Promoting Renewable Energy in India: The Potential of Micro-Hydropower Turbines for Small-scale Power Generation

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***Abstract-* In India, the reliance on fossil fuels for power generation in households and local businesses is a prevailing practice, with approximately 80-85% of the consumed electricity originating from non-renewable sources. The escalating demand for power consumption has led to the depletion of natural resources, emphasizing the urgent need for alternative energy solutions.**

Renewable energy has emerged as a primary focus for industries and businesses, especially those requiring large-scale power generation. Meeting their energy demands while maintaining high-quality standards for their products or services is crucial. However, it is equally important to consider the energy needs of small households and local businesses, providing them with innovative solutions that contribute to the promotion of renewable energy.

***Keywords-* Renewable energy, micro - hydro, CFD simulation, power generation, renewable energy, micro-hydropower turbines, small-scale power generation, energy sustainability, India.**

I. Introduction

In India, the majority (80 - 85%) of the power/electricity consumed in households or local businesses is generated mainly from fossil fuels. Over the years, the demand for power for consumption has been increasing rapidly, which calls for deterioration of natural resources in the process of supply.

Currently, renewable energy is the main focus of industries and business, which require power generation on a large scale. Their needs have to be met with, without any compromise in quality as the product or service they provide will be directly or indirectly affected.

However, small households and local business owners can incorporate a few innovative solutions to aid this renewable energy promotion. One of which is, a micro - hydropower turbine to be used for power generation. These turbines can provide electricity on a small scale, ranging from 5kW to 100kW, enough for a household, farm, shop etc.

II. Literature Review

Energy Generation By Using Small Hydro Power-An Analysis

Tap water power is produced using a variety of technologies, such as pressure-driven systems, hydropower turbines, and hydrokinetic turbines. The most widely utilised device, the hydropower turbine, creates electricity by turning a turbine with the kinetic energy of flowing water. On the other hand, hydrokinetic turbines can produce energy using the pressure of flowing water and are made to work in low-flow or low-head water environments, such as pipes or channels. In pressure-driven systems, a turbine that produces energy is powered by the pressure of water flowing through a pipe.

The technology utilised and the circumstances in which it operates have an impact on how efficiently tap water is produced. With efficiencies ranging from 60% to 90%, hydropower turbines are often more efficient than hydrokinetic turbines, which typically have efficiencies of approximately 30% to 40%. Pressure-driven systems can achieve efficiencies of up to 80%, making them comparatively efficient as well.[1]

Integrated Solar and in-Pipe Hydro Energy from Overhead Tank for off-Grid Applications

An innovative EEF hybrid model of solar photovoltaic (SPV) energy paired with in-pipe hydro energy (HER) recovered from high head water (HHW) flows in the water lines is proposed in this research study for stand-alone applications (SOA) in high-rise buildings (HRB). An uninterrupted, dependable, and environmentally friendly electric power source for SOA may be offered by integrating SPV and HER at the lowest possible cost per unit. A functioning prototype of the suggested system has been created, set up in a typical multistory apartment building, and tested.[2]

The design and construction of a low-cost micro hydro turbine (converted from a commercially available water flow meter) is discussed in this work.

It is useful for mountainous and/or rural areas as basic power household systems (3V-12V and 7W-10W), and it is also effective for electrifying those areas. Water flow drives the turbine rotor inside the stator, and the turbine rotor's rotational speed changes in response to changes in water flow rate.

Water Flow Generator: Innovating Water Faucet Use
Using simple physics concepts, this review investigates the feasibility of converting water flow energy into electrical energy with a mini generator design.Harnessing potential of water flow could retrieve a large amount of usable electrical energy from simple, everyday actions with minimal impact to daily operation. This design holds promise for off-grid energy generation in the future.

III. METHODOLOGY

A. Materials/Components

The hydro power generator consists of these main components namely, inlet pipe to allow flow of water into the system, outlet pipe which is connected to a rotor which in turn is linked to a DC motor.

The DC motor is used to generate electricity. For the casing of the turbine, we have used a cork on one side of the system and a flat surface which acts like a supporting interface for the turbine mechanism.

Fig.1 shows the casing which is a protective cover for the rotor/ impeller or any other moving part of the system.

Fig. 1. Casing

Figure.2 shows the impeller/ rotor which is the rotary component of the system. It is used to increase the flow and pressure of the fluid flowing into it.

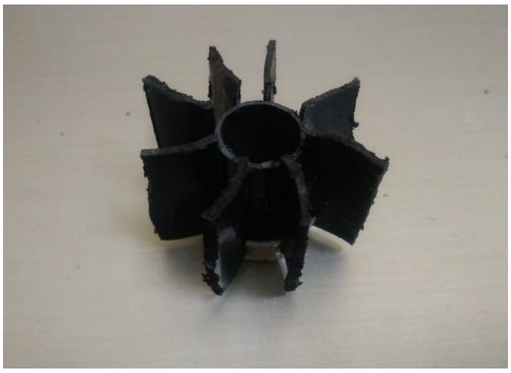

Fig. 2. Impeller

Fig. 3 shows the dynamo (12V) which converts mechanical energy into electrical energy using a commutator.

