VORTEX BLADELESS TURBINE

NITEEN KUMAR (niteenpratap@gmail.com), KHURSHEED ALAM (kalam5025@gmail.com), SUDHANSHU KUMAR (sudhanshusingh131997@gmail.com)

D Y PATIL COLLEGE OF ENGINEERING, AMBI, PUNE (MH)

ABSTRACT

The development of wind power in India began in the 1986 with first wind farms being set up in coastal areas of Maharashtra (Ratnagiri), Gujarat (Okha) and Tamil Nadu (Tuticorin) with 55 kW Vestas wind turbines. These demonstration projects were supported by MNRE. The capacity has significantly increased in the last few years. Although a relative newcomer to the wind industry compared with Denmark or the United States, India has the fourth largest installed wind power capacity in the world. In 2009-10 India's growth rate was highest among the other top four countries.

I. INTRODUCTION

The potential for wind farms in the country was first assessed by Dr. Jami Hossain using a GIS platform to be more than 2,000 GW in 2011. This was subsequently re-validated by Lawrence Berkley National Laboratory, US (LBNL) in an independent study in 2012.

As a result, the MNRE set up a committee to reassess the potential and through the National Institute of Wind Energy (NIWE, previously C-WET) has announced a revised estimation of the potential wind resource in India from 49,130 MW to 302,000 MW assessed at 100m Hub height. The wind resource at higher Hub heights that are prevailing is possibly even more. In the year 2015, the MNRE set the target for Wind Power generation capacity by the year 2022 at 60,000 MW. As of 31 Aug 2016 the installed capacity of wind power in India was 27,676.55 MW, mainly spread across South, West and North regions.This placed the India at this time as the world's fourth largest producer of wind power (behind 1. China, 2. USA and 3. Germany), having overtaken Spain in 2015. East and North east regions have no grid connected wind power plant as of March, 2015 end. No offshore wind farm utilizing traditional fixed-bottom wind turbine technologies in shallow sea areas or floating wind turbine technologies in deep sea areas are under implementation. However, an Offshore Wind Policy was announced in 2015 and presently weather stations and LIDARs are being set up by NIWE at some locations.

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

[3] Robert Correa,Eric Cremer,Wind harvesting via Vortex Induced vibration; BJS-WD14 ;in this he studied that; There is a need for renewable energy sources to be more feasible. The purpose of this project is to develop a compact device that is able to harvest wind energy and transform it into electrical energy using the concept of vortex shedding. When calibrated correctly, the vortex shedding will induce resonant oscillation. Electricity would be collected from this oscillation using a magnet and coil assembly. This method was proven to work in water, but has not been applied to air currents. This team designed and built a small-scale prototype to be tested in WPI's closed circuit wind tunnel. The wind harvester works at a moderate wind range of 5.4 to 6.6 m/s. Data was collected on the amplitude and frequency of motion of the cylinder during its lock-in condition. Calculations were done to find position, velocity, and acceleration of the system over a complete cycle. The results demonstrate a potential for vortex induced vibration to be utilized with wind to create electricity, however it will be difficult due to the low density of air compared to other fluid mediums, such as water.

[4] J.C.Cajas,D.J.Yanej;SHAPE Project Vortex Bladeless:Parallel multi-code coupling for fluid structure interaction in wind energy; www.prace-ri.eu ;in this he studied that;Vortex -Bladeless is a Spanish SME whose objective is to develop a new concept of wind turbine without blades called Vortex or vorticity wind turbine. This design represents a new paradigm in wind energy and aims to eliminate or reduce many of the existing problems in conventional generators. Due to the significant difference in the project concept, its scope is different from conventional wind turbines. It is particularly suitable for offshore configuration and it could be exploited in wind farms and in environments usually closed to existing ones due to the presence of high intensity winds.

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, etcetera, so the maintenance requirements could be drastically reduced and their lifespan is expected to be higher than traditional wind turbines.

