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# Optimization of Efficiency in Piko Hydro Power Plants on Using Pumps as Turbines

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***Abstract***: The use of the NS 50 water pump which functions as a turbine for the Pico Hydro Power Plant is an idea in finding alternative energy that is simple and easy to assemble. In this application the NS 50 water pump is used as a turbine so that the working principle is reversed, where water from a certain height will drive the pump, so that the pump impeller rotates and continues to rotate the generator and will produce electrical energy. This study emphasizes a pump that functions as a turbine (PAT) by utilizing a height difference of 14.51 m at a flat distance of 46.21 m with a pipe installation with a slope of 17.43o. The variable used is the water level (H) on the different V-notch weir, namely 15, 12 and 11 m with the impeller used having an inlet and outlet angle of 30/75. The pump is then connected to a generator and the result is electricity. The results showed that the best efficiency was 23.33%, the rotation was 1500 rpm and the power generated was 283.5 watts.

***Keywords****— pump as a turbine, pico hydro, NS-50, rapid pipe slope*

## I. INTRODUCTION

Energy demand will always increase as a function of population growth. For conventional energy such as oil and gas, high demand if not matched by production capacity causes a shortage which results in price increases and an energy crisis. One of the efforts related to energy policy is to develop and increase energy diversity including potential energy now and in the future. This shows the importance of developing the renewable energy sector.

Indonesia is targeting an electricity level of 90% for a population with a current (estimated) number of more than 273 million. The average standard for electricity is 450 watts per house. Thus, around 9000 MW is needed until 2025. Hydroelectric power plants (HPP) in Indonesia have the potential to reach 70,000 MW. Thus the 9000 MW shortfall is predicted to be met through hydropower. Of the 70,000 MW potential, only about 6% has been utilized. In remote areas, meeting electricity needs through hydropower can be assisted by Picro Hydro Power Plants (PHPP).

Indonesia's natural conditions are very rich in water potential that can be used as a power plant. Therefore, it is necessary to optimize the use of water resources for energy fulfillment. The Picohydro system as one of the new renewable energy sources that can provide great benefits for the community in meeting electrical energy without having to incur high costs for power transmission systems or environmental care in general because the implementation of the system is integrated with its utilization.

One of the economical alternatives to build a small-scale hydroelectric power plant is to use a pump as a turbine. The field of science that specializes in the operation of pumps as turbines is often referred to as PAT, short for Pumps As Turbine. Several types of water pumps can be applied as water turbines, usually the pump is driven by an electric motor to raise a certain amount of water to a certain height. In the application of the pump as a turbine,

the working principle of the pump is reversed, which is given a drop of water from a certain height to rotate the pump plunger. This impeller rotation will continue to turn on the generator so that electricity is generated.

One important thing in optimizing this turbine is that the performance of the turbine will change if there is a change in the incoming flow rate. In this study, it will be tested experimentally to determine the performance of the output power produced by the turbine blades by varying the inflow discharge using variations in the water level on the V-notch weir, namely 15 cm, 12 cm and 11 cm. This research was carried out at the Laboratory of the Mechanical Engineering Department at the Merdeka University of Madiun and the application in Poncol Village, Magetan Regency.

The problem that will be discussed in this study is how the inflow discharge affects the turbine mechanical power, generator power and turbine efficiency. while the scope of this research are: 1. The difference between the height of the turbine and the upper reservoir is 14.51 meters; 2. The flat distance between the turbine and the upper reservoir is 46.21 m; 3. The slope of the pipeline is 17.43o; 4. The impeller used has an inlet and outlet angle of 30/75; 4. Variation of inflow discharge with variation of water level on V-notch weir : 15 cm, 12 cm and 11 cm.

## II. BASIC THEORY

The basic principle of hydroelectric power plants, if water can be channeled from a certain height to a lower level, then the resulting head of water can be used to do work. This use can transfer mechanical components into rotational energy which is channeled to the shaft to drive a generator to produce electricity. The choice of a good turbine for each site depends on the characteristics of the site, the head and the exhaust available. Modern, expensive turbine innovations are all obstacles to rural communities. However, if we use pumps that are mass- produced and are affordable, clean, green and sustainable are the solutions to the electricity needs of rural communities. The targeted generation scale for household use ranges from 400W - 5000 W.

A water turbine is a device for converting the potential energy of water into spherical energy and then converted into electrical energy by a generator. Before designing and selecting a water turbine, it is necessary to test the feasibility and analyze the water resources that will be used for its potential energy, especially the availability of head and water discharge from the water source for the designed load.

After knowing the potential head that is in the water flow source, then determine the type of turbine and the planned load. Where the design load should not exceed the availability of potential energy from water sources, because it will result in not achieving maximum operational efficiency and causing economic loss

### *A. Pico Hydro*

A pico-scale hydroelectric power plant is a power plant that produces an electrical power output of not more than 5 kW. Pico-scale hydroelectric power plants in principle use different heights and the amount of water discharge per second that is in the flow of water from irrigation canals, rivers or waterfalls. This water flow will rotate the turbine shaft to produce mechanical energy. This energy then drives a generator and the

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generator produces electricity.

