

DESIGN AND DEVELOPMENT OF PICO MICRO HYDRO SYSTEM BY USING HOUSE HOLD WATER SUPPLY

Gunjan Yadav¹, A.K Chauhan²

¹M.Tech, Department of Mechanical Engineering, KNIT, Sultanpur, UP, India

²Assistant Professor, Department of Mechanical Engineering, KNIT, Sultanpur, UP, India

Abstract

The energy demand in the World is increasing day by day due to rapidly increasing population and advancement in science and technology. But in present era there are too many obstacles which decrease the consumption of electricity for common peoples, high cost of fuel, high demand and low supply of fuel. Fuels like coal, petroleum, CNG, LPG, nuclear energy are depleting day by day and also degrades our eco-system. Installation cost of large hydro power project are very high and cannot be installed anywhere. Due to these reasons; there is a high time to follow such a system which sort out all these problems. One such a system is proposed in this paper. The aim of this research paper is to build such a system which gives electricity at low cost, which must be eco-friendly, easy to use and to store the generated power by means of battery charging for future use particularly during electricity blackouts. The work of this paper is performed by designing a Pico Micro Hydro system by using house hold water supply. In the domestic pipeline the flow of water has enough kinetic energy to rotate the blade of a small hydro turbine which in turn rotates the rotor of a generator to generate electricity in addition to the other routine activities such as laundry, cook and bathe.

Keywords: Pico hydro system, energy storage, renewable energy and small turbine.

1. INTRODUCTION

The hydro power which has a maximum electrical output of five kilowatts (5kw) is come under the category of Pico Micro Hydro [1]. This system is beneficial than other large hydro system as it have low cost, can be installed anywhere, eco-friendly and easily available to people. New Pico micro hydro technology have made it more economical power source in the developing country. AC can be produced which can be used to drive standard electrical appliances. Examples of devices which can be run by this system are light bulbs, radios, television, refrigerator and many more.

Generally, Pico micro hydro system is installed at rural and hilly areas [3]-[5]. Figure 1 shows an example of Pico micro hydro system used in hilly area [2].

In this system water (from lake and Small River) firstly stored in a reservoir (forebay tank). This stored water is flows downhill through a pipe (penstock). The running water in the penstock has a enough kinetic energy to rotates the blade of a turbine which in turn rotates the rotor of a generator which produce electricity. However in this research paper it is shown that house hold water supply also have enough kinetic energy to rotate a small hydro turbine for energy production.

Hence this research is done to show that house hold water supply has additional capability for electrical energy production instead of other routine activities like bath, laundry, cook and cloth washing. Production of the electricity can be done without pay extra charges on the water bill.

The main function of this system is to store the generated power by means of battery charging for future use particularly during electricity blackouts.

The proposed system produces 8.408W power which is very less as compare to other Pico micro hydro system but it is cost effective, easy to use, eco-friendly and easy to installed anywhere.

2. DEVELOPMENT OF THE PROPOSED PICO MICRO HYDRO SYSTEM

The proposed Pico Micro Hydro System (PMHS) was fabricated at K.N.I.T Sultanpur. It consists of a pelton turbine and an alternator. The experiments were performed

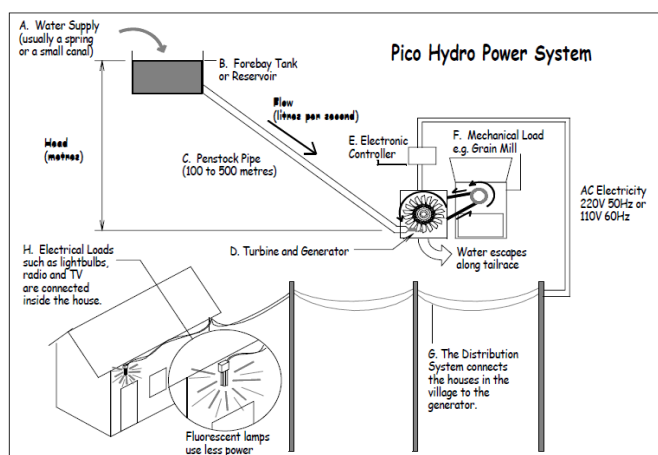


Fig 1: Pico Micro Hydro system

on the above mentioned test rig in Raman Hostel by utilizing the normal water supply.

