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Harvesting Electricity from Water Pipeline in Hydro Power Generator

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Abstract-
The purpose of this endeavour is to build a small-scale hydroelectric power plant that can produce energy for household use using water from a storage tank. One trustworthy and efficient kind of clean, green power is picohydroelectricity. It generates electricity with low maintenance and no fuel use. Water moving through residential pipes provides the kinetic energy to generate electricity for storage of energy. The design and construction of a pico-hydro generating system that extracts water from the water tanks of residential buildings are covered in this study. Three unique mechanical arrangements are added for improved operation and energy production: U-tube piping, a big nozzle pipe end, and an air bladder for sustaining water pressure. As a result, we might design a mechanical system which could produce electricity using the potential energy contained in a water storage tank from a water head.

Key words: Renewable energy, Hydroelectricity, turbine , diaphragm pump, portable etc.

1. Introduction

Water flow energy has long been used by humans to produce the earliest mechanical power and, more recently, electricity over the last century. Early applications included milling, pumping, and machine drive. 365 days a year, with the exception of wind and sun, proper water supplies can be guaranteed. Pressurised, flowing water is a very dense resource that hydropower systems convert into electricity at a rapid rate because the resource gets stuck in the pipes or the flame. A vertical drop produces pressure, and the constant water flow of a hydroelectric system offers a dependable supply of pressurised liquid energy. Hydro-electricity basically combines water velocity with vertical drop, as it is commonly termed. This allowed early settlers to operate grain mills and irrigation pumps, and it allows people to create energy from renewable sources at a reasonable cost today. This method stores household water in a tank then transfers it through a penstock, a downward-sloping conduit. The main function of this system is to store energy generated during the charging process for use at a later time, especially in the event of an electrical blackout. The recommended system uses far less power (8W) than the Pico micro hydro devices already in use, yet it is still reasonably priced, easy to use, ecologically friendly, and portable.

2. Problem Identification

Energy is among the most basic elements in the cosmos. It is also essential for employment and economic growth. Encouraging infrastructure, health, education, and transportation to reach a livable level of life is crucial for development efforts as well as survival. Over the past decade, there has been a surge in worldwide concerns around the energy problem, such as the demand for power, climate change, the oil crisis, and restrictions on whole sale markets. Technology-based solutions are required to ensure the resolution of these issues because they are always becoming worse.

Using environmentally friendly sources of energy, such wind, solar, tidal, or hydroelectric dams, to produce electricity as near to the point of use is one of these technical choices. Hydroelectric power is a green power source that comes from flowing water. Power can only be produced by flowing water. As the water descends because of gravity, its potential energy changes into kinetic energy. Hydraulic turbines use blades or vanes to transform the momentum of flowing water into mechanical energy. The turbine turns the generator's rotor, and this mechanical power is then converted to electrical energy.

The power produced by falling water has been put to many diverse applications, such as grain grinding, wood cutting, and irrigation water pumping. To harness the mechanical power of flowing water, slow-turning water wheels were used. Hydroelectric turbines were made possible by the design and efficiency improvements of these early water wheels. The earliest hydroelectric generators were developed in the 1880s. Large-scale hydroelectric dams presently provide 16% of the world's power, according to estimates from the international economic agency (IEA). However, these kinds of projects usually have a negative impact on the environment and require large amounts of dam construction, flood control, and land impoundment.

3. Objective

In India, energy is considered to be the main driver of many companies and enterprises. In a country where energy and income are agonisingly low, renewable energy sources will provide the greatest answer to these problems.

The primary objective of this project is to use a hydro generator to generate pipeline electricity.

- Examining current turbine designs to create the best power-harvesting turbine possible in order to generate an affordable, clean energy source.
- This project's goal is to create a pipeline turbine system that can produce power, with an emphasis on finding the best rotor.

4. Literature Review

P. Padmarasan et. al. 2016, The project's goal was to produce useable power from waste energy that was present in municipal and local drinking water systems. Hydroelectric energy is not a new technology. However, the plan was to apply the same concept on a more modest scale. The water turbine plan will employ smaller turbines that connect to water mains that go into cities and towns rather than the bigger turbines seen in dams. These turbines may be placed strategically at the foot of hills or tall towers of water to gather surplus energy that is not being used. The fact that the water turbine construction was successfully finished shows that there is energy available to us every day that may be used effectively. It is anticipated that energy will grow more and more scarce in the next years, therefore we must make every effort to be resourceful. The ongoing water turbine project serves as an excellent example. We are turning extra energy into usable electrical energy rather than letting it go to waste. The project is an excellent example of a multidisciplinary effort that combines renewable energy sources with electromechanical engineering.

