

Phenomenon characteristics water turbine screw type scale prototype to changes in operational conditions

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Abstract

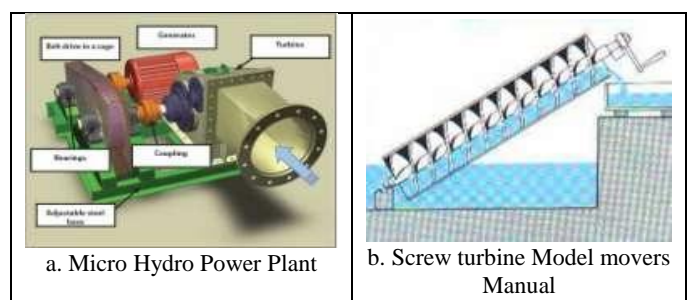
Utilization of water energy as a renewable energy source generally requires high investment. But for the scale of prototype can be done by using materials that exist around the residence. One form of utilization is to use Micro Hydro Power Plant. The main component used in Micro Hydro Power Plant is turbine, in this prototype scale research is used turbine screw. The use of turbine screw started in Europe at the end of 2007 ago, in Indonesia just started in 2009 area of West Java. Threaded turbines have high efficiency and can work on low head, this is in accordance with the number of potential water energy with low head in Indonesia. But as a new turbine technology, so far there is very little theory or reference available regarding research and references on threaded turbines. Lots of design parameters that have not been well known, one of which is the slope of the turbine shaft. The purpose of this research is to know the characteristics of turbine type scew water operated with various operational needs. The experimental method was conducted experimentally by finding and determining the optimum shaft angle angle, comparing the slope of the turbine shaft, with a pitch angle of 30° , 45° and 60° . While the discharge water is $4 \text{ m}^3/\text{h}$, $6 \text{ m}^3/\text{h}$, $8 \text{ m}^3/\text{h}$, $10 \text{ m}^3/\text{h}$, $12 \text{ m}^3/\text{h}$ and $14 \text{ m}^3/\text{h}$. Based on the results of the tests that have been done and analyzed it can be concluded that the screw turbine with a shaft angle of 60° and water flow $14 \text{ m}^3/\text{h}$ better and effective than the angle of the shaft 30° and 45° .

Keywords: screw turbine, angle of the shaft, pressure, micro hydro

1. Introduction

The need for electrical energy is increasing now with the increase in human growth and equipment using electrical energy such as electricity for housing, electricity for transportation such as electric trains, household appliances and others. Electrical energy required by humans can be generated by power plants that use several energy sources such as hydroelectric power, steam, fuel oil, solar, nuclear and other (Kumar *et al.* 2012) [6]. Currently energy sources for power plants such as fuel oil or steam power derived from petroleum and coal energy sources have begun to thin out and in addition to raw materials there is no coal processing system that is environmentally friendly. This encourages researchers or designers to look for other potential alternative energy sources. Current potential energy sources are hydro power, solar power, and wave power where for this energy source the equipment or processing machine from kinetic energy or heat is used for electrical energy (Gundukeya *et al.* 2013) [5]. Micro hydro is a technology utilizing water in generating electrical energy. Microhydro utilization begins with problems for remote areas of electricity supply. Remote areas that have the potential for water flows such as rivers and irrigation do not get adequate electricity supply caused by the area is far from the reach of the power grid from the central (power) power plant. Given this potential it can be used to generate power plants with capacities less than 100 kW using microhydro (Anggraeni *et al.* 2012) [1].

Working principle Micro hydro power plant using turbine screw is utilizing head and water discharge per hour flowing in irrigation channel. This water flow will move the turbine screw. The turbine screw movement will rotate the connecting shaft between the turbine and the generator (generating mechanical energy). The shaft will move the generator so that the mechanical energy of the shaft will be converted to electricity in the generator. Figure 1. example of machine components and micro hydro power plants. The energy problem is strictly related to human needs and represents one of the first concerns for the human race. It covers a wide range of fields: technical, political, social, environmental and sometimes ethical. It may be no exaggeration to say that the future of the world and every single country depends upon it (Adenikinju, 2005) [2].



