Design and Performance of Savonius Vertical Axis Wind Turbine: A Study Experimental of Blade Models

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Abstract. Massive energy consumption and pollution from the environment have emerged as major issues. A new alternative energy sources is a critical solution. Nowadays, the use of air conditioning machine also contains wasted heat energy resulting from the work of the outdoor unit. This research is an experimental of designing and fabricating a prototype. Wind turbine blades with a tiny Savonius Vertical Axis provide various benefits likely low wind speed to operate the rotor. The methods used are literature study, documentation and blade making and testing. The wind turbines made are four and six blades used a reducer to increase the air velocity driving the turbine blades with variations of wind speed tested 3 m/s, 4 m/s and 5 m/s. This study, we used a reducer with two model blades as a starting point, we discovered that the rotation speed was drastically improved from 18% to 71% in less than 90 s. Furthermore, while the maximum net power taken by four-blades ranges from 2% to 54% of turbine power (Watt), the –addressed. In addition, we showed for the generator efficiency indicated that the model with four blades achieves the highest power generator efficiency of 65.07% with 4.2 watts of turbine power and 320rpm of rotation speed.

Keywords: Experimental study · Savonius VAWT · Blades · Performance

1 Introduction

Based on the Ministry of Energy and Mineral Resources of the Republic of Indonesia within EBTKE claims that Indonesia's energy resources are rapidly running out. The demand for fossil fuels is still very high since it is growing faster than the energy supply can keep up with it. Additionally, using fossil fuels contributes to global climate change because they release more greenhouse gases into the environment. Therefore, the goal must be raised in order for the usage of new renewable energy to be a remedy. Hence, wind energy is one of the most commonly used alternative energies [1–4].

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As would know the use of electrical energy is very highly consumer sector both in the industrial and homes. One solution from alternative energy sources is to utilize the output in the form of wind energy exhaled from the outdoor Split AC which is used in people's homes or industries. Utilization of wind energy (dry air) from outdoor exhaust from the air conditioner machines likely split or chiller can be converted into electrical energy and can be distributed and reused in various needs for electrical energy. Previous research stated that the greater the indoor cooling load can result in an increase the temperature both input and outdoor to the evaporator, its mean the coefficient of performance also decreases ranging from 53% to 76% which of course can cause waste in the use of electrical energy [5].

Wind turbines are tools that can be developed and then used to convert wind energy into electrical energy [6]. Wind energy resources like from the outdoor of air conditioner has a lot of energy potential that can be use, specifically the exhaust air velocity in the outdoor unit, which is 2m/s to 6m/s. It is possible to convert energy conservation into electrical energy by designing a wind turbine that uses the potential dry air velocity that produced by the outdoor unit [7]. Of course, a wind turbine is required for converting wind turbine into electrical energy by a device made up of blades. The turbine blades are arranged in such a way that they can make the shaft rotate and mechanical energy in the form of rotation from the rotation of this shaft can be used to drive a generator as a converter of wind energy into electrical energy [8]. The power coefficient produced by converting wind energy to mechanical turbine power which depends on the ration of the wind speed before and after being converted [9].

This study is focused of the effect of varying the number of turbine blades on the performance of the designed a Savonius wind turbine. Thus, was carried out on a wind turbine with 3D printing blades and a U-shaped frame with a height of 1200mm and a radius of 250mm. According to [10] it is possible to conclude that there is a relationship between the number of blades and the generator output power also [11] describes the greater the number of blades that the greater the value of the generator output power.

As a results, this study was carried out by developing a turbine blade design. The designed wind turbine is a vertical axis with a savonius blade that captures wind/dry air from the outdoor unit of air conditioner machine and coverts in into electrical energy. Therefore, it's a simple prototype of efficient energy conservation.

2 Method and Procedure

2.1 Method

Observations, air flow simulation, design of Savonius blades, data collection, testing of blade models and evaluation of wind turbine performance will be used in this study. The flow chart in Fig. 1 explains the order of experimental research.

