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REVIEW ARTICLE

DESIGN OF WIND TURBINE IN VERTICAL AXIS

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ABSTRACT

This paper proposes to construct a wind turbine that has a very low cut in speeds and aims to optimize the earlier model of Vertical axis wind turbine (VAWT). A wind turbine is a device which is generally used to convert wind energy into mechanical energy, which is in turn converted into electrical energy. Wind turbines are broadly classified into two types: Horizontal axis wind turbine (HAWT) and Vertical axis wind turbine (VAWT). For the optimization of the earlier model of VAWT, using the curved blades made of acryl polymer which reduces the drag force and overcomes the problem of poor starting. In VAWT, the mechanical power generation equipment can be located at ground level, so it makes the maintenance easy and they are omni-directional (they do not need to be pointed in the direction of the wind to produce power).

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INTRODUCTION

A wind turbine is a device, which converts kinetic energy from the wind into mechanical energy. If the mechanical energy is used to produce electricity, the device may be called a wind generator or wind charger. If the mechanical energy is used to drive machinery, such a as for grinding grain or pumping water, the device is called a windmill. Developed for over a millennium, today's wind turbines are manufactured in a range of vertical and horizontal axis types. (Ackermann, 2002) The smallest turbines are used for applications such as battery charging or auxiliary power on sailing boats; while large grid-connected arrays of turbines are becoming an increasingly large source of commercial electric power.

A horizontal Axis Wind Turbine is the most common wind turbine design. In addition to being parallel to the ground, the axis of blade rotation is parallel to the wind flow. Some wind turbines are designed to operate in an upwind mode (with the blades upwind of the tower). Large wind turbines use a motor-driven mechanism that turns the machine in response to a wind direction. Smaller wind turbines use a tail vane to keep the blades facing into the wind. Other wind turbines operate in a downwind mode so that the wind passes the tower before striking the blades. Without a tail vane, the machine rotor naturally tracks the wind in a downwind mode. Although vertical axis wind turbines have existed for centuries, they are not as common as their horizontal counterparts. (Alexander, 1978) The main reason for this is that they do not take advantage of the higher wind speeds at higher elevations above the ground as well as horizontal axis turbines. The basic vertical axis designs are the Darrieus, which has curved blades, the Gyromill, which has the straight blades, and the Savonius, which uses the scoops to catch the wind. A vertical axis machine need not be oriented with respect to wind direction. Because the shaft is vertical, the transmission and generator can be mounted at ground level allowing easier servicing and a lighter weight, lower cost tower. Although vertical axis wind turbines have these advantages, their designs are not as efficient at collecting energy from the wind as are the horizontal machine designs.

Yaw Mechanism

Unlike the VAWTs, the HAWTs are in need of a yaw mechanism. The function of yaw mechanism is to direct the rotor in the wind direction in order to maximize the aerodynamic efficiency. In includes an electrical motor as a drive mechanism and a control system, which detects the wind direction and command the mechanism to rotate. The main disadvantages are need for maintenance and the cost of the

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equipment, installation and operation. Additionally, there is a delay in rotation of the nacelle in the right direction due to the time response. VAWTs on the other hand, do not need yawing mechanism, while they are unidirectional and they can rotate in both directions. (Baumiester, 1978) This property makes VAWTs highly suitable for locations where the wind is gusty or turbulent like mountainous areas and urban neighborhoods.

Axis of Direction

Some advantages and considerations for VAWTs come with vertical axis of rotation. Usually, HAWTs drive train is located in nacelle on top of the tower. This increases mechanical stress on the tower, which requires strong foundation. In VAWTs a part of the drive trains i.e. the generator and the control equipment can be located on the ground (Benesh, Alvin, 1988). The mechanical power in transferred via a long shaft from the hub to the generator, which has many advantages. The generator size and weight will have low priority as a design constraint.

