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Investigation on the Micro Hydropower Undershot Type Floating Blade Tilt Angle for Low-flow Hydropower

Investigation on the Micro Hydropower Undershot Type Floating Blade Tilt Angle for Low-flow Hydropower

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Abstract. Many rivers or streams of water around us can be used for energy. River flow is very promising to be utilized as much as possible in producing electricity. Potential energy from small river fluid flow or irrigation can be extracted into electricity that can be utilized. This research can be used as one of the references in varying the angle of inclination at the blades at 15º, 30º, and 45º. From the analysis of experimental results, the greatest efficiency obtained is 11.14% with an angle of 30º with turbine power of 104.62 watts. This is followed by the lowest efficiency at a slope angle of 45º with turbine power of 111.49 watts with an efficiency of 10.73%. From the highest and lowest results there is a slight difference in the value of efficiency which is classified as low. This is caused by differences in density causing water to pound on the blades made of acrylic with an iron frame to become heavy and friction on the v-belt and pully. Therefore, the rotation cannot produce the maximum transmission.

1. Introduction

The high energy demand in Indonesia which continues to increase has caused major problems when fossil energy resources are increasingly limited. Therefore, there is urgent need to develop renewable energy [1]. Water is an easy source of energy, because in water there is potential energy where water falls and kinetic energy in water flow [2]. Water power is the energy obtained from the energy of flowing water found in these areas [3]. The energy contained in water can be utilized and used in the form of mechanical and electrical energy. Utilization of water energy is mostly done by using waterwheels that utilize river water flow [4]. Waterwheel is one of the energy conversion machines that utilize the flow rate of water [5]. By utilizing water energy into mechanical energy in the form of shaft rotation on the generator it will produce electrical energy using 16 blades until 12 gets an efficiency of 16% [6]. The maximum efficiency of modern water wheels can be maintained at such high values over a wider range of flow rates and hydraulic conditions with respect to longer installations [7], if you already get the maximum results it can incorporate the industrial revolution through research-based products utilizing river flow [8].

Nishi has conducted an experimental research on gravitational vortex-type water turbines with data output in the form of turbine efficiency, torque and computing [9]. Whereas Chehouri himself has targeted future energy needs over the past 30 years, which has evolved from a metric of the previously maximized power coefficient to the maximization of annual energy production so that it becomes a challenge, problem and development [10]. Whereas Nishi himself developed a water turbine that is suitable for low heat in open channels, with the ultimate goal of effectively utilizing hydroelectric energy that is not used in agricultural waterways [9] can also be utilized breastshot type waterwheels are gravity hydraulic machines used in heat locations that are low [11], in addition it can utilize Archimedes hydrodynamic screw-type waterwheel (AHS) [12]. This research was based on previous research conducted by Setyawan [13] which designed an undershot type waterwheel with twelve blades. From several analyzes from the results of previous studies, this analysis aims to get the right angle in order to get maximum efficiency so that 3 angles are chosen, namely the inclination of 15º, 30º, and 45º which can later be made for street lighting around the river. This is because many certain points that do not get proper lighting at night.

2. Method

To carry out this experimental test, the first thing to do is to make a floating micro hydro waterwheel with the undershot type. The first step was to make a waterwheel frame 400 mm wide, 170 mm long and 0.8 mm thick. while for the turbine cover right and left are made of acrylic with an outer diameter of 500 mm, an inner diameter of 25 mm, and a thickness of 2 mm, for the blade itself is made of PVC with a length of 400 mm, width 93 mm. for axles used iron with a diameter of 20 mm, to rotate the generator, add a pulley with a diameter of 350 mm having a v-belt type A groove, with a DC generator with a capacity of 300 watts and a 3-phase electric current that is converted into 1 phase. Polyurethane is used as material for making the buoys. The use of polyurethane as a float is by mixing two types of liquid polyurethane A and B in a ratio of 2 to 3. After mixing, the polyurethane is stirred using a hand drill that has been given a stirrer on the drill bit until the polyurethane mixture expands. After that, it is poured into the pre-prepared mold. Then, it is allowed to expand on its own until it forms a mold and is left to dry, as shown in Figure 1.

