

DESIGN OF VERTICAL AXIS SAVONIUS WINDMILL FOR GENERATING ELECTRICITY USING PERMANENT MAGNET

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ABSTRACT

At present the use of wind energy in Indonesia is still relatively low, but has enormous potential. One reason is because the average wind speed in the territory of Indonesia is classified as low wind speed, which ranges from 3 m / s to 5 m / s making it difficult to produce electrical energy on a large scale. However, the wind potential in Indonesia is available almost all year long, making it possible to develop small-scale power generation systems. Innovations in modifying windmills need to be developed so that in conditions of low wind speeds can produce electrical energy. In this research, a prototype was developed by designing a vertical axis windmill power plant model Savonius using a permanent magnet generator, which can produce optimal electrical energy by utilizing relatively low wind speeds. From the generator test it was found that with a rotor rotation of 50 rpm up to 500 rpm can produce an electrical voltage of 0.02V to 10V and an electric current of 0.60A to 4.53A.

Key Word : *axis windmills, Savonius, permanent magnet generators*

Renewable energy can be used as an alternative solution for the use of fuel oil. This energy assessment is absolutely necessary to prevent an energy crisis. Through the study of energy conversion machines, renewable energy in Indonesia can be optimally utilized for energy needs in supporting sustainable development and human needs in the energy sector. One of the uses of renewable energy which currently has great potential to be developed is wind energy. This energy is clean energy and in its production process does not pollute the environment.

The development of wind energy in Indonesia is currently relatively low. One reason is because the average wind speed in the territory of Indonesia is classified as low wind speed, which ranges from 3 m / s to 5 m / s making it difficult to produce electrical energy

on a large scale. Nevertheless, the wind potential in Indonesia is available for most of the year, making it possible to develop small-scale power generation systems.

Windmills with vertical axes are relatively easy to make. This type of windmill rotates by utilizing wind speed from various directions, and is easily converted to generate electricity.

Windmill

Windmills have the function of changing the kinetic energy of the wind into mechanical energy in the form of shaft rotation. The shaft rotation is then used to turn the dynamo or generator to produce electricity.

Based on the shape of the rotor, windmills are divided into two types, namely Horizontal Axis Wind Turbine and Vertical Axis Wind Turbine (Daryanto, 2007).

Vertical axis wind turbines are vertical axis wind turbines whose shaft and rotor movements are parallel to the wind direction, so the rotors can rotate in all wind directions. Vertical axis wind turbines have several advantages and disadvantages. The advantage, which has a high torque so that it can rotate at low wind speeds, the generator can be placed at the bottom of the turbine so that the maintenance and work of the turbine is not affected by the wind direction. The drawback is that the wind speed at the bottom is very low so that if you do not use the tower will produce a low rotation, and lower efficiency compared to horizontal axis wind turbines.

There are three models of rotors in this type of wind turbine, namely: Savonius, Darrieus, and H rotors. Savonius turbines utilize the drag force while Darrieus and H rotors utilize the lift force. (Mittal, 2001). The Savonius turbine was invented by a Finnish scholar named Sigurd J. Savonius in 1922, the turbine construction was very simple, composed of a half-cylinder blade (Soelaiman, 2006).



Figure 1. The vertical axis windmill of the Savonius model

Permanent Magnet Generator

The design of the permanent magnet generator is designed by considering the main energy that is converted is wind energy. It takes a low rpm to turn a permanent magnet generator to produce electricity.

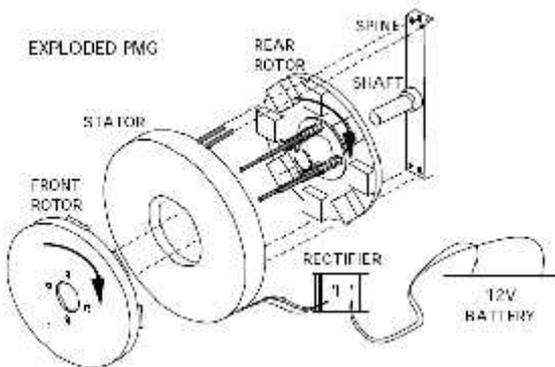


Figure 2. Construction of a permanent magnet generator

The magnetic flux needed to generate electrical energy is obtained from a permanent magnet, so the generator does not require the generation excitation process so that the efficient use of electrical energy to be utilized as a supply of loads is very good.

