Design of Microhydro Power Plant Prototype Based on Kelekar River Flow Discharge

Indrayani\textsuperscript{1,}\textsuperscript{*} and Renny Citra Ramadhani\textsuperscript{2}
\textsuperscript{1}Civil Engineering Department, Politeknik Negeri Sriwijaya, Palembang, Indonesia
\textsuperscript{2}Renewable Energy Study Programs, Politeknik Negeri Sriwijaya, Palembang, Indonesia
Corresponding author: iin_indrayani@polsri.ac.id

Abstract. Indonesia is a country that has a very large water source, so it has the potential to develop hydro power plant as a superior resource. One of the rivers in the province of South Sumatra has the potential to be developed as a source of micro-hydro power plants, namely the Kelekar River in Ogan Ilir Regency. The existence of the Sriwijaya University Embung which is located on the Kelekar River can certainly support the use of Kelakar River water as a micro hydro power plant. The design of a prototype for a micro-hydro power plant aims to obtain a model of the tool as a reference in making a power plant tool in the field. Making prototypes of the tool refers to the results of previous research on the characteristics of the Kelekar River, namely the design discharge (Qd) of 0.45 m\textsuperscript{3}/sec, the effective fall height (Heff) at the embung is 3.475792 m, the water flow power is 15,344 kW, and the power (pt) produced by the turbine is 11,508 kW with the turbine efficiency (\(\eta_t\)) of 0.75. The resulting discharge is 0.000145 m\textsuperscript{3}/s with a transmission speed of 23.078 m/s, and the resulting energy is 4.944 Watt.

1. Introduction
Micro hydro power plant is renewable electrical energy that is environmentally friendly since this plant uses water as its driving force. Indonesia has a very large potential for water sources so that this hydroelectric power plant can be developed as a superior energy source. Several studies related to the development of micro hydro power plants have been carried out by utilizing river flows that are scattered throughout Indonesia, including in Ngatang District, Malang Regency, East Java [1], on the Way Besai River, West Lampung Regency [2], and on the Uwe River, Jayawijaya Regency [3]. Other research that conducted to this hydroelectric power plant is the effect of fall height on the power generated by micro hydro power plants [4].

One of the rivers in South Sumatra Province that has the potential to be developed as a source of micro-hydro power is the Kelekar River, which is located in Ogan Ilir Regency. The Kelekar River is supported by the existence of the Embung of Sriwijaya University which has a spillway design with 2 sluice gates and a peak elevation of +6.00 [6], so that the existence of this embung can support the utilization of Kelakar River water as a micro hydro power plant.

From the research that has been done previously, it was found the amount of discharge generated by the Kelekar River and the height of the water fall that can encourage the movement of the turbine to drive the generator and the amount of energy produced is based on the discharge and the height of the water fall. To apply a micro hydro power plant in the field, it is necessary to make a prototype of a tool first with the aim of getting a model of the tool as a reference in making field tools.
This hydroelectric power plant has several classifications based on the power produced, namely large hydro that produces power> 100 MW, medium hydro produces power 15 - 100 MW, small hydro produces power 1 - 15 MW, mini hydro produces power 100kW < x < 1 MW, micro hydro generates power in the range of 5 - 100 kW which is usually used as a small power supply in rural areas or small rural industries outside the grid system, and finally pico hydro produces power < 5 kW [7]. Based on this classification, the planned power plant is included in the micro hydro category because the energy generated from river discharge and water fall height is 11,508 kW.

From this background, research was carried out on the prototype design of this micro-hydro power plant based on the water discharge produced by the Kelekar River, Ogan Ilir Regency.

2. Methodology
The design of this micro hydro power plant prototype is based on the flow rate of the Kelekar River and the height of the spillway at the Embung of Sriwijaya University. The design, assembly, and testing of a micro hydro power plant prototype was carried out at the Sriwijaya State Polytechnic Laboratory for approximately 2 months.

The equipment and materials used in making the prototype of this micro-hydro power plant include a tub to hold water, a turbine to drive a generator, a centrifugal pump to pump water from the reservoir to the water reservoir, a digital flow meter to measure the flow rate of water, a digital tachometer to measure speed turbine rotation, digital multimeter to measure electric voltage, electric current, and power produced, AC generator to convert mechanical energy into electrical energy, 1 inch PVC pipe as a penstock to drain and direct water from the storage tank to the turbine, and 1 inch PVC pipe as a circulation pipe to move water, 1 inch elbow, 1 inch tee, ball valve, LED light.

The steps taken in testing the tool are as follows: (i) preparing a prototype of a micro hydro power plant, (ii) filling the 500 liter water tank to the brim, (iii) connecting the instrument socket to the electricity, (iv) turning the switch to the right to start the water pump, (v) fully opening the valve (V9 / Overshoot Horizontal), (vi) observing the process, (vii) recording data on the results of the experiments that have been carried out (flow rate, turbine rotation speed, and electric current) for 10 minutes, (viii) repeat the experiment starting from steps 5 to 7 with valve openings 0, 25, 50, 75, and 100% for each flow direction, the minimum and maximum flow rates, (ix) after completing the experiment, closing the valve to stop the flow of water to the turbine, (x) turning the switch to the left on the control panel to turn off the circulation pump. The micro hydro power plant design approach can be seen in Figure 1.

