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The Effect of Brake Load on The Performance of A Cross Flow Turbine With 24 Blades

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ABSTRACT: *The research aims to determine the effect of mass loading on the performance of a Crossflow turbine with 24 blades. The methods used in this research are literature studies and experimental studies. The turbine blades used in this research use 24 blades providing loading starting from the lowest load point to the maximum, namely 1 to 9 kg. The water flow that flows to the turbine is constant, namely 1 m3 / minute. The results of this research show that as the load on the turbine increases, the average turbine rotation decreases by 14.24%. Meanwhile, turbine torque experienced an average increase of 24.53%. Turbine efficiency increased by an average of 22.41% at a loading of 1 to 5 kg, while at a loading of 5 to 9 kg the efficiency decreased by an average of 7.66%.*

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I. INTRODUCTION

Indonesia is an archipelagic country with many areas that are still remote and there is no electric lighting that is accessible from the State Power Plant. Even though electricity or lighting is really needed by the area so that the area is not left behind in obtaining information aimed at advancing the area and increasing the productivity of its people. The need for electric lighting for remote areas requires the creation of devices that can reach remote places that are cheap and environmentally friendly, namely new, renewable energy.

A hydroelectric power plant is a system that uses potential energy from water on a small or large scale. One of the main hydroelectric power plants is a water turbine. The type of water turbine used in Crossflow turbine research where this turbine is part of the impulse turbine type is used in the low and low flow ranges.

A micro hydro power plant is a type of power plant that utilizes water energy to drive a turbine. The kinetic energy of water is converted or transmitted into mechanical energy in the turbine, because the water rotates the turbine blades. The mechanical energy produced is then converted into electrical energy through a generator. Using the Cross-Flow Turbine type is more profitable than using water wheels or other types of micro hydro turbines. Using this turbine for the same power can save the cost of making a prime mover (runner) by up to 50% compared to using a water wheel with the same material. Likewise, the average usability or efficiency of this turbine is higher than the usability of a water wheel. The results of laboratory tests carried out by the West German Ossberger turbine factory concluded that the efficiency of even the most superior type of water wheel only reached 70%, while the efficiency of the Cross-Flow turbine reached 82%. The high efficiency of the Cross-Flow Turbine is due to the utilization of water energy in this turbine twice, the first is the impact energy of water on the blades when the water starts to enter, and the second is the thrust of the water on the blades when the water leaves the runner. [1]

The effect of the number of blades on the performance of the crossflow turbine using variations in discharge of 0.49 l/s and 0.53 l/s and variations in the number of blades of 15 and 30. The test results show that the torque obtained is directly proportional to the increase in discharge, rotation and number of blades, thus affecting the torque value and turbine power produced. In the discharge condition of 0.49 l/s the greatest power for 30 blades is at 89.3 rpm with a turbine power of 0.0037. The lowest power is at 32 rpm, namely 0.0018 with the number of blades 15. Meanwhile, in the condition of 0.53 l/s the greatest power is at 98.4 rpm with power. amounting to 0.0051, the number of blades is 30 and the lowest rotation power is 40.4 rpm with a power of 0.0025, the discharge is 0.53 l/s, the number of blades is 15. [2]

The development of undershot type kinetic turbines using experimental and numerical methods has been carried out, including testing turbines with inlet speeds of 1 m/s, 3 m/s, and 5 m/s and variations in the number of blades of 6, 7, 8, 9, and 10 The number of blades of 8 blades with a diameter of 0.984 m is most efficient with an inlet speed of 1 m/s [3]. In the experimental test using two turbines simultaneously with a number of blades of 12 dimensions, blade length 600 mm and blade width 100 mm with a turbine diameter of 499 mm in river flow with an average speed of 1 m/s, resulting in turbine I rotation of 91 Rpm and turbine II of 78 Rpm, with a torque of 39.2 N [4]. Research on the performance of an undershot water turbine with a bowl-shaped blade model shows that the highest efficiency from testing 4 6 and 8 blades with a turbine diameter of 300 mm was obtained in a 6 blade turbine producing 20 rpm which was found at a discharge of 0.01228 m3/s [5]. Maximum turbine performance at a flow direction angle of 350, number of blades of 12 diameter, rotation of 90 rpm, water capacity of 50 m3/hour and with a power output of 21,365 Watts, efficiency of 33,241%, and torque of 3,864 N.m [6]. Maximum turbine performance occurs on spoon-style turbine blades with a value of 0.555 Nm, while the lowest torque occurs on curved blades with a value of 0.360 Nm [7]. In the inclined blade water test with a diameter of 1000 m, the flow rate was 0.050 m3/s - 0.032 m3/s at loads of 2 kg, 4 kg, 6 kg and 8 kg, the inclined blade water wheel produced water wheel power of 17,955 Watts to 3,273 Watts at load 8 kg. [8]

Factors that influence the quality characteristics of optimum turbine performance are variations in the number of blades, variations in valve openings, and variations in the width of the flow intake. The variation factor for the number of blades is 18, 20 and 22. The optimum rotation results are obtained at the selected factor level A1 (18 units) with a rotation result of 310.2 rpm. From the valve opening variation factor of 50%, 75% and 100%, optimum rotation results are obtained. at the selected factor level B2 (75%) the rotation result was 321.1 rpm, and from the variations in the flow intake area of 120 mm, 125 mm and 130 mm, the optimum rotation result was obtained at the selected level C1 (120 mm), the rotation result was 295.7 rpm. [9]

II. RESEARCH METHODS

The material used to make the blade uses an iron pipe with a thickness of 2 mm, to make the disc disc uses an iron plate with a thickness of 5 mm and the shaft itself uses solid iron with a diameter of 2.5 cm and a length of 35 cm.

