# DEVELOPMENT OF A MINI HYDROELECTRIC POWERPLANT DEMONSTRATING APPARATUS FOR LYCEUM OF THE PHILLIPINES UNIVERSITY- CAVITE MECHANICAL ENGINEERING LABORATORY

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*Abstract:* **The purpose of this study is to give an idea to the Mechanical Engineering Students of the Lyceum of the Philippines University- Cavite on how a Hydroelectric Powerplant works. The researchers believe that the study will broaden the knowledge of mechanical engineering students about theories and main components involving in a hydroelectric powerplant. The researchers made a prototype that can demonstrate the process in a hydroelectric powerplant. The actual data is gathered by turning valve that controls the flowrate of the prototype. After the actual data is gathered the researchers will see if the desired objectives of prototype are met. Hence, the prototype can be used as a demonstrating apparatus for Mechanical Engineering students of LPU-C.**

*Keywords:* **LPU-Cavite, resort Campus, Demonstrating Apparatus and Hydroelectric Power plant.**

## I. INTRODUCTION

Libraries of schools in the Philippines has a good resource of books and computers that can be used by students to further enhance their knowledge on certain subjects and topics. The world has advanced to the point where information can be accessed with just a single push of a button. Even libraries today can be scanned from a single application on a phone. But not everything can be learnt through reading. Sometimes, like little kids, high school and college students will have a much easier time understanding certain lessons if they are actually seeing what they are reading. Processes, formulas and theories that are hard to understand if you are just simply listening to your college professor. Demonstrators of power plants, industrial plants, machines that are used in the industry will have a much bigger impact to the engineering students who are trying to study these things. How turbines work, how gravity help fluids flow, how and what do you use to convert one form of energy to another. Those things can be tackled and will be explained much easier by having demonstrators. In view of the situation and experiences of the researchers, they conducted a machine that will serve as a demonstrator of a hydroelectric power plant. The focused of this study is to develop an equipment that can help the Lyceum of the Philippines University - Cavite Engineering students enrolled to understand how Hydroelectric Power Plant works.

## II. LITERATURE REVIEW

A Hydropower plant works by capturing the energy of falling water to generate electricity. A turbine converts the kinetic energy of falling water into mechanical energy. Then a generator converts the mechanical energy from the turbine into electrical energy. There are various types of a hydroelectric power plant namely Impoundment, Diversion, and Pumped Storage. The most common type of hydroelectric power plant is an impoundment facility. An impoundment facility, typically a large hydropower system, uses a dam to store river water in a reservoir. Water released from the reservoir flows through a turbine, spinning it, which in turn activates a generator to produce electricity. The water may be released either to meet changing electricity needs or to maintain a constant reservoir level. A diversion dam is designed to divert water from a watercourse such as a waterway or stream into another watercourse, irrigation canal, stream, water-spreading system, or another waterway. The purpose of the practice is to improve the beneficial use of water, or divert damaging flows to another watercourse that is more stable or otherwise more capable of reducing damage. One of the more common uses of this practice is diverting water from a stream or river into a canal used for irrigation purposes. A diversion, sometimes called run-of-river, facility channels a portion of a river through a canal or penstock. It may not require the use of a dam. Another type of hydropower called pumped storage works like a battery, storing the electricity generated by other power sources like solar, wind, and nuclear for later use. It stores energy by pumping water uphill to a reservoir at higher elevation from a second reservoir at a lower elevation. When the demand for electricity is low, a pumped storage facility stores energy by pumping water from a lower reservoir to an upper reservoir. During periods of high electrical demand, the water is released back to the lower reservoir and turns a turbine, generating electricity. These hydroelectric power plant has three classification of sizes a large hydropower that have a capacity of more than 30 megawatts (MW), A small hydropower that can generate 10 MW or less of power and lastly a micro hydropower that have a capacity of up to 100 kilowatts. One of the main components of a hydroelectric power plant is a turbine. A turbine is a device that harnesses the kinetic energy of some fluid - such as water, steam, air or combustion gases - and turns this into the rotational motion of the device itself. These devices are generally used in electrical generation, engines and propulsion systems and are classified as a type of engine. Turbines are often used in energy power plants to provide electricity to millions of people. In our apparatus we use three different types of turbines namely pelton, turgo, and crossflow. A Pelton Turbine or Pelton Wheel is a type of turbine used frequently in hydroelectric plants. These turbines are generally used for sites with heads greater than 300 meters. Then a Turgo turbine is an impulse turbine, and can handle flow rates that are higher than those a Pelton turbine can handle. This ability to deal better with large volumes of water gives the Turgo turbine an advantage when used in hydroelectric plants that have medium hydraulic heads. And lastly a cross-flow turbine is drum-shaped and uses an elongated, rectangular-section nozzle directed against curved vanes on a cylindrically shaped runner. The cross-flow turbine allows the water to flow through the blades twice. The first pass is when the water flows from the outside of the blades to the inside; the second pass is from the inside back out.

