Experimental Performance of Turbine Reaction Flow Type Straight with Blade Ratio Variation

Priyo Heru Adiwibowo, A Grummy Wailanduw

Abstract: ***One of the forms of energy that can be harnessed is the energy potential of water, and use the turbine vortex is very useful to maximize the potential. The purpose of this study is to determine the power and efficiency resulting from the broad optimum of the turbine blade reaction flow vortex type of the blade cross-section is straight. This research uses experimental methods, namely by making the turbine vortex type blade section straight that has an area with blade ratio (BR) 0.90, 0.95 and 1. Load variation that is used the increase of 5000 grams to a round shaft on the turbine stops. Testing will be done to get the power and efficiency of the vortex flow. The highest power generated by the turbine with blade ratio 0.90, which occurs on the capacity of 12,341 L/s with a loading 40000 grams, has a power of 44,44 watts. The highest efficiency is produced by the turbine with a blade ratio 0.90 which occurs on the capacity of the 10,803 L/s with a loading 45000 grams, has an efficiency of 53,82 %.***

Keywords : blade ratio, vortex turbine, straight-Sided Blades

I. INTRODUCTION

At present, electrical energy is one of the most needed sources of energy for human life, both in the household, public and industrial sectors. At this time the energy that is still used in Indonesia still comes from fossil energy, namely oil and gas. Provision of electricity is already one of the obligations that must be met in each region for the economy to run. Based on data from the Director General of Renewable Energy and Energy Conservation of Energy and Mineral Resources, in 2011 Indonesia had the potential of Renewable Energy (EBT) of more than 158.288 MW. Hydropower is a type of renewable energy that has the greatest potential compared to other renewable energy sources. The potential of hydropower in Indonesia reaches 75.861 MW including the potential of mini / micro hydro resources. The total potential of New Renewable Energy is not entirely used as electricity generation, only about 6.8% of the total energy used by Indonesia.

The type of turbine used in PLTMH has many types classified based on the height of water falling into the turbine (head), one of which is the vortex turbine. Researcher from Germany Viktor Schauberger (1936) researched on a whirlpool-based water turbine (vortex). This type of turbine utilizes a whirlpool obtained from the spiral basin form of the turbine and then exits to an outlet located just below the basin. This vortex turbine attracts the attention of an Austrian researcher, Franz Zotlöterer (2007), in his patent he stated that a vortex turbine can be used with the lowest water fall height of 0.7m. In his research the theoretical energy that can be converted has an efficiency of 80% and in an actual state an efficiency of 73% is obtained. At present, electrical energy is one of the most needed sources of energy for human life, both in the household, public and industrial sectors.

Research has also been carried out by Widiyatmoko (2012) entitled "Effect of Variations in the Number of Blades Against Electric Output on Vortex Turbines", research was conducted to determine the effect of the number of vortex turbine blades on total efficiency. The results obtained the highest efficiency of 6.02% in the number of blades 8 and 1.85 watts of power with a mechanical power verification of 3.44 watts.To increase the efficiency of the water turbine, a guide vane must be installed. This steering blade serves to direct the flow of water toward the turbine, so that the flow of water that hits the turbine can increase the turbine rotation and can increase turbine efficiency. In the application of the Francis turbine and Banki turbines the driver blade has been installed, but in the vortex turbine the driver blade has not been installed. Research conducted by Andrian Maidangkay (2014) entitled "Effect of Flow Direction Angle and Number of Single Wheel Hinged Radius Blades on Kinetic Turbine Performance" showed the results with 35 ° directional blade angle is the most optimal angle with the highest efficiency at the number of 12 blades ie 33.241%. The power and torque produced are 21.365 Watt and 3.864 Nm.

Research on guide vane has also been carried out by Moch. Asief Rosyidin, from this study it was found that the change in guide vane at different heads affected the performance of the cross flow air turbine. The largest WHP of 25.0957 kWatt and the highest BHP of 7,7679 kWatt were obtained at 80% guide vane opening, head height of 13.75 m with a discharge of 0.2880 m3 / s. The greatest efficiency is found in the opening of the 80% guide vane, head height of 13.55 m with a discharge of 0.2759 m3 / s, which is 31.42%. In this study shows that each opening angle of the directional blade has certain characteristics

With this research, it is expected that the most optimal inlet notch angle in a vortex turbine can be used as a reference in future studies.

