m and at the speed of 480 rpm. Therefore power develop is 191.5 watts. [6]

The number of observation are given below :

SR NO	Length(L) M	Frequency (Fn) Hz	Torque (T) N-m	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: Oobservation

II. Conclusion

It is generating alternative energy that is used for wide application of range with the help of vortex shedding phenomenon. This model extracts energy from the wind and converted in to useful energy. It is easier, simpler and economical way of generating power.

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