The next stage is assembling the materials according to the design that has been determined using the materials that have been prepared, then testing the equipment that has been assembled with the first stage is turning on the inverter to turn on the pump then increasing the frequency of the inverter according to the standard used by turning the controller inverter which aims to get a water flow of 1 m3/minute. When the water has entered the turbine and rotates the turbine, the rotation is checked using a tachometer. After the inspection is carried out, a braking load is attached by wrapping the rope around the pullley that is already on the turbine shaft. After it is installed, the braking is carried out in stages starting from a load of 1kg to 9 kg and every An increase in braking load will require rotation data to be taken using a tachometer.

The variables in this research consist of: independent variables, dependent variables and controlled variables.

a. An independent variable is a variable whose value has been determined.
    1. Water discharge: 1 m3/minute.
    2. Number of turbine blades 24
b. The controlled variable is the braking load on the turbine shaft which is determined to be 1, 2, 3, 4, 5, 6, 7, 8 and 9 kg.
c. The dependent variables in this research are torque and turbine power.

Tools and materials

a. Installation of turbine testing equipment
b. Rope brake test equipment
c. Turbine with 24 blades
d. Measuring Instruments (Tacometer, flow meter and spring balance)

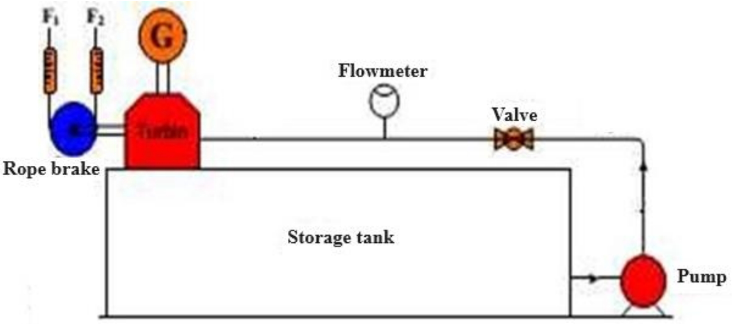

Fig. 1 Turbine test equipment installation

III. RESULTS AND DISCUSSION

Fig 2 shows that the greater the load given to the turbine, the smaller the rotation produced by the turbine, and vice versa, the smaller the braking load, the higher the turbine rotation produced. It can be seen that at 24 blades without using a 0 kg load it is 1744 rpm, at a 1 kg load it is 1594 rpm and the higher the load until the maximum load point is 9 kg the smaller the shaft rotation, namely 426 rpm. As the braking load on the turbine increases, the average turbine rotation decreases by 14.24%. This condition occurs because the greater the braking load, the greater the braking force. The greater the braking force, the greater the normal force. Likewise, if the normal force becomes greater, it causes the rotation of the turbine shaft to slow down or decrease.

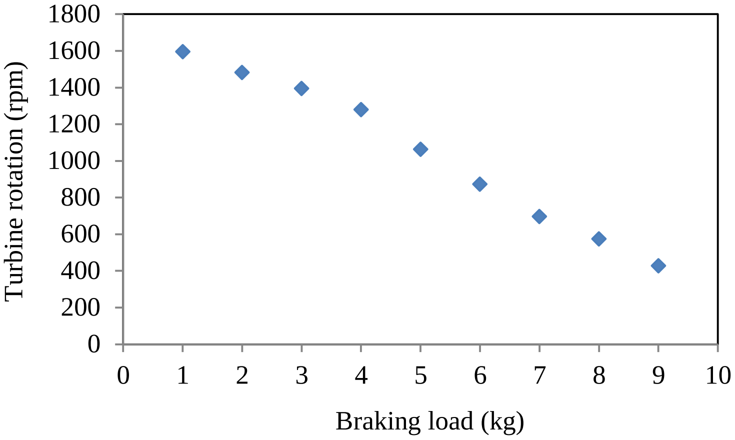

Fig. 2 Relationship between braking load and turbine rotation

In Fig 3, the relationship between turbine torque and loading shows that the greater the load, the more the torque value will increase. The torque value increases because the braking load applied increases. Likewise, the smaller the braking load given, the lower the torque produced by the turbine. This is due to the large straight loading torque with the braking force. The highest torque value is at a load of 9 kg, reaching 6.62 Nm and the lowest torque is at a load of 1 kg with a value of 0.74 Nm. The research results show that turbine torque has increased on average by 24.53% for every 1 kg increase in braking load.

