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25–26 October 2017, Manado, Indonesia

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Preface

The 2nd ICIEVE 2017, the International Conference on Innovation in Engineering and Vocational Education, held on October 25-26, 2017 at Aryaduta Hotel, Manado, North, Sulawesi, Indonesia, is hosted by Universitas Pendidikan Indonesia (Indonesia), Universitas Negeri Manado (Indonesia), and Rajamangala University of Technology Thanyaburi (Thailand).

The conference was a platform for scientists, scholars, engineers, industrial professionals, and researchers to exchange, share, and discuss their innovation, experiences, research works and problem solving techniques in all issues in engineering and vocational education.

The participants of ICIEVE 2017 were from around the world with a variety of background, including academics, industry, and even well-known enterprise. In general, there were 140 papers discussing such various topics as engineering and technology innovation (mechanical engineering, chemical engineering, civil engineering, etc.), engineering education (basic science in engineering education, engineering education reforms, new technologies in education, etc.), and vocational education and training (industry-driven training programs and collaborations, lifelong learning – reskilling and upskilling, government and policy, etc.).

We would like to thank all of those who helped and supported ICIEVE 2017. Each individual and institution's support was very important for the success of this conference. Specifically, we would like to acknowledge the advisory board, scientific committee, and organizing committee for their valuable advice, help, suggestions, and support in the organization and helpful peer-reviewing process of the papers. This year, we would like to express our deepest gratitude for all the co-hosts of ICIEVE 2017, UNIMA, Indonesia, and Rajamangala University of Technology Thanyaburi, Thailand for the collaboration. We would also extend our best gratitude to keynote speakers for their valuable contribution for sharing ideas and knowledge in the ICIEVE 2017.

We sincerely hope that ICIEVE 2017 will be a forum for excellent discussions for improving the quality of research and development in relation to innovation in engineering and vocational education. We also hope that this forum will put forward new ideas and promote collaborative researches among participants. We believe that the proceedings can serve as an important research source of reference and the knowledge. Indeed, the proceedings will lead to not only scientific and engineering progress but also other new products and processes for better science and technology in vocational education.

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Performance of Savonius Blade Waterwheel with Variation of Blade Number

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Abstract. The utilization of water energy source is mainly used as a provider of electrical energy through hydroelectric power. The potential utilization of water flow energy is relatively small. The objective of this study is to know the best blade of Savonius waterwheel with various variables such as water discharge, blade number, and loading. The data used the efficiency of waterwheel, variation of blade number, variable water discharge, and loading in the shaft. The test results have shown that the performances of a top-water mill with the semicircular curve where the variation in the number of blades are 4, 6, and 8 at discharge and loading of 0.01587 m^3/s and 1000 grams respectively were 9.945%, 13.929%, and 17.056% respectively. The blades number of 8 obtained the greatest performance. The more number of blades the greater the efficiency of the waterwheel Savonius.

1. Introduction

The condition of Indonesian topography which has many mountains and hills as well as the stretch of river is almost found in every region [1]. Water energy is the energy that is suitable and the most potential to be developed in Indonesia. The rate of growth of hydropower in Indonesia is very slow, whereas the potential of Indonesia's hydro power is quite large reach 75.000 MW. Utilization through the national electricity supply only reached 10.1% or 7,572 MW. Based on data from the Ministry of Energy and Mineral Resources, the potential of hydropower energy is spread by 15,600 MW in Sumatra, 4,200 MW in Java, 21,600 MW in Kalimantan, 10,200 MW in Sulawesi, 620 MW in Bali-NTT-NTB, 430 MW in Maluku and 22,350 MW in Papua. While in the world, the potential for water energy is estimated to reach 657 million HP or 489,924.8156 MW, but the utilization to 15%. The potential of water energy in each continent is different [2] and we can be seen in the Table 1.

The greatest potential energy of water is in the African continent [3]. It can be seen with the river Congo in Africa which became the largest potential energy of water in the world as well as several other rivers that are used as a producer of electricity. Electric power is obtained from the conversion of hydropower that turns the waterwheel or water turbine that utilizes the waterfall or stream in the river [4].

Fine the optimum performance of each specific amount of blade, i.e. 4, 6 and 8 blades on the water (discharge) and the constant end equal head for Savonius model blade of capacity used for hydropower. Determine the maximum power coefficient of the change in the number of Savonius model drops used for hydropower [5]. As reference in the design of water wheel with the Savonius model savings benefits research. The research results can be applied in the field of renewable energy conversion, especially in the design of small-scale hydro power plant to micro [6].

