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Determining the Right Nozzle Diameter Size and Their Effect on the Performance of Picohydro Technology

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ABSTRACT

New energy and renewable energy are solutions that can be applied to meet energy needs, especially those that are environmentally friendly. Currently, people, especially those living around energy sources such as rivers and irrigation, can independently create renewable power systems to produce energy. The application of picohydro power generation technology is the best solution in the application of environmentally friendly, independent, and renewable technologies. The purpose of this study was to determine the best performance of the nozzle output diameter of 3", 4", and 5" on picohydro technology using an Archimedes screw turbine. The research method was carried out by means of a prototype experiment using continuously circulated water fluid. The data collection process starts from the water discharge from the flowmeter, the rotation of the turbine blade, the rotation of the transmission, the rotation of the alternator, the pressure in the pressure gauge, and the power generated. The research results obtained information that at the smallest diameter (3") the nozzle pressure to the screw tip is not optimal because the water released by the nozzle only hits part of the screw leaf side, so that the performance is not optimal where the turbine shaft rotation at a maximum discharge of 30 m^3/h is obtained at 230 rpm, while if the diameter of the output nozzle is given (5"), a lot of water is sprayed by the nozzle and it fills the screw leaves, which causes water to also overflow onto the screw in front of it, so that the flow does not normally flow from each screw, and it is also possible that the size of the input screw is not proportional to the output screw turbine, where the maximum rotation at a discharge of 30 m^3/h is obtained at 247 rpm. For the size (4") it looks higher when viewed from the data obtained, this condition looks ideal in the size ratio between the input and output nozzles so that the resulting flow is also right to drive the turbine screw. The shaft rotation results obtained are 269 rpm for a water discharge of 30 m^3/h.

1. Introduction

At this time all countries in the world through the unity of nations are busy looking for renewable energy sources as a substitute for conventional energy which will soon run out. This condition is

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experienced not only by developed countries but also developing countries such as Indonesia, Malaysia, and other ASEAN-level countries. Currently, energy inputs used in several countries in the world still use conventional energy from coal, natural gas and petroleum funds, which of course will run out soon [1-2]. Therefore, listening to this situation has become a shared obligation and responsibility, both as individual and group of people, to look for new and renewable sources of alternative energy income in serving people's life. One of the new and renewable energies that can be utilized is using pico-hydro technology, or better known as the Pico-hydro Power Plant, as its main component are water flow, stock pipe, nozzles, turbine and a generator [3-4]. The advantage that can be picked up with this generation technology model is that with only a small water discharge it can produce electricity above 1 kW which can turn on the lights and the electricity needs of the community, but the maximum only produces below 5 kW which is why it is called a pico-scale generator [5]. This research makes complete picohydro technology system that is installed screw turbine and focus of the test model is nozzle. This nozzle as the main component has an important role as regulator of pressure and speed in the water which will rotate turbine blades. Therefore, diameter design is needed to be applied in the field, so that it can push water properly [6-8].

State of the art from the results of research related the topic of latest research development, pico-hydro power generation system are still not widely carried out and applied in application for utilizing renewable energy based on irrigation and river flow. So far, several researches have been conducted on micro-hydro generators and large-scale hydropower plant with the aim of generating more than 1 MW of power, while pico-scale generators still need to be developed so that they become tools that are ready to be applied to applications with actual power below 1 kW. Therefore the researchers conducted a measurable study in this study which focused on the nozzle output diameter which is one of the main components of picohydro technology. The main component of pico-hydro technology, namely the nozzle, was chosen as the research object because this part is the basis for entry of water flow which will drive the turbine blades, therefore applied and measured research for the conditions and diameter of the nozzle which will produce optimum pressure is the focus of this research. this can, of course, be further developed in real terms.

Pico hydro power plant is a power generation system that uses hydropower sources on a small scale with a capacity of under 5 kW which can be applied to rivers, irrigation [9]. Someone who is going to build the infrastructure for a hydropower plant model must meet several main requirements such as the flow of river water that has a good enough spring and an adequate place for the construction of a power plant in terms of the height and width of the river where generator is placed. Several references have also been put forward by researchers who are concerned with the field of hydropower, as has been done Budiarso *et al.,* [10], Zitti *et al.,* [11] presented his findings saying that the main part of the guide in the form of a nozzle has an impact on shaft performance for the turgo turbine type, so the nozzle model must be made according to the condition of its application [12,13]. The angle of Blade section is the most important component in water energy conversion system as tool that interacts directly with flowing water. The screw type water turbine is divided into two type, namely the steel tough type and the closed compact installation type. The steel trough type screw turbine is a type of turbine that has an open blade or blade, so that the water flowing into the turbine blade is only as wide as the bucket [14-16]. Whereas in the other part, the closed compact installation type screw turbine is a type of turbine that has all installations tightly closed [17-19]. In this type of turbine it is possible to ensure that the water flowing to the turbine blades meets the part covering the turbine installation [20].