Hani Muhsen et. al. 2019, In this paper, many turbine designs for the in-pipe hydropower system have been proposed. By implementing the suggested concepts into a working prototype that mimics an in-pipe network with a gravity-fed structure, the performance of all of them was compared. The excess water flow in the in-pipe systems has to be transformed into energy in order to provide green electricity that can then be utilised to power tertiary applications like lights or other loads. This work phase has addressed design aspects such as the number of scissors, angles of attack, and blade thickness. The six rotors that were proposed and researched were implemented using a 3D printer and the software SolidWorks. Each turbine's output power and pressure drop were monitored separately. The trial results showed that the spherical rotor design outperformed the hybrid H-Egg designs due to its larger frontal area blades. The increased number of water streamlines impacting the blades caused the rotational speed to increase. 16 W of output power was generated by the four-blade spherical turbine, which is good for a tiny prototype.

Marco Casini et. al. 2015, To optimise the utilisation of renewable energy supplies in urban centres, integrated and smart power systems in future smart cities will employ the distributed energy producing idea. When water grid conditions allow, it is highly recommended to install in-pipe systems because, as analysis has shown, they can offer many advantages in terms of energy production and supply consistency with no the problems with architectural cooperation and weather dependence that come with photovoltaic and breeze systems. In order to support these promising renewable energy systems, it is therefore advised to expand, coordinate, and disseminate the results of in-pipe micro and pico hydro development in order to enhance operational performance, reduce costs, and foster methods to better support the integration into the grid of a great deal of variable renewable energy. This will contribute to the development of a robust, clean electrical system that enables cost-effective, dependable, flexible, and efficient operation.

Pushpender Kumar et. al. 2017, The development in urbanisation has caused a rapid increase in the global energy consumption. What kind of green power system can meet this need for inexpensive, safe, dependable, and clean electricity? We need rapid, easy-to-implement, cost-effective, eco-friendly energy generating techniques that are up to date. Any energy savings—no matter how small—contributes to environmental preservation. Water availability is a major factor in metropolitan expansion, therefore maintaining a consistent supply of water across the metropolitan area usually requires rather high general pressure in urban clean water pipes. The velocity and pressure of the water cause the turbine within the water pipe to revolve; this rotating turbine is linked to a machine to generate power. In this study, a proposal to generate energy from the high head levels of water in the pipes is proposed and explored. Hydraulic energy recovery in drinking water systems for producing electricity is a theoretically feasible substitute for energy efficiency and conservation. Since many of the components of the required hydropower system are already in place, there are several deployment methods that may be used with less expense and without negatively affecting the processes involved in the distribution and treatment of water. Combining the various models can enhance the energy recovery system's benefits that have been examined and suggested.

5. Block Diagram

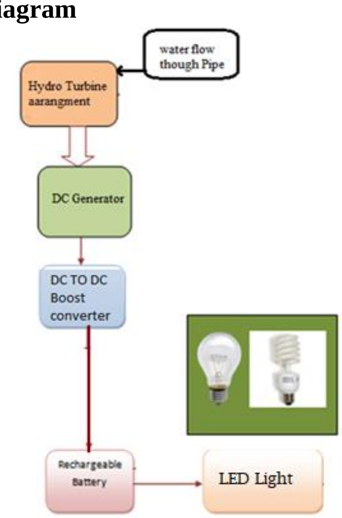

Figure 1 Block Diagram

6. Experimental working

In order to replicate residential structures, storage tanks for water are positioned at particular heights. First, we must consider residential buildings, such as villas and flats, which house a large number of people in a small area. The first water tank installed in the residential building will be rather huge. When the volume increases, the maximum rate of flow is then reached.

Residential buildings such as flats will consume the most water in the morning between five and ten in the morning. Almost everyone will be utilising one or more sources of water for cleaning, bathing, and cooking throughout this period.

We have now reached our highest rate of flow since the water is being utilised continually. To maintain water pressure or head, the water tank has to be filled each day prior to the start of consuming time.

Following are the working of total system;

• The pipe has three installed hydro turbine generators that start up when water runs out of it at a certain height. The whole amount of water discharged at the output falls into a large hydro turbine power source, forcing the water to flow in a single direction and starting the turbine generator's rotation, which generates electricity. When water is utilised to rotate a turbine, a generator starts up and starts producing electricity.

• A DC to DC boost converter is a device that processes all of the electrical energy by raising the DC voltage. Before being kept in a battery, it also passes via an unidirectional current controller.A controller is used in a control board that has an LCD display. This control board is used to measure the output voltage.

• To convert the voltage between DC to AC, another inverter board is used. Lastly, the output is linked to an AC load.

• In doing so, a prototype hydroelectric power generating model will be used in the pipeline work.

7. Components Specification

- **DC Generator**

A powerful magnet The ideal application for the mechanical energy produced by a pico-hydro system would be to run a DC generator. Even at the smallest voltages required for replacement of batteries and the functioning of direct current loads, a DC generator might supply high currents. Additionally, they are smaller and far less costly. This type of generator is believed to have been more efficient since no electricity is wasted while producing the magnetic field.

- **Hydro Turbine Module**

A turbine made of water is a revolving machine that generates mechanical work by harnessing the kinetic and potential energy of water. The flow of water directed onto the turbine runner's blades produces a force on the runner's blades. This is how the turbine receives power from the water's flow.

