Design & Analysis Of Bladeless Windmill

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Abstract: It uses a radically new approach to capturing wind energy. The device captures the energy of vortices, 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. [1]

Keywords- Bladeless windmills, Vortex Shedding Effect, Vortices, Oscillating.

I. INTRODUCTION

Renewable energy is generally electricity supplied from sources, such as wind power, solar power, geothermal energy, hydropower and various forms of biomass. These sources have been coined renewable due to their continuous replenishment and availability for use over and over again.This seminar report focuses on the regardless of wind speed. [1]

Bladeless windmill uses a radically new approach to capturing wind energy. The device captures the energy of vorticity, an aerodynamic effect that has plagued structural engineers and architects for ages (vortex shedding effect). As the wind by passes 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. Instead of avoiding these aerodynamic instabilities, this technology maximizes the resulting oscillation and captures that energy. Instead of the usual tower, nacelle, and blades, the device has a fixed mast, a power generator, and a hollow, lightweight, and semi-rigid fiberglass cylinder on top. [2]

II. OBJECTIVES

To avoid those aerodynamic instabilities, this technology maximizes the resulting oscillation and captures the energy. Naturally, the design of such a device is completely different from a traditional turbine. Instead of the usual tower, nacelle, and blades, the device has a fixed mast, a power generator, and a hollow, lightweight, and semi-rigid fiberglass cylinder on top.[2]

III. BLADELESS CONCEPT

The characteristic that set this wind generator apart from others is that it is fully supported and rotates with no risk of animal killing. This is vertically oriented with at the centre moving mast and generator.

It seems that basic generator would be most effective placing inside mast. This fig. Shows a basic structure regarding how the bladeless turbine integrated into design. The magnet used inside coil is cylindrical shape magnet,which moves and cause electricity generation output [1]

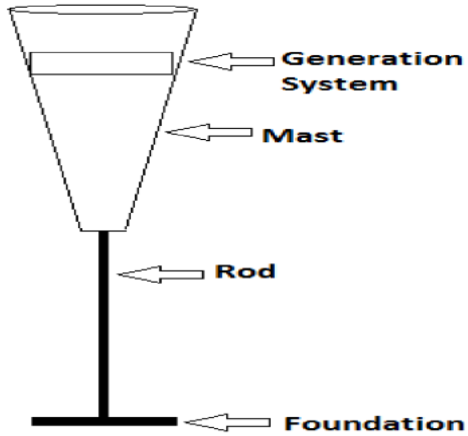

Fig 1.Schematic Model [Ref 1, for reference only]

IV. COMPONENT DETAILS

i)MAGNETS:

Out of the four options of magnets and as seen from the B-H graph the permanent magnets that that were chosen for this application were the N52 magnets. These Nd-Fe-B permanent magnets are nickel plated to strengthen and protect the magnet itself. For maximum output the coil must be such that a complete circular magnet move in or move out of the winding in this case only the maximum energy generation is possible.

ii) MAST:

After a thorough research into both sub types of vertical axis wind turbine blades configuration, we decided to base the foundation of our design on the CATIA model. This design was attained with only single sheet of triangular shape cut out from aluminium metal sheet and due to flexibility of sheet metal, we are able to make it in conical shape which uses vortex shedding effect for electricity generation which explained previously in effect of wind structure on wind turbine.

iii) WINDING:

The number of winding per coil produces a design challenge. The more windings will increases the voltage produced by each coil but in turn it will also increase the size of each coil. In order to reduce the size of each coil a wire with greater size gauge can be utilized. Again another challenge is presented, the smaller the wire becomes the less current will flow before the wire begins to heat up due to the increased resistance of small wire.

iv) COIL DESIGN:

These coils are arranged inside the blade, the coils are raised to a certain height for maximum energy generation and for maximum output the coil must be such that a complete circular magnet move in or move out of the winding in this case only the maximum energy generation is possible. If the magnet moves only in half part of coil instead of moving in or out completely then there is less energy generation than first case, so proper care must take while designing the coils and selecting magnet length. The coils are arranged in series aiding to obtain maximum output voltage. 1]

V. PARAMETERS AFFECTING PERFORMANCE

1. POWER

Tesla turbine is best suited for low power generation spectrum or where primary cost is critical or where fluid properties hinder the performance of conventional turbine. The power output throughout the literature has shown as low as in milliwatt while the notable values are around 1kw to 2kw. Still, most of the results obtained are about under 500 watts but that can be improved largely according to theory.

2. NOZZLE

For the same pressure drop, diverging nozzle produces about one-third more horsepower than the straight nozzle. It is an impulse turbine as all the expansion of steam occurs in the nozzle only rather than onto the rotors (as a result of which the exhaust holes are placed as nearer to the centre of the rotor).Main drop in the overall efficiency is seen due to the less efficiency of the nozzle.

