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THE EFFECT OF THE ANGLE OF ATTACK OF THE BLADE ON THE PERFORMANCE OF THE VORTEX TURBINE

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ABSTRACT

Electrical energy is one of the primary human needs that continues to increase. Dependence on fossil energy and the lack of use of renewable energy is one of the weaknesses in the implementation of energy policies. Hydroelectric power is one of the options in utilizing renewable energy sources. The availability of water in Indonesia has the potential to be used as a renewable energy source. This study aims to determine the effect of variations in angle of attack and variations in flow rate on turbine performance (turbine rotation and torque produced). 0.006 m^3/s, 0.0083 m^3/s and, 0.01 m^3/s. The results showed that the greater the angle of attack of the turbine, the greater the turbine rotation obtained. The greater the flow rate, the greater the value of the turbine torque produced. The largest rotation was obtained at 67.7 rpm at an angle of attack of 90° at a discharge of 0.01 m^3/s, and the largest torque value obtained is 1.043 Nm at an angle of attack of 45° at a discharge of 0.01 m^3/s.

INTRODUCTION

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 consumers, especially in remote highland areas. In fact, the potential of natural resources in Indonesia can be utilized as a small-scale power plant.

Hydroelectric power is one of the options in utilizing renewable energy sources, because the availability of water in Indonesia has the potential to be used as a renewable energy source. Then this type of power plant in the manufacturing process is very economical, because it is still on a small scale. This means that a generator like this is only able to meet the use of electrical energy for a number of homes. This type of hydroelectric power plant is often called micro-hydro or often also called pico-hydro depending on the output of electrical power generated. This technology consists of the main components, namely a water turbine and an electric generator.

A water turbine is an energy conversion machine that converts the kinetic energy and potential energy of water into electrical energy. In addition, MHP does not need to build large reservoirs such as hydropower and most of the existing MHP utilizes high water heads to produce electrical energy. Meanwhile, the river flow with low head has not been used optimally.

The type of turbine used in MHP has many types classified based on the height of the water falling into the turbine (head), one of which is the vortex turbine. This type of turbine utilizes the whirlpool that is obtained from the spiral basin shape of the turbine and then exits to the outlet which is located just below the basin.

Vortex turbine is utilizing an artificial whirlpool to rotate the turbine blades and then the energy of the whirlpool is converted into rotational energy on the shaft. The process is that water from the river is flowed through the inlet to the turbine tank which is circular in shape and in the center of the bottom of the tank there is a small circular exhaust channel. As a result of this exhaust channel, the water flows will form a whirlpool flow. The water level (head) required for this turbine is 0.7 – 2 m and the discharge is around 1000 lt/s. These turbines are simple, easy to maintain, small, powerful, and last up to 50 – 100 years [1].

Turbine is the most important part of a power plant. In the turbine the water flow is converted into kinetic energy which will rotate the rotor. With a belt, pulley or gearbox on the rotor connected to a generator that will convert the resulting rotation into electrical energy [2].

The moving part of the turbine is called the rotor or turbine blade, while the non-rotating part is called the stator or turbine housing. In general, a turbine is a mechanical device consisting of a shaft and blades. Fixed blades or stationary blades, do not rotate with the shaft, and function to direct fluid flow. While the rotary blade or rotary blade, changes the direction and speed of fluid flow so that a force arises that rotates the shaft. Water is usually considered as an incompressible fluid, that is, a fluid whose density virtually does not change with pressure [3].

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 driving vane has the highest power that occurs at a capacity of 8.1327077 L/s with a loading of 20 kg (23.96 W), and the highest efficiency occurs at a capacity of 5.65 lt/s with a loading of 15 kg (57. 26 %) [4].

Vortex is a major component in turbulent flow. In the absence of an external force, viscous friction in a fluid tends to create a flow into clusters called irrotational vortices. In such a vortex, the velocity of the fluid is greatest beside the imaginary axis, and the decrease in velocity is inversely proportional to the distance from the imaginary axis. The eddies are very high in the core region around the axis, and nearly zero at the ends of the eddies; while pressure drops sharply as it approaches the region. Once formed, the vortex can move, stretch, rotate, and interact in a complex manner. A moving vortex carries with it angular and linear momentum, energy, and mass in it. In a stationary vortex, the streamlines and pathlines are closed. In moving or expanding eddies, streamlines and pathlines usually move in a spiral [5].

