

# Experimental Study of Incorporating Fins on the Rotor Blades of Savonius Wind Turbine

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**Abstract** – The significant rise of electricity energy consumption from fossil fuel has increased the search for viable sources of energy. Wind as an environmentally friendly renewable energy source can be an alternative solution to generate electrical power. This research aims to analyze the influence of incorporating blade on the fin of a Savonius wind turbine type L and S. It adopts a rotor dimension with 1.1 m diameter and height of 1.4 m. The material used for the blade is aluminum plate. Experimental works were performed by incorporating different number of fin on the rotor blades and the electrical power generated was evaluated. Under different wind speed conditions, it evaluates the performance of the vertical axis wind turbine by adding 1 to 4 fins into the rotor blades. This research suggests that the fin blade incorporated affect the performance of the turbine to generate electricity. However, the power generated does not linearly increase with increasing number of fins. Adding one fin on the blade of the Savonius turbine generate more power than the one without fin with a value of 10.66 watt for L blade type and 13.40 watt for S blade type at wind speed of 4.5 m/s. However, adding more than one fin results in less power generated as adding 4 fins on the blade generate only 8.13 watt and 10.80 watt at the same value of wind speed for L and S blade type, respectively. It implies that the performance of a Savonius vertical axis wind turbine can be improved by modification of the blade design.

## 1. Introduction

According to 2014 statistic report, petroleum reserves of 3.6 billion barrels, natural gas of 100.3 TCF and coal reserves of 32.27 billion tons in Indonesia. It is estimated that petroleum will be exhausted in 12 years, natural gas in 37 years, and coal in 70 years, assumed that there is no new reserve discovery [1]. The fossil fuel reserves will be faster than expected due to the increasing trend of fossil energy production.

The shifting from fossil-based energy into renewable energy is expected to be a trend in the future. Wind is an abundant source of renewable energy that will not produce pollution to the environment [2]. As a tropical country, the average wind speed in Indonesia is in the range of 2-3 m / s [3], but the wind energy has not optimally utilize. Advanced technology in small-scale wind turbin has led to the possibilty in harvesting electrical energy in low wind speed area.

Many researches on increasing the power efficiency of wind turbin are intensively conducted, especially to have more power generated with lower wind speed. Improving the wind turbines performances are achievied by modifying the transmission system as well as the design of the rotor blades. The Savonius rotor is put in interest since it is capable to generate power in relatively low wind speed, simple in structure and has good starting characteristic (<http://www.sciencedirect.com/science/article/pii/S111001681200049X>). The research before, experimentally studied the performance of a Savonius Vertical Axis Wind Turbine (VAWT) with 2 (two) different blades, U-type and L-type blades [4]. They concluded that L type savonius blade has better performance compared to the U- blade. The power generated by a Savonius VAWT under different number of blades [5]. It is found that two blades of VAWT is more effective in converting kinetic energy into electrical energy compared to the rotor with three or four blades. Hasan et al



examined the performance of Savonius VAWT under various number of fin incorporated in the U-type rotor blade [6]. Fin is an additional or modified portion of the turbine blade that minimizes the space and increases the pressure along the blade width. The research suggests that additional fin in the blade affects the performance of the wind turbine to produce electrical power. In this work different numbers of incorporated fin blade are experimentally studied in order to determine the most effective design parameter of a L-blade Savonius rotor [7].

## 2. Methods

This study examined the performance of Savonius vertical wind turbine with L and S-type blade using the specification as shown in Table 1.

**Table 1.** Specification of The Savonius VAWT

| Specification             | Value           |
|---------------------------|-----------------|
| Tower height / Tower      | 2500 mm         |
| PMG type generator        | 200 watt        |
| Pulley transmission ratio | 1 : 4.2         |
| Rotor diameter            | 1100 mm         |
| Shaft diameter            | 20 mm           |
| Blade diameter            | 600 mm          |
| High blade / blade        | 1380            |
| Number of blades          | 2               |
| Material blade            | Aluminum 0.3 mm |

Variation of fin number for the experimental works was performed on the 2-blade rotor as shown in Figure 1. Experiments were conducted to test the ability of wind turbines to generate electricity with number of fin blades from 1 to 4 fins.