2.2 Procedure and Materials

We have testing starts from the preparation stage of testing tools and materials, then continues with design and manufacturing of blades wind turbine. The stages carried out includes:

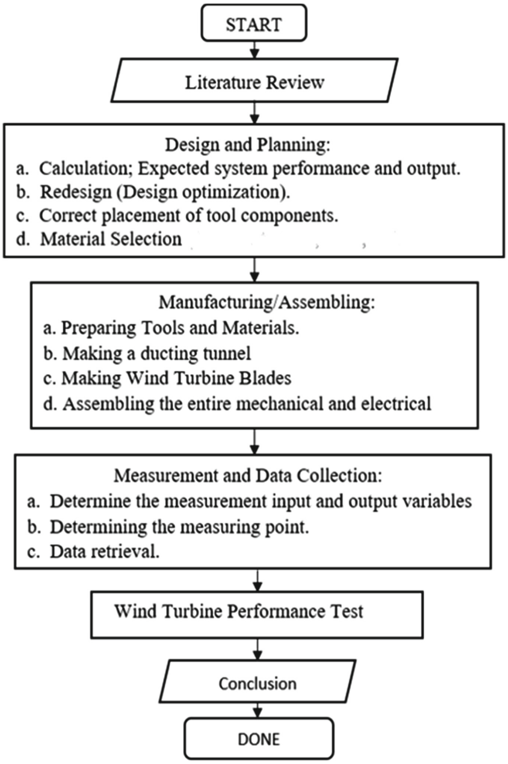


Fig. 1. Schematic of Experimental study

a. Design creation, the first stage begins with preparing demensional with the 3D digital designed using the Inventor Autodesk such as Fig. 2 and Fig. 3
b. Set the position of the object. Adjust the position of the object to fit the print area or printer base. The goal is that the object sticks firmly to the base so that the object does not shift or change shape while being printed.
c. Set the density level and 3D printing speed. The next step is to set the density level of the object to determine its density. A density of 0% means that the print has no voids or lines at all whereas a density of 100% means that the object will be completely filled with filament. Then, don't forget to adjust the speed of the printing machine to be just right. Because if it's too fast it will cause the filament to still melt before it has time to stick to the object.
d. Set up connectivity. Aims to regulate from printing nozzles to machine temperature.
e. Setting up a 3D printing machine with a computer. After the connection is successfully connected, all the basic components of the 3D Printer can be managed via the computer.
f. 3D design file storage, this stage is necessary so that we don't have to rearrange the design if we want to reprint it.

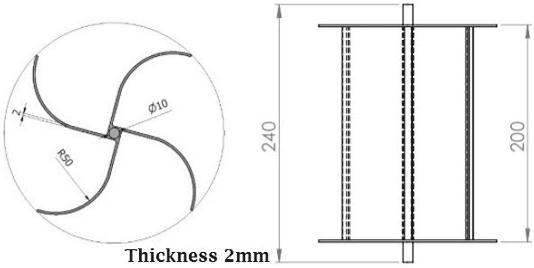


Fig. 2. Layout Design for four blades

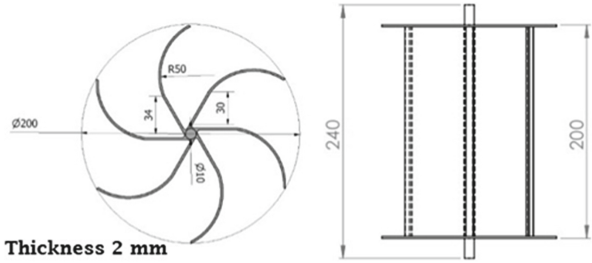


Fig. 3. Layout Design for six blades

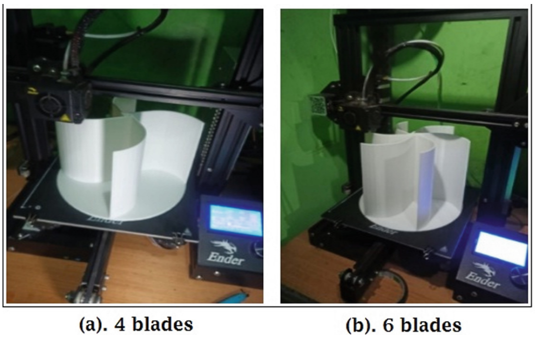
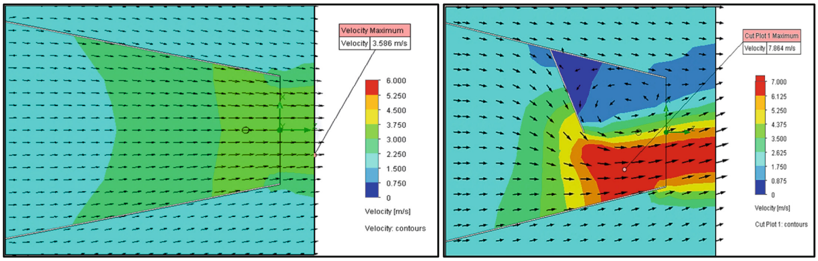


Fig. 4. 3D Printing process

g. Wind turbine object printing. This is the final stage of the object printing process and sure the filament or printing material that will be used is installed correctly that showed on Fig. 4.

