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Design And Analysis Of Savonius Wind Turbine Blades

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Abstract
There are two kinds of wind turbines according to the axis of rotation to the ground, horizontal axis wind turbines (HAWT) and vertical axis wind turbines (VAWT). VAWTs include both a drag type configuration like Savonius wind turbine and a lift-type configuration like Darrieus wind turbine. Savonius wind rotor has many advantages such as low starting speeds and no need for external torque for its starting. Moreover it is cheaper in construction and has low maintenance. It is independent of the wind direction and has a good starting torque at lower wind speeds. The experimental study conducted in this paper aims to investigate the effect of number of blades and other criteria that can affect the performance of the model of Savonius type wind turbine. The experiments used to compare 2, 3, and 4 blades wind turbines to show tip speed ratio, torque and power coefficient related with wind speed. A simulation using ANSYS 13.0 software will show pressure distribution of wind turbine. The results of study showed that number of blades influence the performance of wind turbine. Savonius model with three blades has the best performance at high tip speed ratio.

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. The popularity of renewable energy has experienced a significant upsurge in recent times due to the exhaustion of conventional power generation methods and increasing realization of its adverse effects on the environment. This popularity has been bolstered by cutting edge research and ground breaking technology that has been introduced so far to aid in the effective tapping of these natural resources and it is estimated that renewable sources might contribute about 20% – 50% to energy consumption in the latter part of the 21st century. Facts from the World Wind Energy Association estimates that by 2010, 160GW of wind power capacity is expected to be installed worldwide which implies an anticipated net growth rate of more than 21% per year.

II. TYPES OF WIND TURBINES

A. Horizontal axis wind turbine

Many types of turbines exist today and their designs are usually inclined towards one of the two categories: horizontal-axis wind turbines (HAWTs) and vertical-axis wind turbines (VAWTs). As the name pertains, each turbine is distinguished by the orientation of their rotor shafts. The former is the more conventional and common type everyone has come to know, while the latter due to its seldom usage and exploitation, is quiet unpopular. The HAWTs usually consist of two or three propeller-like blades attached to a horizontal and mounted on bearings the top of a support tower as seen in Figure 1.1

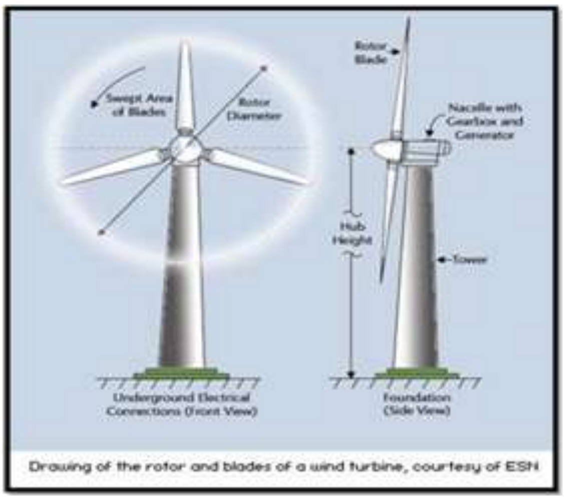

Figure 1.1 -Horizontal Axis Wind Turbine

When the wind blows, the blades of the turbine are set in motion which drives a generator that produces AC electricity. For optimal efficiency, these horizontal turbines are usually made to point into the wind with the aid of a sensor and a servo motor or a wind vane for smaller wind turbine applications.

B. Vertical axis wind turbine

With the vertical axis wind turbines, the concept behind their operation is similar to that of the horizontal designs. The major difference is the orientation of the rotors and generator which are all vertically arranged and usually on a shaft for support and stability. This also results in a different response of the turbine blades to the wind in relation to that of the horizontal configurations. A typical vertical axis design is shown in Figure 1.2.Their design makes it possible for them to utilize the wind power from every direction unlike the HAWTs that depend on lift forces from the wind similar to the lift off concept of an airplane.

