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Application of Pelton Turbine in Pico Hydro Renewable Energy System at Sinar Negeri, Negeri Sakti Village

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Abstract

Some residents of Sinar Negeri Hamlet use the nearby spring as a place to raise freshwater fish. Residents have solely utilized this spring for everyday needs up until now, and it serves as the primary water source for fish ponds. Since technology would increase residents' productivity, they are excited about the chance to employ it in Sinar Negeri hamlet. Farmers also complain that there is no lighting surrounding the cultivation ponds, which makes it challenging for fish farmers to move around and perform their duties at night. Alternative small-scale power plants known as pico hydropower plants can be used in rural locations with rivers that continuously discharge water and a relatively modest waterfall to power a turbine that generates electricity. The spring has a head of 0.75 meters and a flow rate of 0,002 m^3/s. Natural resource potential can be used to generate an environmentally friendly small-scale power plant using alternative energy. Through the use of turbine technology, potential energy from the water head and flow rate is converted into electrical energy produced by a generator with an approximate output of 8,79 watts.

Keywords: *picohydro, hydroelectric power, pelton turbine, fish, environment*

1. Introduction

The target area is Sinar Negeri Hamlet, Negeri Sakti Village, Pesawaran Regency, Lampung Province. The residents of this village usually have a business or livelihood as breeders of freshwater fish such as catfish, tilapia, and gourami. Productivity and utilization of natural resources in this hamlet are very minimal. Reduced nighttime productive activities such as bathing, washing, etc. Feeding and control of fish is disrupted so you have to use a flashlight. There are no lighting lamps near the cultivation pond. Fish farming farmers use the water around the river as a source for cultivating freshwater fish, so lighting is needed at night around the pond so that cases of fish theft can be minimized. There is no technology for utilizing river water flow. So far, residents have only used springs and river flows as freshwater fish cultivation ponds and also for bathing, washing, and other purposes.

Dokumen diterima pada 12 April 2023
Dipublikasikan pada 31 Mei 2023

Figure 1. Photo of the target area for freshwater fish farming

A lot of water is wasted through springs near the river, in addition to the lack of knowledge among residents regarding the use of the river flow. For this reason, it is necessary to provide education to the residents of Sinar Negeri hamlet regarding the technology for utilizing flowing water into useful energy that can be used to help the activities of farmers or residents near river flows. Picohydro Hydroelectric Power Plant is a power plant that uses water power as the main medium to drive turbines and generators [1]–[6]. Pikohydro is a hydroelectric power plant that has power from hundreds of Watt to 5 kW. Technically, pico hydro has three main components, namely water (energy source), turbine and generator. In Picohydro Hydroelectric Power Plant the process of changing kinetic energy in the form of water speed and pressure, which is used to drive water turbines and electric generators to produce electrical energy. Some of the benefits we get from using micro hydropower plants are as follows [7]–[13]:

a. Compared to other types of power plants, pico hydropower plants are quite cheap because they use natural energy [14]–[18].
b. It has a simple form of construction and can be operated in remote or rural areas with skilled residents with little training.
c. Can be combined with other programs such as irrigation and fisheries[19]–[26].

2. Materials and Methods

2.1 Turbine Technology

Since the selection of turbines for small-scale hydropower schemes is mostly dependent on the water head and available flow rate, each potential site is regarded as unique. Generally speaking, a lower head means a higher flow rate. To sustain the increment, the penstock and turbine should be expanded proportionately. It is crucial to take action to identify effective ways of providing standardized equipment, engineering designs, and implementation methods specifically for a given place, given the uniqueness of each location. The power produced by a hydropower turbine can calculated using the following equations:

$$P = \eta \rho g H Q \tag{1}$$

$$H = h - h_f \tag{2}$$

$P = Power\ output$

$\eta = Total\ efficiency$

$\rho = Density$
$g = Gravitational\ constant$
$H = Net\ head$
$Q = Flow\ rate$
$h_f = \text{Head friction loss}$

Impulse and reaction turbines are the two types of turbines that need to be taken into account. Reaction turbines are often employed for low head sites and impulse turbines for high head sites. The fluid-embedded impulse turbine is powered by the pressure drop across the apparatus. Pelton turbines are appropriate for low and medium head [24],[25]. Crossflow turbines are appropriate for medium head [24],[30]. Reaction turbines work by allowing the flow to enter an open space and striking the turbine as a jet, with the kinetic energy providing the power. While Kaplan and propeller turbines are appropriate for low head applications, Francis turbines are employed in mid head schemes.

2.2 Test Site Location and Locals Support

A site within Negeri Sakti Village, Gedong Tataan District, Pesawaran Regency has been selected for test study. A natural pond with continuous water flow is used as the source for water intake. Data obtained from testing are used in consideration of turbine selection. Based on measurements at the location the flow rate is 0,002 m^3/s and the head is 0,75 m. Flow conditions can be seen in Figure 2.

