Performance Test of Pelton Micro-Hydro Turbine with the Variations of Parameter to Produce the Maximum Output Power

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Abstract. The objectives of this performance test were to determine the angle of nozzle output, the number of a turbine blade and the optimum water discharge to produce the maximum output power from the rotation of Pelton micro-hydro turbine. The performance test was done by using the prototype of Pelton micro-hydro turbine which will later be applied in Sungai Medang Village, Air Hangat Timur district, Kerinci. The waterfall itself has a height of 10 meters with an average water flow discharge of 46.745 m³/s. The performance test itself was carried out with a water flow discharge variation of 20, 25, 30, and 35 litre/minute, with the output nozzle angle of 50°, 55°, 60° and 65°, with the turbine blade numbers of 4, 8, 12 and 16. Based on the performance test, the maximum output power produced was 15.89 Watt when the turbine rotation was 691.3 rpm, the water flow discharge of 35 litre/minute and the number of turbine blades was 16 with the nozzle output angle of 50°.

1. Introduction

In this advanced technology era, many technical tools are developed to meet human needs. However, technology development depends on energy needs. The energy that we use for technology development is very limited and expensive, especially electricity. Electricity is the main energy required by a human to carry out daily activities. Because of that lack of electricity will cause the energy crisis that hit the world, especially in Indonesia. Thus, it attracted many experts to find new energy resources that are cheaper and more efficient. From the studies that have been carried out by experts, it can be concluded that one of the energy sources that can meet the expectations above is hydro energy. Indonesia is known as a rich country for its natural resources such as fossil and non-fossil energy [1-3]. In this case, non-fossil energy is possible to be developed especially geothermal, wind, solar, hydro and micro-hydro energy. Furthermore Indonesia is listed as a rich country in micro-hydro energy sources. Based on the name itself, micro-hydro energy sources are energy sources that utilize hydro energy on a smaller scale. Because of the overall description above, it shows that micro-hydro energy is very suitable in Indonesia. The potential of micro-hydro itself is big, but it has not been used optimally. Therefore, the development of micro-hydro energy is required to produce
electricity optimally and meet the expectation to solve the energy crisis in Indonesia, especially for rural and remote areas [4]-[7].

2. Research Methodology
The method used in this performance test was to experiment in laboratories by using flow discharge variations of 20, 25, 30 and 35 Litre/minute, nozzle output angle of 50°, 55°, 60°, and 65°, and the turbine blades number of 4, 8, 12, and 16 to produce the turbine rotation and maximum output power [8]-[10].

This research was carried out by using a Pelton micro-hydro turbine that has a digital reading and measurement system of rotation, current, and power. For the measurement of water flow discharge, flow meter was used. In this study, the prototype design of Pelton turbine was made based on the principle of micro-hydro turbine [3] where the flow of water was assisted by a pump that produced a powerful flow like a river or a waterfall. Then by using a valve, the flow rate of the water that went to the turbine can be adjusted to fit the desired value by reading on the flow meter, based on the variations of water flow discharge. Furthermore, the number of nozzles used was one only to focus the flow so that it was easier to hit the turbine blades from various sides. The angle of nozzle output was also varied so that there were various variations to get the optimum conditions. This Pelton turbine used continues cycle where the water that hit the turbine was flowing back to the storage tank so that it could be pumped back through the nozzle. In general, this turbine was divided into four parts such as container, pump, nozzle and the turbine blades. A 40 x 60 cm container was installed at the bottom so that water easily circulated which later pumped back to the turbine blades through the nozzle. The pump used is a centrifugal pimp with an input power of 125 Watts [10-12]. The nozzle was used with a diameter of 6 mm. The Pelton turbine blades used had a total of 16 blades, a rotor diameter of 20 cm that made by using a mixture of tin and nickel metal. It was expected to have a lighter weight to reduce the required force to rotate the turbine blades. The generator used was a 12 Volt DC generator, a current of 9 Ampere and an inverter of 1,000 Watt [13-14]. The overall design of the Pelton micro-hydro turbine is shown in figure 1.

![Pelton turbine prototype](image)

**Notes:**

1. Frame  
2. Base  
3. Control Panel  
4. Suction Pump  
5. Coupling  
6. Exhaust pipe  
7. Coupling belt  
8. Blades  
9. Shaft  
10. Impeller  
11. Shaft bolt  
12. Pump  
13. Inverter  
14. Power supply  
15. Lamp  
16. Switch  
17. Lamp  
18. Water discharge pipe  
19. Elbow  
20. Penstock  
21. Storage tank

**Figure 1.** Pelton turbine prototype.
3. Result and discussion

3.1. Test result from the effect of water flow discharge and nozzle output angle on turbine rotation

Based on the experiment, it is seen that the highest rotation that produced was 446.2 rpm at the water flow discharge of 35 Litre/minute and nozzle output angle of 65°. The lowest was 201 rpm at a water discharge of 20 Litre/minute and nozzle output angle of 65°. The overall result of the experiment shown in table 1 and figure 3.