Direct Drive

VAWTs are more suitable for direct drive applications compared with the HAWTs. Electric machine in direct drive wind system usually operates with low speed and high torque. For a constant power rating and constant torque density of a machine, weight is positively correlated with the torque rating. Consequently design with higher torque in direct drive will have more weight. In HAWTs higher weight of the machine in direct drive puts more mechanical stress on the tower. Unlike HAWTs, this is not an issue for a VAWT, as the machine is located on the ground.

Fluid Dynamics

Fluid dynamics has a wide range of applications, including calculating forces and moments on aircraft, determining the mass flow rate of petroleum through pipelines, predicting weather patterns, understanding nebulae in interstellar space and modelling fission weapon detonation. Some of its principles are even used in traffic engineering, where traffic is treated as a continuous fluid, and crowd dynamics. Fluid dynamics offers a systematic structure which underlies these practical disciplines that embraces empirical and semi-empirical laws derived from flow measurement and used to solve practical problems.

Computational fluid dynamics

ANSYS computational fluid dynamics (CFD) simulation software allows you to predict, with confidence, the impact of fluid flows on your product throughout design and manufacturing as well as during end use. The software's unparalleled fluid flow analysis capabilities can be used to design and optimize new equipment and to troubleshoot already existing installations. ANSYS renowned CFD analysis tools include the widely used and well-validated ANSYS Fluent and ANSYS CFX, available separately or together in the ANSYS CFD bundle. Because of solver robustness and speed, development team knowledge and experience, and advanced modelling capabilities, ANSYS fluid dynamics solutions provide results you can trust. The technology is highly scalable, providing efficient parallel calculations from a few to thousands of processing cores. (Germanischer Lloyd, 1993) Combining Fluent or CFX with the full-featured ANSYS CFD-post processing tool allows you to perform advanced quantitative analysis or create high-quality visualizations and animations.

ANSYS CFD solutions are fully integrated into the ANSYS Workbench platform. This environment delivers high productivity and easy-to-use workflows. Workbench integrates all your workflow needs (pre-processing, simulation and post-processing) as well as multiphysics functionality (fluid–structure interaction, electronic–fluid coupling). Workbench allows for automated and easy-to-set-up optimization or design exploration studies (for example, design of experiments, six sigmaanalysis).

Design of vertical axis wind turbine and its components

Design of blade

Blades are the most important component of both horizontal axis and vertical axis wind turbine. It is mainly responsible for harnessing the power from the wind. The efficiency of a wind turbine completely depends upon the blades of the wind turbine. To overcome the failures like drag force and poor starting of blades in earlier model we had designed a curved blade (Chen, 2008). So that the attack angle of the air is altered and then the drag force is reduced. In order to yield maximum efficiency we had chosen a blade material made of acryl polymer which is a type of plastic material. This blade was chosen by considering the temperature condition and moisture content in this particular region and it is lighter in weight. (Chou *et al*., 1996) To improve the efficiency we used four blades.

Blade specification

Material	: Acrylate polymer (plastic material)
Length	: 300mm
Thickness	: 5mm

Modeling of blade

After importing the co-ordinates of the blade as per the required dimension the blade is modeled in Pro-E.

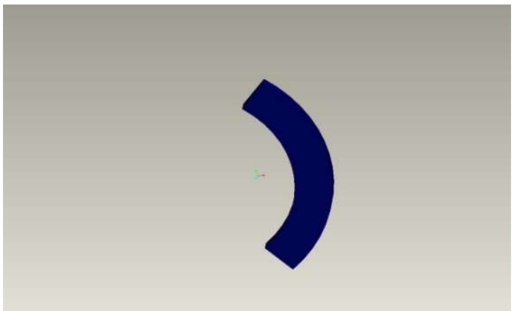

Fig. 1. Design of Blade

Conclusion

The objective of this paper is to increase the efficiency of the earlier models of vertical axis wind turbine and also to make the wind under low starting torque conditions. We have fabricated the model of the vertical axis wind turbine with curvy blade material made of acryl polymer material so that the blade can rotate freely with reduced drag force. We are planning to make further improvements in the future and have found that this type wind turbine has a greater scope in the future. But commercializing this model of VAWT we can produce cheap and green energy. As this is a rooftop model, it can be used in regular homes and industries.

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