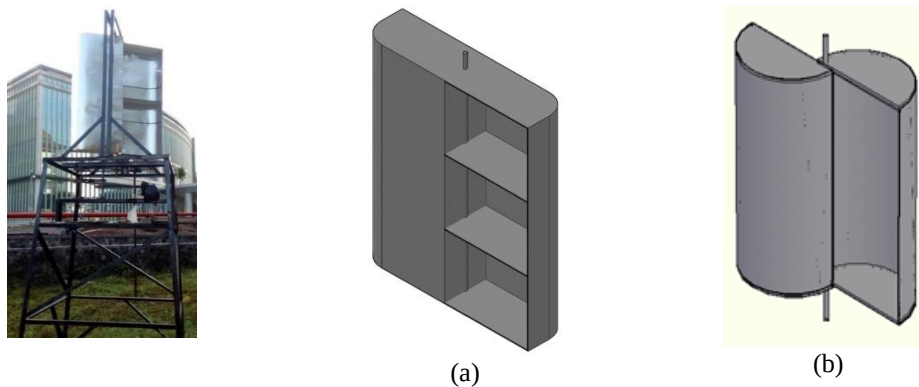


**Figure 1.** The Savonius Wind Turbine: (a) The L rotor (b) The S rotor

The experiment was conducted in Campus UNS Pabelan area for 8 days during March to April 2017 in cloudy weather conditions. The wind speed was measured 5 times for each measurement in the interval of 0.1 m/s.

### 3. Results and discussion

#### 3.1 Effect of incorporating fin blade on the electrical voltage generated

The direct current (DC) generated from the turbine was measured using a digital voltmeter gauge. Data of the electrical voltage is presented in Figure 2.

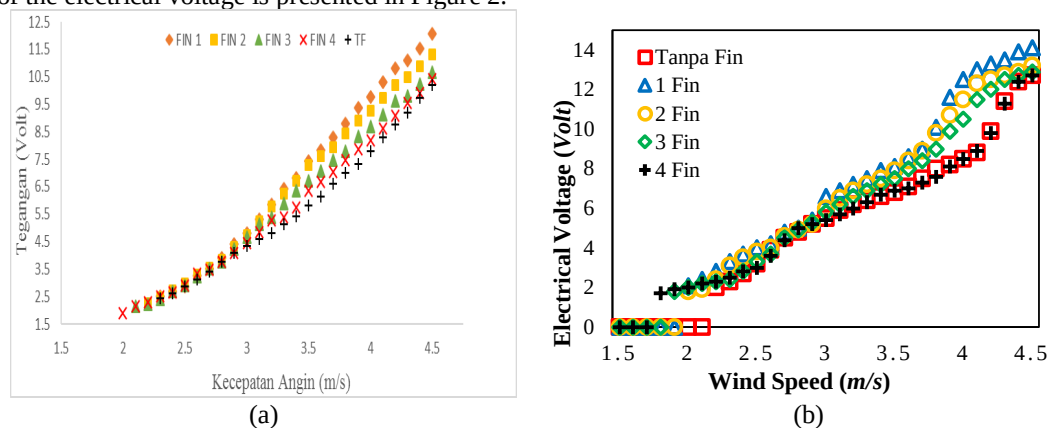


**Figure 2.** Electrical voltage generated with varying numbers of fin blade: (a) The L rotor (b) The S rotor

It was reported that the maximum wind speed observed is 4.5 m/s with an average of 2.3 m/s. Electrical power generated by the VAWT in various values of wind speed is presented in Figure 2. Figure 2 shows that the turbine is not able to generate electricity at less than 2 m/s wind speed, led to the conclusion as the starting velocity both for rotor blade with fins and without fins is 2 m/s. At 4.5 m/s wind speed, the turbine with no fin in the blade can generate electrical power of 10.2 Volt. Incorporating 1, 2, 3 and 4 fins in the rotor blade generate electrical power with the voltage as following: 12.04 volts; 11.3 Volt; 10.68 Volt; and 10.4 Volt, respectively.