## III. METHODOLOGY

Experimental method was used in the Development of Mini Hydroelectric power plant demonstrating apparatus. The researchers based the design and construction of the prototype to the present Hydropower plants operating in today's time. Principles of how the water will behave on a hydropower plant are from articles and engineering books of power plants. The pelton, turgo, and crossflow turbines are scaled from bigger turbines found on catalogues of suppliers.

The following materials were the materials used to develop the device:

- Crossflow Turbine (3D Printed)
- Pelton Turbine (3D Printed)
- Turgo Turbine (3D Printed)
- Digital Voltmeter (LCD Type, Two wire 0-20 V, Digital Panel)
- Generator (12/24 10amp motor)
- Light bulbs (15 W LED light bulb)
- Lower Reservoir (Acrylic glass, Rectangular, 45in x 30in x 8in)
- Penstock (PVC pipe)
- Pump (Submersible Pump, Bi-directional)
- Upper Reservoir (Glass tank, 40in x 15 in x 20in)

*A. Project Construction Procedures*

Data Development

⇩

Specification of Materials ⇨ Obtaining of Materials

⇩

Fabrication of the Demonstrator ⇨ Finalization of the Demonstrator

*B. System Model*

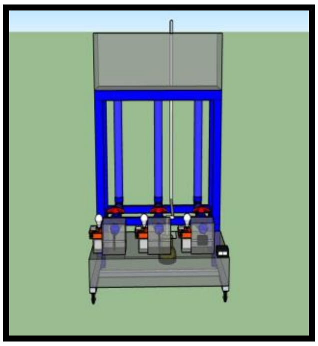

**Fig. 1. Front view of demonstrator**

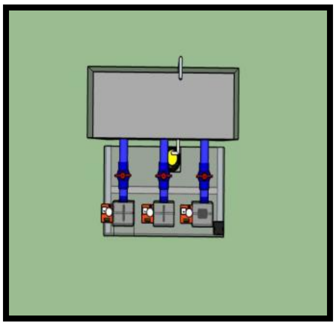

**Fig. 2. Top view of demonstrator**

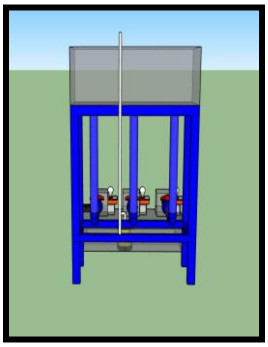

**Fig. 3. Back view of demonstrator**

## IV. ANALYSIS AND PRESENTATION OF DATA

*A. Dimension of Turbines (3D printed)*

**TABLE I: DIMENSION OF TURBINES**

| **Turbine** | **Diameter (from tips of opposite buckets)** | **Diameter (Original dimension from the internet)** | **Shaft Diameter** | **Size of buckets/blades** | **Size of buckets/blades (Original dimensions from the internet)** | **Number of buckets/blades** |
|---|---|---|---|---|---|---|
| Pelton | 5in. | 6.48in.. | 20mm | 1 in. | 1.16in. | 20 buckets |
| Turgo | 5in. | 6.48in.. | 20mm | 1 in. | 1.16in. | 20 buckets |
| Crossflow | 5in. | 4.72in. | 20mm | L of blades = 4 in. | 7.87in. | 16 blades |

