Design & Analysis of Vortex bladeless

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ABSTRACT

Turbines that would provide a quiet, safe, simple and efficient alternative to our supposedly advanced bladed turbine aircraft engines are the need of the hour. One such turbine called the bladeless turbine that poses to be the ideal replacement for the conventional turbines was successfully designed. The design of such an unconventional turbine was conceived considering the catastrophic effects that conventional turbines may have on the machines they are incorporated. The turbine is designed in such a way that the blades of a conventional turbine are replaced by a series of flat, parallel, conical shaped structure spaced along a shaft. The Structure is used to eliminate the expansion losses that are incurred in conventional turbines and also to reduce noise considerably at high RPMs. Furthermore, the design of the turbine ensures that the turbine rotates at high RPMs with total safety unlike a conventional turbine which explodes under failure due to fatigue. The engines making use of these bladeless turbines can run efficiently on any fuel, from sawdust to hydrogen. Bladeless turbines are also the greenest turbines with almost nil harmful effects on the environment. Another major advantage of this design is that this turbine has only one moving part, thereby reducing the vibrations to a minimum. Overall this design aims at bringing out a new age turbine with improved performance that can provide an engine that is economic, eco- friendly and reliable as the expensive, complicated and wear prone transmission is eliminated.

Key-Words: Bladeless turbine , Boundary layer , Connectional design .

INTRODUCTION:

Bladeless Wind Turbine uses a radically new approach to capturing wind energy. Our device captures the energy of vorticity, an aerodynamic effect that has plagued structural engineers and architects for ages (vortex shedding effect). As the wind bypasses a fixed structure, its flow changes and generates a cyclical pattern of vortices. Once these forces are strong enough, the fixed structure starts oscillating, may enter into resonance with the lateral forces of the wind, and even collapse.

There is a classic academic example of the Tacoma Narrows Bridge, which collapsed three months after its inauguration because of the Vortex shedding effect as well as effects of flattering and galloping.

Instead of avoiding these aerodynamic instabilities our technology maximizes the resulting oscillation and captures that energy. Naturally, the design of such device is completely different from a traditional turbine. Instead of the usual tower, nacelle and blades, our device has a fixed mast, a power generator and a hollow, lightweight and semi-rigid fiberglass cylinder on top.

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 the cylinder in a spinning whirlpool or vortex. That 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.

This puts the technology at the very low range of capital intensity for such projects, it also makes it highly competitive not only against generations of alternative or renewable energy, but even compared to conventional technologies.

Literature survey

[1] Antonio Barrero-Gil, Santiago Pindado, Sergio Avila; Extracting energy from Vortex-Induced Vibrations: A parametric study; Universidad Politecnica de Madrid, Plaza Cardenal Cisneros 3, E-28040 Madrid, Svain;

In this he studied that Here, Vortex-Induced Vibrations (VIVs) of a circular cylinder are analyzed as a potential source for energy harvesting. To this end, VIV is described by a one-degree-of-freedom model where fluid forces are introduced from experimental data from forced vibration tests. The influence of some influencing parameters, like the mass ratio m* or the mechan-ical damping C in the energy conversion factor is investigated. The analysis reveals that:

(i) the maximum efficiency r\M is principally influenced by the mass-damping parameter m*C and there is an optimum value of m*C where r\M presents a maximum;

(ii) (ii) the range of reduced velocities with significant efficiency is mainly governed by nf, and

(iii) (iii) it seems that encouraging high efficiency values can be achieved for high Reynolds numbers.

[2] Saurav Bobde,Sameer Jadhav, Study of Vortex Induced Vibrations for Harvesting Energy; IJIRST – International Journal for Innovative Research in Science & Technology| Volume 2 | Issue 11 | April 2016, in this he studied that

Today, India is stepping towards becoming a global super power. This implies that, it is leading the list of developing countries in terms of economic development. Hence its energy requirement is going to increase manifold in the coming decades. To meet its energy requirement, coal cannot be the primary source of energy. This is because coal is depleting very fast. It is estimated that within few decades coal will get exhausted. The next clean choice of energy is solar power, but due to its lower concentration per unit area, it is very costly. India is having fifth largest installed wind power capacity in the world. As the regions with high wind speed are limited, the installation of conventional windmill is limited. Windmills that would provide safe, quite, simple, affordable and work on lesser wind speeds are need of the hour. The Bladeless Windmill is such a concept which works on the phenomenon of vortex shedding to capture the energy produced. Generally, structures are designed to minimize vortex induced vibrations in order to minimize mechanical failures. But here, we try to increase the vibrations in order to convert vortex induced vibrations into electricity. The paper studies the scope and feasibility of the bladeless windmill.