3. FLOW CHARACTERISTICS

Presence of the turbulent flow conditions at the transition from laminar to turbulent till mid turbulent gives the best power output i.e. the Reynolds number approximately 450,000. (Medium- compressed air)

4. FRICTION FACTOR

Poiseuille number increases with the surface roughness. (By Gamarat)

This increase in the number is of substantial help here as it improves the performance of the rotor as the primary force of running the turbine is shear force. The second benefit of increasing the roughness is the increase in the momentum transfer of the fluid to the discs thereby increasing the drag force and faster the tangential velocity drop.

5. RPM

Effectiveness of operating the turbine can be maximized by running at a lower rpm and more flow rate. This increases the momentum transfer of the fluid to the discs.

6. INTERDISK SPACING

Torque and power are found to increase by decreasing spacing between the disks up to 0.5mm. This spacing can be more optimized but according to experimental results the minimum ratio of the rotor's radius to the interdisc spacing should be 20. According to Warren Rice, the highest efficiency is seen the turbine when the distance between the disks is equal to two times the boundary layer thickness.

7. NUMBER OF DISKS

By increasing the number of disks, the surface area on which the fluid flows increases thereby increasing the torque acting and hence the efficiency. Most of the experiments have been carried out by taking 6 to 10 disks in general. Though there is no specific consideration on the number to be fixed as it depends on several other conditions like the power output required, number of nozzles used inter disk spacing and also the pressure of the working fluid used.[3]

VI. Formula for determining torque

Tesla describes a dynamic relation between the disc and the fluid [3]. However the mass and viscosity of the fluid are essential in developing an equation that will work across fluid. The equations are:

Momentum = mass * velocity (1)

Kinetic energy = (mass*velocity2) / 2 (2)

Also engineers have developed a dynamic relation between torque and fluid viscosity as follows,

Torque = (3uvr2) / 2h (3)

Where ,

v = velocity of the fluid, in meters/second

u = viscosity of the fluid, in Pascal-second

r = radius of the disc, in meters

h = half of the distance between the discs, in meters[4]

VII. Study of Vortex Induced Vibrations(VIV)

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 occur. 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.[5]

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.

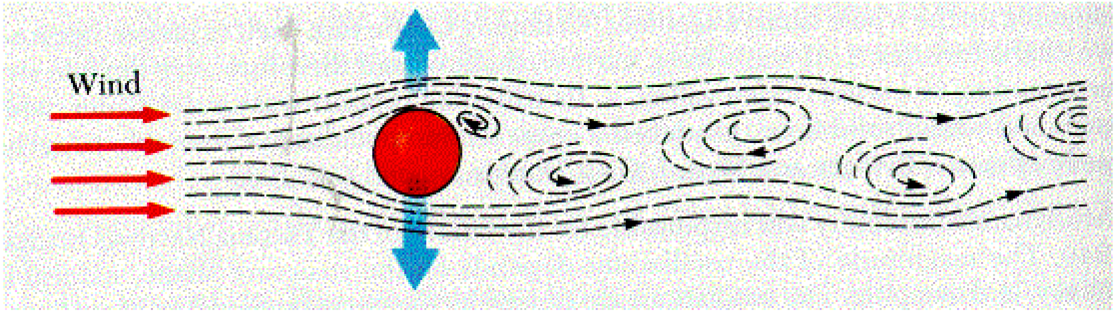

Fig 2.Vorticity and Vortex Shedding Effect[Ref 5, for reference only]

IX. ADVANTAGES

- Simple, low cost, Compact size and lightweight.
- 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.

X. DISADVANTAGES

- This technology is in development phase and requires huge stakes by investors.
- The Major problem faced by this windmill is that it requires a starting torque.
- The output power depends directly on the height of the mast.
- Electrical power generation affected by environmental changes.

XI. APPLICATIONS

- Bladeless wind energy can be used in a variety of industries and applications, including marine off- grid systems, industrial applications, remote telemetry and mobile base stations for houses, schools and farms.
- Bladeless energy for agriculture: Remote power systems are needed more and more in the world of farming.
- Bladeless energy for telecoms: with more and more mobile communication and Broadband technology being deployed in rural and remote areas, providing power for the Transmission equipment can be a problem.
- Bladeless wind energy for off-grid lighting: small scale bladeless wind turbine generators are ideal for providing efficient and reliable lighting in off-grid locations.
- The bladeless energy generates free renewable energy which can be stored in battery, illuminated when it gets dark.
- Streets, playgrounds, parks and car parks are good examples to name a few.
- Bladeless energy can also be utilized for Rail signaling: large parts of rail network lack convenient mains electricity.
- Bladeless wind power generators can be installed near railway signals to supply power to the signaling systems.

XII. CONCLUSION

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From above information it is clear that the Bladeless turbine wind generator is the best option for electricity generation using wind power due to its various advantages wind turbine is the best solution. It will help to increase percentage of renewable energy for electrical power generation and provides electrically as well as economically efficient power to the consumers. Hence we have to spread this concept because only renewable energy can survive the world in coming future and in that wind energy is efficient option.[1]

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