Design of Horizontal Axis Wind Turbine Simulator Using Smart Monitoring System

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***Abstract*— Wind turbine shows the direct utilization of mechanical energy and occurs as follows: the wind that moves hitting the wing of the ferris wheel causes the ferris wheel to spin. The rotation of the ferris wheel causes the formation of mechanical energy, while the conversion of wind energy into electrical energy is as follows: the wind through the ferris wheel plants causes the ferris wheel to spin. The spin of the ferris wheel causes the generator to spin. Inside the wind, energy generator is converted into electrical energy. In the Final Task that did the design of this prototype, do a comparison between the horizontal axis wind turbine with variations in the number of blades, with blade variations totaling 3 and 5. So, there will be 2 wind turbines with different numbers of blades in one prototype. Comparisons are made to find out the performance carried out by the two wind turbines that aim as a learning medium in the Measurement Instrumentation Laboratory. This final task is divided into five stages tool design, tool characterization, tool validation, tool testing, and comparing tools. The process of designing tools that are divided into two methods, namely covering the formation of hardware and the formation of software. The graph data contained in the discussion shows the performance with the propeller amounting to 5 produces a higher current and voltage output and rpm on this prototype scale than the number of propellers 3, with the value for example at the acceleration of fan 5 with a wind speed of 3.9 m / s on the propeller amounting to 5 resulting in an average current value of 3.2 mA, a voltage of 1.98 V, and rotor rotation of 234 RPM. While at the number of propellers 3 with the same wind speed produces smaller current output, voltage and rpm, which is obtained an aage current of 2.3 mA, a voltage of 1.88 V, and rotor rotation of 243 RPM.**

Keywords*— *Output performance comparison, Horizontal axis wind turbine, Blade variations

I. Introduction

As currently the development of new renewable energy (EBT) refers to Presidential Decree No. 5 of 2006 on Energy Policy National. The Presidential Regulation mentions the contribution of NRE in the mix of national primary energy by 2025, especially for wind energy which is 5% [1]. Therefore, it is necessary to develop local wind turbines either by LAPAN, BPPT, universities high, or the general public. But the point of attention namely in the Indonesian environment is the wind speed that tends to be low in the range of 2.5 - 6 m/s and the magnitude of the fluctuation wind speed and direction. Therefore, it is necessary to develop wind turbines in order to optimize the existing wind speed in the Indonesian environment. Wind turbine design and development has become a topic that has attracted the attention of many researchers with the issue above. Currently, the wind turbine is horizontal axis wind turbine (HAWT) has been widely created, used or developed compared to the type of vertical axis wind turbine (VAWT) because HAWT has a better efficiency value than VAWT in the use of wind in electrical energy [2].

The main principle of the energy produced by the wind is to change the electrical energy of the wind becomes the kinetic energy of the shaft. The amount of energy that can be transferred to the rotor depends on the density of air, area, and wind speed. Kinetic energy for a mass of wind moving with velocity v which will be converted into shaft energy. The wind is air (which moves caused by the rotation of the earth and also due to differences in surrounding air pressure. Wind moves from a place of pressure high air to low air pressure [3]. Wind energy is one of the renewable energy potentials that can make a significant contribution to energy demand electricity, especially in remote areas. Wind energy can be utilized into electrical energy by a wind turbine. The basic working principle of a wind turbine is to change the energy of the motion of wind into rotating energy on the wheel, then the rotation of the wheel is used to turn a generator, which will eventually produce electricity. This plant can convert wind energy into electricity using a wind turbine or windmill. System electricity generation using wind as an energy source is an alternative system that is growing rapidly, considering that Wind is one of the unlimited energies in nature. HAWT is a turbine whose main shaft rotates according to the direction wind. For the rotor to rotate properly, the wind direction must be parallel with the turbine shaft and perpendicular to the direction of rotation of the rotor. Usually, this type of turbine has an airfoil-shaped blade like the shape of the wing on an airplane. In general, the more blades, the higher the turbine rotation [4].

The comparison of the number of blades in the Final Task this time is to compare the number of blades 3 and blade 5. By perfecting previous research whose results are still confused due to different results. The more blades, the lower the power generated and vice versa, this includes the solidity effect. Each blade produces different generator power. The number of blades 3 produces greater power with an average value of generator power of 0.12446 Watts and a power utilization effectiveness of 0.014. For the number of blades, 5 produces a generator power of 0.07728 and utilization effectiveness of 0.0087. So, the more blade numbers the greater the bland force produced [5]. While in other studies the number of blades 5 gives a

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higher average rpm, value compared to 3 blades and 4 blades. The highest rpm is obtained at the number of blades 5 and wind speeds of 5m / s which is an average of 576 rpm with an average power of 23,775 Watts [6].