II. MATERIALS AND METHODS

All materials and methods that have been used in the work must be stated clearly and subtitles should be used when necessary.

A. *Research variable*

The independent variable is the variable that influences or

Revised Manuscript Received on January 10, 2020.

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is the cause of the change or the appearance of the dependent variable. In this study, the independent variable is blade ratio using 0.90, 0.95 and 1.

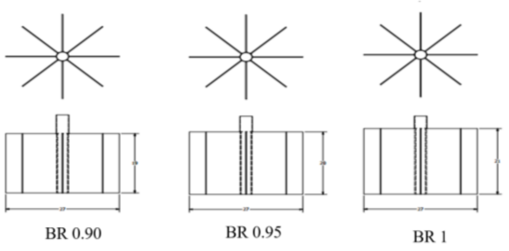

Figure 1. Variation of blade ratio

The dependent variable is the variable that is affected or which is due, because of the independent variables. In this study the dependent variable is the power and efficiency produced in each variation of the steering blade.

Control variable is a control variable that is a variable that is controlled or made constant so that the influence of the independent variable on the dependent is not influenced by external factors not examined. In this study has several control variables, namely:

Basin diameter used 56 cm.

Basin height used is 70cm.

Steering blade material is made of iron plate (2mm).

The turbine used is a vortex turbine with a number of 8 blades and a diameter of 21 cm.

The turbine used uses type straight turbine.The diameter of the outlet basin is 9 cm.The load variations used are 5000g, 10000g, 15000g, 20000g, until stop.

The capacity used is 9.414 l/s , 10.803 l/s and 12,341 l/s.

III. RESULTS AND DISCUSSION

A. *Result*

Data retrieval is carried out three times, which is then taken the average value of the three data. The variation of blade ratio using 0.90, 0.95 and 1.with loading of 5000g, 10000g, 15000g, 20000g, 25000g, 30000g, 35000g, 40000g and the addition is made 1000g before the turbine stops. This is done so that the data obtained is really valid. The values obtained from the test are shaft rotation, balance sheet value, and vortex height which are then processed to get the flowing water power, torque, turbine power, and efficiency. To obtain the above data, several calculations are needed, namely,

- Calculation of Water Capacity

Measurement of water capacity using the following equation:

$$Q = Cd.\frac{8}{15}.\sqrt{2g}.tg\frac{\theta}{2}.H^{\frac{5}{2}}$$

- Flowing Water (Pa)

Theoretical water power can be calculated using the following equation:

- Torque (T)

Torque can be calculated using equations

$$T = F.r$$

- Angular Speed (ω)

Turbine rotation speed is calculated using the equation:

$$\omega = \frac{2\pi n}{60}$$

- Turbine Power (Pt)

Turbine power is calculated by the following equation:

$$Pt = T.\omega$$

- Turbine Efficiency (ηt)

Efficiency can be calculated by the following equation:

$$\eta = \frac{Pt}{Pa} x\ 100\%$$

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B. *Discussion*

a. The Effect of Blade ratio Variations on Power in Each Capacity

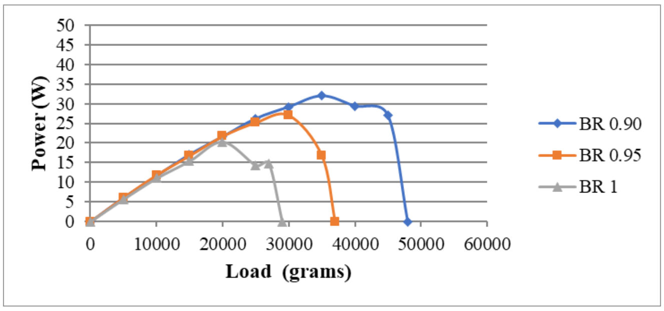

Figure 2. Effect of Blade ratio Variations on the Capacity 9.414 L/s on the Power Generated