Pelton turbine test-rig coupled to an AC generator through shaft which has an electrical output 5.65 V as shown in figure 2. The generated power is 8.408 W corresponding to a turbine generator efficiency of 50 % [1].



Fig 2: Proposed PMHS

2.1 Water Supply System

1000 L of water storage tank at a height of 6.4 m from the ground and the net head available to the turbine is 6 m. Tap (as a nozzle) of varying diameter from 0.5 cm to 1.2 cm is used in the proposed system. The (pipe) penstock consists of 9 m in length and of 1.5 cm diameter and the flow rate into the turbine is 0.285 L/s. In this system friction losses in the pipe and pipe fitting is consider negligible. This means that the net hydro power available at the consumer's end is more or less similar to hydro power to turbine. The net hydro power available to the turbine at inlet is 16.817 W.

2.2 Design of Pelton Turbine Test-Rig

The turbine blades are made up spoons of stainless steel which are 7 cm length of tail and 7 cm length of curve and are fabricated (welded) on the 21 cm OD cycle rim. Total 12 number of stainless steel spoons are used to construct the turbine figure 3 shows the proposed pelton turbine test rig.



Fig 3: Proposed Pelton Turbine test-rig

C. Pulley System

The torque and power from the main shaft is being transmitted to the shaft of the alternator through belt pulley system figure 4 shows the pulley system.



Fig 4: Pulley system

The circumference of the large pulley is ten times that of the small pulley; the small pulley will rotate ten times for every one time rotation of the large pulley.

2.4 Alternator

Two pole alternators is used in this system. Winding on the stator is done by using 38 gauge wires and has 800 turns. The winding is done on a soft iron rod. The shaft of the magnet is connected to the small pulley. Rotation of the small pulley rotates the magnet of the alternator.

When magnet rotates between the winding produces AC in the winding by induction. AC produced is transmitted to the full wave rectifier to convert AC into DC, which is used for charging battery figure 5 shows the alternator.



Fig 5: Alternator

2.5 Full Wave Bridge Rectifier

Since AC is produced in the proposed PMHS and we need DC to charge battery. So we need rectifier to convert AC into DC.

Full wave bridge rectifier is used in this proposed system. 4 Pine diode and 1000 mfd capacitor are used to make full wave bridge rectifier.

2.6 Battery

In the proposed PMHS 6 V rechargeable lead-acid battery is used. This is charged by the alternator of the proposed PMHS. Through this battery a 5 W CFL is lighted up.



Fig 6: 6V Rechargeable Battery

2.7 Inverting Kit

Inverting kit which is used in the proposed system converts DC to AC and also amplifies the voltage from 6 V to 175 V.

3. MATHEMATICAL ANALYSIS

3.1 Head Measurement

When determining head (falling water), gross or “static” head and net or “dynamic” head must be considered. Gross head is the vertical distance between the top of the penstock and the point where the water hits the blades of the turbine. Net head is gross head minus the pressure or head losses due to friction and turbulence in the penstock. These head losses depend on the type, diameter, and length of the penstock piping and the number of bends or elbows. Gross head can be used to estimate power availability and determine general feasibility, but net head is used to calculate the actual power available.

There are many methods of head measurement. However the proposed PMHS uses domestic water supply and in this system Raman Hostel water supply is used which has 1000L of water storage tank at a height of 21 feet from the ground and the net head available to the turbine is 20 feet. Measurement of head is simply done by measuring height from the top of the floor where 1000L tank is installed and the point where the water hits the pelton turbine test-rig.

