Crossflow Hydro Turbine with the Interference Blade Improve Turbine Performance

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Abstract. Crossflow turbines are widely used in small-scale hydropower systems because of their relative flexibility in various heads and discharges, simple design, sturdy construction, and durability. Crossflow turbines work very fundamentally differently from Pelton and Francis turbines, where each crossflow turbine between the blades occurs two times. However, the power produced by the crossflow turbine tends to be low, so the crossflow turbine needs to be developed by adding an interfering blade, with variations in the length ratio of the interfering blades that will be used in this study having values of 0.25, 0.375 and 0.5 with various capacities and loads. The experimental results show that the nuisance blade ratio of 0.375 produces optimal performance in terms of power and efficiency. The highest power produced is 4.461 watts, at a load of 9000 g and a capacity of 18.113 L/s, while the highest efficiency is 96.20%, with a load of 5000 g and at a capacity of 11.024 L/s. Able to utilize the flow of water properly on the main blade and turbine interrupter blades so as to produce a large thrust and able to rotate the turbine with high rpm and large torque.

Keywords: Interference Blade · Performance · Crossflow Turbine · Hydro Turbine

1 Introduction

The Sustainable Development Goals (SDGs) or Agenda 2030 were declared on September 25, 2015, coinciding with the United Nations General Assembly (UNGA) at the United Nations Office, New York, United States of America. The implementation of the Sustainable Development Goals (TPB/SDGs) has entered the end of its fifth year or at the global level is called the "Decade of Action" period. For Indonesia, this momentum is also the time to evaluate the implementation of the first five years and formulate plans for the next five years, which will be outlined in the TPB/SDGs Action Plan document, which is in line with the 2020–2024 RPJMN [1].

In the National Research Priorities (PRN) for 2020–2024, nine research focuses have been set, one of which is energy. The focus of energy research is expected to be able to produce and utilize renewable energy sources, such as fuel based on new and renewable energy and electricity technology based on new and renewable energy [2]. Rising

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living standards and populations have led to rapid growth in electricity consumption in Southeast Asia, raising concerns about energy security, affordability and environmental sustainability [3].

One of the renewable energies that have the potential to be developed in Indonesia is hydroelectric power. In many parts of the world, hydropower is one of the most efficient ways to produce reliable renewable energy. There are water resources available, and I hope that they will become an important part of sustainable energy systems in the future [4].

This system can improve the living standards of rural communities and support development services such as education and health care. The main barriers to the further adoption of small-scale systems are cost and long-term sustainability. The advantage of this turbine is that it is easy to design and can be manufactured locally at low cost but has no lower efficiency. Current turbine designs have an efficiency of around 70–85% [5][6]. The crossflow turbine is a unique type of hydro turbine with two collisions, both without guide vanes, capable of achieving a total load efficiency of over 90% [7][8].

Based on data in the 2018 Indonesia Energy Outlook BPPT book, Indonesia has a total geothermal potential of 29,544 MW, hydropower resources reaching 75,091 MW, biomass potential of 32,654 MW, and potential from other renewable energy sources. However, the potential utilization of these renewable energy sources has not been maximized, especially in hydro and marine power. One way to utilize hydropower is to convert the hydropower into electricity using a water turbine. Using alternative energy can also prevent the accumulation of fossil fuel pollution so that our air is not dominated by carbon dioxide and carbon monoxide, which interfere with the respiratory system and damage the atmosphere [9].