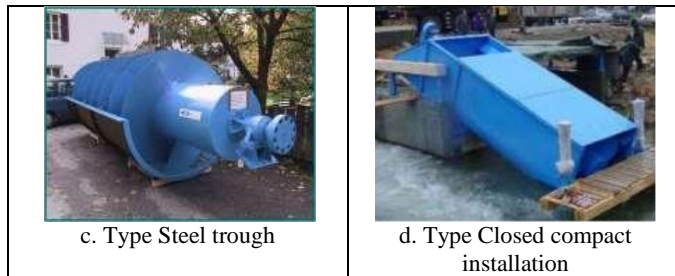


Fig 1: Machine Components and Micro Hydro Power Plant

This paper will focus mainly in making a prototype and experimentation of Archimedean screw turbine under the micro hydro range for low head applications. Simple manufacturing methods using locally available material will be presented. The performance of the test unit will be explored and evaluated as well as identify potential areas for improvement.

Micro hydro power plants with other generators such as windmills and other species require dams or dams to regulate the flow of water for their propulsion, intake tower building to drain the water from the intake, overflow water, tranquilizers and pipe that serves to Drain water into the turbine (Nieman., 1987-). In a rapid pipe the potential energy of water is converted into kinetic energy that will rotate the blade. Upon exiting the water pipe into the turbine through the inlet in which there is a vane steering which is useful for opening and closing the turbine, adjusting the amount of water entering the blade so that it moves and produces kinetic energy that spins the turbine shaft. Axis rotation will generate mechanical energy transmitted to the generator to produce electrical energy. The generator transmission system can occur directly or indirectly. For direct transmission the shaft power is directly related to the generator shaft through the coupling while the system does not directly use the belt or belt in its power transfer process (Muller., 2009) [7].

The capacity to produce this energy is dependent on both the available flow and the height from which it falls (Graham *et al.* 2010). The Erijiyan town located in Ekiti State, Nigeria, is blessed with natural water fall from a hill with sufficient head; installation of a micro hydro turbine will be very efficient. Archimedes screw Turbine has shown to be excellent type of micro hydro turbine under low head conditions specially suited to large flow site, installation of this type of turbine is more effective and efficient. The Archimedes screw is one of the oldest hydraulic machines known to man. It was employed as a pump, but the French engineer Navier already mentioned the possibility of employing it in a power generation role at the beginning of the nineteenth century (Bozhinova *et al.* 2012) [3]. The efficiency of Archimedes Screw is a function of mechanical, hydraulic and leakage losses only (Nagel and Radlik, 1988). Measurements of the Archimedean screw as an energy converter showed the effect of inflow water level to diameter, and gave efficiencies between 79 and 84%, making it an interesting alternative for turbines in low head hydropower applications (Hellmann, 2003) [4].

The experimental screw turbine study still needs to be developed to get real information in order to apply the screw turbines optimally. Screw turbine is applied on river flows and

irrigation canals, which they are in open surface condition. Prime mover of the open flow is the weight of fluid that influenced by gravitation and its pressure distribution is hydrostatic. Character of the open flow could be indicated by dimensionless parameter; it is called by Froude Number (Fr). This research is important because the water flow is the source of kinetic and potential energy which was used in screw turbine power generation system. The experimental screw turbine was made in a laboratory scale using stainless steel material. The aim of this is to determine the screw turbine efficiency by observing the effects of the Froude number (Fr) and the flow phenomenon. The linear momentum flow equation application on a one-dimensional control volume of a screw turbine blade is the hydrostatic force toward the blade screw, shown in Figure 2. The screw turbine hydrostatic force is the resultant between the hydrostatic force along the turbine axis with the number of helix turns m and pitch per number of blades (Stergiopoulou., *et al.* 2013) [10].

The purpose of this research is to know the characteristics of turbine type scew water that can be operated with various operational needs.

2. Research Method

The experimental method was conducted experimentally by finding and determining the optimum shaft angle, comparing the slope of the turbine shaft, with the axial inclination angle of 30° , 45° and 60° While the discharge water is $4 \text{ m}^3/\text{h}$, $6 \text{ m}^3/\text{h}$, $8 \text{ m}^3/\text{h}$, $10 \text{ m}^3/\text{h}$, $12 \text{ m}^3/\text{h}$ and $14 \text{ m}^3/\text{h}$. In this study using a series of prototype scale test equipment installation, then at the end of the research to make correlation with the results of previous research and analyzed in advance the results of the test tersebut.setup test tool can be seen in Figure 2, while the operational parameters in the data collection Required can be seen in table 1.

