Design of a prime mover turbine propeller open flume micro-hydro electric power plant 1 kW

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Abstract. West Java has many rivers that have high falls and varied water discharges where utilization is not optimal. The study aims to utilize water energy to be able to produce a Micro Hydroelectric energy generator. The design of this PLTMH starts from measuring the potential of water, designing turbines and generators, then observing the work system of PLTMH and estimating the electric power that will be generated by the PLTMH. From chosen location, it is known that the water flow is 0.0059 cubic per second and has a waterfall height of 4 meter. This data is used to select the type of turbine, selection of reservoirs, rapid piping, and generator design. The results obtained by the design of Micro Hydro Power Plant (PLTMH) using open flume propeller turbines and 3-phase generators are changed to 1 phase. Open flume propeller turbines have a simple construction and can be operated at a waterfall height of 3-6 meters and low water discharge so that the use of open flume turbines for micro-hydro power plants will be used in river flows that have high waterfall and water discharge the low one is very appropriate. With a turbine rotation speed of 2,063 rpm, this PLTMH is capable of producing 1,346 watt turbine power with a 45 liter per second water flow so that the power obtained is 1,076 watt.

1. Introduction
A Micro Hydro Power Plant (PLTMH) is a small scale power plant that uses hydropower as it is driving force, such as irrigation channels, rivers or natural waterfalls by utilizing high waterfalls and the amount of water discharge. Water fall and capacity of water affect the electric power generated. Flowing water then flowed to the generator house, then the water turns the turbine.

Micro Hydro Power Plant (PLTMH) is an alternative source of electrical energy for the community. This power plant utilizes a river that has a low head of less than 50 meters as its driving force and has a capacity 1 kW until 100 kW [1]. Electricity generation is mostly done by rotating synchronous or asynchronous generators so that electric power is obtained with alternating voltage of three phases.

The mechanical energy needed to rotate the synchronous generator is obtained from the generator drive engine or commonly called a prime mover. Generator drives are widely used in practice, namely: diesel engines, steam turbines, water turbines, and gas turbines [2].

2. Methods
The research method explains the design of construction of PLTMH and the application of open flume propeller turbines. Where the design is divided into two part, namely the design of building construction and design of turbine construction. The first research flow is to conduct a literature study that is to get information about the basic theories as a source of making and writing this research.
Survey and data collection were carried out to determine the strategic location for micro-hydropower plants [3-4]. The calculation of water discharge and measurement of waterfall height are carried out to find out how much power capacity will be generated and the type of turbine [5].

The block diagram of the working principle of the Micro-hydro system can be show Fig. 1.

![Diagram block working principle micro-hydro system.](image)

**Figure 1.** Diagram block working principle micro-hydro system.

Energy potential water flows into the turbine after the turbine rotates generate mechanical energy, turbines in coupling with the generator by using the V-belt generate electrical energy and then goes into the control panel and protection then electrical energy into the resistive load and the burden on consumers, capacity ballast load must be the same as the generator due to accommodate the unused power of the load, because when the load exceeds the capacity there will be a trip and the power will automatically move to the resistive load [6].

3. **Prototype design**
   This stage begins by conducting the following in Fig. 2 is the overall design picture of open flume turbine propeller construction [7].

![Open flume propeller turbine construction.](image)

**Figure 2.** Open flume propeller turbine construction.

4. **Results**
   This chapter will discuss the results of tests on the design of open flume propeller turbines that have been made. This test aims to find out whether the equipment made has gone well as planned or not. The suitability of the system with planning can be seen from the results achieved in testing the tool [8]. Testing also aims to determine the strengths and weaknesses of the tools that have been made. The physical form of the open flume propeller turbine that has been installed with an AC generator can be seen in Fig. 3.
4.1. Measurement and calculation of water discharge

To determine the amount of discharge water contained in a river/irrigation or micro-hydropower plants it can be done by measuring the velocity of the water entering through the pipe rapidly [9-10]. From the results of research on measurement and calculation of water discharge, the results are obtained in Table 1.

