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Submission date: 08-Apr-2023 07:58AM (UTC+0700)
Submission ID: 2058717458
File name: Heriyani_2019_J._Phys.__Conf._Ser._1373_012012_1.docx (245.51K)
Word count: 1233
Character count: 6051

Performance of dethridge wheel as low head power generator and loss analysis

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Abstract. This research to measure the performance of dethridge wheel using a very low head as a driving force and analyze losses in the testing system. The parameters measured in this research are flow rate (m^3/s), water velocity (m/s), water level (m), torque (Nm), and rotation (rpm). Debit is a variabel that is given treatment with variations in the difference between the initial flow rate and the next is 0.002 m^3/s. The highest efficiency resulted in the first flow rate of 43.314% with hydro power of 1.862 watts and the power of the water wheel 0.806 watts. The higher increase flow rate causes the losses that occur are also grater, the state of the flow is more turbulent, and the loss due to force and fiction increase water.

1. Introduction

Electricity has become a primary need at this time. Various independent efforts to produce electricity continue to be carried out by researchers. One energy source that is often used is hydropower. The use of hydro energy to produce electrical energy encourages various countries to evaluate available energy sources [1]. The oldest mechanical equipment used to convert the energy of water flow into work is a water wheel. The limited location of high head water, the utilization of water flow with a low head is a concern and Zuppinger wheel is very suitable for producing electricity by utilizing water flow with a head less than 5 *m* [2]. Water flow with head less than 5 *m* can be found in irrigation canals. Water flow in irrigation channels that have a low head can be used to generate electricity [3]. To utilize low head water flow, such as irrigation flow, Dethridge wheel, which was initially used as a flow measurement, is currently used for electricity generation with an efficiency of 60% [4] and its performance increases on the channel with a width of two to three times greater than the wheel width [5]. In this research, Performance and loss of dethridge wheel as an electric generator drive measured.

2. Experimental Set Up

The dethridge wheel in this research was made of steel plate with a thickness of 1.8 *mm*. Runners use a 15 *mm* plywood that coated with waterproof coating. The geometry size of the Dethridge wheel refer to previous reseach [4], as can be seen in figure 1.

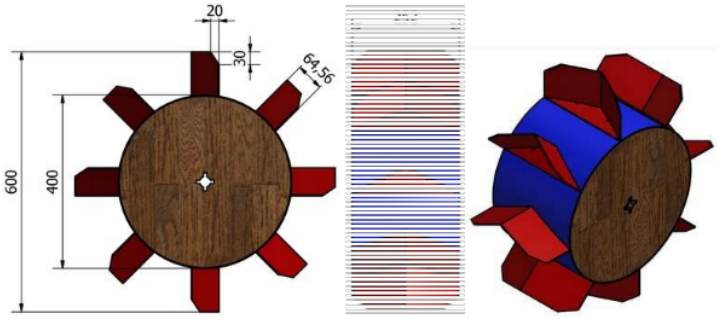

Figure 1 Dethridge Wheel Geometry

Experimental rig material in this research is 15 *mm* plywood that coated with fiber and waterproof coating. Dimension is shown in figure 2.

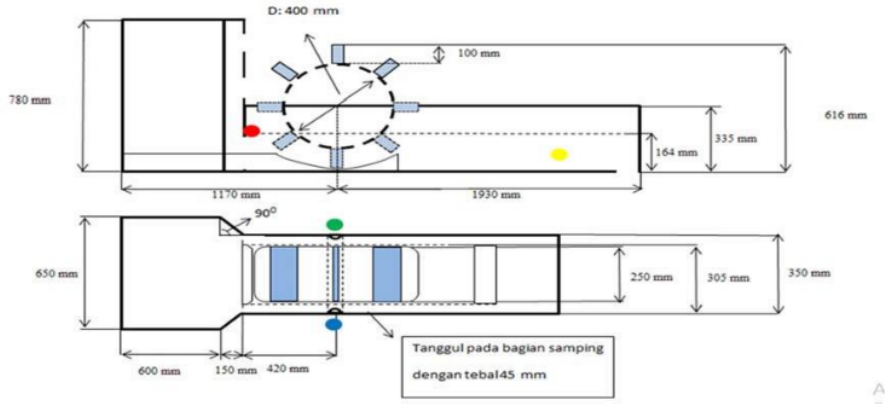

Figure 2 Canal Geometry

The experiment use six variations of flow rate, 0.006 m^3/s, 0.008 m^3/s, 0.010 m^3/s, 0.012 m^3/s, 0.014 m^3/s, and 0.016 m^3/s. Water is pumped from the storage tank to the water column through a flow meter. From the water column, which aims to stabilize the flow, water flows through the canal and then rotates the waterwheel and then flows back to the storage tank.

Water level measured before the wheel by attaching a permanent gauge to the walls of the experimental rig as well as after the wheel. The increase in water height starts from the first flow rate to the last flow rate as in the pattern of figure 3.

