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RESEARCH ARTICLE

Design of a 25 W Picohydro Power Plant Using Proportional Integral Derivative (PID)

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Abstract

Energy is a very important resource in achieving social, economic and environmental goals for sustainable development and is a supporter of national economic activities. Energy use in Indonesia is increasing rapidly in line with economic growth and population growth. Two-thirds of the total national energy needs come from commercial energy and the rest comes from biomass which is used traditionally (non-commercially).

Pikohydro is a hydroelectric power plant that has a power of under 5kW per unit. Picohydro usually has three main components, namely water (energy source), turbine and generator. Picohydro can be used as an alternative to oil-fueled diesel power plants which are not environmentally friendly and have relatively expensive operational costs. This system is designed by utilizing the flow of water flowing in the river using the on grid method because the current in the river tends to be stable if you don't use batteries because it is more economical. Apart from that the voltage is relatively unstable because the voltage that is converted to AC electricity tends to fluctuate, therefore To increase the voltage, use a DC to DC converter which is equipped with a PID system to stabilize the voltage. In this DC to DC converter, it is used to provide a DC output voltage that varies in size according to the demand on the load.

Keyword: PID, Pikohydro, Powerplant, Renewable Energy

Introduction

Energy is a very important resource in achieving social, economic and environmental goals for sustainable development and is a supporter of national economic activities. Energy use in Indonesia is increasing rapidly in line with economic growth and population growth. Two-thirds of the total national energy needs come from commercial energy and the rest comes from biomass which is used traditionally (non-commercially). About half of all households have not been reached by the national electrification system. The need for electrical energy is currently a major need both in big cities and in rural areas. PT. PLN is making innovations to meet electricity needs in Indonesia, for rural areas PLN is making hydroelectric power plant innovations as an effort to utilize local resources. One alternative that can be used to obtain electrical energy is using a picohydro electric power plant.

Pikohydro is a hydroelectric power plant that has a power of under 5kW per unit. Picohydro usually has three main components, namely water (energy source), turbine and generator. Picohydro can be used as an alternative to oil-fueled diesel power plants which are not environmentally friendly and have relatively expensive operational costs. This system is designed by utilizing the flow of water flowing in the river using the on grid method because the current in the river tends to be stable if you don't use batteries because it is more economical. Apart from that the voltage is relatively unstable because the voltage that is converted to AC electricity tends to fluctuate, therefore To increase the voltage, use a DC to DC converter which is equipped with a PID system to stabilize the voltage. In this DC to DC converter, it is used to provide a DC output voltage that varies in size according to the demand on the load. The weakness of picohydro power plants is that the voltage that comes out is sometimes unstable, therefore it is necessary to have a controller or PID controller. The working principle of a PID controller uses a PID algorithm with a boost converter as a plant for response characteristics until there is a problem or error. Based on the explanation above, the author designed a Picohydro Power Plant design using the Proportional Integral Derivative (PID) method with an output target of 25 Watts.

Method

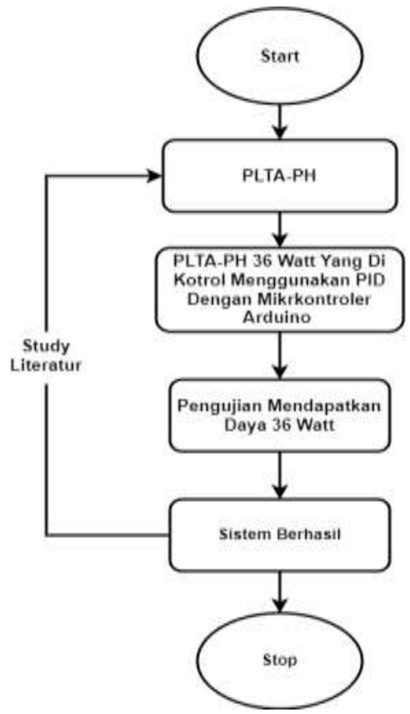

Fig 1. Reasearch Flow Chart

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The diagram above explains several research stages that will be carried out, namely by creating a PLTA-PH series, with a target power output of 25 Watts.

