Simulation of Piko Hydro Power Generator Using Thread Turbine With 10-Watt Power

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***Abstract*—Renewable energy is one of the efforts to utilize electricity from renewable energy sources. Hydroelectric power is one of the plants that utilizes water as the main energy. Although the amount of energy is abundant, but in Indonesia the use of water as a power plant is still below 7%. This is due to the lack of human resources to manage water energy. Therefore, in this study, a simulation of a pico-hydro power plant using a screw turbine was designed which is expected to provide benefits. This tool is equipped with digital monitoring using Arduino Uno. Power monitoring on this tool uses the INA219 power sensor which is displayed on the LCD display. This tool uses a 12-24V DC generator. The turbine used is a screw turbine type. This pico-hydro power plant simulation is capable of turning on a load equivalent to 1 lamp of 10 watts/12 VAC with an inverter. The measurement of the current and voltage of the generator shows that the average current reaches 11.75 mA and the average voltage produced is 2.11 VDC and the power generated is 24.82 mW. The resulting step-up voltage measurement to charge the battery is 13.04 VDC and the current is 12.4 mA and the battery charging power is 0.161 watts.**

***Keywords*— Piko hydro, DC Generators, Threaded Turbine, Arduino Uno, INA219 sensor**

I. INTRODUCTION

Rivers are a source of water for life on earth, both humans, animals and plants. All living things need water to survive. The river flows from upstream to downstream moving from a high place to a low place [1]. According to the Regulation of the Minister of Public Works and Public Housing No. 4/PRT/M/2015 in Indonesia there are 128 river areas consisting of 5 transnational river areas, 31 trans-provincial river areas, 28 national strategic river areas, 52 trans-regency/municipal river areas, and 12 river areas within regencies/cities. [2]. Energy needs are also increasing along with the increasing development of human needs. Various diversification of the use of energy sources is carried out to overcome the depletion of energy sources that use fuel oil (BBM). One solution is to utilize new and renewable energy, such as solar, wind, biomass and water energy [3]. One option in the development of the energy sector is the use of Micro Hydro Power Plants (PLTMH) and Pico Hydro Power Plants (PLTPH) for remote areas that are not covered by the PLN electricity network. The construction of PLTMH and PLTPH does not require the relocation of local people's residences due to the construction of dams or reservoirs. Utilization of PLTMH and PLTPH is expected to provide cheap and environmentally friendly electricity and can have an impact on public awareness to conserve forests as guardians of water resources [1]. MHP refers to power plants with a scale of under 100 kW. Small-scale PLTPH under PLTMH is a small-scale power plant that uses hydropower as its driving force, such as irrigation canals, rivers or natural waterfalls by utilizing the head and the amount of water discharge. PLTPH utilizes the potential energy of water flow which has a certain head and discharge into electrical energy. Utilization of water as a source of electrical energy is only on the energy potential of water with high heads and large discharges, even though many areas in Indonesia have the energy potential of river water flows with very low heads (< 3 meters). Therefore, it is necessary to develop a type of turbine that can take advantage of the energy potential of water with a very low head. Several types of water turbines that can work at low heads are waterwheels, Kaplan turbines, and screw turbines [4]. Screw turbines have been applied to PLTPH, one of which is in Banda Aceh. Specifications Turbine head turbine 1 m, flow speed 2.054 m/s, turbine length 1 m, pitch distance 0.132 m, with a power of 66.4 W [5]. The Archimedes screw turbine is a technology that since ancient times has been invented and applied as a pump, in its construction consisting of one or several helical blades mounted on a shaft and functioning as a moving bucket to bring water up. Along with the need for utilization of potential sources of water energy with low head, the use of screw is applied as a water turbine. The advantages are that it can be operated at a very low head of up to 1 meter, does not interfere with the river ecosystem, the turbine life is more durable, especially if it is operated at low rotation, easy to operate, and cheap to maintain [4].

