Energy Generation By Using Small Hydro Power-An Analysis

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Abstract - *Small or micro hydropower projects (SHP or MHP) are helpful for the solution of sustainable, eco-friendly, long-term, and renewable resources of energy for the future. Most of the electricity shortage is on the rural side of every country, so the alternate energy source for household power requirements is essential. Also, this source must be portable and easily operated by the common man. This paper shows different types of micro-hydro turbine which can be used in remote areas nearby river or water resources that should be more efficient and some studies also has analysis*.

Key Words: Micro hydro turbine, Portable Water Turbine, Pico Hydro Powerplant, In-pipe hydrogenerator

1. INTRODUCTION

According to United Nations Conference on Trade and Development (UNCTAD), 2019 report, 570 million (or about two-thirds of the world population) do not have access to electricity[1] which means today also there is a shortage of electricity and most probably there is a shortage in the rural side for this most of the innovator had focused on the rural side they came up with the solution where people who live on hilly areas or nearby water resources can use the portable micro-hydro turbine which can generate some DC for their daily small use.

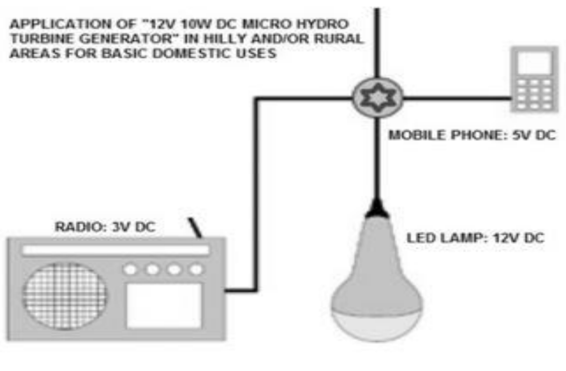

Fig -1: Basic electricity home system (Rural Area)

This micro-hydro turbine converts hydraulic energy into electric energy which is a sustainable and renewable source of energy. The flow of water has kinetic energy turns water turbine for the production of electricity. The energy produced here will be clean and does not cause global warming.

Some of the innovators had also focused on the experimental test and feasibility of micro-hydropower generators on University buildings. These also gave an idea about the dimension of height or head of water for smooth power generation.

2.1 MICRO HYDRO TURBINE

These small turbines are easily available in markets and easy to use, this turbine has a maximum of 12 volt and 10 watts as an output. When the water or any fluid with good kinetic energy turns its turbine it will generate electricity as it consists of the integrated generator.

Fig -2: Micro Hydro Turbine

Priyabrata Adhikary et al. had done CFD analysis on this 10 watt and 12-volt micro-hydro turbine while comparing the numerical and experimental analysis data shows that both analyses perform nearly accurately but in low flow rates Micro-hydro turbines are not much accurate due to rotor/bearing drag that decelerates the rotor. Almost 5% of the minimum rated flow capacity is required. The turbine is not recommended to run at high velocity because premature bearing wear or damage can occur. Need to be careful while measuring fluids that are non-lubricating because bearing wear can cause an error

Analysis with CFD, the rotor driving torque (and power) can be calculated on blades with parameters like boundary conditions. Using conservation of mass, momentum, and energy for advanced CFD is done by using Reynold-Averaged-Navier-Stokes (RANS) equations. [2]

Conservation of Mass: $\frac{\partial \rho}{\partial t} + \rho \nabla V = 0$

Conservation of Momentum: $\rho \frac{DV}{Dt} = \rho g + \nabla . \tau'_{ij} - \nabla p$

Conservation of Energy: $\rho \frac{Dh}{Dt} = \frac{Dp}{Dt} + \nabla(k \nabla T) + \phi$

2.2. PORTABLE WATER TURBINE

This Turbine prototype has been fabricated by 3D printing in this turbine there are 6 components mainly i.e. Outer Body, Nose Cone Half, Stationary Blades, Rotary Blades, Rear Cone, and Motor

Fig -3: Portable Water Turbine

As this is a prototype researchers had done tetrahedral Meshing for analysis and founds maximum stress on blades and theoretically found this prototype will generate 20 watts.

Theoretical power that can be generated by a hydro turbine can be calculated as below:

$P = \eta \times \rho \times Q \times g \times h$

Where P is power in watts, η is the dimensionless efficiency of the turbine, ρ is the density of water in kilograms per cubic meter, Q is the flow in cubic meters per second, g is the acceleration due to gravity, h is the height difference between inlet and outlet in meters[3]

2.3. A PORTABLE SPIRAL VORTEX HYDRO TURBINE FOR A PICO HYDRO POWER PLANT

Pico Hydro Power Plant (PHPP) can be specified as hydro-electric power plant with a capacity below 5 kW. This plant can be applied to areas that have many rivers with slopes having a slope angle around 10 degrees. The Pico Hydro Power Plant is a waterway type of power plant that uses a water intake upstream of the river then flows the water downstream through a channel of water with a rather small gradient.

