

Design and implementation: Portable Floating Pico-Hydro

D Dewatama^{*}, M Fauziah, H K Safitri and S Adhisuwarnjo

Department Electrical Engineering, State Polytechnic of Malang, Malang, Indonesia

*denda.dewatama@polinema.ac.id

Abstract. Malang City which is located at an altitude between 440 - 667 meters above sea level, and surrounded by mountains. Thus, the city of Malang has many springs and rivers with high speed flow. At present, river flow energy that used as hydroelectric power is very least. River flow hydroelectric power schemes are often presumed to be less ecologically damaging than large-scale storage hydroelectric power schemes, and then low priced materials, easy to use and easy to care for. Therefore, researchers have design of Portable Floating Pico-Hydro (PFPH). PFPH using a low speed DC generator (500rpm, 18VDC, 15A), controller, DC-DC converter and battery as a load. Voltage output of PFPH is set to have a constant output of 14 volts DC with PI control algorithm. Specifications of PFPH are turbine diameter is 500mm, turbine width is 500mm, overall length is 1200mm and overall width is 1200mm. PFPH tested at a water speed of 1.5 m/s - 4 m/s and generated power 10W-223W.

1. Introduction

The need for electricity in the last few years in Indonesia has grown in line with population and economic growth. Unfortunately, the increased utilization of electrical energy has not been fully offset by an increase in electricity supply by Indonesia State Electricity Enterprise (PLN). Where, in 2017 PLN was only able to provide 95.35% of the needs [1]. Most of the areas that have not been electrified because of geographical problems (one of which is mountainous areas). While the utilization of renewable energy is 13.7 MW from 60789.98 MW that has been provided by PLN [1]. On the other hand, ecological maintenance has also been an issue in recent decades.

Malang City is a city located in East Java Province, Indonesia. Malang City is located on a plateau with a height of between 440-667 meters above sea level. Malang City has many springs and rivers. Small hydro-power plants and pico-hydro power plants have acquired increasing attention due to their ecological irreproachability and acceptable prices for generating electricity available without producing harmful pollution and greenhouse gases [2]. For a well, planned and operated hydropower project, electricity generation technology is stated as one of the cheapest in terms of possible costs because of the working fuel availability free of cost without its wastage [3].

Currently, most hydropower projects are built using dammed to created reservoir [4]. The construction of a hydropower project requires a large amount of funds. This is not suitable to be developed in remote areas, where the community must provide their own electricity needs. Successful isolated rural micro-hydro systems usually have one thing in common: a competent, resident, on-site operator [5]. Lack of funds to build the hydroelectric power plant is also one of the obstacles. The villagers are also characterized by their low economic income [6]. Maintenance is a problems that include training, technical and organizational skills. On the other hand, water reservoir development has an ecological impact on river flow [7].



Floating electrical generator is one solution that does not disturb the ecosystem, is low cost, easy to use and easy to maintain. The way a floating electrical generator works is to utilize river flow without damming or building water reservoirs. Water flow in the river depends on precipitation and ground water flow. These parameters may have substantial daily, monthly, or seasonal variations.

The contribution of this work is to propose a design of a floating electrical generator that works independently. This system is made portable so it is easy to use in areas that need it, cheap and easy to maintain. This system does not require permanent installation on a river or canal. This is purely a renewable hydro powered with pollution free.

This paper explains the results of the installation and measurement of PFPH. This paper is organizational as follows. Section 2 discusses the research method, consisting of the specifications of the equipment designed. Section 3 discusses the results of testing the PFPH output power at different water speeds. Section 4 is the conclusion of this paper.

2. Methods

2.1. Floating pico-hydro

To design a floating pico-hydro portable, a waterwheel with a water flow is needed below. A waterwheel rotates because of the kinetic energy stored in the flow of water. The undershot water wheel which is also known as the stream wheel is shown in Figure 1. In the undershot wheel, entering the water level is always below the wheel axis [8].

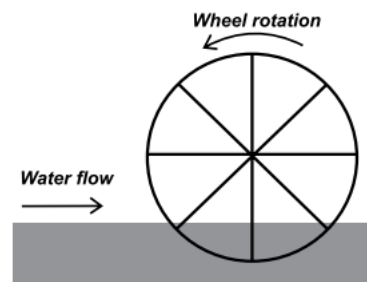


Figure 1. Undershot water wheel mill.

In this type of water wheel design, the wheel is simply placed directly into a fast flowing river and supported from above. The motion of the water below creates a pushing action against the submerged paddles on the lower part of the wheel allowing it to rotate in one direction only relative to the direction of the flow of the water.

Aluminium was chosen as a pico-hydro floating system material. The basis of this system is made aerodynamically in order to make maximum use of water flow and has stability in its place moored. The overall mechanical design of floating pico-hydro can be seen in Figure 2, overall specification can be seen in Table 1.