Pikohydro PLTH PID Design

The picohydro workflow section is carried out to find out the stages of work that will be carried out in this research. There are several steps that will be taken as shown in Figure 2 below.

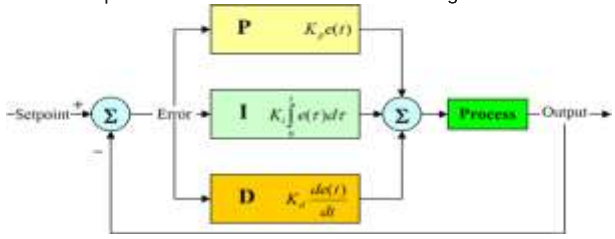

Fig 2. Picohydro Workflow

In the first step, identification of water sources is carried out with the aim of determining the location of the water source that will be distributed. The selected location has sufficient and stable water sources so that sufficient energy is obtained. Next, the water discharge is measured and calculated to understand the potential power that can be generated by the water flow. Measurements and calculations are carried out by calculating the cross-sectional area and water speed. Next, the power potential is calculated using the formula Power (watts) = Discharge (m^3/s) × Density (kg/m^3) × Gravity (m/s^2) × Height Increase (m). After obtaining the power potential value, the power generation system design is then carried out which includes generator selection, turbine selection and other supporting components. Next, the PID system was designed, where the PID functions to stabilize the power output of the Pikohydro PLTH. After the system is formed, testing and evaluation is then carried out to obtain results that are deemed good enough so that data analysis can be carried out.

PicoHydro System Design

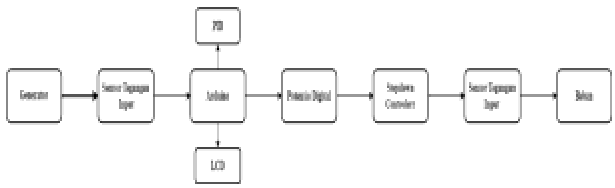

Fig 3. Diagram Block System

The design of the picohydro system is carried out in several stages, namely field observations, where at this stage the available water potential is measured. Next, picohydro mechanical design is carried out. Next, the electronic system design is carried out, at this stage the electronic components needed for this research are designed.

PicoHydro Mechanical Design

Table 1. Data and Specification Mechanical Design

Fungsi	Keterangan	
Pipa Saluran air sungai ke penampungan	Panjang	28m
	Diameter	1Inch
Penampung Air	Tinggi	90cm
	Diameter	59cm
Pipa saluran air dari penampung ke generator	Panjang	12m
	Diameter	1inch
Nozzle	Panjang	20cm
	Diameter *Input*	1inch
	Diameter *Output*	1/2Inch
Rangka Generator	Panjang	50cm
	Tinggi	32cm
	Lebar	33cm
Turbin	Tinggi	4cm
	Diameter	14cm
	Lubang As	7mm