A. New Renewable Energy

Indonesia's potential for renewable energy for electricity reaches 443 GW, including geothermal, water and micro-mini hydro, solar, wind and ocean wave bioenergy. The potential for solar power in Indonesia has the largest portion, more than 207 MW, followed by water and wind. Even though it has a very large and diverse potential for renewable energy, its utilization is still minimal. Indonesia's new and renewable energy development is still lagging behind when compared to the G20 countries which are transitioning to a low-carbon economy in an effort to achieve the Paris Agreement targets. Indonesia has a challenging homework to do to encourage optimal use of renewable energy and reduce dependence on fossil energy. These factors prompted the Indonesian government to issue a National Energy Policy (KEN) on national energy management. KEN also compiled a roadmap towards increasing the role of renewable energy in national electricity generation. The following are power plants that utilize renewable energy sources according to KEN, namely hydroelectric power (PLTA) and micro hydro (PLTMH), solar power plants (PLTS), wind power plants (PLTB), biomass power plants, and electric power plants. geothermal energy (PLTPB). It is stated that in 2025 it is expected that the role of renewable energy will reach at least 23% of the total national power generation capacity [6].

B. Hydroelectric Power Plant (PLTA)

Hydroelectric power (PLTA) is a generator that relies on the potential and kinetic energy of water to produce electrical energy. The electrical energy generated is commonly referred to as hydroelectric. The main form of this type of power plant is a generator connected to a turbine which is driven by the kinetic energy of water. In hydropower, the water potential is converted into electric power, first the water potential is converted into mechanical energy in a water turbine, then the water turbine rotates a generator that generates electrical energy. Utilization of hydroelectric power plants is classified according to the amount of power generated. Based on the classification of hydroelectric power plants, it can be seen the function and capacity advantages of several hydro. The Pico Hydro Power Plant (PLTPH) is a water plant that has a capacity of less than 500 W, this plant is a type of hydroelectric power plant that is suitable to be applied in locations that have low fall height and not too much water flow [6][12, 13, 14, – 16].

C. Micro Hydro Power Plant (PLTMH)

Micro Hydro Power Plant (PLTMH) is a small-scale power plant (less than 100 kW), Pico Hydro Power Plant (PLTPH) is a scaled plant under PLTMH that utilizes water flow as a source of energy. PLTPH is a renewable energy source and deserves to be called clean energy because it is environmentally friendly. Hydropower comes from the flow of a small river or lake that is dammed and then from a certain height and has the appropriate discharge to drive a turbine which is connected to an electric generator. The higher the water drop, the greater the potential energy of the water that can be converted into electrical energy. Hydroelectric power is a form of energy change from hydropower with a certain height and discharge into electric power, using water turbines and generators [1].

Turbine is the most important component in Micro Hydro Power Plant (PLTMH). The turbine used in the modeling of this PLTMH is an Archimedes screw turbine. This Archimedes screw turbine is still very rarely used in Indonesia. Research on the use of screw turbines in PLTMH makes it easier to carry out tests related to the parameters that affect the performance of the Archimedes screw turbine, one of which is the effect of water pressure [7].

The use of screw turbines for Micro Hydro Power Plants (PLTMH) is a breakthrough. An appropriate technology and can be developed in villages that have irrigation canals. Furthermore, power plants are expected to be able to use screw turbine innovation in the development of power plants so that they can be used for villages that have irrigation canals, because electricity is needed [8]. The process of making a screw turbine consists of several stages, namely the plate cutting process, the plate cutting process, the withdrawal process (press), the welding process (joining), the balancing process, and for the screw housing the rolling process is carried out [9]. optimization of the prototype of the Arhimedes screw turbine in the Micro Hydro Power Plant can be done using a variation of the gearbox. The gearbox ratio used is a ratio of 1.5, a ratio of 2, a ratio of 2.4, and a ratio of 2.8. The water discharge used is 2.91 l/s and the head tilt is at an angle of 20°. The turbine used has 3 blades on a 3 phase low rpm generator. Based on this optimization, a fairly good electricity conversion ratio is produced based on the use of screw turbines in power plants [10].