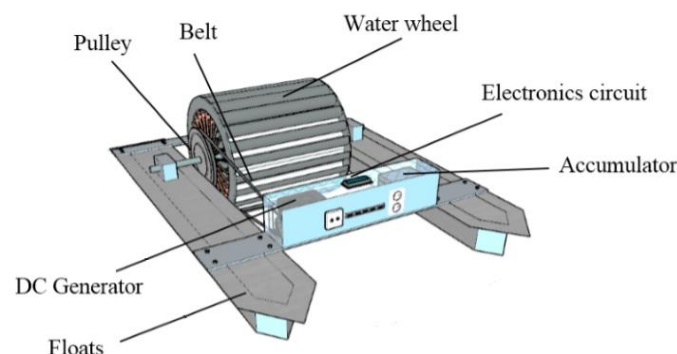


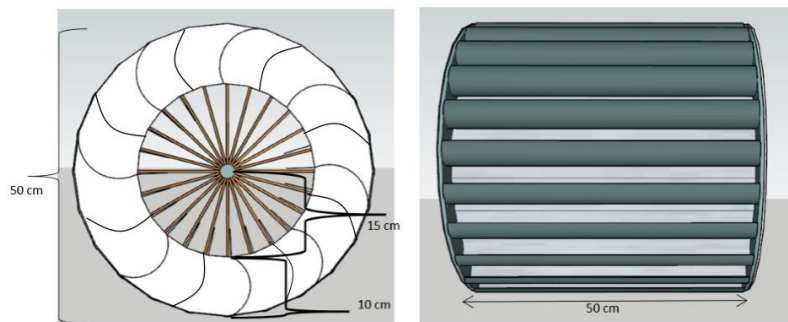
Figure 2. Floating pico-hydro design.

Table 1. Floating pico-hydro specification.

Specification	Unit
Material	aluminium
Number of float	2
Dimension of float	30cm x 100cm x 30cm
Total length	100cm
Total width	120cm
Diameter ratio pulleys wheel and generator	10:1

2.2. Undershoot water wheel

Water turbine is made of aluminium plate with 16 closed blades. The blade is closed in a design like Pelton; when the water comes to hit the turbine, it gets trapped and pushes the turbine. The Pelton turbine consists of specially shaped buckets [9]. Design undershoot water wheel show in Table 2.

**Figure 3.** Water wheel design.**Table 2.** Undershoot water wheel specification

Specification	Unit
Material	aluminium
Number of blade	16 pcs
Wheel diameter	50 cm
Wheel width	50 cm
Height blade	10 cm
Rotation wheel at flow 4 m/s	40 rpm

2.3. DC generator magnet permanent

The generator is an important part in the electrical generating system, because the generator functions to change the energy of the motion (water wheel rotation) into electric power. Some parameters that need to be considered in choosing a generator, such as nominal speed, power output, dimensions, and weight. The generator used in this study can be seen in Figure 4 and its specifications in Table 3.

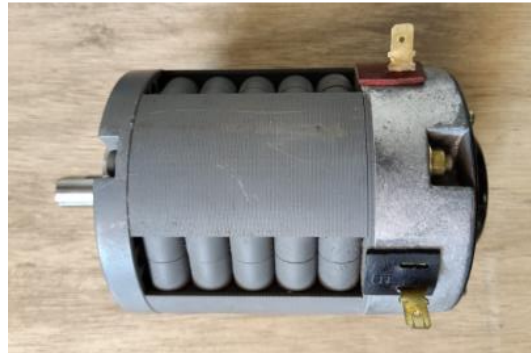


Figure 4. Permanent magnet DC generator.

Table 3. Specification permanent magnet DC generator.

Specification	Unit
Length	10.5 cm
Diameter	8.5 cm
Type	Permanent magnet
Nominal speed	500 rpm
Weight	2.7 kg
Voltage	DC 12-18V
Current	15A

2.4. Electronics circuit

Some of the main parts in the electronic circuit are generators as electric power generators, dc-dc converters as DC voltage conversion, voltage and current sensors to detect input and output voltage and current dc-dc converters, micro controllers as overall system control, LCD as displays and batteries as a load. The block diagram of an electronic circuit can be seen in Figure 5.

