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A Novel Small Scale Hydro Electric Power Generation System

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Abstract :- Pico hydroelectric power emerges as a dependable and efficient form of clean, renewable energy. The focus of this initiative revolves around designing and developing a pico-hydro generation system that utilizes water from the water tanks of residential buildings. The kinetic energy within the water flow in domestic pipes presents an opportunity to generate electricity, contributing to energy storage. This endeavor introduces three innovative mechanical arrangements: an air bladder for water pressure maintenance, U-tube piping, and a broad nozzle pipe end. These additions aim to enhance the overall functionality and efficiency of the system, ensuring improved energy generation. The resulting electricity generation comes with no fuel costs and entails low maintenance requirements. Importantly, the proposed mechanical arrangement allows for the harnessing of potential energy from water storage tanks with a water head as low as 3 meters and above. The primary objective of this research is to develop a small-scale hydro generation system utilizing water from residential water tanks as an alternative source of electrical energy. By tapping into the kinetic energy present in everyday water usage, this system offers a sustainable and accessible solution for residential energy needs.

Keywords: *Kinetic energy, U-tube piping, Energy generation, Small-scale hydro generation*

1. Introduction

Hydroelectric power (HEP) stands as a prominent renewable energy source globally, playing a crucial role in electricity generation by harnessing the fundamental principles of physics. The process revolves around the kinetic energy derived from falling water under high pressure. In HEP stations, turbines are activated by this descending water, and through magnetic induction, the generator transforms the turbines' mechanical energy into electricity. This innovative technique involves leveraging dammed water's descent to turn the generator's turbines, converting mechanical energy into a valuable electrical form seamlessly integrated into the national grid system. The optimal location for a hydroelectric power station requires expert analysis to determine the most effective head, ensuring maximum efficiency.

Hydraulic systems extend the application to slower water streams. A notable advantage of hydro power lies in the fact that water remains available for other uses post-generation. Rivers with substantial water flow and head elevation prove superior sources for hydropower. Flow rate, indicating the speed at which water passes a specific point in the river per second, and head, representing the vertical distance from the slope's top to the power station, are critical considerations. To enhance hydropower efficiency, dams with significant drops are constructed, elevating the water's potential energy. The intake, strategically positioned at the bottom where pressure is highest, allows gravity to guide water through the penstock. At this level, the kinetic energy is adequate to turn the turbines, converting it into electricity. Notably, the landscape of global energy sources is poised for transformation in the coming years, driven by the imperative need to address environmental concerns, particularly the reduction of CO_2 emissions. This urgency serves as a powerful catalyst for the development of green power.

Projections indicate that up to 60% of electrical power by the year 2030 in European power grids will be generated from renewable energy sources (RESs). Over the last three years, Ukraine has witnessed a significant surge in the volume of RESs, with continuous monthly growth. This upward trend underscores the global shift towards a more sustainable and environmentally conscious energy base.

2. Literature Survey

For the Hydro Electric Power Generator, extensive research has been conducted, with numerous papers referenced in the list [1] to [7]. [1] focuses on small and mini hydroelectric power plants as effective compensation for instability in non-guaranteed renewable energy sources power plants. These hydroelectric power plants (HPPs) play a crucial role in balancing the power system operation mode. To address the growth of RES generation, hydropower plants can be initiated as consumers in pump mode. This study delves into the trends of installed capacity in hydroelectric power plants worldwide and in Ukraine. It also examines the dynamics of annual hydroelectric power generation (HPG) using data from the International Renewable Energy Agency (IRENA) for both global and Ukrainian contexts.

In [2], rain falling from the sky is explored as a clean energy source with significant potential. The Rain-Power Utilization System is introduced, involving an initial rainwater disposal system and a multi-stage energy conversion system. [3] discusses stream turbines as a source of renewable energy for mechanical, urban, and rural areas, employing a 3D-printed core rotating part within a hollow pipe. The turbine blades are designed to strike the liquid flow, providing rotational movement to the generator shaft. [4] addresses the challenge of supplying electrical energy to remote areas, emphasizing Pico hydro technology as a cost-effective solution for hilly regions with water sources. In [5], the focus shifts to Bataan Province, where farming, particularly rice cultivation, is a significant livelihood. Central Luzon Region, to which Bataan belongs, is a major rice producer in the Philippines. The study highlights the shift in percentage share of play production in Central Luzon, and notes the prevalent use of diesel pump systems for crop irrigation among Bataan farmers in 2019.

3. Objectives

The increasing global population and advancements in technology demand substantial electricity for various purposes, including creation, construction, and expansion. Back in the 1920s, hydroelectric plants played a significant role, supplying up to 40 percent of the electric energy produced. Despite a steady increase in energy production through hydroelectric means, the growth rate of other types of power plants has outpaced it. Currently, hydroelectric power contributes around 10 percent of the electrical generating capacity in the United States. Hydropower maintains its crucial role in the national power grid due to its unique ability to respond swiftly to rapidly changing loads or system disturbances. This responsiveness is a key advantage over base load plants powered by combustion or nuclear processes, which struggle to accommodate such variations. In essence, hydropower remains an essential contributor to the resilience and adaptability of the U.S. electrical infrastructure.

