In-Line Water Power Generation Using Spherical Turbine

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Abstract—This paper turbine design on the harvested energy from in-pipe systems. turbine designs are involved in this study which includes the spherical turbine and the Helical with five blades. The proposed turbines are designed and they have been implemented in a prototype to determine the performance of design. The study presents design procedures and the design requirements of each employed turbine before the implementation phase. The next step is to collect the produced torque, rotational speed, pressure drop, and output power for turbine experimentally. The results have been analysed and compared to show the design impact on these parameters. which are benefited from the implementation of the in-pipe system with the examined turbines.

Index Terms—in-pipe system, energy harvesting, turbine design

1. Introduction

In this current smart era, electricity is considered a necessity for development as almost all of machinery and circuitry runs on electrical power. Therefore, the production of electricity is a must for attaining progress. But nowadays, there is a constant struggle for access to large fossil reservoirs and the development for renewable resources is slow. There have been innovative inventions such as the wind turbines, water turbines, solar cells and many other renewable sources. These resources have slowed down the depletion of fossil fuels to a certain extent, but these inventions do have their shortcomings and most areas where energy harnessing is possible, are left unanswered. One such area where energy conversion is possible is in the water transportation system. To harness electrical energy from this system, a small turbine generator can be installed onto the pipelines to harness the kinetic energy of the flowing water in them. Hence forth by applying this research, another renewable energy resource is developed. This paper presents the development of a hydroelectric generating system that generates electricity from the potential energy of water flowing inside building's water pipelines through converting the kinetic energy of water into electrical energy that can be stored in batteries to be used as power supply for LED lighting, network routers, and for charging mobile phones. The developed system is inline hydroelectric generator designed for small sized pipe. It contains a turbine that rotates by the running water in these pipelines to generate the electricity and a charging circuit to store the generated electricity into battery cell. By increasing the flowing of water, the rotation of the turbine will be increased and the amount of generated electricity will be increased, big turbine can be connected with municipal water pipelines, which ensures greater flow of water and generating more energy that can be used for road lighting and other uses. The results show that the proposed hydroelectric generator can harness the untapped kinetic energy of water flowing inside the pipelines and produce power around 10 W when the velocity of water flow is more than 3.5 l/min which is enough to operate continuously and safely the low-power electrical devices (mobile phones, LED lights).

2. Methodology

There was structured approach for power generation using inline turbine. The process starts with testing of water, and proceeds with theoretical calculation of available power, CAD modelling of turbine assembly, CFD analysis of turbine assembly and finally the fabrication and testing of prototype in actually field. All the mentioned processes are explained below in detail.

Theoretical calculation.

Determination of power output

P = g * Q * H * So

Where

P = power developed

g = gravitational acceleration

Q = design flow rate

H = head

So = overall efficiency

In our case;

Turbine efficiency=0.85

P=9.8x00.0023x2x0.85=8.986w

Assumptions: (One Apartment)

Loss of pressure head (h) = 2 m_{water}

Pipe diameter (D) = 19.05 *mm* (3/4 *in*)

Velocity = 8.0 *m/s*

Calculations: (One Apartment)

(Q) = Velocity × Area

= 8.0× ($\pi D^2/4$) = 0.0023 m^3/s

Pressure loss (Δp) = $\rho \times g \times h$

= 1000 × 9.81 × 2 = 19,620 *Pa*

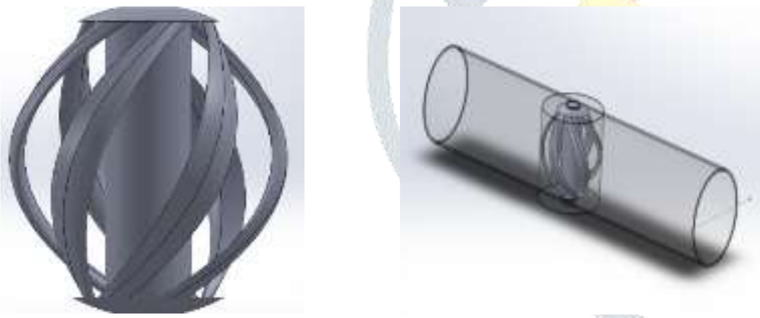
Power (P) = 0.8 × 19,620 × 0.0023 = 36 *W*

