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Two Way Power Generation by Using Rain Water and Piezoelectric Materials

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Abstract: A micro hydroelectric system is an energy conversion approach to generate electricity from potential (motion) from flowing water energy to an electrical energy. It is desired to be implemented by using a micro-hydro electric generator which is attached to the continuous flow of effluent discharge. Nowadays, a variety of advanced technology has been introduced. Researches related to renewable energy nowadays have been extremely explored. This project will investigate the possibility of kinetic energy of rain drops be harvested as renewable energy and method to convert mechanical energy from raindrop to electrical energy. Each piezoelectric can be generated in average of 1 volt for each pressure at that surface. Using more piezoelectric in series connection will supply more power to the load. The output from the piezoelectric produced alternating current (AC), then using rectifier circuit for convert to direct current (DC). This project also included a power bank for the power storage generated.

Keywords: Rainfall energy, Micro-water turbine, DC Motor and Piezoelectric transducers.

I. INTRODUCTION

On Earth, water is constantly moved around in various states, a process known as the Hydrologic Cycle. Water evaporates from the oceans, forming into clouds, falling out as rain and snow, gathering into streams and rivers, and flowing back to the sea. All this movement provides an enormous opportunity to harness useful energy. Prior to the widespread availability of commercial electric power, hydropower was used for irrigation, and operation of various machines, such as watermills, textile machines, and sawmills. Compressed air was produced from falling water, which could then be used to power other machinery at a distance from the water.

Hydro power continued to play a major role in the expansion of electrical service around the world. Hydro electric power plants generate from few kW to thousands of MW and are much more reliable and efficient as a renewable and clean energy source than fossil fuel power plants. This resulted in upgrading of small to medium sized hydro electric generating stations wherever there was an adequate supply of moving water and a need for electricity.

As an ecological source of renewable energy, the available kinetic energy of rainfall is not trifling, especially in tropical countries at the equators. The research on the use of piezoelectric transducer to harvest raindropkineticenergyisgainingmoreandmoreattentionrecently.Thisarticlereviewsthestate-of-the-artenergy harvesting technology from the conversion of raindrop kinetic energy using piezoelectric transducers as well as its interface circuits for vibration-based energy harvesters. Piezoelectric materials are able to convert mechanical energy to electrical energy because of the unique property known as the direct piezoelectric effect. Moreover, the mechanism is simple and straightforward, which is important for mass production. Therefore, it has becoming a key material for harvesting the kinetic energy of the falling raindrop. Harvesting rain drop kinetic energy by means of impacting the piezoelectric material has gained a greater interest in recent years. Different from macro energy harvesting technology which generates kW or MW level power, piezoelectric energy harvester is a micro energy harvesting technology that generates only mW or mW level power.

II. LITERATURE SURVEY

Arjun [1] has developed a Micro-Hybrid Power System using Solar & Wind that harnesses the renewable energies in Sun and Wind to generate electricity which resulted that the site is abundant in renewable energy and the hybrid nature increases the reliability and reduces the dependence on one single source.

Shamim Kaiser [2] has analyzed the Hybrid Options for Power Systems in St. Martin's Island for fulfilling the energy demand using Solar & Wind resources and analyzed that it will be better to use Wind-PV combination system for 50 homes instead of single home system & the overall cost of energy would be low if turbine cost decreases.

Benasciutti and Moro L [3] confirmed that the single drop of water hitting the piezoelectric plates generates voltages less than a dozen of volts (peak to peak), but no evaluation on power has been proposed. The drops of rain strike the piezoelectric material in a cantilever configuration, which may be subject to study to improve the energy produced.

Vatansever et al. [4] studied comparison of different piezoelectric materials finalized to investigate the possibility of energy generation water droplets energy sources for low power electronic devices.

Williamson S J et al. [5] Head hydro turbine selection using a multi-criteria analysis. Explained that the most effective way to choose a type of turbine for electricity generation in small-sized water resources with low turning speeds is to consider the last user. This method will assign the optimal type of usage pattern, and will be applied to remote areas consisting of different levels of water.

Behrouzi F et al. [6] gave review of Various Designs and Development in Hydropower Turbines. The research mentioned that hydro energy was the best alternative energy resource that could be transformed into electricity, and it was able to be more developed and has a more effective design when the focus is on increasing the output of the turbine by the least force. The number of researchers who are interested in turbine designs for irrigation canals therefore increased, and many kinds of research focused on designing and developing turbines into various patterns to catch energy from water flow to generate the most electricity.

III. OBJETIVES AND METHODOLOGY

3.1 Objectives

The main objective of this proposed work are as follows:

- Improve the utilization of renewable source of energy for the generation of power, create awareness about the power generation for domestic purpose.
- Rain water and piezoelectric materials are the source of power generation.
- Initially rotor which converts mechanical energy into electricity due to the potential energy of rain water by the gravity.
- Then piezoelectric transducer which converts impact energy into electricity.
- Simultaneously rain water is conserved and used for domestic purpose.

