RESEARCH PAPER ON BLADELESS WINDMILLS BASED ON THE PRINCIPLE OF VIBRATION

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The bladeless windmills use a radically new approach for capturing both intermittent wind energy pulses and constant wind flow under specified wind velocity and pressure. The windmill utilizes the energy of vorticity, an aerodynamic effect (vortex shedding). As wind strikes a fixed structure, its flow changes and a cyclical pattern of eddies or vortices are formed in the vicinity of the structure. As these forces go strong, the structure starts vibrating. Consequently, these aerodynamic instabilities can be utilized to run a linear alternator or a crankshaft. The natural frequency of the structure should not match with the frequency of vibration, which is one of the design criteria, our design takes care of this major criteria. The design of our windmill is entirely different from a traditional windmill. Instead of the huge tower, nacelle and blades, this device has a conical frustum mast made up of fiber-glass (pivoted at one-third length from bottom), a crankshaft, a crank, a connecting rod and a hinge joint. The hollow and light weight mast makes this device portable and user-friendly. Also, this low cost components opens a way for low cost renewable source of energy.

The bladeless windmills run on the principle that when wind is allowed to strike the column mast, it tends to vibrate and this vibrational energy is further converted to mechanical (crank shaft) or electrical energy (direct connection to alternator). When the wind impinges on the projected surface area of the mast from one specified direction, stream lines of the wind tend to depart and get sheared off. Further passage results into the formation of wind currents called vortices or eddies. When they are strong enough to overcome the internal resistance offered by the mechanism (crank shaft or direct linear alternator), the mast vibrates due to spring connected at outside surface of the mast. The then spring is connected to the foundation seat. The connecting rod is bound to transmit this vibration to the crank. The crank shaft can be connected to a generator further. We can also connect the lower end of the mast with the linear alternator directly.

Obviously, we can use a rectifier circuit to transform this A.C. current to D.C. current and charge a battery or connect it the load.

**ABSTRACT**

The bladeless windmills uses a radically new approach for capturing both intermittent wind energy pulses and constant wind flow under specified wind velocity and pressure. The windmill utilizes the energy of vorticity, an aerodynamic effect (vortex shedding). As wind strikes a fixed structure, its flow changes and a cyclical pattern of eddies or vortices are formed in the vicinity of the structure. As these forces go strong, the structure starts vibrating. Consequently, these aerodynamic instabilities can be utilized to run a linear alternator or a crankshaft. The natural frequency of the structure should not match with the frequency of vibration, which is one of the design criteria, our design takes care of this major criteria. The design of our windmill is entirely different from a traditional windmill. Instead of the huge tower, nacelle and blades, this device has a conical frustum mast made up of fiber-glass (pivoted at one-third length from bottom), a crankshaft, a crank, a connecting rod and a hinge joint. The hollow and light weight mast makes this device portable and user-friendly. Also, this low cost components opens a way for low cost renewable source of energy.

**KEYWORDS:**

Bladeless windmills, Vortex, Pollution, spring, dynamics of machinery.
4. EXPERIMENTAL CALCULATIONS AND SPECIFICATIONS

**Mast:**
- Larger Radius of the mast, $R = 0.125$ m
- Smaller Radius of the mast, $R = 0.0625$ m
- Height of the mast, $L = 1$ m

**Lateral Surface area of the mast (open), $S = \pi \times (R_1 + R_2) \times L$**

\[
= 3.14 \times (0.0625 + 0.125) \times 1.00 \\
= 0.5887 \text{ m}^2
\]

**Density of the Fibreglass, $\rho = 1760$ kg/m$^3$**

**Thickness of the FRP sheet, $t = 2$ mm**

**Mass of the mast, $m = \rho \times S \times t$**

\[
= 1760 \times 0.5887 \times 0.002 \\
= 2.068 \text{ kg}
\]

**Centre of gravity, C.G (from the bottom end)**

\[
= 1 - \frac{h (R_1 + 2R_2R_1 + 3R_2^2)}{4(R_1 + R_2R_1 + R_2^2)} \\
= 1 - 0.39 \\
= 0.61 \text{ m}
\]

**Velocity of the wind, $v = 40$ m/s (Gujarat, India)**

**Projected area of the mast exposed to wind,**

\[
A = (R_1 + R_2) \times L
\]

\[
= 0.1875 \text{ m}^2
\]

