PAPER NAME

EXPERIMENTAL EFFECT OF MULTI NOZ ZLE ON TURBINE CROSS FLOW PERFOR MANCE

AUTHOR

Corvis L. Rantererung

WORD COUNT

2643 Words

CHARACTER COUNT

15174 Characters

PAGE COUNT

7 Pages

FILE SIZE

103.9KB

SUBMISSION DATE

Jan 25, 2023 11:25 AM GMT+8

REPORT DATE

Jan 25, 2023 11:26 AM GMT+8

14% Overall Similarity

The combined total of all matches, including overlapping sources, for each database.

- 14% Internet database
- Crossref database
- 0% Submitted Works database
- 4% Publications database
- Crossref Posted Content database

Excluded from Similarity Report

- Small Matches (Less then 25 words)

VOL. 15, NO. 13, JULY 2020 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

EXPERIMENTAL EFFECT OF MULTI NOZZLE ON TURBINE CROSS FLOW PERFORMANCE

Corvis L. Rantererung[1], Titus Tandiseno[2], Mika Malissa[3]
[1]Department of Mechanical Engineering, Paulus Christian University of Indonesia, Makassar,Indonesia
[2]Department of Electrical Engineering, Paulus Christian University of Indonesia,Makassar ,Indonesia
[3]Department of Accounting, Paulus Christian University of Indonesia,Makassar ,Indonesia
E-Mail: corvisrante@yahoo.com

ABSTRACT

Cross flow turbine with multi nozzle is very suitable to be used as a power plant in rural areas to optimize the use of small or large scale water energy. Water energy is converted into mechanical energy in turbines and then mechanical energy is converted into electrical energy by generators. However, turbine performance must be improved by using a multi nozzle cross flow turbine and its maintenance is continuously maintained. Cross flow turbine with multi nozzle, turbine blades are able to absorb water energy greater than water jets through multi nozzle. Potential water energy is first converted into kinetic energy in the water turbine nozzle. The spray jet of water coming out of the nozzle that has a high speed is able to move the turbine blade, resulting in high rotation in the multi-nozzle cross flow turbine so that it is very effective to improve the performance of the cross flow turbine as an electric generator drive.

Keywords: experimental, performance, crossflow turbine, multi nozzle.

1. INTRODUCTION

The existence of the electricity crisis in each region in Indonesia can certainly lead to an energy shortage, this is because the electricity supply available with the amount of electricity usage and new installation requests by customers is unbalanced [1]. We can imagine a worse possibility in the future, when the number of residents and homes increases and at the same time likes to use electricity, both for lighting and turning on various household appliances. Electricity is now a basic need for humans [2]. Imagine, if the electricity goes out at night, the settlement seemed to be a ghost town. More than 60% of household appliances operate using electricity so that it can be imagined, if the power goes out what will happen. So that residents in remote areas of the country can only bite the fingers imagining electricity will go into their homes [3]. Actually we can supply electricity ourselves, by utilizing the flow of river water, waterfalls that we often encounter in villages or mountain areas. Utilization of this river water flow can save electricity supply from the State Electricity Power Plant but indeed the power delivered is not as big as the electric energy provided by the State Electricity Company [4]. Such power plants are called Micro Hydro Power Plants (MHPP), because the power generated is relatively small if in a matter of hundreds of kilo Watts. This water power can come from river channels, irrigation channels, natural waterfalls, or even just a trench from which the water continues, by utilizing the height of the waterfall and the amount of water discharge [5].

Infrastructure development is important to sustain the country's economic growth and whatever energy this sector is one of the most important elements of infrastructure. Energy demand continues increased because of industrialization and increasing population [6]. Renewable energy sources are hydro, solar, geothermal, wind, tides and biogas, are cheaper, environmentally friendly, inexhaustible, and abundant in nature. Among all renewable energy sources, micro hydro is the cleanest and most promising source of energy to produce electricity [7]. Hydropower is to direct renewable sources for electricity generation universally, supplying 71% of all renewable electricity. The most common use of turbines is producing electricity. Almost all electricity is produced using turbines of a certain type. Turbine is part of the engine as a prime mover.

