Performance of Combined Vertical Axis Wind Turbine blade between airfoil NACA 0018 with Curve Blade with and without Guide vane

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Abstract— This article proposes a model design of vertical axis wind turbine with blades hybrid is a combination of NACA 0018 airfoil profile blades and curve C with and without a guide vane tested with subsonic wind tunnel for four Reynolds number. Results of the study describes the addition of guide vane in the wind turbine model is able to improve the performance of wind turbine models significantly. The increase in performance compared to using the guide vane wind turbine model without a guide vane on the maximum condition reached 150%, besides the addition of guide vane is able to improve self-starting wind turbine model.

Index Terms— Blades, NACA 0018, Curve C, Vertical axis wind turbines, Hybrid blades, Subsonic wind tunnel , Guide vane, .

1. INTRODUCTION

Wind is one of the energy sources that are renewable and environmentally friendly where Indonesia with a coastline 80791.42 km are potential areas for wind energy development with an average wind speed of Indonesian coastal area is generally between 3 m/sec to 6.3 m/sec, estimated total wind energy potential to reach 9 GW [1].

The geographical position of Indonesia as a tropical country causing characteristics of the wind in Indonesia is very different from the characteristics of the wind in the developed countries that have used wind as a source of energy include wind direction change often, where this condition causes the sustainability of energy production from wind turbines horizontal axis disturbed because the turbine rotor must always dealing with the arrival of the wind direction [2], it is not found on the vertical axis wind turbine in which a turbine of this type of movement is not dependent on the direction of the wind and can work on wind speed is less than 3 m/s. Based on the characteristics of the wind Indonesia which has a low speed and frequent change, the focus of the development of vertical axis wind turbines as wind energy equipment extract is very urgent. There are two types of vertical axis wind turbine that is the type of drag that is commonly known as the Savonius wind turbine and the type of lift is commonly known as the Darrieus wind turbine [3].

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Savonius wind turbine has high efficiency at low wind speeds but has the disadvantage because of the limitations of the tip speed ratio is small otherwise Darrieus wind turbine has efficiency at high wind speeds but turbines of this type have drawbacks in terms of self-starting. To overcome these weaknesses have been numerous studies done by combining the wind turbine blades with blade Darrieus wind turbine Savonius [4-7].

The combination of the turbine blade Darrieus and Savonius turbines can increase efficiency 10 to 25% than the Darrieus wind turbine without the combination [8].

Another method to improve the performance of wind turbine Savonius wind by modifying the blade Savonius be Savonius Diffuser Blade (SDB) and moving deflector (guide blade), the function of SDB increase the speed ratio in the narrow gap also increases the drag force on the surface of the blade [9]. Neither conducted by Burçin Deda Altan et al [10], they added a steering wind in front of wind turbine Savonius by varying the steering openings. The results showed the addition of directional wind turbine is able to improve the performance reach 100% of Savonius turbine conditions without steering. From the foregoing description it appears that many researchers have combined blade airfoil with blades Savonius (blades S) has not seen a combination of blade airfoil with a profile curve C for the writer is interested to do research on a model wind turbine with blades hybrid is a combination between the blades profile airfoil NACA 0018 with blades curve C.

2. WIND TURBINE PERFORMANCE PARAMETERS

So that data of test results are analyzed and presented in a graph, it would need to set out the parameters of wind turbine performance is

1. Wind power is the energy per unit time of the air moving at a certain speed which is formulated as follows:

$$P_W = \frac{1}{2}\rho S U^3 \qquad (1)$$

2. Wind turbine power is energy per unit of time that can be extracted from the wind turbines that moves with certain velocity are formulated as follows:

$$P_T = T\,\omega \qquad (2)$$

where is the torque of the turbine (*T*) measured using Rope brake system such as figure 1.

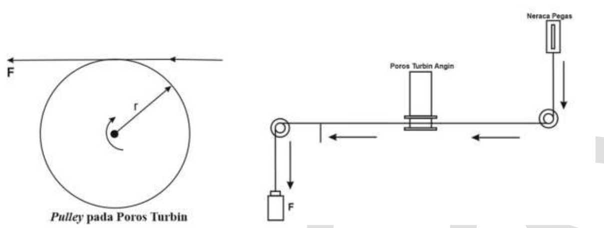

Figure 1. The scheme of the braking rope on a wind turbine shaft to get the torque

3. Wind turbine Performance coefficient is a value which shows the efficiency of wind turbines wind power potential in converting power into wind turbines that are formulated as follows :

$$Cp = \frac{P_T}{P_W} \qquad (3)$$

4. Tip Speed Ratio is a comparison of speed at the turbine end with wind speed that is formulated as follows:

$$\lambda = \frac{\omega R}{U} \qquad (4)$$

5. Wind turbine Torque coefficient is a value that indicates the ability of wind turbines produce torque are formulated as follows:

$$C_T = \frac{C_p}{\lambda} \qquad (5)$$

3. EXPERIMENTAL SETUP

In research conducted now dimensions model wind turbines can be seen in table 1, where the parameters of research for blade pitch angle C remains at 15^0 toe-out and the blades NACA 0018 15^0 toe-in with and without Wind (Figure 2 and 3). The study was conducted in subsonic wind tunnel with a exit cross sectional area is 2025 cm^2.