It is clear that the proposed device is of prime interest, and that scientific investigation of the response of this wind energy generator under different operation scenarios is highly desirable. Thus, the objective of this SHAPE project is to develop the needed tools to simulate Fluid-Structure Interaction (FSI) problems and to reproduce the experimental results for scaled models of the Vortex-Bladeless device. In order to do so the Alya code, developed at the Barcelona Supercomputing Center, is adapted to perform the Fluid-Structure Interaction (FSI) problem simulation. The obtained numerical results match satisfactorily with the experimental results reported.

III.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.

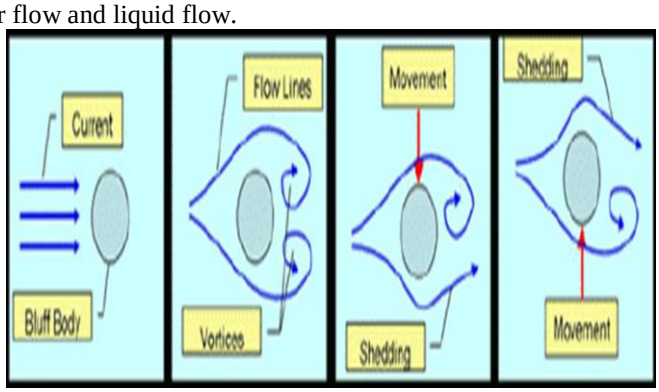


Fig: Principle of Vortex

VORTEX SHREDDING

Vortex shedding is a widely occurring phenomenon applicable to nearly any bluff (non streamlined) body submerged in a fluid flow. Since any real fluid flow is viscous, there will be a significant boundary layer on the bodies' surface for all but the lowest Reynolds number flows. At some point along the bodies' surface, separation of the boundary layer will occur, depending on the exact surface geometry. This separated layer, which bounds the wake and free stream, will tend to cause fluid rotation, since its outer side, in contact with the free stream, moves faster than its inner side, in contact with the wake. It is this rotation which then results in the formation of individual vortices, which are then shed from the rear of the body and travel down the wake. Typically, a pattern of periodic, alternating vortex shedding

Fig: Vortex shedding periodic pattern

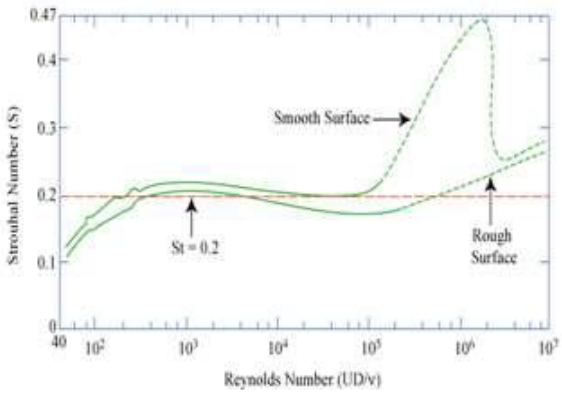


Fig: Vortex shedding periodic pattern

will occur in the flow behind the body, which is referred to as a vortex street. Depending on the characteristics of the flow, mainly the Reynolds number, different types of vortex streets may form, which will be discussed later in more detail. When the pattern of shed vortices is not symmetrical about the body, which is the case in any vortex street, an irregular pressure distribution is formed on the upper and lower sides of the body, which results in a net lift force perpendicular to the flow direction. Since the vortices are shed in a periodic manner, the resulting lift forces on the body also vary periodically with time, and there for can induce oscillatory motion of the body. This occurrence alone would qualify as vortex induced vibration; however, there is a more interesting and important phenomenon, similar to linear resonance, which can occur when the frequency of vortex shedding (fs) is close to the natural frequency of the body in motion, (fn). In this phenomenon, referred to as "lock in", the vortex shedding frequency actually shifts to match the bodies' natural frequency, and as a result, much larger amplitudes of vibration can occur.