PRINCIPLE :

When a fluid flows toward the leading edge of a bluff body, the pressure in the fluid rises from the free steam pressure to the stagnation pressure. When the flow speed is low, i.e. the Reynolds number is low, pressure on both sides of the bluff body remains symmetric and no turbulence appears. When the flow speed is increased to a critical value, pressure on both sides of the bluff body becomes unstable, which causes a regular pattern of vortices, called vortex street or Kármán vortex street. Certain transduction mechanisms can be employed where vortices happen and thus energy can be extracted . This method is suitable both air flow and liquid flow.

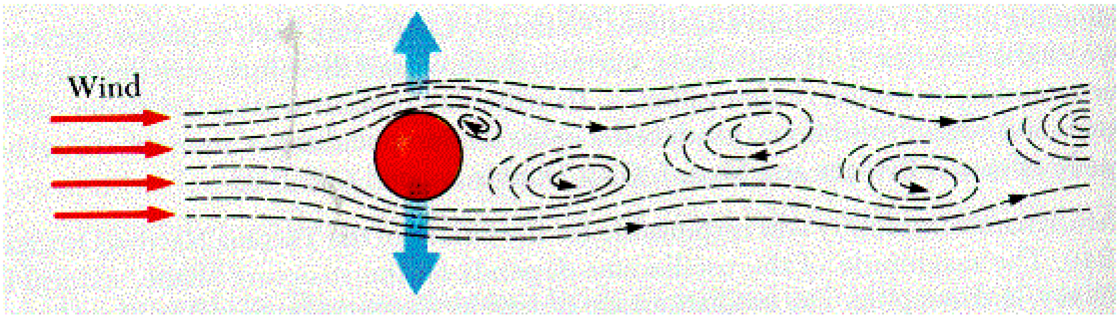

Fig: pattern of vortex shedding

METHODS OF ELETRICITY GENERATION:

BY LINEAR GENERATOR:-

When a magnet moves in relation to an electromagnetic coil, this changes the magnetic flux passing through the coil, and thus induces the flow of an electric current, which can be used to do work. A linear alternator is most commonly used to convert back-and-forth motion directly into electrical energy. This short-cut eliminates the need for a crank or linkage that would otherwise be required to convert a reciprocating motion to a rotary motion in order to be compatible with a rotary generator.

It fails in our project because our project is a small prototype so, it is unable to generate that amount of pressure required for electricity generation from piezoelectric materials. But it is possible with real project with large dimensions

In this we have studied the design of the mast in which we designed and analyzed it for the maximum output frequency for the lock in frequency. For the calculations of the design the following procedure is carried out.

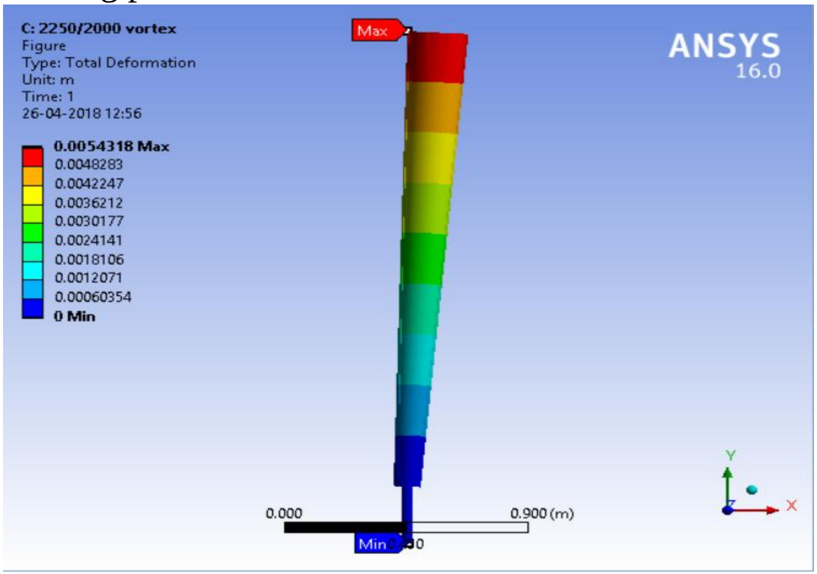

Fig: Total Deformation of Prototype

CALCULATION:

Lets consider a structure called Tapered Oscillation Cylinder.