4. Component Description

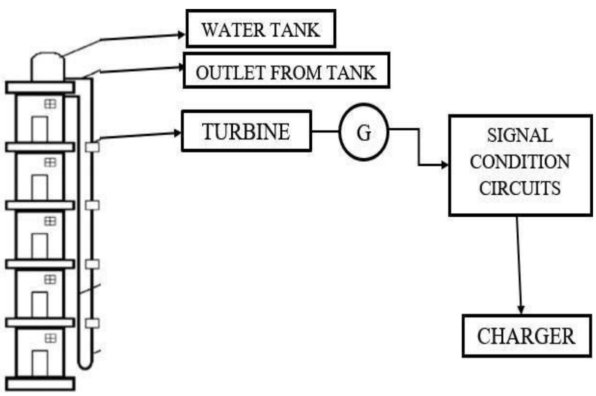

Figure 1. Proposed System Block Diagram

Turbine:

A turbine plays a pivotal role in converting the energy present in falling water into shaft power. There exist various types of turbines, which can be categorized in several ways. The selection of a specific turbine is primarily based on the available pressure head and the design flow for the proposed hydropower installation. Many systems also incorporate an inverter to transform the low-voltage direct current (DC) electricity produced by the system into either 120 or 240 volts of alternating current (AC) electricity. Alternatively, one can opt for household appliances that operate directly on DC electricity. For instance, certain stand-alone systems utilize batteries to store the electricity generated by the hydropower system.

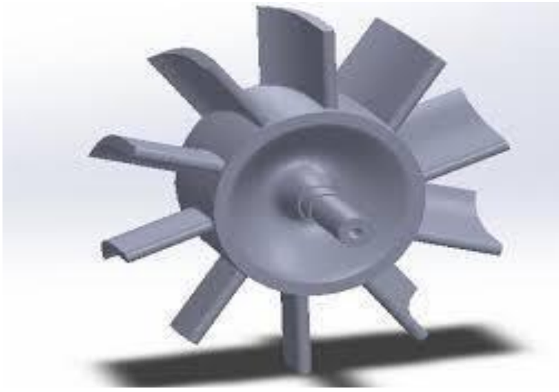

Figure 2. Turbine

Motor:

A DC motor is an electrical machine that converts electrical energy into mechanical energy. The fundamental working principle of the DC motor is based on the interaction of a current-carrying conductor with a magnetic field, resulting in a mechanical force. As the conductor moves within the magnetic field, it cuts the magnetic flux, leading to the generation of electromotive force (emf) in accordance with Faraday's Laws of electromagnetic induction. This induced electromotive force can drive a flow of current when the conductor circuit is closed. According to Faraday's law, when a current-carrying conductor experiences a changing magnetic field, emf is induced in the conductor. Applying Fleming's right-hand rule, the direction of the induced current changes with alterations in the motion direction of the conductor. Consider an armature rotating clockwise with a conductor on the left moving upwards. After the armature completes half a rotation, the motion direction of the conductor reverses, moving downward. Consequently, the direction of the current in each armature alternates accordingly.

Figure 3. Motor

Battery:

In the realm of electrical components, any movement signifies the transformation of the potential energy inherent in water into mechanical energy. Hydro turbines play a pivotal role in this process by converting water pressure into mechanical shaft power. This mechanical power can then be harnessed to drive an electricity generator, completing the crucial link in the conversion of water's potential energy into usable electrical power.

5. Results

Hydropower stands as a renewable and environmentally friendly energy source. The inherent ability of hydropower stations for instantaneous operations makes them highly responsive compared to many other energy sources, enabling them to meet peak demand effectively and enhance the overall reliability of the power system. The performance of operating power stations is evaluated using various parameters, including capacity utilization, annual generation, sale, and revenue realization, as stipulated by regulatory bodies such as the Central Electricity Authority (CEA) and the Central Electricity Regulatory Commission (CERC).

Figure 5. Hydroelectric Power Generator

6. Conclusion

Hydropower holds significant operational advantages, distinguishing itself by requiring no "ramp-up" time, unlike many combustion technologies. This unique characteristic allows hydropower to swiftly adjust its power supply to meet fluctuating demand, contributing to its crucial role in load-following, peaking capacity, and voltage stability within the electricity system. In a market-driven industry, these capabilities ensure reliable electricity service and align with customer needs. Notably, hydroelectric pumped storage facilities currently stand as a substantial method for electricity storage. The ability of hydropower to offer peaking power, load following, and frequency control plays a pivotal role in safeguarding against system failures that could result in equipment damage or blackouts. Beyond its emissions-free and renewable nature, hydropower's operational benefits enhance the efficiency, security, and, most importantly, the reliability of the electric system. Recognizing water as a valuable resource, hydropower maximizes the potential of this renewable treasure. As a leader in hydropower management, Reclamation contributes to meeting the nation's present and future energy needs. Through improvements and effective operation of hydropower projects, Reclamation plays a crucial role in achieving a balance that not only meets energy demands but also protects the environment in our ongoing efforts to deregulate the electric industry.

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