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EXPERIMENTAL STUDY OF SAVONIUS TURBINE PERFORMANCE ON THE BEACH COAST OF DEMAK DISTRICT OF DEMAK ELECTRICAL POWER GENERATED

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KEYWORDS

Wind energy
Savonius VAWT
Wind Velocity
Demak

ABSTRACT

Energy from fossil fuels consisting of petroleum, coal, natural gas containing raw material for energy fulfillment in Indonesia is still very central through the use of raw materials from renewable energy is still very low. In Indonesia, the potential for renewable energy such as wind energy needs to be optimized. One of the uses of wind energy is through savonius wind turbine as electricity generators. Characteristics of savonius wind turbine with vertical axis rotors which gave a simple shape, and that able to control low speeds. This is in accordance with regions in Indonesia that have low average speeds. This experimental study aims to determine the description of wind potential and determine the performance of savonius wind turbines on the coast of Demak regency on the electrical energy produced. Savonius wind turbine used is made of galvalume material in the form of an S type rotor with diameter 1.1 m and height 1.4 m, using pulley transmission system with multiplication ratio 1:6 dan using generator type PMG 200 W. This research uses the method experiment. Data collection in the form of wind speed, humidity, temperature, rotor rotation speed, voltage, and an electric current is carried out at 14.30 to 17.30 Western Indonesian Time. Data Analysis in this study uses quantitative descriptive analysis. The result showed the potential of wind on the coast of Demak regency have an average wind speed of 2,02 m/s with a temperature of 31,34 0C and humidity of 76,96. And the performance of the installed wind turbine produces the highest power 3.5 watts with an electric power coefficient of 0,181 and a tip speed ratio around 1,75. From these results, the potential of wind with performance savonius turbine can generate electricity used for pond lighting in the village Berahan Kulon Wedung.

INTRODUCTION

The raw materials for power plants that are the prima donna in Indonesia and in the world are still around fossil energy, namely coal, oil, and gas. In the future, this fossil energy will increasingly run out. According to the 2018 Statistical Review of World Energy, energy consumption in Indonesia increased by 5% in 2017 and the average increase in the 2006-2016 period was 2.9%. Energy from fossil fuels consisting of petroleum, coal, natural gas which act as a raw material for energy fulfillment in Indonesia is still very central, while the use of raw materials from renewable energy / new renewable energy is still very low. The use of fossil energy as a raw material for meeting energy needs causes high pollution and plays a role in producing greenhouse gases that can damage the earth's ozone layer. The government is trying to innovate and compete as much as possible to use renewable energy (EBT). New and renewable energy is a source of energy that is inexhaustible and can be renewed. In addition, the existence of new and renewable energy is relatively easy to obtain, free, and with minimal waste/pollution. The new and renewable energy category includes solar, wind, water, ocean waves, biogas, and biomass, while the potential for wind energy is very abundant (ESDM, 2016).

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In the coastal area of Demak Regency, Central Java, there is the potential for wind energy which can be used to generate electricity. The coast of Demak, which is dominated by fisheries in the form of ponds, is located far from village settlements. Therefore, it requires high costs for the PLN electricity installation if we expect to light around the ponds. Based on pre-experimental data conducted in the morning, afternoon, evening, and night on the coast of Demak, it is obtained that the wind speed is constantly ranging from 2 to. 4 m / s in the afternoon. According to Pamungkas (2017) with this wind speed, it can produce electricity of 13.40 watts using the Savonius wind turbine.

Utilization of the potential of wind energy in Demak as power generation energy can be done through wind turbine technology. The wind turbine that can be used is the savonius wind turbine. This turbine includes a vertical axis turbine that easily rotates in low wind speed conditions (Kamal, 2008). And this wind turbine can receive wind from all directions, is easy and cheap to manufacture, and can rotate at a fairly low angular speed (Akwa, Vielmo & Petry, 2012: 3055). And also by Pamungkas (2017) who conducted a study on the performance of the S-type Savonius wind turbine with variations in the addition of fins to blades and wind speeds, which states that the Savonius wind turbine can produce efficient electric power. This research was conducted in order to find out a description of the potential of wind on the coast of Demak Regency for wind power plants and to test the performance of the Savonius wind turbines in the coastal area of Demak against the electricity produced.

