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The analyse of the automotive alternator as a generator in Picohydro system: Laboratory experiment test

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Abstract. The aim of this article is to evaluate the feasibility of using an automotive alternator as a Pico water turbine (Picohydro). The automotive alternator system is examined by the pump as a turbine, using water energy in the simulator system to generates the automotive alternator. The simulator equipment that has been made is used to see the performance of the automotive alternator as a generator and recorded a few parameters in the closed-loop system. From this evaluation, the greater the water flow or water pressure that drives the pump as a turbine, the higher the power is produced from the automotive alternator. The Study shows that automotive alternator can be used as a generator and an alternative to generating electricity.

1. Introduction

The scarcity of fossil fuels and the effects of environmental pollution are some of the factors to convert conventional energy sources into renewable energy sources. Several studies have been conducted to develop green energy sources such as geothermal energy, biomass, solar energy and water wave energy. Among renewable energy resources, energy from micro hydropower has its own appeal because of its environmentally friendly operation. So that makes it the best choice for electricity in rural areas.

Indonesia has many renewable energy sources but has obstacles in getting energy development targets. Because it still relies on energy from fossil fuels around 96% (48% fuel, 30% coal, and 18% gas). The development of power plants between 2003 and 2013 has increased by around 7.3% per year. From various power plants in Indonesia, gas power plants have the highest growth rates of around 10% per year. The use of steam power plants has a growth rate of around 9.3% per year. Based on consumption, steam power plants have the highest consumers, 46.7%, followed by a combination of steam and gas power plants (19.3%) and diesel power plants (11.6%). Meanwhile, consumption of renewable energy power plants is still very low; Hydroelectric power plants are 9.9%, geothermal power plants 2.6%, mini hydro power plants are 0.2% and micro hydro power plants are 0.1% [1]. The energy sector in Indonesia is undergoing significant changes that create challenges and opportunities. Energy demand continues to grow along with the nation's economic growth. The challenge is to meet the increasing demand while advancing towards a sustainable energy system. This challenge requires the use of new energy technologies, increasing the use of renewable energy sources, and increasing energy efficiency [2].



Hydroelectric power generation is the oldest renewable energy source. By converting mechanical energy into an electric energy generator. This is one of the renewable energy sources that are not polluted and environmentally friendly. This energy source is also free from inflation due to the absence of fuel costs.

There are several similarities in the theory of automotive alternator. But the difference is how energy transfer occurs. Water turbines convert the potential energy from water into mechanical energy of the shaft rotation. And then energy from shaft rotation transfer to automotive alternator to generate an electricity.

Hydro power that has electricity output below five kilowatts (5kw) is in the Pico-Hydro category. This system is more useful than other large hydro systems because it has a low cost, can be installed anywhere, environmentally friendly and easily available to people. The new Pico-hydro micro technology has made it a more economical power source in developing countries. The voltage generated can be used to drive standard electrical equipment such as bulb, radio, television, refrigerator and others [1].

Among the components that are demanded to be found in local market yet bear high cost for still being imported is low speed generator. This condition has driven people to make use of any available and cheap generator types. One of them is automotive alternator [3].

An automotive charging system is made up of three major components: the battery, the voltage regulator and an alternator. The alternator works with the battery to generate power for the electrical components.

This choice is motivated by the following reasons.

- Low cost: due to the high volume of alternators manufactured yearly for automotive application, they are inexpensive.
- Availability: alternators can be found in most parts of the world.
- Maintainability: in automotive application, alternators have been found to have high robustness even when they are used in harsh operating conditions.
- They are designed specifically to generate electricity for battery charging [4].

2. Methodology

Based on introduction, a tool had been made to see the performance of the automotive alternator as a power plant turbine at the time as a driver of water flow rate. The method used is by making test equipment to measure the performance of the automotive alternator connected to pump as a turbine with the closed-loop method of water flow, while the research process diagram is shown in figure 1.

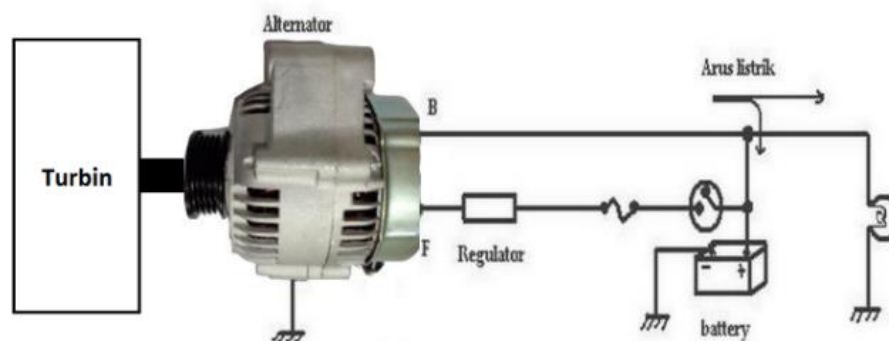


Figure 1. Automotive alternator connected to pump as a turbine.

