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Improved Vortex Channel for Whirlpool Generator for Harnessing Water Flow Energy from Irrigation

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Abstract—*Irrigation is the primary water source in the Philippines' rice fields. This water supply is limitless, and water flow can be exploited to convert energy into electricity. One of the options for altering the flow into energy was Pico and Mini-hydro. However, the unpredictability of water levels caused them to suffer from time to time. To mitigate the limitations of the later technology, improved water flow was used to generate a whirlpool using a vortex. This study utilized an eight-type propeller vortex instead of the conventional five propeller vortex. The findings are analyzed using a two-sample t-test. The H0 is that the discharge rate of the five-propeller vortex generator is like that of the eight-propeller propeller vortex generator. Because the solution p-values are 5.1, the H0 is rejected, implying that the two models provide different results. The eight-type propeller whirlpool generator outperforms the five-design propeller whirlpool generator. This design is suitable for harnessing the energy in the irrigation using a vortex channel Whirlpool generator to produce electricity.*

Keywords— *Whirlpool Generator, Vortex Channel, Water Discharge, Flow Rate, Hydro Generator*

I. INTRODUCTION

Technology is the most critical advancement in our society worldwide, specifically in the automation industry, a necessity in bringing about progress as we move along this world advancement [1]. Vortex Power Generation is a technology-based on a cylindrical basin with a central drain. Above the drain, the water forms a vertical turbine that drives the generator or motor [2]. Vortex Power Generation is a low–rpm head. The whirlpool can execute it as the turbine revolves at a certain speed by using multiple pulleys to generate a low – rpm to high – rpm [3]. The Vortex Power Generation is a clean, effective means of generating renewable energy that can cause eco-friendly power generation [4]. Utilizing conducting this technology is also to help the living creature, especially in riverbanks [5].

Hydropower is an excellent example of renewable energy, and its potential application to future power generation cannot be underestimated [6]. The concept of micro-hydropower systems can generate electricity. Gravitational Water Vortex Power system, which is classified as micro hydropower, can provide a solution for this environmental problem [7]. It is a horizontal form of a hydroelectric dam. In Surigao, a location suitable for installing a Vortex Power Generation may be found in Barangay Escalon Caging. Escalon River, which provides irrigation to the rice fields, is a large river that frequently floods when the weather is terrible, such as after a typhoon or other natural disaster [8].

The researcher offers a solution to conduct a Hydraulic analysis in the Escalon River to install or put the Vortex Power Generation in that area. One of the research projects is to know the water flow velocity if it is a good area. The researcher conducts this study to analyze the two different designs of vortex channels to produce a whirlpool, which can drive a generator to convert electricity. The research aims to maximize the best device to generate maximum electricity in the available water flow.

II. RELATED LITERATURE

Although most new developments are large-scale projects, global hydropower installation is accelerating annually. Small hydropower (SHP; less than 10 MW) and micro-hydro systems can be used to develop many impoverished places (less than 100 kW) [9]. Low-head sites (from 0.8 m to 2 m) represent an underserved power generating niche that avoids many environmental concerns associated with traditional MW-scale hydroelectric plants, such as the destruction of river ecosystems through the construction of big dams [10]. Avoiding dams also limits the social impacts of reducing water access to downstream users, particularly important in economies that rely heavily on agriculture, such as Peru [11]. As the generated power depends on the head (potential energy) and the flow, high-head sites can operate at relatively low flows [12].

In contrast, low-head sites require high-flow conditions. Such a system is highly suitable for isolated rural areas and is already being implemented in Nepal [13]. Water volumes of 0.5–20m3/s are suitable for yielding 17–3300 MWh/y. Hydropower, large and small, remains by far the most important of the "renewables" for electrical power production worldwide, providing 19% of the planet's electricity [14]. Small-scale hydro is in most cases "run-of-river", with no dam or water storage, and is one of the most cost-effective and environmentally benign energy technologies to be considered both for rural electrification in less developed countries and further hydro developments in Europe [15]. The European Commission has a target to increase small hydro capacity by 4500MW (50%) by 2010 [16].

III. CONCEPTUAL FRAMEWORK

This section explains the concept of the research using input, process, and output models, as shown in Figure 1. The input block presents the requirements in the hydraulic analysis of the vortex channel needed to design the power generator.