3.2 Water Flow Rate Measurement

The simplest flow of measurement for small streams is the bucket method [4]. Therefore, this method is used because the capacity of the proposed hydro power system is significantly small. Moreover, this method is considerably more practical in the proposed PMHS which is very uncommon compared to other system in its category. Throughout this method, the flow rate of the distributed water is diverted into a bucket or barrel and the time it takes for the container to fill is recorded. The volume of the container is known and the flow rate is simply obtained by

dividing this volume by the filling time. For example, the flow rate of water that filled 20 litres bucket within one minute is 20 litres per minute or 0.333 L/s. This is repeated several times to give more consistent and accurate measurement.

$$\text{Flow Rate } (Q) = \frac{\text{Volume of the bucket } (V)}{\text{Filling Time } (T)}$$

In this system 2 L of bucket is used and tap water takes 7 sec. to fill this volume.

So,

Volume in 7 seconds = 2 L

So, the flow rate (Q) = 2 / 7 = **0.285 L/s**

In minute Q = 0.285 x 60 = 17.14 L/m

3.3 Power Estimation

In general, the feasibility of the proposed PMHS is based on the following potential input/output power equation [2]:

$$P_{in} = H \times Q \times g \quad (1)$$

$$P_{out} = H \times Q \times g \times \eta \quad (2)$$

Where,

P_{in} = Input power (Hydro power)

P_{out} = Output power (Generator output)

H = Head (meter)

Q = Water flow rate (liter/second)

g = gravity (9.81 m/s²)

η = efficiency

In the proposed system

Head = 20 feet or 6 meters

Q = 0.285 L/s

g = 9.81 m/s²

Using eq. 1

$$P_{in} = 6 \times 0.285 \times 9.81$$

$$= \mathbf{16.817 \text{ W}}$$

Using eq. 2

$$P_{out} = 16.817 \times 50/100 \text{ (here } \eta \text{ is taken as 50 \% [1])}$$

$$= \mathbf{8.408 \text{ W}}$$

Hence from the proposed system we get 8.408 W corresponding to turbine power efficiency (50%).

3.4 Measurement of Speed, Current and Voltage

In this proposed system RPM is measured by digital tacho meter by attaching a pin into the big pulley and readings are noted at different diameters of the tap (nozzle). Since the ratio between pulleys is 10:1, so the small pulley of the system rotates 10 times more than big pulley. Current and Voltage are measured by Digital Multi meter.

For measuring their values 2 cases has been taken.

Case 1 Reading at 20 Feet Head

At 20 feet current, voltage and rpm is measured at different values of diameter of tap (nozzle) as shown in table 1.

Table 1 Values of RPM, Voltage and Current at 20 feet for different dia. of tap at 20 feet

Diameter (tap) (mm)	RPM (small pulley)	Voltage (V)	Current (mA)
5	150 × 10	5.646	6.87
6	140 × 10	5.04	6.14
8	133 × 10	3.98	4.85
12	122 × 10	2.89	3.52

Graph between different parameters (current, voltage, diameter and RPM × 10) at 20 feet as shown below in figure 7