To make an experiment analysis, a test design has created by collecting the material and then assemble all the material at once for recording and data analyzing. The flow process is shown in Figure 2.

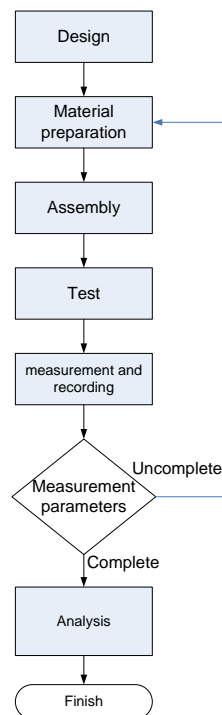


Figure 2. Research process diagram.

This design is to see the performance of the automotive alternator connected to pump as turbine in variations in water flow rate and variations in water pressure.

The manufacture of test equipment was built in a mechanical workshop owned by Infrastructure Company in Jakarta to simulate an automotive alternator connected to centrifugal pump system as a water turbine under water pressure control and water flow rate control. The pump as the drive is controlled by the flow and pressure of the water by adjusting the rotational speed of the pump using the variable drive (inverter). Then this pump is connected to automotive alternator to generate an electricity. So that the automotive alternator as a generator can see its performance. All settings components are schematically shown in figure 3.

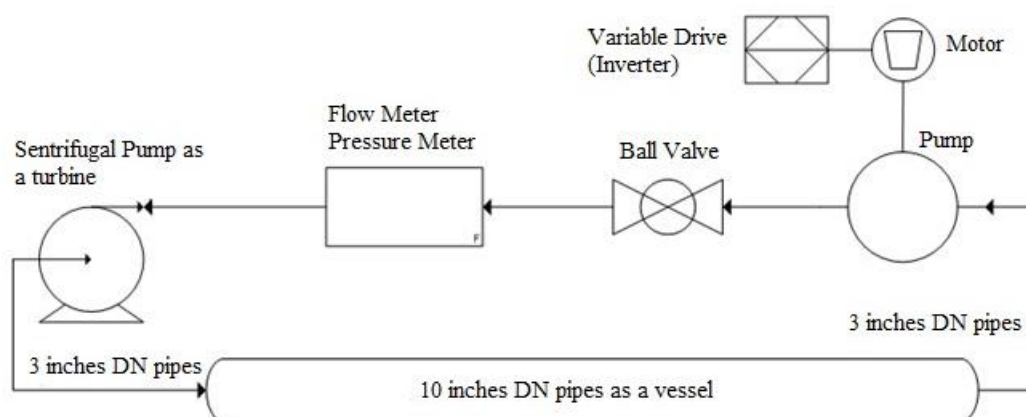


Figure 3. The pico-hydropower schematic test.

The details of the equipment used in this study as shown in figure 3 :

- 2.1. *Automotive alternator*
Brand: Wujin Electrical
Product number: 2JF200
Type: Negative pole to earth
Capacity: 200 Watt
- 2.2. *Pump as turbine*
Brand: Ebara
Type: Centrifugal end suction
Serial no: 3S 50. 125/3.0
Kapasitas: 1000 liter/minute
Rotation speed: 3000 Rpm
Fabrication no: D-08
- 2.3. *Multi stage pump as a power to drive water*
Brand: Grundfos
No. Seri: CR30-50AFA-BBVE
Capacity: $3,0 \text{ m}^3/\text{hour} = 0,83 \text{ liter / second}$
Maximum pressure: 16 Bar
- 2.4. *Motor as a pump drive*
Brand: Grundfos
Power: 7,5 Kw
Voltage: 380 – 415 Volt
- 2.5. *Variable drive (Inverter) as a pump motor controller*
Brand: Fuji Electric
Type: FRN11AR1M-4A
- 2.6. *Flow meter and pressure meter*
Brand: Premier Isoil
Model: ML250
No. Seri: 39L4385
- 2.7. *AVO Meter*
Brand: Fluke
Type: 336
- 2.8. *Rotation measuring instrument (Tachometer)*
Brand: Lutron
Model: DT 2234BL



Figure 4. Test equipment.

The observed parameters:

- Power output from automotive alternator in various load.
- Shaft Rotation of centrifugal pump used as a turbine
- Flow rate of water
- Pressure / head of water

3. Results and discussion

From the results of observations in the parameters numbers 3, 4 and 5 above, the measurement data is obtained as shown in table 1.

Table 1. Measurement data.

Pump Shaft Rotation (Pump as Turbin)	Flow Meter (l/s)	Pressure (bar)
1240	5.28	0.51
1264	5.27	0.51
1663	6.23	0.85
2045	7.20	1.26
2414	8.09	1.73
2768	9.21	2.25
3084	9.87	2.77

Based on the measurement results, a graph of data is made and shows that the hydro energy flowing to the pump is directly proportional to the rotational speed of the pump shaft. The higher the hydro energy flowing the higher the rotation on the pump shaft. To obtain efficiency data, it is necessary to have pump characteristic data to be used as a turbine as shown in Figure 4 and based on these characteristics it is assumed that the pump efficiency is 60% [5].

