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Experimental Analysis Of Vortex Turbine Performance On Changes In Variation Of Angle Of Attack And Flow Rate

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Abstract – A vortex turbine is a turbine that utilizes an artificial vortex to rotate the turbine blades and then converts it into rotational energy on the shaft. The process is that water from the river flows through the inlet to the turbine tank which is circular in shape and in the center of the bottom of the tank there is an exhaust channel. As a result of this exhaust channel, the water flow will form a vortex. In the design that has been carried out, to determine the maximum output of the performance of the vortex turbine is to vary the shape of the angle of attack of the vortex turbine blades, namely angles of 30°, 45° and 90° and the flow rate of 0.006 m^3/s, 0.0083 m^3/s and 0.01 m^3/ s. So that the maximum power and efficiency is obtained from the design. Small scale vortex turbine design and testing the effect of blade angle of attack on power and efficiency. Experimental tests have been carried out on a vortex turbine by varying the angle of attack. The results showed that the highest power produced was 6.26 Watt at an angle of attack of 90° with a flow rate of 0.01 m^3/s. The highest efficiency is found in the variation of the angle of attack of 90° with a flow rate of 0.006 m^3/s and an efficiency of 19.4% is obtained.

Keywords – turbine, vortex, angle of attack, power, efficiency

I. Introduction

A micro hydro power plant is a small-scale power plant (less than 100 kW) that uses water as its driving force, such as irrigation canals, the amount of water discharge and rivers or waterfalls by utilizing the height of the falls. A water turbine is an energy conversion machine that converts mechanical energy into kinetic energy, then into potential energy and then into electrical energy. The current micro hydro power plant utilizes a high head of water to generate electrical energy. Meanwhile, the river flow with low head has not been used optimally. Utilization of river flows that have a low head at this time there is no solution to this problem.

Electrical energy is one of the primary human needs that continues to increase. This is due to the increasing number of human activities and the growth of the human population which continues to increase significantly, especially in Indonesia. Currently, most of the electricity demand in Indonesia is still supplied by fossil fuel power plants. Dependence on fossil energy and the lack of use of renewable energy is one of the weaknesses in the implementation of energy policies. One of the problems in the distribution of electricity is the distance between the power source and distant consumers, especially in remote areas.

Research on the effect of variations in the number of blades on the electrical output power of the vortex turbine, shows that for the number of blades as many as 2, 3, 4, 6, and 8 pieces, the more blades the higher the electrical output power of the vortex turbine. The highest efficiency of 6.02% is obtained at the number of 8 blades and at 1.85 watts of power with a mechanical power verification of 3.44 watts. The above research has not explained the effect of variations in the optimum blade area so that researchers will conduct research that varies the optimum blade area on the turbine [1].

Variations in the blade angle greatly affect the power and efficiency produced by the vortex turbine. Experimental Test of the Performance of the Vortex Flow Reaction Turbine Type Straight Cross Section with Variation of Blade Height. The guide vane with an angle of 17.82° has the most optimal power and efficiency than the angle of 13.32°, 7.26° and 0° (without the vane). At 17.82° the vane has the highest power that occurs at a capacity of 8.1 lt/s with a load of 20 kg (23.96 W), and the highest efficiency occurs at a capacity of 5.6 lt/s with a loading of 15 kg (57.26%) [2].

Research on the effect of variations in the number of blades on the performance of vortex flow reaction turbines with flat plate cross-sectional blades, states that between 6 blades, 8 blades, and 10 blades shows that 8 blades have the highest power of 21.84 watts at a capacity of 8.89 Experimental Test of Vortex Flow Reaction Turbine Performance Straight Cross Section Blade Type with an Optimum Blade Area of 111 lt/s with a load of 25 kg and an efficiency of 44.3%. This is because the turbine with 8 blades has a more tenuous distance between the blades because it has fewer blades, this causes the volume of water that enters the gap of each turbine to increase. This study only describes the number of blades but not the size of the blades, therefore this study will be used as a reference in determining the number of blades to be studied [3].

The turbine diameter of 27 cm has the most optimal power and efficiency at a water discharge of 11.04 lt/s with a loading of 40 kg which is 40 watts and an efficiency of 51.33%. Turbine power tends to increase with the addition of the blade width, this can be seen from the test results between 21 cm and 27 cm diameter turbines, but there is a decrease in power and efficiency in 33 cm and 39 cm turbines [4]. The highest power is owned by a turbine with a height of 21 cm at a water flow of 13,443 lt/s with a loading of 30 kg, has a power of 42.97 watts. Efficiency of 51.37% [5].

