Effect of Slotted Angle on Savonius Wind Turbine Performance

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Abstract. The potential of wind energy is very abundant but its utilization is still low. The effort to utilize wind energy is to utilize wind energy into electrical energy using wind turbines. Savonius wind turbines have a very simple shape and construction, are inexpensive, and can be used at low wind speeds. This research aims to determine the effect of the slot angle on the slotted blades configuration on the performance produced by Savonius wind turbines. Slot angle variations used are 5^o ,10^o , and 15^o with slotted blades 30% at wind speeds of 2,23 m/s to 4,7 m/s using wind tunnel. The result showed that a small slot angle variation of 5^o produced better wind turbine performance compared to a standard blade at low wind speeds and a low tip speed ratio.

Introduction

Nowadays, research on the development of new renewable energy that is clean and environmentally friendly has been carried out, starting from the discovery of basic technology to improving energy efficiency so that it is not inferior to the performance of conventional energy. As with the development of research on wind energy, there are many wind turbine models that are ready to be used, but researchers continue to look for wind turbines that are suitable to the conditions in the geographical area of an area. in Indonesia, for example, which is a two-season country with low wind speed conditions, vertical axis wind turbines are studies that will continue to receive attention so that performance can be improved. in terms of the shaft rotation, wind turbines can be divided into two, namely horizontal axis wind turbines (HAWT) and vertical axis wind turbines (VAWT). VAWT have the advantage of being able to receive wind from all directions and can be installed in towers that are not too high so that the manufacturing costs are not too expensive with construction that tends to be simpler. However, VAWT has a lower efficiency than HAWT. So, many research developments have been done to improve the performance of VAWT. One type of VAWT that is widely developed is Savonius wind turbines. Savonius wind turbines have very simple construction so that they can be easily made.

Savonius wind turbines are drag axis vertical axis wind turbines because the drag force works when the wind hits the rotor, but the lift force still works when the power is transmitted to the shaft [1]. There are several parameters that can affect the performance of Savonius wind turbines, namely design parameters such as aspect ratio, number of blades, blade shape, overlap ratio, end plate etc. Each parameter affects the performance characteristics of Savonius wind turbines. The aspect ratio in savonius wind turbine can work on the needs of the rotation rate of the generating system. this happens if the aspect ratio rises, angular acceleration increases while moment and inertia decrease [2]. At this time the development of savonius wind turbine blades is by providing a variety of slots on the blades, also known as slotted blades.

The research related to the configuration of the new Savonius wind turbine with slotted blades to improve the effect of torque performance and wind turbine generator power by varying the slot position, the results show that for slots placed near the rotor shaft can improve performance at a low tip speed ratio, which proves the initial torque better [3]. Another research about slotted blade position showed that the highest power coefficient was produced by Savonius wind turbine by the slotted blade variation of 5 mm at 30% blades chord, the value of power coefficient was 0.118 at TSR 0.350 [4]. Slotted blade at 25 % blades position can increase 14.4 % power coefficient from conventional Savonius wind turbine [5]. Besides the influence of the slot position on the bar there is the influence of the slot angle. CFD simulations to determine the effect of the slot angle show that the performance of Savonius wind turbines with slotted blades decreases at a high tip speed ratio and a small slot angle (β = 5 °) results in better performance at a low tip speed ratio [6].

This research about Savonius wind turbine aims to determine the performance of the turbine with slotted angle variations of 5˚, 10˚ and 15˚ at the slotted position 30% from the center of the rotor. The performance tested is the turbine power produced on the wind speed and the effect of the power coefficient on the tip speed ratio.

Experimental Method

The research method used in this research by using wind tunnel with wind sources from the fan, as shown in Fig. 1 below.

