A SIMPLIFIED METHOD FOR CONVERSION OF PUMP TO TURBINE (PAT) FOR RURAL AREAS APPLICATION

[1]S. M. Lawan, [2]W. A. W. Z. Abidin, [1]A. Y. Abdullahi and [3]A. Aminu,

[1,2]Centre for Renewable Energy and Climate Change, Kano University of Science and Technology, Wudil

[2]Department of Electrical and Electronic Engineering, Universiti Malaysia, Sarawak 94300, Kota Samarahan Sarawak

[3]Department of Electrical Engineering School of Technology, Kano State Polytechnic

Corresponding author email: salisumuhdlawan@gmail.com

ABSTRACT: *Electricity plays an important role in our daily life. Thus, the generation of electricity becomes a first priority issue. The electricity that generates from non-renewable energy such as coal or diesel is a common method for decades. More research had done on renewable energy such as hydro, wind, and biomass in order to produce green energy. For example, hydro turbine utilizes water to revolve the shaft hence generate power. On the other hand, the pump is commonly used to displace water from one place to another by using electricity. This paper shows a simplified hydro turbine design to power a small village. By reversing the method of the pump and convert it into a turbine where electricity generated. This method is known as Pump as Turbine (PAT). Developed PAT has advantages in terms of size and cost. The pump is smaller and compact compare to the conventional turbine. In addition, the cost of the pump is relatively cheaper than the normal turbine. In terms of maintenance, the spare parts of the designed pump are cheap and available. The designed PAT will benefit the rural area especially in Sarawak, where transportation is a problem and do not connect to a grid. Lastly, green energy is produced and it can replace the application of using combustible fuel in a diesel generator.*

1. INTRODUCTION

Energy is very essential to all human beings in the world. These include commercial activities such as the countries that are developing from an economic point of view. Generation of electricity is becoming an important role in developing the economy's infrastructure of a country. Nowadays, non-renewable sources that are used in electricity generation are very common, for example coal, oil and gas. Due to environmental concern, non-renewable energy sources are not environmentally friendly. The impact of using non-renewable energy is the emission of major greenhouse gas (GHG) and leads to global warming [1]. Renewable energy is recommended when dealing with global warming. Renewable energy can be described as harnessed, inexhaustible and it is a clean alternative to fossil fuels [2-3]. There are several renewable energies available in the world due to the ease of researcher to explore it. The available renewable energies are solar energy, bioenergy, wind power, hydropower, ocean energy, geothermal energy and technologies for renewable energy [4]. Among all the renewable energy, hydropower is the most promising and often used to produce electricity [5]. In Malaysia, water sources are suitable for generation of energy because currently Malaysia has 54 large dams in operation and 87 percent of safe drinking water supplies are in a rural area [6]. Micro-hydropower is a practical and potentially a low-cost option for generating electricity at remote sites, particularly for small villages in a hilly area [1]. This applicable to most of the indigenous people in Sarawak, where they are staying so remote that is not economical to have them connected to the electricity grid line. Diesel generator which is the source of electricity can only be affordable for some villagers while the rest will be in darkness after the sun set [7]. One of the easiest ways to reduce the equipment cost is the use of centrifugal pumps in reverse mode and can be used as an alternative to the conventional hydraulic turbine. The research on using the pump as turbine (PAT) was started around 1930 [7]. Pumps are mass produced and less complicated to operate than the turbine. Pumps working as turbine are an unconventional final solution for producing energy in water systems like natural falls, irrigation systems, sewage systems, etc. [8-9].

2. METHODOLOGY

The method of testing the capability of the pump as the turbine is very important in this project. This testing can estimate the performance of the pump as the turbine in terms of how much energy can be created. Besides that, spinning speed of the pump as a turbine which can generate sufficient energy is measured. The testing starts with finding the suitable pump from the pump shop. In terms of availability, a centrifugal pump is the most common pump uses among the villagers or resident people. The main purpose of this centrifugal pump is to displace water from low pressure to high pressure. A centrifugal pump is easy to find at any pump shop and the price is relatively cheap.