Historically, turbine was originally discovered as a rotating machine that takes energy from fluid flow. The moving fluid works to transfer energy to the blades to turn the turbine blade and deliver energy to the rotor. The use of turbines begins with windmills and waterwheels or water wheels. Turbines and windmills receive or absorb energy from the water fluid while pumps and compressors provide energy to the fluid. Water turbines usually have "casings" around the blades which focus and control the fluid. Casings and propellers may have variable geometries that can make operations more efficient for some fluid flow conditions [8]

The choice of turbine type can be determined based on the strengths and weaknesses of the turbine types, especially for a very specific design. In the initial stage, the choice of turbine type can be calculated by considering special parameters that affect the turbine operating system, [9] viz (1) High effective water fall and discharge factors that will be utilized for turbine operation are the main factors influencing the choice of turbine type, for example: pelton turbines are effective for operations at high heads, while propeller turbines are very effective operating at low heads, (2). The desired power factor is related to the available head and discharge. (3). The speed of the turbine rotation that will be transmitted to the generator. For example for a direct couple transmission system between a generator and a turbine at a low head, a reaction turbine (propeller) can reach the desired rotation,

while a pelton turbine and cross flow rotate very slowly (low speed) which will cause the system to not operate.

Water turbine is a driving machine that converts potential energy into mechanical energy with water as its working fluid. As water flows from a higher place to a lower place, the potential energy of the water gradually turns into kinetic energy in the flow process in the pipe [10]. In a turbine, the kinetic energy of water is converted into mechanical energy. Grouping and naming of turbines in general can be seen from the working fluid, like a water turbine working fluid is water as well as for other working fluids such as steam, gas, and wind.

At present cross flow turbines receive a lot of attention because they can be applied to a wider range of flow and head. These characteristics make cross flow turbines widely used in small scale hydroelectric power plants. Besides cross flow turbines also have a simple and economical construction. Use of this turbine for the same power can save the cost of making an initial drive up to 50% from using a waterwheel with the same material [11]. This savings can be achieved because the size of crossflow turbines is smaller and more compact than waterwheels. The diameter of the waterwheel ie the road wheel or runner is usually 2 meters and above, but the diameter of the cross flow turbine can be made only 20 cm so that the materials needed are far less, which is why it can be cheaper. Likewise the average efficiency or efficiency of this turbine is higher than the efficiency of a waterwheel.

Since the advent of cross flow turbines, much progress has been made through research through experimental methods laboratory mainly on turbine design parameters such as angle of arrival, number of blades, runner diameter ratio, runner width, and nozzle width [12]. Laboratory studies have been carried out to show a series of cross flow turbine test results made based on specifications as they are available. A water turbine is a simple generator consisting of four main components, namely water sources, channels, water turbines and generators. Water turbines play an important role to function to convert potential energy and kinetic water in the turbine runner blade into mechanical power in the form of shaft rotation. Turbines consist of rows of rotating blades (rotors) and blades that do not rotate (stator). The way to utilize the speed of water flow to turn the turbine is impulse by pushing or by the reaction force of water flow leaving the rotor blade [13]. In the way the water velocity impulses hit the rotor blades and the rotor moves swivel, the rotor blades cause a reaction force that produces power which increases the rotor rotation [14].

2. LITERATURE REVIEW

Micro hydro power plant is a small-scale power plant that utilizes water flow power as an environmentally friendly source of renewable energy. In terms of technology, it was chosen because the construction is simple, easy to operate, and easy to maintain and provide spare parts. Economically, the operation and maintenance costs are relatively cheap, while the investment costs are quite competitive with other power plants [15]. Socially, MHPP is easily accepted by the wider community, when compared, for example, economically, the operation and maintenance costs are relatively cheap, while the investment costs are quite competitive with other power plants. MHPP are usually made on a village scale in remote areas that have not yet received electricity from PLN. Water power used can be in the form of water flow in irrigation systems, dammed rivers or waterfalls.

