Possibility of Using Waste Water Energy to Generate Electricity Using Small Design Hydropower Technology Throughtout Home Pipeline

Muhamad Faiz Bin Yusoff
Faculty of Electrical Engineering
University of Technology Mara (UiTM)
Shah Alam, Malaysia
muhamadfaizyusoff@yahoo.com.my

***Abstract*—: This paper presents a small design hydropower technology that used to generate electricity. The system design should be able to generate power, use a pressure water instead of flowing water to rotate the turbine and can be applied on domestic pipeline. Three different direct current motor are tested in order to generate electricity. Water pressure gauge and valve is used to control the water pressure. The greater the pressure the greater power can be produce. This technology found that the small design hydropower technology instead of flowing water able to produce electricity.**

Keywords – Hydroelectric, Permanent Magnet DC motor, Turbine, Water Pressure, Model Casing

I. INTRODUCTION

Hydropower is not a new technology. But the technology is one of green technology, renewable and clean source compared to others. Most people that live in 20th century made hydropower is one of greater influence [1]. Hydropower system are classified as large, medium, small, mini, and micro [2]. The classified is depend on the capacity of power generation. Table 1 show the hydro power scheme according to the size of electrical power produced [3].

Table 1. Classification of Hydropower

Type of hydro	Power Generate
Pico	< 5 KW
Micro	5 - 100KW
Mini	100 - 1000 KW
Medium	1 – 15 MW
Power plant	> 100 MW

In hydropower there are two ways to get energy to rotate the turbine; from flowing water or falling water. Both way provide potential energy which can cause the turbine spin [2]. Whereas the different is gravitational effect. Falling water is influence by gravitational force. This is because the water flow from high point to the lower point. For flowing water is totally use pressure of water due to horizontal applied on pipeline as Figure 1.

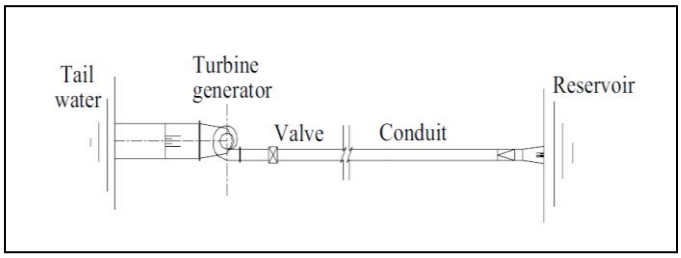


Fig. 1: Overview of generator applied on pipeline

Dam or storage is hydropower system plant. This plant provide more than 10 Mega Watt. In addition, the technology also can be applied on domestic pipeline. The study on micro hydro generator that applied on domestic pipeline use a concept of run of river to generate electricity [4]. Kinetic energy plus gravity force from water is used to generate electricity.

Cost and demand of electricity strongly growth by year. Based on dam system of hydropower concept, small size hydropower is designed and created. It is use water as medium part to rotate the turbine and to generate electricity. The energy of flowing water throughout domestic pipeline is use to rotate the water turbine in order to rotate the shaft of the generator to produce electricity. The factors that can influence the power generation from the pipeline is depend on the water pressure and water consumption [4]. The greater the water pressure greater power can be generation [1]. The benefit of this system is no effect the environmental because not dam is required [5].

This project use direct current motor as a generator. Generator is device that convert mechanical energy to electrical energy. According to Faraday's Law, voltage and current can be induced by changing in magnetic flux through coil or conductor which cause from the changing of magnetic field.

Water turbine plays an important role in this technology. It is used to rotate the rotor of the motor. Small size of water turbine is designed due to suitability to be used in domestic pipeline [4].

In order to rotate the turbine, water pressure is needed. The higher the pressure the high the power can be generated. This pressure usually measure in PSI pounds per square inch. There are two type of water pressure [1].

