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ANALYSIS OF THE PERFORMANCE OF PIKO HYDRO TURBINE ACRHIMEDES POWER PLANT ON THE EFFECT OF WATER PRESSURE

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ABSTRACT

Turbines are the most important component in Pikohidro Power Plant (PLTPH). The turbine used in this PLTPH modeling is the Archimedes screw turbine. This Archimedes screw turbine is still very rare to use in the city of Pontianak. This study aims to make it easier to conduct tests related to parameters that affect the performance of the Archimedes screw turbine, one of which is the influence of water pressure. This study will discuss the influence of water pressure on the rotation produced by the Archimedes screw turbine so that it can be seen the voltage, current, power generated by the generator, in PLTPH modeling. The change in water pressure given is 3 psi, 4 psi, 5 psi. The results showed that the increase in water pressure given caused the performance of PLTPH to increase, where the highest efficiency was obtained at a pressure of 5 psi and the lowest efficiency was obtained at a pressure of 3 psi.

Keywords: PLTPH, Archimedes Turbine and Screw,Water Pressure

ABSTRAK

Turbin merupakan komponen yang terpenting dalam Pembangkit Listrik Tenaga Pikohidro (PLTPH). Turbin yang digunakan dalam pemodelan PLTPH ini adalah turbin Archimedes screw. Turbin Archimedes screw ini masih sangat langka digunakan di kota Pontianak. Penelitian ini bertujuan untuk mempermudah dalam melakukan pengujian yang berhubungan dengan parameter yang berpengaruh pada kinerja turbin Archimedes screw salah satunya yaitu pengaruh tekanan air. Pada penelitian ini akan membahas mengenai pengaruh tekanan air terhadap putaran yang dihasilkan oleh turbin Archimedes screw sehingga dapat dilihat tegangan, arus, daya yang dihasilkan oleh generator, pada pemodelan PLTPH. Perubahan tekanan air yang diberikan yaitu sebesar 3 psi, 4 psi, 5 psi. Hasil penelitian menunjukan bahwa peningkatan tekanan air yang diberikan menyebabkan kinerja PLTPH semakin meningkat, dimana diperoleh efisiensi tertinggi pada tekanan 5 psi yaitu dan efisiensi terendah diperoleh pada tekanan 3 psi.

Kata Kunci : PLTPH, Turbin Archimedes dan Screw,Tekanan Air

1. Introduction

Microhydro Power Plants (PLTMH) are small-scale hydropower generators that offer numerous advantages, especially as they do not require reservoirs, are environmentally friendly, and utilize renewable energy sources. Consequently, they are frequently constructed to supply electricity in rural areas. PLTMH units are generally permanent installations, with the primary challenge being the relatively high construction costs. A prototype of a Micro Hydro Power Plant employing an

Archimedes screw turbine is capable of operating with small-scale water flow [1]. Electricity has become a fundamental necessity in modern human life, with nearly all activities relying on it as an energy source. As a result, the demand for electric power has continuously grown. Starting with the discovery of electricity by Thales in 640-546 BC, the field has evolved up to the present day. In Indonesia, electricity generation began in the 19th century, initiated by several Dutch companies to meet their energy needs, primarily relying on steam and water-based power generation [2].

Indonesia "has significant potential in the field of water resources, and currently, the government is actively seeking support in the water resources sector to meet its needs, particularly in the procurement of electricity from renewable energy sources. This involves optimizing the potential of water resource infrastructure such as dams, reservoirs, and irrigation channels, which can be utilized by the private sector through collaborative infrastructure utilization agreements [3] This natural resource that has great potential as a power plant is a source of water energy, considering that Indonesia has a wealth of forests and rivers. However, research related to water has cost a lot of money because of its location and huge investment and long construction. The right solution to the problem of hydropower plant investment which is quite expensive is to use Micro Hydro Power Plants [4].