The explanation in the background description is the most important part for determining focused and detailed research objective. So that researchers have conducted research related to the right nozzle dimension model in the application of picohydro technology as an energy source for

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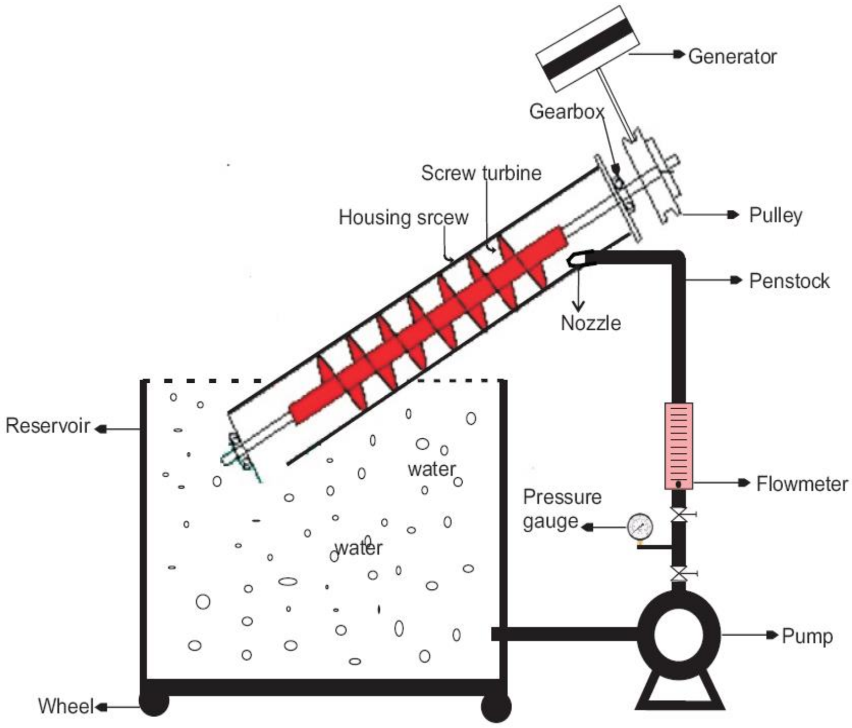
producing environmentally friendly electricity [21], namely with the aim of this study is to find out the best performance nozzle output diameter of 3", 4", 5" in picohydro technology using an Archimedes screw turbine.

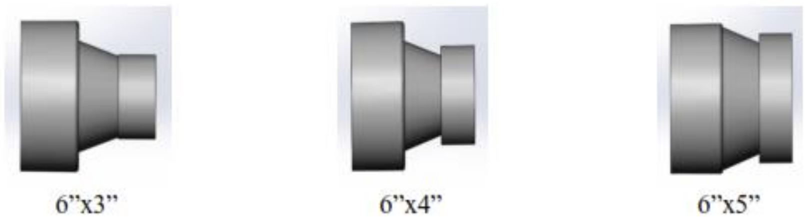
2. Methodology

Figure 1 is a series of equipment showing experimental conditions including the design of test equipment, measuring equipment and test models in the form of variations in nozzle diameter with sizes of 3", 4" and 5" which are installed alternately during data collection. In Figure 1 there are several different view, parts (a), (b) and (c) are side views, while a photo of the original experimental device can be seen from above in Figure 1(d). Explanation that appears from the Figure 1(a) is a set up design of the test equipment used in this study, in which the complete installation of the main components of the picohydro technology is installed on the device to the measuring devices used in the measurement process when the operational conditions for data collection are carried out. The working of the prototype of this picohydro technology test tool starts when the water pump is turned on to suck water from the reservoir, the water is then flowed into the connecting pipe that has been installed at the output of the water pump to the nozzle, in this testing process the water flowing through the stock pipe will be measured for pressure and incoming water discharge, where this condition is likened to the height that is owned if the application is carried out in actual conditions. Next, after the water reaches the nozzle and then moves or rotates the turbine blades, the next step is to measure the rotation of the turbine shaft, measure the resulting load and record the electric current obtained on the generator. In this test, a repeated process was carried out, which means that after the water rotates the turbine blades and falls into the reservoir, the water is not wasted but is directly sucked in by the pump and then flowed back into the stock pipe. Figure 1(b) is a variation of the test model used in the research process, namely the input nozzle is made constant at 6" while the output section is varied with sizes of 3", 4" and 5". Figure 1(c) shows the type of screw turbine used in this study and the nozzle placement used in this study. It should be stated that each testing of the test model is carried out alternately, meaning that the tests are carried out one by one in order to obtain maximum results according to what has been planned.

In the process of this research, it has been carried out with an applied experimental method using a prototype scale test model before later being tested for industrial feasibility to be applied to actual system condition, then at the end of the study, conducting data processing while making correlations with research results related to this research in particular which is close to the basic theory and its relation to appropriate standards or applicable standards with optimal performance [22]. If described in general, the implementation process in field consists of the initial preparation process, implementation process, analysis and completion.