Based on data and theoretical analysis in measurements where water flow and pressure change linearly higher, then the power data is obtained in Watt units as shown in table 2.

Table 2. Flow and pressure move up.

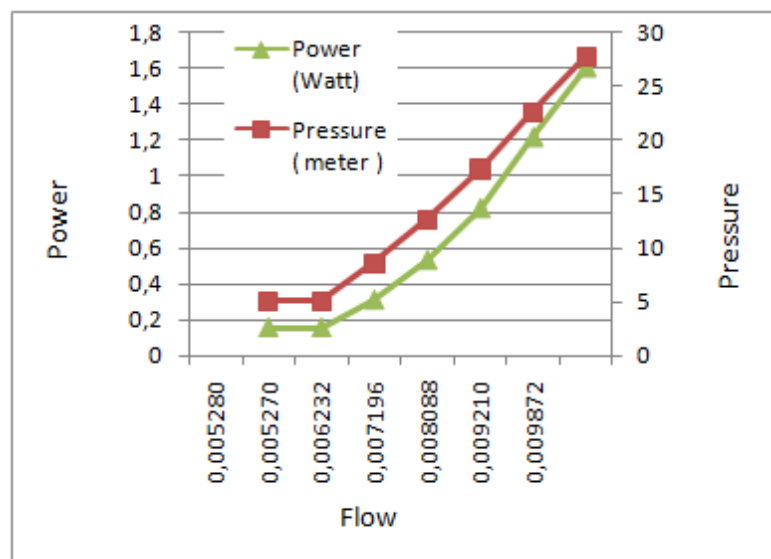
Flow Meter (m^3/s)	Pressure (meter)	Power (watt)
0.005280	5.06	0.1567
0.005270	5.06	0.1564
0.006232	8.48	0.3100
0.007196	12.60	0.5319
0.008088	17.32	0.8218
0.009210	22.54	1.2178
0.009872	27.74	1.6065

Based on data and theoretical analysis in measurements where the flow of water moves higher linearly while the pressure does not change or is stable at 0.4 meters' pressure, then the power data is obtained in Watt units as shown in table 3.

Table 3. Pump hydropower, Flow move up and pressure stabilizes.

Flow Meter (m^3/s)	Pressure (meter)	Power (watt)
0.004400	0.4	0.010325
0.005300	0.4	0.012436
0.006110	0.4	0.014337
0.007060	0.4	0.016566
0.007980	0.4	0.018725
0.008900	0.4	0.020884
0.009760	0.4	0.022902

Based on the data that has been taken in the experiment that the pump as a turbine can produce electricity where the greater the pressure and water flow received by the pump, the greater the power produced. Where the characteristic curve of the centrifugal pump used as a turbine is shown in figure 5.

**Figure 5.** Pump curve, Flow and pressure move up.

And if we maintain in a stable pressure position and the water flow tends to increase then we will get a characteristic curve as shown in figure 6.

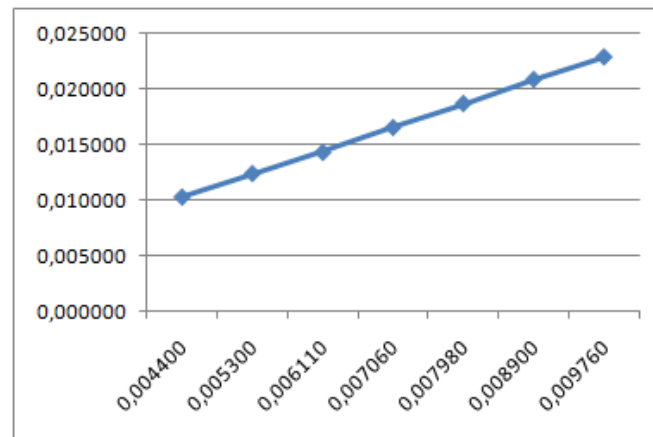


Figure 6. Pump curve, Flow moves up and pressure stabilizes.

The data/curve shows that the greater the water flow and or water pressure that drives the pump as a turbine, the higher the power produced. And with this data that the power is marked straight towards the water flow and water pressure.

4. Conclusion

Pumps are available in wide variations and models where water pressure and flow rates are important parameters for the application of industrial, commercial and domestic sectors. They experience various advantages compared to conventional hydro turbines namely. low cost, mass production, availability for various pressures and flow rates, short delivery times, large availability in standard sizes and parameters, ease of spare parts availability, easy installation, etc. It has been found that, technically all types of pumps namely axial flow, mixed flow, radial flow, double suction and multistage pumps can be used in turbine mode for electricity generation.

In this paper, the use of centrifugal pumps as turbines in a low-pressure Pico hydro system is obtained by a number of data. First, centrifugal pumps are reverse operated in various operations. Then a test equipment was built to see the characteristics of the centrifugal pump when operated as a water turbine.

this study shows that centrifugal pumps can function as water turbines and are an alternative to produce electricity with low efficiency. And the use of a pump as a turbine can easily be accessed by pump units and spare parts because the amount is quite a lot in the market.

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