Design and Construction of Pico Hydro Power Plant is a small-scale hydroelectric generator designed to harness the power of water. It acts as an intermediary between the alternator and the water wheel, with the battery serving as a temporary energy storage location to be used for electrical loads. Based on the results obtained from this design, it operates in accordance with the planned principles, discussing the functionality of the alternator, water wheel, and battery as the main components of the Pico Hydro Power Plant [5]. analyze the effect of the head on the power and efficiency generated by the Three-Blade Archimedes Screw Turbine. Furthermore, the test result data is processed in the form of calculations then the data will be reprocessed and presented in graphic form to determine the performance of the Archimedes Screw Turbine. The method of data collection is carried out experimentally. Data retrieval is carried out by flowing water with a specified head variation to the turbine with a change in head [6].

Water is one of the renewable energy sources that can be utilized for Microhydro Power Plants (PLTMH). The city of Batu has a water energy source that can be used for designing a water turbine prototype for PLTMH. This research aims to determine the power that can be generated by the turbine [7]. The potential of water energy is significant, both for large and small-scale applications. As the demand for energy continues to grow, energy becomes a crucial element in the development of a country or region. Cross-flow turbines are commonly used for PLTMH. In this study, the design of a cross-flow water turbine is applied to the height and the amount of water per second in an irrigation channel. This flow of water rotates the turbine shaft, generating mechanical energy [8]. optimize the performance of the Archimedes screw turbine Pico Hydro Power Plant so as to produce a better power output. In this study the authors designed an Archimedes screw turbine model with a screw angle of 28°, 5 blade type screw, and 40° turbine tilt. This study focuses on a transmission system using a belt and pulley ratio of 1:3, with two levels of transmission, and a turbine tilt angle of 40°. The method used in this study is the experimental method. As a result, after trials were carried out on a stream located in the Sungailiat Archipelago Fishing Port area, the highest turbine rotation value was 146 rpm and generator rotation 756 rpm, resulting in a power output of 8 watts within 45 minutes of the trial period in the field [9].

Testing related to parameters affecting the performance of the Archimedes screw turbine includes the impact of water pressure. This research discusses the influence of water pressure on the rotation generated by the Archimedes screw turbine, allowing for the observation of voltage, current, power produced by the generator, torque, and efficiency in the PLTMH modeling [10]. knowing the comparison of Arcimedes water turbine performance with variable number of blades, blade distance, and turbine shaft type to output power and efficiency. This generating system uses Arcimedes turbines to utilize the flow of wasted water with a head of 5 meters [11].To reduce the use of fossil fuels, research on renewable energy sources, such as micro-hydro, has been conducted. The operation principle of PLTMH utilizes water energy converted into electrical energy. This thesis research has involved the modeling of a power generator [12]. knowing the performance of the Pikohidro Archimedes Screw Power Plant by using the mainstay irrigation discharge of the Bincau Village Fish Buididaya Installation. Test results with a discharge of 47.88 ltr/s, with a Soak Level (I) of 0.7 and a Slope of 11° resulted in a rotation of 301 rpm with Torque (?) of 2.82 Nm. [13]

This research aims to introduce the primary benefits of the procedure to the public through the task of optimizing the design and operation of the Archimedes screw turbine [14]. Pico Hydro Power Plants are one of the renewable energy sources that harness small head and flow rates from water or irrigation channels. Several factors can influence the hydrolysis power and the power of the screw turbine rotation, one of which is the turbine design. Existing turbine designs need to be evaluated based on factors such as inner and outer screw diameter, pitch, pitch distance, the number of blades, and the inlet and outlet channel conditions, as well as head and water flow [15].

2. Methods

The method used in this study is to make it easier to conduct tests related to parameters that affect the performance of the Archimedes screw turbine, one of which is the influence of water pressure. This study will discuss the effect of water pressure on the rotation produced by the Archimedes screw turbine so that it can be seen the voltage, current, power generated by the generator, in PLTPH modeling with changes in water pressure given

Data analysis is one of the research processes used to comprehensively address the research problem. The analysis method employed is quantitative data analysis because it relies on the ability to calculate data accurately. Quantitative data analysis techniques are commonly used in research where data can be measured or quantified. This data can also be processed using statistical and computational techniques.

