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Journal of Physics: Conference Series

PAPER • OPEN ACCESS

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To cite this article: Kukuh Mukti Wibowo *et al* 2019 *J. Phys.: Conf. Ser.* **1153** 012140

IOP Conf. Series: Journal of Physics: Conf. Series **1153** (2019) 012140 doi:10.1088/1742-6596/1153/1/012140

Experimental study on pitch angle effects on the performance of Sg-6043 horizontal wind turbine

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Abstract — Worldwide energy usage continues to increase along with the depletion of fossil fuel reserves. This condition encourages society to develop renewable energy. Wind is one of the form of renewable energy which has low utilization. Furthermore, the available wind turbine has low efficiency especially in low wind speed condition. One way to improve a wind turbine's performance in a low wind speed is the use of pitch angles. This study aims to determine the effect of pitch angle on SG-6043 wind turbine, the pitch angle variations used are 0˚, 2˚, 4˚, 6˚, 8˚, 10˚, 12˚ and 14˚. The data were collected using an experimental wind tunnel. The test results show that the pitch angle of 10˚ produces the most optimal power when compared to other angles, which is 6.82 watts, whereas the angles 0˚, 2˚, 4˚, 6˚, 8˚, 12˚ and 14˚ produces power of 0; 0; 0; 0; 6.50; 6.55; 6.30 watts respectively.

1. Introduction

Worldwide energy usage continues to increase along with the depletion of fossil fuel reserves. Indonesia as a country that has an abundant natural resources are facing the problem resulted from this fossil energy. The petroleum reserves will be exhausted within 13 years while gas is estimated to be 34 years and coal 72 years (KESDM, 2016). This condition is dangerous for energy's security. Therefore, renewable energy such as solar, water, geothermal, biomass and wind must be increased in energy mix. One of the energy that has great potential in Indonesia is wind energy. However, this resource is still not used optimally, only 0.03% of the capacity is available today. This is due to the low wind speeds ranging from 2 m / s to 5 m / s (Rachman, Akbar, 2012).

To convert this wind's energy source, a generating system is needed in the form of a horizontal wind turbine and vertical wind turbine. The horizontal wind turbine has a higher efficiency when compared to the vertical wind turbine (Vito, Ismoyo, 2015: Vol 1). Most horizontal wind turbines that have been mass-produced are less suitable to be using in low-speed winds. In Salih, Mohammed, Talha's research (2018), wind turbines can produce an optimal power by obtaining a cut in speed at a speed of 5 m / s, with this speed it's not suitable to be used in Indonesia because the average wind speed in Indonesia per year is of 2.5 - 5.0 m / s.

There are various ways to improve the performance of a horizontal wind turbines to be used in low wind speed condition such as by determining the airfoil type and its pitch angle. Several studies have been conducted such as by Giugere and Selig, whom had tested several types of airfoil which are SG-6040, SG-6041, SG-6042 and SG-6043 (P Giugere, Selig. 1998). The results of the study showed that

SG 6043 is a type of airfoil with a high efficiency since it has a high lift and drag ratio when compared to other SG's airfoil types.
Another factor that may affect the wind turbine's performance is the use of pitch angle. By adjusting this angle at optimum conditions it will obtain a maximum power. (Faqihudin, 2014: 85-86). Research from Atmadi, fitroh (2009) stated that the additional pitch angle up to 10 ° causes significant power degradation i.e. from 50 kW to 23.3 kW, and an additional pitch angle up to 1˚ does not cause any changes, so this addition is at least 2˚. This study aims to determine the effect of pitch angle on SG-6043 wind turbine, pitch angle variations used are 0˚, 2˚, 4˚, 6˚, 8˚, 10˚, 12˚ and 14˚.

2. Experimental Methods

This research developed a horizontal wind turbine with SG-6043 airfoil type. Turbine's specification and design can be seen in table 1 and Figure 1. The turbine was designed based on SG-6043's profile with the airfoil made from mahogany, along with a wind tunnel test.