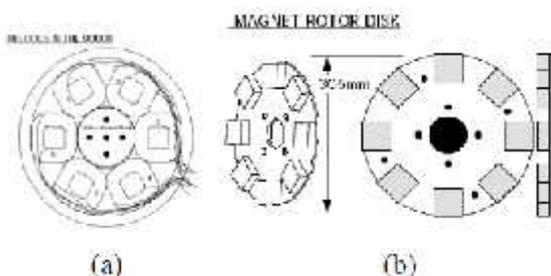


Figure 3. Construction (a) stator and (b) rotor permanent magnet generator

METHOD

Windmill Design

In this research, a prototype of a vertical axis windmill Savonius model was developed. In this type, the wind that blows one of the rotor blades is expected to flow more to the other rotor blades through the gaps around the shaft so as to provide additional thrust on these rotor blades, consequently the rotor can spin faster.

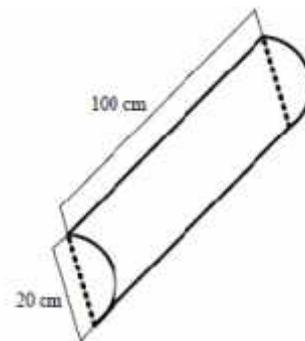


Figure 4. Windmill blade design

The vertical axis windmill design is made with 6 (six) blades whose construction model is made portable, so that it can be assembled and moved easily.

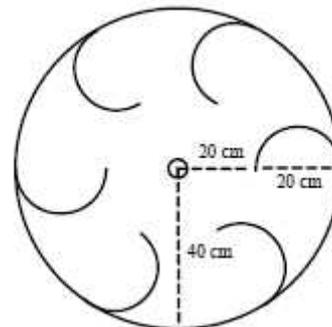


Figure 5. Design of a windmill blade housing

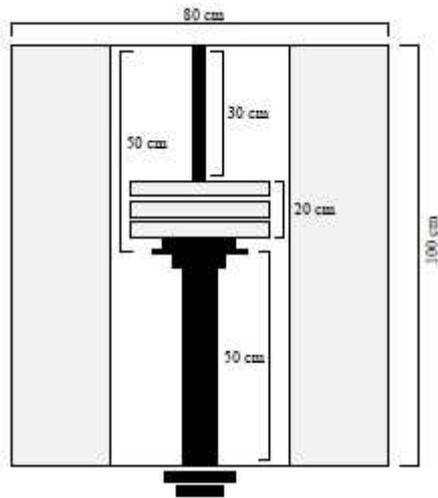


Figure 6. Vertical axis windmill design and permanent magnet generators

Making Windmills

In the process of making the blade, materials are chosen from PVC pipes with a diameter of 20 cm and a length of 100 cm, while for the upper and lower blade housing of iron plate material with a diameter of 80 cm.



Figure 7. Construction of six windmill blades

Design of Permanent Magnet Generators

In designing permanent magnet generators the design of the stator and rotor is first performed. Some parameters that can determine the desired generator power capacity such as, the strength of the magnetic flux, the number of coils and windings, the number of magnets and the diameter of the wire. The purpose of designing this tool is to make it easier to determine the number of coils on the stator and the diameter of the copper wire and the number of magnets to be used.

Stator Design

The generator stator has 12 coil windings that are series in 1 phase. While each coil is

made with a diameter of 3 cm and 6 cm. The coils are made of enameled wire with a size of 1 mm with a total of 150 pieces.

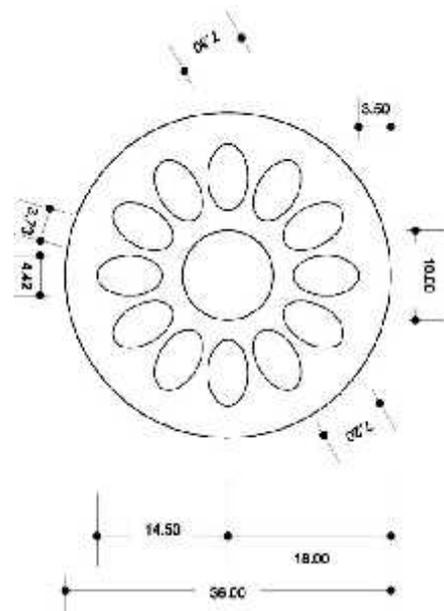


Figure 8. Design of permanent magnet generator stator

Rotor Design

The rotor generator is designed to have 12 1-phase pole pairs. The poles are composed of permanent ND-35 magnets measuring 50 mm x 15 mm x 6 mm. These magnets are arranged on an acrylic disk mounted on a pulley to form a magnetic disk. The two magnetic plates are arranged face-to-face with the north pole of the first magnetic disc facing the south pole of the second magnetic disc.