1. The turbine's angle results in efficient power output.
2. The power output under various water pressure conditions on the turbine.
3. The turbine's efficiency at different water pressures.

This research aims to understand the impact of varying water pressure on the turbine's rotation and the power it generates. It seeks to identify the most effective configurations that can be used for the community's everyday life.

a. Field Study Method

Direct observations are conducted in the field, specifically at the Laboratory of Mechanical Engineering, Muhammadiyah University of Pontianak. This study is carried out to observe the actual field conditions, making it easier to determine the requirements for this research activity, such as using a pump to measure head and flow rates.

b. Design Method

The design method involves the stages or steps used in designing an object. In the design process, a well-defined design method is essential to facilitate the designer in creating or developing an object, whether in the form of a replica or the original, for testing and evaluation.

c. Testing Method

The testing method used for the Pico Hydro Power Plant employs an experimental approach. In this method, the turbine is directly tested to assess the power output and the influence of RPM on that power. Various measuring instruments used for testing include:

- Multimeter.
- Digital Tachometer.
- Pressure gauge.

d. Water Circulation Process (Water Flow Process)

In the water circulation process, artificial water flow is required to drive the fluid, which in turn moves the screw turbine of the Pico Hydro Power Plant. This often involves creating an artificial water flow using a pump to propel the fluid, thus driving the power plant's turbine.

e. Testing and Research Procedures

The steps for testing and researching the PLTPH turbine are as follows:

1. Verify the water flow used to drive the turbine.
2. Ensure that all components of the turbine are functioning properly.
3. Inspect all testing equipment and measuring instruments.
4. Submerge the turbine in water.
5. Measure the turbine's rotation (RPM) using a tachometer.
6. Assess the current generated by the turbine using a multimeter or under load conditions.

These steps provide a structured process for evaluating the Pico Hydro Power Plant turbine.

1. Water flow acceleration
2. Rotations per minute
3. Generated power
4. Water discharge

• Kinetic Energy

It is the energy of motion, also known as the energy associated with the movement of an object. The magnitude of kinetic energy in an object depends on its mass and velocity. The magnitude of kinetic energy can be expressed by the following equation:

➢ The formula of energy kinetic ; $Ek = ½\, m.v2$ ……………………………...……………(1)

• Potential Energy

It is the energy associated with the position of an object, also known as potential energy. This is because even stationary objects can possess energy, and any movement of the object will result in a change in potential energy.

➢ The formula for potential energy is: $Ep\ \ m.g.h$……………………….....…...…………..(2)

• Pressure Energy

➢ $Et = P.\frac{F}{A}$ ………...…………………………..…....…....(3)

• Screw Turbine Dimensions

➢ $Q = k\, n\, D^3$………………………………………….…………………........………(4)

• Flow Velocity (V)

It represents the distance an object will travel per unit of time. Water discharge measures the volume of water that can pass through a specific location and is contained in a given place per unit of time.

The formula for flow velocity is: $V=\frac{Q}{A}$…………………………...........…………………………(5)

• Fluid Power Calculation (WHP)

Fluids are essential in daily life and are used for drinking and cleaning. Fluids can be divided into two types: static fluids and dynamic fluids.

- The formula for fluid power calculation is : $WHP = \rho.g.Q.Ht$.................................. (6)

• Power

Power is the rate of work done or the comparison of work to time. As one of the measurement parameters in physics, power has units in the International System of Units (SI). The unit of power is the Joule per second (J/s) or watt (W).

The formula for calculating power is:

$P = \rho.g.Q.Ht\ (watt)$………………………………………………..……………..(7)

So in power Kw (kilowaat) is:

P = $\frac{\rho.g.Q.Ht}{1000}\ (Kw)$…………………………………………………………...……….(8)

Turbine Efficiency

Efisiensi = $\frac{P\ out}{P\ in} \times 100\ \%$...(9)

3. Results and Discussion

Discussions and Tools Used

Pico hydro power plants have various components and tools to measure them and their components;

a) Blade Blade Blade.
b) Transmission System
c) Generator
d) Multimeter
e) Digital Tachometer.
f) Pressure gauge

Below is an illustration of the pico hydroelectric power generator.

