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International Journal of Engineering Advanced Research
eISSN: 2710-7167 | Vol. 1, No. 4, 41-48, 2020
http://myjms.mohe.gov.my/index.php/ijear

International Journal of Engineering Advanced Research (IJEAR)
eISSN: 2710-7167 [Vol. 1 No. 4 December 2020]
Journal website: http://myjms.mohe.gov.my/index.php/ijear

EFFECT OF CANAL BASE GEOMETRY ON DETHRIDGE WHEEL EFFICIENCY

Oktarina Heriyani[1], Dan Mugisidi[2*], Moh Yusuf Djeli[3] and Yasrian Iqbal[4]

[1 2 3 4] Faculty of Engineering, University of Muhammadiyah Prof. Dr. HAMKA, Jakarta, INDONESIA

*Corresponding author: dan.mugisidi@uhamka.ac.id

Article Information:

Article history:

Received date	: 20 November 2020
Revised date	: 5 December 2020
Accepted date	: 6 December 2020
Published date	: 7 December 2020

To cite this document:

Heriyani, O., Mugisidi, D., Djeli, M., & Iqbal, Y. (2020). EFFECT OF CANAL BASE GEOMETRY ON DETHRIDGE WHEEL EFFICIENCY. *International Journal Of Engineering Advanced Research, 1*(4), 41-48.

Abstract: *The Dethridge wheel is a water wheel that suitable at very low heads for hydro energy generation. One of the factors affecting the efficiency of the Dethridge wheel is the shape of the channel bed. Therefore, this study aims to determine the channel bed geometry that provides the highest efficiency on the Dethridge wheel. This investigation was carried out experimentally at the UHAMKA Faculty of Engineering. Variations in the shape of the channel used are full, one-quarter, half, and three-quarters with variations of discharge ranging from 25 m^3 / hour to 60 m^3 /h. The results show that the shape of the channel with three-quarter variation produces the highest efficiency, namely 56%. This is influenced by the water level within the blades and influenced by the geometri of the channel base.*

Keywords: canal, detridge wheel, efeciency, geometry, irigation.

1. Introduction

In line with the increase in population, the increase in energy demand will also increase to nearly 1.3% in the world in 2019 (Looney, 2020). However, this is not proportional to the availability of energy itself. Therefore, the use of alternative energies, such as biomass, sunlight, water, geothermal energy, waves, and others, is developed as renewable energy. Indonesia, as the largest energy consuming country in the ASEAN region, has only developed 15.9% of renewable energy (Sharif et al., 2020). Water energy is one of the types of energy providers in Indonesia after oil, coal and gas. However, the contribution of hydroelectric power (PLTA) to provide electricity is only 6% of the power generating capacity (Ministry of Energy & Mineral Resources of the Republic of Indonesia, 2018). Hydroelectric plants are placed in the highlands and far from settlements resulting in very expensive distribution costs. The lowest cost power plant option for generating electrical energy in areas far from the power line is pico hydro(Williams & Simpson, 2008). Utilization of pico hydro in remote areas is more profitable than using diesel, engines, wind generators, and even solar cells (Balkhair & Rahman, 2017). Therefore, researchers began to develop low-head hydropower performance with pico hydro for its utilization. Recent developments have shown that waterwheels are suitable devices for the low head as an efficient and environmentally friendly source of electricity generation in rural areas. (Quaranta & Revelli, 2015), (Pelliciardi, 2015).

Waterwheel is one of the benefits of low head technology. At very low heads, below 2.5 m, the use of traditional technology, such as waterwheels, can produce electric power up to under 50 kW (Bozhinova Hecht, Kisliakov, 2012). Simple and easy design and maintenance with propulsion capability make the waterwheel an attractive resource for decentralized rural applications.