RESEARCH METHODS

The experimental method used in this research is in the form of research on the performance of the Savonius wind turbine installed on the tower. The activities are undertaken in this research include, literature study, preparation of wind turbine installations, data collection, and data analysis. Data was collected by measuring wind speed, temperature and humidity of the environment, electric current, electric voltage, and generator rotation speed. Electric power is obtained from the multiplication of current and voltage. Data analysis using descriptive analysis techniques.

Table 1. Specifications of the Savonius Wind Turbine Series

Specification	Value
Tower height	6000 mm
Generator	200 Watt
Pulley Transmission Ratio	1 : 6
Shaft diameter	20 mm
Blade diameter	700 mm
Blade high	1400 mm
Overlap blade	200 mm
Number of blades	2 unit
Blade material	Galvalum

The data collection technique was performed using an anemometer, tachometer, voltmeter, and ammeter. The numbers displayed on the measuring instrument are recorded in the prepared table. Retrieval of data on the wind turbine for 3 days starting at 14.30 until 17.30 WIB periodically every minute as much as 10. Then the data is used to describe the electrical power profile of the wind turbine.

The measurement result data is in the form of a diagram and then analyzed using the quantitative descriptive investigation method. Quantitative descriptive research to investigate the problem of the use of renewable energy in the form of wind by analyzing the causal relationships by comparing the factors studied.

RESULTS AND DISCUSSION

1. Result

Data were collected for 3 days, namely on March 22 to 24 2019 at 14.30 s.d. 17.30 WIB 1 minute interval. Based on pre-experimental data at 14.30 WIB the wind turbine began to rotate at a constant speed so as to produce an electric current that was read on the ammeter and voltmeter and also at 17.30 the wind speed was no longer constant so that the electric current was not read on the ammeter and voltmeter. So that the research data collection will be carried out from 14.30 to 17.30 WIB every minute 10 data is taken for 3 consecutive days. Then the data is entered into Ms. Excel for data processing. The following data obtained include:

Wind speed frequency

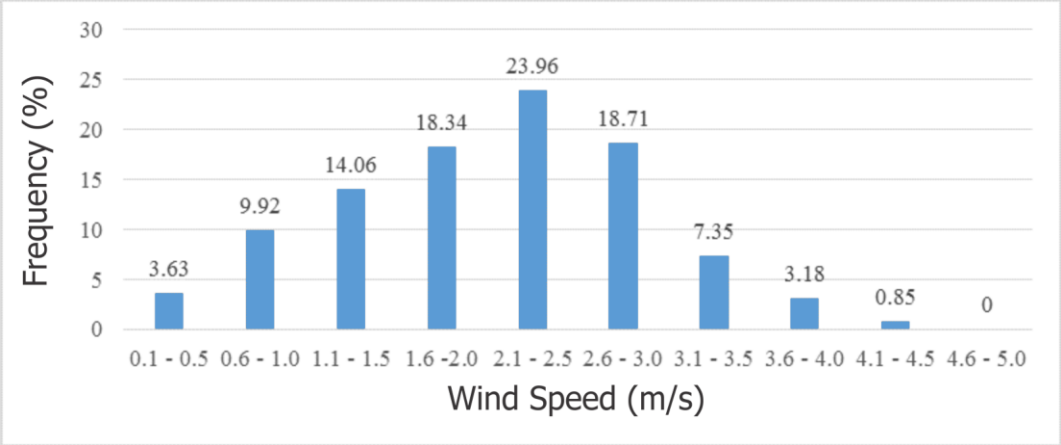

Figure 1 Wind speed frequency data

Based on Figure 1 shows that the highest wind frequency is in the wind speed interval of 2.1 to 2.5 m / s, which is 23.96% with a total of 1101 data, while the smallest frequency data is in the wind speed interval of 4.1 to 4.5 m / s which is equal to 0.85% with a total of 39 data. The average wind speed (mean) for 3 consecutive days was 2.02 m / s. The median and mode of these wind speeds are 2.3 m / s and 2.2 m / s.