II. METHOD

The PLTPH design stage uses a screw turbine following the research method as follows. The system explains how water is converted into electrical energy. The research method includes tool planning, tool testing, data collection, data analysis, and drawing conclusions.

The design of a piko hydro power plant prototype follows the input, process, and output stages. The input stage consists of an on/off switch, where the switch functions to turn the system on and off. The process block consists of a water pump, turbine, generator, and current, power and voltage monitoring. This water pump functions to pump water from the bucket to the tub and fill it to turn the turbine. The screw turbine functions as a rotating tool when exposed to water which will drive the generator. The generator is used to convert the mechanical energy obtained from the rotation of the water turbine into electric power. Monitoring current, power and voltage using the INA 219 sensor.

The output block consists of generating electricity and turning on the light. The process of the occurrence of electricity begins with water flowing into the storage container and reaches a minimum height. The water will flow through the screw turbine and drive the turbine. Then the turbine rotates and causes the generator rotor to rotate so that it converts mechanical energy into electrical energy. The output of the generator is stabilized by a solar charge controller. The electricity is stored in the battery, from the battery the electric current is converted which is initially DC into AC current using an inverter so that electricity can be used to turn on the lights.

The research design of PLTPH follows the flow chart as a standard to describe the process. Each step in the system is represented by a symbol and the flow of each step is represented by a line with arrows. The flow chart can be seen in Fig. 1.

The working principle of the Piko Hydro Power Plant Simulation that shows in flowchart system Fig. 1 is started by water flowing into the reservoir and reaching a minimum height. Water will flow through the screw turbine and drive the turbine. Then the turbine rotates and causes the generator rotor to rotate so that it converts mechanical energy into electrical energy. The output of the generator is stabilized by a solar charge controller. Electricity is stored in the battery, from the battery the electric current is converted which is initially DC into AC current using an inverter. The electricity produced can then be directly utilized.

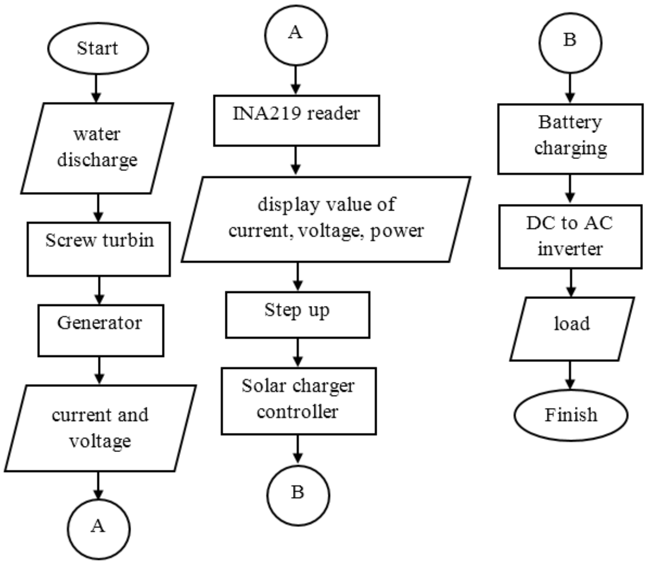

Figure 1. Flowchart System

The design of this research PLTPH follows Fig. 2.