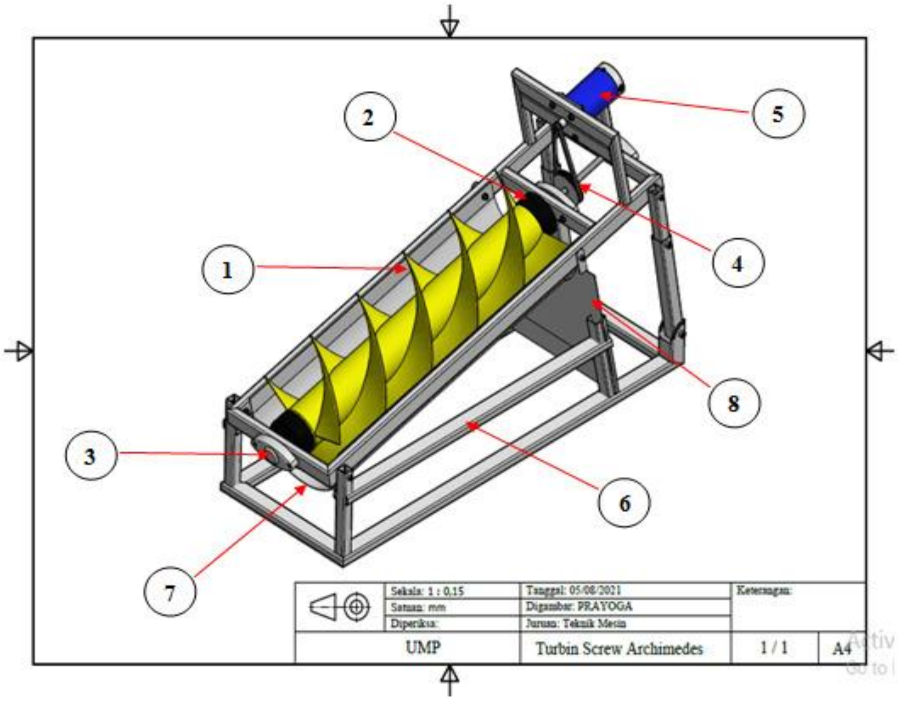

Figure 1. Pico Hydroelectric Power Generator

Information:

1. Screw
2. Shaft
3. Bearing
4. Pulley
5. Dynamo
6. Frame
7. Trough
8. Dam

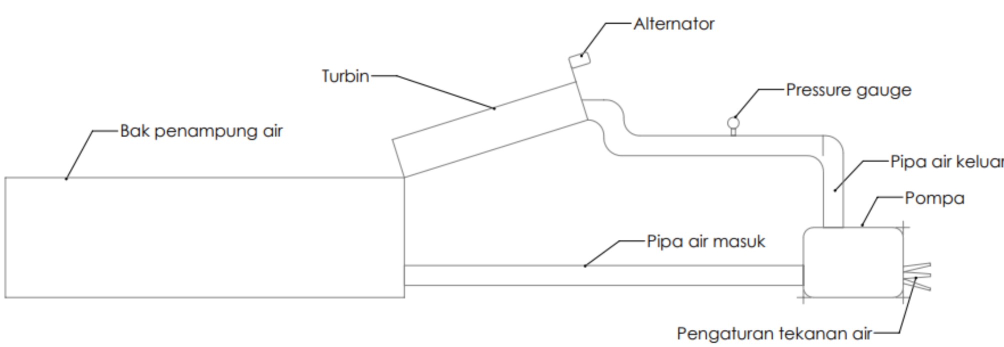

Figure 2. Turbine installation using pumps

Research Data

From the measurement results, with a turbine angle of 16 degrees, the data is as shown in the table below:

Table 1. Turbine Angle Inclination

No.	Debit [L/S]	Pressure [psi]	Voltage [V]	Amperes [A]	Power [watt]	Turbine Rotation [RPM]
1	3,89	3	76,6	0,79	60,514	67,4
2	4,48	4	84,6	0,88	74,448	84,4
3	5,11	5	109,6	1,03	112,888	116,1

