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# A LABORATORY SCALE CURVE BLADED UNDERSHOT WATER WHEEL CHARACTERISTIC AS AN IRRIGATION POWER

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**ABSTRACT**

*Water wheels have been used in rural areas people to distribute water to wet rice fields that are higher than the water source level. The water wheel has a relatively simple design, large diameter, low rotation speed and high torque.*

*This research is a research to make a laboratory scale undershot water wheel model. For further development, this research is expected to be developed in developing countries rural areas.*

*The conclusion from this study is that the higher the water flow rate with a large number of buckets, the lower the water wheel rotation. Conversely, the lower the water flow rate with a smaller bucket number, the higher the water wheel rotation. The lowest efficiency is found under the 12 water wheel buckets and the highest efficiency is found under the 6 water wheel buckets.*

**Keywords:** Water wheel, curved blade, irrigation power, laboratory scale.
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## 1. INTRODUCTION

The waterwheel is the oldest type of hydraulic machine. This waterwheel has a relatively simple design, large diameter, low rotation speed and has a high torque [1-2]. Villagers in rural areas have used water wheels to lift and distribute water to the rice fields, which has a higher elevated place than water sources [3-4]. As mentioned above that the waterwheel

design is relatively simple and has a high torque. But implementing water wheel as a micro-hydro with a high speed and a small diameter should be explored further [5-7].

Water wheel is a movable prime mover because of the water flow. In the available water flow, a certain amount of energy can be used as a renewable energy resource [8]. The rotating part of the wheel is the rotor, while the standstill part is mentioned as the stator (water wheel housing). This water wheel is used to lift water to irrigate rice fields and other human living needs [3].

The water lifting system besides using a wheel and other supporting parts also requires several components that will support each other, even though each has a different function. These components include power sources, bearings, water wheels, shafts, water lines and metal. Windmills can be made from wood, metal plates, split used drums, used car rims and car axle.

Waterwheels made from wood are very suitable for areas that have a lot of wood supplies, for example, areas around the forest or places that are far from welding locations. The cost of making a wooden water wheel is relatively cheap. The water wheel construction can be done directly in the location. The weakness of this wooden water wheel is easily decayed, especially if it is made from young wood or low quality wood and less efficient [9]. The type of wood suitable for making windmills is the hard wood or ironwood. Water wheel made from drum material is simple and easy to make and the material is easy to get. Unfortunately, this wheel cannot be enlarged because it depends on the drum size. So it's only suitable for small scale water wheel [3]. On a large scale it is more profitable to use a car axle as a material for the mill. The reason is, that the power produced can be larger and the wheel can be more durable. The disadvantage is that the windmill requires relatively expensive costs. Also for individual use, it is not suitable. In producing the windmill from second hand car axles, some welding process is needed, so that the manufacturing process is more difficult.

The use of second hand axles is strongly recommended to reduce manufacturing costs. The water wheel is operated by the force produced by the high stream river flow or made to be a swift high stream water flow. The swift river flow under the wheel will cause the wheel blades to be pushed so that the windmill rotates. Water tubes that are assembled between the water wheel blade will take the water, while they are immersed in the water, and spill it on the water wheel top side. The water, which spills into the gutter, will flow to the land that need to be watered.

**Figure 1** Undershot Water Wheel

(Source: http://osv.org/education/WaterPower)

The working mechanism of the undershot waterwheel. The waterwheel operates if there is a running water or a water flow rate. The water running would hit the blade wall, located at the bottom of the waterwheel. The undershot type waterwheel does not have an additional benefit from the head energy [1, 10]. This water wheel type is suitable to be installed in shallow waters and in flat areas. This water wheel type is also called "Vitruvian". The water

flow direction is opposite to the blade direction that rotates the wheel [11]. The advantages of an undershot waterwheels [12] are: (1) Simpler construction; (2) More economical; (3) Easy to move. The disadvantages of this undershot waterwheel [13] are: (1) Low efficiency; (2) The power produced is relatively small.