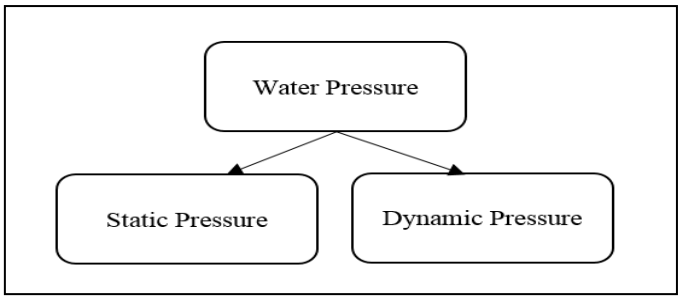


Fig. 2: Type of water pressure

Static pressure is the water pressure when water not flowing and the dynamic pressure is the pressure of water when flow through the outlet [6].

The purpose of this project design is convert use water consumption daily energy to useable energy. This means that, instead of flowing water, electricity can be generate for applied to electric devices. In addition, the design also need to be suitable to be applied anywhere on domestic home pipeline.

There are three objectives that be consider of the system designed. There are:-

1. To design the power generator system by using waste water flowing energy to electrical energy
2. To observe the possibility of permanent direct current motor (PMDC) to generate electricity.
3. To design the power generation system that can be installed anywhere on domestic pipeline

II. METHODOLOGY

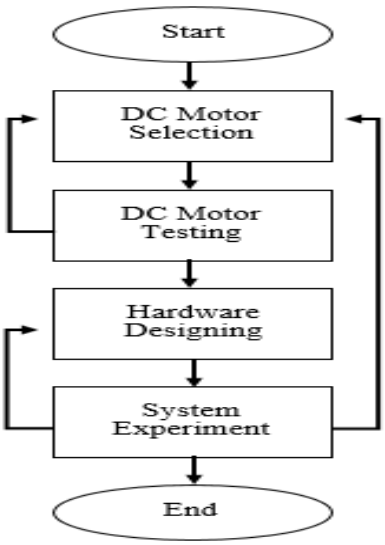


Fig. 3: Flow chart of experiment

A. Permanent Magnet Direct Current Motor

Fig. 3: PMDC motor

Figure 3 show the PMDC motor that use in this experiment of the project. Permanent magnet direct current motor also known as PMDC Motor is used as a generator. This motor have high lifetime, less electromagnet noise generation, high power and high speed. Besides that, the selection of motor also depend on cost, minimum starting torque and size of the project. In addition, this motor able to produce maximum voltage output. The advantages of PMDC motor compared with shunt motor as below [3]:

i. Simplification of construction and maintenance.
ii. No electrical energy is absorbed by the field excitation system.

B. Designing Part

i. Water Turbine

Water turbine which convert water energy to mechanical energy by using flowing of water. There are two type of water; turbine impulse and reaction turbine [7]. Usually turbine impulse use water flows out of a nozzle and reaction turbine use in high water pressure but low in velocity. This is because turbine will fill with water when working [7].

In order to complete this project, water turbine is designed in small size due to suitability to be applied to the domestic pipeline. The blade of the water turbine is made up from aluminum material due to the light weight and the low cost compared to the steel. Besides that, the aluminum material is easy to construct.

In this project, eight blade is used. Two circle prospects are used and stick to sides of the blade. The design is to make sure all the blade fit in size. The diameter size of the turbine is about 93mm and the width is about 30mm. Besides that, the thickness of blade is about 1mm. The size is fit to the casing because to make sure the water only can flow through the blade instead to get the maximum rotation per minutes.

Besides that, the blade of turbine is little bit curve. The design is to reduce the friction between blades of turbine with the water.

ii. Model Design

Fig. 4: Casing of system turbine

In order to get the maximum flowing water, the shape of casing is designed according to the water turbine shape. This is because to ensure that there is no space of water can be store or static. The model casing is made up of prospect because light in weight and colorless make it easier to troubleshoot if water turbine inside the case stop working.

