



## Hydroelectric Power Plant Design with Hydraulic Pump System

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### Abstract

The goal of this research is to develop a small-capacity power generator that may be used as an alternative energy source for home use, particularly in rural regions. The hydraulic ram pump was included in the design as a critical component for extending the duration of power production by turbines and generators, which was achieved via innovative engineering. During the manufacturing of hydraulic ram pumps, there are three test variants, which are comprised of the intake pipe length (2.6m), the output pipe height (2.5m, 3.2m, and 3.7m), and the outlet pipe diameter (3/4") of each pump. As a consequence of these findings, the average maximum performance of the hydroelectric power plant with the hydraulic ram pump system in this research was achieved at a reservoir height of 2.7 (m), with a voltage resulting in 7.3 (volts) (volts). With a turbine diameter of 46 cm, an intake pipe diameter of 3/4 cm, and a turbine inlet discharge of 7.2 liters per minute, the generator can produce electrical energy to the tune of 7.3 kilowatt hours (volts).

## Introduction

Nature and technology are inextricably linked in terms of energy. Energy is generated by nature, and it may be used to its full potential via the application of energy technology (Wang, 2013). A growing population and more human activity are both contributing to a rise in the demand for energy at this time (Wilkinson et al., 2007). With population expansion and increasing industrialization, there has been an imbalance between supply and demand, which has resulted in the absorption of energy sources, particularly fossil fuels, which are the world's primary energy source. The development of simpler renewable energy sources must be promoted in order to satisfy energy demands, at the very least to meet the residential energy requirements of the average family (Sovacool, 2012). The hydraulic ram pump is a technique that raises water from a certain height to a higher level by using the natural characteristics of the water (Omer, 2008). The purpose of the hydraulic ram pump mechanism is to introduce water into the system that has been constructed, creating a water hammer to occur in the system, causing the water to collide with one another and create pressure.

If the hydraulic ram pump mechanism is used in conjunction with a system that will spin a turbine, the water flowing to a high elevation by the hydraulic ram pump will cause the turbine to be rotated. A connection between the efficiency of the hydram discharge and the power that can be produced according to the data received from running the plant is explored in this study, which focuses on how the form of an efficient hydram pump in raising water is developed (Intriago Zambrano et al., 2019; Muriuki2019). Then design a standard operating mechanism for the tool so that it may be utilized without wasting energy

## Methods

This study's variables are statistics on the electrical energy generated by power plants, which were collected from various sources. From the use of hydraulic ram pumps in power plants to their usage in homes, data on extra water discharge utilized during operation can be obtained by graphing the connection between the quantity of energy and the efficiency of hydraulic ram pumps. When comparing the amount of water used with the amount of electricity produced.

Multiple parameters, including the height of the fall, the diameter and type of pipe used, the characteristics of the exhaust valve, and the lengths of the inlet pipe and the pipe on the exhaust valve, influence the effectiveness and efficiency of the hydraulic ram pump's performance, among other things (Shui, 2018; Jafri et al., 2020). Among its many other advantages, the hydraulic ram pump has a straightforward construction, does not necessitate lubrication, can operate continuously for 24 hours without interruption and does not generate noise, is simple to operate, has low manufacturing and maintenance costs and is energy-efficient and environmentally friendly, among other things.

## Research Scheme

It is the motion energy that is captured by the wheel that will be used to drive the generator, which will be turned into electrical energy. The pinwheel frame, blades, pulleys, v-belts, batteries, hydraulic ram pumps, and light bulbs are some of the components that go into making this gadget work. Despite the fact that the blade is 46 cm in diameter and that the type of blade used in this study is a plenum turbine type, what distinguishes this blade from other types of blades is that it has a basin that is at an angle of 45° to accommodate the water that comes out of the jet of water, allowing the blade to be loaded. and has the ability to spin to its best advantage

In this instance, an overshot windmill was utilized. This kind of overshot wheel may be utilized in locations where there is enough height for the wheel to be spun by using the energy produced by the water that falls to the surface of the wheel, as opposed to flat areas where the wheel cannot spin (Syafriyudin & Firman, 2017). In comparison to other mills, this kind of mill is more energy-efficient to run. It is advantageous to use the overshot type because of its high efficiency rate of up to 85 percent, the fact that it does not require a large amount of flow, the fact that it is simple to construct, easy to maintain, and the fact that it is a simple technology that is simple to apply in remote areas.

A tool's performance will be affected by the materials used and the requirements set out for them (M'Saoubi et al., 2015). For this instrument to function well, the technical materials used must match the required specifications, which include being strong and capable of supporting the tool's performance while also being simple to get. The framework of the tool that is being utilized in this instance is made of steel. Light-weight iron is utilized in the construction of this instrument, which makes it easy to manoeuvre and resistant to the load produced by the water that falls from the pipeline (Emmitt, 2018).