II. METHOD

The methodology of this study is shown in figure 1 below.

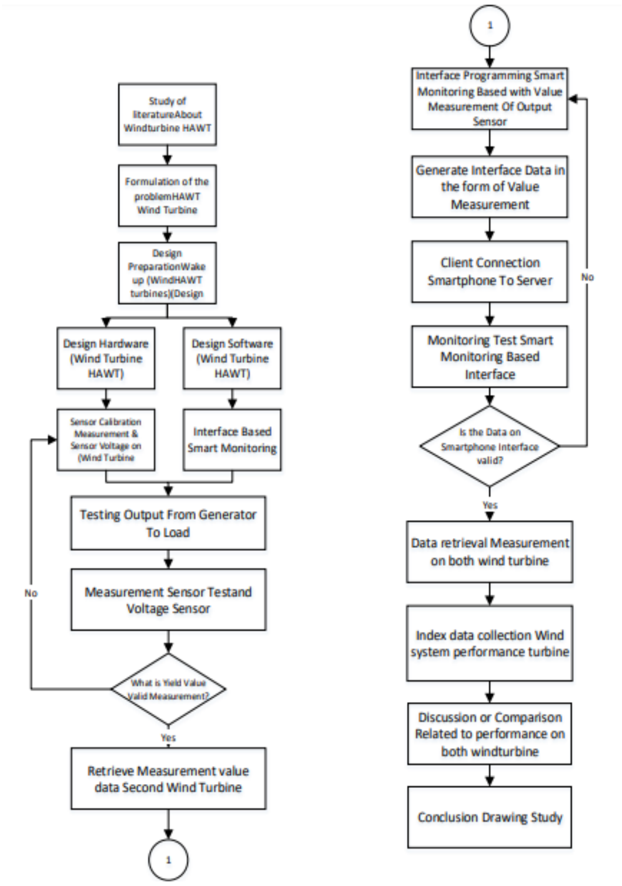

Figure 1. Research Methodology

The flow of work in this research, on the task flow diagram Finally, there are several stages, starting from the problem formulation stage, the study of hardware and software design literature, to the data comparison stage.

A. Propeller Design

The determination of the value of the turbine blade radius above is based on prototypes made with spin output in mind the rotor, the output current and the resulting voltage. So that calculation is based on determining the value of the blade radius first then calculating the maximum output of the round rotor, current and voltage output.

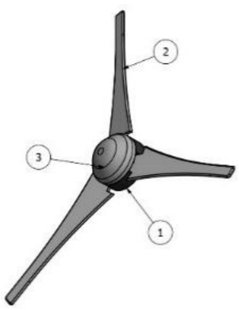

Figure 2. Propeller Design With 3 Blades

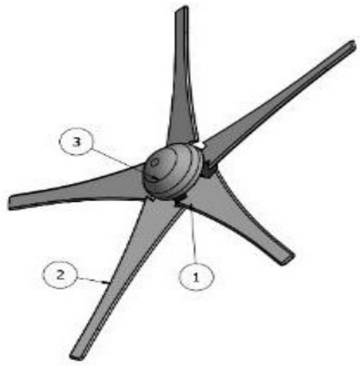

Figure 3. Propeller Design With 5 Blades

The length of the propeller radius is 231.67 mm can be seen in the specifications in Figure 4.

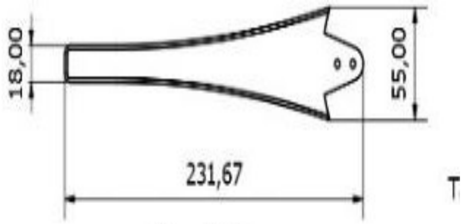

Figure 4. Blade Size

B. Mechanical Design of Prototype

Wind turbine prototype design with 3 blades and blades 5 as a performance comparison using the SketchUp application to find out the results of the prototype design later.

