

Design and Experimental Testing of Savonius Wind Turbine U Three Blades Type Performance as an Alternative Energy Resource

Rizky Arman

Mechanical Engineering Department, Bung Hatta University
Jl. Gajah Mada No. 19 Olo Nanggalo, Padang, 25143, Indonesia

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Correspondence should be addressed to rizky.arm@gmail.com

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Abstract

Indonesia is famous for its potential natural resource especially energy in the form of mining, water and air. Wind energy is a natural resource that can be obtained for free of charge among the most abundant and available continuously throughout the year. The issue of energy is one of the greatest challenges facing today's society in the world. The utilization of wind energy can be used in sloping areas, mountains, and the waterfront. The principle of conversion of wind energy into electrical energy is as follows: The wind through the blades of the wind turbine spinning pinwheel cause, round lead generator wind turbine spins that into electrical energy. More than 86% of the world's energy comes from fossil fuels, while the demand for energy worldwide continues to grow rapidly. We all know that the source of non-renewable nature of fossil energy if we only using fossil fuels as an energy source, a current source of energy will be depleted. Then the use of electrical energy derived from fossil also have an effect on the levels of emissions (CO₂) in the air so called that the greenhouse effect. The application of wind energy in this study utilized as a small-scale electrical energy plant by utilizing a savonius wind turbine U three blades to generate electricity by using a generator and as a storage current battery. From design calculation results is obtained material on the blade is iron plate with a diameter of 0.6 m and blade's high of 0.9 m. The location for this experiment is at the area of gunung panggilun, precisely in building E on 5th floor the Faculty of Industrial Technology, Bung Hatta University.

Keywords: wind energy, savonius wind turbine U three blades, generator, and storage battery.

1. Introduction

Indonesian is famous for its potential natural resource especially energy, whether it be mining, water and air. Wind energy is a natural resource that can be obtained free of charge, abundant and available continuously throughout the year. According to the guidebook renewable energy organized by *Contaned Energy Indonesia*, in 2010, many countries have realized the importance of the exploitation of

sources of renewable energy (wind energy, biomass, and biogas) as a substitute for non-renewable energy such as oil, coal and gas, which has caused devastating effects on the earth. The utilization of wind energy can be used in the ramps, hills, and the waterfront. The principle of conversion of wind energy into electrical energy is as follows: The wind through the blades of the wind turbine will cause the wheel spinning and the effect also

spins the generator which will produce the electrical energy [1-5].

Since 2011 until now, it's often happen blackouts especially in the area of West Sumatra. State Electricity Company (PLN) resorted to rolling blackouts in West Sumatra because the electricity supply in the region of West Sumatra deficit of 20 MW during maintenance. Based on the problem above, there are two things that should be done simultaneous to address these issues: conservation and diversification of energy sources. It can be done by implementing business energy consumption savings and then at the same time, also do a search and intensive use of renewable energy sources (renewable energy resources) [6-10].

One of renewable energy source is wind energy. Wind energy is one of the abundant resources, environmentally friendly and renewable nature and potentially to be developed. Conditions of wind speed data in Indonesia especially the city of Padang has a low wind speed which ranging between 3 to – 7 m/s so that the type of vertical axis Savonius wind turbine considered suitable to be applied for easier spinning at low wind speed conditions. Savonius wind turbine has a good self starting so as to rotate the rotor despite lower wind speeds, in addition to the torque generated relatively high [11-14].

2. Material and Methods

Wind is moving air due to the pressure difference with the direction of wind flow from a high pressure to a lower pressure or from areas with more low temperature to a high temperature. Winds' blowing on the earth's surface is due to a difference in the reception of solar radiation, resulting in differences in air temperature. The existence of this temperature difference causes a difference in pressure, eventually leading to air movement. Heat changes between day and night is the main driving force wind systems daily, because the differences between the strong hot air over the land and sea or the higher air above ground (mountains) and low ground (valley). The greater the difference in pressure, the faster the air moves. Moving air, this can be used to rotate the propeller and can ultimately generate electricity. Wind is moving air caused by the rotation of the earth and also because of differences in air pressure (high pressure to low pressure) in the vicinity.

Based on data from GWEC (Global Wind Energy Council), the growth of wind power

generators development was 32% from 2005. Wind power plant is very suitable for island states such as in Indonesia. Wind power plant can be built in areas that are not reached by electricity as far away from the center, so it is able to increase the electrification ratio. But keep in mind that the efficiency of a wind power plant in accordance with the Law Betz no more than 59%, therefore it needs to be optimized. So that the efficiency of a wind power plant is capable of approaching 59%. Many methods for optimizing the power output of the wind turbine. Able to measure the rotational speed of the rotor generator, then the optimum output is calculated and then compared with the output fact. It could also measure wind speed, then we get the optimum rotor speed so that it can obtain the optimum power.