Figure 2. River Flow

Residents play an important role and support all programs that have been launched in Negeri Sakti Village, Gedong Tataan District, Pesawaran Regency, Lampung Province, which is a strategic place and supports the creation of hydroelectric power plants because it is supported by natural resources and is by the needs of the community[19], [20], [28]–[32]. The village head, residents as well as lecturers, and fellow students helped to achieve this program which aims to improve the welfare of the people of Negeri Sakti Village, Gedong Tataan District, Pesawaran Regency.

2.3 Hydroelectric Power Plant Design

Based on the spring conditions at the location, the Pelton turbine was chosen as a hydroelectric power plant. After determining the type of turbine that will be used, the next process is designing the Pelton turbine. The design process goes through several stages starting from calculating turbine dimensions to the process of creating 3D drawings. The layout was designed by [27]. The design of the Pelton turbine and the layout of the hydroelectric power plant can be seen in Figures 3 & 4 respectively.

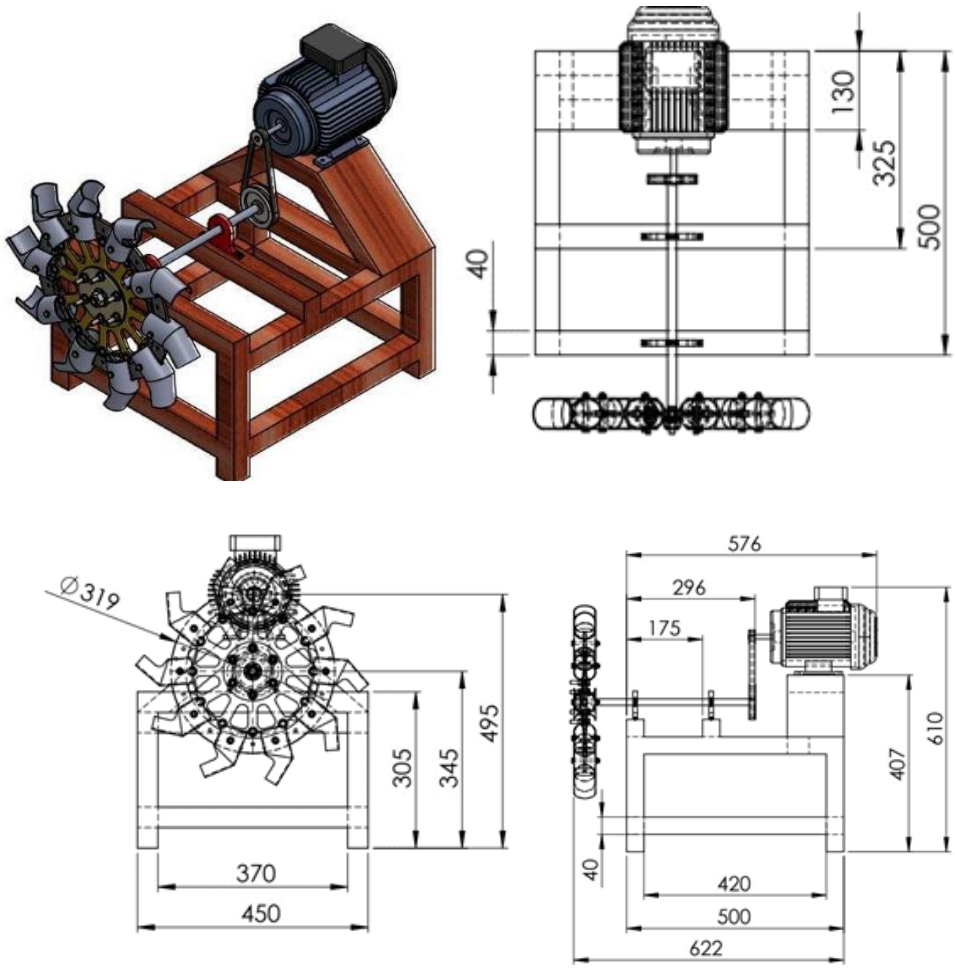

Figure 3. Hydroelectric Power Plant Design

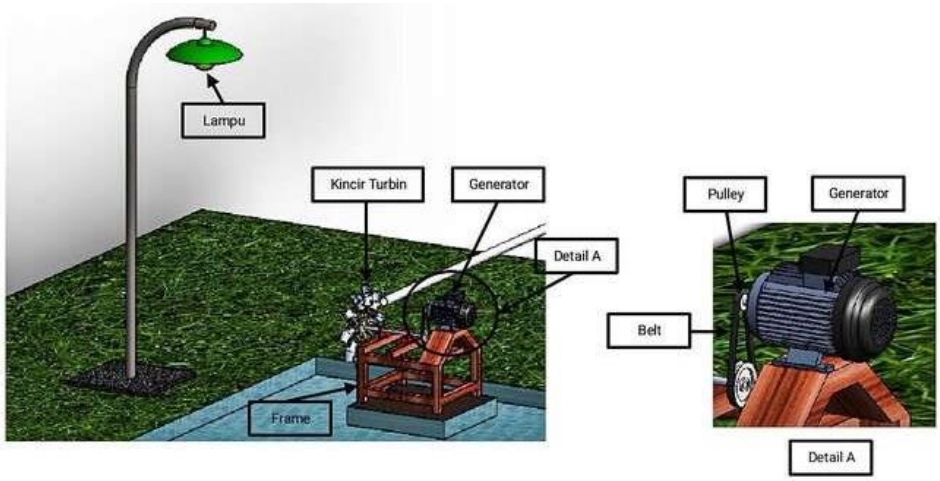

Figure 4. Hydroelectric Power Plant Layout

2.4 Tool Making Process

The tool-making process is divided into several stages, namely cutting, drilling, welding, and coating. After everything has been done according to the stages, the final stage is testing and running to meassure the performance of Pico Hydro. The tool-making process can be seen in Figure 5.

(a) (b)

(c) (d)

Figure 5. (a) Cutting, (b) Drilling, (c) Welding, (d) Coating

3. Results and Discussion

The results of the spring flow measurements were calculated and the hydraulic electric power potential results were obtained. Hydraulic power is the potential electrical power produced by the flowing air flow. The following is a hydraulic power calculation using equation (3), the results of the hydraulic power calculation are as follows:

$$Ph = \rho \times g \times Q \times h \tag{3}$$

$$Ph = 997\frac{kg}{m^3} \times 9{,}81 m/s^2 \times 0{,}002 m^3/s \times 0{,}75 m$$

$$Ph = 14{,}67\ watt$$

$$P = Ph \times \eta T \tag{4}$$

$$P = 14{,}67 \times 60\%$$

$$P = 8{,}79\ watt$$

