Initial prototype of power plant based on river currents prime mover: design and testing

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Abstract. The river currents is one of renewable energy types. It can be utilized for electrical generation. This study discusses about design and testing of initial prototype of power plants based on river currents prime mover. The working principle of this prototype is to convert kinetic energy from water current into electrical energy. The prototype testing were carried out at several variations of river currents velocity: 0.6, 0.8, 0.9, 1.2 and 1.3 m/s. The testing at 1.3 m/s velocity produced 1300 rpm of generator rotational speed, 0.22 A of electrical current, 5.2 V of electrical output voltage and 1.14 Watt of electrical power output.

1. Introduction

Indonesia has many large and small rivers. The river has a very vital function, such as being a source of drinking water, transportation facilities, cultivation facilities, conservation sites, recreation areas, etc [1]. Other than that, the river holds the potential for developing electrical power based renewable energy to support community activities. The river utilization to generate electrical power can be a solution to the depletion of fossil energy sources or other non-renewable energy sources [2,3]. Another advantage of this river energy power plant is the low operating costs and does not cause pollution.

The model of micro-hydro power plant generally designed as run off river type. The type requires no dam or reservoir [4]. In principle, micro scale hydroelectric power plants utilize different heights and debit in the flow of water from irrigation channels, rivers or waterfalls. This water flow will rotate the turbine shaft so that it produces mechanical energy. This energy then drives the generator and the generator generates electricity [5]. A micro-hydro scheme requires two things namely, water debit and the height of the fall (head) to produce power that can be utilized. This is a system of energy conversion potential energy into the form of mechanical energy and electrical energy. For rivers that do not have different heights, the river current can be utilized as electrical generator prime mover [6]. The river currents prime mover power plant can be operated as distributed generation (DG). It connected directly to the load or isolated mode operation [7-9].

2. Methods

2.1 Prototype design

The prototype design consists of turbine design, turbine pole or shaft design, and final design. The turbine used in this study was a four axis blade turbine. The turbine design shown in figure 1. The turbine pole and axle design shown in figure 2. The complete prototype design shown in figure 3. The complete prototype design is a combination of turbine design, turbine pole and shaft design, and generator installation on the top of the turbine shaft.

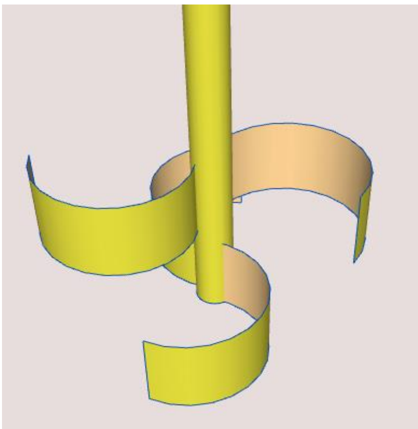

Figure 1. Turbine design.

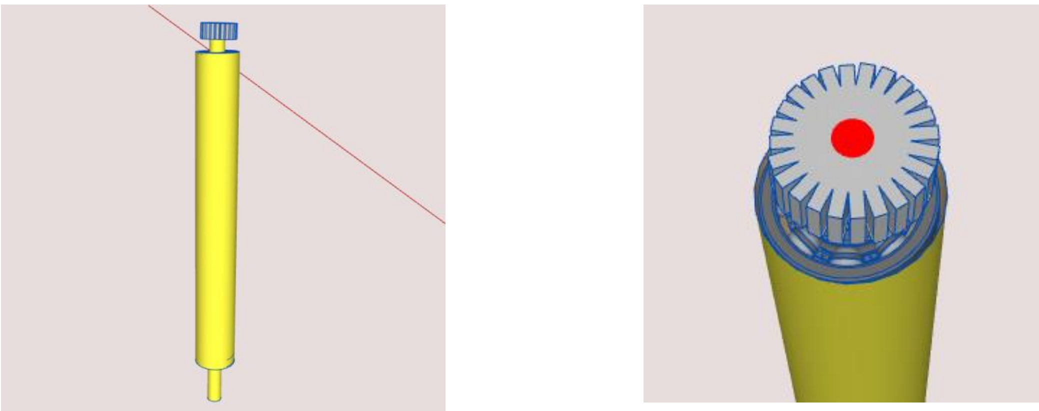

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Figure 2. Turbine pole and axle design (a) side view (b) top view.