On the other hand, a generator is known as the most common device that people use to generate electricity. The basic way that the generator produces electricity is spinning the shaft of the generator (kinetic energy to electric energy) where the magnets are integrated inside the core of the generator. By using the same method, spinning the pump's impeller where the impeller is connected to the motor, therefore electricity will be generated. This method can be applied if the motor has the magnet attached to the core as well. This concept is based on Faraday's law.

The impeller is the main part in transferring the rotational energy to the motor. The design process begins with fabricating a new shaft to replace the impeller's role so that rotational energy is fully transferred to the motor. The belting system is chosen as the method for testing because the pulley is easy to obtain and various sizes can be used. In this testing, an electric motor is used as a driver. Both electric motor and pump are connected by using a belt. The multimeter was used to measure the voltage produced. The speed of the electric motor is adjusted by a regulator, thus various speeds can be achieved. The pulley used for the electric motor is 3:1 in the ratio of the pump pulley. This method is to make sure that a higher speed can be transferred to the pump. Next, the electric motor is started and the voltage produced by the pump is recorded.

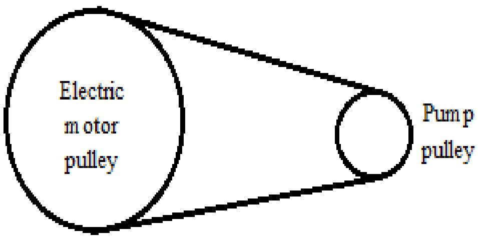

Fig 1: 3:1 Ratio Pulley

Simple testing is done by using a normal Light Emitted Diode (LED), 15W electric lamp, energy saving lamp 20W and a normal 40W fluorescent lamp were used to test the efficiency of the pump. The first test is to light up the LED. LED is used to test whether the system is AC or DC. The light continues light for 2 minutes; this is to make sure the voltage is stable. Once the testing is done, LED is connected to the opposite terminal to the output and the pump is operated at 2 minutes as well. This time the LED's brightness and the voltage are observed.

The next test is on the 15W electric lamp. The speed regulator adjusts to the speed that can light up the 15W electric lamp. The lamp able to light when the pump speed reaches approximately 3000 RPM. The next step is connecting the lamp in the series. When lamps are connected in series form, the power usage will be double from the single bulb.

Further testing is done by using 20W energy saving fluorescent lamp. The testing begins with installing a three head plug that used for any electrical appliance. Testing is continued by connecting energy saving fluorescent lamp.

Lastly, the testing is done by connecting a four head extension plug on the output of the pump. This time two energy saving fluorescent lamps are used as testing. The last test is using a normal fluorescent lamp and energy

3. RESULTS AND DISCUSSION

From the testing that has been done, the result is presented in Table 1. Table 1 shows that the speed of the electric motor reacts towards the voltage output of the pump. From the table, the pump is able to produce 256 V when it is rotated at 3208 RPM. Basically, the voltages produced are mostly in the region of 20V when pump speed is in the region of 2700RPM.

Table 1: Motor Speed at Different Voltage

Speed Regulator Value	The speed of Electric Motor (RPM)	The speed of Pump (RPM)	Voltage (V)
10	295	925	0.54
15	448.6	1405	1.49
20	594.1	1855	2.37
25	741.4	2329	5.96
30	881.9	2759	20.1
35	1024.3	3208	256

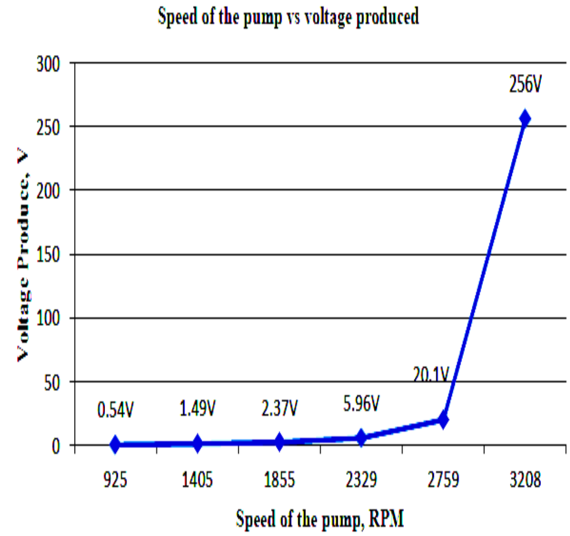

Fig 2: Figure 2: Speed of Pump towards the Voltage Produced.

