KnE Energy
ISSN 2413-5453 Volume 2 (2015) 172-175
New, Renewable Energy and Energy Conservation Conference and Exhibition
(The 3rd Indonesia EBTKE-ConEx, 2014)

Design and Contruction of Vertical Axis Wind Turbine Triple-Stage Savonius Type as the Alternative Wind Power Plant

Tedy Harsanto[a]*, Haryo Dwi Prananto[a], Esmar Budi[a], Hadi Nasbey[a]

[a]*Department of Physics, Faculty of Mathematics & Natural Science, State University of Jakarta, Jakarta, Indonesia*
Jln. Pemuda No. 10 Rawamangun, Jakarta Timur 13220, Indonesia

Abstract

A vertical axis wind turbine triple-stage savonius type has been created by using simple materials to generate electricity for the alternative wind power plant. The objective of this research is to design a simple wind turbine which can operate with low wind speed. The turbine was designed by making three savonius rotors and then varied the structure of angle on the three rotors, 0˚, 90˚ and 120˚. The dimension of the three rotors are created equal with each rotor diameter 35 cm and each rotor height 19 cm. The turbine was tested by using blower as the wind sources. Through the measurements obtained the comparisons of output power, rotation of turbine, and the level of efficiency generated by the three variations. The result showed that the turbine with angle of 120˚ operate most optimally because it is able to produce the highest output power and highest rotation of turbine which is 0.346 Watt and 222.7 RPM.

Keywords: Output power; savonius turbine; triple-stage; the structure of angle

1. Introduction

The fulfillment of electrical energy for various needs perceived at this time is still very dependent on energy resources that are not renewable. The conditions of energy resources most of which cannot be renewed, especially petroleum, the longer the more limited.

With the need for electrical energy constantly increases over the progress of civilization and the increase of the number of human beings as well as the reduced level of fulfillment and the availability of resources energy which cannot be renewed, so that is extremely needed renewable energy resources that are more environmentally friendly. One of the natural energy that we can take advantage is the wind energy because it is easy to obtain and take place continuously. This energy is one of the clean energy and in the production process are not polluting the environment.

One of wind energy utilization is by the use of wind turbines. A wide variety of shapes and designs of wind turbines as alternative energy sources have been found long time ago. But in its development still requires considerable investment. Therefore, it needs an alternative in the development of wind turbines so that can be utilized maximally by the public.

A wind turbine is a tool that can convert the kinetic energy of the wind into electrical energy or mechanical energy. Wind is used to rotate the blade, which when spinning it will produce energy. One type of simple wind

* Corresponding author. Mobile phone.: +62 838 7413 0449
E-mail address: tedy.harsanto@gmail.com ; tmail_gender@yahoo.com

Selection and peer-review under responsibility of the Scientific Committee of The 3rd Indonesia EBTKE ConEx 2014.
DOI http://dx.doi.org/10.18502/ken.v2i2.373

turbine is the savonius wind turbine. This turbine is a type of vertical axis wind turbines and is not affected by wind direction so it can spin at low wind speeds.

2. Research methodology

The research done in the Renewable Energy and Mechanical Laboratory of Physics Department, State University of Jakarta. In this study, used the method of experimentation with the laboratory-scale measurements using the blower as a source of wind.

In this research, there are three savonius rotors with two blade in each rotor. The dimension of three rotors are created equal with each rotor diameter 35 cm, each rotor height 19 cm, and the gap distance of the blade is 3 cm.

The three rotors of savonius arranged three-stage and then varied the structure of the angle between the rotor to be studied it impact on output power produced. The variations in the structure of the angle that used in this research is angle of 0˚, 90˚ and 120˚.

On the testing, data retrieval is done manually using the digital multimeter to measure the output voltage and current generated by the generator by using a resistor as the load.

(a) (b) (c)

Fig. 1. (a) The structure of 0˚; (b) The structure of 90˚; (c) The stucture of 120˚.

In Figure 1(a) show that the three rotors arranged with 0˚ so the three rotors will be parallel to each other. Figure 1(b) show the tree rotors arranged form the angle of 90˚ to each other so the first rotor will be parallel to the third rotor. And in the Figure 1(c), none of the rotor are parallel to each other when the three rotors are arranged to form the angle of 120˚.

3. Result and discussion

Through the measurements obtained the data show that the influence of the structure of angle on the rotors with the resulting of output power and the rotation of turbine.

Table 1. RPM result of three angle variatons.

