The performance of numbers of blade towards picohydro propeller turbine

R Kurniawan*, D A Himawanto and P J Widodo

Mechanical Engineering Department, Faculty of Engineering, Sebelas Maret University, Surakarta 57126, Indonesia

*riski.i0414044@gmail.com

Abstract. The blade is one of the main component of a turbine that is very interesting to study. The number of blades greatly affect the performance of a turbine. This research was carried out by varying the number of turbine blades in the horizontal flow and additional bulb in the pipe that used to break the fluid flow and direct the turbine blade. Variations in the number of turbine blades start at 4, 5, 6, 7, 8, with a water discharge of 5.3 1/s, 7.3 1/s, 8.5 1/s, 9.6 1/s and 11.4 1/s. The best results obtained on variations of blade 6 and discharge 11.4 1/s resulted in electrical power of 23.92 Watt with the voltage of 76.3 Volts and the current strength of 0.31 A.

1. Introduction
Indonesia is a tropical country and has high rainfall. Rainwater can be an alternative energy source by means of water flowing in a ditch or pipe used as a source of driving a water turbine which then passed to the generator [1][2]. Water is an environmentally friendly renewable energy. Hydroelectric power plants are based on a simple concept, namely water that moves to the turbine, the turbine rotates the generator, the generator converts mechanical energy into electrical energy [3].

The Picohydro system is one of the renewable energy sources that can provide great benefits for the community in meeting electricity without having to spend high costs so that it can be used for household purposes[4]. Compared to air, water has greater density and momentum so that the resulting power output is greater [5].

High rainfall can be used as a new renewable energy source, which is a small-scale hydroelectric power plant (picohydro). Picohydro is a small-scale power plant that is powered by hydropower using head and water discharge, the maximum power produced is 5 kW [6]. Where rainwater is collected in a tank at a certain height as a head. Water is then flowed into a pipe to the turbine that will drive the generator [7].

2. Research method
This experiment was carried out on horizontal flow with a 2 meter head using piping installation system [8]. Additional bulb components before the turbine aims to break the fluid flow so that the water is right on the turbine blade. Variations in the number of blades used are 4, 5, 6, 7, 8 and water discharge 5.3 1/s, 7.3 1/s, 8.5 1/s, 9.6 1/s, 11.4 1/s. This test aims to find the electric power of the generator. Data retrieval is done 3 times to get a valid result. Figure 1 shows the research test equipment.

The additional component of the bulb before the turbine aims to break the flow of water, so that the water is right on the turbine blade [9]. The placement of the bulb on the piping system can be seen in
Figure 3. This research was conducted by varying the number of blades 4, 5, 6, 7, and 8 at a slope of 30° [10] with variations in valve openings the pipe. Figure 2 is a variation in the number of blades with a slope of 30°.

Figure 1. Research test equipment

Figure 2. Six blades with a slope of 30°

Figure 3. Placement of the bulb on the piping system

3. Result and discussion

3.1. Hydrostatic power

Water power is the ability of a water to rotate a turbine with a certain discharge. Water power is a function of water discharge \((Q = \text{m/s})\), gravitational field \((g = 9.81 \text{ m/s})\), water density \((\rho = 997.01 \text{ kg/m}^3)\), and height of water-fall \((h = 2 \text{ meters})\) from the upper reservoir to the turbine shaft. Water power can be calculated using the equation formula as follows:

\[
P_{\text{water}} = Q \rho g h
\]

The results of the calculation of water power can be seen in Figure 4.

Figure 4. results of water power testing
Figure 4 shows the graphical relationship between water power and water discharge. The best results were obtained at discharge of 11.4 l/s with water power of 222.95 Watts and the lowest yield was obtained at water discharge of 5.3 Fs with water power of 104.36 Watt. These results indicate that water power is directly proportional to the flow rate of water, because along with the increase in water debit, the power produced by water also increases. The value of water power is affected several factors such as water discharge, gravitational acceleration, water density, and height of water-fall. The parameters of this study assumes that the value other than water discharge is considered the same, namely the gravitational potential energy of 9.81 m/s, water density of 997.01 kg/m, and height of water-fall of 2 meters.

3.2 Electrical Power

Electrical power testing is done by calculating the multiplication results between the voltage and current generated by the generator, where \( P_{\text{out}} = V \times I \). \( V \) is the generator’s electrical voltage and \( I \) is the generator's electric current. The best generator output is at a discharge of 11.4 l/s with electric voltage of 76.3 V and electric current of 0.313 A, while the lowest yield is at a debit of 5.3 Fs with electric voltage of 12.3 V and electric current of 0.03 A. Figures 5 and 6 show the same characteristics, when the water discharge increased the voltage and current produced will increase, so it can be concluded that the voltage and current strength are directly proportional to the water discharge. The increase of voltage and current in the generator cause by potential energy of the water increase, so that the axial force on the turbine also increase and causes the generator shaft rotation speed to increase.

![Figure 5](image_url)

**Figure 5.** (a) The relationship between (a) electric voltage and water discharge and (b) electric current and water discharge

The working principle of the generator is to convert mechanical energy into electrical energy, when the rotor rotates to the stator it will emerge an electromagnetic field and will be converted into electrical energy by the coil in the stator. The amount of electrical power depends on the magnitude of the electromagnetic field produced by rotation of the rotor on generator.

Figure 6 (a) and (b) show the results of testing the voltage and electric current produced by the generator. The maximum point of electrical voltage generated by the generator is the variation of the number of blades 6 with 11.4 l/s producing an electric voltage of 76.3 V and an electric current of 0.313 A, while
the minimum point is in the variation of blade number 8 with a discharge of 5.3 l/s produces an electrical voltage of 12.34 V and an electric current of 0.03 A. Electrical power is calculated using the equation Equation 2. Figure 7 shows a graph of the results of testing the electrical power to the number of blades.

![Figure 6](image1.png)

**Figure 6.** (a) The relationship between (a) electric voltage and variations in number of blades, and (b) electric current and variations in number of blades

Testing the generator output to variations of the number of blade can be seen in Figure 7. The test results in Figure 7 shows that the best result produced by the generator are on blade 6 with a discharge of 11.4 l/s resulting in electrical power of 23.9 W, while the minimum results are in the variation of the number of blade 8 with a debit of 5.3 l/s produces electrical power of 0.46 W. Seen in Figure 7, by all discharge variations given shows the number of blade 4 increased to the maximum point on blade 6, and from blade 6 has decreased to the minimum point to blade 8. The increase of electrical power is due to the narrowing between the 4, 5 and 6 blades, causes the pressure of the flowing water to increase, if the pressure of the flowing water bumps into the blade, the axial force produced by the turbine will also increase. In contrast to the 7 and 8 blades which experience a decrease due to the narrowing between the blades which causes water to flow through the gap between blades to become obstructed and cause the work produced by the turbine to decrease. Decreased turbine work will result in reduced rotational speed of the shaft on the generator, if the generator shaft rotation is relatively slow then the magnetic field produced by the coil in the generator is also relatively small so that the electrical power produced by the generator is also small.

![Figure 7](image2.png)

**Figure 7.** Relationship between electrical power and variations in number of blades
4. Conclusion

Based on the results of the testing and analysis that has been carried out, it can be concluded that the number of blades greatly affects the electrical power produced by the generator. The number of blades and gaps between blades on the turbine affects the axial force received by the turbine. The best results obtained from variations in the number of blades are blade 6 with a water discharge of 11.4 l/s resulting in an electric power of 23.9 Watt with an electric voltage of 76.3 Volts and an electric current of 0.313 Ampere.

5. References

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