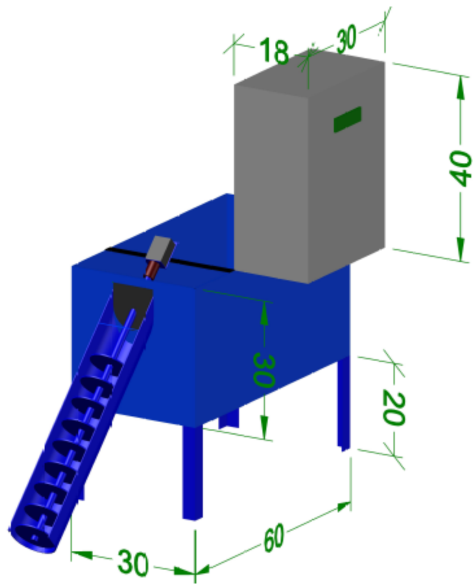

Figure 2. Mini PLTPH Design in centimeters

III. RESULTS AND DISCUSSION

Tool testing is then carried out on the implementation of the completed tool design. Tool testing aims to determine and analyze the level of success, weaknesses and limitations of PLTPH using a screw turbine that has been made. PLTPH Simulation Testing Using Screw Turbine With 10 Watt Power. analysis of test results from the PLTPH simulation in the form of calculation analysis, analysis of readings of measuring instruments and sensors. Analysis of calculations and measurements will be presented in the form of tables and graphs. Tests carried out such as generator testing, namely measuring current and voltage.

A. Current and voltage testing

The test is carried out by comparing the results of the INA sensor readings with a digital ammeter. The test was carried out with a water discharge of 5.67 x 10^{-4} m^3/s. The test was carried out by collecting data five times. Based on Table I, the readings of the INA 219 sensor with the measurement results show that the lowest average difference is 0.1 mA while the highest difference is 1.3 mA.

TABEL I

TEST RESULTS OF CURRENT AND VOLTAGE FROM SENSOR INA219

No	Test	INA219 (mA)	*Ammeter* (mA)	Generator speed (rpm)
1	Test 1	11,6	11,5	184
		11,2	11,3	183
		11,4	11,3	180
	Mean	11,4	11,3	182,3
2	Test 2	13,6	11,6	185
		13,1	13,4	180
		13,8	14,5	181
	Mean	13,5	13,1	182
3	Test 3	12,4	12,4	191
		12,3	12,1	192
		12,2	12,6	199
	Mean	12,3	12,4	194
4	Test 4	12,2	12	189
		12,5	12,8	182
		12,9	13,5	185
	Mean	12,5	12,7	185,3
5	Test 5	10,9	11,3	182
		10,9	11,5	180
		11,1	11,4	185
	Mean	10,9	11,4	182,3
	Total Mean	12,2	12,18	185,1

Fig. 3 is a comparison graph of the results of measuring current values using the INA219 sensor and the results of measuring currents using an ammeter. The blue line is the result of the INA sensor detection while the orange line is the result of the Ammeter current measurement. From the graph, it can be seen that the difference in value between the sensor detection results and the measurement results is quite balanced.

Based on Fig. 3 on the comparison of the current sensor and ammeter generated by direct measurements during the study, it was found that in tests 1 to 5 it can be seen that the current value in the current sensor and ammeter measurement is directly proportional to the value at the generator speed. The greater the speed of the generator produced from the screw turbine which moves at the speed of water flowing with a certain discharge, the greater the current generated, and vice versa [11]. shown in Fig. 3. also shows a precise graph of the measurement results between the current sensor and the ammeter with the total average value of each measurement of 12.2 A and 12.18 A at a generator speed of 185.1 rpm.

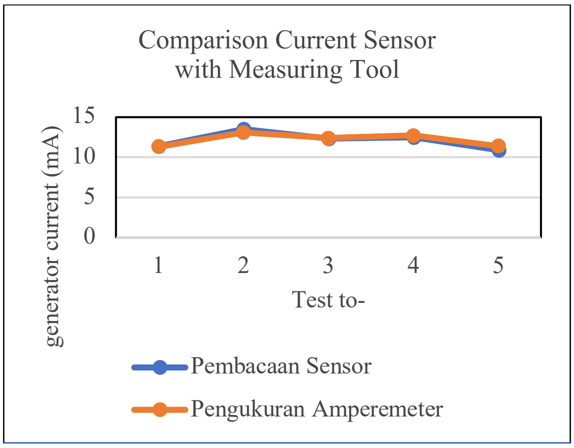

Figure 3. Comparison current values result

The sensor INA 219 voltage measurement test result is shown in Table II.

