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The utilization of moving train as an alternative energy sources in railways with savonius wind turbine

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Abstract. The purpose of this research is to obtain the dimensions of the savonius wind turbine and to test the calculation results and design of the savonius wind turbine based on the wind speed generated due to the movement of the train in the tunnel. The method used is to calculate the dimensions of the turbine diameter. The results of the calculations show that the savonius wind turbine diameter is 60 cm with a height of 60 cm. The maximum voltage generated is 12.26 V with a current of 0.52 A at a wind speed of 5.7 m/s.

1. Introduction

Currently, to reduce the greenhouse effect, the consumption of fossil fuel energy must be reduced. This is in line with the decreasing availability of fossil fuels so that new alternatives are needed to produce renewable energy. One alternative energy that can be used is wind energy. To utilize wind energy into electrical power, wind turbine is necessary. There are two wind turbines, namely the vertical axis and the horizontal axis[1]. For low wind speeds, the vertical axis is an option that can be used to convert wind energy into electrical energy

The need for electrical energy with renewable energy such as tunnels is very much needed because it is far from a power source. Two types of wind energy can be utilized in the tunnels, namely due to rail cracking and natural wind. Like a vehicle traveling at high speed, the air around the car will be dragged and form a slipstream, so that it can move the wind turbine [2]. [3]. The need for electrical energy with renewable energy such as tunnels is very much needed because it is far from a power source. Two types of wind energy can be utilized in the tunnels, namely due to rail cracking and natural wind. Like a vehicle traveling at high speed, the air around the car will be dragged and form a slipstream so that it can move the wind turbine.

Researchers (Pan et al., 2019) conducted research using s-rotor and h-rotor wind turbines. The study was conducted using experimental and simulation. Based on this research, the energy generated is used for sensor use. (Bethi et al., 2019) conducted numerical research with savonius wind turbines and studied the characteristics of wind turbines around the tunnel. This research also investigates the placement of wind turbines. Based on this research, the need for renewable energy around the tunnel is interesting to learn.

The savonius wind turbine was chosen because it has characteristics that can move at low wind speeds [4]–[6][7]. The characteristics of the savonius wind turbine that are easy to make and can be easily placed anywhere are an option in this study [8], [9]. The savonius wind turbine has two sides, one side is in charge of receiving the drag force that will be used to drive the wind turbine [10], [11][12].



Because the power generated is relatively small when compared to other wind turbines, many researchers want to research and increase the coefficient of energy [13], [14],[15]. Based on this, this research will calculate, design, and test the power of the Savonius wind turbine that will be placed in the tunnel.

2. Method

The method used in this research is to take the wind speed resulting from the movement of the train. Wind speed taking the survey is located in the Karangates 2 railway tunnel. The resulting wind speed will be the basis for calculating the diameter of the savonius wind turbine.

Tabel 2.1 Wind speed data generated from the movement of the train.

No	Time	KA name	Destination Station	Velocity
1	11.50	Penataran	S.pucung-Pohgajih	5,7 m/s
2	12.00	Penataran	Pohgajih-S.pucung	6,1 m/s
3	12.40	Majapahit	Pohgajih-S.pucung	6,2 m/s
4	14.20	Gajayana	S.pucung-Pohgajih	6,1 m/s
5	14.50	Malioboro	Pohgajih-S.pucung	6,1 m/s
6	15.15	Gajayana	Pohgajih-S.pucung	5,8 m/s



Figure 2.1 Wind speed data retrieval

Based on table 2.1, the average speed of the train movement is 6 m / s. From the wind speed data, it can be a reference for performing calculations to determine the diameter of the savonius wind turbine. The way to find out the diameter size of the angina savonius turbine is by using the formula :

$$P = C_p \times \frac{1}{2} \times \rho \times A \times V^3 \dots\dots\dots (2-1)$$

Information :

P = Power

C_p = Coefisien power

ρ = Air mass weight

A = Diameter

V = Wind speed

Meanwhile, to find out the size of each blade diameter and height using the formula:

$$A = H \times D \dots\dots\dots (2-2)$$

Information :

A = Sweep area
H = Hight
D = Dimention

After getting the dimensions of the turbine diameter, the next step is to determine the material to be used in this study. The material to be used is an aluminum plate. Aluminum was chosen because it has a lightweight. The bearings to be used are 6204 RS with an inner diameter of 20 mm and an outer diameter of 14 mm. The generator used has the technical specifications in table 4.2.

Table 4.2 Generator technical specifications

Model	30 watt DC electric generator
Rated power (W)	14 V
Max power (W)	100 V
Rated voltage (V)	12/24 V
Rated rotated speed (rpm)	0 – 5000 rpm

Function testing is carried out to test the power generated by the Savonius wind turbine. The wind speeds used in this study were 4.1 m / s, 4.7 m / s, and 5.2 m / s. after that, the data collection of voltage and current is done to test the performance of the Savonius wind turbine.

