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Artikel Penelitian

Design and Construction of Micro-hydro Model With Different Flowrate as a Learning Medium

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A B S T R A C T

Renewable energy generation such as hydropower, micro-hydro, and pico hydro are among the concerns of the government to reduce the greenhouse effect, gas emissions, and global warming and have set targets in 2025. Higher education institutions are expected to contribute to government development targets, one of which is by producing human resources, which is reliable, especially in the field of renewable energy and hydropower generation. So, we need innovative learning methods or media in the teaching and learning process. In this case, a set of demonstration tools in the form of a micro-hydro system model with varying parameters so that students can easily understand a course and could connect the theory with the real world/industry.

1. INTRODUCTION

The provision of renewable energy electricity generation is increasingly urgent as efforts to reduce greenhouse gas emissions and global warming. Renewable energy usages is a solution to overcome environmental pollution, which has now become a global problem, especially the Indonesian government. The Indonesian government has made efforts to reduce fossil energy consumption, which has set a target for renewable energy mix by 25% by 2025 [1]. Hydroelectric power plants, micro-hydropower plants, and pico hydro are some of the renewable energy sources that are of concern to the government, wherein the first quarter of 2019, the hydropower that has installed were 4947 mW [2]. This potential is still far from the energy mix target of 2025.

To achieve these targets, the government cannot be alone in carrying out development, especially in electricity powerplant. Universities or institutions, in this case, contribute to the development of targets to be achieved by the government. Institutions are expected to be able to produce qualified human resources in the field of renewable energy, especially in large and micro-scale hydroelectric power plants, so that they can contribute to development. In the context of science and technology, Indonesia belongs to a group of technology adopters and has not yet reached the implementation stage. It can be seen in the gross enrollment rate, where Indonesia ranks fourth in ASEAN under Singapore, Thailand, Malaysia, and the Philippines [3].

In this case, The Institut Teknologi Nasional (Itenas), as the tertiary institution of engineering, must innovate in terms of learning. The teaching process is not fixed with the teaching and learning process in class, which only contains a theory but can carry out teaching and learning processes that are practical and direct implementation. Fig.1 is a cone of Edgar Dale's experience [4], where students who conduct live demonstrations will remember 50% better than just reading and listening. In this study, how to make a model or miniature that can stimulate students to implement the theory in the classroom and do a direct demonstration by varying several variables to produce conclusions. So that the design of the hydropower model is chosen because students are expected to experience firsthand in analyzing the hydropower system.

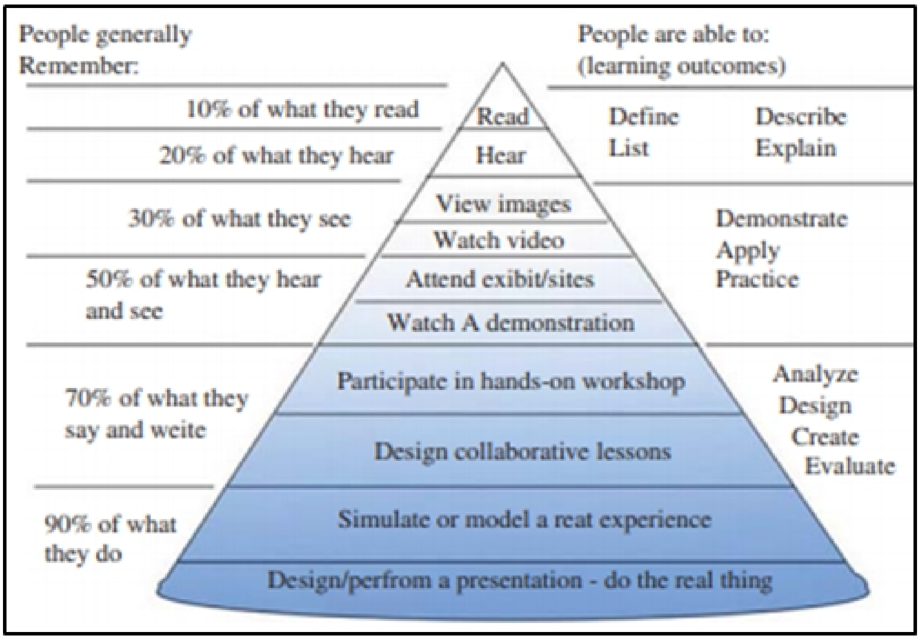

Figure 1. Dale's Cone Experience

Research in making models to provide education was carried out by [5] with the design and construction of a mini-hydro turbine model. The model can produce a discharge of 4L/s with a turbine rotation at 520 rpm, where the research aims to demonstrate raised awareness of the importance of energy production without pollution in developing countries.