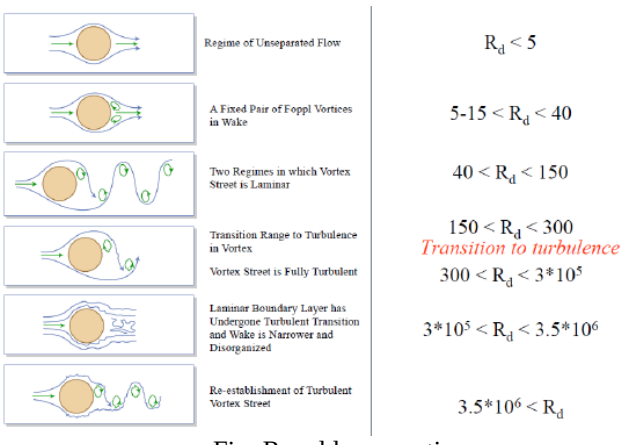


Fig: Renolds propertis

That means value of Reynolds number should be greater than 300.

IV. CALCULATION

Lets consider a structure called Tapered Oscillation Cylinder.

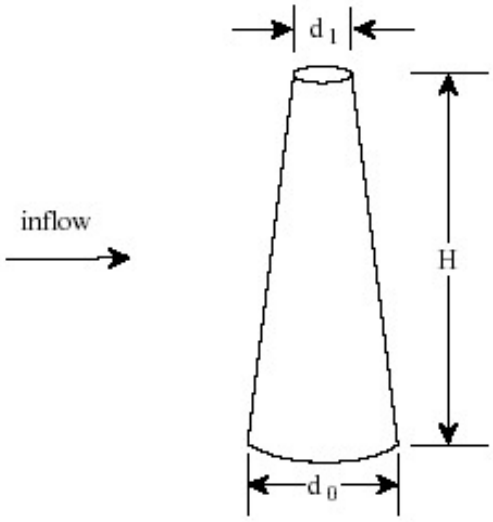


Fig: Tapered cylindrical structure

Considering the notations as,
d0= Dmax,
d1= Dmin,
D= (Dmax + Dmin)/2
H= L,
U= Air velocity,
ν= Kinematic viscosity,
fs= Oscillation frequency,
Now, we know Reynolds Number (Re)
Re= (UD)/ν
and Strouhal Number (St)
St= (fsD)/L
Area of tapered cylinder,
Ap= (π/2)*(Dmax + Dmin)*L
Rt= Taper Ratio =L/(Dmax + Dmin)

Reynolds Number distinguish the flow of fluid as Laminar or turbulent. So we are targetting Re values 300<Re<3*105 for better frequency of vibration.(From graph)

Now for Reynold number to be 300<Re<3*105 , 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

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.

V. METHODS OF ELETRICITY GENERATION

1.BY PIEZOELECTRIC MATERIAL:-

Piezoelectric Effect is the ability of certain materials to generate an electric charge in response to applied mechanical stress. The word Piezoelectric is derived from the Greek piezein, which means to squeeze or press, and piezo, which is Greek for “push”.

One of the unique characteristics of the piezoelectric effect is that it is reversible, meaning that materials exhibiting the direct piezoelectric effect (the generation of electricity when stress is applied) also exhibit the converse piezoelectric effect (the generation of stress when an electric field is applied).

When piezoelectric material is placed under mechanical stress, a shifting of the positive and negative charge centers in the material takes place, which then results in an external electrical field. When reversed, an outer electrical field either stretches or compresses the piezoelectric material.

There are many materials, both natural and man-made, that exhibit a range of piezoelectric effects. Some naturally piezoelectric occurring materials include Berlinite (structurally identical to quartz), cane sugar, quartz, Rochelle salt, topaz, tourmaline, and bone (dry bone exhibits some piezoelectric properties due to the apatite crystals, and the piezoelectric effect is generally thought to act as a biological force sensor). An example of man-made piezoelectric materials includes barium titanate and lead zirconate titanate.

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(vortex size>2m).

2. 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.