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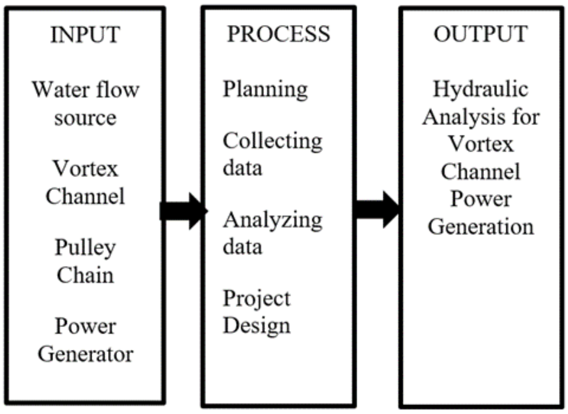

Fig. 1. Conceptual Framework of the Study

In the process, the block shows methods of how the project will be implemented, such as planning are the first method to have the best way to build the vortex channel. The second is collecting data that can get the honest output of the vortex channel. The third is analyzing data which the data can produce in that area or needs more improvement and final project design where the design is implemented in that area. The output block presents the hydraulic analysis for the vortex channel required for power generation design.

A. Theory

This section explains the theories that anchored the designed for the improved vortex channel for the whirlpool generator to harness water flow energy from irrigation. This section describes the ideas that have anchored the improved vortex channel for the whirlpool generator to channel the flow energy from the irrigation.

For the design of the hydroelectric turbines to be efficient, the blade of the turbine and the basin should be observed. Calculation of theoretical power is given by

$$P = Q\gamma h \qquad (1)$$

where: γ is the specific weight of the water, N/s3, Q is the volumetric discharge of the water, m3/s, h is the effective head of the water, m.

Calculation of basin design is given by

$$Q = AV \qquad (2)$$

where: Q is the volume discharge, m3 /s, A is the cross-sectional area of the water at the source, V is the velocity of water at the penstock.

Here the blade chord is denoted by C, and the UK is the local relative fluid velocity in the plane of the airfoil section. It should be noted that the effects of aerodynamic stall are automatically introduced into equation (2) through the section lift coefficient.

Hydro-turbines convert water pressure into mechanical shaft power, which can be used to drive an electricity generator or other machinery. The power available is proportional to the product of the pressure head and volume flow rate. The general formula for any hydro system's power output is:

$$P=\eta\rho gQH \qquad (3)$$

where P is the mechanical power produced at the turbine shaft (Watts), h is the hydraulic efficiency of the turbine, r is the the density of water (kg/m3), g is the acceleration due to gravity (m/s2), Q is the volume flow rate passing through the turbine (m3/s), and H is the effective pressure head of water across the turbine (m). The best turbines can have hydraulic efficiencies in the range of 80 to over 90%

Higher than most other prime movers), although this will reduce with size. Micro-hydro systems tend to be in the range of 60 to 80% efficient A detailed study of these reports was conducted. The performance characteristics of overshot water wheels were analyzed to assess the application of such wheels for electricity generation. It was found that water wheels have to be designed for a given flow rate, head difference, and intended operating regime. Properly designed overshot wheels have an efficiency of 85% undershot wheels of approximately 75% for 0.2 < Q/Qumix < 1.0, making this energy converter suitable for exploiting highly variable flow.

IV. METHODOLOGY

This research is implemented using an experimental design. The improved vortex channel for the whirlpool generator for harnessing water flow energy from irrigation is comparing the standard five-blade to eight-blade vortex generators as shown in Figure 2.

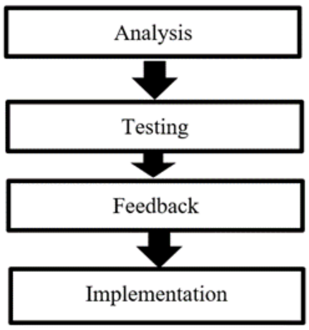

Fig. 2. Experimental Analysis

As shown in Figure 2, the system's design analyzes the character of the vortex channel the flow rate of the water located in a specific area. Instruments are used to test the characteristics of the flow rate and movement of the vortex channel and the discharge of the vortex channel, which can achieve the desired velocity.

A. Project Design

This project is designed that water flows energy as an input. Water flows to spin the vortex propeller connected to the generator. Rotor and stator in the generator create mutual induction, which creates electricity as an output, as shown in Figure 3.