![Micro hydro Power Plant Design](image)

**Figure 1. Micro hydro Power Plant Design**

Caption:
1. Turbine
5. Techometer
3. Results and discussion

3.1. Existing location

The design of this micro-hydro power plant prototype is based on the flow of water in the Kelekar River which is located in Ogan Ilir Regency. The existing conditions of the Kelekar River and the location of the Embung of Sriwijaya University can be seen in Figure 2. Meanwhile, the water flow velocity is based on the height of the water falling on the spillway at the Embung of Sriwijaya University floodgate. The condition of the spillway can be seen in Figure 3 and Figure 4.

![Figure 2. Location of Kelekar River and Embung of Sriwijaya University](image)

![Figure 3. Spillway at the water gate of the Embung of Sriwijaya University](image)

![Figure 4. Spillway Design Cross-section](image)

From previous research, it was found that the Kelekar River flow rate was 211.109 m$^3$/sec ($Q_{R_{\text{max}}}$) and 15.732 m$^3$/sec ($Q_{R_{\text{min}}}$) design discharge ($Q_d$) of 0.45m$^3$/sec, high effective energy ($H_{\text{ef}}$) of 3.475792 m,
the power of the water flow of 15.344 kW, and the power generated by the turbine (P_t) of 11.508 kW with turbine efficiency (\( \eta_t \)) of 0.75 [5][6]. This data will be used as the basis for designing a prototype of a micro hydro power plant.

3.2. Micro hydro power plant prototype design
The results of the micro-hydro power plant prototype design based on the flow rate of the Kelekar River and the height of the water fall on spillway of the Embung of Sriwijaya University can be seen in Figure 5 and Figure 6.

3.3. The results of the prototype experiment
From the experiment using 4 mm diameter nozzle within 60 seconds the volume was 8.7 liters. The performance results of 19 blade turbine using 4 mm diameter nozzle can be seen in Table 1.

| Lamp Load (watt) | Rotation (rpm) | Voltage (volt) | Electric current (Ampere) |
|------------------|----------------|---------------|--------------------------|
| 0                | 236            | 12.5          | 0                        |
| 5                | 234            | 12.3          | 12                       |
| 10               | 228            | 12.1          | 28                       |
| 15               | 219            | 12            | 44                       |

From the results of the experiment, it can be calculated that the discharge generated by the prototype of the micro-hydro power plant, namely: the discharge (Q) used is 0.000145 m³/s, the spray speed is 23.078 m/s, the power produced is 4.944 watts, to adjust to field conditions, the power must be multiplied by 3103.4483 so that the resulting power is 15343.4483 watts.
4. Conclusion

From the Kelekar river flow, the design discharge $Q_d$ is 0.45 m$^3$/det, while the high effective energy $H$ is 3.475792 m, the amount of power from the water flow is $P = 15,344$ kW, with turbine efficiency $\eta_t = 0.75$, the power generated by the turbine is $P_t = 11,508$ kW. Furthermore, from this data was made the prototype of a micro hydro power plant using 4 mm diameter nozzle, the discharge ($Q$) of 0.000145 m$^3$/s, the spray speed of 23.078 m/s, the resulting energy ($P_{in}$) is 4.944 watts. From the results obtained, it shows that the Kelekar river flow that flows into the Reservoir of Sriwijaya University can be used as a micro-hydro power plant because it can generate electricity with a capacity of 11,508 kW.

5. References

[1] Hanggara I, Irvani H 2017 Potensi PLTMH (Pembangkit Listrik Tenaga Mikro Hidro) di Kecamatan Ngatang Kabupaten Malang Jawa Timur Jurnal Reka Buana Vol 2 No 2 p 149-155.

[2] Dwiyanto V, Indriana K, Tugiono S 2016 Analisis Pembangkit Listrik Tenaga Mikro Hidro (PLTMH) Studi Kasus: Sungai Air Anak (Hulu Sungai Way Besai) JRSDD Vol 4 No 3 p 407-422.

[3] Wibowo N A, Dermawan V, Harisuseno D 2014 Studi Perencanaan Pembangkit Listrik Tenaga Mikro Hidro (PLTMH) Wamena di Kabupaten Jayawijaya Provinsi Papua Jurnal Teknik Pengairan Universitas Brawijaya.

[4] Buyung S 2016 Analisis Pengaruh Tinggi Jatuhnya Air (Head) terhadap Daya Pembangkit Listrik Tenaga Micro Hydro Tipe Turbin Pelton Jurnal Teknik Mesin, 2016 Politeknik Katolik Saint Paul Sorong.

[5] Ramadhani RC, Indrayani, Yerizam M 2020 Analysis of Ogan Ilir Regency's Kelekar River Runoff Discharge in Micro Hydro Power Plant (PLMTH) Planning Science Technology Indonesia Vol 5 No 2 2020 https://doi.org/10.26554/sti.2020.5.2 p 41-44.

[6] Indrayani, Ramadhani R C, Yerizam M 2020 Preliminary Design of Micro Hydro Power Plant in Kelekar River Ogan Ilir District Technology Report of Kansai University Japan Vol 62 Issue 04 p 1837-1844.

[7] Japan International Cooperation Agency 2011 Guideline and Manual for Hydropower Development Vol 2 Small Scale Hydropower Electric Power Development Co Ltd.

Acknowledgments

Acknowledgements for: (i) Ministry of Research and Technology/ National Research and Innovation Agency of Field Research and Development for the Magister Thesis Grants funding that has been given, (ii) Politeknik Negeri Sriwijaya, Palembang, Indonesia.