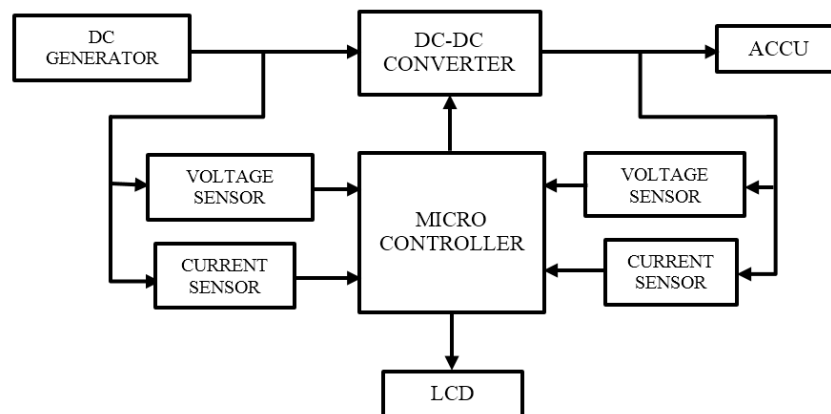


Figure 5. Diagram block.

3. Result and discussion

The results of the PFPH design can be seen in Figure 6. The PFPH has been tested by observing changes in river flow velocity to changes in power generated. The results of the inhibition are tabulated in table 4 and graph in Figure 7.



Figure 6. Portable floating pico-hydro.

Table 4. Water flow versus output power.

Water flow (m/s)	Output power (Watt)
1	3
1.5	12
2	28
2.5	54
3	93
3.5	140
4	205

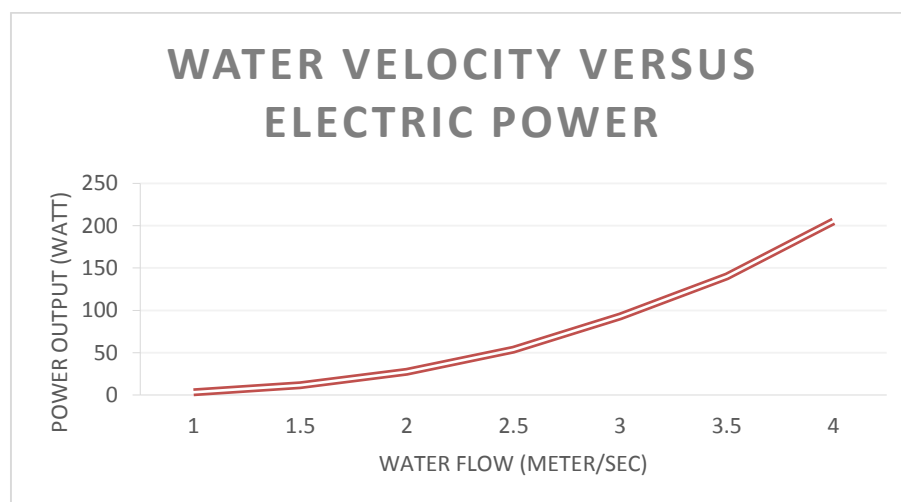


Figure 7. Power curve.

Based on the data, the power output increases logarithmic based on changes in flow velocity. At a flow speed of 4 m / s it produces 205 watts of power.

4. Conclusion

Portable floating pico-hydro is an efficient device compared to conventional devices. This is a cost-effective system because it does not require permanent installation of civil works, is easy to operate, and does not disturb river ecology. Output power increases exponentially with water flow. The output power at 4 m / s water speed is 205 watts.

References

- [1] Indonesia Ministry of Energy and Mineral Resources 2018 *The Book of Electricity Statistics* Number 31 [Online] Retrieved from: www.djk.esdm.go.id
- [2] Wang L, Chen S-J, Jen S-R and Li H-W 2012 Design and implementation of a prototype underwater turbine generator system for renewable micro hydro power energy *IEEE Industry Applications Society Annual Meeting*
- [3] USA Department of Energy 2012 *Hydropower Technology Information Basic Energy Information* [Online] Retrieved from: www1.eere.energy.gov/water/hydro_plant_types.html
- [4] International Energy Agency Technology roadmap: Hydropower [Online] Retrieved from: <https://www.iea.org/publications/freepublications/publication/technology-roadmap-hydropower.html>
- [5] Kumara, Suparyawan D P D, Ariastina W G, Sukerayasa W and Giriantari I A D 2014 Microhydro powerplant for rural area in Bali to generate green and sustainable electricity *International Conference on Smart Green Technology in Electrical and Information Systems (ICSGTEIS)* IEEE
- [6] Robinson P 1988 Microhydro in Papua New Guinea—the experiences of an electrical engineer *Power Engineering Journal. Institution of Engineering and Technology (IET)* **2** 5 pp 273
- [7] Gary S B, Niall G B, Matthew D T, Jeremy C G and Harriet G O 2017 The effects of run-of-river hydroelectric power schemes on invertebrate community composition in temperate streams and rivers *Plos One*
- [8] Denny M 2004 The efficiency of overshot and undershot waterwheels *Eur. J. Phys.* **25** 2 pp 193–202
- [9] Joseph R and Umanand L 2012 Turbine emulator for development of variable speed microhydro power generation systems *IEEE Third International Conference on Sustainable Energy Technologies (ICSET)*