The stronger the water flow is, the higher output voltage is produced. As the motor continues spinning, the more water flow, the faster the motor will spin so the sensor will detect if the turbine is over speeding at the designated speed to protect the motor if the sensor notices that the engine is over speeding, it will give the signal to the microcontroller, and the microcontroller will automatically provide the signal to the motor driver, and also the brake drum will turn on to make the turbine slower.

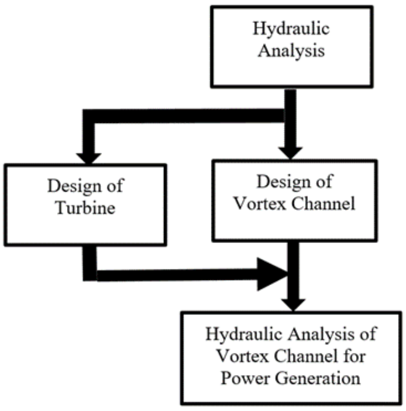

Fig.3 Project Design

B. *Project Settings*

To implement the project study, we conduct research for those remote areas, an area where rivers are vital enough pressure to spin the vortex propeller turbine. This project operates when the vortex propeller starts to spin. When the motor turns to the maximum speed, that will make the motor damage because of the uncontrollable water flow. The microcontroller sends the signal to the brake so that the motor will slowly spin. We are securing the device to avoid damage and checking the stability so that the motor's position is sturdy and can give its full power, as shown in Figure 4.

Fig. 4. Project Settings

As shown in Figure 4, this is the mapping location of the Escalon River located at Barangay Caging, and this location is not recognized in the google map.

C. *Instruments*

A generator is a machine that transforms one form of energy into another, such as mechanical energy into electrical energy, as in a dynamo, or electrical energy into sound, as in an acoustic guitar. The tachometer is an instrument measuring the rotation speed of a shaft or disk, as in a motor or other machine. The device usually displays the revolutions per minute (RPM) on a calibrated analog dial. Still, digital displays are increasingly common, as shown in Figure 5.

Fig. 5. Instruments

Ping-Pong Ball is an alight hollow ball used in playing table tennis. ball - the round object that is hit or thrown or kicked in games; "the ball traveled 90 mph on his serve"; "the mayor threw out the first ball"; "the ball rolled into the corner pocket." Pulley and belt a wheel with a grooved rim around which a cord passes. It acts to change the direction of a belt or taut cable. The device helps in power transmission using a line or a belt. A timer is an automatic mechanism that turns on a gadget at a particular time.

D. *Data Collection and Interpretation*

The two designs are implemented and record the water flow rate of the source discharge rate of the vortex. The recording is done using ten trials and recording the discharge rate of the two designs. The data was then processed using two sampled t-test inferential statistics to show the correlations of the data.

V. Results and Discussion

This section is the results of the fabricated vortex generator, the flow characteristics of the water source, the set-up of the vortex generator, data on water discharge flow rate of each design, and computation of two-tailed t-test using Python.

A. *Fabricated Vortex Generator*

The five and eight-blade vortex generator has a 1.2m diameter,30cm inlet of the vortex, and at the center of the vortex is the outlet which is the place where the water is discharged, as shown in Figure 6.

(a) Eigh Blade Design

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(b) Five Blade Design
Fig. 6. The Vortex Generator

It has 20 cm in diameter. This is a ¼ ratio out of the design vortex, which has a 15-kW output. As shown in Figure 6, this is the design of the turbine that has eight and five pieces of the propeller. The size of the propeller is 50 cm x 30 cm.

Fig. 7. Pulley Design in a Steel Shafting

As shown in Figure 7, there are two pulleys in the single steel shafting. The pulley from driver to driven pulley has a diameter of 3" and 16". The 3" pulley is the driven pulley. The driver pulley is the connected turbine. The 16" pulley is the driver pulley to the following pulley to create more speed or greater motor rpm.

B. Flow Characteristic of the Water Source

Figure 8 indicates that the velocity of the water is the distance over time, as determined by the speed of the water.