Several studies related to waterwheels have been conducted, among others: (1) observing the blade variations [13-14]; (2) design testing, fabrication and testing of waterwheels for electricity generation in an open channel flow [15-17]; (3) testing of a breastshot water wheel [18-20]; (4) Testing the water wheel performance [1, 19]; (5) Analysis the overshot and undershot water wheel efficiency using a curved plate blade [1]; (6) Testing and analyzing the relationship between variated water wheel dimension towards the water flow velocity [21].

## 2. EXPERIMENTAL SETUP

This research is a laboratory-scale research that is by making an undershot curved water wheel model. The expectation from this research is to be a miniature for the water wheel development that can be developed in areas with water source difficulties.

The equipment and material used in this study are the water pump, acrylic sheet, bearing, 6 mm thick sheet metal, angle bar, steel plate, water tube, water reservoir for water circulation, pipes, paint, bolts, nuts, valves, rope, sock drag, pipe joints, elbow pipes, korean glue, silicon glue, pipe insulation. The equipment used for the research consists of a water wheel, volumetric flask, stopwatch, pen, paper, small size tub, ruler.

The water wheel is made from a 6 mm thick metal sheet which is shaped like a bicycle rim, while the water wheel blade is made from Acrylic material sheet. The steps are as follows: cutting a 6 mm sheet metal, and then bend the sheet metal to be a water wheel with a diameter of 44 cm (2 pieces are needed), weld both ends. The blade number is 12 with 4 mm height and 8 cm wide dimensions. The blades were made from acrylic sheet, and mounted on the water wheel. The water wheel function to lift water from a low level area to a higher level area.

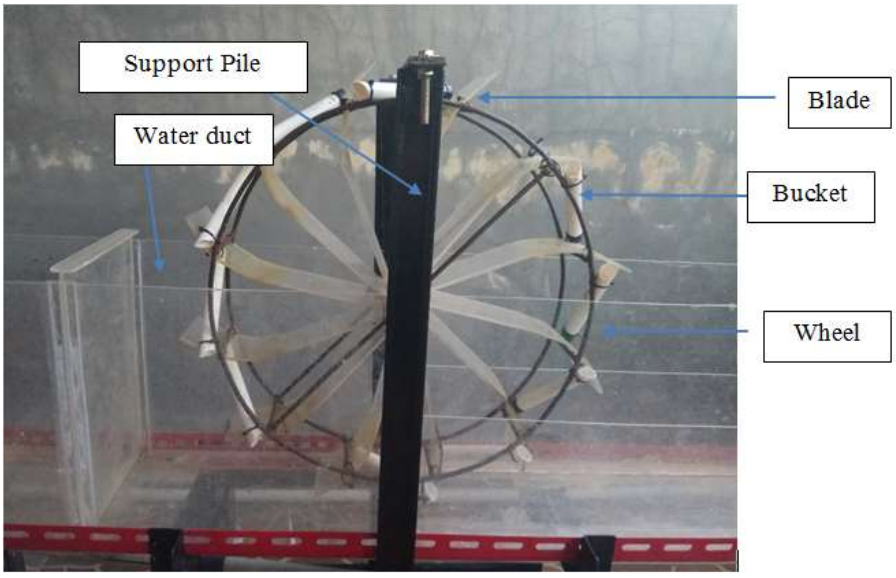


**Figure 2** Curved blade water wheel

## 3. RESULTS AND DISCUSSIONS

From the research result initial data, it is obtained:

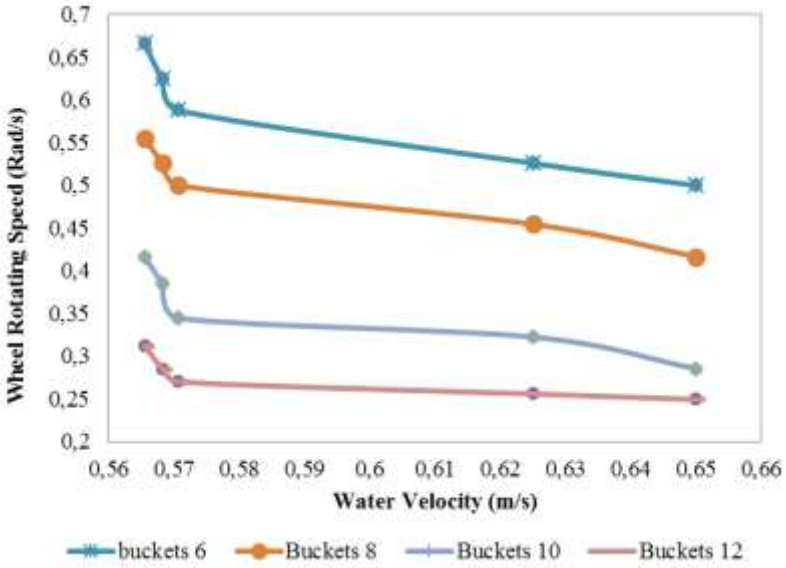


**Figure 3** Flow velocity vs water wheel the rotation speed

Based on Figure 3, the relationship between the flow velocity toward the water wheel speed rotation, on the 6 bucket water wheel, the water wheel rotation has a higher value compare with the 12 bucket water wheel speed rotation. This is due to the flow velocity with the 6 bucket numbers did a smaller amount drawing water, which causes the water wheel would spin faster. Whereas at the same water velocity, but on an increasing bucket number, which are 8, 10 and 12, the lifted load will be even greater to lift water so that the spinning wheel would be slower.

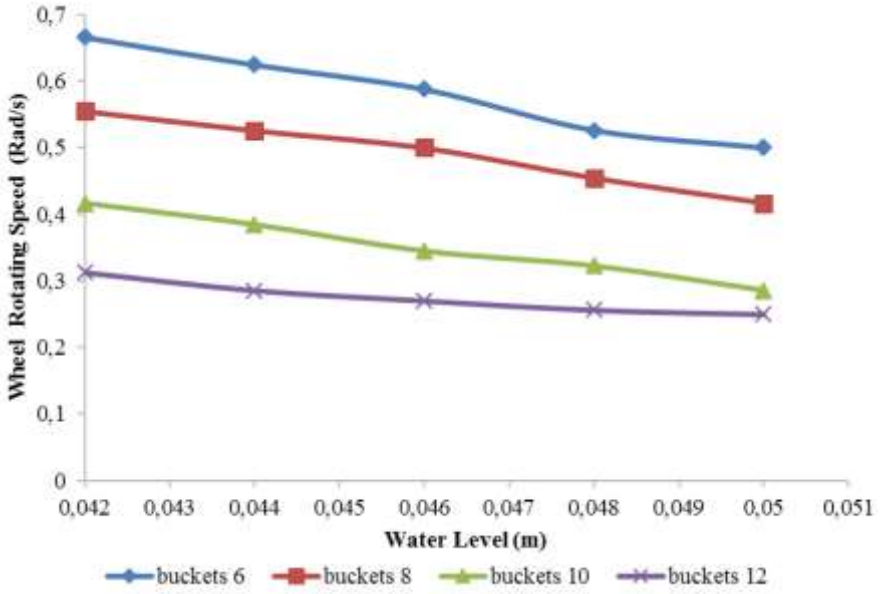


**Figure 4** Water level vs Wheel rotating speed.

In Figure 4, this is the relationship between the water flow height and the water wheel bucket number. It is found that, the higher the water level, the slower the water wheel

spinning. The effect of the waterwheel slowing down spinning is also influenced by the number of the water wheel, bucket lifting water, the less the bucket, the greater the speed of the wheel because the load to lift water is less.