2. METHODS

Fig. 2 is a research flowchart in the design of this micro-hydro model. Where in the Itenas both the mechanical engineering and electrical engineering departments do not have micro-hydro courses explicitly. But in the process, the discussion about micro-hydro is implicitly discussed in several courses. For example, both fluid mechanics and fluid engineering course, both are compulsory subjects in mechanical engineering, where one of the chapters discusses the design and micro-hydro turbines. The purpose of this study is to design a micro-hydro model with different diameters and the addition of the gate system.

2.1. Parameters

In this study, the parameters used are height, discharge, and output power. To measure the discharge of power can use several methods available [6]. One of them is by calculating the area of the average speed that passes through the penstock.

$$Vr = l/t \tag{1}$$

Where

$Vr = average\ flowrate\ \left(\frac{m}{s}\right)$

$l = penstock\ length\ (m)$

$t = time\ (s)$

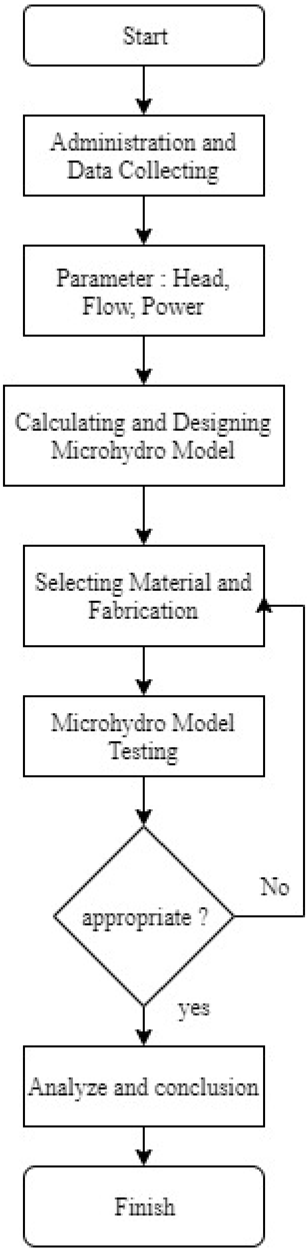

Figure 2. Research Flowchart

After that, calculating the flowrate

$$Q = A.vr \tag{2}$$

where

$Q = flowrate\ \left(\frac{m^3}{s}\right)$

$A = cross - sectional\ area\ (m^2)$

$vr = average\ flow\ spee\ \left(\frac{m^3}{s}\right)$

and the power production is

$$P = Q.\rho.g.H.\eta_{turbin} \tag{3}$$

where

$P = Output\ power\ (watt)$

$Q = flowrate\ \left(\frac{m^3}{s}\right)$

$\rho = mass\ density\ \left(\frac{kg}{m^3}\right)$

$g = gravitaional\ accelaration\ \left(\frac{m}{s^2}\right)$

$H = head\ (m)$

$\eta_{turbin} = turbine\ eff\ (\%)$

From the above equation, the parameters needed for the initial design of the micro-hydro model can be obtained. In fig.3 is the initial design of the micro-hydro model. Where the height is 80 cm, the length of the penstock is 127.5 cm, and the diameter of the penstock is 0.8 cm, 1.6 cm, and 1.9 cm, respectively. Meanwhile, for the selection of turbines for this micro-hydro model using mini turbine 5 VoltDC and 10 watts of power.