The 3D printing machine process is showed in Fig. 4. Also, the air flow modeling simulation used Fluid Dynamics is shown in Fig. 5a, the turbine blades are propelled by 3.724m/s of dry air. In Fig. 5b, the air velocity that powers the turbine blades reaches 7.601m/s when a reducer is used.

To conduct this research, the following research materials are needed on Table 1.



(a) without Reducer b) Used Reducer

Fig. 5. Fluid dynamics Simulation

Table 1. Materials needed

No	Materials
1	Blower 220 V with Variation wind speed
2	12V/AC Permanent Magnetic Generator
3	3D Printing Machine
4	Connecting Shaft
5	Arduino uno for acquisition data
6	Sensor Speed rotation
7	Sensor Flowmeter
8	Wattmeter
9	Load 12V/3W
10	PLA (Polylaxtic acid)
11	Wind tunnel

3 Results and Discussion

The experimental study is obtained for configuration of Savonius Vertical Axis Wind Turbine blades for two blade models, its four blades and six blades at dry air velocity 3.0 m/s, 4.0 m/s and 5 m/s. An experimental study, the all data are taken using measuring tools such as Arduino Uno as the acquisition data. According to [12] on Fig. 6 illustrates the design of Savonius Vertical Axis Wind Turbine shows a simple design using dry air from outdoor unit of air conditioning machine and used the closed loop also reducer to increases the potential head of wind power.

3.1 Initial performance test

Figure 7 shows the initial testing of Savonius blade models. According to the experimental results, the maximum speed that six blades can achieve is lower than that of four blades. That also demonstrated the result of a test with two blade model; at a wind

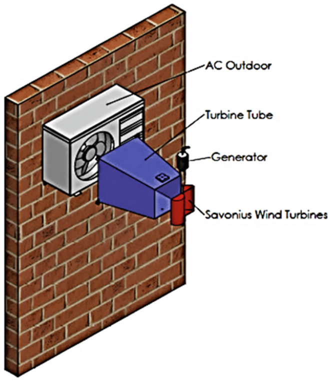


Fig. 6. Layout of Experimental study

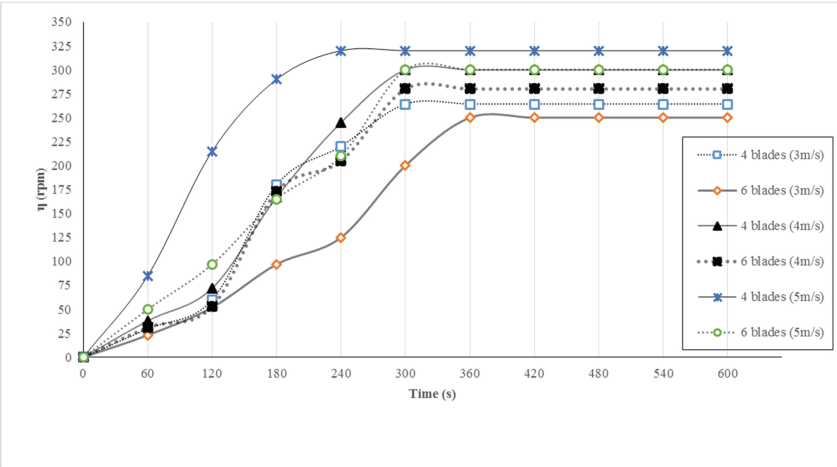


Fig. 7. Illustrates the starting performance

velocity of 5 m/s, four-bladed model can reach its maximum rotation speed of 320 rpm in 240 s. At 5 m/s wind speed, the six blades were slower to self-starting within 264rpm at 300 s. However, at 4 m/s wind speed was quite reachable in 320 rpm. The wind turbine can reach 215 rpm in less than 120 s when the wind speed is 5 m/s, and 60 rpm when the wind speed is 3m/s. In other hand, six blades in running test was reaches to 300 rpm at 5m/s and 23 rpm at 3 m/s. Finally, the four blades as initial test, we discovered that the rotation speed ranged from 18% to 71%.