Micro hydro power plant is a power plant that utilizes the mechanical energy of water to be converted into electrical energy. In principle the same as a hydroelectric power station. The difference is that the power generated is small, namely less than 100 kilo Watts. Micro hydro is a term that consists of the word micro which means small and hydro which means water. Technically, micro hydro has three main components, namely water as an energy source, turbines, and generators. Micro hydro gets energy from water flow which has a certain height difference [16].

Basically, micro-hydropower utilizes the potential energy of a water fall (head). The higher the water fall, the greater the potential energy-water that can be converted into electrical energy. In addition to geographical factors such as the layout of the river, the height of water fall can also be obtained by blocking the flow of water so that the surface water becomes high. Water is flowed through a pipe rapidly into the power plant which is generally built at the river's edge to drive a turbine or a micro hydro water wheel.

Mechanical energy that comes from the turbine shaft rotation will be converted into electrical energy by a generator. Micro-hydro can utilize water levels that are relatively small in the amount of energy produced by micro-hydro compared to large-scale hydropower, implying the relative simplicity of equipment and the small area required for microhydro installation and operation. This is one of the advantages of micro hydro, which does not cause environmental damage [17]. The difference between hydroelectric power plants and micro hydro especially in the amount of electricity produced, hydropower under 200 kW size is classified as micro hydro. Mico Hydro Power components as follows:

a) Diversion Weir which serves to divert water from the river to get to the settling basin. This dam is the MHPP water supply that will be used.

b) Intake as a gate that functions to regulate the water supply from the dam.

c) Settling Basin is used to move sand particles or other water-soluble materials. The aim is to protect the advanced components from the impact of sand deposits that can be fatal. This tub is made by deepening and widening the conduit and adding it to the drainage channel of dirt, rock and sand.

d) Headrace only functions as a carrier channel. This channel will follow the contour of the hillside to maintain the elevation of the water being channeled. So that the water that is channeled is not too heavy. Headrace is usually used when the water source is located far from where the MHPP is located.

e) Headtank functions as a regulator of the difference in water output between the headrace and penstock. Besides that, it is also used for the final separation of impurities in the water. Such as sand, wood etc. So there are 2 stages of filtering.

f) Penstoc functions to drain water before entering the turbine. In this pipe, the potential energy of water in the sedation pond is converted into kinetic energy which will turn the turbine wheel. Rapid pipe is usually made of steel that is rolled, the connection between pipes must also be strong. In addition, a solid foundation is needed to be able to withstand static and dynamic loadsIn the application, not all of these components are used. Such as headrace. The location of the water source is not far from the MHPP, so the headrace may not be needed.

Turbines are rotating machines that function to take mechanical energy from fluid flow. In a micro hydro power plant, a water turbine is used. This turbine will convert into angular motion energy. Water turbines have casings that focus and control fluid. Energy is obtained as the driving force of the shaft to produce a rotary motion. Turbines can have high power, because the ability of turbines to get water power to operate at very high speeds. But in PLTMH, the turbine used has a low energy density with the flow of water also not too heavy [18].

A micro-hydro scheme requires two things namely, water discharge and head height to produce power that can be utilized. This is a system of energy conversion from the form of altitude and flow (potential energy) into the form of mechanical and electrical energy. The incoming power (Pgross) is the sum of the power generated (Pnet) plus the energy loss factor (loss) in the form of sound or heat. The construction of MHPP begins by constructing a water extraction dam to regulate water supply. Dams need to be equipped with intake door openers and filters so that waste can be filtered. This dam must be located on a riverbed that is stable and safe from flooding. From the intake, water is channeled through the headrace which is equipped with an overflow channel to remove excess water. But it can also be unnecessary overflow channels, depending on conditions.