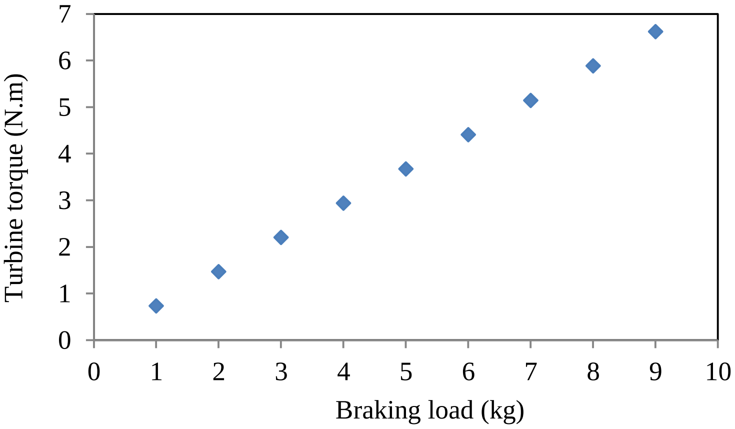

Fig. 3 Relationship between braking load and turbine torque

The maximum load that can be read is the braking force which is equal to the rotational force of the turbine shaft. The effect of excessive braking load can reduce turbine power. The research results show that with a load of 5 kg, a maximum power of 408.94 Watts is obtained. Then, at a load of 6 kg to 9 kg, the turbine power begins to decrease due to the addition of excessive load to the turbine blades. Turbine power increased by an average of 22.41% at a loading of 1 to 5 kg, while loading 5 to 9 kg experienced an average decrease in turbine power of 7.66% (Fig 4).

Fig 5 shows that the maximum load that can be read is the braking force which is equal to the rotational force of the turbine shaft. Excessive braking loads can reduce turbine efficiency. The research results show that at a load of 5 kg, a maximum efficiency of 70.45% is obtained. Then, at a load of 6 kg to 9 kg, the turbine power begins to decrease due to the addition of excessive load to the turbine blades. There was an average increase in turbine efficiency of 22.41% at a loading of 1 to 5 kg, while a load of 5 to 9 kg experienced an average decrease in turbine efficiency of 7.66%.

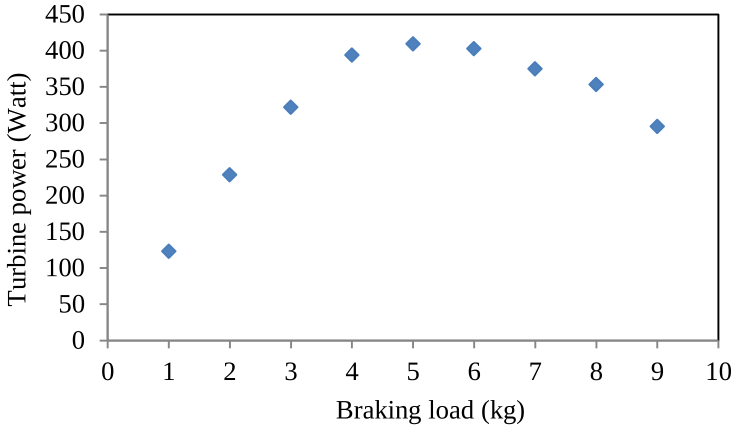

Fig. 4 Relationship between braking load and turbine power

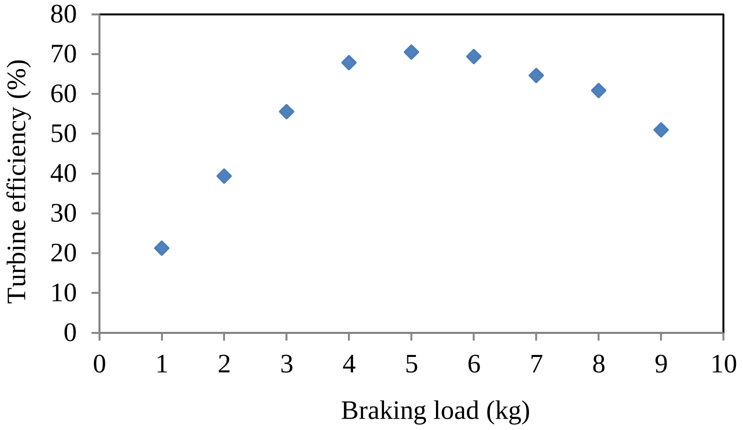

Fig. 5 Relationship between braking load and turbine efficiency

IV. CONCLUSION

The results of this research show that as the load on the turbine increases, the average turbine rotation decreases by 14.24%. Meanwhile, turbine torque experienced an average increase of 24.53%. Turbine efficiency increased by an average of 22.41% at a loading of 1 to 5 kg, while at a loading of 5 to 9 kg the efficiency decreased by an average of 7.66%.

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