(a)



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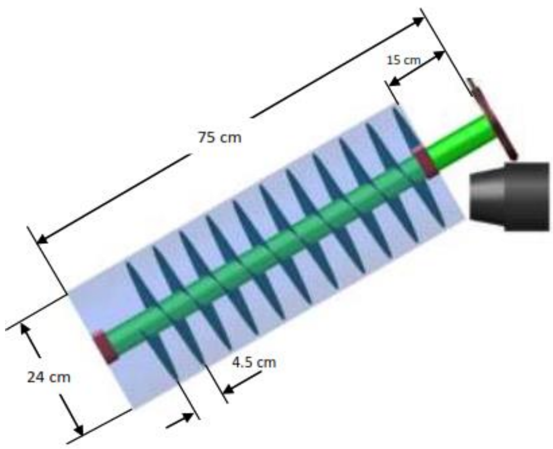


(c) (d)

Fig. 1. Design, measuring tool, and set up of Picohydro Technology test model (a) Setup test equipment design (b) Test model design (nozzle diameter of 3", 4"and 5") (c) The design screw turbine model and the location of nozzle (d) Photo of tool for experiment

2.1 Process Outline
2.1.1 Initial preparation process

In this initial preparation process, it is carried out by preparing all the need related to what will be gone through in preparing the next processes, for example what is being done is procuring materials for the installation of prototype tool and equipment to support smoothness in making picohydro technology experimental test equipment. The materials for the components for making this tool are standard, which means they are not too heavy and not too light, for example the material for making turbine blades, plate with strong and light material are selected so that they can rotate perfectly and are strong in all operational condition. Instrument equipment is also installed to make it easier to detect accurate measurement result [23], The equipment includes water flow meters, pressure sensor, tachometers, manometers and load cells, while other materials are also prepared, including elbow water pump, reservoir tank, generator, PVC pipe, angle iron. All measuring instruments before being tested to obtain data must first be calibrated with predetermined standard [24,25]. Calibration is part of the research process that is carried out to obtain data accuracy, especially on measuring instruments that are installed on each part of the object being observed. The flowmeter is calibrated one to two times by means of the experimental device in the on position, then measurements are made by observing the pendulum printed on the flowmeter, if the pendulum works normally, the measuring instrument is in good condition, but if it is the other way around, the flowmeter will be opened, then readjusted. pendulum position in the lower and upper positions. Calibration was also applied to all measuring instrument used in this experiment prior to actual data collection.

2.1.2 Implementation process

In principle, the process of carrying out experimental data collection is carried out after the preparatory stage is complete and it is truly feasible to be tested. In this implementation part, actually the process of collecting test data, with operational conditions that have been set according to what was previously planned, for example data on variations in nozzle diameter, determination of the angle of Archimedes screw, torque section, voltage and flow rate visualization on the flow meter, so that from the data From this, you will get information on the performance of the Archimedes screw turbine which is applied to picohydro technology tool.

2.1.3 Data analysis process and completion

Important data analysis is carried out to obtain the desired information according to the design of the test model that is made, after that a structured discussion is carried out and focuses on the goals to be achieved. From this research it is expected to obtain a real picture related later if its application is carried out in actual conditions, in agricultural irrigation flows, ditches, rivers and some recommended places.

In actual conditions to complete and facilitate the specifics of this research work, it is presented in the detailed specifications of the research tools in Table 1. and the test parameters are in the form of Table 2. The operational conditions are tested to obtain data that is in accordance with research standard. Before testing the research equipment, calibration is carried out based on the applicable measurement rules.

Table 1
Specifications of measuring instruments used in this research

Measuring tools and equipment	Units	Specifications
Frame material (steel box)	mm	20 x 40 x 6
Nozzle Thickness	mm	2
Service pump	HP	Induction motor 2.0
Storage tank	m	1.2 x 1.2 x 0.75
Laser digital tachometer	rpm	Measuring range 2.5-99.999
Generator low	Watt	Magnet neyodimium N52
Pressure gauge	kg/cm^2	1 until 6 maks
Rotameter	gpm	0 until 30 maks

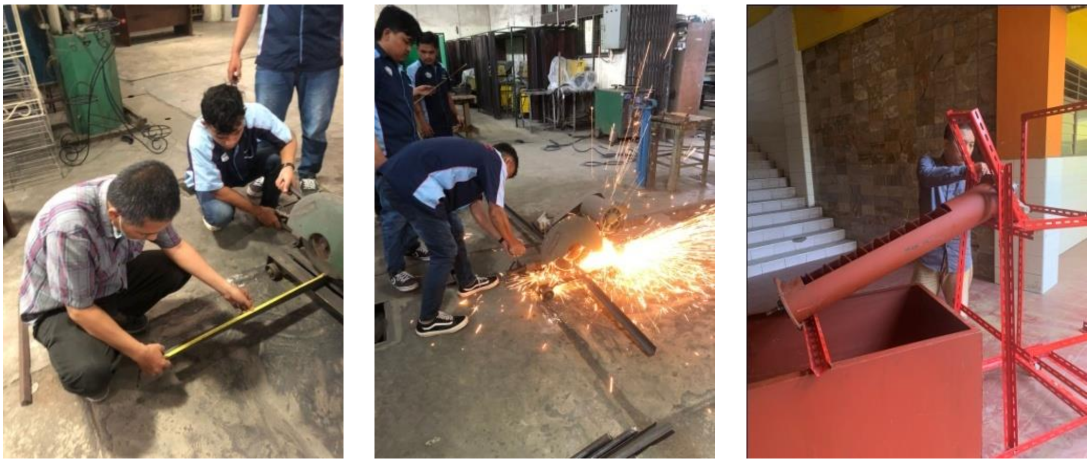
Table 2
The test parameters used in this study