#### 3.2 Effect of incorporating fin blade on the electrical power generated

By measuring the electrical current generated using amperemeter digital, the electrical power was obtained and displayed in Figure 3.

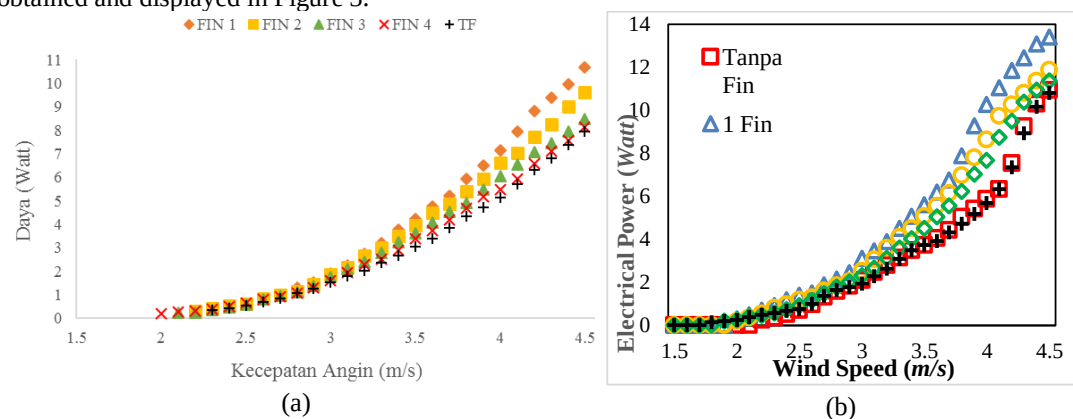


**Figure 3.** Electrical power generated with varying numbers of fin blade: (a) The L rotor (b) The S rotor

Figure 3 shows that the electrical power generated by the Savonius wind turbine increases linearly with increasing of wind speed. However this research fails to estimate the electrical power produced at above 4.5 m/s referring the observation in the site. From Figure 3, it can be seen that the rotor without fins in the blade produces the least electrical power. Meanwhile, the rotor incorporating one fin in the blade generates the highest electrical power compared to others with 10.66 Watt and 13.40 Watt for L and S rotor blade type, respectively. It is also found the more fin in the blade results in the less power generated. Adding a fin in the blade affects the power generated by wind turbines due to the influence of the space divided by the fin blade. However, adding more fins results smaller space the area between fin in the blade which causes the flow of wind centralized and produce greater pressure in the blade. The increase in pressure that occurs in the area of the blade is proportional to the increase in the amount of force generated. So that the thrust force generated at the time will move bigger when fin mounted more [8].

### 3.3 Effect of incorporating fin blade on the rotation of generator

The rotation speed of the generator is measured using digital tachometer. The measurement of rotation speed of generator can be seen in figure 4.