Research Methods

The tools and materials used in this research are:

1. Sitting cutting grinder.
2. Electric welding
3. Acetylene welding
4. Drilling machine
5. Lathe
6. Work safety equipment.
7. Used oil drum.
8. Plate 0.8 mm turbine material.
9. Solid iron.
10. Hollow round iron.

11. Pulleys.
12. Bolt nut.
13. Bearings.

Test procedure

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 3-6 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 2-8 in 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 2-8 in point A of the first test.

Results and Discussion

The results of the study for the height of the vortex at each flow rate can be shown in Figure 1. Figure 1 shows the relationship between the flow rate and the height of the vortex (hv), the greater the flow rate, the more water will be in the drum, so that the volume of water increases and The whirlpool will also be higher so that it will affect the height of the vortex. The high and low hv will affect the water power and the performance of the turbine, for example it will slow down or speed up the turbine rotation, because part of the turbine body sinks and there is also a turbine that sinks as a whole as the flow rate increases.

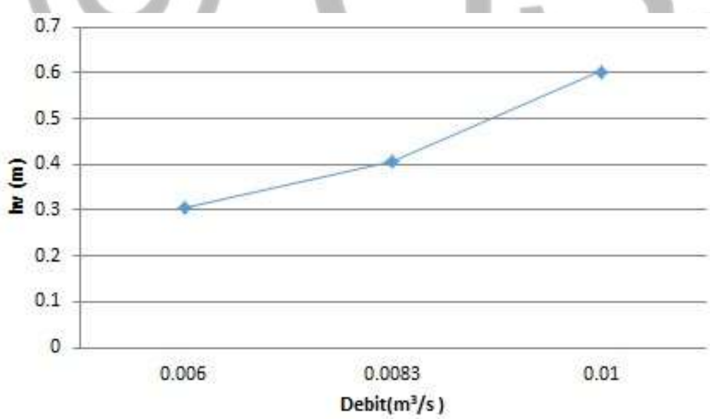

Figure 1. Relationship between discharge and vortex height (hv)

The results of measuring the rotation of the turbine shaft using a tachometer obtained rotation as shown in Figure 2. In Figure 2, the relationship between turbine rotation and flow rate is seen, for a flow rate of 0.006 m^3/s it can be seen that at an angle of attack of 45° it has the lowest value, which is around 46.4 rpm, then followed by an angle of attack of 30° with a rotation of 50.7 rpm, and the highest rotation at this discharge is an angle of attack of 90° which is 56.4 rpm. For a flow rate of 0.0083 m^3/s, it can be seen that the turbine with a blade angle of 30° has the lowest value of 48.4 rpm, then the angle of attack is 45° with a rotation of 55.5 rpm and the highest rotation is the turbine with an angle of attack of 90° at 63.1 rpm. At a flow rate of 0.010 m^3/s, it is seen that the turbine with an angle of attack of 45° has the lowest value of 46.4 rpm, then followed by an angle of attack of 30° with a rotation of 50.7 rpm and the highest rotation at an angle of attack of 90° which is 56.4 rpm. The increase in flow rate greatly affects the rotation of the turbine shaft, this is because if the flow rate is greater, the volume of water in the basin will experience an increase in volume so that the body of the turbine will sink in water and the difference in the size of the blade angle on the turbine will also affect the turbine rotation. where the greater the angle of the blade, the greater the impact of water on the turbine blades, but it is different from the angle of attack of 30° which is greater in value than the turbine with an angle of attack of 45° at a discharge of 0.006 m^3/s, this is due to the difference in height of the vortex at each The angle of attack of the turbine causes the area of water impact on the turbine blade to be greater, so that it will affect the turbine rotation whose value is greater than the turbine with an angle of attack of 45° at a discharge of 0.006 m^3/s, this is due to the difference in height of the vortex at each angle of attack of the turbine. causing the impact area of the ai r on the turbine blade is getting bigger, so it will affect the turbine rotation.