Test parameters	Units	Research Range
Head maks (h)	meter	8
Water discharge (Q)	m^3/h	2 until 30
Nozzle diameter	Inchi (") or cm	3, 4 and 5
Nozzle angle (α)	Degree	60
Load (m)	kg	0.2-1.2

3. Results

3.1 Manufacturing of Picohydro Technology Test Equipment

Manufacturing or manufacture of picohydro technology test equipment is carried out after the design has been completed with precise and detailed calculations, the next stage is to manufacture or collect all materials and component that have been purchased according to the desired requirement [26-28]. Tool making is carried out as part of the research process to obtain information data related to picohydro technology as planned [29]. In this manufacturing process several interrelated components are collected in one unit, this is done to facilitate the process of searching for interrelated materials. assembly or installation of parts of picohydro technology into a form of prototype tool that will be used for the process of collecting test data to obtain secondary data information which is very important and will become a reference in the next research process. Figure 3 is a photo of documentation carried out by the team in the fabrication process of the picohydro technology test equipment, namely section Figure 2(a) is a picture of the measurement and preparation for the process of cutting several components that will be determined for nitro installation, especially on the tool frame and the holder of the screw turbine. After that, in Figure 2(b), you can see the process of cutting components carried out by field assistants in this study. All materials were cut after being measured. according to the drawings that have been made before, while Figure 2(c) is the assembly process of all the components that have been cut that have been provided to become a single unit of micro-hydro generator technology for a prototype scale.



(a) (b) (c)

Fig. 2. Photo documentation of the manufacturing process of the picohydro technology test equipment (a) Measurement and preparation of the cutting process (b) Component cutting process (c) Assembly test tool

3.2 Realization of Picohydro Technology Prototype

This study tested picohydro technology on a prototype scale which was modeled on a laboratory scale. The implementation of this research was carried out experimentally using equipment that had been designed in such a way according to the principles of engineering science. Figure 3 is the realization of the results of making tools and experimental models with various placement of components of measuring tool and apparatus to detect flow systems that occur in pico-hydro generator models.

(a) (b) (c)

Fig. 3. Photo documentation of the picohydro technology prototype as a test tool (a) Flow meter installation (b) Tool installation process (c) Commissioning test

In Figure 3(a), It can be seen that the research team is installing measuring instruments according to the working drawings, while Figure 3(b). is the process of installing all the main components as well as carrying out initial commissioning tests to ensure that all equipment functions as desired, observations in experimental sampling to obtain the desired data according to the predetermined model shown in Figure 3(c). In this study the model in question is to observe various conditions of the nozzle diameter which is installed alternately, namely sizes 3", 4" and 5" with a water flow rate starting from 2 m^3/h to 30 m^3/h where each increase is taken from an even number with a difference 2 per each given sample flow rate, that is 2 then 4, 6, 8, 10 to 30 m^3/h, then each data is collected sequentially.