## Results and Discussion

Table 1. Hydrum Pump Test

Experiment	Inlet Pipe Length (m)	Outlet Pipe Height (m)	Outlet Pipe Diameter (Inc)	Output (liter/minute)	Leakage (liter/minute)
I	2.6	2.5	$\frac{3}{4}$	2.80	4.32
II	2.6	3.2	$\frac{3}{4}$	2.73	4.38
III	2.6	3.7	$\frac{3}{4}$	2.60	4.42

The experimental data in Table 1 was used to guide us through three experiments, and it can be seen that the difference in the resulting water discharge and the level of leakage is related to the height of the outlet pipe, as well as the relationship between the height of the outlet pipe, output, and leakage. When the reservoir was at its highest point (3.7 meters), the greatest leakage discharge at the hydram pump occurred in experiment III at a rate of 4.42 liters per minute (m). The water output that could be flowed into reservoir I was 2.60 (liters/minute), while the smallest leakage discharge was found to be 4.32 (liters/minute) at a reservoir height of 2.5 (m). In the first experiment, the water output that could be flowed into reservoir I was 2.80 (liters/minute), and the water output that could be flowed into reservoir II was 2.60 (liters/minute).

Table 2. Table of Mill Tests

Experiment	Reservoir Height (m)	Pipe Length (m)	Mill Height (m)	Water Discharge (liter/minute)	Voltage (volt)
I	1.5	3.2	1.5	5.83	3.2
II	2	3.2	1.5	6.43	5.2
III	2.7	3.2	1.5	7.20	7.3

Following up on the findings of Table 2 and 3 trials, it can be inferred that reservoir height has a significant impact on the voltage produced, since the higher reservoir height corresponds to higher water flow into the wheel. This conclusion is supported by data from the research in Table 2. The highest discharge efficiency used on the wheel is 7.2 (liters/minute) with a reservoir height of 2.7 (m), and the resulting voltage is 7.3 (volts), whereas the lowest discharge efficiency used on the wheel is 5.83 (liters/minute) with a reservoir height of 1.5 (m), and the resulting voltage is 3.2 (volts). The highest discharge efficiency used on the wheel is 7.2 (liters/minute) with a reservoir height of 2.7 (m), and the resulting (volts).

Table 3. Table of the resulting voltage to the load

Voltage without Load (volt)	Load				Voltage after Load (volt)
	Lamp I (0.5 watt)	Lamp II (1 watt)	Water Dynamo (1.2 watt)	Total (watt)	
7.3	☐	-	-	0.5	6.7
7.3	-	☐	-	1	5.8
7.3	-	-	☐	1.2	5.2
7.3	☐	☐	-	1.5	4.8

In accordance with the experimental findings in Table 3, As soon as a load is applied to the generator's output, the voltage produced by the generator changes. Using a variety of loads, including 0.5 watt lights, 1 watt lamps, and a 1.2-watt water dynamo, the starting voltage is increased to 7.3 volts, with the greatest final voltage generated at 0.5 watts of lamp load and a huge power of 6.7 watts (volts). On the basis of the calculations and analyses that have been performed, it has been determined that, as the outlet pipe is raised, the water discharge generated by the hydraulic ram pump decreases, and the leakage rate increases as well. Thus, as a function of reservoir height, both the water outflow as well as the resultant voltage will be increased. The resultant voltage will be lower regardless of the size of the load.

## Conclusion

Water output into reservoir I can be as high as 2.60 (liters/minute) when the reservoir height is 3.7 (m), and the largest leakage discharge at the hydram pump is as high as 4.42 (liters/minute) when the reservoir height is 2.5 (m), and the smallest leakage discharge is found at a reservoir height of 2.5 (m) when the water output into reservoir I can be as high as 2.80 (liters/minute) when the reservoir height is 2.5 (m). Water discharge on the wheel can be

as high as 7.2 (liters/minute) with a reservoir height of 2.7 (m), with the resultant voltage reaching 7.3 (volts). Conversely, the smallest water discharge on the wheel can be as low as 5.83 (liters/minute) with a reservoir height of 1.5 (m), with the resultant voltage reaching 3.2 (volts) (volts). A reservoir height of 2.7 (m) was found to be optimal for the average performance of the hydraulic ram pump system in this research, with the resultant voltage being 7.3. (volts). According to the calculations of the generator power produced after being provided a load, it is capable of turning on a 0.5 (watt) light with a final power of 6.7 watts (volt).

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