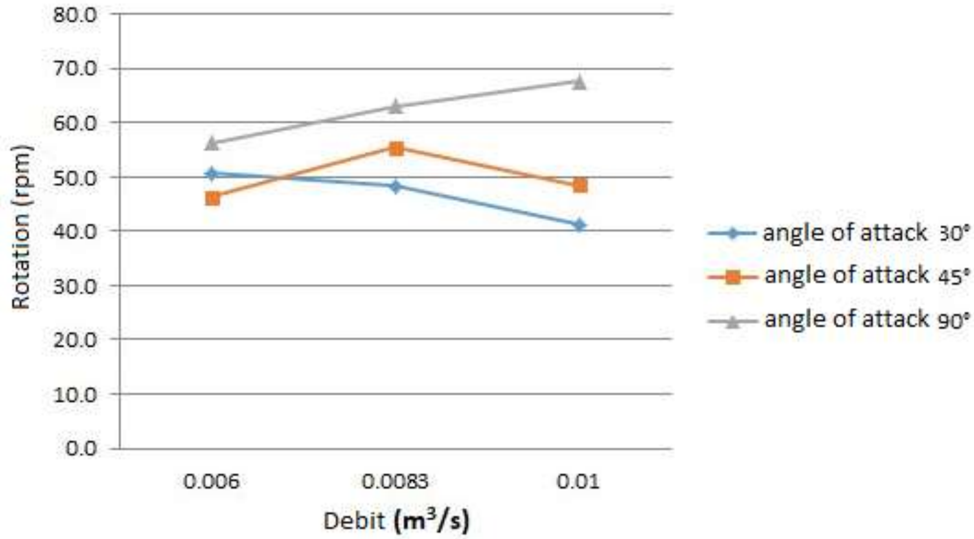

Figure 2. The relationship between turbine rotation and flow rate

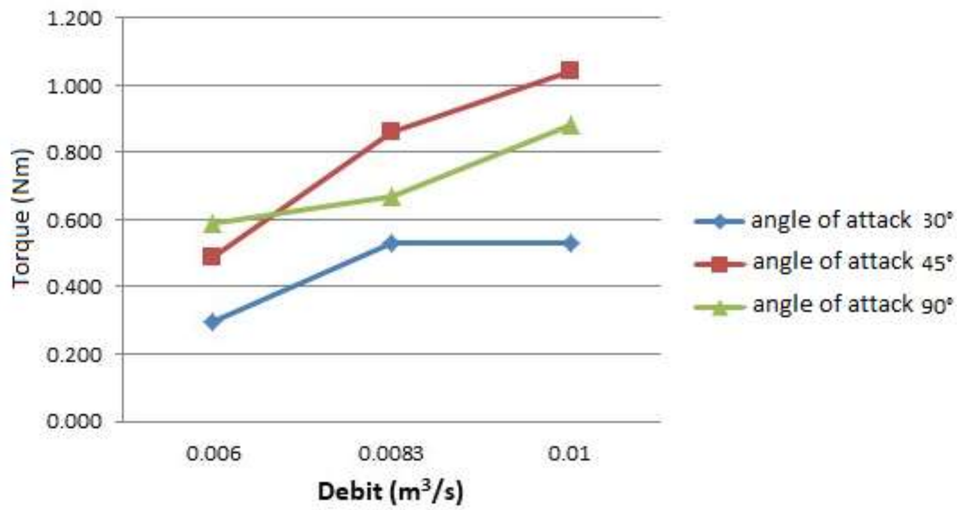

Figure 3. The relationship between Torque and flow rate.

In the picture of the relationship between torque and flow rate as shown in Figure 3, at a flow rate of 0.006 m^3/s, it can be seen that the angle of attack is 30° with the lowest torque value of 0.294 Nm, the angle of attack is 45° with the lowest tosi value of 0.490 Nm and angle of attack 90° which is equal to 0.589 Nm. This shows that the greater the angle of the blade, the higher the torque value. But this is not the case for the next discharge, at the flow rate of 0.0083 m^3/s, the lowest torque value is at an angle of attack of 30° of 0.530 Nm, an angle of attack of 90° which is 0.667 Nm and an angle of attack of 45° with a torque of 0.859 Nm.

Conclusion

The turbine rotation value at the variation of the angle of attack and flow rate on the vortex turbine obtained the highest rotation value, namely the turbine with a variation of the angle of attack of 90° at 0.01 m^3/s discharge of 67.70 rpm, and the smallest rotation value obtained by the turbine with a variation of the angle of attack 30° at discharge. 0.0083 m^3/s at 48.37 rpm. The torque value generated in this study was obtained that the highest value was found at an angle of attack of 45° at a discharge of 0.01 m^3/s with a torque value of 1,043 Nm, then the smallest torque value was found in a turbine with a variation of an angle of attack of 30° at a discharge of 0.006 m^3/s. with a torque value of 0.294 Nm.

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