C. Water Pressure Pipeline

In term of hydropower on pipeline, water pressure is very important to make a water turbine rotate and to determining how much power can be generated. The higher the pressure the higher the power can be generated. In this project, the pressure is measure by pressure meter gauge and control by valve.

Fig. 5: Pressure meter gauge

III. Result and Discussion

There are two main experiment in order to get the best performance of the system. There are voltage produce by dc motor and the system test.

A. PMDC Motor Performance Test

Figure 6 shows the experimental setup for permanent direct current motor performance. The purpose of this analysis is to make sure the PMDC motor can be used as a generator. The experiment is conducted by using three different PMDC motor. The variable motor depends on maximum voltage that can be supply.

Fig. 6: Testing speed and voltage generation

The motor is coupled two motor together by using coupler [3]. This means that, one of the motor will be injected by direct current generator as a supply and the other motor will attach to that motor to form a generator. This is because when rotor of the motor rotate the voltage will be produced. This concept use of conversion from mechanical energy to electrical energy.

When voltage supply is vary, the speed of motor also vary. The speed of motor is read from tachometer. From the test, output voltage is taken from other motor by using multimeter.

Figure 7 shows the result of three permanent direct current motor in term of speed (RPM) versus voltage generated. The high the speed the high voltage can be produced. The figure clearly show that the high velocity of rotation per minute the high voltage that can be generated.

Table 3: Voltage Generated by RS-550PC-8019 (12V) as motor 1

RPM	Voltage Generated, V
1144	0.44
1362	0.58
1735	0.68

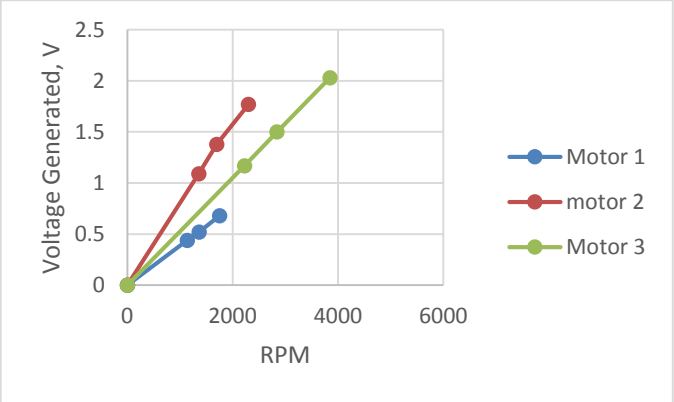
Table 4: Voltage Generated by RF-300FA-12350 (6V) as motor 2

RPM	Voltage Generated, V
1355	1.09
1700	1.38
2300	1.77

Table 5: Voltage Generated by 260RA-2670 (4.5V) as a motor 3

RPM	Voltage Generated, V
2228	1.17
2842	1.50
3846	2.03

Table 2, Table 3 and Table 4 shows the data that collected from the performance test experiment. The different value of speed and voltage generated from the motor are due to internal resistance of the motor. Internal resistor is due to coil winding inside the motor. The bigger the input voltage that can supply



the motor the bigger the internal resistance.

Fig.7: Relationship between speed of rotation and voltage generated.

From figure 7, motor 3 note as a highest voltage produced followed by motor 2 and the lower voltage generated is motor 3. Based on figure also motor 2 is the better generator compared to other. This is because of the speed of rotation. The lower voltage that can be generated from motor 2 is 1.09 v in 1355 rpm. For the others, motor 1 and motor 3 voltage also can be produce but at the high speed of rotation. From this performance experiment, motor 2 is be selected. The reason of the selection based on the speed of the water flow and the speed of motor performance.