Based on the testing, high voltage only can be produced when the pump is running at its synchronous speed. Figure 2 illustrates the voltage produced for each speed. The speed of the motor is indicated by RPM (Revolution per minute) and voltage is indicated as V.

Table 2: Type of Testing and the RPM Needed to Light On

Type of testing	RPM needed to achieve the same brightness as connected to the electric supply.	Results
1 Electric lamp	2944	Lamp On
2 Electric lamps in series	3113	Lamps On
20W energy saving fluorescent lamp	2988	Lamp On
60W (energy saving and normal fluorescent lamp)	3179	Lamp On

4. CONCLUSION

In his paper, PAT was successfully designed and tested. From the result part, it shows that the concept of the pump as the turbine be able to light the lamp. Further testing will be disassembled the parts of the pump in order to understand more about energy generation by the pump as a turbine. This may include how to generate more energy from the centrifugal pump that selected as the pump as turbine and the sustainability of the pump as a turbine. Further study of the Faraday's law may help to increase the generation of energy as well. In addition, software that can demonstrate the mechanism of the magnetic field will another advantage in terms of understanding the optimum condition in creating maximum energy.

ACKNOWLEDGMENT:

The authors wish to extend their gratitude to the Universiti Malaysia Sarawak under the postdoctoral fellowship program and for their financial support on this project.

REFERENCES:

[1] S. M. Lawan, W. A. W. Z. Abidin, S. Lawan, and A. M. Lawan, "An Artificial Intelligence Strategy for the Prediction of Wind Speed and Direction in Sarawak for Wind Energy Mapping," in *Recent Advances in Mathematical Sciences*, Singapore: Springer Singapore, 2016, pp. 71–82.

[2] J. Teknologi, S. M. Lawan, W. A. W. Z. Abidin, A. M. Lawan, M. Mustapha, and S. L. Bichi, "ANN AND GIS-ASSISTED METHODOLOGY FOR WIND RESOURCE ASSESSMENT (WRA) IN SARAWAK."

[3] A. A. Rahman, N. A. Bakar, F. Hanaffi, A. Khamis, and U. Teknikal, "Study of Renewable Energy Potential in Malaysia," pp. 170–176, 2011.

[4] B. Safari, "Modeling wind speed and wind power distributions in Rwanda," *Renew. Sustain. Energy Rev.*, vol. 15, no. 2, pp. 925–935, Feb. 2011.

[5] S. M. Lawan, W. A. W. Z. Abidin, W. Y. Chai, A. Baharun, and T. Masri, "Wind Energy Potential in Kuching Areas of Sarawak for Small-Scale Power Application," *Int. J. Eng. Res. Africa*, vol. 15, pp. 1–10, Apr. 2015.

[6] S. M. Lawan *et al.*, "A Methodology for Wind Energy Evaluation in Complex Terrain Regions of Sarawak," *Int. J. Electr. Eng. Informatics -*, vol. 7, no. 2, 2015.

[7] M. Anyi, B. Kirke, and S. Ali, "Remote community electrification in Sarawak, Malaysia," *Renew. Energy*, vol. 35, no. 7, pp. 1609–1613, Jul. 2010.

[8] H. H. Öztürk, "Experimental determination of energy and exergy efficiency of the solar parabolic-cooker," *Sol. Energy*, vol. 77, no. 1, pp. 67–71, Jan. 2004.

[9] S. D. Pohekar and M. Ramachandran, "Multi-criteria evaluation of cooking energy alternatives for promoting parabolic solar cooker in India," *Renew. Energy*, vol. 29, no. 9, pp. 1449–1460, Jul. 2004.