Furthermore, water will enter the settling pond to settle the sand and filter out dirt so that the water entering the turbine is clean. Furthermore, water will enter the penstock and flow into the turbine. In penstock, the potential energy of water will be converted into kinetic energy. In a turbine, water will hit the inlet and in it there is a guided vane to regulate the amount of water entering the blade. Then this turbine blade is made of sturdy steel which is welded on 2 parallel plates so that the system is balanced. Turbine equipped casing to direct the flow of water to the propeller. The power from the turbine shaft is transmitted into the generator to be converted into electrical energy.

Direct transmission system has the advantage of more compact, easy to move power and high efficiency. But the axis must be really straight and the turbine rotation is the same as the generator rotation. To overcome this problem, a gearbox can be used. Gearbox can be used to change the rotation speed ratio. Micro hydro power is now widely applied in Indonesia, because there are a lot of potential water flows that can be utilized for this technology, especially in areas that have not yet received electricity. Micro-hydro power plants in principle utilize different heights and the amount of water discharges per second that is available in irrigation channels, rivers or waterfalls. This water flow will rotate the turbine shaft so that it produces mechanical energy. This energy then drives the generator and produces electricity [19].

Micro hydro needs to start with the construction of dams to regulate the flow of water that will be used as a driving force for hydro power. This dam can be in the form of a concrete dam or a dam. Dams need to be equipped with sluice gates and trash filters to prevent the entry of dirt or silt. Dams should be built on river beds that are stable and safe from flooding. Near the dam a retrieval building is built. Then proceed with the making of a conduit that functions to drain water from the intake. This channel is equipped with an overflow channel at any given distance to remove excess water. This channel can be either open or closed channel. At the end of the overflow channel a settling pond is built. This pool serves to precipitate sand and filter out dirt so that the water entering the turbine is relatively clean. This channel is made by deepening and widening the conduit and adding it to the drain. The forebay pool is also built to calm the flow of water that will enter the turbine and direct it into the pipe rapidly (stocker). This channel is made with concrete construction and is as close as possible to the turbine house to save pipeline rapidly.

The pipe functions to drain water quickly before entering the turbine. In this pipe, the potential energy of water in the sedation pond is converted into kinetic energy which will turn the turbine wheel. Usually made of rolled steel pipes, then welded. For connections between pipes, flange connections are used. This pipe must be supported by a strong foundation and be able to withstand static and dynamic loads. These foundations and foundations are as straightforward as possible, because they need to be designed according to soil conditions. The aim is to avoid problems caused by vibration. The turbine house must be designed so as to facilitate maintenance and inspection. After coming out of the pipe rapidly, water will enter the

turbine at the inlet. Inside there is a guided vane to regulate the opening and closing of the turbine and regulate the amount of water that enters the runner / blade (the main component of the turbine). Runners are made of steel with high tensile strength welded on two parallel plates. The water flow will rotate the runner and produce kinetic energy which will rotate the turbine shaft.

Energy arising from the shaft rotation is then transmitted to the generator. The whole system must be in balance. Turbines need to be equipped casing that serves to direct water to the runner. At the bottom of the casing there is a turbine lock. Bearing (bearing) is on the left and right of the shaft and serves to support the shaft so that it can rotate smoothly. Shaft power from this turbine must be transmitted to the generator so that it can be converted into electrical energy. Generators that can be used on micro hydro are synchronous generators and induction generators. This power transmission system can be a direct transmission system (the shaft power is directly connected to the generator shaft with the aid of a clutch), directly, that is, using a belt or belt to move power between two parallel shafts.