- **Battery**

Batteries are used to store the energy produced by wind and solar energy. The capacity of the battery may be impacted by the size of a solar or wind turbine plant. The battery should have low maintenance requirements and little charge leaking. When all these considerations are made, the free discharge type is the best choice. Multiple cells can be connected in series or parallel to increase or reduce the battery's capacity, depending on the hybrid systems' output.

- **DC to DC Boost Converter**

A boost converter, often referred to as a step-up converter, is a power converter from DC to DC that lowers current while raising voltage between its input (supply) to its outputs (load). An energy storage element, such as a capacitor, an inductor, or both, and at least two semiconductors—a diode and a transistor—are present in this kind of switched-mode power source (SMPS). To reduce voltage ripple, capacitor-based filters are commonly included in such a converter's supply-side and output (load-side) filters.

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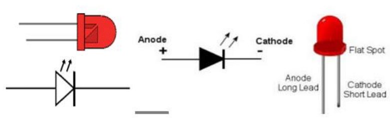
- **Light-Emitting Diode (Led)**

The longer lead is called the anode (+), while the shorter lead is called the cathode (&minus). The schematic representation of an LED (bottom) shows the anode on the left with its cathode on the right. LEDs are parts of electronics used for light signaling.



8. Calculation

Power Generation

The head and velocity of water in a stream or river determine the power potential of a micro hydro system. Here is how one might compute potential power:

$$P = Flow\ rate(Q) \times Head(H) \times Gravity(g) \quad (2.1)$$

$Where$

$P = Power\ (W)$

$H = Head\ (m)$

$Q = Water\ flow\ (m3/sec)$

$g = gravity\ constant\ (9.81\ Newton)$

The potential energy will become kinetic energy when the water bursts out of the pipeline & falls over the head. The pressure in the form of kinetic energy rotates the shaft of the hydraulic turbine. The mechanical power from the turbine will then drive the synchronous generator, producing alternating current (AC) power. Next will be the delivery of electricity to residential buildings. The AC power supply needs to be maintained at a constant 50 or 60 cycles per second in order to dependable power every device that uses it. This frequency is set by the turbine's speed, which must be controlled to an exacting degree. The best places to use micro-hydro power are areas having year-round, steep rivers, including those found in mountainous locations, the hilly sections of nations with a lot of rainfall, or the foothills of large mountain ranges.

Experimental Results

The empirical results for the recommended turbines, where power output varied according on the model design used, are summarised in this section's Table 3. An in-pipe hydropower plant that is gravity-fed can have its output power estimated using the following formula. [8], [11]:

$$P = \eta \times \rho \times H \times Q \times g \quad (1)$$

where,

$P \equiv$ The output power [W]

$\eta \equiv$ Turbine efficiency

$\rho =$ Water density $\left(1000kg/m^3\right)$

H = Net head (m)

Q = Water flow rate $\left(m^3/s\right)$

g = Gravity acceleration constant $\left(9.8m/s^2\right)$

A differential pressure (DP) transmitters was used to monitor the pressure, and a tachometer was used to measure the speed in revolutions per minute. Equation was used to compute the speed in (rad/s).

$$\omega = \frac{2\pi N}{60} \quad (3)$$

where,

$N = revolution\ per\ minute\ (rpm).$

The flow rate was determined using the Arduino flow metre. The three- and four-bladed spherical turbines have been eliminated from the research due to their subpar performance.

9. Main Benefits from This Technology

• It produces energy that is tidy and clean and has no adverse impact on the environment.

• It is not weather dependent in the same manner as the wind and solar systems.

• It makes no difference to the drinking water quality.

• In comparison to solar and wind power, which need up to four times as much money to produce the same quantity of energy, it is among the most affordable methods of producing electricity. • Pipelines used in industry, agriculture, and wastewater can also contain it.

• Electricity may be produced continually by using water flow.
• Easy to install
• Retrieves energy from operations.

10. Advantages

• It produces clean, orderly energy and has no adverse impact on the environment.
• It is not weather dependent in the same manner as the wind and solar systems.
• It makes no difference to the drinking water quality.
• In comparison to solar and wind power, which need up to four times more money to produce the same quantity of energy, it is among the most affordable methods of producing electricity. • Pipelines used in industry, agriculture, and wastewater can also contain it.
• Water that flows continuously may produce power. Installation happens quickly.
• Retrieves energy from operations.

11. Future Scope

• No carbon emissions are released during the production of power, and neither coal nor oil are used in the process. The life of natural resources is longer.
• It will enable the supply of electricity to all locations by lowering the per-unit consumption rates.
• It is safer in comparison to fossil fuels and nuclear power. These methods include the use of substances which, if consumed on a daily basis, can result in several health problems.

12. Conclusion

One alternative energy source to be developed is a pico-hydro generating system that harnesses water from domestic buildings' water tanks. This might be a consistent and ecologically friendly energy source that can be generated to increase small-scale hydropower production. Even in distant parts of the world, AC energy may be produced with this highly versatile power source.

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