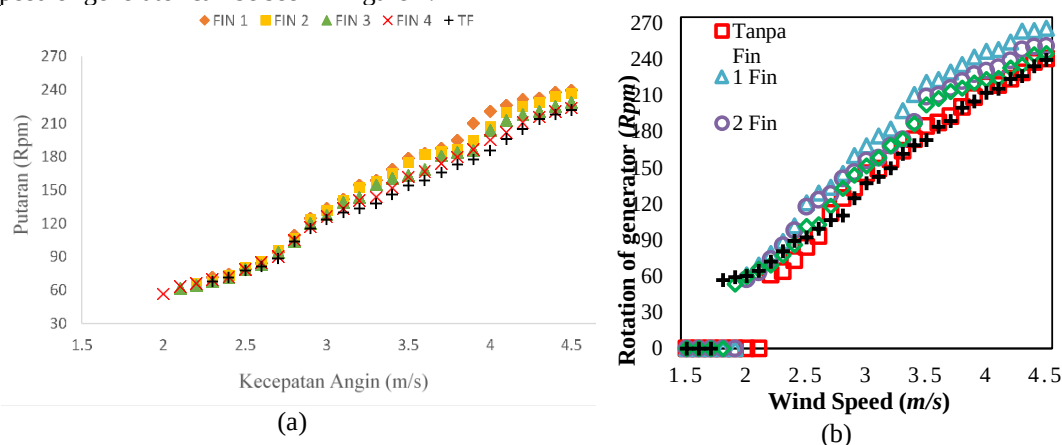


**Figure 4.** Speed of rotation with varying numbers of fin blade: (a) The L rotor (b) The S rotor

Similar to electrical power, the generator can only rotate at wind speed above 2 m/s. At wind speed 4.5 m/s the generator of rotor with no fin in the blade rotates for 222 rpm. While the highest speed of rotation is achieved by the rotor incorporating one fin in the blade for 240 rpm [9].

## 4. Conclusion

It can be concluded that incorporating fin in the turbine blade increases the generator's electrical power. Adding 1 fin in the rotor blade increases the electrical power of the VAWT with no fin in the blade by 25%, 2 fins by 17%, 3 fins by 5% and 4 fins by 2%. The highest electrical power generated by the turbine with 1 fin at 4.5 m/s wind speed is 10.66 Watt. By knowing the shape of the rotor, the dimensions of the rotor, the addition of fin, the transmission and generator used can be found alternatives to increase the electrical power generated by wind turbine Savonius.

## References

- [1] Sugiyono, Anindhita and Adiarso 2016 *Outlook Energi Indonesia 2016* Jakarta: Pusat Teknologi Sumber Daya Energi dan Industri Kimia (PTSEIK-BPPT) ISBN 978-602-74702-0-0 (www.bppt.go.id)
- [2] Nakajima M, Lio S and Ikeda T 2008 Performance of Savonius Rotor for Environmentally Friendly Hidroulic Turbine *Journal of Fluid Science And Technology* **3** 3 420-429
- [3] Faqihuddin M F, Nizam M, Danardono D and Prija D 2014 Karakteristik Model Turbin Angin Untwisted Blade dengan Menggunakan Tipe Airfoil Nrel S833 pada Kecepatan Angin Rendah **12** 84-88
- [4] Soelaiman F A T, Tandian P N and Rosidin N 2007 *Perancangan, pembuatan dan pengujian Prototipe SKEA menggunakan Rotor Savonius dan Windside Untuk Penerangan Jalan Tol* Laporan Penelitian ITB Bandung
- [5] Qurthobi A, Hicary S 2014 Analysis on The Influence of Blade Number on Savonius Vertical Axis Wind Turbine Against Voltage and Current in The Accumulator Filling Process 0-7
- [6] Hasan O D S, Hantoro R and Nugroho G 2013 Studi Eksperimental Vertical Axis Winmd Turbine Tipe Savonius dengan Variasi Jumlah Fin pada Sudu *Jurnal Teknik POMITS* **2** 2 350-355
- [7] Daryanto Y 2007 *Kajian Potensi Angin Untuk Pembangkit Listrik Tenaga Bayu* Balai PPTAGG - UPT-LAGG
- [8] Irawan Rudi 2014 *Pengaruh Profil dan Jumlah Sudu pada Variasi Kecepatan Angin terhadap Performa Turbin Angin Vertikal Axis Savonius* Skripsi: Universitas Sebelas Maret
- [9] Ramadhan F 2017 Pembuatan dan Pengujian Kincir Angin Savonius Tipe L sebagai Sumber Energi Terbarukan *Jurnal Teknik Mesin UBH Universitas Bung Hatta* **8** 2 8