Based on Figure 2 with the addition of the capacity of the surface area of the blade that is hit by the water becomes more so it is very influential on the resistance to the loading and the value of the power generated. From the graphic results obtained by a turbine with blade ratio of 0.90 to get the results of power continues to increase until the loading of 35000 grams by getting power results of 31,968 watts and decreased in power value until the turbine stops at 48000 grams of loading. At a blade ratio of 0.95 the value of the power generated continues to increase until the loading of 30000 grams to get the power output of 27.049 watts and experience a decrease in power until the turbine stops at 37.000 grams loading. At blade ratio of 1the value of the power generated continues to increase until the loading of 20000 grams by getting the power output of 20.331 watts and has decreased power until the turbine stops at 29,000 grams of loading. From the results of these graphs and tables it can be concluded that the turbine at blade ratio of 0.95with a capacity of 9.413 L / s at a loading of 35000 grams has the highest power value of 31,968 watts. This happens because with increasing capacity, the surface area of the blade that is hit by the water becomes more, therefore the turbine is more resistant to high loading so that the power generated is greater.

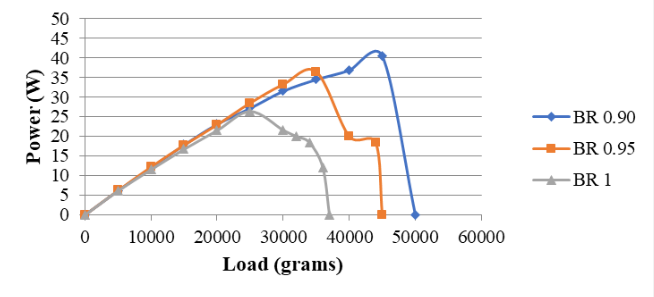

Figure 3. Effect of Blade ratio Variations on the Capacity 10.803 L/s on the Power Generated

Based on Figure 3, capacity addition is very influential on the resistance to the loading and the value of the power generated. At this capacity, the variation made on the turbine blade height tends to increase in the value of the power even though the condition is given a few moments when the load is not completely submerged. From the graphic results obtained by a turbine with blade ratio of 0.95, the power results continue to increase until the loading of 45000 grams by getting a power output of 40.50 watts and a decrease in power value until the turbine stops at 50000 grams loading. At a blade ratio of 0.95 the value of the power generated continues to increase until the loading of 35,000 grams by getting the power output of 36,431 watts and experiencing a decrease in power until the turbine stops at 45,000 grams of loading. At a turbine blade height of 21 cm, the value of the power generated continues to increase until the loading of 25000 grams by getting a power yield of 26,363 watts and has decreased power until the turbine stops at 37,000 grams loading. From the results of these graphs and tables it can be concluded that the turbine at blade ratio of 0.95with a capacity of 10.803 L / s at a loading of 45000 grams has the highest power value of 40.50 watts. This happens because increasing the capacity makes the turbine more resistant to high loading, so the power generated is greater.

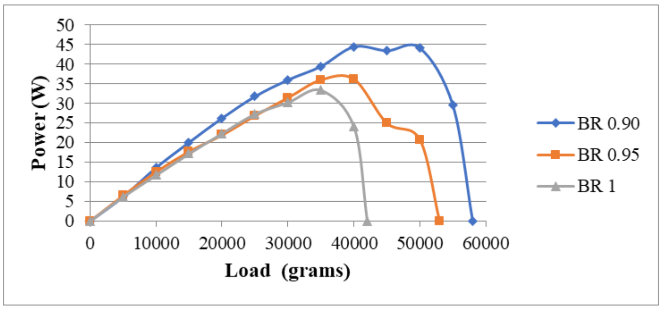

Figure 4. Effect of Blade ratio Variations on the Capacity 12.341 L/s on the Power Generated