Temperature and humidity

Figure 2 shows that the lowest average temperature and the highest average humidity are on day 1, namely the temperature of 76.65 with a humidity of 31.48 ^{0}C. While the highest average temperature and the lowest average humidity was on the second day, namely 31.48 ^{0}C with a humidity of 77.17.

Day	Time	Temperature	Temperature Average	humidity	Humidity average
	14.31-15.30	32		74.98	
1	15.31-16.00	31.36	31.48	77.32	76.65
	16.31-17.30	31.3		77.67	
	14.31-15.30	31.92		75	
2	15.31-16.00	31.28	31.26	76	77.17
	16.31-17.30	30.57		80	
	14.31-15.30	31.57		76	
3	15.31-16.00	31.66	31.3	76	77.08
	16.31-17.30	30.67		80	

Figure 2 Temperature and humidity

This shows that the environmental conditions in the savonius wind turbines on the coast of Demak have an inverse ratio between temperature and humidity. Based on the data obtained for 3 consecutive days that took place in Berahan Kulon Village, W Gedung District, Demak Regency, the wind speed, temperature, and humidity on the Demak coast can be used for wind power plants.

Generator Rotation Speed

The results of the research data from measuring the rotational speed of the generator were obtained using a digital tachometer measuring instrument to determine the speed of the wind turbine rotor. Based on Figure 3, the generator starts to rotate at a wind speed of 2.0 m / s with a rotating speed of 68 rpm. And the highest generator rotation at a wind speed of 4.4 m / s by producing a rotation of 804 rpm.

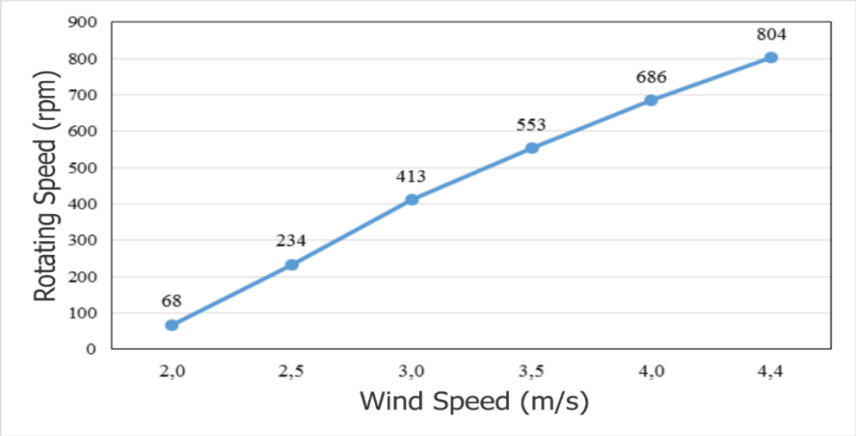

Figure 3 Generator rotational speed

Electricity Voltage

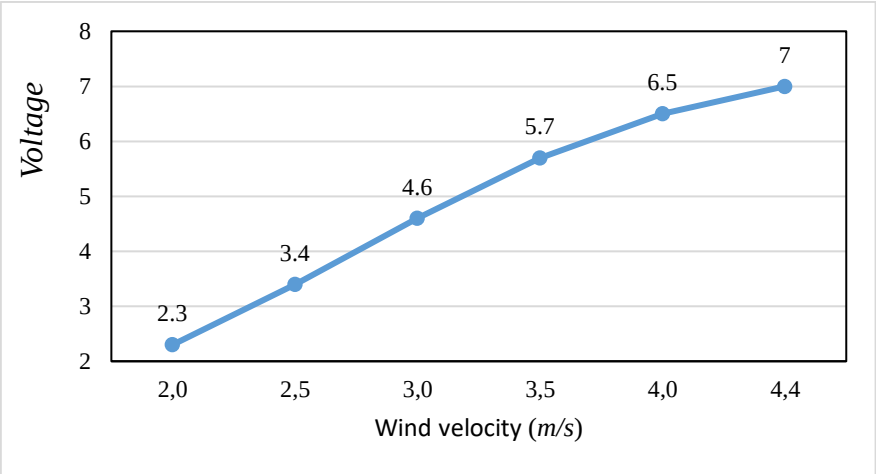

Figure 4 Electric voltage

The electric voltage data shows that the wind speed starting from 2.0 m/s starts to produce an electric voltage of 2.3 volts and increases according to the wind speed. The largest voltage recorded was 7 volts at a wind speed of 4.4 m/s.