One of the instruments that is often used to utilize energy from microhydro is a water turbine. Hydropower turbines are generally categorized into two types, namely impulse turbines and reaction turbines. The various types of impulse turbines are Turgo, Pelton and Cross flow turbines. In the reaction turbine group, there are Francis and Kaplan turbines as well as vortex flow reaction turbines. Micro-hydro power plants have good economic value, although they are limited to only being able to meet the use of electrical energy for a number of homes. The vortex flow reaction turbine has its own advantages, namely that it can be built in remote areas with water potential that does not have to be large. The vortex turbine has a relatively low head of 0.7 m – 3 m with a discharge of 50 lt/s [6].

II. Research Methods

Research variable

Independent Variable

The independent variable is a variable that affects or is the cause of changes or the emergence of the dependent variable. In this research the independent variables are:

a. Variation of angle of attack blade : 30^o, 45^o, and 90^o

b. Variation of flow rate is 0.006 m^3/s, 0.0083 m^3/s and 0.01 m^3/s.

Dependent variable

The dependent variable is a variable that is influenced by the presence of an independent variable. The dependent variable in this research is the power and efficiency of the vortex turbine.

Testing Steps

1. The first test uses a turbine angle of attack of 30° with variations in flow rate.

   a. Install the turbine with a 30° angle of attack variation in the basin.

   b. Determine the first discharge variation according to the predetermined variable by setting the frequency on the potentiometer and then calculating the flow rate on the flowmeter beside the pump.

   c. Monitoring the water level in the basin to keep it constant.

d. Measure the water discharge coming out of the inlet hole in the basin using a stopwatch and a bucket.

e. Measure the rotation (rpm) of the shaft on the vortex turbine using a tachometer.

f. Measure the load on the turbine using a spring scale.

g. To get more accurate test data, repeat for each data collection 3 times.

h. After the data on the first discharge variation is obtained, repeat the procedure c – g for the second and third discharge variations.

2. The second test with an angle of attack of 45° on variations in flow rate.

a. Replace the previously used turbine blade with a 45° angle of attack variation in the basin.

b. Then do the same procedure b – h at point A of the first test.

3. The third test with the angle of attack of the turbine blade 90° on variations in flow rate.

a. Replace the previously used turbine blade with a 90° angle of attack variation in the basin.

b. Then do the same procedure b – h at point A of the first test.

III. Results And Discussion

The results of the research obtained from the measurement values of torque and turbine rotation, then calculations were carried out to obtain turbine power. The power generated for each turbine is varied at each different flow rate. To see more clearly the relationship between turbine power and flow rate at each different variation of the angle of attack, it can be seen in Figure 1.

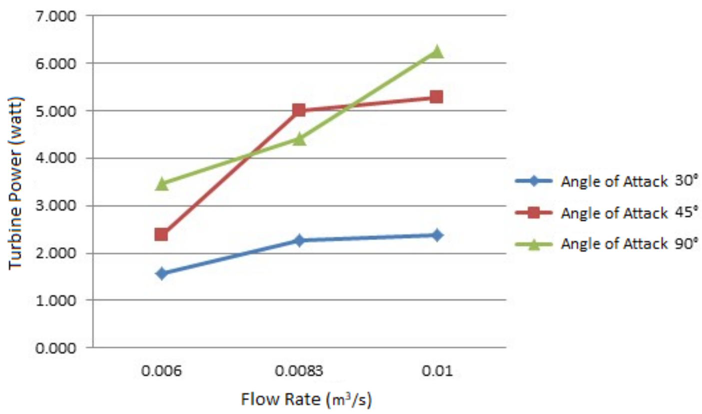

Fig. 1. The relationship between turbine power and flow rate at various angles of attack

In Figure 1 it can be seen that the greater the angle of attack and the greater the flow rate, the greater the turbine power. The turbine power produced at an angle of attack of 90° is lower than the angle of attack of 45° at the same flow rate of 0.0083 m^3/s, this is due to an increase in the shaft rotation value and the torque value at an angle of attack of 45° is quite large compared to torque on the turbine angle of attack 90°.