Table 1. Potential and developed hydropower in the world

Continent	Potential (in million horse power)	Percentage of total	Developed (in million horse power)	Percentage of total
Africa	212	41.4	0.6	0.6
Asia	151	23.0	13.7	13.6
North America	87	13.2	41.1	40.8
Europe	69	10.5	40.8	40.5
South America	55	8.4	3.1	3.1
Oceania	23	3.5	1.4	1.4

2. Methods

This study used experiment in fluid machineries laboratory of Mechanical Engineering Department, Universitas Hasanuddin with the installation as in Figure 1. The data retried by repeating the test/retrieval procedure at least 5 repetitions for analysis. The data collection procedure/testing such as we conducted by: the initial, check the state of the tool to be used on the waterwheel test and check the valve is in good condition; connecting the pump with a power source; set the valve opening to determine the discharge; allow the water to flow for 2 minutes to obtain stable flow conditions in the channel; calculate the amount of first discharge by using bucket and stopwatch; install one of the waterwheels with the number of 4 pieces of blade in position; record the water level and water temperature in the channel; after that calculate the number of turns of the waterwheel using a tachometer without loading until loading until the wheel cannot spin or stop; after that record the amount of rounds generated in each loading; after obtaining the data from the waterwheel test the 4 pumps are turned off by disconnecting the electric current source; and the finally, repeat procedure 2-10 for waterwheels 6 and 8 (Figure 2).

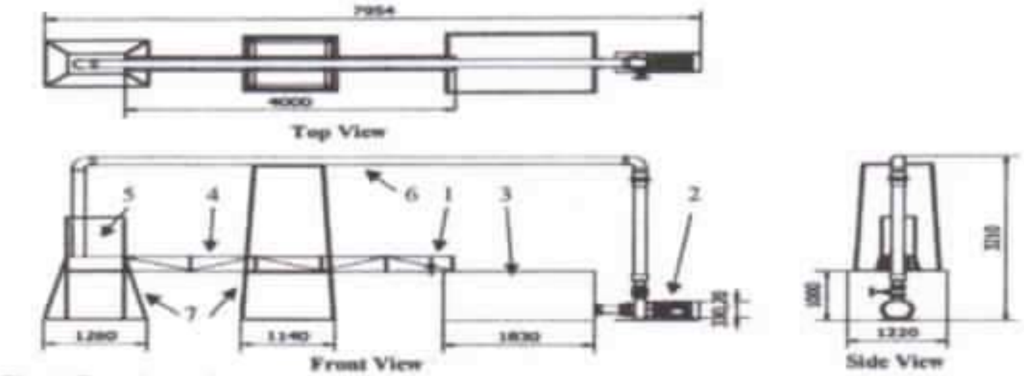

Figure 1. Testing installation

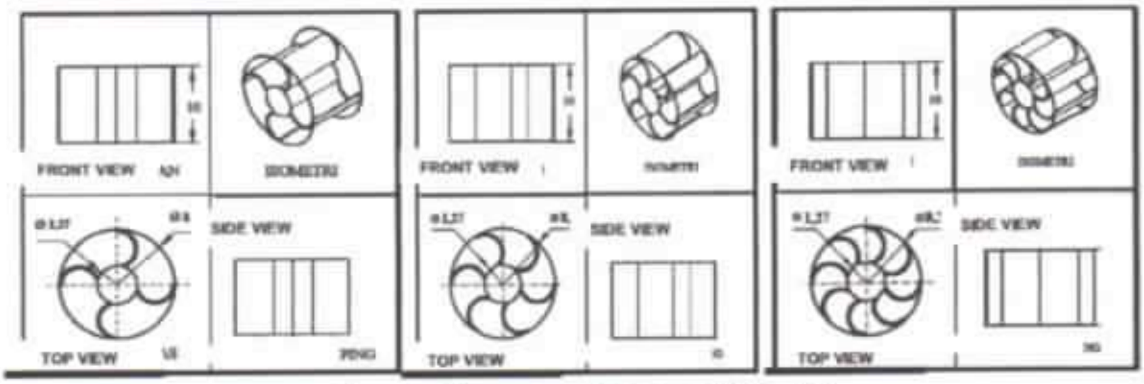

Figure 2. Parameters of Blades (4, 6, and 8)

3 Results and Discussion

3.1. Relation of efficiency to load for 4 blades

The Figure 3 and Table 2 showed the relation of efficiency to the waterwheel load with variation of discharge i.e. 0.01124 m^3/s (Q1), 0.01358 m^3/s (Q2), and 0.01587 m^3/s (Q3) with waterwheels of 4 blades. The maximum efficiencies occurred at 600 gram loading to discharge of 0.01124 m^3/s and 0.01358 m^3/s are 6.13% and 5.95% respectively. While, at discharge of 0.01587 m^3/s and loading of 1000 gram, the maximum efficiency is 9.66%.