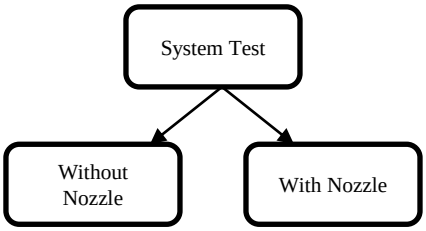
B. Experimental System Setup

The system is setup at domestic pipeline ½ inch. The water pressure gauge is used to monitor the pressure and the valve is used to control the pressure of the water. The purpose of doing this experimental setup is to observe the relationship between water pressure and the output voltage that can be produced by the system.

Fig. 8: System of experimental setup

Figure 8 shows the system of small hydropower experimental setup. First valve is used to control water pressure from water supply and the second valve is used for release water to the system. The aim of valve use is to set, observe and determine the static and dynamic water pressure. The higher the water pressure the higher the output voltage can be generated from the system.

There are two test in this system experiment. The system is conducted without use a nozzle and use 3/8 inch of nozzle size.



The purpose of this test is to observe the ability of water turbine rotating performance instead of water pressure.

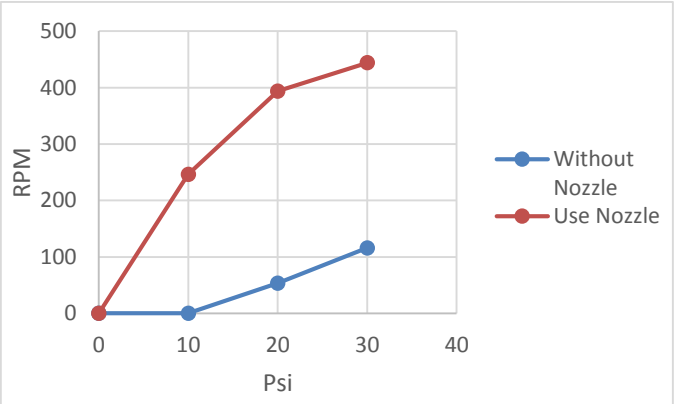


Fig. 9: Relationship of speed water turbine and water pressure

From figure 9 there is clearly shows that speed of water turbine rotation is depend on the water pressure. The greater the water pressure the greater the rotation. 0 to 10 Psi shows that the water turbine is not moving if not use a nozzle. The reason is the water energy and the speed is very low. From the experimental observation, the water flow out through space sides between turbine and the casing model. This make a turbine not rotate although there is has a flowing of water.

When the pressure of water increase from 10 to 30 the rotation is increase directly proportional. The higher speed is 115.7 rpm which is direct proportional to the higher water pressure. This is because of the energy water momentum. The turbine start to rotate once get kinetic energy from flowing water when water pressure is higher. But the rotation of turbine not fully get the maximum rotation due to water friction and other space of water flowing.

From figure 11, the rotation of water turbine increase directly proportional to water pressure. The higher is noted at 443.8 rpm with 30 Psi of water pressure. This value is quite different if compared to the value of rpm in figure 9. This differences is due to the water speed that produce by the nozzle.

Nozzle is used to increase the water flow in the same pressure of water. This method will increase the speed of turbine rotation instead of speed water flow. The size of nozzle is around 3/8 inch. The size is small than the inlet pipe. When the size become smaller the water that flow out from the nozzle will have more kinetic energy compared to the bigger in size.

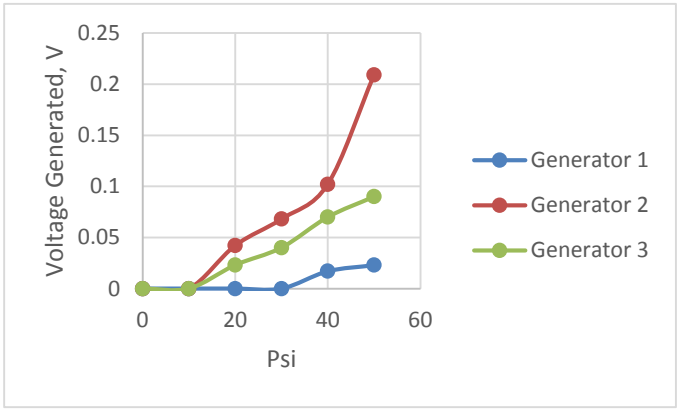


Fig. 10: Relationship between water pressure and the generated voltage of the system without using a nozzle

Figure 10 voltage generated by this system is clearly increase when the pressure of flowing water increase. This is because high pressure will cause the flow rate of water also increase too. Hence, the speed of water turbine will increase direct proportional to the rate of water flow.