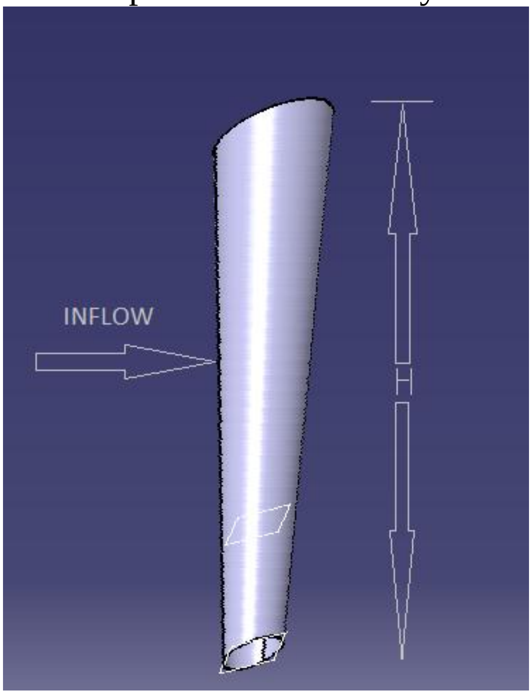

Fig 3: Structural diagram of mast

Considering the notations as,
d_0= D_{max},
d_1= D_{min},
D= (D_{max} + D_{min})/2
H= L,
U= Air velocity,
ν= Kinematic viscosity,
f_s= Oscillation frequency,

Now, we know Reynolds Number (Re)
Re= (UD)/ν

and Strouhal Number (St)
St= (f_sD)/L

Area of tapered cylinder,
A_p= (π/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 targetting Re values **$300<Re<3*10^5$** for better frequency of vibration.(From graph)
Now for Reynold number to be $300<Re<3*10^5$, Strouhal Number should be 0.2 or 0.198 (from graph)
St = 0.198

Now all the 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 precious research paper and past study we take L/D=10
now,
2000/D=10
Dmax=200mm

Now from diffrent Reserch paper we found the taper ratio lies between 14-19 so selecting 16 as a taper ratio r=16

r=L/Dmax-Dmin

16=2000/200-Dmin
Dmin=75mm = 80 mm Approx for smooth taper

Natural Frequency

We know that from Theory of torsion of shaft
we have

$$k_t = \frac{T}{\theta} = \frac{GJ}{l}$$

So **Wn=√(T / I)**

T-torque od rotating member
I- Moment of inertia

now from **CAD drwaing** software and selecting material as pp polypropylene and Determining Thier **mass Proerties** considering wall thickness as 2mm we calculated mass=1.8kg
and also found the position od centre of gravity. **Z= 859.18mm from top mast**

now natural freq fn= 1/2∏*√{(KL^2-2mgL)/4/I}

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 in strouhal formula
st=fs*D/U

fs=3 Hz
This should be equal to natural frequency

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

ADVANTAGES

- Simple and low cost.
- Compact size and light weight.
- Pollution free.
- Corrosion and cavitation is less.
- Vortex bladeless wind-driven generator prototype produces electricity with very few moving parts, on a very small footprint, and in almost complete silence

CONCLUTION:

Tapping the wind for renewable energy using new approaches is gaining momentum in the recent years. The purpose of this paper is to provide some fundamental results on the bladeless wind system and serve as stepping stones for the future development of bladeless wind power generating system. The forces that are beneficial or useful to generate power in bladeless are different from those in conventional horizontal axial wind turbines. Our device captures the energy of vorticity, an aerodynamic effect that has plagued structural engineers and architects for ages (vortex shedding effect). As the wind bypasses fixed structure, its flow changes and generates a cyclical pattern of vortices.

As the wind energy is powerful and consistent, the usage of conventional wind turbine for utilizing the wind energy in lesser area and cost is not possible. Hence bladeless wind energy helps us to achieve these criteria. This project has three main advantages

1. Utilizing less area
2. Generation of high power
3. Economical

In summary, the generation of electricity is made possible by the small structure of bladeless turbine. High efficient power is generated. This project will satisfy the need of continuous generation of electricity. The overall project uses less space area hence highly economical for the rural electrification of India

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