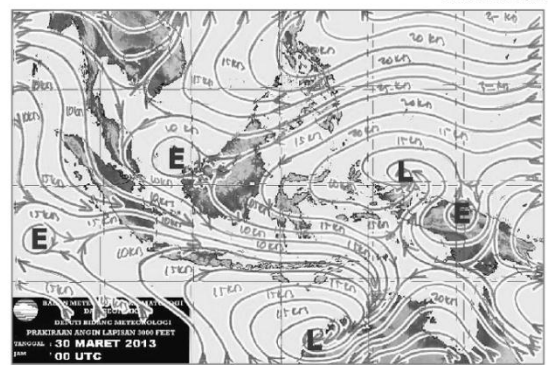


Fig. 1. Characteristic wind flows in Indonesia (an example)

Characteristics of wind determined by the direction and speed. Theoretically, the wind blows from high pressure areas to low pressure areas. At high altitude, the wind direction will be influenced by the rotation of the earth and moving parallel to the isobars lines. In the northern hemisphere the wind rotates counter clockwise, while in the southern hemisphere the wind rotates clockwise. Wind direction is determined by the direction from which the wind was blowing. So, the westerly winds meant the wind that blows from west to east, likewise southeast wind means wind that blows from the southeast to the southwest as can be seen at Fig. 1.

Savonius wind turbine is a type of drag-type wind turbine, where this turbine generates power by utilizing the drag force which is derived from each of each blade. Drag is the force acting opposite the direction of the wind striking the blades angle. Savonius wind turbine can spin at low wind speeds. Savonius turbine manufacturing process is relatively easy and has a low power coefficient. Three-blade concept is

more in balance and the curvature of the blade is more subtle to capture wind energy more effectively. This concept is most often used in commercial turbines. The pattern of wind flow in the U-type wind turbine blades and three-blade concept is shown as Fig. 2.

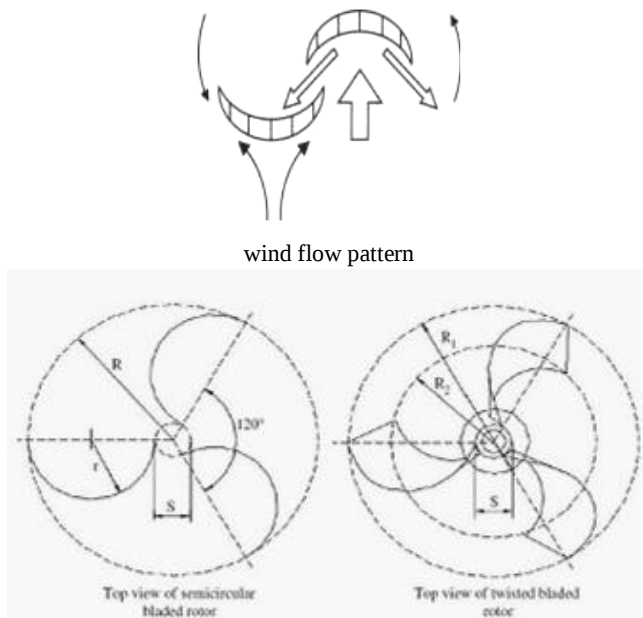


Fig. 2. The air flow pattern blade type U and three blades concept

Wind speed can be measured using a device called Anemometer. In addition, beside measures wind speed but can also be used to determine where it came from the direction of the wind. Wind energy is one form of kinetic energy, where the number of each air mass for each unit of time can be calculated from the following equation,

$$m = \rho A V \quad (1)$$

Thus, the energy that can be produced per unit time is:

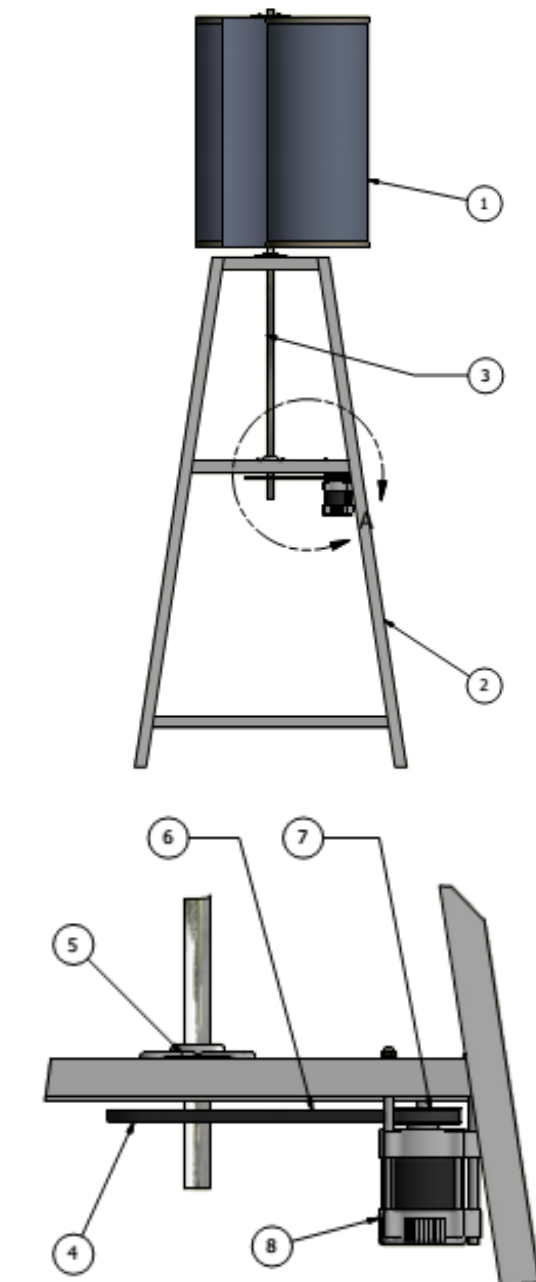
$$\begin{aligned} P &= \frac{1}{2} m v^2 \\ &= \frac{1}{2} (\rho A v) v^2 \\ &= \frac{1}{2} \rho A v^3 \end{aligned} \quad (2)$$

And the rotation, N is determined by the equation,

$$N = \frac{\omega \cdot 60}{2\pi}, \text{ where } \omega = \frac{v \cdot 1000}{D} \quad (3)$$

After going through the stages, planning Savonius wind turbine U three blades as alternative energy sources that include the study

of literature, data collection, used equipment and data processing. Then the results obtained from the design components plans such as shown in Fig. 3.



where:

- | | |
|-----------------|---------------------|
| 1) Blades | 5) Bearing |
| 2) Shaft | 6) V-Belt |
| 3) Tower | 7) Generator pulley |
| 4) Rotor pulley | 8) Generator |

Fig. 3. Savonius wind turbine U 3-blades design components

Shaft design:

Shaft is a stationary rotating parts and usually with a circular cross-section wherein mounted machine elements such as gears, pulleys, flywheel and other elements of the

power transfer. A transmission shaft can be subjected to torsion and bending loads or a combination of torsion and bending. Shaft also got a tensile load or pressure as an example in the shaft propellers or turbines. Shear stress on the shaft is,

$$\tau_A = \frac{\sigma_B}{sf_1 \cdot sf_2} \quad (4)$$

Bearing design:

Bearings are machine elements that become concentrated load shaft so that rotation shaft can rotate in a smooth, safe and durable. Equivalent load and life of bearing are shown in equation 5 and 6 respectively,

$$W_e = (X_r \cdot V \cdot F_r + Y_t \cdot F_a) \quad (5)$$

$$L_H = \frac{L}{60 \cdot n} \quad (6)$$

Pulley and belt design:

Pulley is a revolving belt which will forward rotation speed to the generator. The function of the pulleys is able to increase or decrease the speed of rotation. So the selection of pulley on this plan depends on the number of revolutions produced by the wind turbine and the average number of rounds required by a generator. The design for D_1 and D_2 on Fig. 4 are shown on equation 7 and 8 respectively.

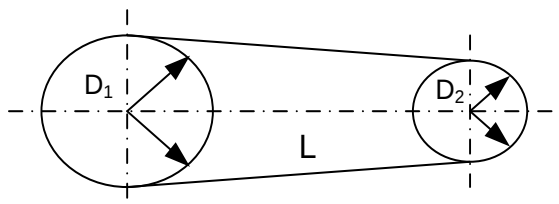


Fig. 4 The air flow pattern blade type U and three blades concept

$$D_1 = \frac{60 \cdot v}{\pi \cdot N_1} \quad (7)$$

$$D_2 = \frac{60 \cdot v}{\pi \cdot N_2} \quad (8)$$

Belt is a component that is capable of delivering moments of rotation of the transmission between the two shafts are far apart. The distance between the two shafts are located far apart can be transmitted in several ways such as by gears or chains and belts. Important characteristics of the belt are the change in shape due to the pressure side and resistance to heat. Materials commonly used are

natural or synthetic rubber. So, the length of the belt is,

$$B_L = 2L + \frac{\pi}{2}(D_1 + D_2) \quad (9)$$

Here are the experimentation procedures:

- ✓ Set up test equipment and measuring equipment vertical wind turbine Savonius type U three blades.
- ✓ Data were and performed simultaneously to get the results of the test data.
- ✓ Wind speed is measured using a measuring instrument anemometer. Before taking the wind speed data, determine the wind direction with the flag and see what direction the wind fluttered, then take the measurement using the tool anemometer wind speed.
- ✓ Testing rotation speed with tachometer measuring instrument that measured the rotational speed vertical wind turbine Savonius type U three blades.
- ✓ Testing the alternator output power measurement by measuring voltage and current at the output of the alternator using a measuring instrument multimeter.