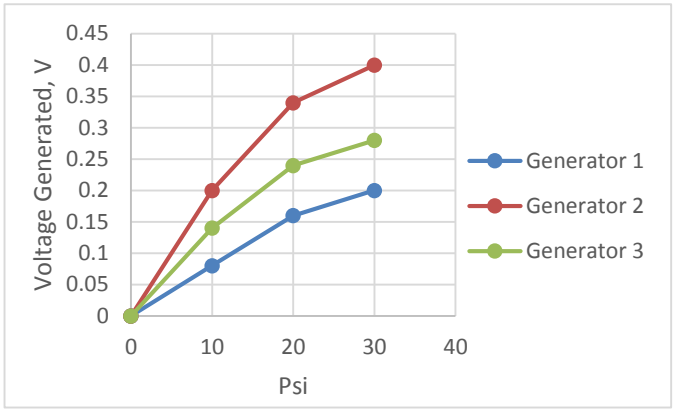


Fig. 11: Relationship between water pressure and the generated voltage of the system using a nozzle

Based on three different PMDC motor, motor 2 shows the higher voltage generated compared other two motor. The voltage generate is based on speed of water turbine rotation and the generator use. In this cases, Generator 2 note that the highest voltage produce. This is because of the generator 2 has a minimum torque, so the rotation is smooth and able to rotate as a well as water flow rate. The lowest voltage produce is by generator 1. This is due to the torque of the generator. The torque make it difficult to rotate. Hence, the magnetic flux also cannot be produced efficiently.

i. Power Generation by System

In term of power generation technology, current and voltage is main part of the system. Both of them make a relationship to produce the power.

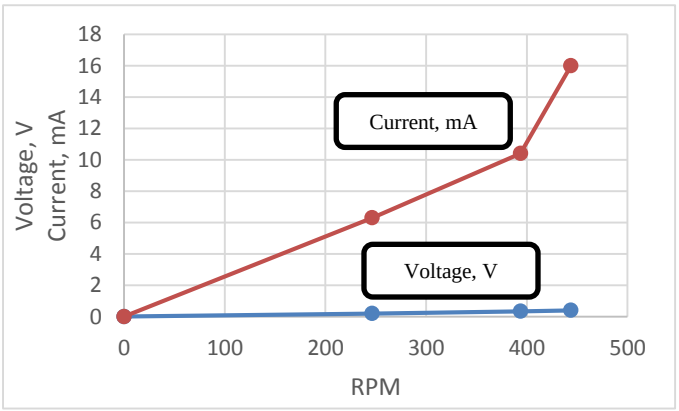


Fig. 12: Relationship between voltage and current based on speed of water turbine

Figure 12 is the voltage and current that produce by the generator 2. From this graft, when the speed of rotation increase both current and voltage increase too. The high voltage is 0.4 V and the highest current is noted at 16.0 mA with the speed 443.8 rpm.

The power generation can be calculate by using this formula; power produce is equal to voltage and current generated.

$$P = IV \quad (1)$$

Where I = Current
V = Voltage

The highest power that can be generate by the system which use a generator 2 is:-

$$P = IV$$
$$P = (16.0\ m)\ (0.40)$$
$$= 6.4mW$$

From the experiment, the power generation is low which around 6.4mW only. This is because highest voltage generation can be produce only about 0.4 volt. This value is too small to generate power. The value of voltage generated is measured by open circuit as a figure 8. In order to measure current simple circuit is created that only use a LED to make a close loop. Unfortunately, the LED cannot be light up due to very small in both current and voltage generated.