Based on Figure 4 the addition of capacity is very influential on the resistance to the load and the value of the power generated. At this capacity, the variation made on the turbine blade height tends to increase in the value of the power even though the condition is given a few moments when the load is not completely submerged. From the graphic results obtained by a turbine with blade ratio of 0.90, the power results continue to increase until the loading of 40000 grams by getting a power output of 44.444 watts and a decrease in the value of power until the turbine stops at 58,000 grams. In blade ratio of 0.95, the value of the power generated continues to increase until the loading of 40000 grams by getting the power output of 36.203 watts and experiencing a decrease in power until the turbine stops at 53000 grams loading. At a turbine blade height of 21 cm, the value of the power generated continues to increase until the loading of 35,000 grams by getting the power output of 33.421 watts and decreases in power until the turbine stops at 42,000 grams of load. From the results of these graphs and tables it can be concluded that the turbine at blade ratio of 0.90 with a capacity of 12,341 L / s at 40000 grams loading has the highest power value of 44,441 watts. This happens because increasing the capacity makes the turbine more resistant to high loading, so the power generated is greater.

b. The Effect of Blade ratio Variations on Efficiency in Each Capacity

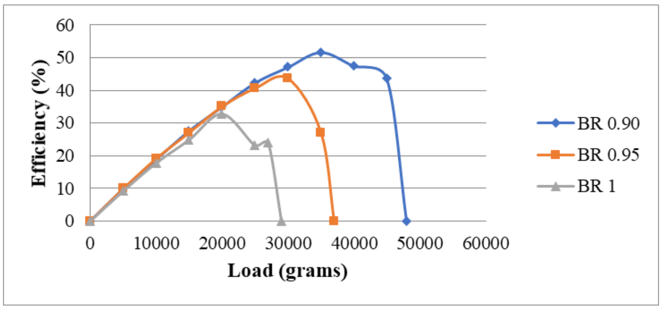

Figure 5. Effect of Blade ratio Variations on the Capacity 9.309 L/s on the Generated Efficiency

Based on Figure 5 capacity addition is very influential on the load resistance and the resulting efficiency value. At a capacity of 9.414 L / s, variations in the turbine blade height tend to increase in efficiency even though the condition of some turbines when given loading is not completely submerged. From the graph the turbine with blade ratio of 0.90, the resulting efficiency value continues to increase until the loading of 35000 grams with the resulting efficiency of 51.665% and decreases the efficiency value until the turbine stops at 48000 grams loading. In blade ratio of 0.95, the resulting efficiency value continues to increase until the loading of 30000 grams with the resulting efficiency of 43.715% and decreases the value of efficiency until the turbine stops at 37000 grams loading. In turbines with blade ratio of 1, the resulting efficiency value continues to increase until the loading of 20000 grams with the resulting efficiency of 32.859% and decreases in efficiency until the turbine stops at 29,000 grams. From the results of these graphs and tables it can be concluded that the turbine with blade ratio of 0.90with a capacity of 9.413 L / s at the loading of 35000 grams has the highest efficiency value of 51.665%. This happens because with increasing capacity, the surface area of the blade that is hit by the water becomes more.

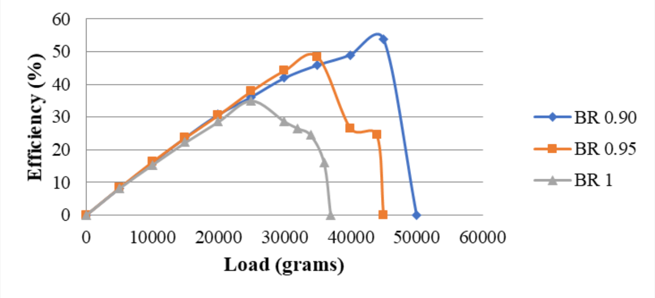

Figure 6. Effect of Blade ratio Variations on the Capacity 11.042 L/s on the Generated Efficiency