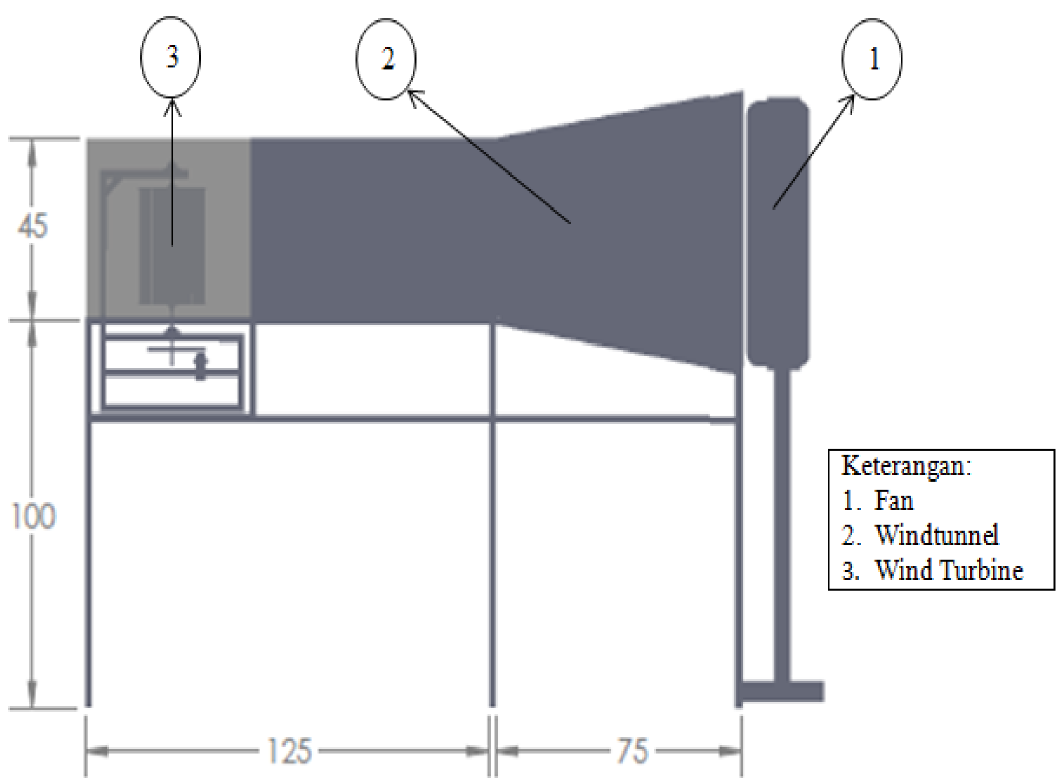

Figure 1. Schematic of a wind turbine tested

Based on Fig.1 wind turbine experiment was tested by using wind tunnel, then the wind speed on the wind tunnel was measured using an anemometer. To get variations in wind speed , a Dimmer Switch is used and measurements of wind speed of 9 points on the wind tunnel are used to get relatively the same wind speed, so that it can facilitate the retrieval of wind turbine testing data. The wind measurement scheme can be seen in Fig. 2.

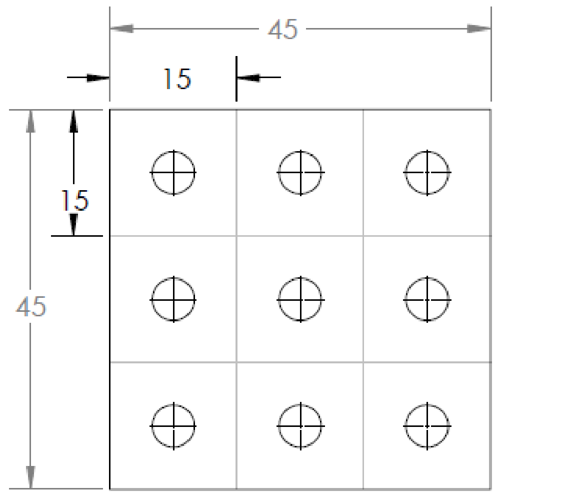

Figure 2. Schematic collection of wind data

The Variation of wind speed obtained is 2,23 m/s, 3,03 m/s, 3,48 m/s, 4,31 m/s, and 4,7 m/s. Then measure the value of the shaft rotation , voltage and current on the generator to get the performance of the wind turbine. The parameter of the Savonius wind turbine used in the experiment can be seen in Table 1.