**Force of the wind on the projected area,**

\[
F_1 = \rho \times A \times v^2
\]

\[
= 1.225 \times 0.1875 \times 11.12 \\
= 28.40 \text{ N}
\]

**Radius of the mast at the point of pivot, $R_3$**

Applying theory of proportionality,

\[
R_3 = R_1 \times 0.39
\]

\[
= 0.048 \text{ m}
\]

**Centre of gravity of frustum portion above the pivot, $L_1$**

\[
= h_{\text{frustum}} \times \frac{h_{\text{frustum}} + 2(R_1 + R_2R_1 + 3R_2^2)}{4(R_1 + R_2R_1 + R_2^2)} \\
= 0.61 - 0.22198 \\
= 0.388
\]

So, Centre of gravity of the frustum above pivot from bottom of whole mast $= 0.338 + 0.39 = 0.778$

**Net distance of Point of hinge from point of pivot $L = 233$ mm**

**Mechanical advantage**

\[
F_2 \times L_1 = F_1 \times L_3 \\
= 28.40 \times 0.388 / 0.233 \\
= 47.29 \text{ N}
\]

The loss at the border contact hinge joint and crank shaft offset is close to 10% (found by experiments)

The length of the connecting rod $>>>$ crank radius

And thus, effect of arc can be neglected.

The net force on the crank shaft is $= 42.56$ N

The crank radius is 25 mm

The net Torque at the end of the crank shaft is $P = 0.025 \times 42.56N$ $= 1.06$ Nm

**Spring:**

The design of the spring is based on the dynamics of machinery. The D’Alembert’s principle is used to determine the natural frequency of the system. The analysis was done with the help of ANSYS software.

The results are as shown:
5. ADVANTAGES

The bladeless windmill does not have any sliding contact joints which reduces the frictional losses in the system thereby reducing wear and tear. The system does lose some electrical conversion capacity, but other pros nullifies this factor.

The material used in the mast is Fibre glass which exhibits high strengths and low weight. Also, The FRP sheets show high environmental resistance. Fire hardness, sound structural integrity and non-corrosive nature makes the device more portable, user friendly and cost effective with durability.

The space required by these windmills is very small. Consequently, 15 windmills can be employed within the same area where one or two conventional windmills are employed. It currently takes up 30% of the area of a conventional generator, with maximum deflection at the top end.

The components of bladeless windmills takes about 35 minutes to assemble. Which is noticeably low when compared to conventional ones.

The provision of crank mechanism and spring makes this windmill run smoothly and swiftly in comparison to other bladeless windmills.

The impact on the bird population is expected to be much smaller, because it does not require the same type of wind velocity, wind force and large area earlier deforested. Besides this, The oscillation frequency is just 14 Hz, the impact sound level is negligible making it possible in future to have noiseless wind farms.

6. DISADVANTAGES

The efficiency of the energy extraction for bladeless windmills from the wind is 40%, while that of conventional windmill is 59.3%.

Thus, it cannot substitute thermal and nuclear power plants, traditional windmills and hydroelectric power plants.

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.

7. 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. Whether it's for powering electric fencing, power water pumping, powering lighting in stables and chicken shade or powering underwater cameras at salmon farms-bladeless energy can be built in small scale as well as large scale to meet the needs. Small scale bladeless wind turbine energy for households are designed to bring energy to an off grid locations and matching it with solar panels and supplement it. This is cost effective for houses where solar energy production is intermittent. Also, it can be used for residential battery charging and grid connection.

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 energy can provide off-grid power solutions needed to support telecom infrastructure.

Bladeless energy for Rail signalling: large parts of rail network lack convenient mains electricity. Bladeless wind power
generators can be installed near railway signals to supply power to the signalling systems.

8. CONCLUSION
The bladeless windmills can offer promising results in near future with respect to efficiency, capacity and productivity.

This topic is a great area for research and so far the results are encouraging.

Further, developments can be done in the mechanism which is converting vibrations to electricity.

The results above are based on 1 m prototype along with ANSYS analysis software outcomes.

The purpose of this paper is to form some basis for the research in the field of renewable resources of energy in near future and be an encouragement for generations to come.

The project has five main advantages: Less space requirement, less impact on fauna, less noise, better running, multiple uses due to its portability and use in case of intermittent pulses of wind and its low cost

Moreover, some disadvantages such as starting torque requirement, low extraction efficiency can be solved with optimization and changes in design.

The use of rack and pinion, direct alternators and slotted link mechanisms can be done instead of crank mechanism.

9. REFERENCES
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