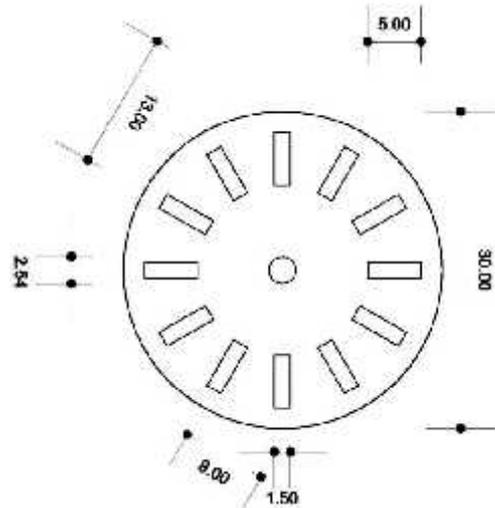


Figure 9. Design of permanent magnet generator rotors

Making Stator and Rotor

This permanent magnet generator is designed to work at a frequency of 50 Hz and rotates at a speed of 500 rpm. The output voltage is designed 41 Volt, 1 phase, the output power capacity is 615 Watt.



Figure 10. Stator generator construction with 12 coil windings



Figure 11. Construction of a generator rotor with 12 permanent magnetic poles

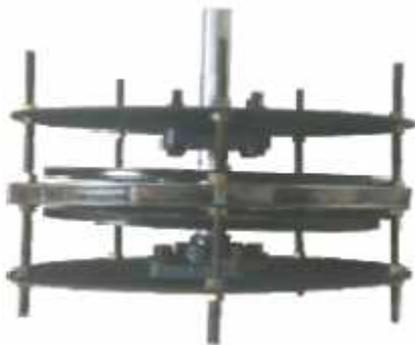


Figure 12. The construction of a permanent magnet generator



Figure 13. Construction of windmill assembly and permanent magnet generator with a supporting pole

RESULTS AND DISCUSSION

Measurement of electrical power

Testing of wind power plants is conducted to determine the power produced by windmills and the characteristics of the minimum voltage and maximum voltage. This test is done by measuring the output voltage without the load of a permanent magnet generator to the rotor generator rotation. Then the permanent magnet generator is tested by measuring the output voltage and the amount of current to the rotational speed of the generator.

Windmill Testing Without Load

In testing with the measurement of the no-load generator voltage at the rotational speed of the generator rotor from 50 rpm up to 500 rpm, the output voltage is 4.7 Volts up to 44.1 Volts.

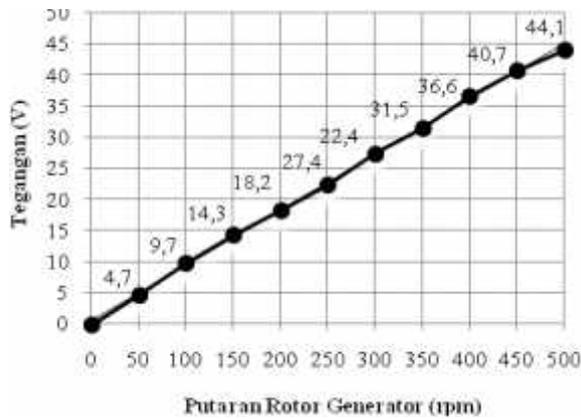


Figure 14. Graph of the relationship of rotor rotation to the output voltage of permanent magnet generator without load

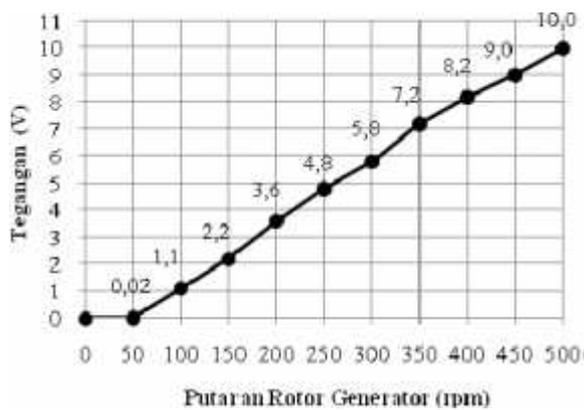


Figure 15. Graph of the relationship of the rotor rotation to the output current of the permanent magnet generator with load