3. Result and discussion

The dimensions of the turbine diameter can be calculated, provided there is a value for the required power, where the desired output power of the wind turbine is 10 Watt. The wind speed value is 6 m / s, and the power Cp coefficient is 0.18, so the area of the swab is 0.40 m². By using a formula like the following:

$$P = CP \times \frac{1}{2} \rho \times A \times V^3$$

$$10 = 0,18 \times \frac{1}{2} \times 1,2 \times A \times 6^3$$

$$A = \frac{10}{0,18 \times \frac{1}{2} \times 1,2 \times 6^3}$$

$$A = \frac{10}{23,328}$$

$$A = 0,42 \text{ m}^2$$

Based on this, the calculation of the height and dimensions of the savonius turbine blade can be calculated by means of :

$$A = H \times D$$

$$0,40 \text{ m}^2 = (X) \times (X)$$

$$4000 \text{ cm}^2 = X^2$$

$$X = \sqrt{4000}$$

$$X = 63,24 \text{ or rounded to } 63 \text{ cm.}$$

Based on these calculations, the dimensions of the savonius wind turbine are obtained as shown in Figure 3.1

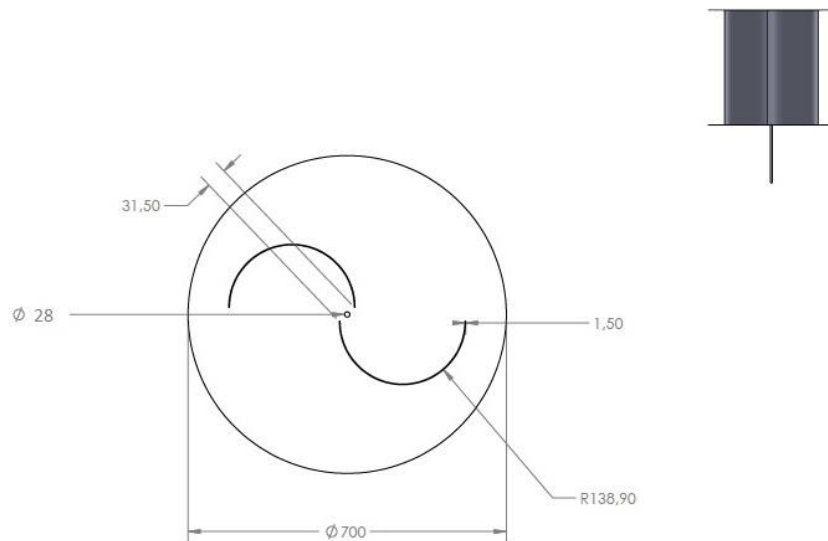


Figure 3.1 Savonius wind turbine geometry.

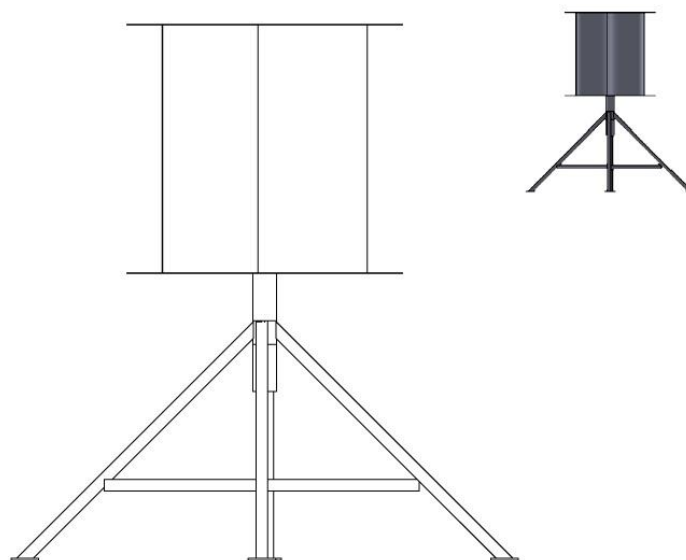


Figure 3.2 Savonius wind turbine design.

The data from the test results of this test are generated from rotating wind turbines because they get the wind force generated by the blower fan and the results of the test voltage and current strength are obtained in a table below:

Table 4.7 Test data

No	Velocity	Voltage	Current
1	4,1 m/s	10,81 V	0,39 A
2	4,7 m/s	11,63 V	0,44 A
3	5,2 m/s	12,26 V	0,52 A

Based on table 4.7, the highest voltage is 12.26 V, and a current of 0.52 A with a power of 6.37 W is produced at a wind speed of 5.2 m / s. In comparison, the lowest voltage is generated at a wind speed of 4.1 m / s with a resulting voltage of 10.81 V and a strong current of 0.39 A. The resulting voltage can be used for storage in batteries and can be used for supporting aspects of railway infrastructure security such as sensors and CCTV. However, it is possible that several other vertical axis wind turbines can be used to replace the savonius wind turbines. So that the resulting voltage is greater.

4. Conclusion

The conclusion obtained by the authors in conducting research and manufacturing savonius wind turbines as a producer of renewable energy sources in the tunnels, among others: Based on the calculation results, the resulting wind turbine diameter is 60 cm, and the height is 60 cm. Utilization of wind energy from the movement of the train obtained the most significant output power of 6.37 watts at a wind speed of 5.2 m / s. The resulting voltage can be fed into the battery storage as renewable energy for safety support facilities in the tunnel.

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