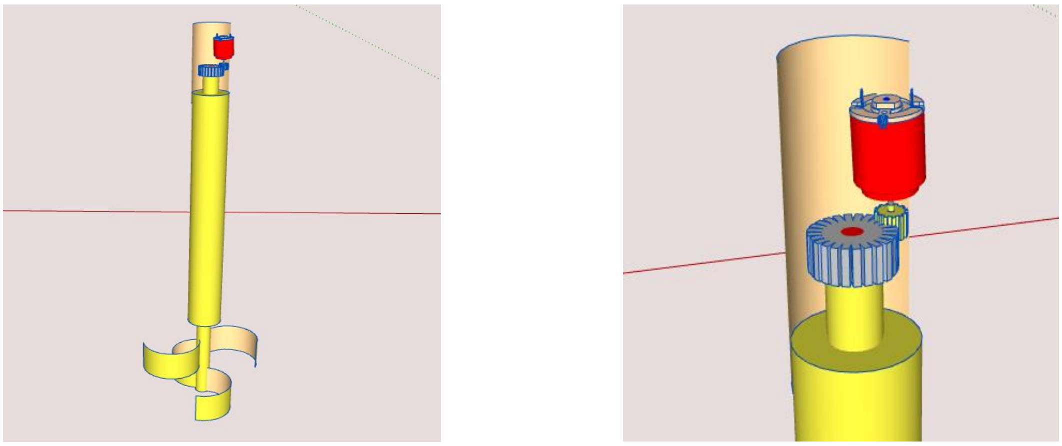

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Figure 3. Complete prototype design (a) side view (b) top view.

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The generator used in this prototype shown at figure 4 and has the following specifications.
Maximum voltage: 24 volts
Current: 0.6 Amperes
Speed: 7000 rpm
Motor length: 33 mm
Motor diameter: 27 mm

Figure 4. DC generator.

2.2 Prototype testing

The data collection process was carried out in the Bendungan Bulu Cenrana river flow, Pitu Riawa District, Sidenreng Rappang Regency. River flow characteristics at these locations have speeds that vary from 0.4m / s to 1.3m / s, so that the location supports the testing process of the equipment we made. The parameters measured at the time of data collection are river current flow speed (m / s), generator rotational speed (rpm), generator output current (Ampere), generator output voltage (Volt), output voltage from boost converter (Volt), and generator output power (Watts).

Current flow velocity measurements using conventional measuring devices, measuring the generator rotational speed using a tacho meter, while measuring current and voltage using an analog multimeter. In addition to measurements using a multimeter, data retrieval is also done by installing a load of ten LED lights on the generator output and a DC light bulb on the output boost converter. The research data obtained from the testing of the tool are as follows.

3. Results and discussion

3.1 Test result

The test was carried out using a four axis vertical turbine turbine and a 24 volt dc generator with the following measurement results as shown in table 1.

Table 1. The test results of prototype.

Current River Velocity (m/s)	Generator Rotational Speed (rpm)	Generator Output Voltage (Volt)	Generator Output Current (Ampere)	Generator Power Output (Watt)
0.6	450	1.8	0.07	0.13
0.8	725	2.9	0.12	0.35
0.9	875	3.5	0.15	0.53
1.2	1195	4.7	0.2	0.94
1.3	1300	5.2	0.22	1.14

3.2 Result analysis

Based on the results of the study table can be obtained a graph of the correlation of water flow velocity on voltage, the correlation of water flow velocity on current, the correlation of water flow velocity on generator rotational speed, and the correlation of water flow velocity on generator output power.