In this research use optimum geometry which obtained from result of turbine device of screw made and tested in scale of prototype, condition of this very influencing result of which is got.

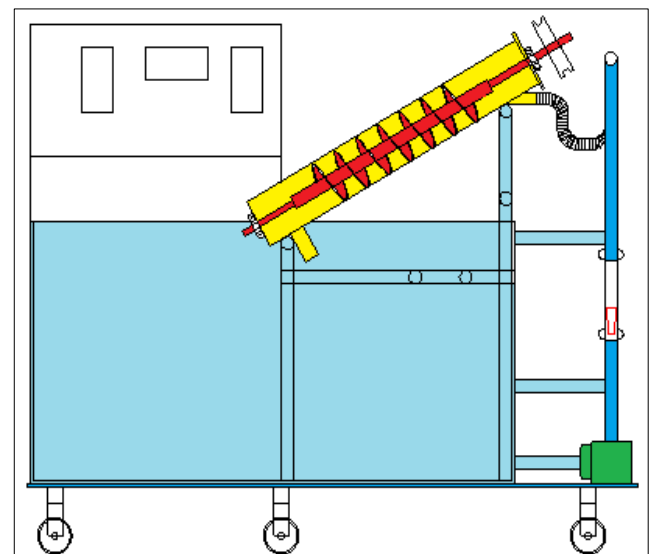


Fig 2: Experimental Set up

Table 1: Experimental conditions

Parameter	Description
Water discharge	4 m ³ /h, 6 m ³ /h, 8 m ³ /h, 10 m ³ /h, 12 m ³ /h dan 14 m ³ /h
The angle of the turbine shaft	30°, 45° and 60°.

3. Results and Discussions

In screw-scale turbine screw testing is done to obtain the results of screw turbine analysis. The workings of this screw turbine tool is to hold water in a reservoir which then using the pump as the driving medium to push the screw turbine blades to generate the resulting spin. In the process of data retrieval on the test turbine screw performed two days with different angle variations of 30°, 45° and 60° and done with no load and use the load. In this test is done according to the correct testing standards by designing tools that have also been standardized, in order to hope the data obtained to be more accurate and exactly as desired.

The first test is carried out with a 30° no-load spin.at angle 30°

In this first test, the first non-loaded loop is done to manage all the equipment used. To start from the tank until the spin turbine blade spin. After the test then obtained the data generated from the pump impulse, as shown in Figure 3 below. In Figure 3 also shows the condition where the slope angle as the model used as the experiment without. This is to get the comparison results if later done by using on the same thing



Fig 3: Screw Turbine angle 30°

Second Testing Round Without Load Angle 45°

The second test for loose rotation with 45° angle is done is to adjust the angle of screw turbine and equipment used. To start from the tub / tank until the spin turbine blade spin. This test is performed at an angle of 45°, as shown in Figure 4 below.



Fig 4: Screw Turbine angle 45°

Third Testing Round Without Load Angle 60°

A third test, for a no-load loop at an angle of 60° is accomplished by adjusting the angle of the screw turbine and the equipment used. To start from the tub / tank until the spin turbine blade spin. This test is carried out at an angle of 60° as shown in the following figure 5.



Fig 5: Screw turbine angle 60°

3.1 Turbine Screw Test Results without load with angle variation 30°, 45° and 60°

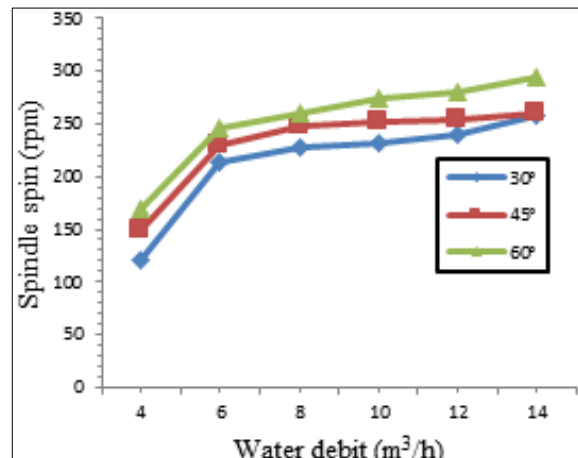


Fig 6: Relation of turbine shaft rotation (rpm) with water discharge (m³/h) angle 30°, 45° and 60°