The advantage of a direct transmission system is that it is more compact, easy to maintain, and has higher efficiency. But the axis of the shaft must be completely straight and the rotation of the generator shaft must be equal to the rotational speed of the turbine shaft. The problem of axis alignment can be overcome with the help of flexible couplings. Gearbox can be used to correct rotation speed ratio. Indirect transmission systems allow for variations in the use of generators more widely because the generator shaft rotational speed does not need to be the same as the turbine shaft rotational speed. The type of belt commonly used for large-scale micro hydro is the flat belt type, while the V-belt is used for scales below 20 kW. Supporting components needed in this system are pulleys, bearings and couplings. Electricity generated by generators can be directly transmitted via wires on electric poles to the consumer's home. This water turbine is usually used for industrial power for the electricity grid. Now it is more commonly used for electric generators. Turbines are now widely used and are a renewable energy source. In hydroelectric power plants, water turbines are the main equipment besides generators. A turbine is a rotating machine that takes energy from the fluid flow. A simple turbine has one moving part, the "rotor blade assembly". The moving fluid makes the propeller rotate and produce energy to drive the rotor. The development of a waterwheel into a modern turbine requires a long period of time. The basic difference between the initial water turbine and the waterwheel is the rotating component of water which energizes the rotating shaft. This additional component allows the turbine to provide greater power with smaller components. Turbine can utilize water with a faster rotation and can utilize a higher head.

Impulse turbines are turbines that utilize the potential energy of water converted into kinetic energy with nozzles. Water exits the nozzle which has a high speed hit the turbine blade. After hitting the blade the direction of flow velocity changes so that a change in momentum (impulse) occurs. As a result the turbine wheel will rotate. Impulse turbines have the same pressure because the flow of water coming out of the nozzle is the same as the pressure of the surrounding atmosphere. Potential energy that enters the nozzle will be converted into velocity (kinetic) energy. The types of impulse turbines include is Cross flow turbine is the flow of water through a cross flow turbine in the simplest form consisting of a road wheel (runner) and nozzle. Runners are composed of two parallel plates connected by a series of curved blades. The crossflow turbine nozzle has a rectangular cross section with a curve at the top cover, which serves to direct the flow to the blade at the runner.

Water flows through the nozzle and enters the runner. Water flow across the blade at the runner occurs twice, the first is when the water enters through the turbine nozzle arch. The two stages of water from the first stage flow through the open center space (inside the runner) and continue through the blade behind and the bottom of the runner. Therefore this turbine is called a two level speed turbine. The part of the water that crosses the runner twice is known as cross-flow, and the name of the turbine comes from this phenomenon. There are some parts of the water that follow the blade and are thrown out of the runner, this is called entrained flow. The performance of micro hydro power plants with cross nozzle multi flow turbines is as follows:

a) Hydraulic power is the power produced by water flowing from an altitude level that can produce energy. The amount of water discharge and each head are obtained using a measuring device attached to the pipe. [20] Head is the energy contained by the fluid of the fluid's heavy union. Head is measured by using a pressure gauge, thus the head size can be obtained

$P_h = H \rho Q g$ ……..(1)

ρ = water density (kg/m3)
g = gravitation (m/s2)
Q = water charge (m3/s)
H = head (m)

b) Daya Turbin adalah daya yang dibangkitkan oleh turbin air dengan mengu- bah energi kinetik air menjadi energi mekanik berupa putaran poros turbin. Besarnya daya turbin dapat dihitung menggunakan persamaan sebagai berikut:

$$P_T = \frac{2\pi n \tau}{60}(Watt) \quad \text{…….. (2)}$$

n = turbine rotation (rpm)
T = torque on the shaft (Nm)

Torque is measured using a rope brake mechanism

3. RESEARCH METHOD

Place and Time The study was conducted in remote rural areas of North Toraja Regency, South Sulawesi, Indonesia. And the time the study was carried out after obtaining approval, i.e. from the date of ratification of the proposal by the manager of the UKI-Paulus Research Institute until it was declared finished. Equipment in this test used several tools including:

A. The application of multi-nozzle cross flow turbines in rural areas consists of several parts, including:

a) Water reservoir, serves as a place to collect, soothe water, settle sand, mud, filter water from sewage into the turbine, a drainage place. more water entering the turbine penstock
b) Using three 3 inch pipe penstock pipes, serves as a penstoc to drain water to the turbine nozzle.
c) Flowmeter, used to measure water discharge
d) Pressure gauge, measuring the pressure of water in the pipe.
e) Tachometer to measure turbine rotation
f) Voltmeter to measure electrical voltage
g) Amperemeter to measure electric current
h) Wattmeter to measure electrical power

B. Operation preparation

Before the test is carried out, first prepare the following things:

a) Make sure the Tachometer is functioning properly.
b) Perform calibration of measuring instruments.
c) Clean the reservoir from dirt, and fill it with clean water at least ¾ of the reservoir volume.
d) Charge and check the condition of the turbine before it is operated.
e) Checking the condition of water flowing through the
f) stockpile
g) Ensure the nozzle can be fully open or 100%.
h) Re-checking the installation of the test equipment so that it is ready to use

C. Operation of a micro hydro power plant can be carried out after all stages of the test preparation are complete.

Data retrieval can begin with:

a) Before the turbine is operated first set the nozzle valve in the fully open position.
b) After the turbine is operated, then add power to the turbine slowly until it reaches the maximum opening of the turbine inlet valve.
c) Measuring water discharge, turbine rotation, generator rotation, electric voltage, electric current and electric power
d) Perform braking load variations
e) Research data collection

4. RESULTS AND DISCUSSIONS

The results showed that the determining parameters were air flow velocity, head, and air power, turbine rotation, to calculate turbine and turbine power and power system efficiency. While the head measurement is done using an air pressure manometer and a meter to measure the height of the air falling or the height of the air. Measurement of air discharge using a flow meter to determine the amount of air discharge that can produce kinetic energy [20]. At each load change determined in accordance with the study, then measurements are made for all parameters of the required variables, installation power plant in Figure-1 and Figure-2 as follow:

Figure-1. Installation Power Plant.

Figure-2. Installation Power Plant Produced Electric

The data obtained are water discharge with height (head), based on water resources available in the test installation and calculation process, design or specifications of impulse turbines with cross flow multi-flow turbine type are 3 pieces and installed on turbine runners which have 24 blades with a nozzle angle of 30 degrees. The results of the analysis of research data obtained by referring to the study of existing theories and data products from research results that have been obtained under stable conditions. At the study site, it was obtained field data that if the large water flow rate was able to produce higher water power. Increase runner rotation, power and efficiency of turbine cross flow with parallel multi nozzle [21]. In Table-1, the performance of multi turbine transverse flow nozzles with three nozzles is

capable of producing hydraulic power which is converted to mechanical power at turbine = 5011.25 Watt, this is strongly influenced by load, head and water discharge capacity.

Table-1. Turbine Power.

Number Of Nozzle	Turbine Power (Watt) at Nozzle Valve Open Variations			
	25 %	50%	75%	100%
1 Nozzle	313.45	1086.26	2031.38	3242.57
2 Nozzle	585.46	1716.66	2947.79	4323.43
3 Nozzle	905.22	2431.93	3670.00	5011.25

The relationship of mass influence on torque testing on turbine rotation can be seen the effect of the amount of mass given to turbine rotation. Where before loading the turbine speed reaches a high speed, but when loading the turbine speed decreases with increasing load. So it can be concluded that the greater the load given, the turbine rotation decreases. The results of testing the power generated by the turbine by comparing the water power used can determine the power of cross-flow water turbines that have been made [22].

In Figure-3, from the results of calculations that have been done it can be seen that the mechanical power of the turbine, making the cross-flow turbine water applied as a micro hydro power plant where the power produced is low capacity. In addition to testing hydropower, it also tests the effect of the use of turbine power on turbine rotation.