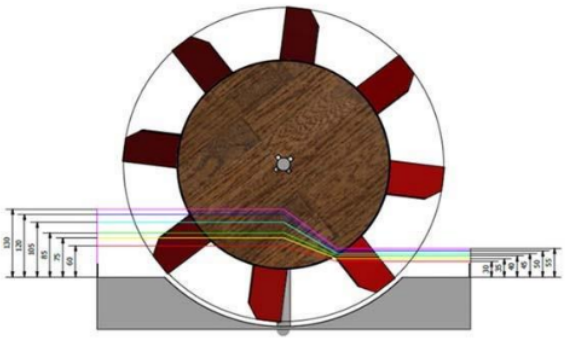

Figure 3 Water Level Pattern

3. Result and Discussion

The results of measurements with six variations of flow rate obtained a comparison of the performance of the wheel for each flow rate as in table 1.

Table 1 Performance Comparison of Debit Variations

Flow Rate (m^3/s)	*Head* (m)	Flow Velocity (m/s)	Rotation (rpm)	Torque (Nm)	Hydro Power (watt)	Wheel Power (watt)	Efficiency (%)
6,360	0,030	0,407	6,908	1,115	1,862	0,806	43,314
8,360	0,040	0,410	10,496	1,144	3,263	1,257	38,516
10,360	0,045	0,452	13,387	1,146	4,549	1,606	35,300
12,360	0,060	0,457	16,361	1,225	7,236	2,099	29,001
14,360	0,070	0,463	18,792	1,189	9,809	2,339	23,845
16,360	0,075	0,484	21,576	1,023	11,973	2,310	19,291

In table 1, it can be seen that there is an increase in flow rate, a decrease in efficiency of the wheel. The highest efficiency is 43.314% with a flow rate variation of 0.006 m^3/s, as shown in figure 4.

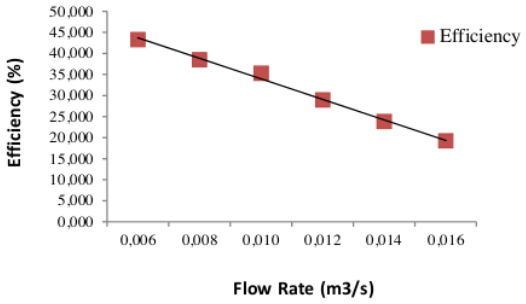

Figure 4 Graph of Flow Rate to Efficiency

The efficiency of the Dethridge wheel decreases when the water discharge is increased. This is because the increase in dethridge wheel rotation is not proportional to the increase in water discharge.

This is due to the water resistance as a reaction when the blade hits the water. In addition, there is friction between the water under the Dethridge wheel with the surface of the water channel.

Because the increase of Dethridge wheel rotation is not proportional to the increase in discharge, the water is retained before the Dethridge wheel so that the water level increases. Increasing the water level causes the potential of water power is also increase. This increase is not proportional as the increase in the power produced by the Dethridge wheel, as shown in figure 5, therefore the efficiency decreases.

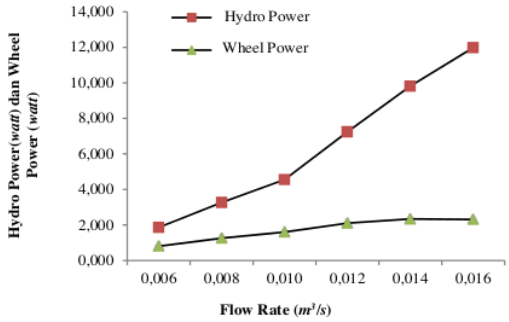

Figure 5 Graph of Flow Rate to Hydro Power and Wheel Power

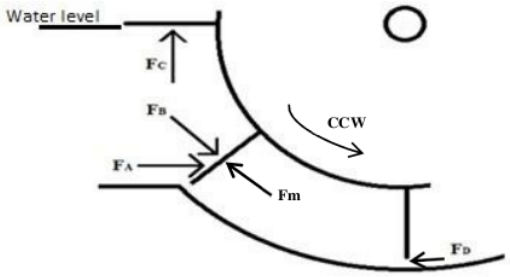

Figure 6. Hydro Force (F_A), Hydro Tangential Force (F_B), Resistance Force (F_c), Hydro Friction Force (F_D) and mass of water (F_m)

Figure 6 show forces when the water pushes the Dethridge to rotate. The force of water that comes from the flow energy pushes the Dethridge wheel to rotate counterclockwise. The thrust of the water, reduced by water reaction when the Dethridge wheel blade hit the water. The water reaction pushes the blade up so that the thrust force decreases. In addition, the friction that occurs between water and the surface of the water channel also reduce the force of water. Furthermore, the water that trapped between the Dethrige wheel blades no longer pushes but becomes an additional loss that also reduces the force of water.

4. Conclusion

Based on the results of testing and data collection, it can be concluded that efficiency the highest is 43.314% with the variation of the first debit amounting to 0.006 m^3/s. The increase in flow rate causes efficiency to decrease, because a lot of hydro power is not maximally used due to hydraulic losses. The cause of efficiency has decreased due to several hydraulic losses. It caused by the drag in the variation of flow rate 0.014 m^3/s and 0.016 m^3/s which causes a decrease in torque at the discharge variation 0.014 m^3/s and 0.016 m^3/s.

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