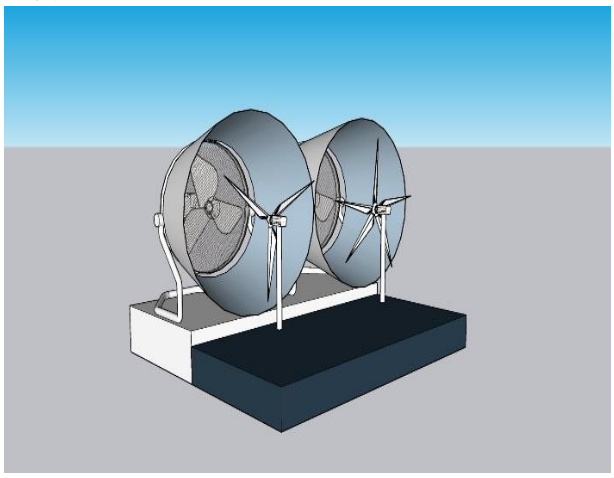

Figure 5. 3D Prototype Design

III. RESULTS AND DISCUSSION

A. Result of Mechanical Design of Wind Turbine Prototype

The result of the design is the result of the manufactured prototype according to the design that has been made. Can be seen in figure 7. There are 2 fans as the source and There are also wind turbines with 3 and 5 blades.

Figure 6. Monitoring Results Using a Smartphone

Figure 7. Prototype Design Results

In the first design, using a wind tunnel on the source of the wind serves to concentrate the wind so that it is directed on the wind turbine blades. However, some findings turbulence occurs in the wind tunnel so that the wind generated by the fan collision occurs in the wind tunnel and resulting in no wind coming out of the wind tunnel.

B. Sensor Testing INA219

Testing the current and voltage sensor readings is carried out with how to compare the accuracy of the readings on the sensor and readings on a standard multimeter.

TABLE 1.
VALIDATION OF INA219 SENSOR READINGS

Level Speed Fan	Speed Wind (m/s)	Voltage (Sensor INA219)	Voltage (Multimeter)	Difference
1	2.9	1.68	1.63	0.05
2	3.4	1.76	1.7	0.06
3	3.6	1.82	1.79	0.03
4	3.7	1.85	1.81	0.04
5	3.9	1.88	1.82	0.06
6	4.2	1.89	1.83	0.06
7	4.3	1.90	1.87	0.03
8	4.4	1.91	1.87	0.04
9	4.5	1.92	1.89	0.03
10	4.7	1.95	1.9	0.05
Average				0.045

C. Testing the RPM Sensor Readings

Testing of the LM393 rpm sensor readings was also carried out with the same method, which is done by comparing the level of accuracy on reading 1 and subsequent readings.

TABLE 2.
LM393 RPM SENSOR READINGS

Level Speed Fan	Speed Wind (m/s)	Rotor Rotation (RPM)
1	2.9	188
2	3.4	192
3	3.6	213
4	3.7	220
5	3.9	234
6	4.2	246
7	4.3	250
8	4.4	258
9	4.5	264
10	4.7	268

D. Comparison Results Against Voltage

TABLE 3.
COMPARISON OF VOLTAGE

Level Speed Fan	Speed Wind (m/s)	Wind Turbine 3 (V)	Wind Turbine 5 (V)
1	2.9	1.68	1.76
2	3.4	1.76	1.85
3	3.6	1.82	1.93
4	3.7	1.85	1.97
5	3.9	1.88	1.98
6	4.2	1.89	2
7	4.3	1.9	2.07
8	4.4	1.91	2.09
9	4.5	1.92	2.1
10	4.7	1.95	2.13

Based on the data above, it can be seen that the 5-wind turbine has a higher voltage output than a 5-wind turbine with the same wind supply.

E. Comparison Results Against the Current

TABLE 4.
COMPARISON OF CURRENT

Level Speed Fan	Speed Wind (m/s)	Wind Turbine 3 (mA)	Wind Turbine 5 (mA)
1	2.9	0.7	1.3
2	3.4	0.9	1.7
3	3.6	1.1	2.1
4	3.7	1.5	2.9
5	3.9	2.3	3.2
6	4.2	3.2	4.2
7	4.3	3.5	4.4
8	4.4	4.6	5.3
9	4.5	4.8	7.3
10	4.7	4.8	7.8

Based on the data above, it can be seen that wind turbine 5 has Higher current output than wind turbine 5 with supplies the same wind.

F. Comparison Results Against RPM

TABLE 5.
COMPARISON OF RPM

Level Speed Fan	Speed Wind (m/s)	Wind Turbine 3 (RPM)	Wind Turbine 5 (RPM)
1	2.9	188	198
2	3.4	192	210
3	3.6	213	225
4	3.7	220	236
5	3.9	234	243
6	4.2	246	256
7	4.3	250	268
8	4.4	258	272
9	4.5	264	288
10	4.7	268	301

Based on the data above, it can be seen that wind turbine 5 has higher RPM output than wind turbine 5 with supplies the same wind.