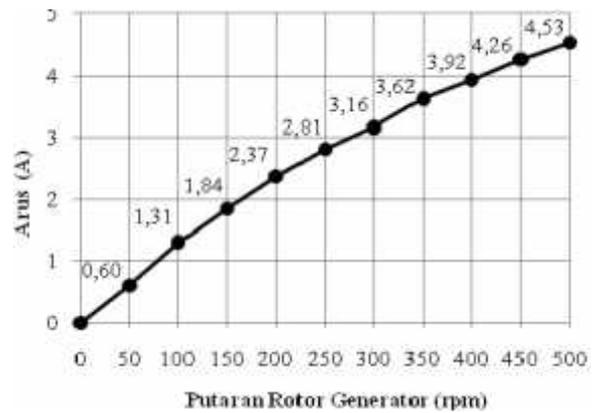


Figure 16. Graph of the relationship of rotor rotation to the output current of a permanent magnet generator with load

The amount of electricity generated during testing of permanent magnet generators with a 70W lamp load is 0.02 V to 10 V with a current of 0.60 A to 4.53 A.

CONCLUSION

1. The Savonius model's vertical axis windmill (VAWT) prototype was designed to build using six blades and a permanent magnet generator with a stator and two rotors and support poles with all component parts and construction models made portable.
2. No-load generator voltage measurement at generator rotor rotation speed of 50 rpm up to 500 rpm produces an output voltage of 4.7 V up to 44.1 V.
3. Measurement of generator rotor rotation after a 70 W lamp load with generator rotor turns 50 rpm up to 500 rpm can produce an output voltage of 0.02 V to 10 V and an electric current of 0.60 A to 4.53 A .

REFERENCES

1. Culp, Archie W., 1991. *Prinsip-Prinsip Konversi Energi*. Jakarta: Erlangga. Terjemahan: *Principles of Energy Conversion*.1979. McGraw-Hill,Ltd.
2. Daryanto, Y., 2007. *Kajian Potensi Angin Untuk Pembangkit Listrik Tenaga Bayu*. Balai PPTAGG-UPT-LAGG.
3. Dutta, Animesh. 2006. *Basics of Wind Technology*. Asian Institute of Technology Thailand.6 Juli 2006.
4. Giles,RanaldV.,1990. *Mekanika Fluidadan Hidraulika (SI-Metrik)*

- Edisi Kedua (Terjemahan)*. Jakarta : Erlangga.
5. Guntoro,W., 2008. *Studi Pengaruh Panjang dan Jumlah Baling-Baling Terhadap Efisiensi Daya Listrik Pada Pembangkit Listrik Tenaga Angin*. Bandung:ITB.
 6. Kamal, Faizul M., 2008. *Aerodynamics Characteristics of A Stationary Five Bladed Vertical Axis Vane Wind Turbine*. Journal of Mechanical Engineering, Vol. ME39,No.2, pp.95-99.
 7. Khan, N.I., Iqbal, M.T., Hinchey, Michael, dan Masek, Vlastimil.2009.*Performance of Savonius Rotor As A Water Current Turbine*. Journal of Ocean Technology.Vol.4,No.2, pp.71-83.
 8. Mittal, Neeraj. 2001. *Investigation of Performance Characteristics of a Novel VAWT*. Thesis. UK: Departement of Mechanical Engineering University of Strath clyde.
 9. Nakajima, M., Lio, S., dan Ikeda, T., 2008. *Performance of Double-step Savonius Rotor or Environmentally Friendly Hidroulic Turbine*. Journal of Fluid Science And Technology. Volume3No.3, pp 410-419
 10. Rosidin, Nanang, 2007. *Perancangan, Pembuatan, dan Pengujian Prototipe SKEA Menggunakan Rotor Savonius dan Windside Untuk Penerangan Jalan Tol*. Bandung : ITB.
 11. PudjiIrasari, Novrita Idayanti, 2007. *Aplikasi Magnet Permanen BaFe12O19 dan NdFeB Pada Generator Magnet Permanen Kecepatan Rendah Skala Kecil*.Lembaga Ilmu Pengetahuan Indonesia (LIPI).
 12. Rochman, S., & Sembodo, B. P. (2014). *Rancang Bangun Alat Kontrol Pengisian Aki Untuk Mobil Listrik Menggunakan Energi Sel Surya Dengan Metode Sequensial*. WAKTU, 12(2), 61-66.
 13. Rochman, S., & Sujiwa, A. *Peningkatan Daya Output Generator Listrik Tipe Afpmg Pada Putaran Rendah Menggunakan 3 Rotor Dan 2 Stator*.