Classification of Hydroelectric Power Plants can be based on capacity of generation,

- Large-hydro: more than 100 MW
- Medium-hydro: between 15-100 MW
- Small-hydro: between 1 - 15 MW
- Mini-hydro: Power range between 100 kW, to 1 MW
- Micro-hydro: between 5kW - 100 kW
- Pico-hydro: range of power is 100 W - 5kW

The speed of the portable spiral vortex hydro turbine can reach 90 rpm if the turbine is coupled with a generator to produce electricity, through a pulley system.

This turbine is a form of cross-flow turbine and weighed 22 kg. It is also a prototype in which analysis has been done.[4]

2.4. MICRO IN-PIPE HYDROPOWER TURBINE USES FOR UNIVERSITY BUILDING

These types of the turbine are very useful for any educational building in this turbine. A small spherical turbine has been fitted in a water drainage system connected with a generator connected to the battery for converting this DC to AC we will use invertors.

Results show that it will generate more power when there is bad weather. [5]

Fig -4: In-pipe Micro Hydro Turbine

3. COMMON TURBINES

Most commonly turbines that are used for analysis purposes are

3.1 Pelton Turbine

This turbine has spoon-shaped buckets which acquire the energy of running water and this energy rotates the turbine which ultimately generates electricity. It consists of a rotor equipped with buckets along the whole periphery of the turbine. The buckets are elliptical. The quantity of water discharged by the nozzle can be controlled by controlling the nozzle's opening using a needle placed in the tip of the nozzle. [6]

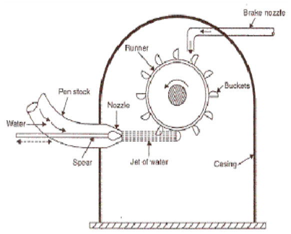

Fig -5: In-pipe Micro Hydro Turbine

3.2 Cross-Flow Turbines

It's a type of impulse turbine The working principle of this turbine was first discovered by an Australian engineer named A.G.M. Michell in 1903. Prof. Donuts Banki had developed and patented the same in West Germany and named after his name Turbine Banki sometimes also called the Michell-Ossberger Turbine.

Using this turbine for the same power can save manufacturing costs for up to 50% of the use of waterwheels with the same material. Because of compactness and smaller size of cross-flow turbine as compared to water wheel reduction of cost is possible. The diameter of the water wheel is usually 2 meters up. In a cross-flow turbine, the flow of water is happened through the turbine transversely, or across the turbine blades. As with a water wheel, the water is admitted at the turbine's edge. Flow movement is like passing to the inside of the runner, it leaves on the opposite side, going directionally outward. Passing through

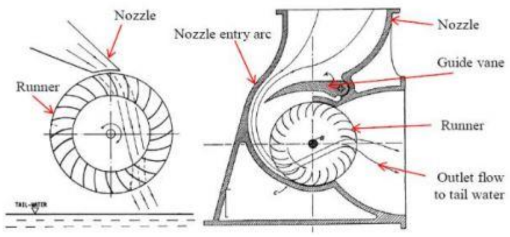

Fig -6: Cross Flow Turbine

the runner twice provides additional efficiency. When the water leaves the runner, it also helps to clean small debris and pollution. A cross-flow turbine is a low-speed machine that is well suited for locations with a low head but high flow. [4]

4. LITERATURE REVIEW

The followings are the review of related literature and studies.

Priyabrata Adhikary et al. (2016) had done C.F.D. Analysis of Micro Hydro Turbine applied Navier strokes principle for advance C.F.D for conservation of mass, momentum, and energy and founds low flow rate for the turbine is not efficient. Almost 5% of the minimum rated flow capacity is required. The turbine is not recommended to run at high velocity because premature bearing wear or damage can occur. [2]

Akshay Sathe et al. (2019) had fabricated portable turbines which have been made by 3D printers, also done tetrahedral meshing for which get to know that maximum stresses are coming on blades. This Turbine Consist of stationary and rotatory blades.[3]

Design and analysis of a portable spiral vortex hydro turbine for a Pico Hydro Power Plant has been done by M N Hidayat et al. (2020) Here author had applied a crossflow turbine with a pulley system. With help of the turbine house spiral vortex water flow can be produced that can enhance the rotary speed of the turbine, generally from 50 rpm to 90 rpm based on input. The turbine rotational speed affects the generator rotation. [4]

Experimental Test and Feasibility of a micro In-pipe Hydro Power Generator at a university building Teruhisa Kumano et al. has fabricated hydro turbine rotors, water guides, and fan blades. Which gave an idea about the feasibility of this type of generator. [5]

Design of Micro Hydro Turbine for Domestic Energy Generation Research by Tunji John Erinle et al. (2020) from this paper, the idea for how to use Pelton turbine for more power output around 35 KW created which is scalable.[6]

5. CONCLUSIONS

Most of the study is done on the types of turbines used for hilly/sloppy or riverside area through which small turbine can generate electricity with good efficiency this is a good alternate source of energy which can help rural areas where energy can be used for small useful work. Studies also show the analysis and selection criteria of the materials according to the stresses developed.

Micro In-Pipe Hydro Turbine Generator used in university building also gave an idea that how to implement this system and whether it is feasible or not and it's 40 % efficient while if weather is bad more power will be generated from the turbine.

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