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Performance Test of Pikohidro Cross Flow Water Turbine Using Multilevel Double Penstock

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ABSTRACT

This study aims to examine the performance of pico hydro scale cross flow water turbines using multilevel double penstock as a conductor of water flow. Multilevel double penstock is used to reduce the transportation process from highways that are affordable to four-wheeled vehicles / cars to the location of the installation of the turbine. This condition causes the need for small-scale water turbine designs with lightweight construction with a kock down system. Overall the picohidro scale turbine construction is needed relatively cheaper transportation costs, so that people who have not been reached by the PLN network can be touched by small and cheap electricity. Turbine construction data has a runner diameter of 170 mm, body dimensions 200 mm x 300 mm x 250 mm, frame 250 mm x 800 mm. Pool tando 600 mm x 1200 mm and penstock length 16m. The power produced is theoretically around 2500 watts, with a data flow of 50 liters / second and a water level of 8 m. 65% efficiency. The research method is analyzing the double penstock water flow, by making paralon pipes in stages, ranging from 5 incci diameter, 4 inches and 3 inches, flow analysis approach using a gradient line, where the incoming water velocity and water velocity come out until entering the transmitting pipe. The performance results of this turbine provide an average actual power of up to 2000 watts. The stability of the inlet water condition is used by the Tando pond as a water bath. If there is excess water in the sediment tank, the water gate is used out, where excess water will automatically flow into the exhaust channel.

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1. INTRODUCTION

This cross flow turbine is designed using double decker penstock. The penstock uses a pipe arranged in parallel, where the dimensions of the penstock diameter from the tando pond to the turbine are arranged in stages. The largest diameter of the penstock is placed in the 5 inch diameter water inlet position, at the next level it is connected with a 4 inch pipe and then up to the 3 inch diameter turbine transmit pipe position. Each level of the connection is given a reduser that is downsizing from a large pipe to a small pipe. One of the considerations for the use of double penstock is to save material costs as well as material transportation costs to the power plant location. Theoretically, the fluid mechanics of multilevel penstock installation is carried out using the gradient line approach. Judging from the theory of power generated using a single penstock, not far changed by using a double stock. This multilevel penstock system provides a fuller flow of water and does not cause air entering the pipe. The air entering this pipe will give a capitation effect to the flow of water entering the turbine through the transmission pipe. Proper water flow analysis will provide a constant laminar flow in the pipeline. When the water reaches the transmitting pipe, the water velocity will increase proportionally to the height of the fall and the reduction in the cross-sectional area of the pipeline. This increase in speed corresponds to the equation of continuity. This increase in flow velocity hits the turbine runner blade. The speed of the flow of water entering the blades in the first level will be continued flow across the blades in the second level. These two cross flow processes can be demonstrated in the theory of the inflow velocity triangle and the outflow velocity triangle. In theory, the ratio of the width of the flow velocity in and outflow is the efficiency of the turbine power produced. Cross flow turbine or also called cross flow turbine can be used in water flow conditions with low flow and low head. Cross flow turbines are also widely used for micro-hydro power plants. This cross flow turbine has the advantage of: producing a high rotation when compared to the rotation produced by the wheel. This high rotation condition can adjust to the rotation of an electric generator or water pump rotation which is widely used for various purposes. This water turbine is an energy source that is environmentally friendly or does not cause air pollution and very low operational costs. Another advantage of this water turbine is that by itself the community will take care of the water source for the flow to this turbine so that the community will certainly not damage the environment by cutting down the forests that are around the plant or water source. The Indonesian government is fully trying to overcome the problem of dependence on fossil energy sources by utilizing new and renewable energy sources (EBT) which are considered to be more environmentally friendly [4].

The natural condition of Indonesia, which is surrounded by mountains, makes PT. PLN unable to reach all regions in Indonesia to meet the demand for electricity [5]. These problems can be overcome by utilizing new and renewable energy, one of which is by building micro hydro power plants (PLTMH) [6]. The factors that must be considered in the utilization of water energy include the amount of water availability, different heights that can be utilized and the distance to the residential location [7]. Turbine designs that vary with the height of water fall and the amount of water available are interesting problems to be considered as research objects in order to find the right system, shape and size in an effort to obtain maximum turbine efficiency. Illustrates that turrbin efficiency is strongly influenced by flowrate. Change in flow rate will affect the resulting efficiency change. Crossflow turbines have relatively stable efficiencies between 70% to 80%. Comparison of incoming water discharge with maximum water flow gives a picture of turbine efficiency approaching constant.