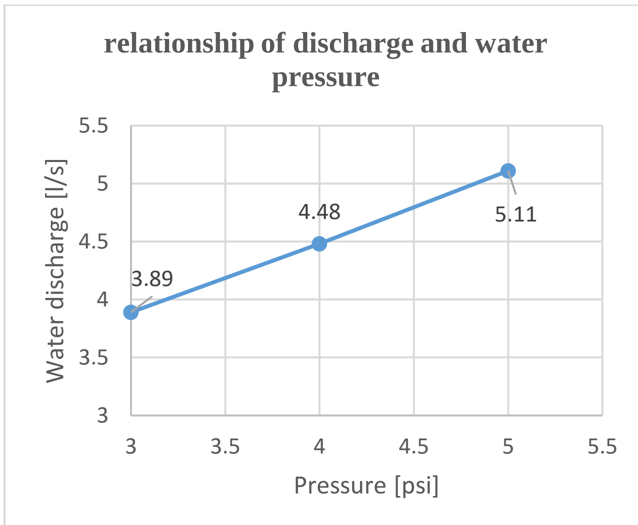

Figure 3: Relationship between Flow Rate and Water Pressure

Testing or data collection was conducted with the lowest water flow rate of 3.89 L/s, moderate at 4.48 L/s, and high at 5.11 L/s, with variations in water pressure ranging from the lowest (3), moderate (4), to the highest (5). This resulted in high turbine rotations at a water pressure of 5 PSI with the turbine angle set at 16 degrees.

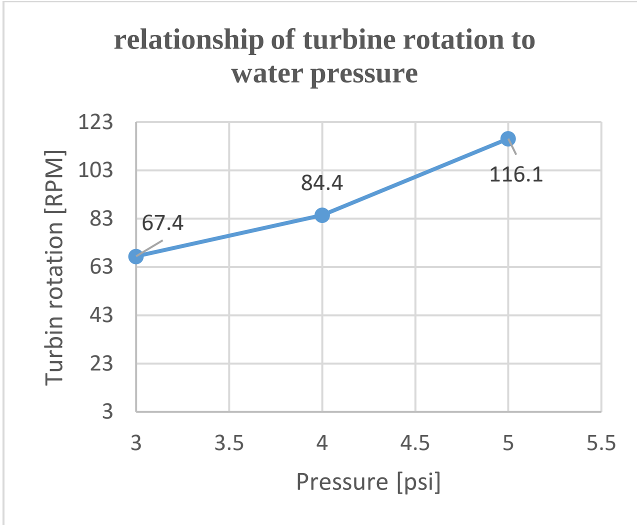

Figure 4: Relationship between Turbine Rotation and Water Pressure

The higher the water pressure, the higher the RPM (Revolutions per Minute) generated, as can be observed from the test or data collection. Test 1, with a turbine angle of 16 degrees, resulted in a turbine shaft rotation of 67.4 RPM. Test 2, with a 16° turbine angle, yielded a shaft rotation of 84.4 RPM. Test 3, with a 16° turbine angle, produced a shaft rotation of 116.1 RPM.

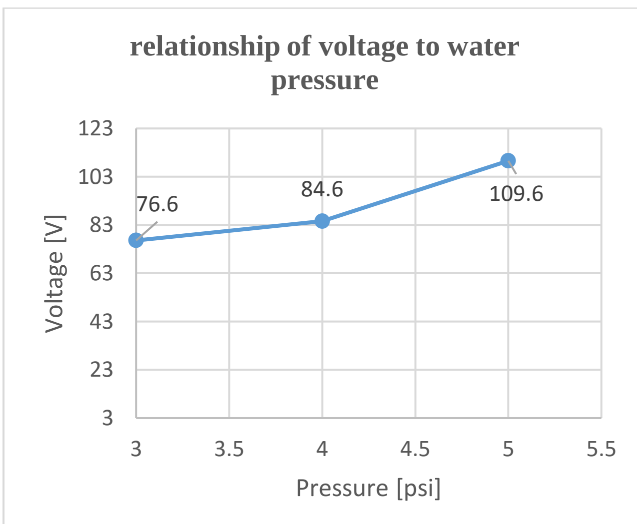

Figure 5: Relationship between Voltage and Water Pressure

The graph of the measurement results shows the change in water pressure against the generator voltage. The highest generator voltage occurs when the water pressure is at 5 psi, which is 109.6 volts, while the lowest voltage occurs at a water pressure of 3 psi, which is 76.6 volts. The highest generator voltage at 5 psi is 112.888 watts.