Table 1. Horizontal wind turbine *SG 6043* and Wind Tunnel spesification

Specification	Value
High turbine	1200 mm
Generator (PMG type)	100 Watt
Rotor diameter	1260 mm
The length of the blade	610 mm
The width of the base blade	115 mm
Width of the tip blade	35 mm
Number of blades	3 pieces
Material blade	Mahoni's wood
Wind Tunnel Length	3000 mm
Wind Tunnel Width	2000 mm
High Wind Tunnel	2400 mm

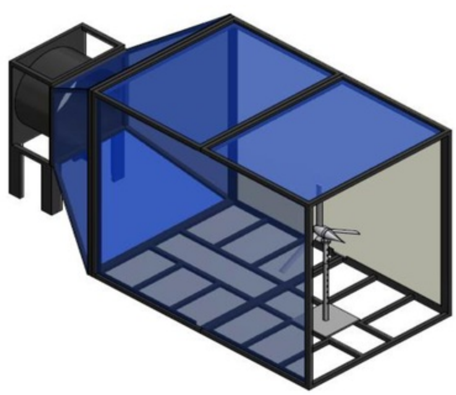

Figure 1. Wind tunnel design

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Figure 2. Turbine design

This experiment was conducted to evaluate the effects of using pitch angles at 0˚, 2˚, 4˚, 6˚, 8˚, 10˚, 12˚ and 14˚ for the power generated by the wind turbine during the testing period. The wind is supplied from the blower located in front of the wind tunnel, while the turbine is located in the middle of the wind tunnel. This research obtains the voltage, electric current and RPM data.

3. Result And Discussion

3.1. Effects of Pitch Angle Against SG-6043 Wind Turbine's Rotor Rotation

Figure 3 shows the results of testing the effect of pitch angle on the rotor's rotation (RPM) produced by SG-6043 horizontal wind turbine

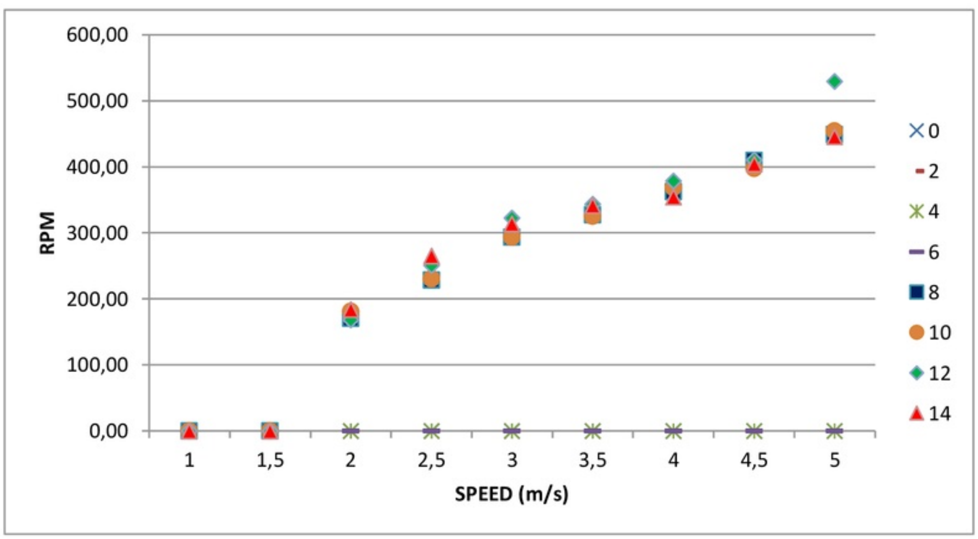

Figure 3. Test results of pitch angle effects on rotor's rotation

From figure 3 above, it is known that at the pitch angle of 0˚-6˚, the wind turbine does not produce any RPM because it fails to rotate. It begins to produce RPM at a pitch angle of 8 ˚, and it increases at a pitch angle of 10˚ by 0.4%. At a pitch angle of 12˚, it increases by 6.8% and decreases at a pitch angle of 12 ˚ to a pitch angle of 14˚ by 3.9%. This shows that at a pitch angle of 12˚, it yields the optimum power.