Then the power of the turbine also depends on how much potential energy the water is converted into kinetic energy in a multi-flow cross-flow turbine nozzle. Water comes out of the nozzle which has a very high speed on the turbine blades. After hitting the blade, the flow velocity changes so that the momentum changes which causes the turbine wheel to spin and produce mechanical power for the water turbine [23]

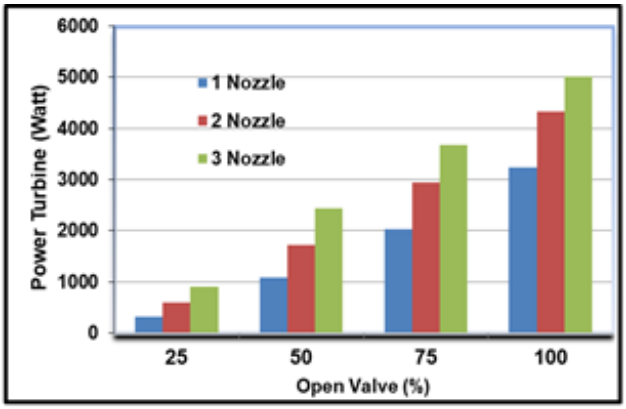

Figure-3. Grafik Power Tubine VS Oven Valve Percent

Micro-hydro power plant is one of the renewable energy sources which has so much potential to be developed in Indonesia. Because the Negar has so many suangai and tropical rain forests as a source of energy, it depends on efforts to implement it, especially in rural areas that have not been touched by electricity. With the presence of MHPP, it is hoped that a village is capable of a village that is independent of its own electricity source. With the existence of electricity sources in the village it is hoped that it will boost the progress of the village in various sectors of life.

5. CONCLUSIONS

The results of the study concluded that the multi-nozzle cross flow turbine had the highest performance. Whereas cross flow turbines with a single nozzle only produce lower performance

ACKNOWLEDGEMENTS

The authors wish to thank the Directorate General of Higher Education (DGHE), Ministry of Education and Culture Indonesia for its support

REFERENCES

[1] Rantererung L. C., Tandiseno T. And Mallisa M. 2019. Multi Nozzle Paralel To Improve Efficiency Cross Flow Turbine. ARPN Journal Of Engineering And Applied Sciences. 14(2) : 550-555.

[2] Rantererung L. C., Titus T. and Mika M. 2019. Application Of Cross Flow Turbine With Multi Nozzle In Remote Areas. International Journal of Mechanical Engineering and Technology. 10(8): 1-10.

[3] Rantererung L. C., Soeparman S., Soenoko R., Wahyudi S. 2018. Vertical And Horizontal Nozzle Effectiveness In Cross Flow Turbines. International Journal of Mechanical Engineering and Technology. 9(10): 504-511.

[4] Bangalore G., Okonkwo N., Ezeonu S. O. 2012. Design and Installation of A Mini Hydro- Electric Power Plant. Scholarly Journal of Engineering Research. 1(1): 19-24.

[5] Rantererung L. C., Soeparman S., Soenoko R., Wahyudi S. 2018. Improvement Of Performance

Cross Flow Turbine With Dual Nozzle. ARPN Journal of Engineering and Applied Sciences. 13(7): 2364-2368.

[6] Rantererung L. C., Tandiseno T. and Mallisa M. 2018. Development Of Cross Flow Turbine With Multi Nozzle. ARPN Journal of Engineering and Applied Sciences. 13(1): 249-254.

[7] Rantererung L. C., Soeparman S., Soenoko. R., Wahyudi S. 2016. Dual Nozzle Cross Flow Turbine asan Electrical Power Generation. ARPN Journal of Engineering and Applied Science. 11(1): 15-19.

[8] Rantererung L. C., Soeparman S., Soenoko R., Wahyudi S. 2016. The Dual Nozzle Cross Flow Turbine Performance. ARPN Journal of Engineering and Applied. 11(13): 8538-8543.

[9] Adhikary P., Roy P. K., Mazumdar A. 2014. Multi Dimensional Feasibility Analysis of Small Hydro Power Project in India: A Case Study. ARPN Journal of Engineering and Applied Sciences. 9(1): 80-84.