Based on Figure 6, the additional capacity is very influential on the load resistance and the resulting efficiency value. At a capacity of 10,803 L / s, variations in the turbine blade height tend to increase in efficiency. With increasing capacity, the surface area of the blade that is hit by the water becomes more so that the turbine is more resistant to high loading and the resulting greater efficiency value. From the graph the turbine with blade ratio of 0.90, the resulting efficiency value continues to increase until the loading of 45000 grams with the resulting efficiency of 53.823% and decreases in the value of efficiency until the turbine stops at the loading of 50000 grams. In blade ratio of 0.95, the resulting efficiency value continues to increase until the loading of 35000 grams with the resulting efficiency of 48.416% and decreases in the value of efficiency until the turbine stops at 45,000 grams loading. In turbines with blade ratio of 1, the resulting efficiency value continues to increase until the loading of 25000 grams with the resulting efficiency of 35.035% and decreases in the value of efficiency until the turbine stops at 37000 grams loading. From the results of these graphs and tables it can be concluded that the turbine with blade ratio of 0.90 with a capacity of 10.803 L / s at a loading of 45000 grams has the highest efficiency value of 53.823%

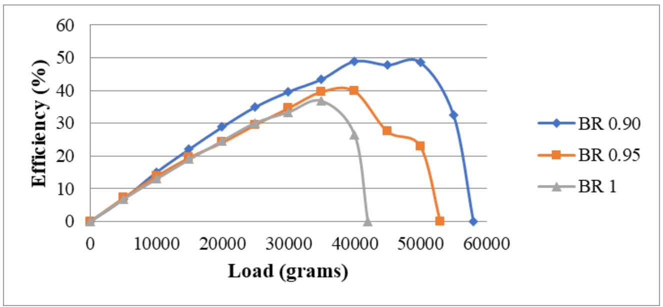

Figure 7. Effect of Blade ratio Variations on the Capacity 13.443 L/s on the Generated Efficiency

Based on Figure 7, capacity addition is very influential on the load resistance and the resulting efficiency value. At a capacity of 12,341 L / s the variation made to the height of the turbine blade tends to decrease in the value of efficiency, although with increasing capacity the surface area of the blade affected by the water hit will be more but not all the additional capacity and loading get a higher value of the resulting efficiency. From the graph the turbine with blade ratio of 0.90, the resulting efficiency value continues to increase until the loading of 40000 grams with the resulting efficiency of 48.944% and decreases the efficiency value until the turbine stops at 58000 grams loading. In blade ratio of 0.95, the resulting efficiency value continues to increase until the loading of 40000 grams with the resulting efficiency of 39.872% and decreases in the value of efficiency until the turbine stops at 53000 grams loading. In turbines with blade ratio of 1, the resulting efficiency value continues to increase until the loading of 35000 grams with the resulting efficiency of 36.808% and decreases in the value of efficiency until the turbine stops at 42000 grams loading. From the results of these graphs and tables it can be concluded that the turbine with blade ratio of 0.90 with a capacity of 12,341 L / s at 40000 grams loading has the highest efficiency value of 48,944%. The more surface area of submerged turbine blade has more influence on the value of efficiency resulting from turbine conditions that are resistant to loading, even though the turbine is completely submerged.

IV. CONCLUSION

- A conclusion section is not required. Although a conclusion may review the main points of the paper, do not replicate the abstract as the conclusion. A conclusion might elaborate on the importance of the work or suggest applications and extensions. The highest power is in the turbine with blade ratio of 0.90 with a capacity of 12,341 L / s with a power rating of 44,441 watts at 40000 gram loading, followed by a turbine with blade ratio of 0.95 with a capacity of 12,341 L / s with a value of 36,203 watts at 40000 grams, and the lowest is found in turbines with blade ratio of 1 with a capacity of 12,341 L / s with a power value of 33.421 watts at a loading of 35000 grams.
- The highest efficiency was found in turbines with blade ratio of 0.90 with a capacity of 10.803 L / s with an efficiency value of 53.823% at a loading of 45000 grams, followed by turbines with blade ratio of 0.95 with a capacity of 10.803 L / s with an efficiency value of 48.416% at a loading of 35000 grams, and the lowest is found in turbines with blade ratio of 1 with a capacity of 10.803 L / s with an efficiency value of 35.035% at a loading of 25000 grams.

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