In Figure 5, for 0.01124 m^3/s of discharge, it is seen that the efficiency increases from no load to 600 gram loading and decreases the efficiency of the waterwheel as the addition of loading, from load 600 to 1200 gram loading. The waterwheel will produce power because the wheel can offset the given torque [7][8][9]. When a given torque is equal to zero, the waterwheel will not produce power because the windmill will spin very quickly as a result of the absence of loading given so that no incubation occurs [10][11]. Conversely, after reaching the critical point along with the increase in loading then braking occurs in the pulley resulting in angular velocity and the power of the waterwheel decreases [12][13][14]. The phenomenon that occurs for discharges of 0.01124 and 0.01358 m^3/s is caused by the same thing that occurs at a discharge of 0.01587 m^3/s for the same blade.

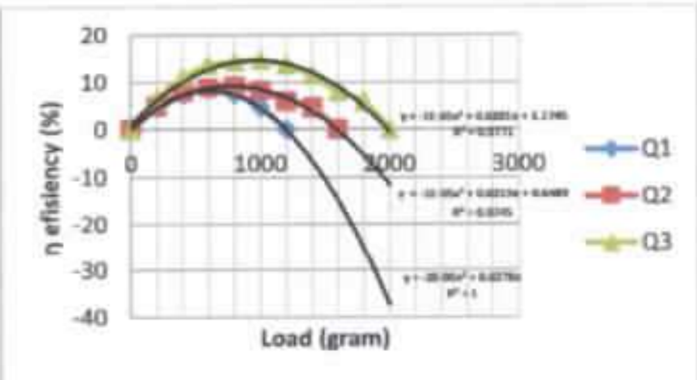

Figure 3. Relation of efficiency to load with variation of discharge on waterwheel with 4 blades

In Figure 4 and Table 2, it is found that the discharge of 0.01587 m^3/s is the largest discharge between the variations of the discharge used where the efficiency of 9.95% to loading of 100 gram. This is because the amount of water flow that flows directly proportional to the water speed in the channel makes the mass of the waterwheel lighter so that the resulting round is also large and requires a large load to brake [15].

Table 2. η efficiency to load and discharge

Load	Variation for 4 blades			Variation for 6 blades			Variation for 8 blades		
(gram)	η (Q1)	η (Q2)	η (Q3)	η (Q1)	η (Q2)	η (Q3)	η (Q1)	η (Q2)	η (Q3)
	0	0	0	0	0	0	0	0	
0	3,213	3,176	3,552	3,797	3,970	4,691	4,674	4,975	
200	5,258	5,161	6,251	6,427	6,749	8,244	8,179	9,097	
400	6,134	5,955	8,099	7,887	8,338	11,087	9,640	12,366	
600	4,674	6,352	9,661	8,179	8,735	12,508	10,516	14,782	
800	2,921	5,955	9,946	7,303	8,933	13,503	10,224	16,346	
1000	0	4,764	9,377	5,258	8,338	13,645	8,763	17,056	
1200		4,169	7,956	4,089	6,948	13,929	6,134	16,914	
1400		0	6,820	0	7,764	13,645	4,674	15,919	
1600			5,115		3,573	12,792	0	15,351	
1800			2,842		0	9,950		2,792	
2000			0			7,814		9,381	
2200						5,117		6,823	
2400						0		3,696	
2600								0	
2800									

Note: variation of discharge i.e. 0.01124 m3/s (Q1), 0.01358 m3/s (Q2), and 0.01587 m3/s (Q3

3.2. Relation of efficiency to load for 6 blades

The relation of efficiency to the waterwheel load with variation of debit i.e. 0,01124 m3 / s, 0,01358 m3 / s and 0,01587 m3 / s with waterwheels 6 blades is shown in Figure 5 and Table 3.

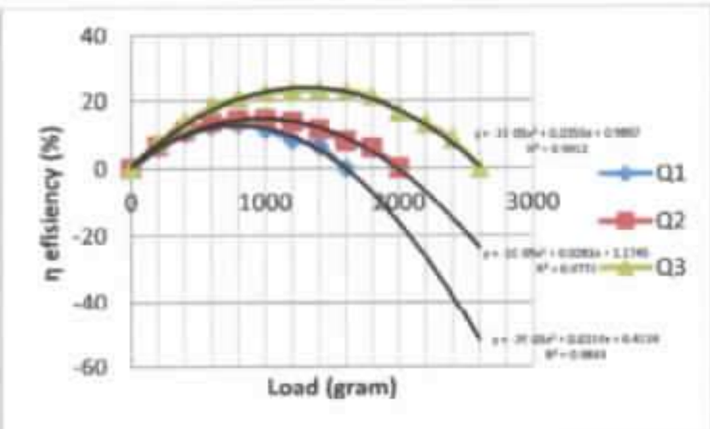

Figure 4. Relation of efficiency to load with variation of discharge on waterwheel with 4 blades

Based on Figure 4 and Table 3 were found that for discharge of 0.01124 m^3/s, the maximum efficiency is 8.17920093% which occurs at 800 gram loading. While at discharge of 0.01358 m3 / s maximum efficiency is obtained 8.93% with loading 1000 gram. While at 0.01587 m^3/s of discharge, the maximum efficiency at loading of 1400 gram is 13.93%.

