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VORTEX BLADLESS WINDMILL WITH MECHANICAL ARRANGEMENT

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Abstract - *-India is a developing country in terms of economic development, it's energy consumption is increased day-by-day. Hence to meet its energy requirement and most of the energy requirement is fulfilled from conventional energy sources, but it is likely to depleted with passage of time so, we seek the other options and the next best clean choice is wind power. Conventional wind turbine required large rotor area between two turbine, it required high velocity of air also they prove fatal to birds. Hence the convectional method of wind power generation has to through of again with an innovative approach. A new concept of a wind turbine without blades called "Vortex Bladeless" or "Vorticity" wind turbine which is introduced by Spanish SME which work on phenomenon of vortex shedding to capture the energy produced. Project work will include the design and development of vortex bladeless wind turbine and rack and pinion arrangement based e-generator to be coupled it to generate the electrical power.*

Key Words: **Vortex Induced Vibration, Rack and Pinion arrangement, Vortex Shedding, Generator etc.**

1.INTRODUCTION

India's increasing population and decrease in traditional resources has led use of renewable energy efficiently. India is the fourth largest wind power producer in the world. And we wat to produce electricity by using "Blade less wind mill" instead of traditional windmill. Vortex bladeless is a project, whose technique is to design new concept of wind turbine without blades called Vortex wind mill. That uses vortex induced vibrations (VIV). In which vortex induced vibrations of a circular tapered cylinder is taken as a potential source for energy harvesting.

The bladeless turbine harness Vorticity, the spinning motion of air or other fluids. When wind passes one of the cylindrical turbines, it shears off the downwind side of cylinder in spinning whirlpool or vortex, then exerts force on the cylinder, causing it to vibrate The kinetic energy of the oscillating cylinder is converted to electricity through a linear generator similar to those used to harness wave energy. The impact on the birds population is expected to be much smaller, because it doesn't required the same type or magnitude of moment has traditional wind turbine allowing for high visibility with the oscillation frequency of element very low, the impact sound level is nonexistent, opening the possibility to make the future wind farms completely silent.

1.1 OBJECTIVE

The main objective of this project is as follows,

1) Vortex Bladeless windmill produce electricity with very few moving part, on a very small footprint and almost complete silence.
2) To produce clean energy to meet the increasing demands.
3) It required less area to installation which increase maximum amount of electricity compared to costing.
4) To reduce pollution and global warming.

2. WORKING METHODOLOGY

The main principal behind of this project is the conversion of linear oscillation of vortex into rotational motion. As the vortex is subjected to wind energy, it tends to oscillate due to the vortex formed around the structure of the vortex or mast which can be converted to the rotational force to generate electricity. In the bladeless wind system configuration, the mast is fixed with respect to the ground and the rib structure at the top end of the nylon rod, i.e. middle of the vortex, comprising of thread or strip arrangement is used for pulling the pinion which is in mechanical arrangement. Energy is obtained by continuously oscillation of the vortex.

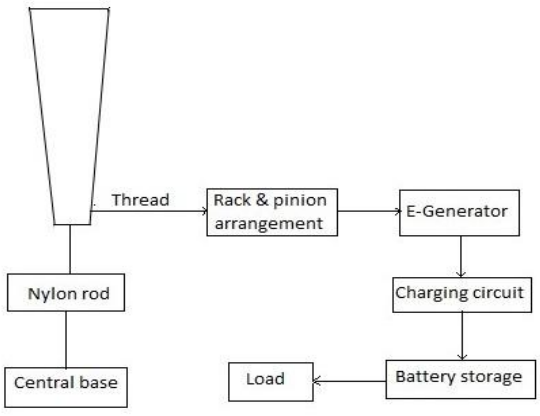

Fig-1: block diagram of set-up

2.1. Vortex Induced Vibration(VIV) Theory

VIV is a result of vortex shedding phenomenon which generally occurs nearly on any bluff body when submerged into fluid flow. Normally, irregular vortex shedding will occurring flow behind the body resulting in the 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.

The VIV application in generating alternative energy is a viable solution of the current energy crisis. Further research on maximizing VIV phenomenon will be done to increase energy extraction rate based on geometries of mast. Different design of VIV system will be numerically and experimentally researched to more vortex shedding activities

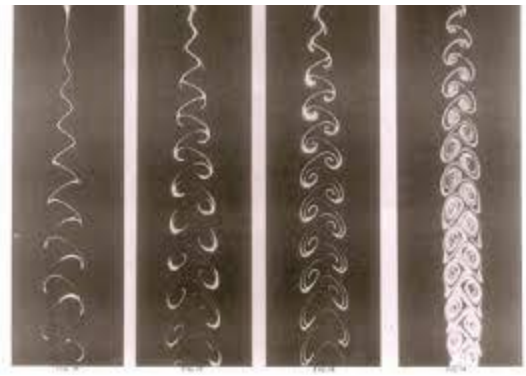

Fig-2: Vortex Shedding Effect

3. VORTEX INDUCED VIBRATION

Let's consider a structural called Tapered Oscillation Cylinder.