Table 1. Test result from the effect of water flow discharge and nozzle output angle on turbine rotation.

| Water Flow Discharge Liter/minute | Output Angle |
|----------------------------------|--------------|
|                                  | 50°          | 55°          | 60°          | 65°          |
| 20                               | 310          | 300          | 231          | 201          |
| 25                               | 431.1        | 400.6        | 272.2        | 231.1        |
| 30                               | 445.2        | 411.6        | 372.2        | 283.3        |
| 35                               | 446.2        | 412.7        | 375.3        | 293.3        |
3.2. Test result from the effect of blade number and water flow discharge on turbine rotation

After obtaining the optimum nozzle output angle, the test was continued by testing the effect of blade number and the water flow discharge on the turbine rotation. The test was carried out with blade number variations of 4, 8, 12, and 16, water flow discharge of 20, 25, 30, and 35 Litre/minute with the nozzle output angle of 50°. The maximum turbine rotation was 460.2 rpm when the water flow discharge was 35 Litre/minute with the blade number of 16. The lowest turbine rotation was 201 rpm when the water flow discharge was 20 Litre/minute with blade number of 4. The overall results of the effect of blade number and water flow discharge on turbine rotation are shown in table 2 and figure 4.

Table 2. The effect of blade number and water flow discharge on the turbine rotation (rpm).

| Number of Blades | Water Flow Discharge |
|------------------|----------------------|
|                  | 20 Liter/minute | 25 Liter/minute | 30 Liter/minute | 35 Liter/minute |
| 4                | 201            | 231.20          | 283.30          | 293.30          |
| 8                | 231            | 272.20          | 372.20          | 375.30          |
| 12               | 300            | 400.60          | 408.60          | 412.70          |
| 16               | 310            | 431.10          | 445.20          | 460.20          |

Figure 3. The effect of water flow discharge variation and output angle variation on turbine rotation with the blade number of 16 chart.
3.3. Result of Testing the Effect of Blade Number and Water Flow Discharge on The Output Power Produced

After obtaining the optimum data of nozzle output angle, a number of blades and water flow discharge to get the optimum turbine rotation, the test continued with testing the effect of blade number and water flow discharge on the output power produced by the Pelton turbine. The test was carried out with the blade number variations of 4, 8, 12, and 16, water flow discharge of 20, 25, 30, and 35 Litre/minute with the nozzle output angle of 50°. The maximum output power produced was 15.89 Watt when turbine rotation was 460.2 rpm, the water flow discharge of 35 Litre/minute with the blade number of 16. The lowest output power produced was 7.28 Watt when the turbine rotation was 201 rpm, the water flow discharge of 20 Litre/minute with the blade number of 4. The overall results of the effect of blade number and water flow discharge on the output power produced are shown in table 3 and figure 5.

Table 3. The effect of blade number and water flow discharge on the output power produced.

| Number of Blades | 20 L/minute | 25 L/minute | 30 L/minute | 35 L/minute |
|------------------|-------------|-------------|-------------|-------------|
| 4                | 7.28        | 11.64       | 11.52       | 14.00       |
| 8                | 11.7        | 11.7        | 11.76       | 14.56       |
| 12               | 11.7        | 14.0        | 14.0        | 14.79       |
| 16               | 11.79       | 15.4        | 15.4        | 15.89       |
4. Conclusion
From the results of the Pelton micro-hydro turbine performance test with a variation of nozzle output angle, the number of blades and water flow discharge, it can be concluded that.
- The optimum nozzle output angle to obtain the maximum rotation during the performance test was 50°.
- The maximum water flows discharge during the performance test was 35 Liter/minute.
- The optimum number of blades to obtain the maximum rotation was 16.
- The maximum turbine rotation obtained during the performance test was 460.2 rpm when the nozzle output angle of 50°, water flow discharge of 35 Liter/minute and blade number of 16.
- The maximum output power produced when the turbine rotated at its maximum rotation speed was 15.89 Watt.
- The lower turbine rotation obtained during the performance test was 201 rpm when the water flows discharge of 20 Liter/minute and blade number of 4.
- The lowest output power produced was 7.28 Watt when the turbine rotated at the rotation speed of 201 rpm.

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