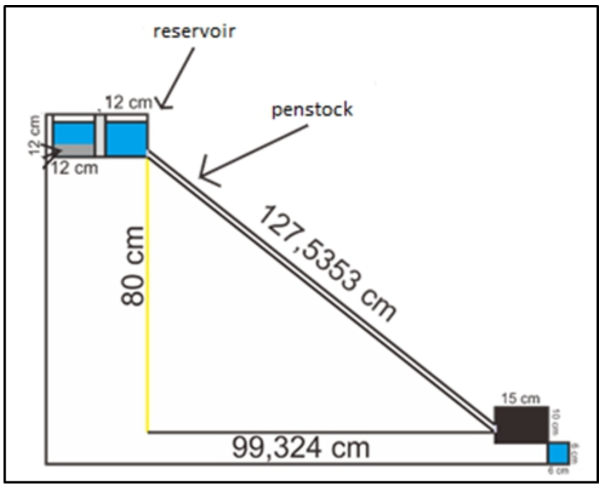

Figure 3. Raw Design Model of Micro-hydro

In this micro-hydro model, an automatic gate system with a wireless system is installed using a Bluetooth device with an Arduino UNO device, so students can apply the software system on the micro-hydro model at a considerable distance using gadgets. Fig. 4. is a flow chart of an automatic gate system.

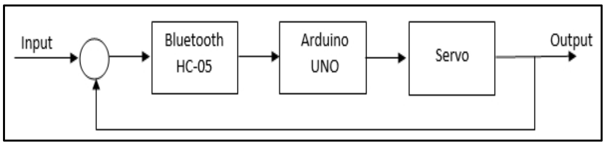

Figure 4. Gate System Flow Chart

Input in the form of a signal is received by a Bluetooth system, which is a connecting system between devices by exchanging information. After that, the signal is processed by Arduino Uno and converted to a motion signal, which then sends a motion signal to the servo motor so that it produces output in the form gate movement in the micro-hydro model. Whereas fig. 5. is a picture of a sequence of gate systems.

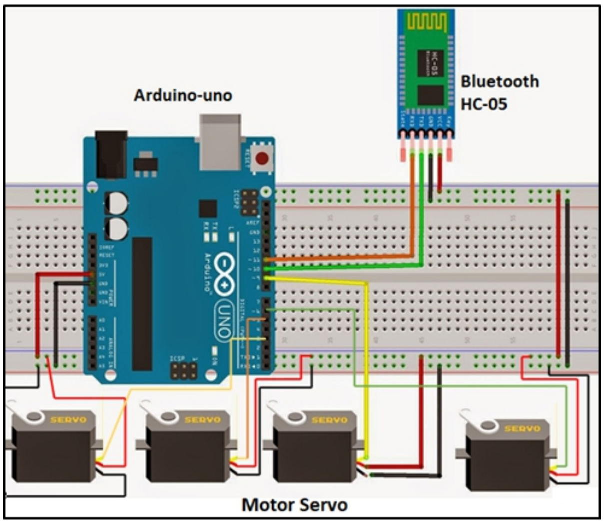

Figure 5. Gate System Sequence

3. RESULT AND DISCUSSION

Fig. 6 is a micro-hydro model that has been fabricated with three micro-hydro turbines with the same power specifications of 10 watts and three penstocks with different diameters, then testing whether the micro-hydro model is in accordance with the design or not. Meanwhile Fig. 7 is a gate system with wireless control that has been attached to the micro-hydro model.

Figure 6. Micro-hydro Model

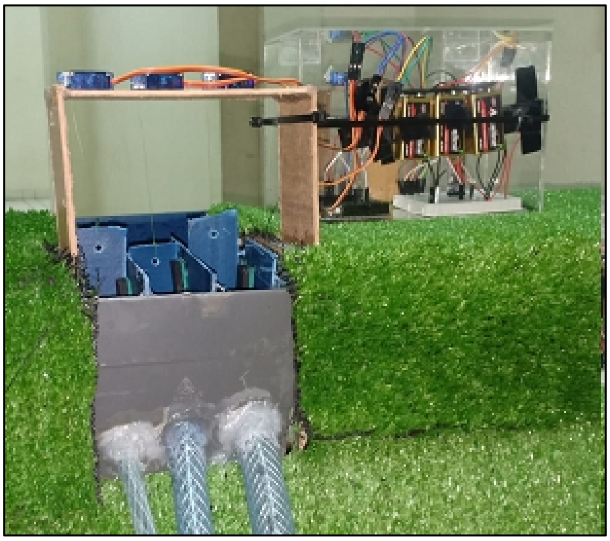

Figure 7. Gate System

Meanwhile, the results of the test can be any difference in the parameters of the voltage, current, and output power parameters.