In the loadless test of the variation angle 30°, 45° and 60°, it can be seen in the graphic image 6 where there is a comparison between the turbine spinning rotation and the test flow flow tested, as shown in the graphic figure 6. As shown in the figure that the flow discharge very influential on the rotation of the shaft is the greater the discharge is given then the rotation on the shaft is also getting bigger.

Based on the research that has been done the effective turbine speed between the angle of 30°, 45° and 60° is at an angle of 60° because at this angle the rotation of the screw turbine can be seen on the graph that the speed of the screw is faster, at the flow of water flow 14 m³/h at the corner 30° is 258 Rpm, the angle 45° is 260 rpm and the 60° angle is 295 rpm. While on the loadless test from the angle of variation 30°, 45° and 60°, can be seen in graph of image 7 below:

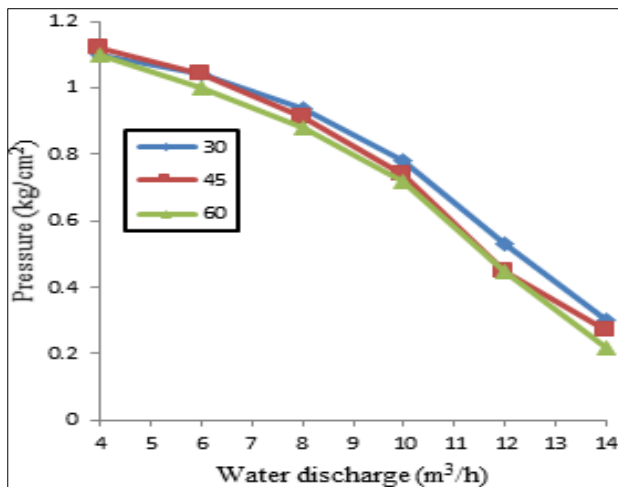


Fig 7: The relationship of water discharge (m³ / h) with pressure (kg/cm²) of angle 30°, 45° and 60°.

If we look at the picture 7 then based on research and the

results of data processing can be concluded that the greater the flow of water then the pressure even further down. Of the three trial between 30°, 45° and 60° the greatest pressure angle is at 45° angle because the slope is most effective. On the other hand, the characteristic phenomenon that occurs in the no-load test with variation angle of 30°, 45° and 60°, can be shown in the following graphic figure 8.

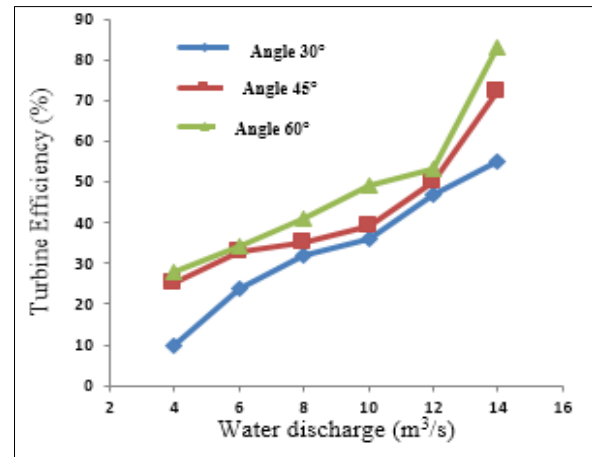


Fig 8: Water discharge relationship (m³/h) to Efficiency (%) with angle of 30°, 45° and 60°

From the graphic figure 8 it can be seen that the efficiency is increasing due to the increase of the water discharge and the turbine produced spin. For the greatest efficiency is at an angle of 60° with 295 rpm spin efficiency produced 75%. While the smallest efficiency is at an angle of 30° with round of 120 rpm with 10% efficiency. While the largest turbine power at a discharge of 14 m³/h is 153 Watt at 60° and the lowest is at the discharge of 4 m³/h is 12.7 Watt with shaft slope angle 30°. Related to the information about turbine power can be seen in the graphic figure 9 below:

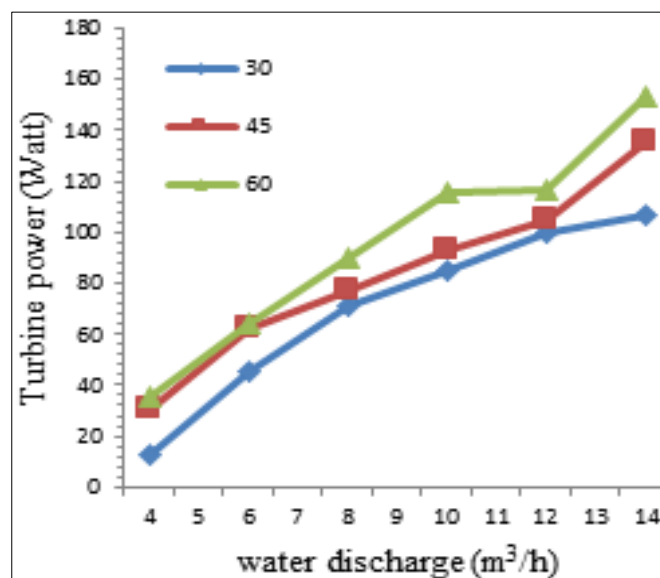


Fig 9: The relationship of water discharge to turbine power at 30°, 45° dan 60°.

From the graphic figure 9 that is the relationship between turbine power to water discharge can be concluded that with increasing the capacity of each discharge the turbine power that is obtained increasing because influenced by the rotation of every corner that has been determined. The largest turbine power is produced at a 60° angle with 153 Watt turbine power at a water discharge capacity of 14 m³/h and the lowest is at a water level of 4 m³/h is 12.7 Watt with a 30° shaft slope.

3.2 Screw Turbine Test Results with load and angle variations 30°, 45° and 60°

In the test using a load with angle variation of 30°, 45°, 60°, can be seen in the graphic image 10 to figure 14 below so that it can be seen the comparison between the turbine spinning rotation with the load tested at each operational condition of the test. Based on the research of the rotation of the turbine shaft (rpm) with the load (gram) as shown in Figures 10 through 14, it states that the research between angles of 30°, 45°, 60° is the same load from an angle of 30°, 45°, 60°. It's just that the different parts of the turbine shaft rounds.

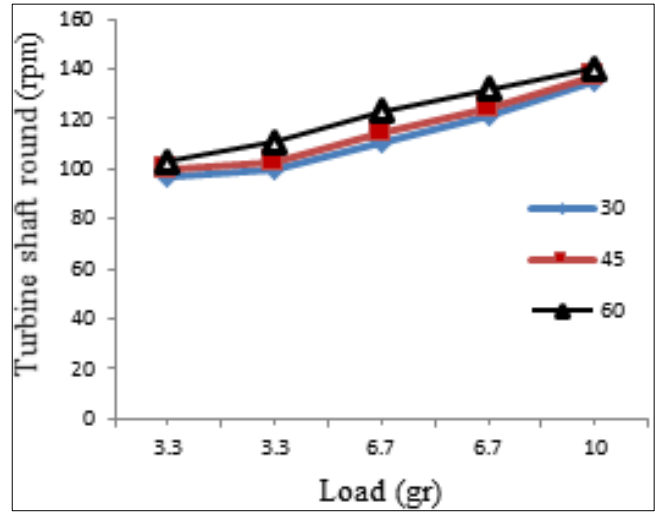


Fig 10: The relation of rotation of the turbine shaft (rpm) to the load (gram) at an angle of 30°, 45°, 60° at a flow rate of 6 m³/h.