Total power of the building

= 40 × 36 = 1,440 *W*

= 1.44 *Kw*

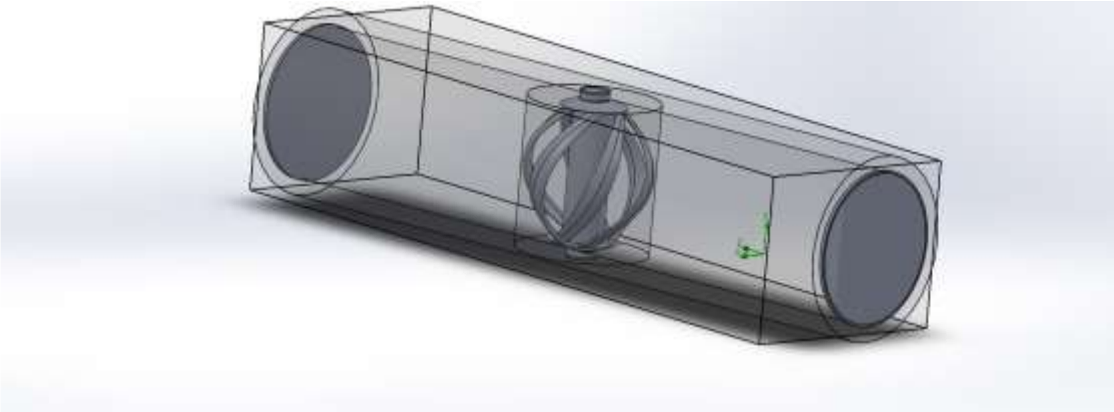
CAD Model of the turbine assembly

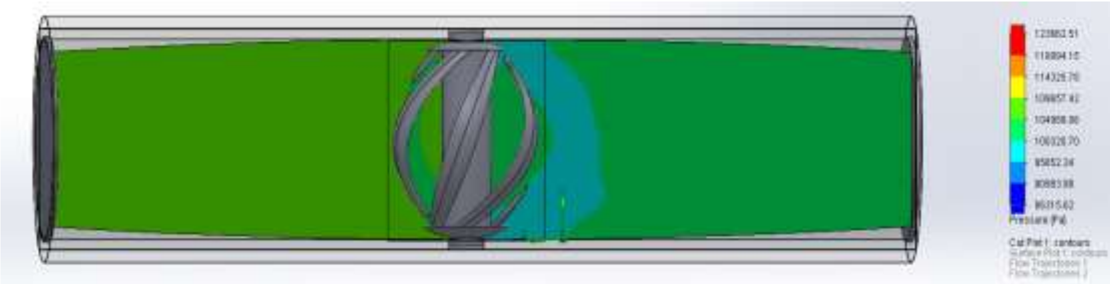


(a) CAD Model of Runner; (b) Assembled view of Runner and Pipe

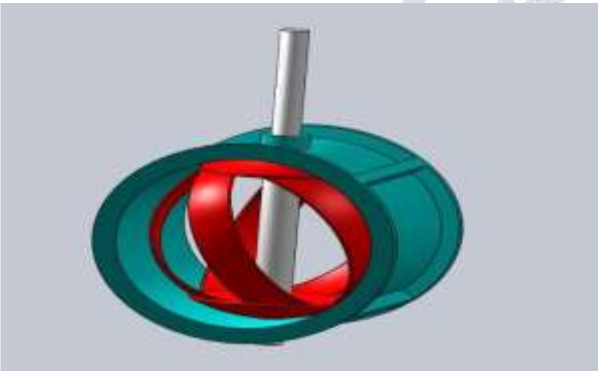
CFD analysis of the turbine assembly

The analysis is done using SolidWorks Flow Simulation The CFD analysis was done with the following settings where in internal flow is chosen as the turbine is fixed in-line with the pipe and the working fluid is chosen as water. The computation domain is cautiously defined by selecting the inner walls of the turbine and pipe. Then the boundary conditions were given for inlet and outlet sections. At the inlet, the flow is assumed to be fully developed flow as the length of the pipe between the tank and turbine is long enough and the mass flow rate of water is given as input. And as outlet condition, environmental pressure is given at the end of the pipeline system. The analysis was done for the different conditions of mass flow rates. In the post processing activity, the pressure and velocity profile across the turbine assembly is analysed and same is used for calculating the power developed by the turbine.





turbine assembly and installation



Prototype design

The external view of the DN250 pipeline for turbine/generator installation is presented in Fig. the device consists of an external hydroelectric generator and highly efficient water turbine which dips into flowing water and reclaims residual pressure. When water passes through, the turbine drives a central rotating shaft and a micro generator to produce electricity. the physical model of proposed hydro turbine, which includes the following major components: 5 blades, bearing, coupling T-joint generator.

Results

S.NO	TRIAL	DIAMETER OF PIPE(INCHES)	SPEED (RPM)
1	1	2	180
2	2	2	200
3	3	3	230
4	4	3	250

S.NO	TRIAL	DIAMETER OF PIPE(INCHES)	VOLTAGE (VOLTS)
1	1	2	1.56
2	2	2	3.76
3	3	2	2.54
4	4	2	4.56

Applications

The reduced footprint of In-Line turbines allows for them to be installed where other turbines would not fit. In-Line turbines share flange-to-flange lengths with many common pressure reducing valves simplifying installation in existing structures and minimizing cost where new construction is required.

SCOPE

1**) Agricultural field**: This proposal can be implemented in agricultural areas. Since there is no cost for power consumption during off peak hours a turbine can be fixed before the outlet of the water pipe. During the time of water flow power can be generated which can be used for the domestic purpose.

2) **Buildings in urban cities**: In most of the urban cities many buildings has more than 20 floors. The pressure in the water pipe is very high which flow from top to bottom. Usually the requirement of water is very high in morning. At that time more power can be generated and it can be used for the later use. This stored power can be utilized for the street lights, garden lights, in and around the building.

3**) Lake areas**: Almost all the lake water is utilized for domestic needs. The water flow in this pipeline may or may not be constant. Thereby fixing the turbines at the top of the pipe more power can be generated and stored for the future use.

CONCLUSION

The purpose of the project was to capture unused energy in the drinking water systems of cities and towns and to turn that energy into useful electricity. Hydroelectric power is not a new technology. However, our plan was to use the same principle but on a smaller scale. The water turbine project is using smaller turbines that will connect to water mains headed into the cities and towns rather than the larger ones in dams. Our prototype takes the energy of the flowing water coming out of the submersible pump and from its travel through our turbine is converts that kinetic energy into electrical energy. This water turbine project is a perfect example. We are capturing surplus energy that would otherwise be wasted and turning it into usable electrical energy.

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