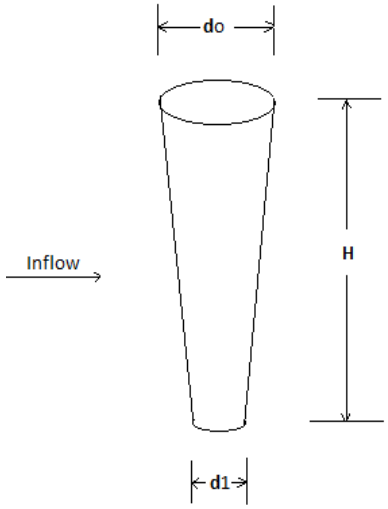

Fig-3 vortex

Considering the notation as,

$d_o = D_{max}$,
$d_1 = D_{min}$,
$D = (D_{max}+D_{min})/2$
H= L,
U= Air velocity,
V= Kinematic viscosity,
f_s= Oscillation frequency,
Now, we know Reynolds Number (Re)
$Re = (UD)/v$

And Strouhal Number (St)
$St = (f_sD)/L$

Area of tapered cylinder,
$A_p = (\pi/2)*(D_{max} + D_{min})*L$

R_t = Taper Ratio $= L/(D_{max} + D_{min})$

Reynolds Number distinguish the flow of fluid as Laminar or turbulent. So we are targeting Re values $300<Re<3*10^5$ for better frequency of vibration.

Now all parameters are known except mean diameter (D). To find mean diameter, we have to do trial and error. By comparing our value of D with L/D ratio of other such experiment.

Lets fix length as L=2m Total length so from "CFD analysis of vortex tube length."
L/D = 10

Now,
2000/D = 10
Dmax = 200mm

r = L/Dmax - Dmin
16 = 2000/200 – Dmin
Dmin = 75mm=80mm Approx for smooth taper

Natural Frequency

We know that from theory of torsion of shaft
We have
$k_t = T/\theta = GJ/l$

So $Wn = \sqrt{(T/I)}$
T-torque od rotating member
I –Moment of inertia

Now from CAD drawing software and selecting material as pp polypropylene and Determining Their mass properties considering wall thickness as 2mm we calculated mass =1kg and also found the position od center of gravity. Z=859.18mm from top mast

Now natural freq $fn = 1/2\pi * \sqrt{\left\{\frac{\frac{(KL^2-2mgL)}{4}}{I}\right\}}$

Putting the values in the formula
I=1/3m*L^2
I=2.4 kg-m^2
now as we know strouhal frequency should be close to natural frequency
so we know St=0.2
putting the value I strouhal formula

st=fs*D/U
fs=3Hz
This should be equal to natural frequency

So by putting **fn=3**
We get **K=834.2 N/m**
value of spring stiffness.
This much force is provided to sustain the Air thrust.

3.1 Mechanical Arrangement:

Rack and Pinion, mechanical device consisting of a bar of rectangular cross-section (the rack) having teeth on one side that mesh with teeth on a small gear (the pinion). The pinion may have straight teeth, as in the figure, or helical teeth that mesh with teeth on the rack that are inclined to the pinion shaft axis. If the pinion rotates about a fixed axis, the rack will translate, i.e. move on a straight path.

Fig-4: Actual Setup of vortex bladless windmill with mechanical arrangement

3.2 Mathematical formulation

According to available design of rack and pinion in market
Number of teeth on rack = 82
Number of teeth on pinion = 24
Length of rack = 35cm
Diameter of pinion = 4cm
Assume, Air velocity (v)=3 to 4 m/s
Speed of Rack,
$V= 2\pi N_1/60$
$4 = 2\pi N_1/60$
$N_1 = 38.19$rpm
Speed of Pinion,
$(T_1/T_2)=(N_2/N_1)$
$(82/24) = (N_2/38.19)$
$N_2 = 130.48$rpm
Actual velocity,
$Vact = 2\pi N_2/60$
$Vact = 2\pi*130.48/60$
Vact = 13.66m/s
Power:
P = Vact*T/1000
Generator specification:- T= 8kg

P = 13.66*8/1000
P= 0.1092 kw
P = 109.2 w

4. CONCLUSION

The purpose of this paper is to provide some fundamental result on the bladeless wind system and serve as stepping stones for the future development of bladeless wind power generating system. The forces that is beneficial or useful to generate power in bladeless are different from those in convectional horizontal axial wind turbines. Our device capture the energy of vorticity, an aerodynamic effect that has plagued structural engineers and architectsfor ages (vortex shedding effect). This system it has been designed to being energy to an off grit locations an matching it with solar panels.

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