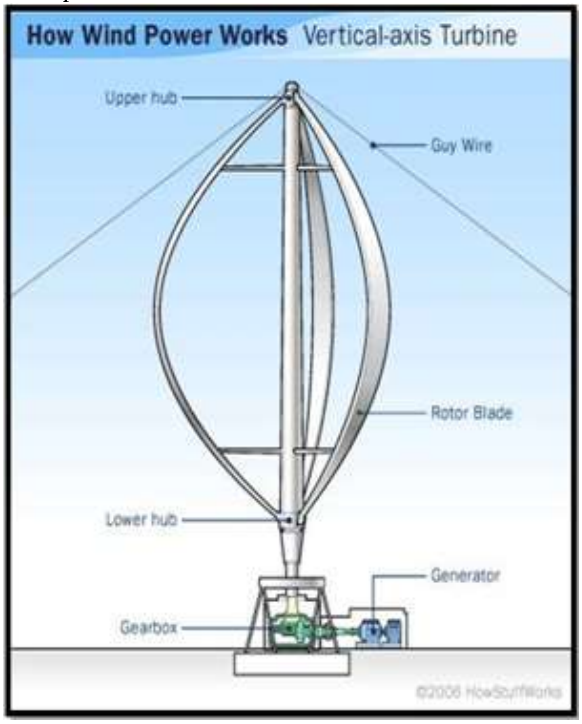

Figure 1.2 -Darrieus Model Vertical Axis Wind Turbine

Vertical axis wind turbines are further subdivided into two major types namely the Darrieus model and the Savonius model. Pictured above in figure 1.2 is an example of the Darrieus Model which was named after designer and French aeronautical engineer, Georges Darrieus. This form of this design is best described as an eggbeater with the blades, two or three of them bent into a c-shape on the shaft. The Savonius model was invented by Finnish engineer Sigurd Savonius and an example is shown in Figure 1.3.

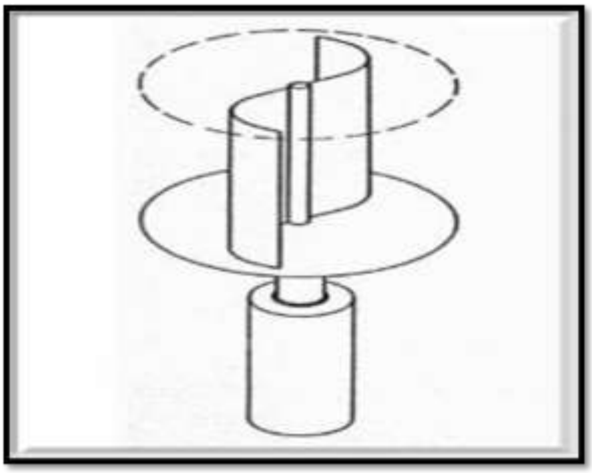

Figure 1.3 -Savonius Model Vertical Axis Wind Turbine

The functioning of this model is dependent on drag forces from the wind. This drag force produced is a differential of the wind hitting by the inner part of the scoops and the wind blowing against the back of the scoops. Like the Darrieus model, the Savonius turbines will work with winds approaching in any direction and also work well with lower wind speeds due to their very low clearance off the ground.

III. CHOICE OF NUMBER OF BLADES

The choice of the number of blades of a wind rotor is critical to its construction as well as operation. Greater number of blades is known to create turbulence in the system, and a lesser number wouldn't be capable enough to capture the optimum amount of wind energy. Hence the number of blades should be determined by both these constraints.

Number of blades will influence the rotation of rotor of wind turbine models. The three blades wind turbine produces higher rotational speed and tip speed ratio than that two and four blades. The highest tip speed ratio is 0.555 for wind speed of 7m/s. Wind turbine rotor with four blades has high torque compared with two or three blades wind rotor. Four blades wind turbine has good performance at lower tip speed ratio, but three blades wind turbine has the best performance at higher tip speed ratio Results of the experiments indicated the relationships between wind speeds and tip speed ratio or actual torque as shown.It shows that the three blades wind turbine model has the highest tip speed ratio. In general the three wind turbine models have significant tip speed ratio at lower wind speed and more stable at wind speed of 7 m/s. It means that the wind turbine models has optimal rotational speed at the wind speed above 7 m/s.Tip speed ratio is related with the performance of rotational speed of wind turbine rotor. Wind turbine with higher rotation will result in higher tip speed ratio. Three blades wind turbine model has the highest tip speed ratio at 0.555 with the wind speed of 7 m/s.