Fig. 8. Flow Rate of the Water Source

As the researcher conducts the study, to determine the velocity of the water flow, the researcher uses a Ping-Pong ball. The formula of the rate is D/t, in that area, the distance of the entrance flow of the water to the inlet of the vortex is 7m, and the time is 5s, so the researcher determines the velocity of it by dividing the distance and time, so the researcher has a V = 1.4 m/s flow of the water flow.

TABLE 1. Flow Rate of the Water Source

Trial	Length (meter)	Time (second)	Flow Rate (m/s)
1	1	0.98	1.02
2	1	1.01	0.99
3	1	0.76	1.32
4	1	0.83	1.20
5	1	0.69	1.45
6	1	0.69	1.45
7	1	0.97	1.25
8	1	0.75	1.39
9	1	0.85	1.28
10	1	0.95	1.33
AVERAGE			1.19

Table 1 shows the flow rate of the water source, the researcher uses a Ping-pong ball as the object to determine the velocity or speed of the water source. As table 1 shows the flow rate of the water source, which is the velocity distance over time. There are five trials that the researcher conducted. The total average of the flow rate of the water is as shown in Table 1, which is good and reliable to work or install a Vortex Channel

C. Set-up of the Vortex Generator

The two design is implemented in the irrigation channel as shown in Figure 9. The researchers need to rechanneled some portion of the flow because we are not authorize to disrupt the channel.

Fig. 9. Set-Up of the Vortex Generator

D. Data Collection of Discharge Flow Rate

Table 2 and Table 3 are the data of the two designs. It shows in the increase of the flow rate of the eight-propeller vortex generator compared to the standard five propeller vortex generator.

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TABLE 2. Five-Propeller Vortex Generator

Trial	Volume (Liter)	Time (second)	Flow Rate L/s
1	10	5.93	1.69
2	10	5.30	1.88
3	10	5.78	1.73
4	10	5.67	1.76
5	10	5.84	1.71
6	10	5.40	1.75
7	10	5.51	1.81
8	10	5.76	1.86
9	10	5.88	1.82
10	10	5.38	1.77
AVERAGE			1.60

TABLE 3. Eight-Propeller Vortex Generator

Trial	Volume (Liter)	Time (second)	Flow Rate L/s
1	10	4.81	2.08
2	10	5.20	1.92
3	10	4.91	2.04
4	10	4.86	2.06
5	10	4.73	2.11
6	10	5.11	1.96
7	10	4.93	2.03
8	10	4.86	2.06
9	10	5.18	1.93
10	10	5.24	1.91
AVERAGE			2.00

E. Computation of two-tailed t-test using python

This section computes the p-value of the two data from the discharge rate of five and eight propeller-type vortex generators, as shown in Figure 10.

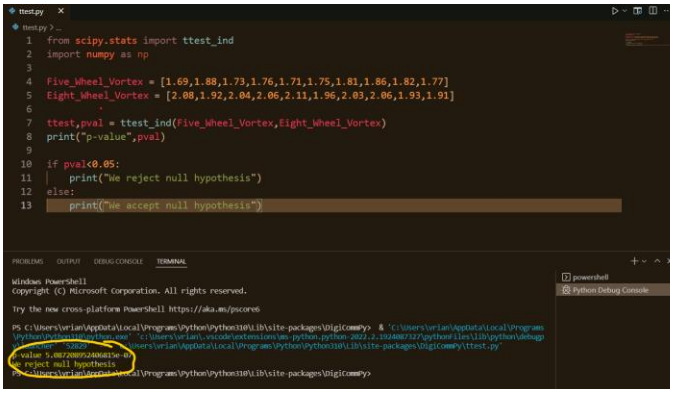

Fig. 10. Inferential Statistics Analysis using Python

The results show that the solve p-value is 5.08721 and rejects the null hypothesis. The H0 is that the discharge rate of the five-propeller vortex generator is like that of the eight-propeller propeller vortex generator. Because the solution p-values are 5.1, the H0 is rejected, implying that the two models provide different results.

VI. CONCLUSION

Fabrication of the vortex generator is successfully implemented. The average water discharge rate from the source is increased using the vortex generator, which creates a whirlpool, thus increasing the discharge rate of the water. Also, the data shows that increasing the propeller blade of the vortex channel improves the whirlpool speed, thus increasing the discharge water flow rate. The flow rate is also a function of the vortex generator's position in the irrigation channel. Thus, improved design of rechanneling some of the water flows will also improve the performance of the vortex generator

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