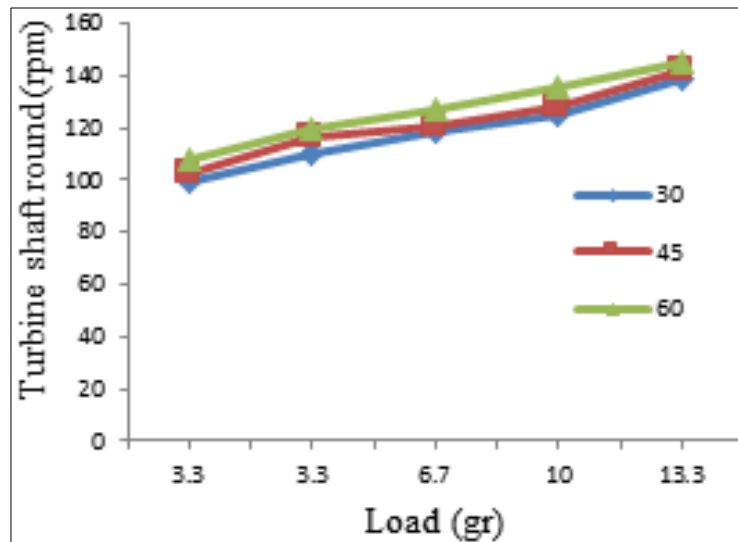


Fig 11: Relation of rotation of the turbine shaft (rpm) to the load (gram) at an angle of 30°, 45°, 60°, at flow rate of 8 m³/h.

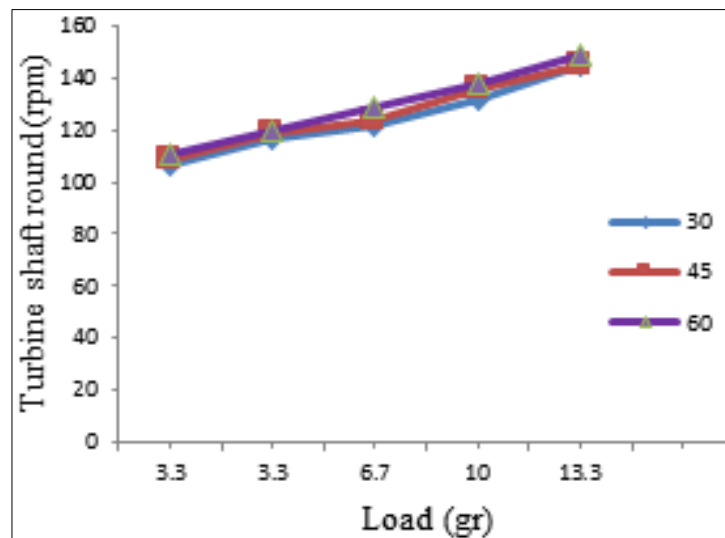


Fig 12: Relation of rotation of the turbine shaft (rpm) to the load (gram) at an angle of 30°, 45°, 60°, at flow rate of 10 m³/h.

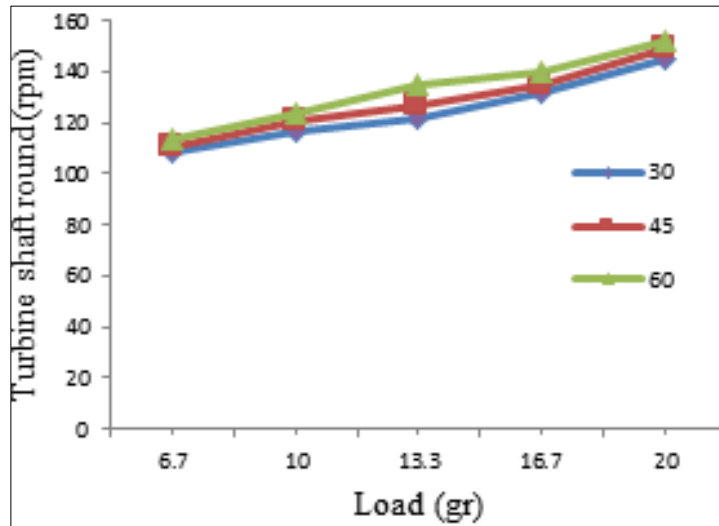


Fig 13: Relation of rotation of the turbine shaft (rpm) to the load (gram) at an angle of 30°, 45°, 60°, at flow rate of 12 m³/h