In Figure 5, for 0.01124 m^3/s of discharge, it was seen that the efficiency increased from no-load to 800 gram loading and decreased the efficiency of the waterwheel as the addition of loading, from a load of 800 to 1600 gram loading. The waterwheel will produce power because the wheel can offset the given torque [7][8][9]. When a given torque is equal to zero, the waterwheel will not produce power because the windmill will spin very quickly as a result of the absence of loading given so that no incubation occurs [16]. Conversely, after reaching the critical point along with the increase in loading then braking occurs in the pulley resulting in angular velocity and the power of the waterwheel decreases [17]. The phenomenon that occurs for discharges of 0.01124 and 0.01358 m^3/s is caused by the same thing that occurs at a discharge of 0.01587 m^3/s for the same blade.

3.3. Relation of efficiency to load for 8 blades

Based on Figure 5 and Table 4 it is found that for debit 0.01124 m^3/s maximum efficiency is 10.52% which occurs at 800 gram loading. While at debit 0.01358 m^3/s maximum efficiency is obtained by 13.90% with loading 1000 gram. While at 0.01587 m^3/s of discharge, the maximum efficiency at loading of 1200 gram is 17.06%.

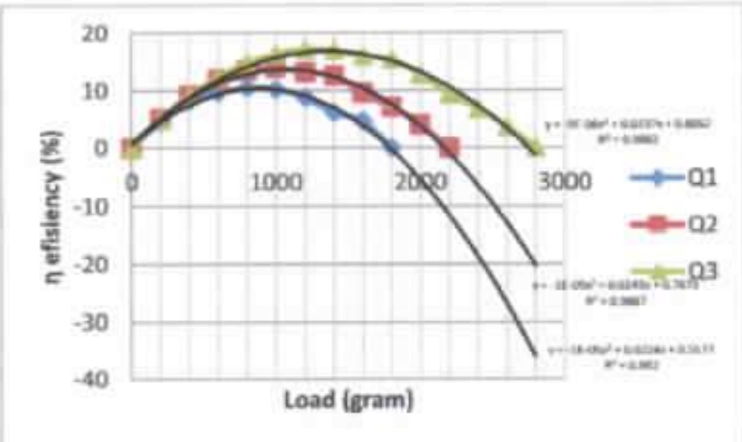

Figure 5. Distributions of the available power per m^2 at seawater column of 20 m when low tide currents at flow rate of 0.3 Sv in the Bangka strait.

In Figure 6 for a 0.01124 m^3/s of discharge, it is seen that the efficiency increases from no-load to 800 gram loading and decreases the efficiency of the waterwheel as the addition of loading from a load of 800 to 1600 gram. The waterwheel will produce power because the wheel can offset the given torque [7][8][9]. When a given torque is equal to zero, the waterwheel will not produce power because the windmill will spin very quickly as a result of the absence of loading given so that no incubation occurs [16]. Conversely, after reaching the critical point along with the increase in loading then braking occurs in the pulley resulting in angular velocity and the power of the waterwheel decreases [17][18][19]. The phenomenon that occurs for discharges of 0.01124 and 0.01358 m^3/s caused by the same thing that occurs at discharge (0.01587 m^3/s) for the same blade [20].

4. Conclusions

The efficiency produced by the waterwheel Savonius blade is affected by the discharge and the amount of the blade. In the waterwheel of 4 maximum efficiency blade obtained 9.95% with debit 0.01587 m^3/s at loading 1000 gram. While on the waterwheels 6 blades, the greatest efficiency of 13.93% is obtained at discharge of 0.01587 m^3/s at 1400 gram loading. While on the waterwheels 8 blades, the greatest efficiency of 17.06% is obtained at a discharge of 0.01587 m^3/s for with a loading of 1200 grams. The maximum power of the wheel produced by the water wheel on the flat plate blade occurs at the opening of the discharge III (Q3 = 0.01587 m^3/s) with the number of 8 blades of 2.403984 W. The greatest efficiency was obtained at 0.01587 m^3/s discharge of 17.06% with 1200 gram loading. So the best blade is a waterwheel with 8 blades.

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20	Proceedings of the 31st Annual Association of Researchers in Construction Management Conference, ARCOM 2015	conference and proceedings	0.210	5	0	124	0	63	123	0.00	0.00
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