After getting the turbine power value, the next step is to calculate the efficiency value of each variation of the angle of attack at different flow rates. To make it clearer to see the relationship between the angle of attack and efficiency at each different flow rate, see Figure 2.

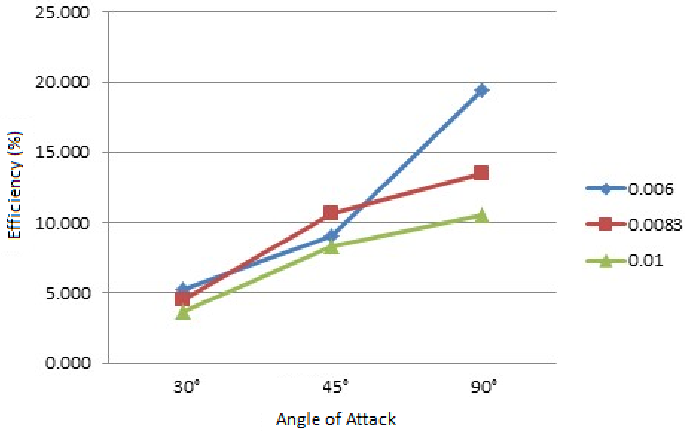

Fig. 2. Relationship of efficiency and angle of attack with various water flow rates

Figure 2 shows that the highest efficiency value is found in the variation of the angle of attack of 90° at the flow rate of 0.006 m^3/s with an efficiency value of 19.4%, then below that at discharge of 0.0083 m^3/s, the angle of attack is 90° with an efficiency value of 13.5%, then at 45° attack at 0.0083 m^3/s discharge of 10.6%, then at 90° angle of attack at 0.01 m^3/s discharge followed by 45° attack angle at 0.006 m^3/s discharge, 0.01 m^3/s, then at attack angle 30° at a discharge of 0.006 m^3/s, 0.0083 m^3/s and the lowest efficiency value at a discharge of 0.01 m^3/s is 3.6%. The size of the efficiency value is influenced by the turbine power and water power, if you want to get a large efficiency value, increase the turbine power value and reduce the water power value, you will get a high efficiency value. efficiency will be small.

IV. Conclusion

The variation of the angle of attack on the turbine power and the resulting efficiency experienced a less significant change. While the variation of flow rate is concluded that there is a significant effect obtained between the flow rate on the turbine power produced. Meanwhile, in the variation of flow rate, it is concluded that there is a significant effect obtained between the flow rate and the resulting efficiency. The results of the vortex turbine research which have been carried out have the highest power generated at 6.26 Watt at an angle of attack of 90^o with a flow rate of 0.01 m^3/s. The highest efficiency is found in the variation of the angle of attack of 90° with a flow rate of 0.006 m^3/s and an efficiency of 19.4% is obtained.

References

[1] Widiyatmoko,“ Pengaruh variasi jumlah sudu terhadap daya output listrik pada turbin vortex,” Tesis tidak diterbitkan. Yogyakarta: Universitas Gajah Mada, 2012.

[2] Achmad, K.H., Adiwibowo, P.H.,“ Pengaruh sudut inlet notch pada turbin reaksi aliran vortex terhadap daya dan efisiensi,” JTM, Vol. 05, No. 02, pp. 61-69, 2017.

[3] Afryzal, N.R., Adiwibowo, P.H, “ Uji eksperimental pengaruh variasi jumlah sudu terhadap kinerja turbin reaksi aliran vortex dengan sudu berpenampang plat datar,” JTM, Vol. 05, No. 02, pp. 147-157, 2017.

[4] Wibawanto, H. H,” Uji eksperimental kinerja turbin reaksi aliran vortex tipe sudu berpenampang lurus dengan variasi lebar sudu,” Jurnal Teknik Mesin Unesa, Vol 6, No 1, Hal. 153-161, 2018.

[5] Hakim, M. F,” Uji eksperimental kinerja turbin reaksi aliran vortex tipe sudu berpenampang lurus dengan variasi tinggi sudu,” Jurnal Teknik Mesin Unesa, Vol 6, No 1, Hal. 85-95, 2018.

[6] Mohanan, A,” Power generation with simultaneous aeration using a gravity vortex turbine,” International Journal of Scientific & Engineering Research, Volume 7, Issue 2, 2016.