The type of pin used at low head continues to be investigated by the researchers. Based on the results of the study of K.S Balkhair et all. showed that the zupinger wheel has an efficiency of up to 75% at a very low head (Paudel et al., 2017). James Senior et al. developed a low head turbine modification, namely hydrostatic pressure wheels with a head difference between 0.2 m and 1 m and a hydrostatic pressure engine with a head difference between 1 m and 2.5 m (Senior et al., 2010). Dethridge wheel is a type of waterwheel that is compatible for low head applications according to the investigation by Paudel et al. (Paudel & Saenger, 2018). The modest and potent design of the blades makes the dethridge wheel more compatible for applications in rustic areas of developing countries. The results of testing the physical model of the Dethridge waterwheel by S. Paudel et al. shows an efficiency of about 60% and a sufficient amount of power output that it can be used for simple applications such as electronic goods, lamps, etc (Paudel & Saenger, 2016). The analysis of losses investigated by D. Mugisidi et all. showed that the shape of the channel can affect the performance of the dethridge wheel (Mugisidi et al., 2018). This is similar to the research conducted by Paudel et al. which determines the effect of channel geometry on the efficiency of the dethridge wheel (Paudel & Saenger, 2018). This study builds on previous research conducted by Paudel et al. and Dan Mugisidi et al. with the aim of seeing the effect geometry of the channel shape on the efficiency of the Dethridge wheel performance. The novelty of the basic shape of the channel in this study is to vary the basic shape of the channel in the form of tembereng. Tembereng is the area in a circle that is built up by the bow and string.

International Journal of Engineering Advanced Research
eISSN: 2710-7167 | Vol. 1, No. 4, 41-48, 2020
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2. Methodology

This research was conducted experimentally at the Laboratory of the Faculty of Engineering, UHAMKA, Indonesia, which varied eight discharge values (25, 30, 35, 40, 45, 50, 55, 60) m^3 / h and five basic forms of canals (P4 = full tembereng, P3 = temberang ¾, P2 = tembereng ½, P1 = temberang ¼, and P0 = without tembereng). The testing system is carried out as shown below.

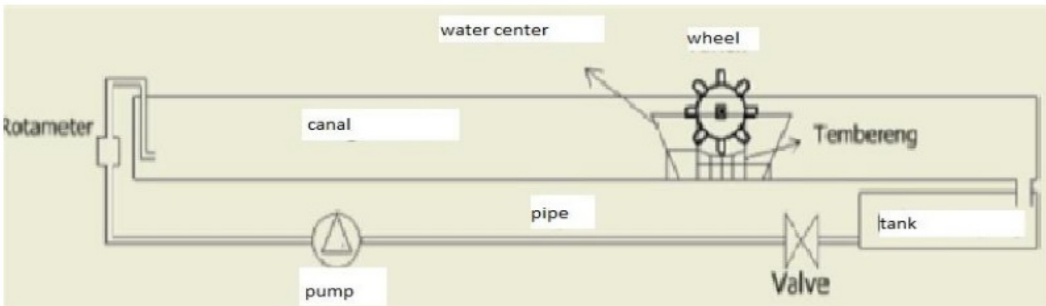


Figure 1: Testing system

Figure 1 shows the circulation of water from the reservoir and then pumped through the rotameter then into the channel until it turns the wheel and go back into the reservoir.

This test uses an open channel and water concentration with the geometry of the canal and wheel as follows. Detridge wheel material made of aluminum with the following dimensions in **Fiqure 2**.