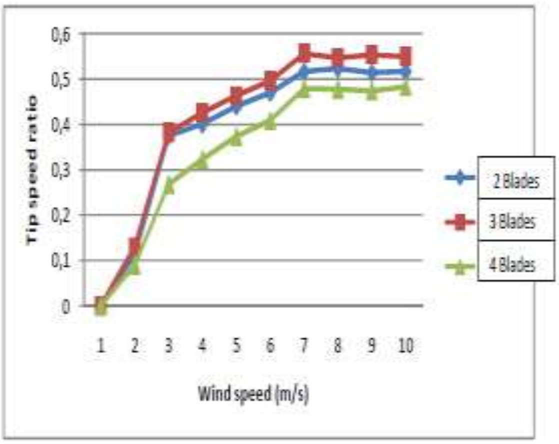

Fig 2.1-wind speed vs tip speed ratio

The deviation of drag forces caused by pressure differences on the blades of Savonius wind turbine will be shown using ANSYS 13.0 software. The simulation was assumed on steady flow with the wind speed of 10 m/s. Fig.2.1 shows pressure distribution for wind turbine rotor with two blades (a), three blades (b) and four blades (c). Pressure on concave blades is higher than pressure on convex blades with result that the deviation of drag forces will rotate the rotor. As shown in Fig. 2.1 (a) and (b), pressure in front of blades is higher than that at the back and wind turbine rotor will rotate. The more blade surfaces with higher pressure is found in four blades wind turbine as seen in Fig. 2.1.(c). It makes that four blades wind rotor has highest torque compared with other wind turbine rotor.