[10] Okorafor O. O., Okereke A. A., Egwuonwu C. C. 2013. Evaluation of Hydropower of Otamiri River for Electric Power Generation. Research Journal of Applied Sciences, Engineering and Technology. 6(24): 4541-4547.

[11] Khan M. A., Badshah S. 2014. Design and Analysis of Cross Flow Turbine for Micro Hydro Power Application using Sewerage Water. International Islamic University. 8(7): 821-825.

[12] Kaunda C. S., Kimambo C. Z., Torbjorn K. N. 2014. Experimental Study On A Simplified Cross Flow Turbine. International Journal of Energy and Environment. 5(2): 155-182.

[13] Edeoja A., Ibrahim S., Kucha E. 2015. Suitability of Pico-Hydropower Technology For Addressing The Nigerian Energy Crisis - A Review. International Journal of Engineering Inventions. 4(9): 17-40.

[14] Chennani M., Salhi I., Doubabi S. 2008. Study of the Regulation of a Micro-Hydro-Electric Power Plant Prototype. International Scientific Journal for Alternative Energy and Ecology. 5(61): 79-84.

[15] Haurissa J., Soenoko R., Wahyudi S., Irawan Y. S. 2012. The Cross Flow Turbine Behavior towards the Turbine Rotation Quality, Efficiency, and Generated Power. Journal of Applied Sciences Research. 8(1): 448-453.

[16] Girma M., Dribssa E. 2014. Flow Simulation and Performance Prediction of Cross Flow Turbine Using CFD Tool. International Journal of Research and General Science. 2(6): 747-757.

[17] Bilal A. N. 2013. Design of High Efficiency Cross-Flow Turbine for Hydro-Power Plant. International Journal of Engineering and Advanced Technology. 2(3): 39-47.

[18] Jose D., Varghese L., Renjini G. 2012. Design of Small Hydro Electric Project Using Tailrace Extension Scheme. International Journal of Advanced Research in Electrical and Electronics Engineering. 3(1): 79-86.

[19] Sangal S., Garg A., Kumar D. 2013. Review of Optimal Selection of Turbines for Hydroelectric Projects. IJETAE Exploring Research and Innovations. 3(3): 424-430.

[20] Joshi H., Dwivedi A., Anand A., Pravin P. P. 2014. Design and Analysis of a Cross Flow Hydrokinetic Turbine Using Computation Fluid Dynamics. Journal of Basic and Applied Engineering Research. 1(3): 55-59.

[21] Patel S. U., Pakale P. N. 2015. Study on Power Generation by Using Cross Flow Turbine in Micro Hydro Power Plant. International Journal of Research in Engineering and Technology. 4(5): 1-4.

[22] Chiyembekezo S. K., Cuthbert Z., Torbjorn K. N. 2014. Experimental Study on A Simplified Cross Flow Turbine. International Journal of Energy and Environment. 5(2) : 155-182.

[23] Kiyoshi Kokubu, Toshiaki, Kanemoto, Sung-Woo Son, Young-Do Choi. 2012. Performance Improvement of a Micro Eco Cross-Flow Hydro Turbine Journal of the Korean Society of Marine Engineering. 36(7): 902-909.

14% Overall Similarity

Top sources found in the following databases:

- 14% Internet database
- Crossref database
- 0% Submitted Works database
- 4% Publications database
- Crossref Posted Content database

TOP SOURCES

The sources with the highest number of matches within the submission. Overlapping sources will not be displayed.

1	ojs.uniska-bjm.ac.id Internet	3%
2	ejournal-s1.undip.ac.id Internet	2%
3	dspace.uii.ac.id Internet	2%
4	core.ac.uk Internet	2%
5	peraturan.bpk.go.id Internet	2%
6	jurnal.stiamak.ac.id Internet	1%
7	repository.untag-sby.ac.id Internet	<1%
8	lrtjabodebek.com Internet	<1%