Table 1. The geometric dimensions of model wind turbine

Profile Blades	NACA 0018
Number	3
Blade cord, [m]	0,1
Blade Span, [m]	0,3
Rotor diameter, [m]	0,3
Profile Blades	C curve
Number	3
Radius, [m]	0,254

Figure 2. Model wind turbine without guide vane

Figure 3. Model wind turbine with guide vane

4. EXPERIMENTAL RESULTS

The performance of the wind turbine Model without guide vane

Wind turbine model testing without the guide vane (Figure 2) work on 4 the value of the Reynolds number which looks at wind turbine model without a guide vane

produced maximum power density of 3.6 W/m² at Reynolds number 122683 See figure 4.

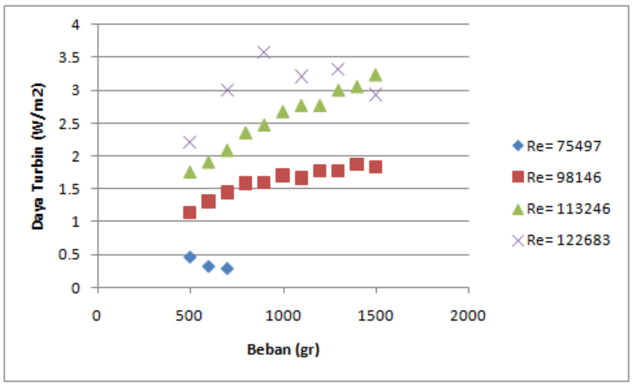

Figure 4. Power density generated by a model wind turbine without guide vane

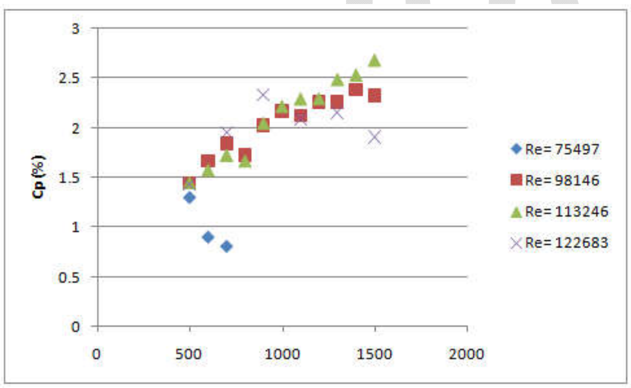

Figure 5. Turbine performance coefficients generated by the model wind turbine without guide vane

Whereas the coefficient of maximum wind turbine performance generated by the wind turbine model was 2.7% in the number of Reynold 113246 or equivalent with a tip speed ratio (λ) 0.23 see Figure 5 and 6.

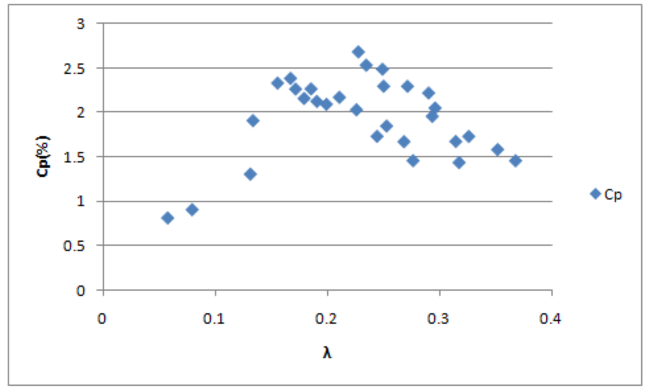

Figure 6. The distribution coefficient of performance model of a wind turbine without guide vane

In Figure 7 to see that maximum value of torque coefficient of 14.9% achieved on the value of the tip speed ratio 0.16. Overall the turbine rotates is dominated by the style of drag produced by the model wind turbines it is characterized by a value of tip speed ratio resulting in smaller than 1 [11].

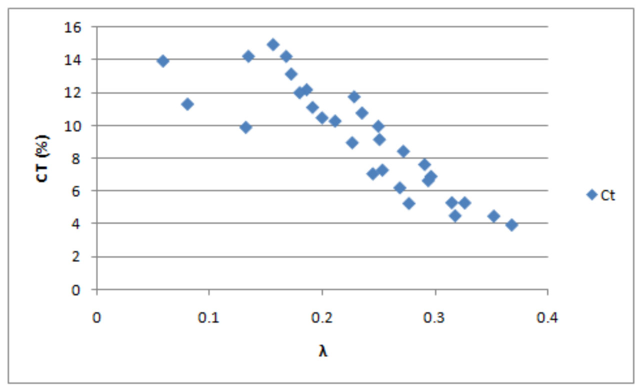

Figure 7. The distribution Coefficient of torque model wind turbine without guide vane

The performance Model of wind turbine with guide vane

For a given wind turbine model with guide vane (Figure 3) shows that performance of wind turbine model improvement significantly which sighted that on the model of wind turbine with guide vane can generates a maximum power density of 9 w/m2 on the Reynold number 122683 see Figure 8. So if compared to the model wind turbine without guide vane increase the resulting power of 150%.