Current Intensity

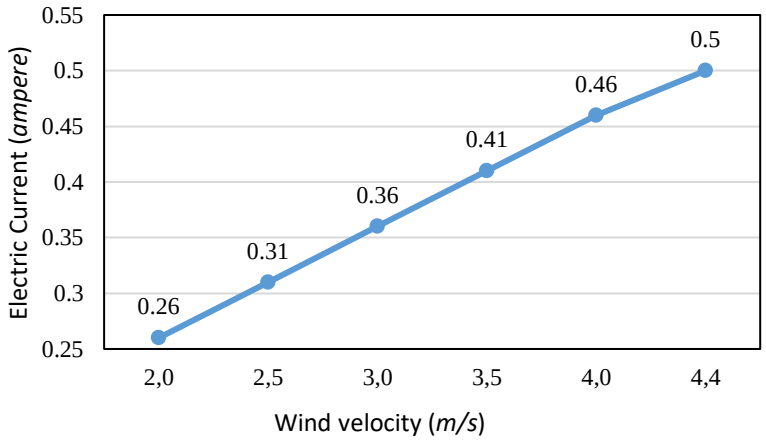

Figure 5. current intensity

The electric current data shows that the wind speed starting from 2.0 m/s starts to produce an electric current of 0.26 A and increases according to the wind speed. The largest recorded electric current is 0.5 A at a wind speed of 4.4 m/s.

RESULTS AND DISCUSSION

The potential of wind on the coast of Demak as a generator of electricity

Based on the data from the measurement of wind speed as in Figure 1 shows that the average wind speed for 3 consecutive days when the test took place in Berahan Kulon Village, W Gedung Subdistrict, Demak Regency was 2.02 m / s. According to Pamungkas (2017), the 1 fin savonius wind turbine with a wind speed of 2.0 m / s starts to produce electrical energy. This means that the wind speed on the coast of Demak coast has met the minimum limit of wind speed to be able to produce electrical energy. Based on the data of temperature and humidity measurement results shown in Table 1, it shows that the average temperature is inversely related to humidity. The difference in temperature and humidity supports air movement. The higher the temperature, the lower the humidity, so that the air will move (Nurchayati, 2009). This means that the humidity and temperature conditions on the coastline support the movement of air to blow. Based on data obtained for 3 consecutive days that took place in Berahan Kulon Village, Wedung District, the wind speed, temperature, and humidity on the Demak coast can be used for wind power plants

The performance of the Savonius wind turbines in the coastal areas of Demak

a. Wind speed to electric power

Based on research data on the measurement of electric voltage and electric current, it is possible to obtain the amount of electrical power generated by the wind turbine generator. The amount of electric power produced is the product of the electric voltage and the electric current.

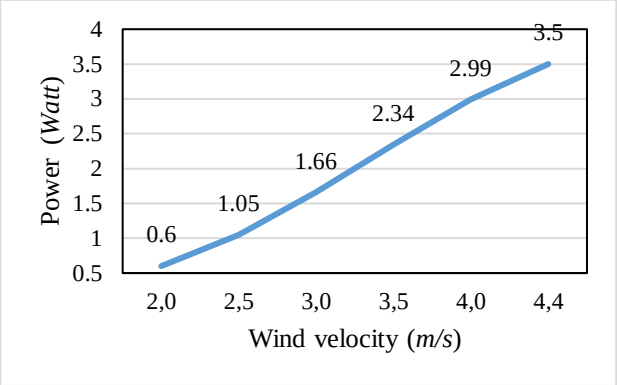

Figure 6. Electric Power

Figure 6 shows that the highest electric power produced is 3.5 watts. From the wind speed range of 2.0 to 4.4 m/s, the electric power generated by the generator tends to increase, although not significantly. From these results, it can be concluded that the wind speed is directly proportional to electric power. The greater the wind speed, the increased electrical power produced.