3.2 Methodology

The Fig.1 shows the flowchart of methodology.

- Frame is fabricated for the artificial rain setup and power generation process according to the requirements.
- Rotor and the piezoelectric chamber is attached in a frame as per our requirement, pump is fitted to the reservoir tank.
- When the pump is on, water flows through the shower, falls on the roof and temporarily collected and made to pass towards the rotor which rotates i.e power generated.
- Then the water leaving from the rotor impacts on the piezoelectric material causes power generation.
- Finally water is stored in a storage tank.

IV. WORKING PRINCIPLE

The power plant from the water depends on the combination of head and flow height. Both must be available to generate electricity. Water is diverted from the rain to the pipe, where it descends the height and is directed through the turbine. The types of rain storm its drop diameter and its velocity is shown in the Table 1.The vertical / head drop creates pressure on the bottom of the pipe.

Pressurized water emerging from the end of the pipe creates the force that drives the turbine. The turbine in turn rotates and drives the generator in which electricity is generated. The water pressure or high drop is created by the difference in height between the water and turbine intake. The head can be expressed as distance, or as pressure.

The net head is the pressure that is available in the turbine during running water, which will always be smaller than the pressure when the flow of water is dead (head static) due to friction between the water and the pipe. The diameter of the pipe also affects the clean head. The discharge is the amount of water available, and expressed as the volume of cubic meters per second (m3/s), or liters per minute (l/s). The design flow is the maximum flow in which the hydro system is designed.

The gravitational potential energy of the rain water would be converted into kinetic energy. The stream of water would strike a turbine to cause the turbine to rotate. The turbine shown in Fig. 2 would be connected to a generator to produce electrical power. The turbine would be placed in the downstream and above the storage tank. It is considered as primary source of power generation.

The piezoelectric system shown in Fig. 3 that recovers the vibrational energy from a piezoelectric structure impacted by falling raindrop. The rain drop falling from sky is accelerated along its motion. This tends to increase its velocity. At the time drag force offered by the air increases its velocity. At a certain point the drop experiences equilibrium and the drop continues to fall with a constant speed called as terminal velocity. It is the kinetic energy of the drop which gets converted into electricity due to piezoelectric materials. This process is enabled by the shredded discharge by turbine, mainly considered as secondary source of power generation.

V. INDENTATIONS AND EQUATIONS

i. Power generation by micro water turbine

Water flow rate (V),

Average time is the result of the division between the total measurement time and the number of repeat measurements.

$T_{average}$= Total time / n (1)

Calculate the velocity (V) by using the mean cross-sectional area variable (A) and the mean time (T) according to the formula. Speed (V) is the result of the division between channel length / current (P) divided by the mean time ($T_{average}$)

$V = P / T_{average}$ (2)

Discharge of water,

$Q = V \times A\ [m^3/s]$ (3)

Q = water discharge (m^3 / sec)

A = Area of cross section (m^2)

V = Water flow rate (m / sec)

Power generated,

$P = g * \square_t \times \square_g \times H \times Q$ [kW] (4)

Where:

P_e = power generator

g = gravity

$\square_t$ = turbine efficiency

$\square_g$ = efficiency of the generator

H = high plunge (m)

Q = water discharge (m^3 / sec)

ii. Kinetic Energy of Raindrop power generation by piezoelectric material

The kinetic energy E_K of the raindrop can then be calculated as,

$E_K = mv^2/2$ (5)

Where, the mass of the droplet is,

$m = \rho V = \rho(4/3)\ \pi(D_{drop}/2)^3$, (6)

V is the volume of the droplet,D_{drop} is the droplet diameter, ρ is the density ofwater, and v is the terminal velocity of the droplet.In Eq. (5),the shape of the droplet is assumed to be spherical and the volume constant while falling. The amount of electrical energy E_U extracted can be expressed as,

$E_U = (k^2Y^2K^TS^2)/2$ (7)

where k is the material coupling coefficient, Y is the Young's modulus of the piezoelectric material, K^T is the active volume covered by conducting electrodes, and S is the average volume deformation variation during impact.