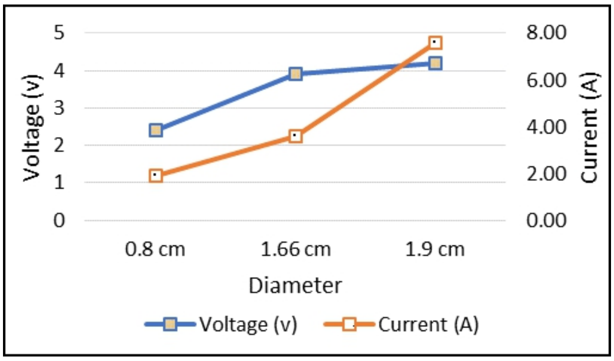

Figure 8. Pipe Diameter vs. Current

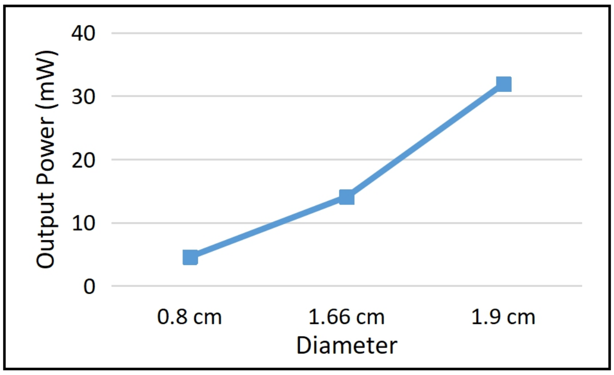

Figure 9. Pipe Diameter vs. Output Power

Fig. 8 is a graph of the different diameters with respect to the measured voltage and current results. It can be seen in the graph where the larger the diameter, the greater the voltage and current generated by micro-hydro turbines, where a penstock with a diameter of 1.9 cm produces a voltage of 4.2 volts and a current of 7.6 mA, while the smallest voltage and currents are generated by a penstock of 0.8 cm in diameter with values of 2.4 volts and 1.9 mA respectively. In Fig. 9, where the penstock with a diameter of 1.9 cm produces the greatest power with a magnitude of 31.92 mW.

4. CONCLUSION

The conclusion of this research is the design of the micro-hydro model has been made by adding a gate system with remote control with wireless control. The test results of the micro-hydro model are still far from the planned results of the model. The measurement results show the largest voltage and current generated by penstock with a diameter of 1.9 cm with a magnitude of 4.2 volts and 7.6 mA, respectively, as well as the power generated is only 32 mW with a flowrate measured of 171 mL.

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DAFTAR PUSTAKA

[1] BPPT, Indonesia Energy Outlook 2018: Sustainable Energy for Land Transportation, Jakarta: PPIPE, BPPT, 2018.
[2] https://investordailyindonesia.co/energi.terbarukan.solusi.lindungi.bumi
[3] https://nasional.kompas.co/bappenas.peran.perguruan.tinggi.penting
[4] B. Davis and M. Summers, " Applying Dale's Cone Experience to Increase Learning and Retention: A Study of Student Learning in a foundational Leadership Course," Science Proceedings, USA: Purdue University, 2014.
[5] E. I. Okhueleigbe and O. D. Ese, "Design and Construction of a Mini Hydro Turbine Model," AJME: Science PG, Vol.4, Nigeria, 2018.
[6] B. A. Nasir, "Design Considerations of Microhydro Electric Power Plant," Elsevier : Energi Procedia, Iraq, vol. 50, 2014.