G. Graph of Comparison Against Voltage

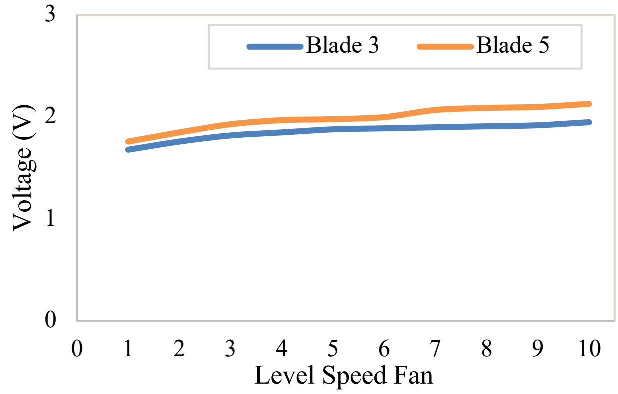

Figure 8. Comparison Graph Against Voltage

H. Graph of Comparison Against Current

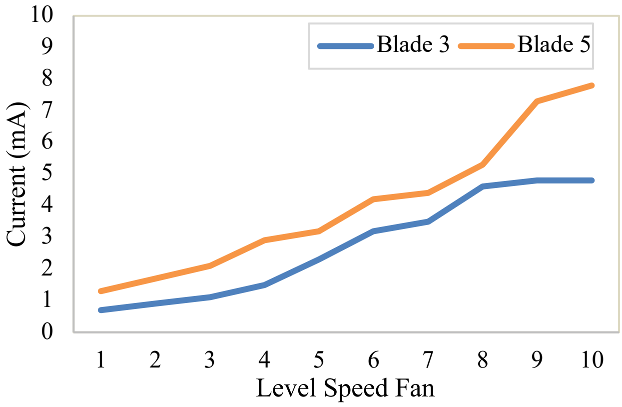

Figure 9. Comparison Graph Against Current

I. Graph of Comparison Against RPM

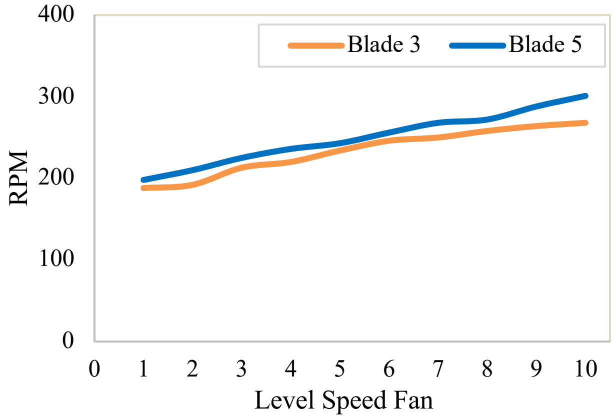

Figure 10. Comparison Graph Against RPM

IV. CONCLUSION

Based on the results of making and reading the data, the conclusions are: from the final project work on the comparison of the performance of a wind turbine type HAWT with the ratio of the number of propellers 3 and 5 are asfollows:

1. Design of a prototype of a physical variable measurement system on the two wind turbines with each number of blades propellers 3 and 5 can be made with parameters of current, voltage and rpm. It was found that when the wind tunnel was installed, the turbine the wind can't turn. This is due to turbulence of the wind in the wind tunnel so the wind can't rotate the propeller.
2. From the graphic data contained in the discussion, it shows performance with 5 propellers produces output higher current and voltage as well as rpm on the scale of this prototype than the number of propellers 3, with the value For example, the acceleration of the fan 5 with speed 3.9 m/s wind on 5 vanes produces the average value of the current is 3.2 mA, the voltage is 1.98 V, and the rotation of the rotor is 234 RPM. While on the number of 3 propellers with the same wind speed produces more current, voltage and rpm output small, that is, the average current is 2.3 mA, the voltage is 1.88 V, and a rotor rotation of 243 RPM.
3. Based on the overall comparison data, it can be concluded that the level of performance on each propeller the propeller shows the propeller with the number 5 produces a larger output value than with 3 propellers

The suggestions from the final project of turbine performance comparison HAWT type wind with a ratio of the number of blades 3 and 5 are as follows:

1. The wind tunnel must be made longer so that the wind can rotate the propeller
2. This technology must continue to be developed to improve the level of accuracy and precision.
3. This smart monitoring technology must be updated in terms of the system and the sophistication of the components used inside it.

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