According to the Energy Journal issued by MHP, in the language, it can be interpreted that micro is small and hydro is water, so micro hydro is a small-scale hydroelectric power plant (PLTA). This power plant utilizes irrigation flow or river flow as a source of power to drive turbines and turn generators. The use of the Crossflow Turbine type is more profitable than the use of other types of micro hydro turbines. At the same power conditions, this turbine has several advantages. The first advantage is cost-effective manufacture due to the smaller size of the Crossflow Turbine and practical compared to other turbines. With a small size, it can be concluded that its manufacture does not require too many materials and high costs. The second advantage is efficiency. The average efficiency of this turbine is relatively high. This is because the utilization of water flow in this turbine is carried out twice. The first is when the incoming water first hits the blade, and the second is the thrust of the water on the blade when the water leaves the runner. The existence of a water turbine like this turns out to be beneficial in terms of effectiveness. Further research is on the analysis of the influence of t blade angle on the work of the horizontal and vertical shaft kinetic turbines with variations in the flow direction angle with angles of 5°, 10°, 15° and variations in flow rate of 50, 70, and 90 m3/hour. In addition, this kinetic turbine uses variations of vertical and horizontal shafts. Based on the results of the study, it can be concluded that the maximum output power produced by the turbine is 1.53 Watts at a flow rate of 90 m3/hour with a flow direction angle of 15°. The highest efficiency of 18% occurs at a flow rate of 50 m3/hour

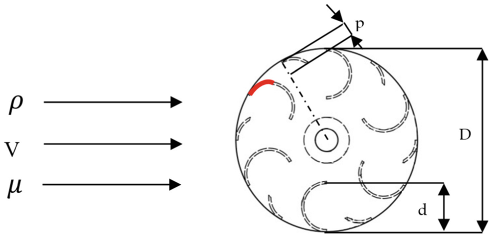

Fig. 1. Turbine illustration scheme with flow direction

with a flow direction angle of 15°. A turbine with a horizontal shaft type has a slightly higher power and efficiency value when compared to a vertical shaft turbine [10].

Meanwhile, the latest research and development activities in the field of hydropower technology with an effort to minimize the environmental impact of Hydroelectric Power Plants are also realized through the use of small-scale and fish-friendly installations [11].

Several previous researchers have made many innovations, but there are still not many researchers who have conducted research on crossflow turbines on a horizontal axis with a ratio of interfering blades. The hope of this experimental research is to produce a horizontal axis crossflow turbine with an optimal turbine disturbance blade ratio in terms of effectiveness and power generated so that it can be used for small-scale settlements close to water sources so that the potential renewable energy can be utilized more.

2 Materials and Methods

2.1 Types of Research

The method used in this research is experimental research. Experimental research data analysis techniques used are using descriptive qualitative data analysis methods.

2.2 Experimental Setup

This research was conducted to determine the characteristics of the turbine blade ratio against the turbine power and efficiency. This research was conducted on conditions and equipment that have been adjusted. The research variables are divided into three variables, namely the independent variable, the dependent variable and the control variable. The independent variables used in this study were variations in the blade ratio of the interfering blades: 0.25, 0.375 and 0.5. The dependent variable is power and efficiency. The instrument used is to measure the force, torque, angular speed, power and efficiency. The first step of conditioning the channel with the initial capacity was then measured at angular speed. Furthermore, given loading with prony brake will be obtained style and stirred angular speed. After that, it is calculated the style and efficiency (Figs. 1 and 2).