b. Wind speed to the rotation of the turbine rotor shaft

Turbine Rotor Rotation speed is obtained from the result data of generator rotation speed and the magnitude of the pulley acceleration ratio. The ratio of the pulley acceleration used is 1: 6, meaning that every 1 rotation of the wind turbine rotor, the generator rotor will rotate 6 times. When the generator rotor speed increases, the amount of electric voltage and electric current generated by the generator increases, so the number of electric power increases.

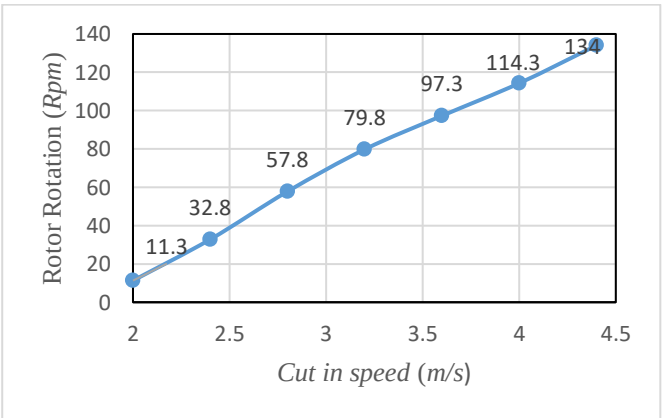

Figure 7. Turbine rotor speed

c. Cut in Speed

The cut in speed is the lowest wind speed at which the wind turbine starts producing useful power. One of the advantages of the Savonius wind turbine lies in its ability to run at low wind speeds. The cut in speed of the Savonius wind turbine varies according to the number of fins used. In this study, 1 was used fin.

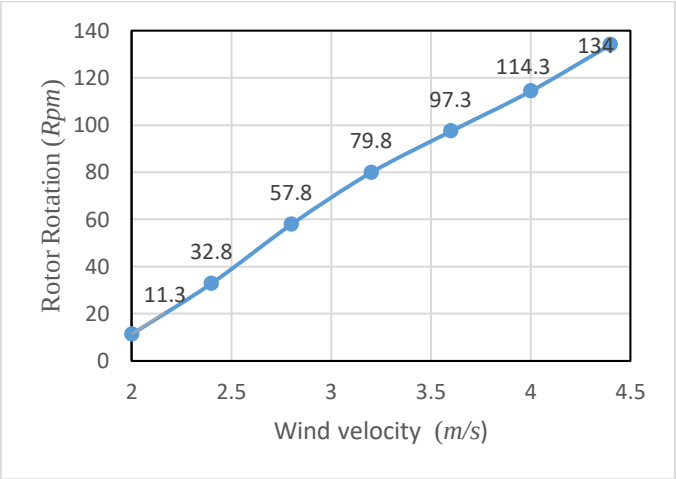

Figure 7 Turbine generator rotational speed

Figure 7 shows that the cut in speed on the Savonius wind turbine with 1 fin starting from a wind speed of 2.0 m / s produces a generator rotation speed of 68 rpm. This is in accordance with previous research, namely by Pamungkas (2017) that the cut in speed of the Savonius wind turbine with a 1 fin variation starts from a wind speed of 2.0 m / s.

d. Savonius wind turbine performance

The performance of the savonius wind turbine is obtained from the tip speed ratio and the power coefficient (Cp). The tip speed ratio shows the ratio of the rotational speed of the turbine rotor to the wind speed while the power coefficient (Cp) shows the efficiency of the turbine. The power coefficient (Cp) is the ratio of the actual power produced to the ideal power of the turbine.In Figure 8, it shows that the highest power coefficient of the Savonius wind turbine with a 1 fin variation of 0.181 at a wind speed of 4 m / s.