VI. FIGURES AND TABLES

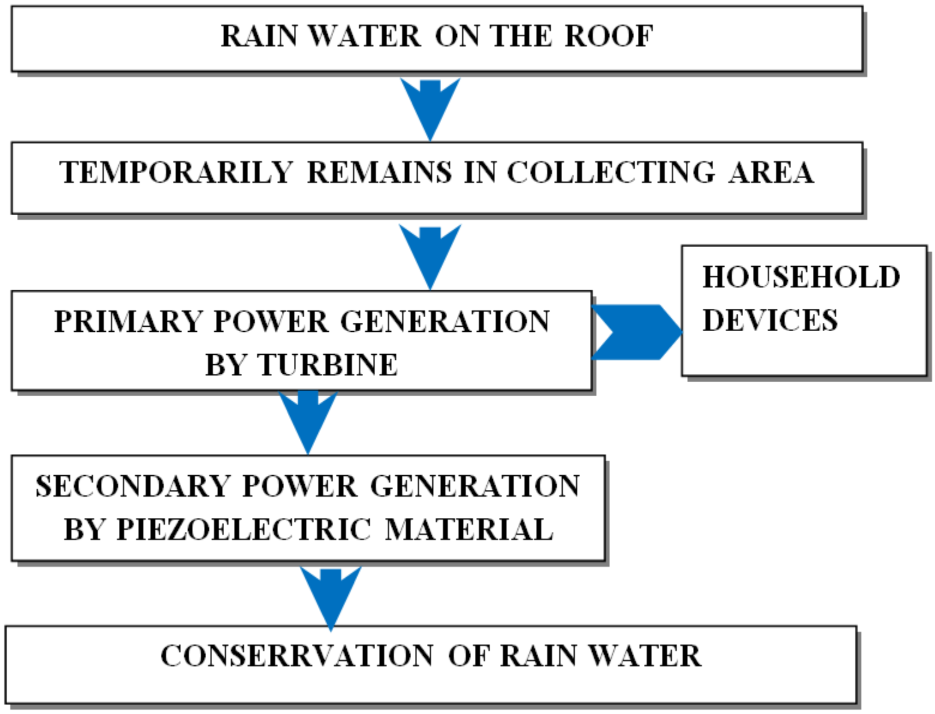

Fig.1 Flowchart of Methodology

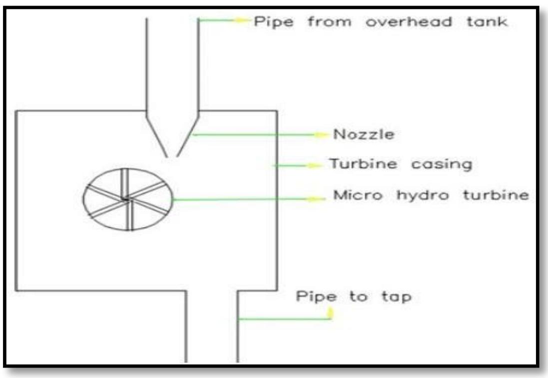

Fig. 2 Turbine System

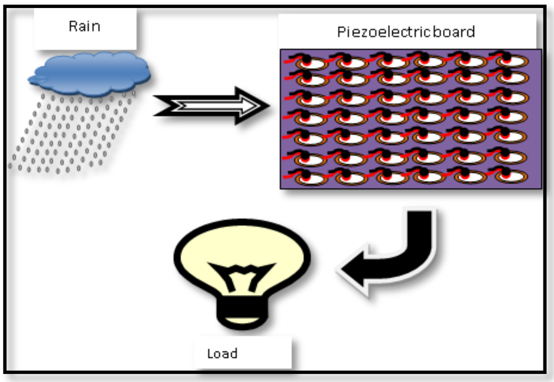

Fig. 3 Piezoelectric System

Table 1: Rain fall rate per hour of different types of storms.

Type of Storm	Rate (mm/hr)	Largest diameter of a raindrop (mm)	Terminal velocity (ms^{-1})
Light rain	2 – 4 mm/hr	2.0	6.49
Moderate rain	5 – 9 mm/hr	2.6	7.57
Heavy rain	10 – 40 mm/hr	5.0	9.09 or 10 [12]
Violent	> 50 mm/hr	N/A	N/A

VII. CONCLUSION AND FUTURE SCOPE OF WORK

7.1 Conclusion

Small hydropower as a sustainable and renewable resource is a major energy source of electricity generation in Nigeria. Small hydropower is a well - developed small scale renewable energy technology which can contribute to the improvement of electricity access in rural areas of the country. One of the major component of small hydropower development, is the hydraulic turbine which converts the energy of falling water to mechanical energy that drives the electric generator. The right choice of hydraulic turbine at any given site that will function optimally irrespective of the varying seasonal water flow is paramount to any small hydropower development.

The rain drops can be used as the energy harvester because output voltage can be obtained when the force of the rain drop hit to the piezoelectric sensor. It is proved that mechanical energy is obtained which can be converted into the electrical energy. The piezoelectric sensor reading is evolving and not only according to the height of floors, even by heavy rain the water mass. This energy can use to power up the home device like Light Emitting Diode (LED) lamp and fan.

7.2 Future Scope of Work

Hydropower provides one of the most effective methods to achieve a renewable energy future. If it is adapted in a accelerate growth in the hydropower sector and to bridge the gap between the actual and planned capacity addition, the private sector is being seen as an important stakeholder. Accessing water is an energy intensive process and recognizing the intersection between energy and water and using rainwater harvesting to approach the problem is a research area being pursued.

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