3.3 Research Results Obtained

In this study the results obtained after analyzing the data were then presented in graphical form, this was used to understand and facilitate presentation in a concise and structured manner. As shown in Figure 4, the following is a graph of the relationship between water discharge and the results of the turbine shaft rotation. In this applied research the turbine shaft rotation presented is an important part that can provide initial information related to performance for other parameters such as power and load. The turbine shaft must work smoothly without hindrance according to the grooves and twisting force which in this case is meant the process of rotating the axis of the shaft surrounded by winding of threaded leaves (screw). Good initial planning, right according to engineering rules can give perfect results, especially when the plant is operating continuously, and of course will have a good impact on other operational conditions [30]. Testing the picohydro technology prototype, the water discharge entered starts from the lowest, namely 2 m^3/h up to the maximum 30 m^3/h with each increase in water discharge income the difference is taken 2 m^3/h, This condition is intended so that the results of the test data obtained are even and the trend is regular. If you pay close attention to Figure 4, the trend line for diameter nozzle 3" (7,62 cm) shows that it continues to increase as long the incoming water discharge also increases. On nozzle diameter 3" with discharge 2 m^3/h at the shaft rotation is obtained at 149 rpm, for water discharge 6 m^3/h result 159 rpm or go on 10 rpm from the lowest discharge earlier while the inclusion of water discharge in the middle is in this number 14 m^3/h round is obtained 188 rpm meaning that there is still an increase in rotation on the resulting shaft. Then for the maximum discharge, which is 30 m^3/h, the shaft rotation is obtained, which is 239 rpm, which indicates that the greater the input, the greater the water discharge has an impact on the increase in the resulting shaft rotation. The phenomenon of increasing turbine shaft rotation results can also be seen from the trend line on the nozzle diameter of 4" (10.16 cm) and nozzle diameter of 5" (12.7 cm). For nozzle diameter of 4", rotation of 169 rpm is obtained with a water discharge of 2 m^3/h, while the maximum rotation for a nozzle diameter of 5" is 247 rpm with a water discharge of 30 m^3/h. The highest turbine shaft rotation is shown in the red line, which is equal to 269 rpm at 4" in diameter with a maximum input water discharge of 30 m^3/h, when viewed from the three variations in nozzle diameter that have been installed and tested alternately, the larger the nozzle diameter does not provide a continuous guarantee of the results of the shaft rotation, where it is precisely at the middle discharge or 4" that the shaft rotation is the greatest. Research results related to the torque generated from testing the three variations in diameter do not form an alignment of the three namely at the smallest diameter (3'') provides information that the pressure of the nozzle to the tip of the screw is not optimal because the water released by the nozzle only hits part of the side of the screw leaf so that it is not optimally produced, whereas if the diameter of the output nozzle is given 5'' the nozzle sprays a lot of water and filling the screw leaves which causes water to also overflow onto the screw in front of it, so that the flow does not normally flow from each screw, and it is also possible that the size of the input screw is not proportional to the output screw turnin/input-output ratio is not ideal. While for the 4'' size it looks better or higher when viewed from the data obtained, this condition looks ideal in the size ratio between the input and output nozzle parts so that the resulting flow is also right to drive the turbine screw.

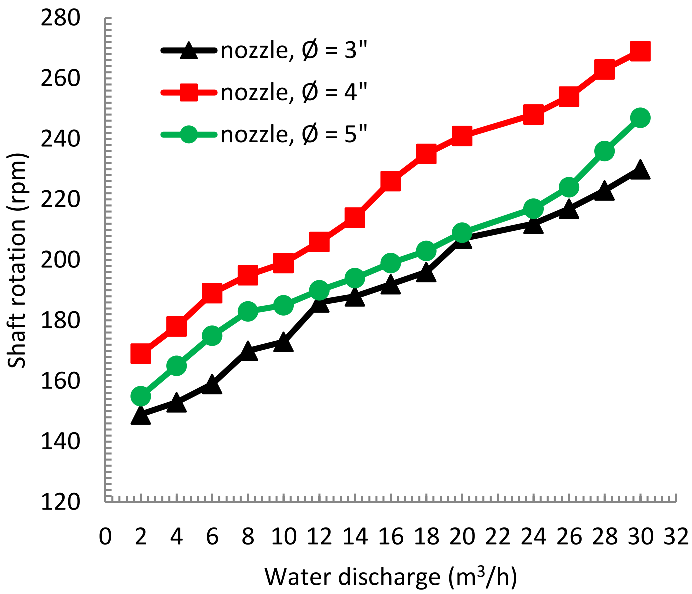


Fig. 4. Graph of the relationship between water discharge and the turbine shaft

Figure 5 shows a graph of the relationship between the inflow of water discharge and the hydraulic power of the turbine produced after testing the picohydro technology prototype. As it is understood that hydraulic power is the power generated by water flowing in the rapid pipe of this picohydro technology [31-33]. The water flowed has been adjusted according to the debit on the measurement starting from the lowest to the highest 2 m^3/h until 30 m^3/h. The results of the data shown in Figure 5, for a nozzle diameter of 3" can be seen in the discharge 2 m3/h obtain hydraulic power 85 W and increases if the added water discharge is greater with an average increase in total hydraulic power of 172 W, where the highest hydraulic power is 136 W. Next, the discussion focuses on a diameter of 4" with the condition that the water discharge input is given from the smallest start then increases to the largest by adding every difference in the water debit intake by 2 m^3/h. The results obtained after the experiment and data analysis were obtained 110 W at the lowest discharge (2 m^3/h) while the highest hydraulic power that is 275 W which in this case is the biggest result compared to other size of nozzle diameter variations. The data for the 5" nozzle diameter can be seen in the graph of figure 5. In fact, it shows the trend of the smallest increase compared to the 3" and 4" nozzle diameter, meaning that the performance at the largest diameter is getting smaller or less optimal. If seen from the data, the nozzle diameter is 5" when the water discharge is 2 m^3/h input, the hydraulic power is 80 W while the maximum hydraulic power is 230 W or less 6 W the hydraulic power results are with a diameter of 3" with an average increase the total hydraulic power is 164.5 W. The analysis of the results shown in Figure 5 shows that the hydraulic power of the turbine increases as the given water discharge increases, with a decrease in power at the 5" nozzle diameter due to the larger diameter of the output nozzle and the uneven water flow to the screw leaf