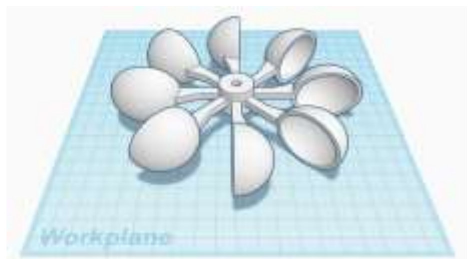

Fig 4. Turbine Design

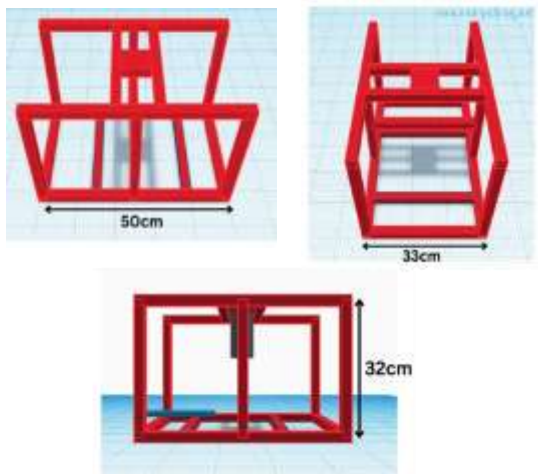

Fig 5. Framework Design

In table 1 you can see the data and mechanical specifications used in this research. Because the location is in a tourist area, the river water is channeled to other places using a 1 inch pipe 28 meters long, then the water that is flowed is collected in a reservoir with a diameter of 59 cm and a height of 90 cm made of plastic. Next, the water is channeled to the generator using a 1 inch pipe with a length of 12 m which is connected to a nozzle with an output hole of 1/2 inch. The water that comes out of the nozzle is used to rotate a turbine with a diameter of 14cm and a height of 4cm which is connected to a generator with a 7mm iron axle. To support the generator, a frame is made of iron measuring 50cm long, 33cm wide and 32cm high.

PID Design

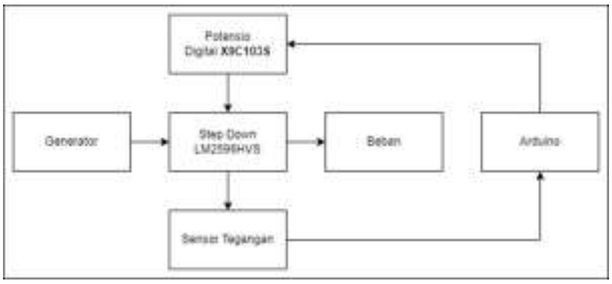

Fig 6. PID Block Design

The PID system design aims to determine the work flow of the PID system on the components used, where the design can be seen in Figure 6. The design above explains that the voltage produced by the generator will be connected to the stepdown, then the output from the stepdown will be connected to the voltage sensor so that when the sensor detects the voltage it will be read by the Arduino, where the Arduino is the center of the PID calculation system.

Results and Discussion

PID system testing aims to reduce spikes in changes in output voltage values produced by the generator. In the PID system, a "SET POINT" value is required, where the setpoint value is used as a benchmark value to calculate the resulting error. From the generator test results, it can be seen that the generator can produce a voltage of 16.1V - 25.0V, therefore it was decided to set the setpoint to 25.0V, where if the voltage value is more than 25.1 it will be considered an error.

The PID circuit system has several paths, namely, the output voltage of the generator is connected to the stepdown input, then the output of the stepdown is connected to the load and the voltage sensor, where the voltage sensor value will be read by the Arduino and then if there is an error (the voltage value exceeds 25.0), the Arduino will give command to the x9c103s digital potentiometer to provide resistance so that the error value can be reduced. In PID testing, several stages are carried out, namely looking for Proportional, Integral and Derivative values, where to find these values, trials are carried out several times until you get the ideal value. The ideal value in question is when the combination of proportional, integral and derivative values produces the most stable voltage, namely 16.0V.

Proporsional (Kp)

The initial step in establishing a PID system requires a Kp value, where determining the Kp value is done manually, namely by carrying out several experiments to get the best Kp value, namely by making sample Kp values of 0,5,10,15 and 20 with results as shown in the picture. following:

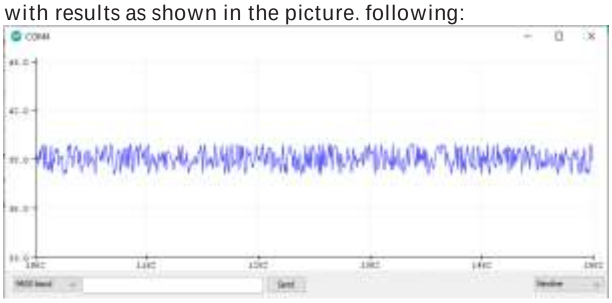

Fig 7. Kp = 1

From testing with a proportional value = 1, it can be seen that the output voltage is 15.3V to 20.7V, whereas without the proportional value the output voltage is 19.1V to 22.1V.