*B. Pump as Turbine*

Hydropower systems convert energy from falling water into mechanical energy by turbines. In some cases, it may be more appropriate to replace the turbine with a centrifugal water pump, and run it in reverse. One of the economical alternatives to build a small-scale hydroelectric power plant is to use a pump as a turbine.

Usually the pump is driven by an electric motor to raise a certain amount of water to a certain height. In the application of the pump as a turbine, the working principle of the pump is reversed, which is given a drop of water from a certain height to rotate the pump plunger. This impeller rotation will continue to turn on the generator so that electricity is generated.

## III. RESEARCH METHODS

The test was carried out at the location of the micro hydro power plant installation in Poncol Magetan village. Equipment used includes: NS 50 pump, piping system and electric generator.

*A. Test installation on pump as turbine*

The installation of a hydroelectric power plant that will be used in this study can be seen in Figure 1 below:

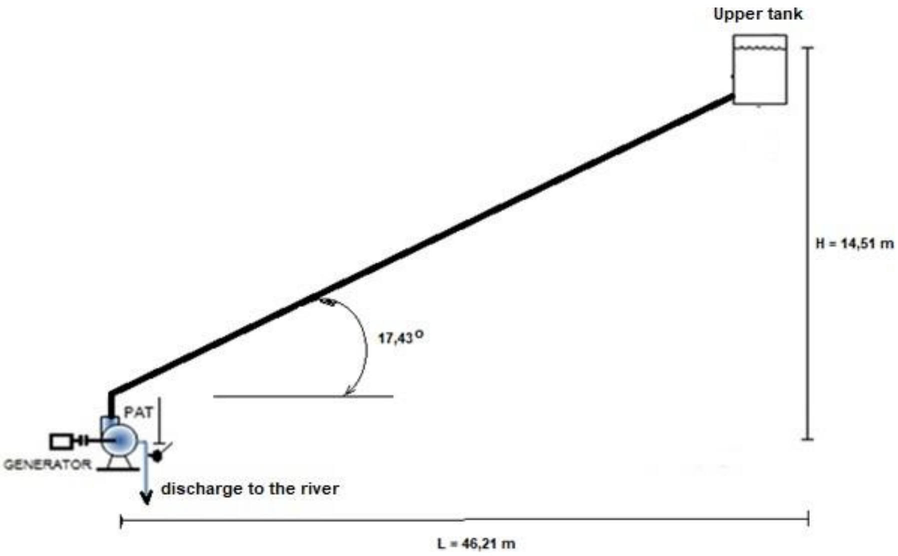


Figure 1. Test installation on the pump as a turbine

*B. Impeller*

In this test, an impeller with an inlet and outlet angle of 30/75 (Forward) is used. Specimen specimens are made of composite materials. This is intended to obtain a material that is lightweight and resistant to pressure.


The illustration of the impeller used can be seen in Figure 2 below.

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Figure 2. Impeller with variations in the angle of entry and exit angle of 30/75

## IV. RESULTS

The test was carried out on the pump as a turbine with a height difference of 14.51 meters while the flow discharge variation was by adjusting the valve opening and measuring the water level on the V-notch weir at a height of: 15 cm, 12 cm and 11 cm. The test results data can be seen as in table 1. below:

Table 1. Experimental data

| | $n_t$ | $n_b$ | $F_s$ | $n_i$ | $n_v$ | i | v |
|---|---|---|---|---|---|---|---|
| Number | rpm | rpm | kg | rpm | rpm | Ampere | Volt |
| 1 | 1500 | 1390 | 2,60 | 130 | 1440 | 2,1 | 135 |
| 2 | 1375 | 1340 | 2,24 | 174 | 1330 | 1,8 | 123 |
| 3 | 1236 | 1125 | 2 | 120 | 1215 | 1,5 | 112 |

Information :
nt = shaft rotation without load (rpm)
nb = shaft rotation without load (rpm)
Fs = force measured on a digital scale
ni = shaft rotation without load (rpm)
nv = shaft rotation without load (rpm) i
= generator current output (Amperes) v
= generator output voltage (Volts)

From the experimental results, then data processing is carried out to obtain torque, turbine power, generator power and efficiency.

*A. Effect of inflow discharge on turbine power and generator power*

From the data processing the experimental results obtained data as shown in the following table.

Table 2. Effect of flow rate on turbine and generator power

| Debit | Generator power (kW) | Turbine power (kW) |
|---|---|---|
| Debit 1 | 0,2835 | 1,22 |
| Debit 2 | 0,2214 | 1,21 |
| Debit 3 | 0,168 | 1,14 |

If plotted on the graph, we will get the relationship between flow rate and turbine power and generator power.