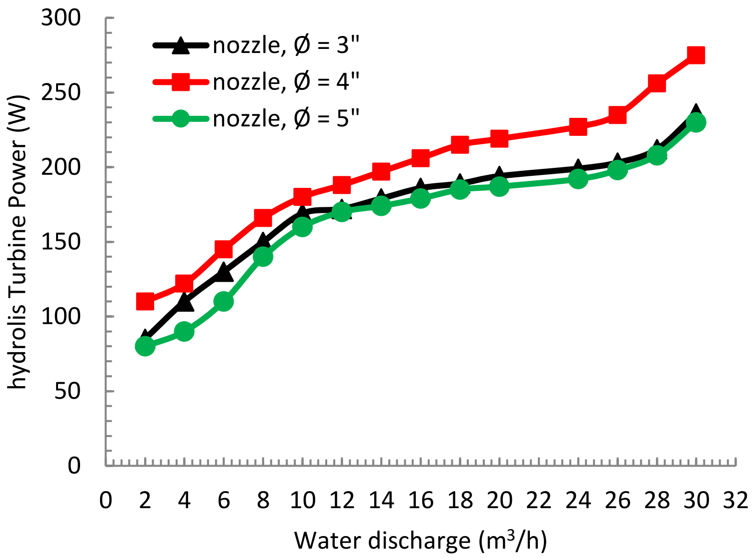


Fig. 5. Graph of the relationship between water discharge and hydraulic power

Turbine power or turbine shaft power is the power generated by a water turbine by converting the kinetic energy of water as turbine power into mechanical energy in the form of turbine rotation [34,35]. The next analysis of the results is outlined in Figure 6, which is a graph of the relationship between flow rate and turbine power, turbine power is measured to obtain the output results from this experiment as an integral part of the process of producing accurate data, as recommendations for further research development. The results of this study, as shown in Figure 6, are the results between the inclusion of flowing water discharge and the turbine power produced by the picohydro technology prototype 2 m^3/h turbine power is generated 8 Watt, this condition continues to increase along with the addition of the discharge given at each difference in the input of the water flow of 2 m^3/h, the average increase obtained until the discharge of 12 m^3/h occurs continuously and increases drastically at the input of the water discharge from 14 m^3/h to 16 m^3/h with a difference reaching 10 m^3/h with turbine power obtained 37 W and continues to increase until it reaches the point the highest is 73 W. Figure 6 depicts subsequent experiments on testing with a nozzle diameter designed and made with a diameter of 4" when a water flow rate of 2 m3/h is given or the smallest or lowest discharge power is obtained. turbine or turbine shaft power of 26 W while the maximum power generated in this test is 97 W where each time a discharge is given, the higher the force generated, the greater the increase.

The next still from the analysis of Figure 6. In the figure, it can be seen that the 5" nozzle diameter shows another main line whose position and trend conditions are the same as the 3" or 4" diameter section, but the difference is the results of the data obtained which is at a discharge of 2 m^3/ h produced a power of 23 W, which in this condition was the smallest result in this test, while for the highest maximum turbine power in this test, it was obtained at 79 W, of course this is a little bigger than the nozzle diameter of 3" or even smaller when compared to at a nozzle size of 4" in diameter, the condition of this phenomenon certainly gives us an idea that fluctuations in the results given by this measurement data need to be carried out a deeper analysis in order to obtain valid information and data to then be recommended for further research. In general, if you look at each of the trend line graphs, the power of the turbine shaft or turbine power increases as the water discharge increases, as the power decreases, for example, at a 5" nozzle diameter, it is caused by the larger nozzle output diameter and the uneven flow of water to the leaves. screw between one another. The power coefficient (Cp) has an influence on the electrical performance produced by picohydro. Therefore, the construction of research tools starting from the flow of water as a source of driving the turbine up to the installed generator must be correct with the calculations during the initial design. The results of this study obtained the maximum power coefficient (Cp) at 3'' diameter = 35 W; 4'' = 45 W and 5'' = 40 W. The results of these power coefficients are in line with the acquisition of other parameters such as rotation and hydraulic power, where the 4" nozzle diameter design has higher and more stable performance.