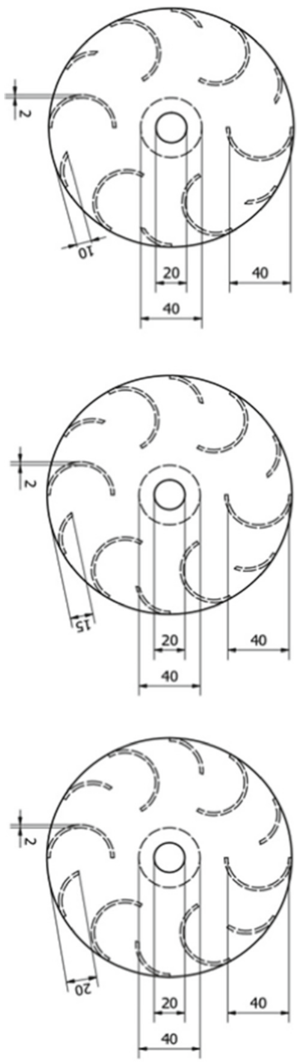

Fig. 2. Main blade with interfering blade

3 Result and Discussion

3.1 Power Turbine

In Fig. 3, it can also be seen that in the graph produced by each turbine interrupter blade, turbine power with a 0.25 interfering blade length ratio has increased to loading of 8000 g worth 4,189 W. Then, the turbine power drops until it stops spinning at a load of 15500 g. Turbine with a nuisance blade length ratio of 0.375 at a load of 9000 g, the power produced is 4.461 Watts. Then the longer the turbine rotation slowly decreases and stops at a load of 16000 g. In a turbine with a blade length ratio of 0.5, the power increases until

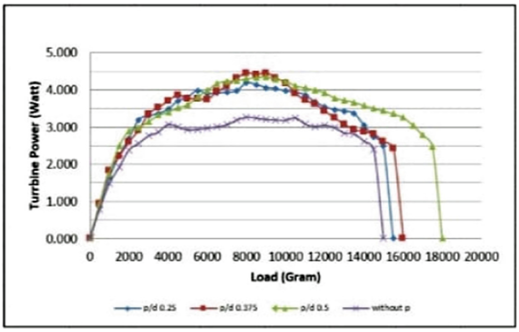

Fig. 3. Turbine power graph with a variety of interfering blades

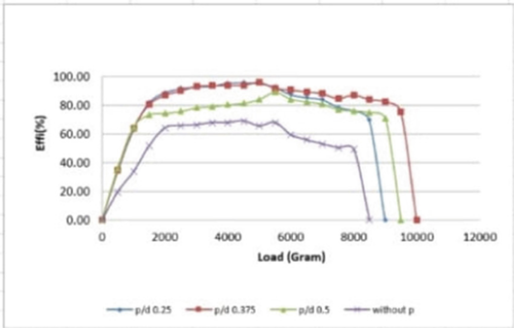

Fig. 4. Turbine efficiency graph with a variety of interfering blades

a load of 9000 produces a power of 4.362 W, which then, with the addition of periodic loads, causes the turbine to stop at a load of 18000 g. In a turbine without a disturbance blade, the power increases until a loading of 8000 produce 3,269 Watts, then decreases gradually and stops at a loading of 15000 g. The conclusion that can be drawn is that a turbine with an interfering blade length ratio of 0.375 at a flow capacity of 18.113 L/s and a load of 9000 g gets the highest power of 4.461 W. This is influenced by the greater the thrust generated by the water capacity and the greater the compressive force, causing the turbine to rotate. However, the power will decrease at a certain point due to the increasing load applied.

3.2 Efficiency

Based on the Fig. 4, it can also be seen that the graph obtained by the turbine with the interfering blade length ratio is 0.25, 0.375, and 0.5. Turbine efficiency of 0.25 interfering blade length ratio experienced a significant increase up to a load of 7000 g with an efficiency result of 63.28%, but at a loading of 10500 g, the turbine stopped rotating, and the efficiency also decreased. In a turbine with a blade length ratio of 0.375, the efficiency increases at a loading of 7000 g, worth 63.44%, then the efficiency value decreases and stops rotating at a loading weight of 14000 g. The efficiency of the turbine with an interfering blade length ratio of 0.5 increases to loading of 7500 g and reaches an efficiency of 61.86%, then the efficiency decreases and makes the turbine stop at a weight of 13000 g. Turbine efficiency without interfering blades increases until the addition of a load of 6000 g with an efficiency of 44.11%, and the efficiency then decreases and stops at a load of 11000 g.

4 Conclusion

The experimental results show that the nuisance blade ratio of 0.375 produces optimal performance, both in terms of power and efficiency. The highest power produced is 4.461 watts, at a load of 9000 g and a capacity of 18.113 L/s, while the highest efficiency is 96.20%, with a load of 5000 g and at a capacity of 11.024 L/s. Able to utilize the flow of water properly on the main blade and turbine interrupter blades so as to produce a large thrust and able to rotate the turbine with high rpm and large torque.

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