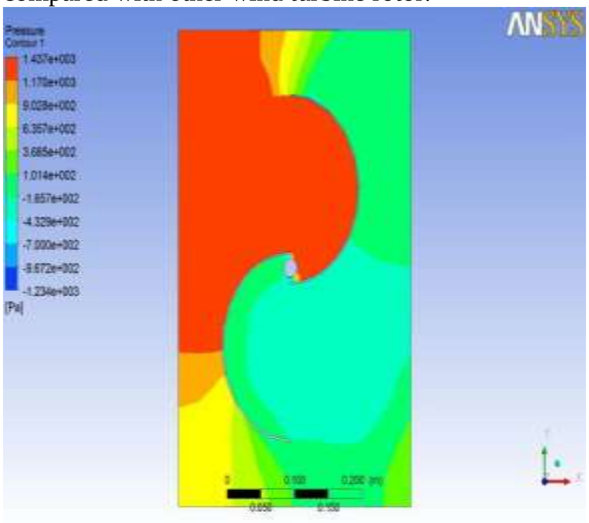

Fig 2.1.a

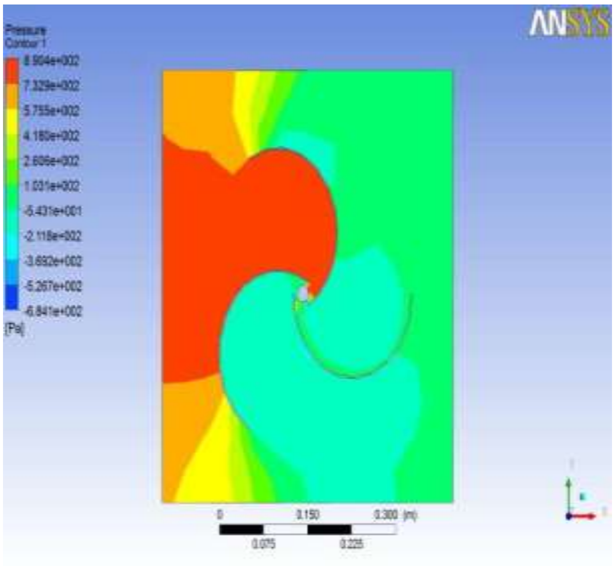

Fig 2.1.b

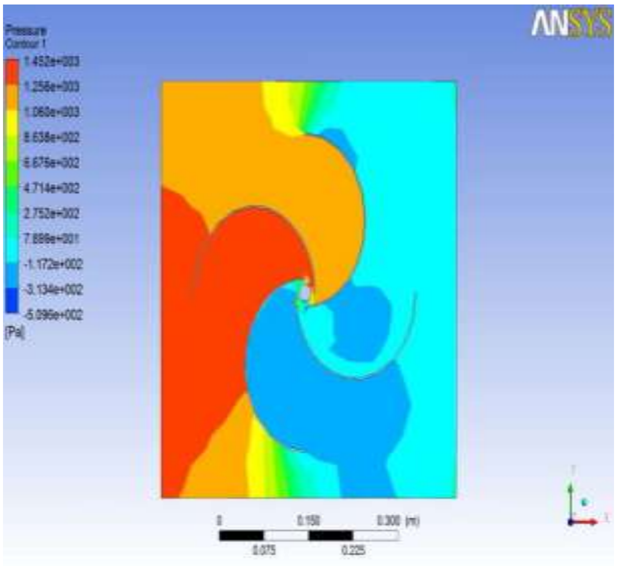

Fig 2.1.c

IV. Specification For The Blades

Dimensions of the blades of Savonius wind turbine model are:
Diameter of blades (*d*) = 200 mm
Gap (*e*) = 0.15
e x d = 0.15 x 200 = 30 mm
Rotor diameter (*D*) = 200 + 200 – 30 = 370 mm
Rotor height (*h*) = 370 mm
End plate diameter (*D0*) = 1.1 x D = 1.1 x 370 = 407 mm thickness of blades and end plates (*t*) = 2 mm.

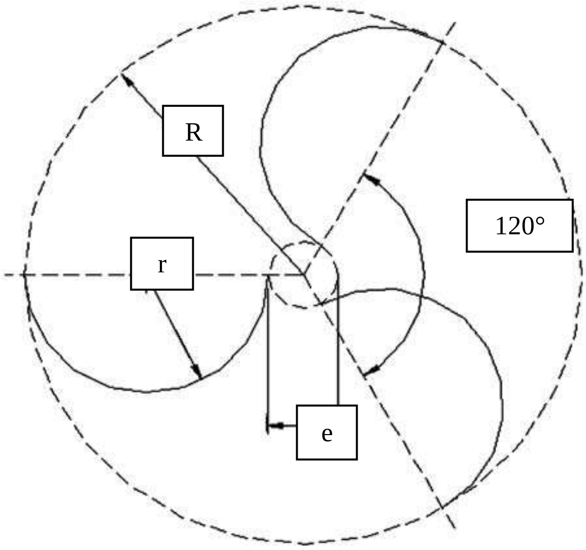

Fig 3.1-ideal blade design

V. CONCLUSION

1. Number of blades will influence the rotation of rotor of wind turbine models. The three blades wind turbine produces higher rotational speed and tip speed ratio than that two and four blades. The highest tip speed ratio is 0.555 for wind speed of 7m/s.
2. Wind turbine rotor with four blades has high torque compared with two or three blades wind rotor.
3. Three-bladed semicircular Savonius rotor is well known for its self-starting characteristics and it has been improved by providing a twist to these blades.
4. Semicircular blades are taken as zero angle of twist, and by increasing the angle, the performance of the Savonius rotor is increased in its performance.

References

[1.] Vertical axis wind turbine system patent no: “US 8648483 B2” Publication date: Feb 11 Inventor: Jonathan Haar Wind turbine patent no: “US 2360791 A” Inventor: Putnam Palmer Crossett.

[2.] Modi, VJ. And Fernando, MSUK. On the performance of the Savonius wind turbine. *Solar Engineering J.* 1989, 11, p 71-76.J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68-73.

[3.] Altan, BD., Atilgan, M. and Ozdamar, A. An Experimental Study on Improvement of a Savonius Rotor Performance with Curtaining. *Experimental Thermal and Fluid Science* 32, 2008, p. 1673-1678.

[4.] Saylers, AT. Blade Configuration optimization and performance characteristics of a simple Savonius rotor. *Institute of Mechanical Engineers J*. 1985, 199, p. 185-191.

[5.] Alexander AJ, Holownia BP. Wind tunnel test on a Savonius rotor. Journal of Industrial Aerodynamics 1978;3:343–51.