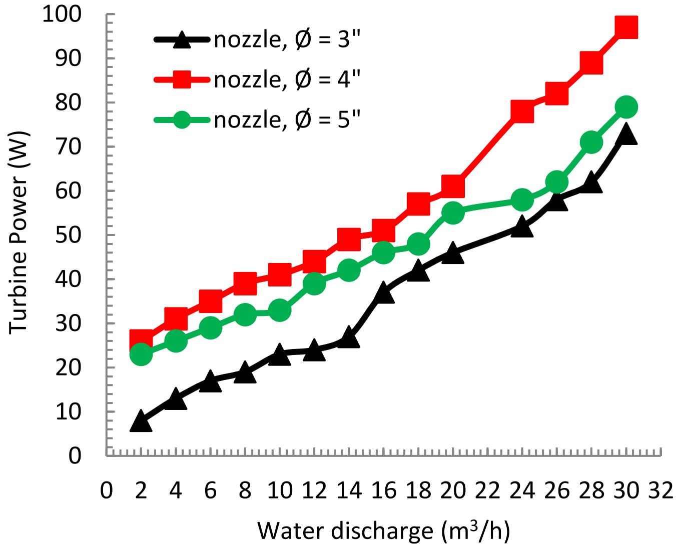


Fig. 6. Graph of the relationship between water discharge and turbine power

Next, a graph of the relationship between load and turbine shaft rotation is presented. As shown in Figure 7, the load entered varies from 4 gr, 8 gr, 12 gr to 32 gr where the difference is taken to get the phenomenon or variable rotation of the turbine shaft. Presentation on Figure 7, this is also seen as the other lines of the graph, namely at 3" in diameter when given a load of 4 gram the turbine shaft rotation reaches 138 rpm while at the input of a higher load or a maximum load of 32 gram it produces 181 rpm. This shows the condition of increasing the turbine shaft rotation by giving an increase in load which are given. Subsequent analysis If you look at the other lines, namely the nozzle diameter of 4" at a load of 4 gr, the turbine shaft rotation is obtained at 151 rpm and this trend shows a line of increase that continues to increase with a maximum rotation obtained of 197 rpm which indicates that this condition is as shown in graph Figure 7. is the highest condition compared to the other lines. The assignment of loads in this experiment is intended to obtain an overview of the power and rotation generated during operation, by applying varying loads and setting a constant rotameter of 30 m^3/h. The results obtained at the 4" nozzle size, the power is 59 W which is the highest result.

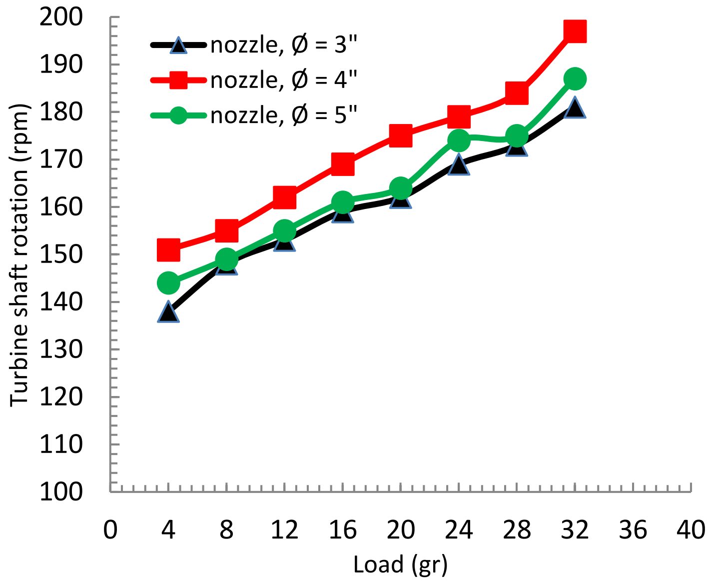


Fig. 7. Graph of load relationship with turbine shaft rotation

The results of data processing for 5" diameter obtained at a load of 4 gr is 144 rpm with a maximum load obtained from this test of 187 so that we can provide an analysis on the graph of the relationship between load and turbine shaft rotation, that greater the load given to provide the effect of increasing the rotation of the turbine shaft in each variation of the given diameter, but it actually gives the biggest increase in impact is obtained at the nozzle diameter which is 4". An overview of graph 7 provides information that a 4" diameter provides the best performance with better turbine shaft results compared to the others 3" or 5" of water output given by a 4" diameter becomes more perfect to drive turbine blades so as to facilitate the turbine shaft in rotating with varying loads so that it becomes a consideration for testing in later stages so that the turbine diameter design is optimal the right approach will have the best impact on optimizing the performance of picohydro technology.

In this discussion, the focus is on the relationship between the water discharge given or included in each test and trial with the efficiency produced by the picohydro generator at each time testing on the diameter 3" dan 5" the water discharge given is the same starting from 2 m^3/h until 30 m^3/h as shown in Figure 8. Test results with diameter 3" results in water discharge 2 gpm efficiency is obtained 14 % then after being inserted or increased the discharge become 4 the result is obtained 16 % and so on every time an additional water discharge is added the efficiency is also greater where the maximum efficiency in the test with a nozzle diameter of 3" produces an efficiency of 45 %. Next is to test the diameter variation 4" for inflow of water discharge from 2 m^3/h generated efficiency of 20% thus additions are made for each difference 2 obtained in the middle test that is 16 m^3/h efficiency is as big 42% while the highest efficiency is obtained at water discharge 30 m^3/h i.e. as big 55% where this condition is certainly greater than the conditions in the 3" diameter test that was previously carried out. The last test was carried out at a diameter of 5" where the operational conditions for flow discharge were when inserting a diameter of 3" and 4".

From the experimental results obtained at flow rate 2, minimum efficiency of 11% was obtained and a maximum efficiency of 41% was obtained, meaning data showed that the result was smaller than the nozzle diameter of 4" or 3" in diameter. The result information that can be given in this condition is that for all operational conditions both those related to shaft rotation, turbine power, and hydraulic power as well as in relation to the given load and the resulting phenomenon giving information on a 4" nozzle diameter is the best result compared to with conditions for nozzle diameters of 3" and 5", this condition may be caused by comparison of the existing designs on the nozzle, namely the input section is designed with constant condition of 6" while the output section is designed to vary 3", 4" and 5".