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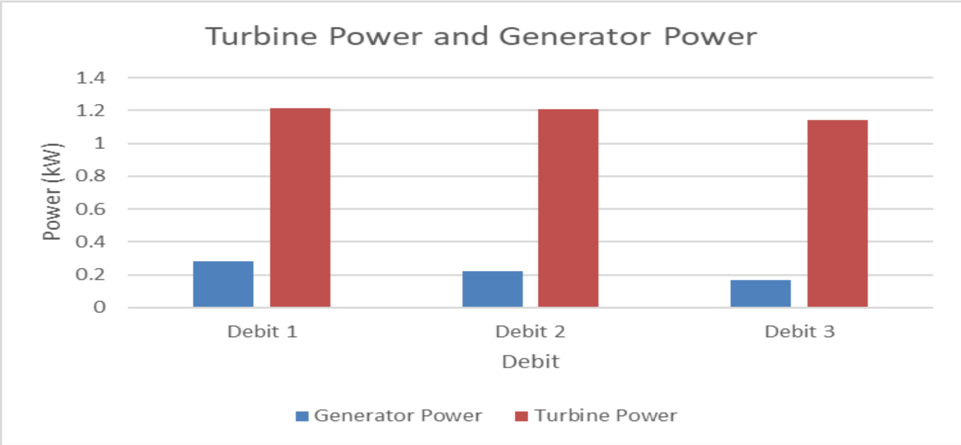


Figure 1. Relationship of flow rate to turbine power and generator power

*B. Effect of inflow discharge on efficiency*

From the processing of the experimental results obtained data as shown in the following table.

Table 3. The effect of variations in flow rate on efficiency

| Debit | Efisiensi (%) |
|---|---|
| Debit 1 | 23,33238916 |
| Debit 2 | 18,33139303 |
| Debit 3 | 14,71124793 |

If it is plotted on the graph, it will be obtained the relationship between flow rate and efficiency.

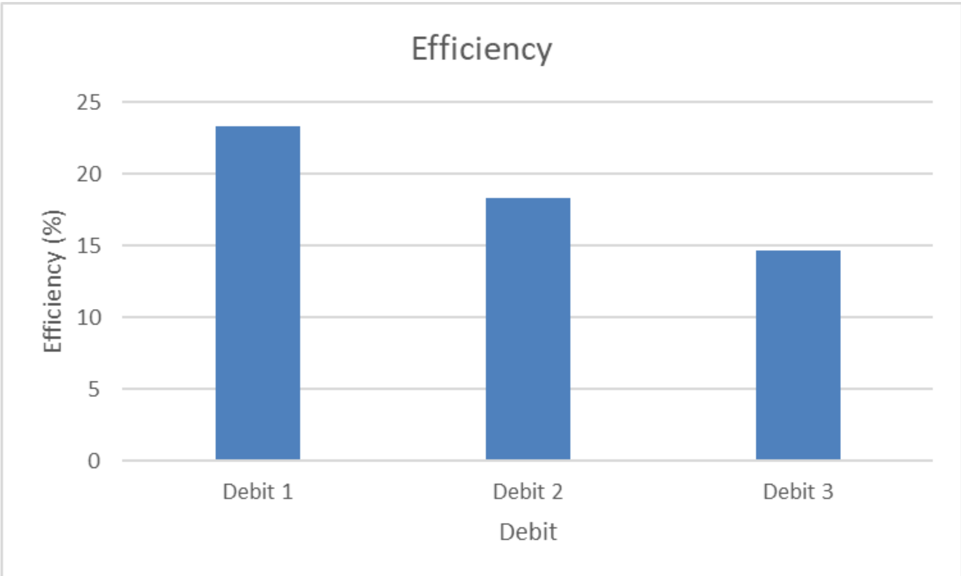


Figure 2. the relationship between flow rate and efficiency

From the graph in Figure 1. it is known that the smaller the flow rate, the lower the turbine power and the generator power of the turbine system. This is because the smaller the flow rate, the water pressure on the

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blades will decrease so that the thrust on the blades decreases. Furthermore, the rotation of the turbine shaft will decrease, so that the turbine power also decreases.

While the generator power with the smaller the flow rate of the turbine shaft rotation decreases, so that the rotation of the generator shaft which is connected to the turbine shaft also decreases, so that the current and voltage produced by the generator also decreases. As a result, the electrical power generated by the generator also decreases. This is because the voltage generated is due to electromotive force, so that if the rotation is greater, the output voltage produced also increases.

If the flow rate is small, the speed of the water flow will increase, but the pressure will decrease. With a decrease in pressure, the thrust of the blades decreases so that the turbine shaft power decreases and in the end the efficiency also decreases.

## V. CONCLUSION

From the results of testing and discussion, the following conclusions can be drawn:

1. The effect of flow rate on turbine power and generator power is directly proportional, as the flow rate decreases, the turbine power and generator power decrease.

2. The effect of flow rate on is directly proportional to the decreasing flow rate, the turbine power and generator power are decreasing, with maximum efficiency 23.33% and minimum 14.71%.

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2. Head of Poncol Village, Poncol District, Magetan Regency.
3. Chairman of LPPM Merdeka University Madiun

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