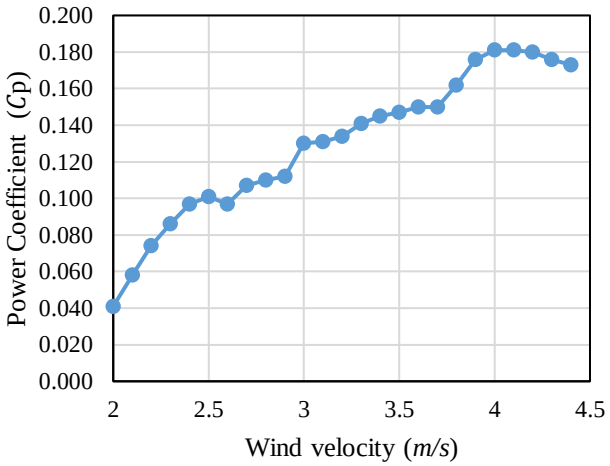

Figure 8 Power coefficient

And also the value of the highest TSR is at 1.75 at a wind speed of 4.4 m / s. This is in accordance with research from Pamungkas (2017) and Mathew (2006) which is shown in Figure TSR and Cp values of various types of turbines.

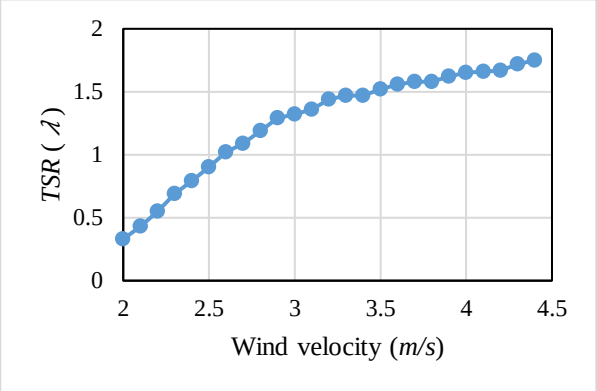

Figure 9 *Tip speed ratio*

Problems and Constraints

Testing of the Savonius wind turbine on the coast of Demak Regency which was carried out for 3 consecutive days, from 14.30 to 17.30 WIB was only carried out with a duration of 3 hours. This is due to uncertain conditions in the coastal area of Demak Regency at night and early in the morning which often rain so that it is not possible to collect data above 17.30 WIB.

Based on the data in Figures 4.2, 4.3, and 4.4, it shows that at the highest wind speed of 4.4 m / s, the generator's rotating speed is 804 rpm with an electric voltage of 7 volts and a strong current obtained of 0.5 amperes. From these data, the highest power is produced, namely 3.50 watts. Power calculation data can be seen in Figure 4.5. This shows that the power generated is very small while the use of the installed generator uses a power input of 200 watts. The power generated by the Savonius wind turbine on the coast of Demak Regency is 3.50 watts with a pulley transmission 1: 6 compared to previous research by Pamungkas (2017) which can produce power of 13.40 watts with a pulley transmission 1: 4 shows the results is a power very far away even though the pulley ratio used has been enlarged.

The installation of the Savonius wind turbine on the coast of Demak Regency, which is installed on the tower, experienced a problem, namely the collapse of the wind turbine from the top of the tower. The collapse of the Savonius wind turbine was discovered in the morning where there was heavy rain on the previous evening. The construction of joints that cannot withstand the fast speed of the wind during a storm causes the wind turbine to collapse. This resulted in reconnecting the Savonius wind turbine on top of the tower.

CONCLUSION

Based on the results of the research that has been obtained and the discussion that has been carried out to determine the electrical power generated from the Savonius wind turbines on the coast of Demak, the following conclusions can be drawn, The wind potential on the coast of Demak Regency has an average wind speed of 2.02 m / s, with an average temperature and humidity for 3 days of testing of 31.34 0C and 76.96. The performance of the Savonius wind turbine installed on the coast of Demak Regency produces the highest electric power of 3.5 watts with an electric power coefficient of 0.181 and TSR (Tip Speed Ratio) of 1.75.

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