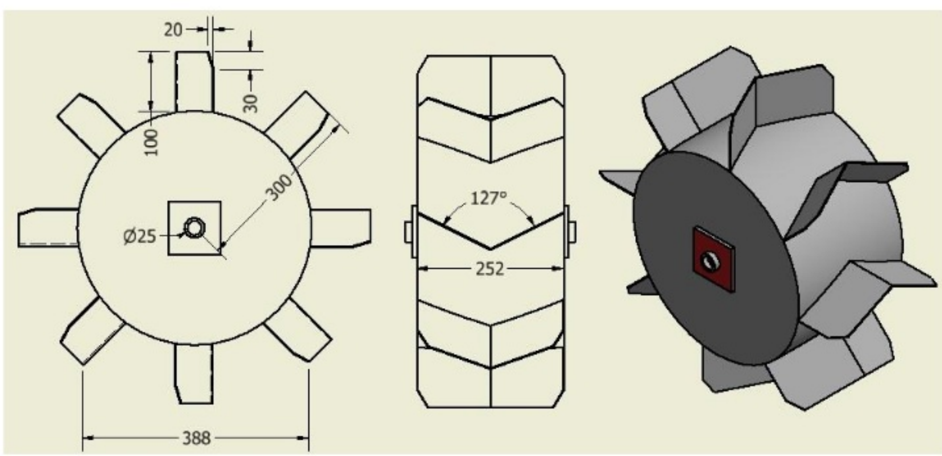
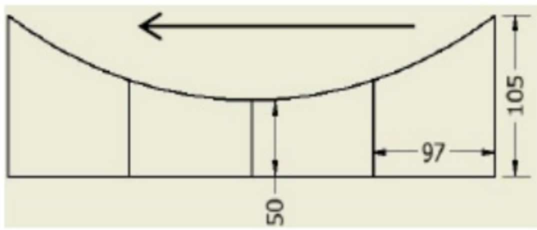
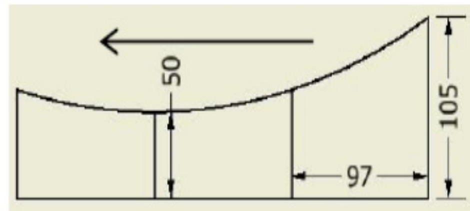


Figure 2: Dethridge Wheel Geometry

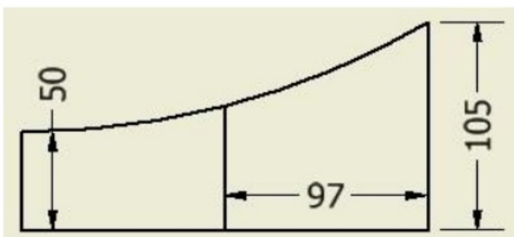
The canal material is made of arkilik with various sizes of tembereng (area in a circle that is built up by the bow and string) shown in **Figure 3** below.



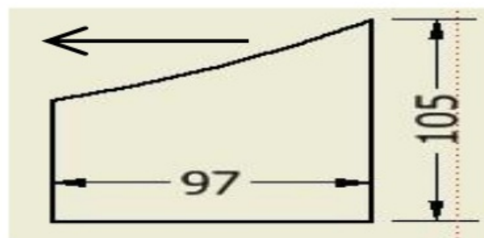
a Tembereng full



b Tembereng ¾



c Tembereng ½



d Tembereng ¼

Figure 3: Geometry of tembereng (area in a circle that is built up by the bow and string)

The test was conducted to collect data starting from the discharge, number of revolutions, torque, input power, output power, water level, flow velocity, and efficiency.

3. Results and Discussion

Based on the test results, the relationship between discharge to power input (P in) is shown as shown in the following **Figure 4**.