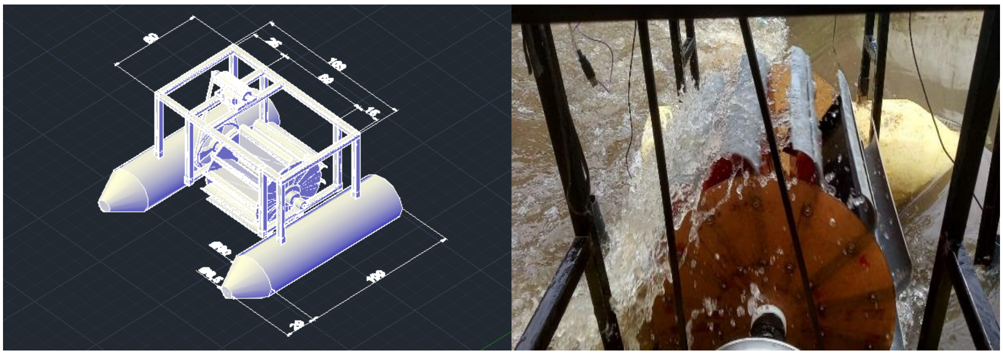

Figure 1. Design and photograph of experimental set up.

Figure1. is a design drawings and the results of making undershot floating micro hydro type to facilitate researchers in making undershot type floating micro hydro prototype. In the manufacturing process used several equations to analyze in the design and results for undershot type floating micro hydro experiments with tilt angles of 15º, 30º and 45º. To determine the volume of the pontoon used so that the load carried is not immersed, the application of the tube volume equation provides the following equation.

$$V = \pi \, . \, r^2 \, . \, t \qquad (1)$$

The volume of the cone cone itself is an upright cone whose upper end is cut off, where the *V* of the cone cone equal to *V* of the large cone minus the cone of the small cone is used the following equation.

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$$V = 1/3 \, . \, \pi \, . \, r^2 \, . \, t \tag{2}$$

Displaced water weight is determined from the volume of the pontoon times 62.4 Lbs. To get the capacity of the pontoon transport used pontoon capacity with Displaced water weight minus the weight of the pontoon. For the turbine calculation itself, especially to find out the velocity of water flow, the following equation is used.

$$v = \frac{s}{t} \tag{3}$$

V is the velocity of water flow (m / s), while s is Distance (m) and t itself is time (s). To find out the water discharge the following equation is used.

$$Q = v \text{ x } A \tag{4}$$

Q itself is the flowrate of water (ℓ/s), for A is the cross-sectional area of the river (m^2) and v is the velocity of water flow (m/s). To find out the hydrolysis power or power produced by water from a height is calculated by hydrolysis power of water as in the following equation.

$$Pa = \rho \, . \, g \, . \, Q \, . \, H \tag{5}$$

Pa is the hydrolysis power of water (watts), ρ itself is the specific gravity of water (kg/m^3), g is the earth's gravitational force (m/s^2), Q is the flowrate of water (ℓ/s), for H itself is Head (m). To find the force on the blade, use the following equation.

$$w = m \, . \, g \tag{6}$$

W is the load force (N), m is the mass (Kg), while g is the earth's gravitational force (9.8 m / s2). To find the torque the following equation is used.

$$T = w \text{ x } b \tag{7}$$

T is the torque of a rotating object (Nm), where w is the load (N), and b is the length of the arm (m). to find out the angular velocity used.

$$\omega = \frac{2\pi \text{ x } n}{60} \tag{8}$$

ω is the angular velocity (rad/s), π has a phi value (3.14), whereas n is the turbine rotation (rpm). Meanwhile, to find the turbine power, the following equation is used.

$$P = T \text{ x } \omega \tag{9}$$

P_t is the turbine power (watt), while T is the torque of a rotating object (Nm) and is the angular velocity (rad / s). Meanwhile, to find out the specific rotation the following equation is used.

$$N_s = n \frac{\sqrt{P_t}}{H^{\frac{5}{4}}} \tag{10}$$

N_s is the turbine specific rotation (rpm), n is the turbine shaft rotation (rpm), P_t is the turbine power (HP), H is the height (m). To find out the efficiency of the turbine, the following equation is used.

$$\eta_t = \frac{P_t}{P_a}.100\% \quad (11)$$

η_t is the turbine efficiency (%),P_a is water power (watts), and P_t is turbine power (watts). To find out the system efficiency can be known after testing the undershot-type floating micro hydro prototype with the following equation.

$$\eta s = \frac{Pg}{Pt} \times 100\% \quad (12)$$

η_s is the efficiency of the system (%), for P_g it is generator power (watts), while p_t is turbine power (watts).

3. Results and Discussions

Undershot type floating microhydro experiment equipment with angular variation is obtained from the results of tests conducted directly and calculated based on the tilt angle of 15º, 30º, and 45º obtained the values in Table 1.

Table 1. Results of the experimental slope angles of floating micro-hydro blades.