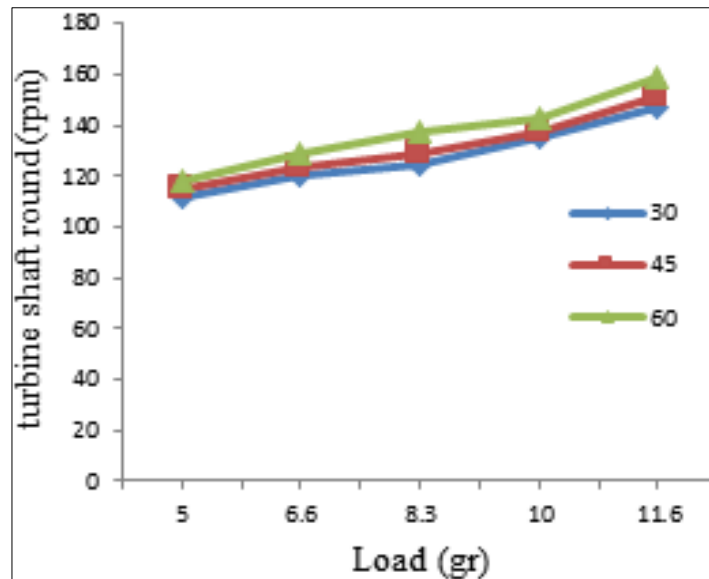


Fig 14: Relation of rotation of the turbine shaft (rpm) to the load (gram) at an angle of 30°, 45°, 60°, at flow rate of 14 m³/h

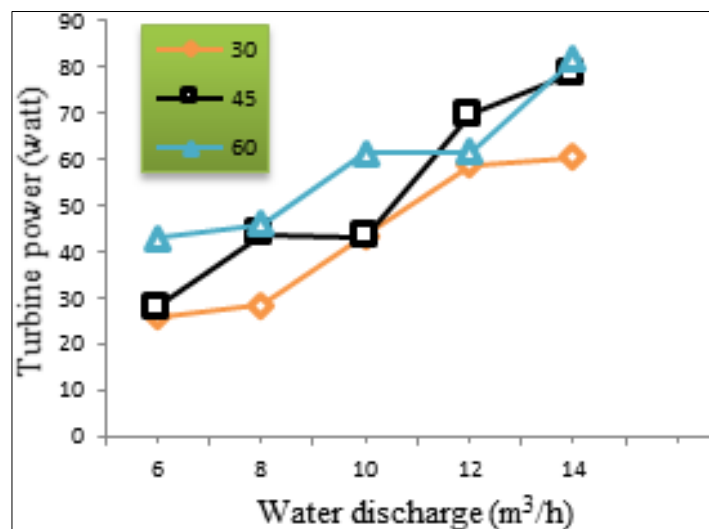


Fig 15: Turbine power relationship (Watt) to water discharge (m³/h) using load at 30°, 45°, 60°

From the graphic picture 15 it is seen that the relationship between turbine power to the water discharge can be concluded that with increasing the capacity of each discharge the turbine power generated is increasing as it is influenced by the rotation of any predetermined angle. The largest turbine power is generated at a 60° angle with turbine power of 81.7 Watt at water discharge capacity of 14 m³/h and at a 45° angle at 10 m³/h discharge decreased by 0.7 Watt from the discharge of 8 m³/h from 44 Watt to 43.3 Watt.

4. Conclusion

From the discussion and analysis that has been done in this research, it can be concluded that the phenomenon of turbine characteristic of water screw type can be operated with various operational needs, that is the bigger the pressure the smaller the rotation that is produced in each slope angle between 30°, 45° and 60°. The greatest pressure is at an angle of 45° with a pressure of 1.12 with a rotation of 150 rpm. meanwhile the lowest pressure is at a pressure of 0.22 at a slope angle of 60° is with a 295 rpm rotation. While in the operational conditions on the variation of water discharge or water capacity can be concluded that the greater the discharge of water that comes out the greater the rotation, torque, turbine power and load in the can - each slope angle between 30°, 45° and 60°. From the flow of water at the most effective angle is the 60° with a water flow of 14 m³/h due to rotation, torque, turbine power and the highest load of 295 rpm, 0.5 kg.cm, 154 Watt, and 20 gram. condition of possibility resulted from by various condition of operational like water debit, different angle corner.

5. Acknowledgements

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