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3.2. Effect of Pitch Angle on SG-6043 Wind Turbine Power

The test results obtained, the voltage and electric current at a speed of 5 m/s for an angle of 0-6 on the wind turbine is 0, because the wind turbine does not rotate, while at the of angle 8˚, 10˚, 12˚ and 14˚ the following voltage is generated: 10.94; 12.44; 10.49; 10.97 Volts, while the electric current generated at a speed of 5 m / s at 8˚, 10˚, 12˚ and 14˚ as follows: 0.59; 0.55; 0.62; 0.58 respectively.

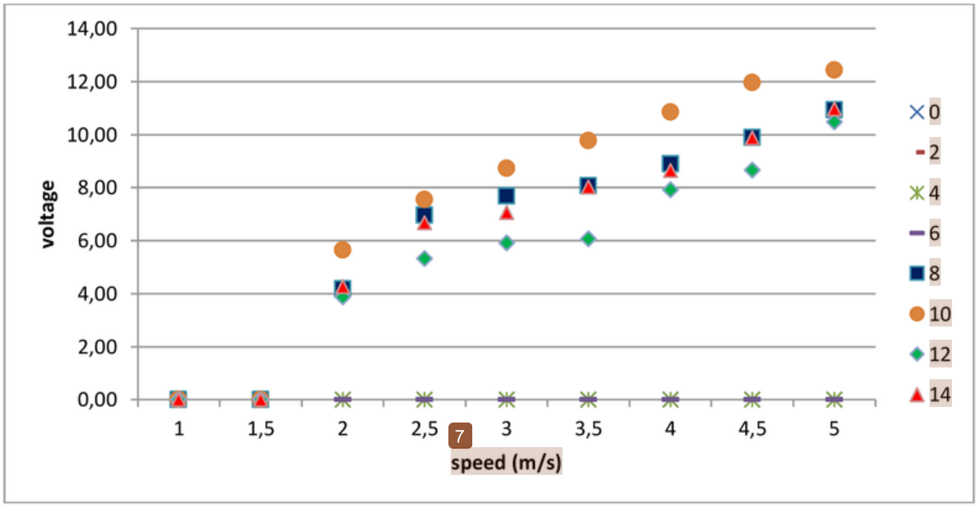

Figure 4. Voltage Results

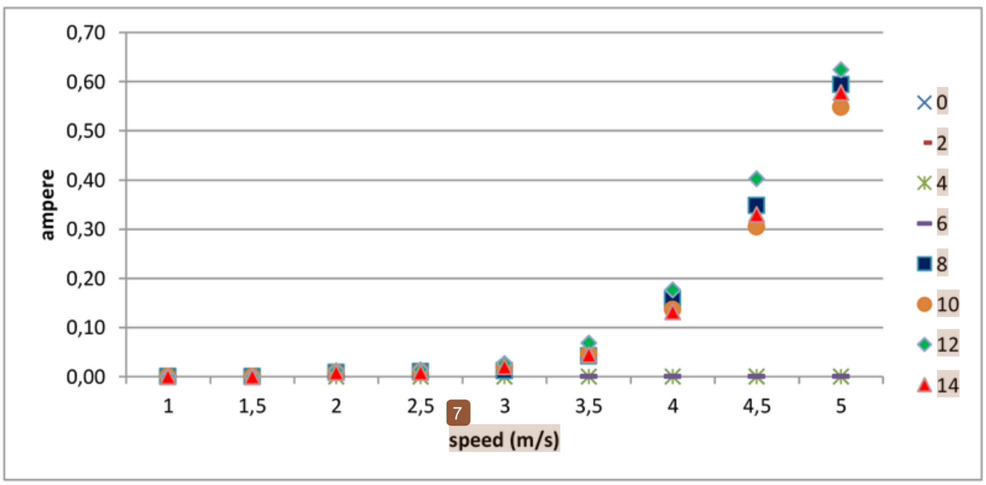

Figure 5. Electric Current Results

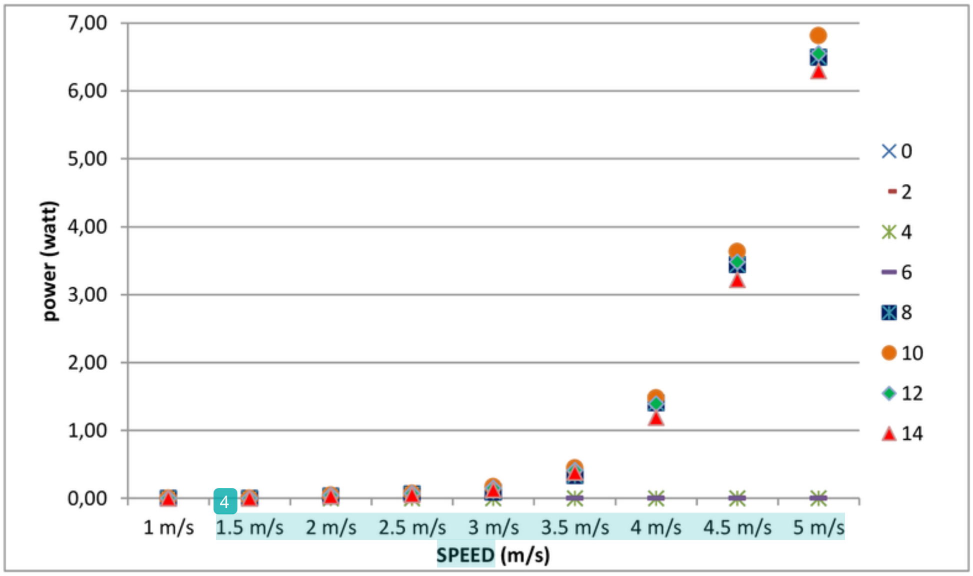

Figure 6. Electrical Power Generated Results

Figure 6. Shows the increase in power generated obtains the highest result by using a pitch angle of 10˚ that produces power of 6.82 watts, and decreases at an angle of 12˚ and 14˚, at an angle of 10˚ an increase by 4.9% from the previous angle. Meanwhile at an angle of 12˚ and 14 it decreases by 3.9% and 3.8% from the previous angle. This is comparable to Atmadi, fitroh's research (2009) states that the additional pitch angle of up to 10 ° causes a decrease in power.