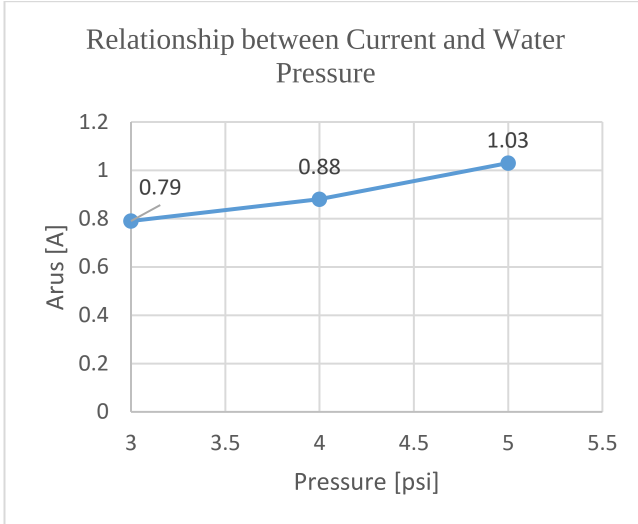

Figure 6: Relationship between Current and Water Pressure

Based on the graph, it can be observed that the highest generator current occurs at a water pressure of 5 psi, which is 1.03 amperes, while the lowest current occurs at a water pressure of 3 psi, which is 0.79 amperes.

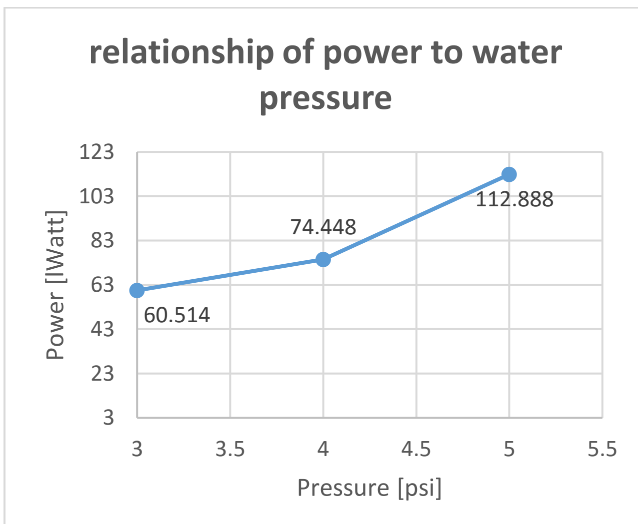

Figure 7: Relationship between Power and Water Pressure

Based on the graph, it can be seen that increasing the water pressure results in an increase in power. The highest power occurs at a water pressure of 5 psi, which is 112.888 watts, while the lowest power occurs at a water pressure of 3 psi, which is 60.514 watts.

4. Conclusion

With the specified model of the Screw Turbine, featuring a 30 cm wide turbine, 60 cm long, helical pitch of 0.229343 m, 3 turbine blades, and a blade diameter of 0.2528 m (25.28 cm), and a turbine angle of 16 degrees, along with variations in water pressure at 3 PSI, 4 PSI, and 5 PSI, the power output differs for each pressure. In the first test, using water pressures of 3 PSI, 4 PSI, and 5 PSI, with a water flow rate of 5.11 liters per second, the best results were achieved at 5 PSI with a shaft

RPM of 204.3, screw rotation at 224.5 RPM, drive pulley at 305.7 RPM, and generator rotation of 370.5 RPM. This resulted in a power output of 41.9 volts DC with 4 amperes and a total power output of 167.6 watts.

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