*B. Actual data gathered*

**TABLE II: GATHERED DATA OF EACH TURBINE**

| TURBINE | VOLTAGE OUTPUT (V) | | POWER OUTPUT (W) | | VOLUMETRIC FLOW RATE ($m^3/s$) |
|---|---|---|---|---|---|
| | Trial 1 | Trial 2 | Trial 1 | Trial 2 | |
| Turgo | 33.14 V | 33.7 | 5.3024 W | 5.394 W | |
| Pelton | 30.65 V | 30.2 | 4.904 W | 4.832 W | |
| Crossflow | 28.49 V | 27.17 | 4.5584 W | 4.6672 W | $4.34257 \times 10^{-4}$ $m^3/s$ |

*C. Theoretical power output of the turbines*

$$P = m \ x \ g \ x \ Hnet x \ \eta$$

*where:*

*P- power (W)*

*m- mass flow rater in kg/s*

*g- gravitational constant, which is 9.81 m/s2*

*Hnet- the net head. Hnet = Hgross x 0.9*

*η- For a typical small hydro system, the turbine efficiency would be 85%, drive efficiency 95% and generator efficiency 93%, so the overall system efficiency would be:*

$$0.85 \ x \ 0.95 \ x \ 0.93 = 0.751 \text{ i.e. } 75.1\%$$

*Data:*

$m = 26.5 \ in^3/s = 4.34257 \ x \ 10^{-4} \ m^3/s = .434257 \ kg/s$

$g = 9.81 \ m/s^2$

$Hnet = 1.0795 \ m$

$\eta = 75.1\%$

$$P = .434357 \ kg/s \ x \ 9.81 \ m/s^2 \ x \ 1.0795(.9) \ x \ .751$$

$$P = 3.109001456 \ W$$

*D. Percentage difference of power output*

- (Turgo)

$$\frac{\text{Theoretical Value- Actual Value}}{\text{Theoretical Value}} \ x \ 100$$

$$\frac{3.109001456 \ W - 5.3024 \ W}{3.109001456 \ W} \ x \ 100$$

= -70.55 %

- (Pelton)

$$\frac{3.109001456 \ W - 4.904 \ W}{3.109001456 \ W} \ x \ 100$$

= -57.74 %

- (Crossflow)

$$\frac{3.109001456 \ W - 4.5584 \ W}{3.109001456 \ W} \ x \ 100$$

= -46.62 %

The percentage difference of theoretical and actual data gathered is in negative because the actual voltage output of the demonstrator is higher than the expected output. Meaning that the demonstrator performed better than the expectation of the researchers.

## V. CONCLUSION

In this study, the main purpose was to design, build, and demonstrate how a hydroelectric power plant works and show the different voltage outputs of the three different water turbines. The researcher's speculation was if a non-stop water source is used and applied to the turbines then energy will be created because the water will cause a rotation on the turbines thus creating energy. Using this speculation, the researchers constructed a device that converted hydropower into energy. This can be seen in the researcher's experiment as the water is transformed into energy by the water wheel. Multiple tests were conducted by the researchers to observe the performance and capability of the power plant in the hydroelectric process. The data gathered in every test shows that the power plant is effective in generating velocity and electricity. There are factors affecting the effectiveness of the process, it includes the flow rate with constant velocity making the turbines spin constantly, the height of the dam which makes the water create more speed as it falls down.

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