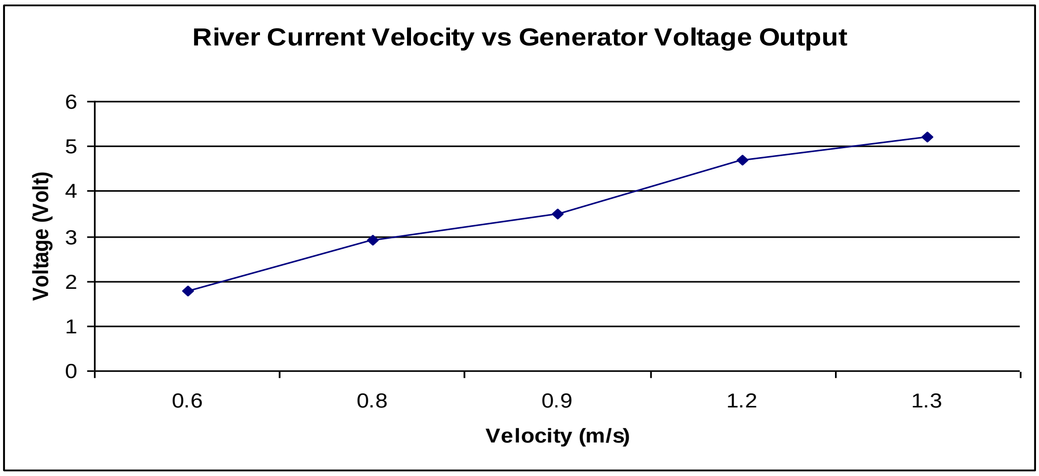

Figure 5. The correlation between river current velocity and generator output voltage.

The figure 5 shows the effect of changes in water flow velocity on the output voltage of the generator where at the lowest speed (0.6 m / s) produces a voltage of 1.8 volts and the highest speed (1.3 m / s) produces a voltage of 5, 2 volts. The increase in voltage from 1.8 volts to 5.2 volts is directly proportional to the increase in water flow velocity, from 0.6 m / s to 1.3 m / s. The graph above shows an increase in voltage that is not constant (linear). One cause of the nonlinearity is the turbine rotation that is not linear to the difference in water flow velocity. At low water speeds the turbine rotates unstable so that the generator output voltage read on the gauge fluctuates.

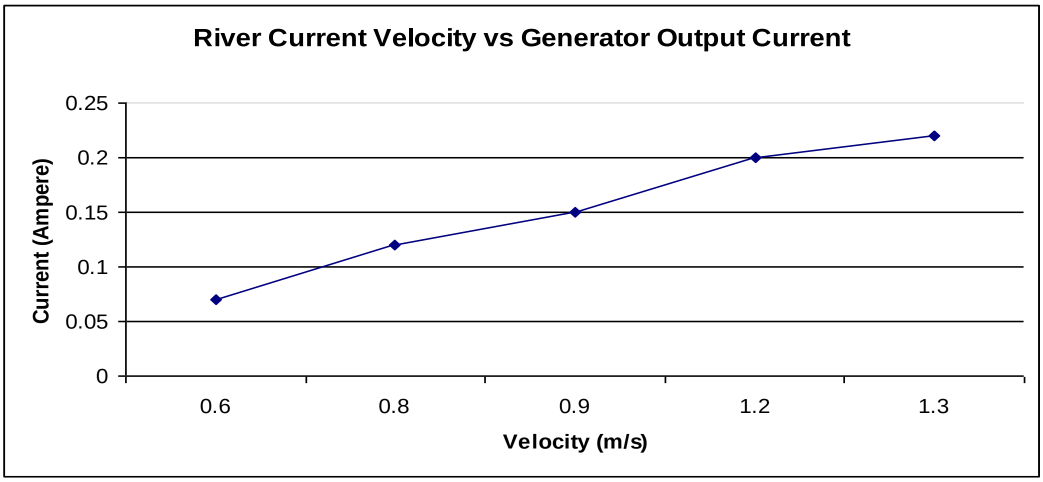

Figure 6. The correlation between river current velocity and generator output current.