Fig. 3. Dynamo

B. Algorithm

Step 1 - Calculations of turbine selections, rotor speed, casing material etc.
Step 2 - Parts production: Procurement of components.
Step 3 - Assembly of procured parts into working system.
Step 4 - Designing of 3D model of power generator using CFD softwares.
Step 5 - Prototyping and testing of project

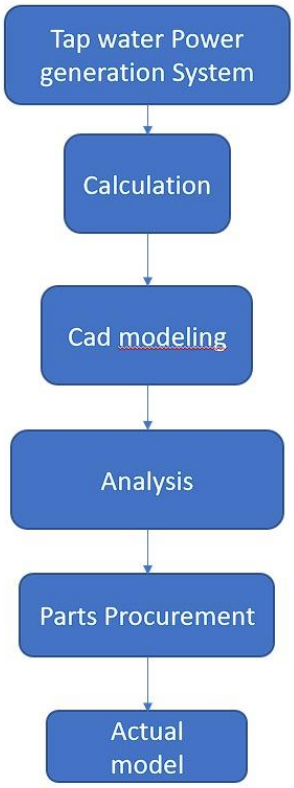

Fig. 4. Flowchart

C. Working

The input pipe allows water to enter the system, and the outlet pipe allows water to exit the system. These are the major parts of the hydropower generator.
pipe that is attached to a rotor that is then connected to a DC motor.
Electricity is created by the DC motor. On one side of the system, we employed a cork for the turbine casing and, on the other, a flat surface that serves as a supporting interface for the turbine mechanism.
The hydropower turbine converts the mechanical energy of the water's flow into electrical energy. The generation of up to 100 kW of power then uses this energy.

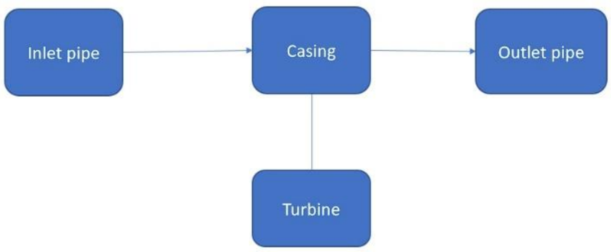

Fig. 4. Block diagram

D. Testing

The testing and trials of the prototype showed appropriate results in working and functionality and further changes and modifications for maximum efficiency were discussed.

IV. RESULTS AND DISCUSSION

The functioning and testing of model has yielded a set of values for pressure and power generated on each floor.
The values of pressure floorwise are:
1st floor: 323730Pa
2nd floor: 294300Pa
3rd floor: 264870Pa
4th floor: 235440Pa
5th floor: 206010Pa
6th floor: 176580Pa
7th floor: 147150Pa
8th floor: 117720Pa
9th floor: 88290Pa
10th floor: 58860Pa

A gradual decrease in pressure can be seen, as we move up each floor. The highest value being on the 1st floor and lowest value being on the 10th floor.
The average pressure calculated = 153904Pa
Similarly, the values of power generated, on each floor are:
1st floor: 17.71 W
2nd floor: 16.10W
3rd floor: 14.48 W
4th floor: 12.88W
5th floor: 11.25W
6th floor: 9.65W
7th floor: 8.04W
8th floor: 6.44W
9th floor: 4.82W
10th floor: 3.23W

The same pattern of gradual decrease can be seen here. The highest power generated on the 1st floor and lowest on 10th floor.

The average power generated= 11W

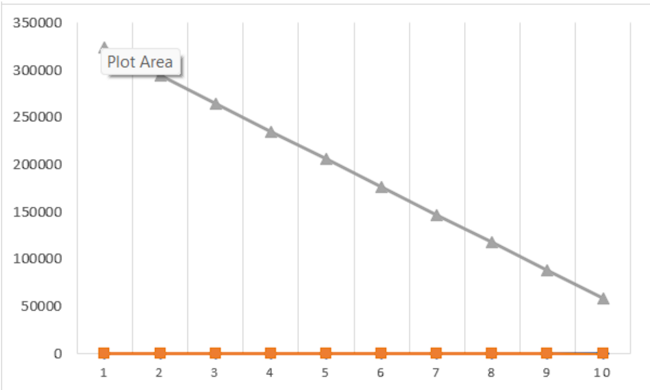

Fig 5. Graph

V. CONCLUSION

Local households and local company owners were able to use this prototype of a similar model to incorporate this concept, and as a result, these turbines were able to generate electricity on a small scale, ranging from 5 kW to 100 kW, sufficient for a household, farm, shop, etc.

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REFERENCES:

1. Chetan Songade, Amit Kumar Kundu, Divyansh Soni, Vikrant Singh Patel, Abhishek Sharma, Vijay Kumar Choudhary Energy Generation By Using Small Hydro Power-An Analysis , March 2022
2. Ayashri E. J, Reshma R, Anand P, Integrated Solar and in-Pipe Hydro Energy from Overhead Tank for off-Grid Applications, March 2018
3. CFD simulation data of a pico-hydro turbine Libia Cenith Alvear Pérez,⁎ Manuel José Anaya Acosta, and Cristian Antonio Pedraza Yepes, December ICONTEC, Código colombiano de instalaciones hidráulicas y sanitarias – NTC 1500, Bogotá, 2017.

4. Ministerio de Vivienda Ciudad y Territorio, Reglamento técnico sector Agua potable y saneamiento básico – Resolución 0330 8 junio 2017, Bogotá, 2017.
5. ANSYS Inc., ANSYS CFX-Solver theory guide, Canonsburg, PA, 2011.
6. ANSYS Inc., ANSYS 13.0 Meshing User's guide, Canonsburg, PA, 2010.
7. ANSYS Inc., ANSYS CFX-Solver Modelling Guide, Canonsburg, PA, 2011
8. Micro-Generation of Electricity From Tap Water Lalitha.S, October 2013.
9. Design and Fabrication of Pico Hydro Turbine Mr.Prasanna Nayak H and Santosh Kumar Singh, 2019
10. Water turbines; contributions to their study, computation and design, S. J. Zowski
11. THE DESIGN OF A LOW-NOISE ROTOR-ONLY AXIAL FLOW FAN SERIES, Sybrand Johannes van der Spuy