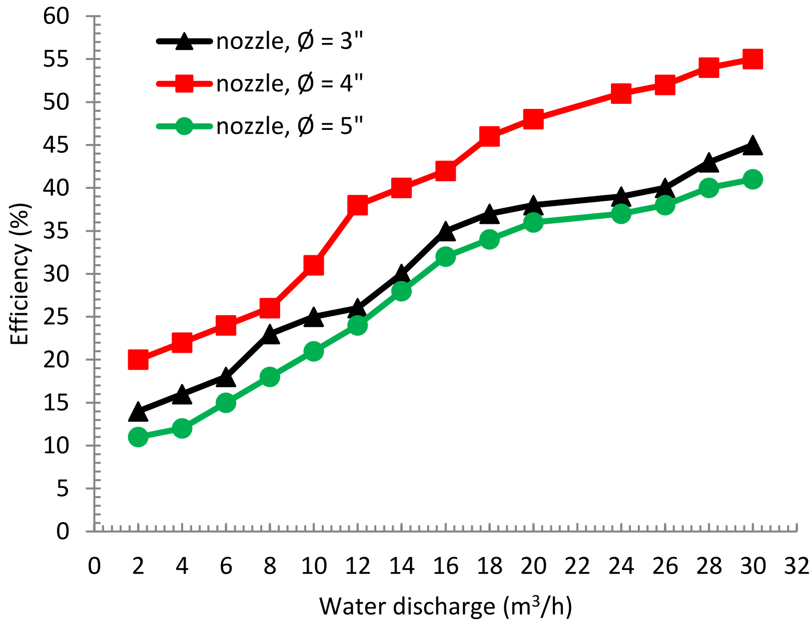


Fig. 8. Graph of the relationship between water discharge and efficiency

In a smaller section of 3", of course the output of water obtained from the nozzle is less than optimal to rotate the turbine so that starting from rotation the load or torque becomes smaller compared to the 4" one, while for a diameter of 5" this gives an illustration that the ratio between the diameters is too large which is designed so that the output of water that arises at a diameter of 5" becomes more so that as a result not all of the water that hits blades of the screw turbine is not all hit at each angle [36], so that it also results in slowing down the rotation that occurs as well as losses or other losses resulting from excess water overflowing to the outside of the turbine blade blades or not maximizing the thrust of the resulting screw. Meanwhile, the 4" diameter in this test generally provides better data compared to the other 2 variation, in terms of water pressure at the nozzle, water speed or in terms of the thrust generated by the water hitting the screw turbine blades. This data analysis has provided an explanation that the efficiency obtained is still relatively low, so it is necessary to carry out increased studies, leading research in solving this efficiency problem. Some theoretical references that can be used as a reference model to increase efficiency, namely, paying special attention to the type of material used, wherever possible the material is light but also strong, especially for turbine thread and nozzle materials installed in picohydro technology.

From a physics point of view, it can be understood that a 4" nozzle diameter produces higher performance when compared to 2 other nozzle diameter. Ideal in the sense here that the flow of water emitted by a 4" diameter nozzle can fill the blades of the turbine and a little is wasted, so that the tangential force that rotates the rows of turbine blades becomes perfect and lightens the rotating turbine shaft. This condition is different from the other 2 nozzle diameters, for a 3" diameter the nozzle mouth is too small so the speed rises but the water spray does not hit all the blades of the turbine as a result the performance is not optimal, while for the 5" nozzle diameter the performance is also below 4" because it is too large Lubar nozzle output so that the water spray is large and a lot of wasted passing through the blades of the turbine blades. This research is an important part of the application and its impact on the community, especially those living in rural areas that do not yet have electricity from the government. Picohydro technology is the right answer to the problem of electrical energy, because by utilizing river water flow with a low discharge it can generate electricity and of course it is adjusted to the water flow rate as a source of water turbine movement in this picohydro technology.

4. Conclusions

The test results show that the nozzle diameter is the best to support the main performance of picohydro technology, which is 4" in diameter, where these results appear to be higher in operational conditions when viewed from the data obtained, for example the shaft rotation section, this condition looks ideal in terms of size comparison between parts. input with output nozzle so that the resulting flow is also right to drive the turbine screw. Shaft rotation results obtained 269 rpm for water discharge 30 m^3/h. On the performance side, the power generated from this tool test is obtained at 4" in diameter, which is the best result, namely 97 Watt. Meanwhile, in the third torque section, variations in the nozzle diameter provide information that there is no alignment or continuity according to the designed diameter and instead the 4" diameter in this case, in the middle gives the highest torque increase impact. The best performance on the torque section is obtained at 4" in diameter both in terms of measurement data and when viewed from the image during the operational conditions of the prototype. While the highest efficiency was obtained at 55% at a nozzle diameter of 4".

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