3.2 Turbine Power

Figure 8 shows that the turbine capability of six blades is somewhat higher than that of four blades. Other researched by [13, 14] that the bigger number of blades which is greater the value of the generator output power. The results test findings reveal that when

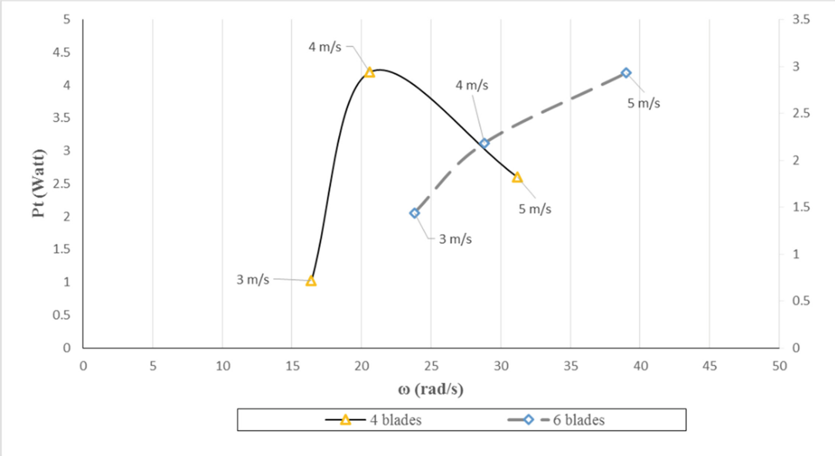


Fig. 8. Power capability characteristics

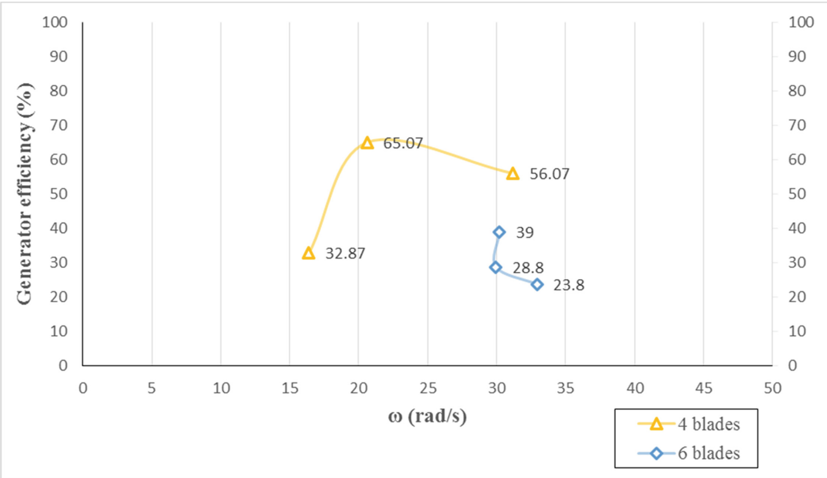


Fig. 9. Generator Efficiency characteristics

a four blade model is put on the main shaft and directly linked to a permanent magnet generator, the turbine power decrease at wind speeds of 3m/s, 4m/s and 5m/s is to 2%, 54% and 46% respectively.

3.3 Generator Efficiency

Figure 9 shows that for six blade net power efficiency is lower than four blade net power efficiency. The graph showed that a four blade model with a wind speed of 4m/s achieved the highest efficiency of 65.07%. Meanwhile, the six blade model has the lowest power efficiency with a wind speed of 4m/s and an efficiency of only reached to 38.96%.

4 Conclusion

The goal of this experimental study was to design, assemble, and test starting, power and generator efficiency results. We was done created designs for two Savonius Vertical Axis Wind Turbine blade models: four and six blades. As a results of the test, the model with four blade has the highest power generator efficiency of 65.07% and 4.2 Watts for turbine power as well as 320 rpm for blade rotation speed. Finally, a wind turbine blade design with exhaust outdoor unit from air conditioner machine provides future challenges, which could be used as a new method in a renewable alternative solution in green energy industries.

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