No.	Tilt Angle	Turbine Rotation (Rpm)	Generator Speed (Rpm)	Volt (V)
1.	15º	65.14	570	22
2.	30º	68	595	23.3
3.	45º	72.46	634	23.93

In Table 1. the resulting voltage based on an angle of 15º is 22 volts. For voltage generated with a slope angle of 30º is 23.3 Volts and for voltage generated at an angle of 45º is 23.93 Volts. from the above data it can be seen that the greater the angle of inclination at the blade, the greater the resulting voltage and from that data a graph can be made as in Figure 2.

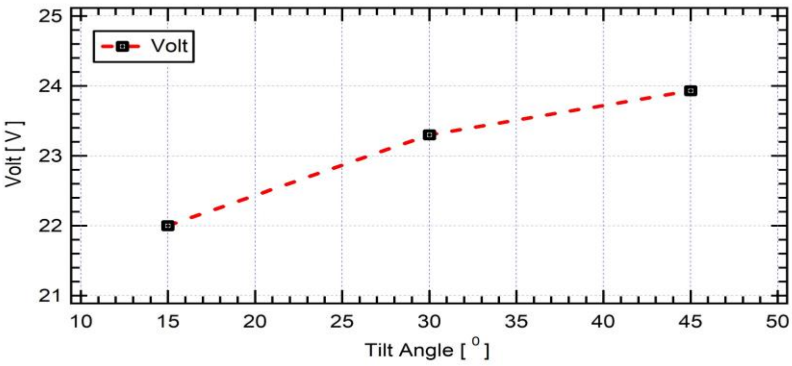

Figure 2. Experiment of the tilt angle of the floating microhydro blade.

In Figure 2, it is seen that the greater the slope angle provided will increase the rotation of the turbine and generator and the resulting volt is also getting bigger. So among the 3 tests carried out as shown in table 1. the angle of the blade of the blade produces the highest voltage is the number 3 reaches 23.93 Volts, with turbine rotation of 72.46 rpm and rotation of the generator at 634 rpm with an angle 45º. The system efficiency obtained after testing the undershot type floating micro hydro as shown in Table 2.

Table. 2 Efficiency of floating micro-hydro test results.

No.	Titl Angle	Turbine Power (Watt)	Voltage (V)	Current (A)	Generator Power (Watt)	Efficiency (%)
1	15º	100,22	22	0,5	11	10,98
2	30º	104,62	23,3	0,5	11,65	11,14
3	45º	111,49	23,93	0,5	11,965	10,73

From Table 2. It can be explained that the efficiency of the system obtained from water turbines with the greatest efficiency is 11.14% with an angle of 30º with turbine power of 104.62 watts. Furthermore at an angle of 15º with turbine power of 100.22 watts and with an efficiency of 10.98% and the last at an angle of 45º with turbine power of 111.49 watts with efficiency of 10.73%.

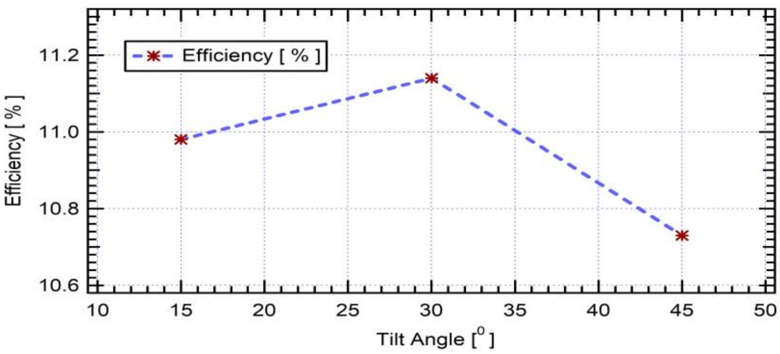

Figure 3. Efficiency of floating micro hydro.

From the results obtained in Figure 3, there is a slight difference in the value of efficiency which is classified as low, because the difference in density causes water to pound on the blades made of acrylic with an iron frame. So much that spreads and causes losses that occur when the turbine rotates. In addition there is also a loss in pulleys, this happens because the pully is exposed to water and causes slippage that occurs in the v-belt and pully, this causes the rotation cannot transmit optimally.

4. Conclusion

From several analyzes of the results of research that have been done with a tilt angle of 15º, 30º, and 45º, obtained the greatest efficiency obtained by 11.14% with a 30º angle with turbine power of 104.62 watts. The lowest efficiency is at an angle of 45º with a turbine power of 111.49 watts with an efficiency of 10.73%. From the results of the highest and lowest experiences a slight difference in the value of efficiency which is classified as low due to differences in density and friction in the v-belt and pully.

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