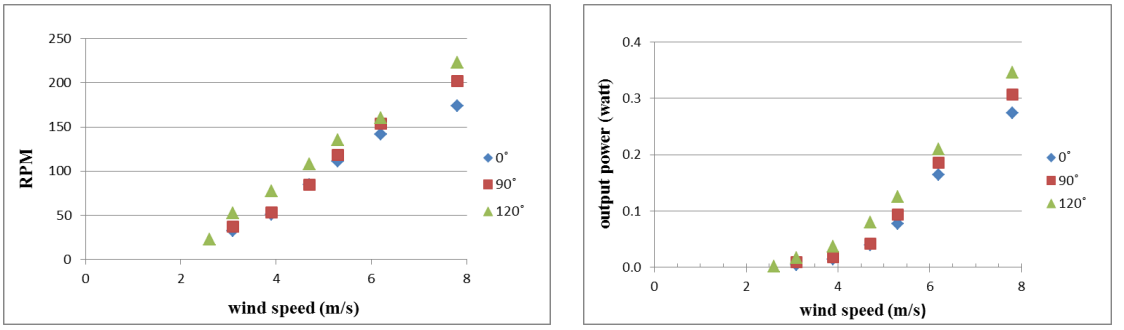
No	Wind speed (m/s)	0˚	90˚	120˚
n			RPM	
1	2,6	0	0	22,42
2	3,1	32,40	37,33	52,10
3	3,9	50,57	52,93	77,47
4	4,7	84,20	84,30	108,30
5	5,3	110,77	118,10	135,40
6	6,2	141,63	153,77	160,23
7	7,8	174,00	202,00	222,70

Table 2. Output power result of three angle variations.

No	Wind speed (m/s)	0˚	90˚	120˚
n			Output power (Watt)	
1	2,6	0	0	0.0022
2	3,1	0.0046	0.0097	0.0163
3	3,9	0.0147	0.0181	0.0369
4	4,7	0.0396	0.0426	0.0794
5	5,3	0.0768	0.0943	0.1253
6	6,2	0.1641	0.1861	0.2099
7	7,8	0.2737	0.3067	0.3456

Based on Table 1 and Table 2, it was known that the three variatons of angle structure of vertical axis wind turbine triple-stage savonius type start to spinning and produce the electric energy at the range of wind speed of 2.6 m/s to 3.1 m/s. The result according to the theory, that the vertical axis wind turbine can be operated at the low wind speed.

From the three variatios of angle structure, the lowest cut in speed is obtained at the angle of 120˚ is 2.6 m/s and the rotation speed of turbine is 22.422 RPM, while at the angle of 90˚ and 0˚ was obtained the same cut in speed which is at 3.1 m/s. These results show that the turbine with the angle of 120˚ can be operated more optimal than the angle of 90˚ and 0˚ because it can spinning at the lower wind speed. It was because at the angle of 120˚, three rotors of savonius capable of receiving rush of winds from all directions in equal quantities any time. Trend of increasing the rotation of turbine to increasing wind speed was shown in Figure 2(a).



(a) (b)

Fig. 2. (a) Chart relation of wind speed to rpm; (b) Chart relation of wind speed to output power.

In Figure 2(b) show that the graph of output power results from three variations of angle structure. From the measurement, the lowest output power was obtained of 0.002 2 Watt at the wind speed of 2.6 m/s and the the highest output power was obtained of 0.345 6 Watt at the wind speed 7.8 m/s which is occurs when turbine at the angle of 120˚. Figure 2(b) show that the increasing output power is directly proportional to the increasing of wind speed. The air flow is given will meet the sweep broad of rotor at the turbine and then occurs the drag force that make the turbine can rotate. That causes the bigger of wind speed given, the rotation of turbine will be more rapid so that the resulting of output power will be increased.

4. Conclusion

Has successfully designed a vertical axis wind turbine triple-stage savonius type and then varied the structure of angle on the three rotors. Through the measurement, optimally results were obtained at angle of 120˚ which able to generated the highest output power and highest rotations of turbine which amounted to 0.346 Watt on 227.7 RPM.

Acknowledgements

The authors are thankful to Physics Department of State University of Jakarta especially for Renewable Energy and Mechanical Laboratory Team for support of facilities in this research.

References

[1] Nakajima M, Lio S, Ikeda T. Performance of Double-step Savonius Rotor for Environmentally Friendly Hidroulic Turbine. Journal of Fluid Science And Technology 2008. Volume 3 No. 3, pp 410-419.
[2] Daryanto Y. Kajian Potensi Angin Untuk Pembangkit Listrik Tenaga Bayu. Balai PPTAGG - UPT-LAGG. 2007.
[3] Soelaiman F, Tandian, Nathanael P, dan Rosidin, N . Perancangan, Pembuatan dan Pengujian Prototipe SKEA Menggunakan Rotor Savonius dan Windside untuk Penerangan Jalan Tol; Bandung. ITB. 2006.
[4] Paraschivoiu I. Wind turbine design with emphasis on darrieus concept Ecole Polytechnique de Montreal. 2002.
[5] Suharmanto, Puji. Pengaruh Jumlah Sudu Terhadap Daya Output Pada HAWT (Horizontal Axis Wind Turbine) Diameter 1,6 Meter di FMIPA UNJ. Skripsi, Program Studi Fisika, Universitas Negeri Jakarta : Jakarta. 2012.
[6] G. Bergeles, and S.N. Athanassiadi, "On the Flow Field Around a Savonius Rotor". Wind Engineering, 1982, Vol. 6, No. 3, pp 140 - 148, Multi-science publishing company.
[7] T. Hayashi, Y. Li, and Y. Hara. Wind tunnel tests on a different phase three-stage Savonius rotor. JSME International Journal, Series B: Fluids and Thermal Engineering, 48(1):9(16), 2005.
[8] Sargolzaei J, Kianifar A. Estimation of the power ratio and torque in wind turbine Savonius rotors using artificial neural Networks International Journal of Energy 2007, Issue 2, Vol. 1