TABEL II
MEASUREMENT VOLTAGE TEST RESULT BY INA219 SENSOR

No	Test	INA219 (volt)	Voltmeter (volt)	Generator speed (rpm)
1	Test 1	2,43	2,09	184
		2,38	2,01	180
		2,41	2,4	183
	Mean	2,4	2,16	182
2	Test 2	2	2,1	185
		2,5	2,8	189
		2	2,4	184
	Mean	2,16	2,43	186
3	Test 3	2,54	2,19	191
		2,53	2,2	190
		2,9	2,1	183
	Mean	2,65	2,16	188
4	Test 4	2,49	2,1	189
		2,45	2,09	189
		2,99	2,33	186
	Mean	2,64	2,17	188
5	Test 5	2,02	2,06	182
		2,05	2,09	189
		2,08	2,27	182
Mean		2,05	2,14	184
Total Mean		2,38	2,21	186

Based on Table II, the measurement results of the INA 219 sensor have the lowest difference of 0.9 volts and the highest difference of 0.49 volts. Fig. 4 is a graph of the comparison of voltage values on the INA219 sensor and voltage measurements using a voltmeter. The blue line is the result of the INA219 sensor detection while the orange line is the result of measuring voltage using a voltmeter. From the graph, it can be seen that the difference in value between the sensor detection results and the voltmeter measurement results is quite balanced.

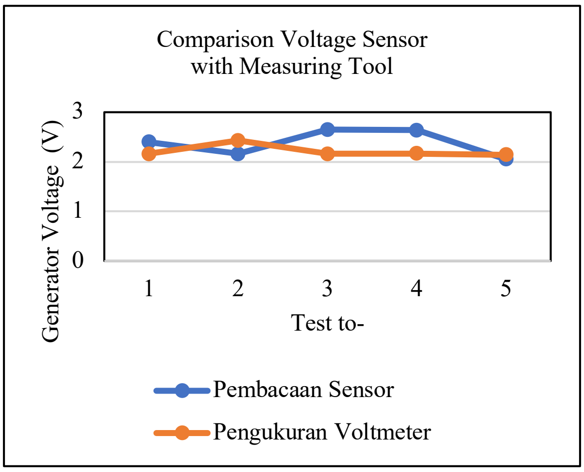

Figure 4. Comparison graph of voltage measurement results

Based on Fig. 4 Regarding the comparison of the sensor voltage and the voltmeter generated by direct measurements during the study, it was found that in tests 1 to 5 it can be seen that the voltage value on the voltage sensor and voltmeter measurements is directly proportional to the value of the generator speed. The greater the speed of the generator produced from the screw turbine which moves at the speed of water flowing with a certain discharge, the greater the voltage generated, and vice versa [11]. shown in Fig. 4. also shows a precise graph of the measurement results between the voltage sensor and voltmeter with the total average value of each measurement of 2.38 V A and 2.21 V at a generator speed of 186 rpm.

IV. CONCLUSION

PLTPH can work well when the water in the reservoir is pumped through the pipe to the PLTPH system after which it passes through the screw turbine and rotates the turbine which is connected to the generator to produce electricity. The electricity generated is monitored in the form of current, voltage, and power displayed on a 16 character x 2 line LCD. This generator simulation works at a pump discharge of 34 l/min which is equivalent to 5.67 x 10^{-4} m^3/s with a turbine rotation of 185.7 rpm. The generator voltage is 2.11 VDC, the generator current is 11.75 mA and the power generated by the generator is 24.82 mW with a 15 W light bulb load. The resulting step up voltage to charge the battery is 13.04 VDC. As for the current is 12.4 mA. The battery charging power is 161 mW.

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