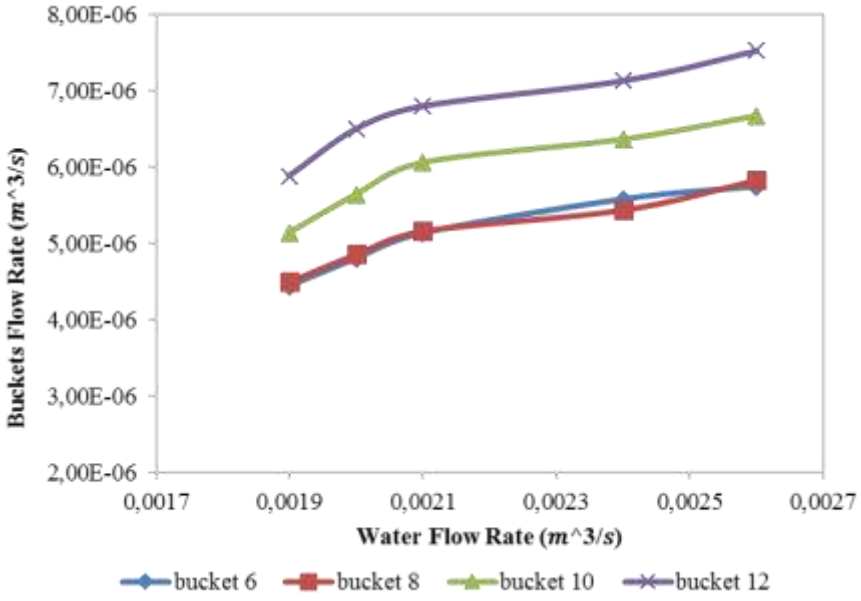


**Figure 5** Water flow rate vs Bucket flow rate

The water flow rate produce by the bucket is greatly influenced by the flowing water flow rate and the bucket number. The greater the water debit, the greater the water produced by the bucket. Similarly, the large number of buckets will result in more water produced by the bucket, which can be seen in Figure 5.

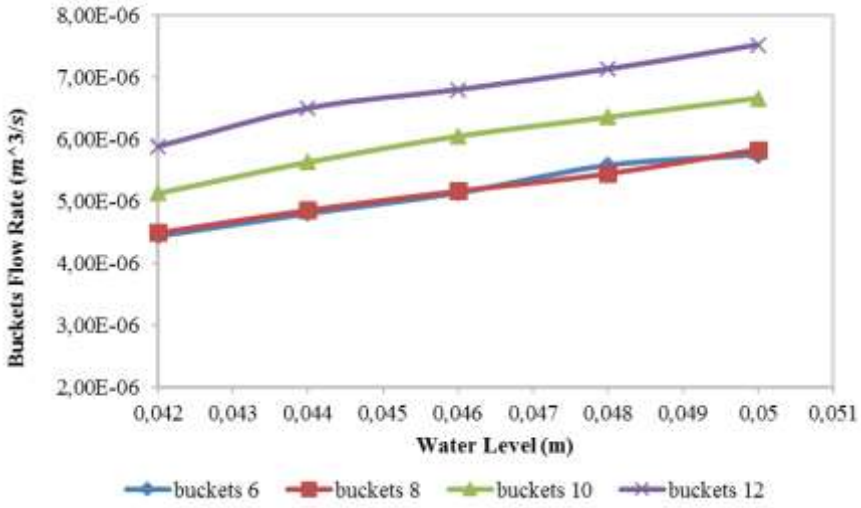


**Figure 6** Water level vs bucket flow rate

The relationship between the water flow height toward the bucket water flow rate is proportionally linear, as shown in Figure 6. Where for the less buckets number as in the 6 bucket number and in the 8 bucket number, with a low water flow, the bucket water flow rate will be small, this is because a few buckets that lifting water, so that the water flow rate produce by the bucket is small. Conversely, on a large number of buckets such as the 10 and 12 bucket number with a high water flow the bucket water flow rate will be much higher, this

happens because the large number of buckets that lift water produces a lot of bucket discharge.

## 4. CONCLUSION

The higher the water flow with a large number of buckets, the slower water wheel speed of rotation. Conversely, the lower the water flow with a smaller bucket number, the water wheel speed of rotation will be higher. The lowest efficiency result is in the 12 bucket number and the highest efficiency is in the 6 bucket number.

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