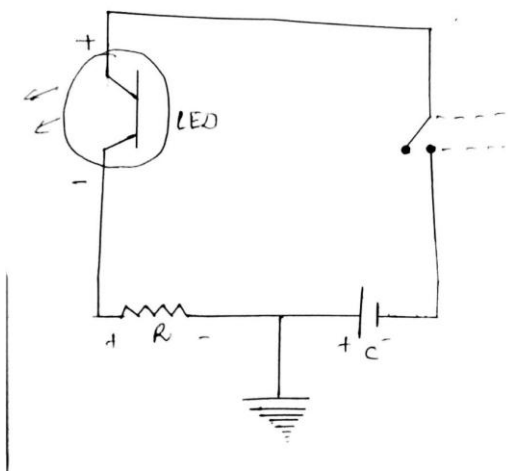
It fails in our project because our project is a small prototype so, it is unable to generate that amount of pressure required for electricity generation from piezoelectric materials.

But it is possible with real project with large dimensions(vortex size>2m).

3.BY RACK& PINION MECHANISM :-

Here the reciprocating motion of the vortex turbine is converted into rotary motion using the rack and pinion arrangement. The speed due to the rotary motion achieved at the pinion is less. This speed which is sufficient to rotate dynamo. The dynamo which rotates within a static magnetic stator cuts the magnetic flux surrounding it, thus producing the electric motive force (emf). This generated emf is then sent to a circuit which is used to the storage battery where it is stored during the day time.

CIRCUIT DIAGRAM:



Since the current comes from the dc dynamo is fluctuating type therefore we need this above circuit. In this when current comes to circuit is stored in capacitor then it get converted into linear current which is either stored in battery or directly use to blow LED bulb.

In our project we use this mechanism but by making its larger model we can use above two mechanism (i.e.piezoelectricity,linear generator concept).

Here our main aim is to invent a new renewable source of electricity generation which can be done by VORTEX BLADELESS TURBINE.Which can be done by any of the above three methods.

VI. ADVANTAGES & DISADVANTAGES

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
- It supposedly has a greater than 50 percent manufacturing cost advantage and a 40 percent reduction in its carbon footprint compared to standard wind turbines, the system also seems to offer direct economic advantages.
- Many opponents of spinning wind turbines point to their supposed danger to birds and other flying animals, as well as their rather noisy operation and – particularly in commercial installations – their enormous size which is not present in this vortex turbine.

Disadvantages:

- Large power fluctuations.
- Low energy conversion.
- High mechanical stresses
- No control of active and reactive power

VII. CONCLUSION

The issue of global climate change and the growing energy demand induce a need for innovative energy harvesting devices. Geophysical flows represent a widely available source of clean energy, useful to tackle the global energy demand using for example wind turbines, marine turbines or wave energy converters. Yet, the energy density in geophysical flows is small, and large systems are required in order to harvest significant amount of energy.

The turbine generator is the most mature method for flow energy harvesting. However, the efficiency of conventional turbines reduces with their sizes due to the increased effect of friction losses in the bearings and the reduced surface area of the blades. Furthermore, rotating components such as bearings suffer from fatigue and wear, especially when miniaturised. These drawbacks of turbine generators urges emergence of a new area in energy harvesting, i.e. energy harvesting from flow induced vibration. The flow here includes both liquid flow and air flow. There are three main types of energy harvester of this kind. They are energy harvesting from vortex-induced vibration (VIV), flutter energy harvesters and energy harvesters with Helmholtz resonators.

Flow-induced vibration, as a discipline, is very important in our daily life, especially in mechanical engineering. Generally, scientists try to avoid flow-induced vibration in buildings and structures to reduce possible damage. Recently, such vibration has been investigated as an energy source that can be used to generate electrical energy. Two types of flow-induced vibration are studied so far: vortex-induced vibration and flutter.

VIII. FUTURE SCOPE

- Since most of states of India has many villages where there is still very less amount of available electricity distribution.
- So at that places establishment of this type of ‘bladeless wind turbine’ will help them to avail electricity as well as job for family persons.
- It must be established in every states of India because of it is environment friendly as well as seeking available amount of non – renewable energy sources.

IX. REFERENCES

[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

[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

[3] Robert Correa,Eric Cremer,Wind harvesting via Vortex Induced vibration; BJS-WD14.

[4] J.C.Cajas,D.J.Yanej;SHAPE Project Vortex Bladeless:Parallel multi-code coupling for fluid structure interaction in wind energy.

[5] www.prace-ri.eu

[6] www.vortexbladeless.com