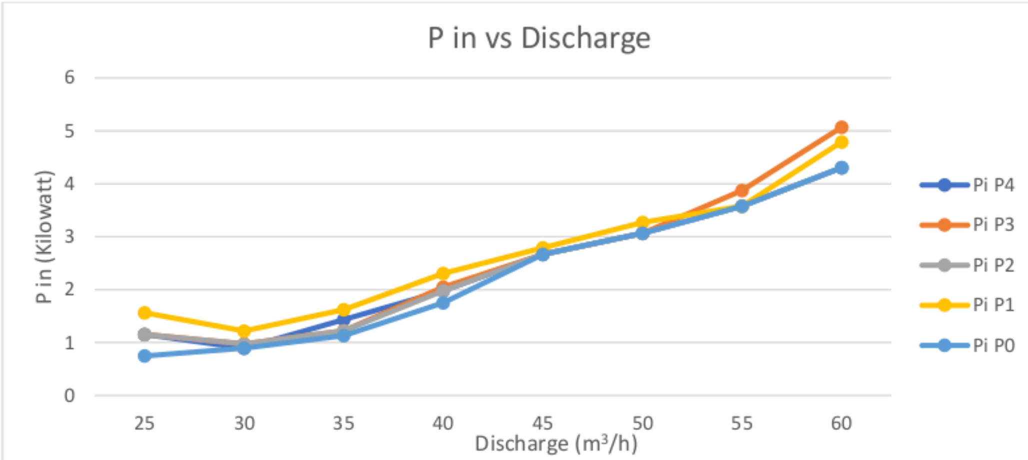


Figure 4: Graph the effect of base canal on P in

Figure 4 shows that the average water power with the variation of the discharge used and refers to the basic shape of the channel ¾ all variations of discharge show the highest value at debit of 60 m^3/h of 5.1 kilowatts. This proves that the power of water is very much influenced by the height of the water. The higher the increase in water passing through the wheel, the greater the power produced. Theoretically, the increase in discharge and head, the higher the value of water power.

The largest output based on the test results is seen in tembereng ¾ as shown in **Figure 5** below.

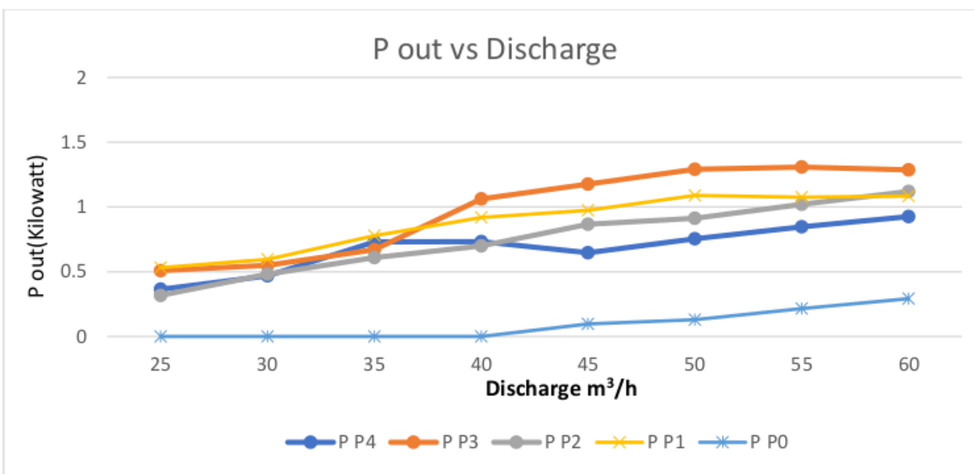


Figure 5: Graph the effect of base canal on P out

Figure 5 shows that the highest turbidity is owned at the bottom shape of the canal ¾. This shows that the power produced has an effect on the value of the rotation of the wheel. Theoretically, the increase in discharge can affect the rotation of the wheel. The greater the water flow velocity value, the greater the wheel rotation produced (Mugisidi et al., 2018). The largest P output at debite of 55 m^3 / h is 1.31 Kilowatts.

Based on the resulting Pin and Pout, it can be seen that the resulting efficiency is based on the geometry of the basic shape of the channel as shown in **Figure 6** below.

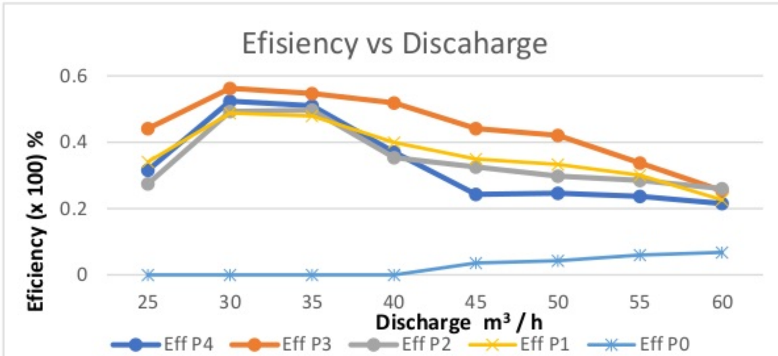


Figure 6: Graph the effect of base canal on Eficiency

It shows that the highest efficiency is owned by the bottom geometry of the canal ¾. There is a decrease in efficiency because water energy is lost when the water passes through the wheel, so that the wheel does not receive the maximum water energy.