Where Ph is the hydraulic power, P is the electrical power, ρ is the density of the water, g is the earth's gravity, Q is the water discharge, and h is the head or height of the waterfall. The calculation of hydraulic power (Ph) was found to be 14.67 watt, this value has not been multiplied by the turbine efficiency. Based on [33] the efficiency of the Pelton turbine depends on the head, usually around 60-80%. So the electrical power obtained using equation (4) is 8.79 watt. Voltage and current measurements can be seen in Figure 6.


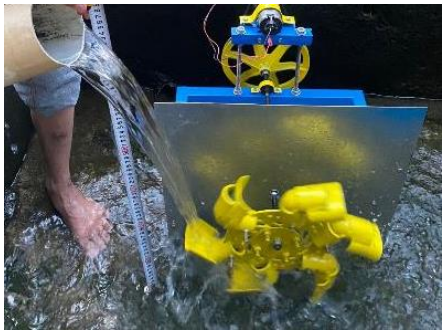


Figure 6. Voltage and Current Measurements

The benefits that can be taken from this activity include Resolving Street lighting problems in certain locations to reduce the risk of criminal acts on the street at night, saving energy and costs for turning on street lights and making it easier for people to move around at night because visibility is poor. dark and makes it easier for people to carry out activities, increases the ability of partners to overcome various problems encountered in the use of river flows as a source of electrical energy, and enriches the existence of science and technology in the application of using turbines as a source of electrical energy for lighting hydroelectric pools [33].

4. Conclusion

Several inhibiting factors related to this activity include: First, in general, the river in Sinar Negeri hamlet has a big influence on rainfall. Due to the prolonged dry season, the flow of water flowing in the river has decreased and as a result, it is quite difficult to rotate the pelton turbine that has been implemented in the Picohydro Hydroelectric Power Plant. Second, the use of rivers in Sinar Negeri hamlet has been implemented with current technological developments, so that river water is not wasted. Third, the productivity of freshwater fish farmers increases when there is lighting at night. Breeders can carry out full-night activities without the help of flashlights or other lighting equipment. Fourth, the hope is that the existence of the Picohydro Hydroelectric Power Plant can increase production figures and minimize acts of theft. Picohydro Hydroelectric Power Plant is an alternative solution to help freshwater fish farmers. Village areas can be cleaner, and more comfortable and become villages with the current implementation of appropriate technology. Turbine technology converts potential energy from the height and flow of water so that it drives the turbine blades into electrical energy from a generator with an electrical power of around 8.79 watt. Therefore, it can only turn on one LED light and one DC pump.

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