Table 1 Wind turbine parameters

Parameter	**Value**
Turbine blade height	300 mm
Endplate diameter	200 mm
Aspect Ratio	1.5
Number of blade	2
Slotted blades position	30%

The variation of slotted blade angel of wind turbines can be seen in Fig. 3.

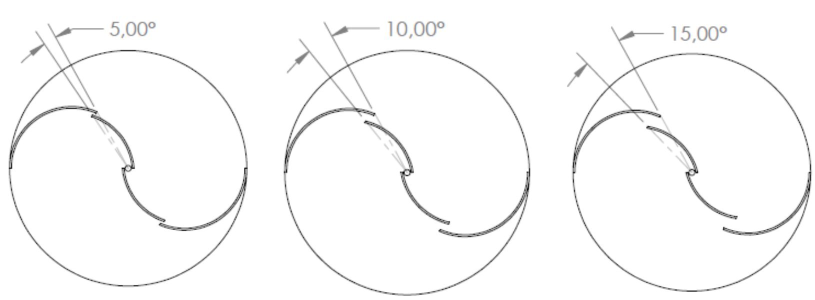

Figure 3. Variation of slot angle (a) 5 °, (b) 10 °, and (c) 15 °

The test of the three variation of the slot angle was carried out at five wind speeds that had previously been obtained from wind speed testing. the results of the data from the test are turbine shaft rotation (rpm), voltage (V) and current (A). voltage and current are used to calculate the actual power of the turbine (Watt) like an Eq. 1.

$$P_A = VI \quad (1)$$

while the turbine shaft rotation is used to calculate the value of the tip speed ratio (TSR) as in the Eq. 2.

$$TSR = \frac{2\pi\omega}{v} \quad (2)$$

Where v is wind speed in $\frac{m}{s}$. To get the value of the power coefficient using the Eq. 3.

$$C_p = \frac{2P_A}{\rho v^3 A} \quad (3)$$

Where ρ is air density in $\frac{kg}{m^3}$ and A is swept area of the rotor in m^2.

Results and Discussion

Data obtained from the results of wind turbine experiments in the form of power generated data, power coefficient (C_P), and tip speed ratio (TSR) are displayed as shown below.