Figure 7 shows the effect of the bottom geometry of the full blade canal which is immersed into the water causing a decrease in efficiency because there is a dam when the water wants to come out from under the wheel. The figure shows that the power generated by the wheel is affected by the amount of immersed blade (Tevata & Inprasit, 2011).

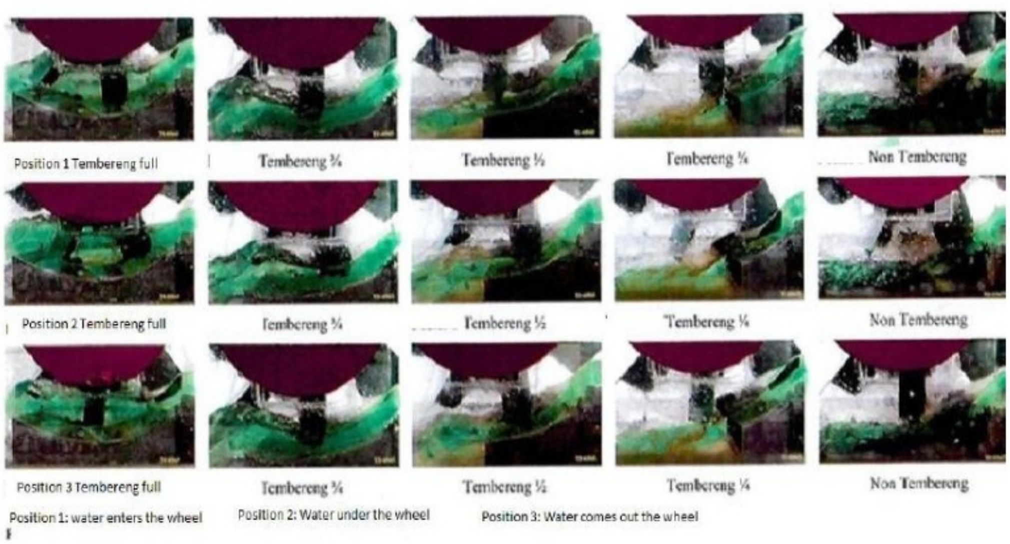


Figure 7: The influence of the basic shape of the canal on water flow

Decreasing efficiency is due to hydraulic losses (Mugisidi et al., 2018). The basic geometry of the blade channel immersed into the water produces the highest turbidity and efficiency. The basic geometry of the ½ blade canal that is immersed into the water causes a decrease in turbine power and efficiency because the water wanting to come out from under the wheel has a path that is shorter than the path in the bottom geometry of the canal ¾, which is 0.194 m. The basic geometry of the canal ¼ the blade that is immersed into the water causes the water to push the blade very slowly, the water enters the wheel, not long after the water falls, because the path under the wheel is shorter than the bottom shape of the ½ canal, which is 0.097 m. The non-basic geometry of the wheel blade canal that is immersed in the water causes the wheel to not rotate optimally.

4. Conclusion

The results show that the shape of the channel with three-quarter variation produces the highest efficiency, namely 56%. This is influenced by the water level within the blades and influenced by the geometri of the channel base.

5. Acknowledgement

This research was funded by DIKTI grant in the PTUPT scheme with contract number 96.AD/LL3/PG/2020. Thank you LEMLITBANG UHAMKA and the UHAMKA Faculty of ENGINEERING as partners who have helped and facilitated a lot.

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