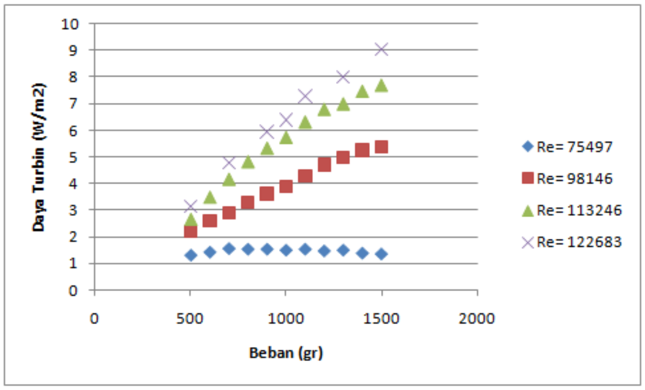

Figure 8. Power density generated by a model wind turbine with guide vane

The model of wind turbine with guide vane can produces maximum performance coefficient of 6.8% in number of Reynold 98146 or equivalent with a tip speed ratio (λ) 0.35 see figures 9 and 10. So when compared with the model of a wind turbine without a guide vane increase in the coefficient of performance of wind turbines produced by 152%.

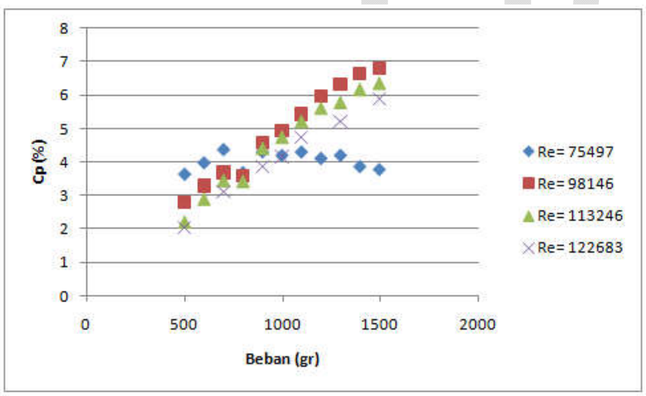

Figure 9.Turbine performance coefficients generated by the model of wind turbine with guide vane

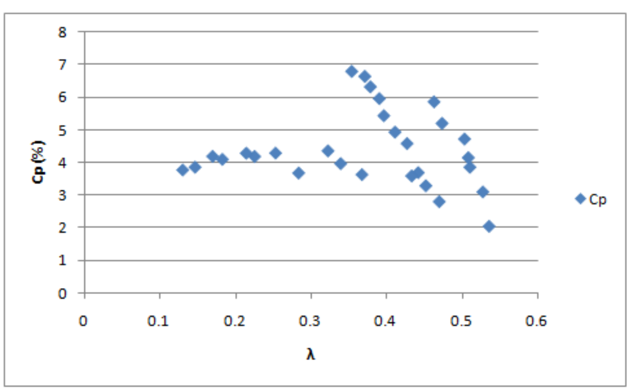

Figure 10. The distribution coefficient of performance model of wind turbine with guide vane

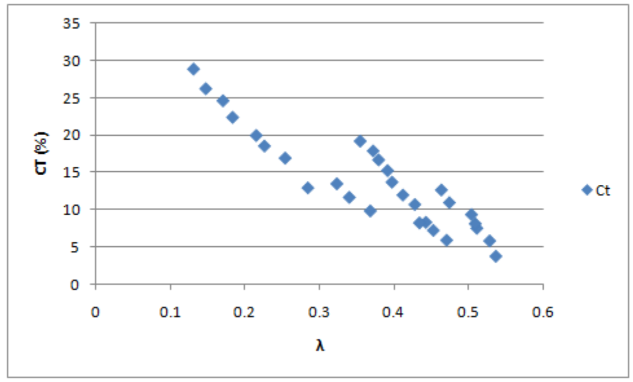

Figure 11. The distribution of torque coefficient model of wind turbine with guide vane

Figure 11 shows the maximum values of the coefficient of torque generated by the model of wind turbine with guide vane reached 28.9% for the value of the tip speed ratio 0.16. the maximum torque coefficient value of tip speed ratio 0.16 indicates the addition guide vane can improving ability of self starting model wind turbines.

5. CONCLUSION

From the explanation above can be drawn some conclusions as follows:

1. The addition of the guide vane at vertical axis wind turbine model with hybrid blade is able to improve the performance of the model include power density, coefficient of performance and torque coefficient model wind turbines more than 150%.
2. Addition of guide vane can improving ability of self starting model vertical axis wind turbine with blades hybrid.

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