| Measurement to - | Hour          | Time (t)  | Discharge (Q) |
|------------------|---------------|-----------|---------------|
| 1                | 10:10:23 WIB  | 2.82 secs | 45.74 L/s     |
| 2                | 10:16:03 WIB  | 2.99 secs | 43.75 L/s     |
| 3                | 10:22:14 WIB  | 3.40 secs | 38.47 L/s     |
| 4                | 10:29:30 WIB  | 3.72 secs | 35.16 L/s     |
| 5                | 10:36:53 WIB  | 3.84 secs | 34.07 L/s     |
| Average          |               | 3.35 secs | 39.43 L/s     |

4.2. Calculation of turbine power

The following in Table 2 is the result of the calculation of turbine output power based on available water discharge.

| Minute Measurement | Water Discharge (Q) | Turbine Output Power (Pt) |
|--------------------|---------------------|---------------------------|
| 1                  | 45.74 L/s           | 1,346 watt                |
| 2                  | 43.75 L/s           | 1,287 watt                |
| 3                  | 38.47 L/s           | 1,132 watt                |
| 4                  | 35.16 L/s           | 1,034 watt                |
| 5                  | 34.07 L/s           | 1,002 watt                |
| Average            | 39.43 L/s           | 1,160 watt                |

Measurement turbine rotation with a water flow of 45 liters/seconds shows in Table 3.
Table 3. Measurement turbine rotation.

| Testing to | Turbine Rotation (rpm) |
|------------|------------------------|
| 1          | 2,063                  |
| 2          | 2,045                  |
| 3          | 2,060                  |
| 4          | 2,061                  |
| 5          | 2,048                  |
| Average    | 2,055.4                |

5. Conclusion
It can be concluded that debit water available in the river Berecek Village when the rainy season reached 59.25 liters/second and during the dry season reached 45.74 liters/second, the characteristics of the discharge water affects the turbine rotation if the discharge is not in accordance with the specifications that should the turbine rotation will decrease from 2,063 rpm to water flow 45.74 liters/second to 2,048 rpm with water flow 34.07 liters/second and turbine mechanical power is reduced from 1,346 watt to 1,002 watt so that it affects the generator output power.

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References
[1] Suryadi A 2015 Electric Energy & LAB Power Plant Diktat (Indorama Engineering Polytechnic Purwakarta)
[2] Afryantima S and Syukri M 2015 Design and Development of Prototype PLTPH Using Open Flume Turbines (Department of Electrical Engineering Syiah Kuala University)
[3] Dwiyanto V 2016 Analysis of Micro Hydro Power Plants (MHP) (Faculty of Engineering University of Lampung)
[4] Wibowo H, Daud A and Al Amin M B 2015 Kajian Teknis Dan Ekonomi Perencanaan Pembangkit Listrik Tenaga Mikrohidro (PLTMH) Di Sungai Lematang Kota Pagar Alam Cantilever: Jurnal Penelitian dan Kajian Bidang Teknik Sipil 4 1
[5] Joni H 2016 Selection of Water Turbines as Generator of 3 kW in Padayo Village Lubuk Kilangan District (Department of Electrical Engineering Padang State Polytechnic)
[6] Yohannes C 2015 Design of Load-Frequency Control Systems in PLTMH Matano East Luwu Regency Department of Electrical Engineering (Faculty of Engineering Hasanuddin University)
[7] Cihanjuang Inti Teknik 2018 Operation Guide for PLTMH Turbine Propeller Open Flume 1 kW
[8] Suryadi A 2017 Over frequency Relay Calibration at the Unit 1 Generator Protection System of PT. Java Bali Power Plant Cirata Generation Unit Juteks 4 1 41-47
[9] Amsary M A 2017 Report on the Design of Hydroelectric Power Plants Designing Propeller Turbines (Department of Energy Conversion Engineering Bandung State Polytechnic)
[10] Akhmad S 2015 Kaplan Water Turbine Simulation on PLTMH in Sampanahan River Magalau Hulu Village Kotabaru Regency (Department of Mechanical Engineering Lampung Mangkurai University)