From the data from the measurement results of the generator output voltage using the turbine, a voltage value of 5.2 is obtained when the water flow rate is 1.2 m / s. In this condition the river current energy power plant has not met the requirements to be implemented in the field. For this reason, turbines and generators with better specifications are needed in order to produce greater voltage.

The graph in figure 6 shows the effect of changes in water flow velocity on the output current of the generator where at the lowest speed (0.6 m / s) produces a current of 0.07 Amperes and at the highest speed (1.3 m / s) produces a current of 0,22 Amperes. The increase in current from 0.07 Ampere to 2.2 Ampere is directly proportional to the increase in water flow velocity, from 0.6 m / s to 1.3 m / s. The graph above shows the output current from a very small generator. Factors causing the small current generated by the generator are the specifications of the generator that cannot produce large currents and the instability of the turbine rotation. Data from the generator output current measurement results indicate the amount of current generated at a water flow velocity of 1.3 m / s, which is 0.22 amperes, while the amount of current needed to carry out the battery charging process is 0.4 to 3 amperes.

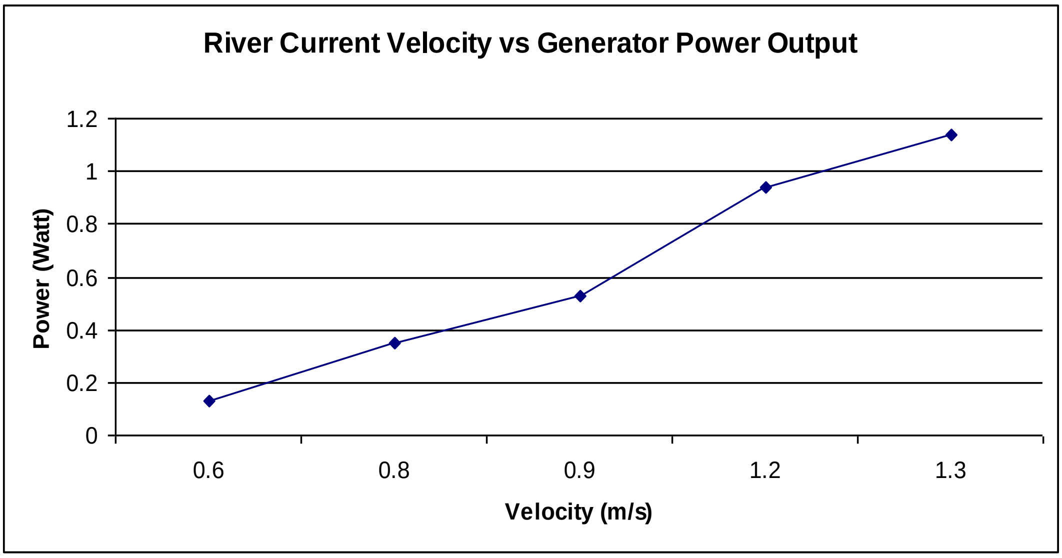

Figure 7. The correlation between river current velocity and generator output power

The graph in figure 7 shows the effect of changes in water flow velocity on the power generated by the generator. The power obtained on the graph is the result of the multiplication of the output voltage and current from the generator with the equation P = V x I. This is caused by the limitations of the measuring instruments used. The graph in figure 7 shows an increase in power that tends to be constant (linear) to changes in water flow velocity. From the graph above it can be seen that the maximum power that can be generated from the device that has been made is equal to 1.14 watts.

4. Conclusion

Based on the results of testing the prototype of a water flow energy power plant, several conclusions can be drawn as follows. This research has succeeded in making a prototype of a power plant by utilizing the speed of water flow as driving energy. The working principle of this prototype is to convert mechanical energy into electrical energy. The electricity generation of river currents has the potential to be implemented in small streams.

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