3. Results and Dicussion

From the tests carried out according to the above, then obtained data for wind speed, the alternator voltage and current as shown in Table1., and graphic of wind speed vs. time is shown in Fig. 5.

Table 1. Wind speed, Alt. Volt and Current

Wind speed (m/s)	Alternator voltage (Volt)	Current (A)
3,41	1,32	14,03
3,05	1,20	10,27
3,84	1,77	15,31
4,56	2,59	16,63
5,12	3,37	18,50
5,65	4,06	20,72
4,05	2,15	15,53
3,60	1,84	12,48
3,33	1,43	10,68

From the data the chart above we can conclude that obtained an average wind speed is 1,96 m / s. Wind speed data retrieval is done every interval of 15 minutes using a measuring instrument anemometer. The highest wind speed is 5.65 m / s which occurred at 15:30 pm. The lowest wind speed is 0.02 m / s at 07.00 pm. From the journal of research that has been done by Ruzita Sumiati obtained an average winds in the area adjacent to the tests performed are 2.7

m / s and the highest wind speed is between 6-7 m / s.

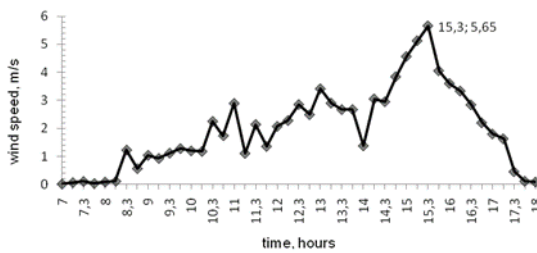


Fig. 5. Graph of wind speed vs. time

For wind speed vs. rotational speed of the rotor as shown in Fig. 6 shows that the wind speed affects the rotation of the wind turbine rotor Savonius type U 3 blades. The faster the wind that drives the blades of the wind turbine, the wind turbine rotor rotation will be faster as well. Likewise the contrary, if the wind drives the blades of a wind turbine rotor rotation slower then slow. The highest rotor rotation obtained in the amount of 115.51 rpm at a wind speed of 5.65 m / s, while the lowest is 58.29 rotor rotation rpm at a wind speed of 3.05 m / s.

While a comparison chart between the wind speeds with a power alternator (Fig. 7), it is known that the higher the wind speed, the power (wattage) will also be higher. Where is the lowest wind speed of 3.05 m / s generating power of 12.32 watts and the highest wind speed of 5.65 m / s to produce power 84.12 watts.

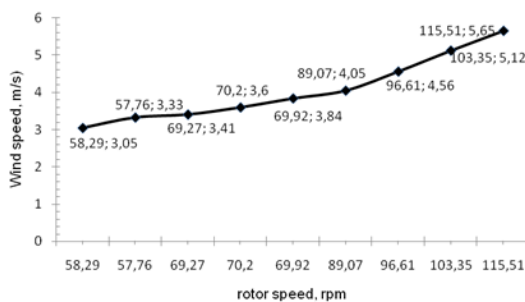


Fig. 6. Graph of wind vs. rotor speed

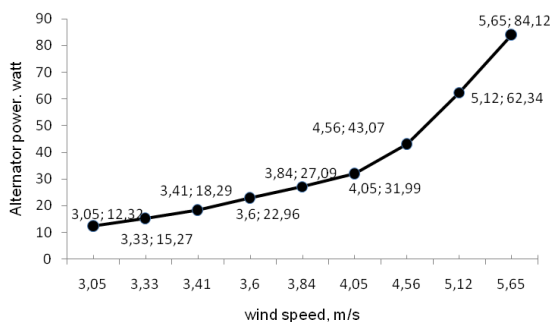


Fig. 7. Graph of wind speed vs. Alt. power

4. Conclusion

Average speed of the wind on this investigation, in the area of gunung panggilun Padang, precisely on the 5th floor of the building E, Faculty of Industrial Technology, University of Bung Hatta from 7:00 to 18:00 pm hour is 1.96 m / s. The highest Rotor speed is 115.51 rpm at a wind speed of 5.65 m / s, while the lowest rotor speed is 58.29 rpm at a wind speed of 3.05 m / s. Lowest power generated by the wind turbine blade U type three is 12.32 watt and the highest wind speed of 5.65 m / s to produce power of 12 watts 84.6. Wind speeds greatly affect large or small value of the power generated by the turbine. The power generated is proportional to the wind turbine rotational speed of the turbine. The increasing the speed of rotation, the turbine generated power turbines will be faster.

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