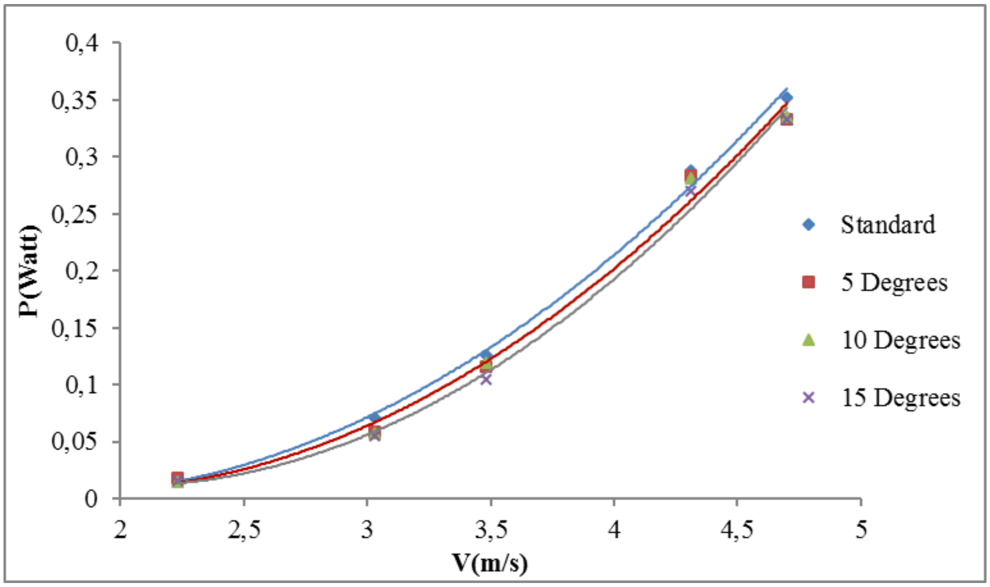

Figure 4. Graph of wind speed to the power generated

Based on Fig. 4, where the graph trend of the power generated will increased by increasing wind speed, this is caused by the higher wind passing through the turbine rotor, the wind turbine rotation will also increase so that it will affect the power generated will increase. The test result that the slot angle variation of 5° has a better power value compared to other variations of 0.018 Watt at a wind speed of 2,23 m/s, but at wind speeds of 3,03 m/s to 4,7 m/s the variation of the standard blade has better power value than the variation of blade with slot.

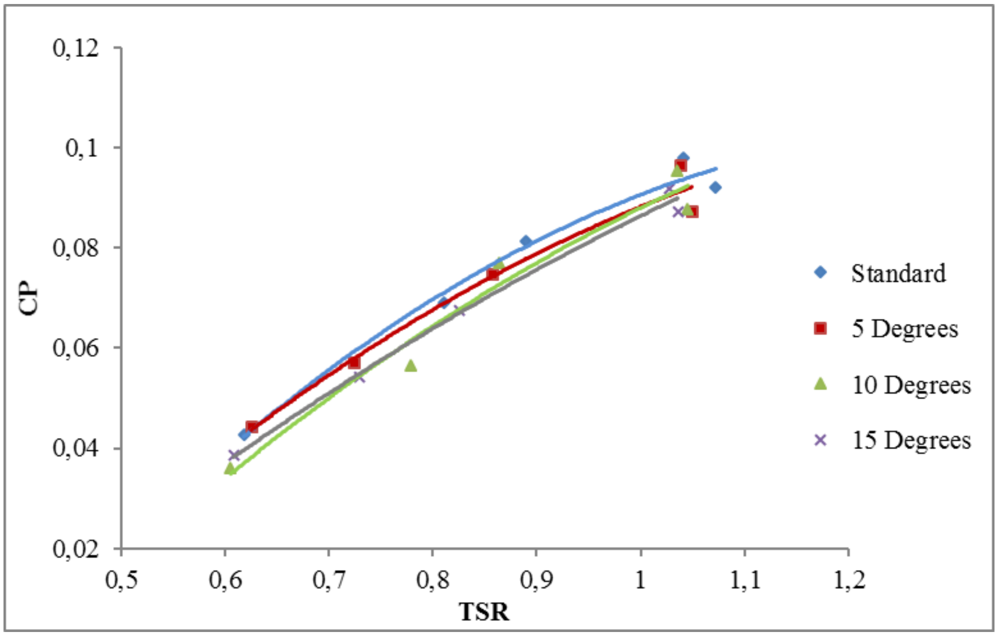

Figure 5. Graph of power C_P to TSR

Based on Fig. 5 the graph of the power coefficient trend relative increase until reaching the maximum value and decreases. The test results in variations of slot angle 5° having a better power coefficient (C_P) value at a low Tip speed ratio (TSR) compared to other variations of 0,0442 at a Tip speed ratio (TSR) of 0,6258. As the Tip speed ratio (TSR) vale incrases, the variation of the standard blade has a power coefficient (C_P) value that tends to be better than slot blades variation. Savonius wind turbine performance with slotted blades decreases for high Tip speed ratio (TSR) compared to those obtained for standard configurations. On the other hand with a small slot angle can result in better performance for a low Tip speed ratio (TSR) [6]. But for the case in this study it shows that slot angle 5 can only be used at very low wind speeds whereas for higher wind speeds standard turbines have better performance.

Conclusion

At low wind speeds, Savonius wind turbine with slot 5 angle has the highest power value among other slot angle variations and standard Savonius turbine at wind speed of 2.23 m / s is 0.018 W and based on the results of the power coefficient of slot 5 angle is able to reach the value highest 0.0442 at TSR 0.6258 so Savonius wind turbines with slots can be used at very low wind speeds. For higher wind speeds standard turbine types have better performance.

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