The SG-6043 horizontal wind turbine works with the wind supplied from the blower located in front of the turbine and fused with the wind tunnel. The additional pitch angle can increase the turbine's start-up or the start speed of the rotating turbine, with reference to previous research by P Giugere, Selig (1998). It explains about the SG-6043 having a high lift ratio Therefore the resulting power capabilities to be optimal at a low speed.

Additional pitch angle variations may also affect the output power. The use of the pitch angle will change the position of the blade against the coming wind. In a previous study of Atmadi, fitroh (2009) stated that the additional pitch angle of up to 10 ° resulted in significant power degradation from 50 kW to 23.3 kW, and the additional pitch angle of 1˚ did not cause any changes, so this addition was at least 2˚. Hence this research is given the treatment of pitch angle with a 2˚ intervals, and resulted the angle with an optimum power output at 10˚ angle which then decreases at 12˚ and 14˚ angle.

4. Conclusions

The use of pitch angle shows a significant change in SG-6043 horizontal wind turbine's performance, in this study the power generated by using the pitch angle of 10˚ shows the most optimum result, i.e. 6.82 watts and at an 8˚ angle yields only 6.50 watts, this shows that there was an increase by 4.9%, but at an angle of 12˚ and 14, it decreases by 3.9% and 3.8% respectively.

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