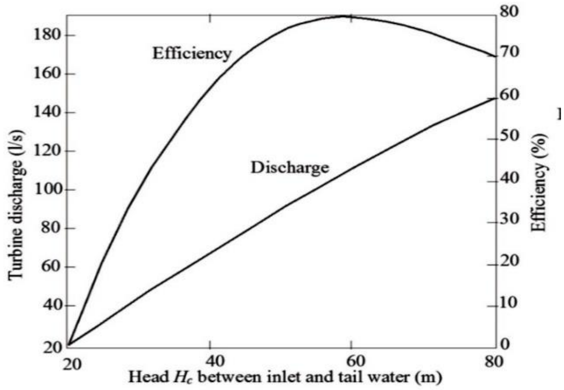

Figure 1 : Characteristic and efficiency curva for a generic turbine

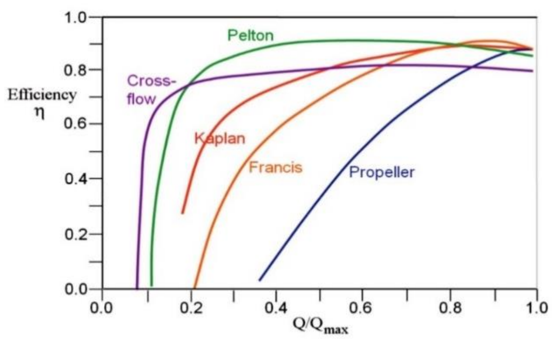

Figure 2 : Efficiency versus discharge for Kaplan, Pelton, Francis, Cross flow and Propeller turbin

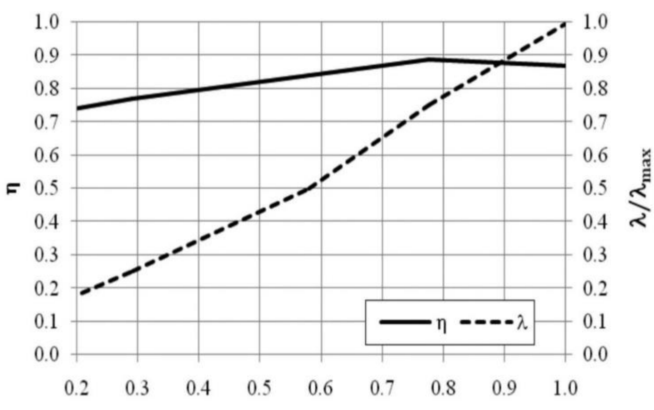

Figure 3 : Efficiency and λ curve of designed turbine

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2. MATERIAL AND METHOD

The method offered in this study is to apply the results of the study, by changing the intake flow system from the water reservoir. The flow system uses a double penstock multilevel system. The application of the double penstock method is aimed at efficiency in the cost of making penstock, efficiency in the transportation of lifting penstock components to the location. The location of the windmill is quite far from transportation that can be passed by four-wheeled vehicles. This condition causes the need for transportation to become more expensive. The penstock system used is to create a multi-level penstock. Penstock is designed starting from the installation of large diameters leading to a turbine transmission pipe that has a small diameter. The design of the penstock design is theoretically adjusted to the gradient line theory approach. In theory with a draft water debin and a 30 ° slope with a total length of 16 m. Theoretically the height of water falls around 8 m. The turbine construction design includes inlet, Tando Pond, floodgate, penstock, reducer, adapter, transmission pipe, body, runner, frame and transmission as well as water outlet.

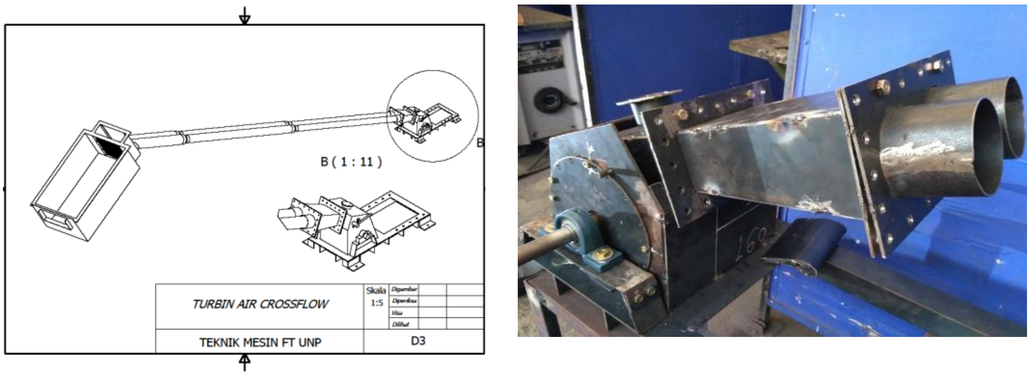

Figure 4 : Pikohydro Turbine Design

Double penstock D1 = 5 1nchi 127 cm = 0,125 , D2 = 4 inchi = 10 cm = 0,1 m. D3 = 3 inchi = 7,5 cm = 0,075 m.

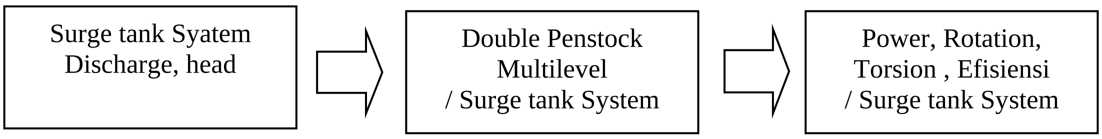

Figure 5 : Method Design

3. RESULT AND DISCUSSION

The turbine performance testing is carried out by measuring the research parameters as follows: Measurement of water discharge, carried out by opening and closing the floodgates at the top of the tando pond, Measurement of electric power generated using a volt meter and ampere meter. Measurements were taken from the control panel pad box which was extracted from the electric generator.