From this test, it is clearly shows that the system is able to produce a power but very small value. The problem is due to low in water pressure. Household only provide a range about 30 to 80 Psi. This pressure cannot make a turbine rotate in fast rotation. When speed of turbine low the power generate also be low too.

Second factor that influence to the problem is the coupling between shaft of the motor with the water turbine shaft. This is because when the coupling of both shaft not in 100% accurate the shaft will be hard to rotate. Third factor is the selection of generator. High torque make it difficult to rotate if use water as a medium to rotate the motor. Although a high torque can provide a high current and voltage generation but the flow rate of water not able to support the speed of motor rotation. This factor also need to be consider in selection of generator.

Fourth factor is the casing design. The design need to be very fit. The reason is to make sure there is only one way of water flowing. From this experimental design, there is little bit space that make a water can flow out when a water turbine shaft connected to the generator. This problem will cause the water turbine not be in maximum rotation.

IV. CONCLUSION

As a conclusion, the system of small design hydropower is one of the renewable technology that does not change or damage the aqua ecosystem due to small in size compare to the dams. This technology is able to install anywhere on domestic pipeline to generate the electricity instead of flowing water. Besides daily use of water, the energy of flowing water can be used to generate electricity. The high the pressure and speed of water the high electricity that can be produce by the generator. In order to speed up the rotation of water turbine the use of nozzle is necessary. The highest rpm when use a nozzle is 443.8 but the highest rpm without use a nozzle only 115.3 only. When the speed of rotation increase the power also increase too. Last but not least, the system is suitable to be used as a power generation instead of water consumption.

V. RECOMMENDATION

There are two recommendation for the future study and research. The selection of motor as a generator is one of the important part. The motor need to be in minimum torque and has a rotation per minute (rpm) quite be same as a water speed. This is because of the average of water pressure is around 40 Psi. So, if high torque of motor use in standard pressure, it will not able to rotate. Besides that, if the motor has a high rpm and use in the same pressure of water, it will be rotate but the power generation will be low due to water flow rate not give the power of rotation same rotation from the power supply like battery.

Furthermore, the casing design need to be fit to the water turbine shape. This problem can make the water turbine rotate at the maximum speed due to only one way to flow out. In addition, the design also able to reduce the water friction. This is because water inside the system can slow rate the rotation.

VI. ACKNOWLEDGMENT

The author gratefully acknowledge to Dr. Zulfakri Bin Mohamad for the advice and consultations in order to completing this project and the technical paper. Special acknowledge to people that involve to complete this project. Last but not least, my sincere thanks to laboratory technician in power measurement for lend me an equipment in order to make an analysis.

REFERENCES

[1] E. Mohammed, T. Gatte, E. Rasim, A. Kadhim, E. Farhan, and L. Rasheed, "Using Water Energy for Electrical Energy Conservation by Building of Micro hydroelectric Generators on the Water Pipelines That Depend on the Difference in Elevation," pp. 379–383, 2010.

[2] K. Aravindal, "Design and Fabrication of Laboratory Scale Micro HydroTurbine Test Rig," 2010

[3]]B. Adhikary, P. Kafle, and S. Thapa, "Study and Design of Drinking Water Hydropower Project for Rural Electrification," pp. 3–6.

[4] T. C. Yan, T. Ibrahim, and N. M. Nor, "Micro Hydro G Generator Applied on Domestic Pipeline," 2011.

[5] Y. Keawsuntia, "Turbine : A Case Study of Crossflow Turbine Electricity Generation from Micro Hydro," vol. 30000, 2012.

[6] P. Hydropower, "The ' Water Baby ' ," vol. 1, no. 506, pp. 1–18

[7] S.N.SINGH, *Electric Power Generation: Transmission and Distribution. PHI Learning Pvt. Ltd., 2008, p.452.*