Integral (Ki)

After knowing the proportional value, then a trial is carried out to get the integral value. The integral value aims to reduce data change time, where the response when only given a proportional value is too fast causes the voltage to rise and fall too quickly, so an integral value is needed to reduce this time so that changes in the output value are expected to be more stable. The test was carried out by carrying out several experiments in which the integral value would be tested with integral values 1,2,3, and 4 with the following results:

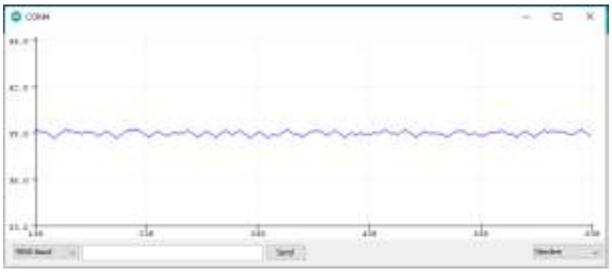

Fig 8. Kp=8,5 + Ki=1

Experiments with values of Kp=8.5 and Ki=1 obtained results that the output voltage change spike was not too fast but the error value which was previously 18.9 to 23.2 increased to 18.8 to239.4.

Derivatif (Kd)

From previous experiments we can know the values of Kp and Ki, then we need to evaluate the derivative or Kd to form a PID system where to get the Kd value several experiments are carried out to get the best value. The derivative value aims to anticipate voltage spikes so that the output voltage is more stable. The trial was carried out by carrying out several experiments in which the derivative value would be tested with integral values 1, 2, and 3, with the following results:

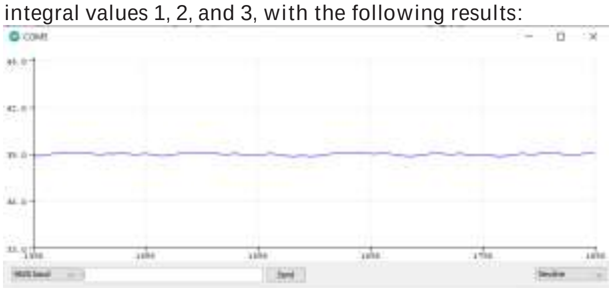

Fig 9. Kp=8,5 + Ki=0,7 + Kd=1

From several experiments that have been carried out, the value Kd=1 was obtained which is considered to be the ideal value because it is able to suppress errors better when compared with derivative values of more than 1 or less than 1.

Result PID Test

From testing the Proportional (kp), Integral (Ki) and Derivative (Kd) values, the PID values have been obtained, namely Proportional = 8.5, Integral = 0.7 and Derivative = 1. This test has obtained quite good results which can show differences in spikes. voltage. The differences can be judged from the following graph:

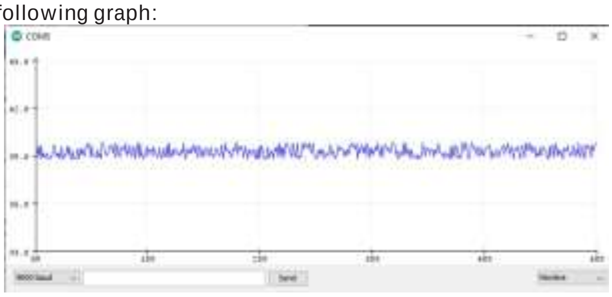

Fig 10. Result Without Using PID

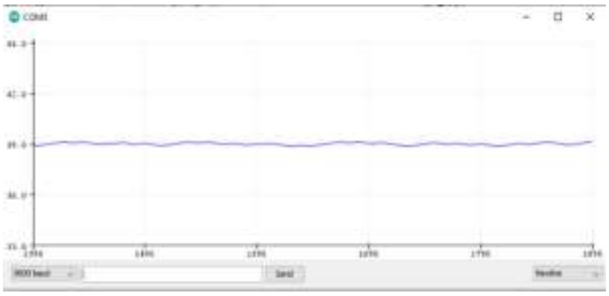

Fig 11. Result Using PID

From the picture above, you can see the comparison between a system without PID and a system that uses PID, where the system that uses PID gets a more stable output voltage than the system that doesn't use PID.

Conclusion

The application of the PID system to the picohydro with values of Kp=8.5, Ki=0.7, Kd=1 and setpoint value = 36 succeeded in stabilizing the voltage when compared to systems that do not use PID. The voltage that does not use PID is 16-25V and that uses PID is 21.92 – 25.11 with an average generator speed of 1024rpm. From this data it can be seen that the use of PID can reduce generator voltage fluctuations which previously reached 3V and can be reduced to 0.54V.

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