The height parameters are constant water, and water density. Efficiency is produced from the ratio of actual power produced and compared to theoretically generated energy.

Tabel 1. The turbine performance testing

Q1 (m^3)	g (m^2/s)	h (m)	ρ (kg/m^3)	P (watt)	ή	P.teo	E (volt)	I (Ampere)	P act	Efficiency
0,05	9,81	8	1000	3924	0,7	2746,8	226	10	2260	0,82
0,045	9,81	8	1000	3531,6	0,7	2472,12	220	10	2200	0,88
0,04	9,81	8	1000	3139,2	0,7	2197,44	210	7,8	1638	0,74
0,035	9,81	8	1000	2746,8	0,7	1922,76	208	6	1248	0,65
0,03	9,81	8	1000	2354,4	0,7	1648,08	205	5	1025	0,62

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The actual energy produced is directly proportional to the flow of water flowing in the turbine. This power is the result of measurements made on the generator output power. Electric generator used with a capacity of 3000 watts. Data from the measurement of electric voltage reaches an average of 220 volts in accordance with the voltage on the generator. Measurement of electric current using amperes, where the measurement results are always changed according to changes in flowrate. The actual power produced is around 2200 watts. This large power can be used by people who live far from the electricity grid. This much power can be used as lighting at night and can be used for simple appliances at home.

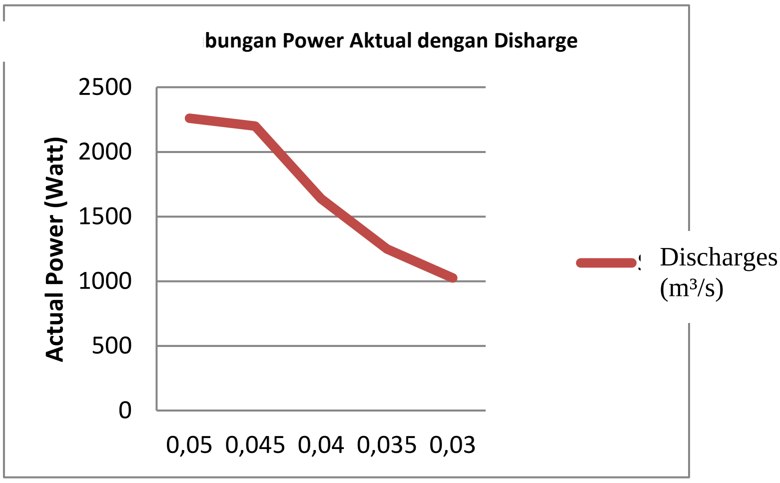

Figure 6 : Actual power and discharge curve

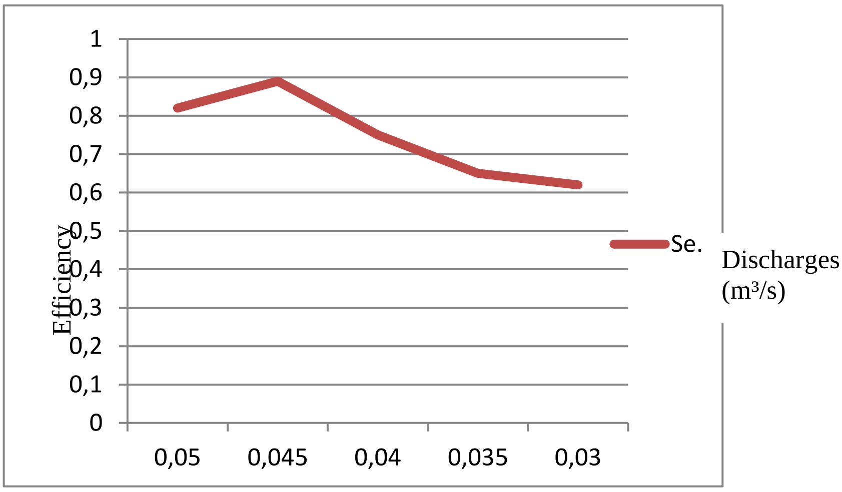

Figure 7 : Efficiency and discharges curve

4. CONCLUSION

The turbine efficiency measurement data shows that the highest efficiency reaches an average of 80% with a flow rate of 45 liters / s. Theoretically, the efficiency of crossflow turbines with pico hiydro scale has a good performance. If the flow of water entering the turbine decreases, the turbine efficiency also decreases. The approach carried out with several previous studies shows that this crosflow turbine in theory does not show a change in efficiency with a change in flowrate. For areas that have a relatively small flow of water and have changed flow rates, especially in rainy or dry seasons, it is appropriate to use this crossflow turbine for small-scale electricity generation.

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