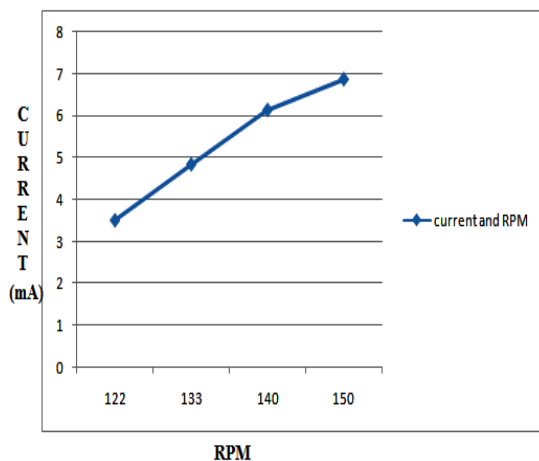


Fig 7(a): Graph b/w Current and RPM

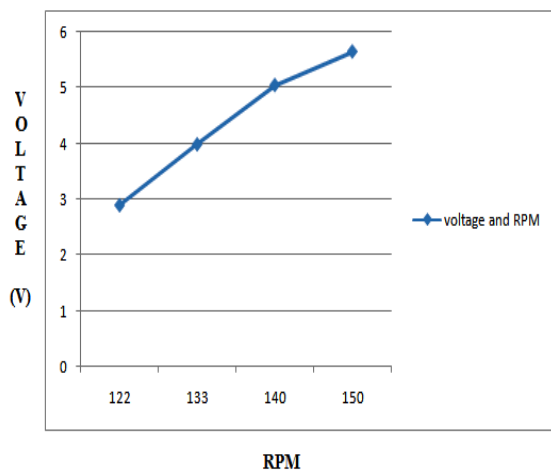


Fig 7(b): Graph b/w Voltage and RPM

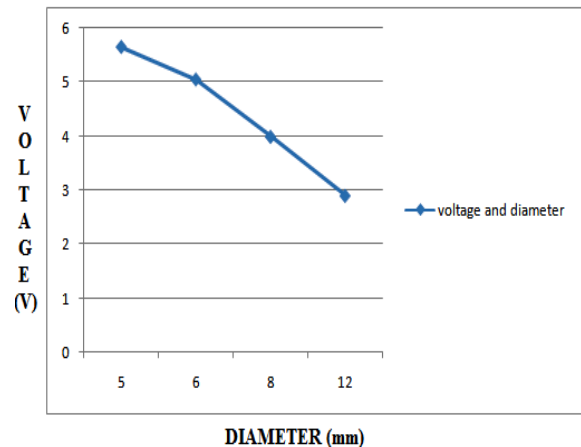


Fig 7(c): Graph b/w Voltage and Diameter (tap)

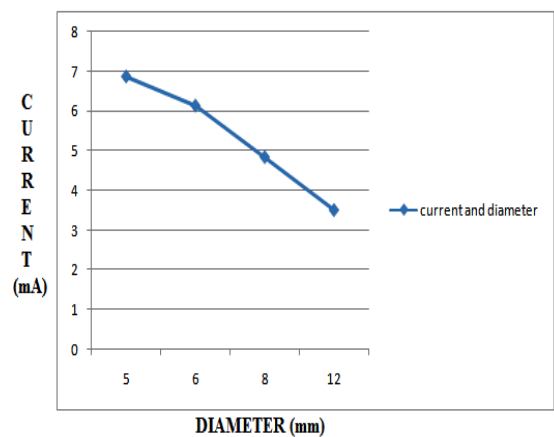


Fig 7(d): Graph b/w Current and Diameter (tap)

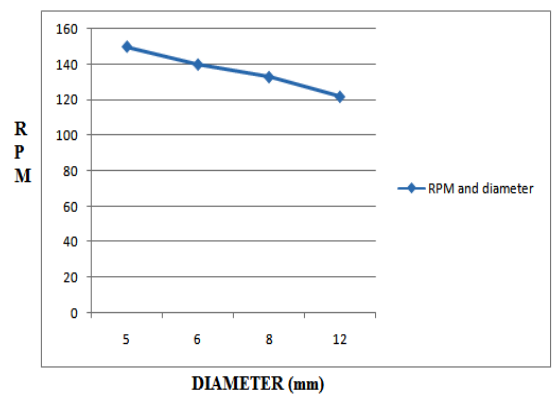


Fig 7(e): Graph b/w RPM and Diameter (tap)

Fig 7 Graph between different parameters (current, voltage, and diameter and RPM × 10) at 20feet

From figure 7 and table 1 we get following results

- From graph 7(a) and 7(d) we depicted that Current increases when RPM increases and decreases when diameter of the tap increases.
- From graph 7(b) and 7(c) we depicted that Voltage increases when RPM increases and decreases when diameter of the tap increases.
- From graph 7(e) RPM increases when diameter of tap decreases.

Case 2 Reading at 10 Feet Head

At 10 feet current, voltage and rpm is also measured for same values of diameter of tap (nozzle) as we taken in 20 feet. These values are shown in table 2.

Table 2 Values of RPM, Voltage and Current at 20 feet for different dia. of tap at 10 feet

Diameter (mm)	RPM (small pulley)	Voltage (V)	Current (mA)
5	100 x 10	2.66	2.76
6	92 x 10	2.41	2.50
8	80 x 10	2.08	2.16
12	66 x 10	1.68	1.744

Graph between different parameters at 10 feet as shown in figure 8

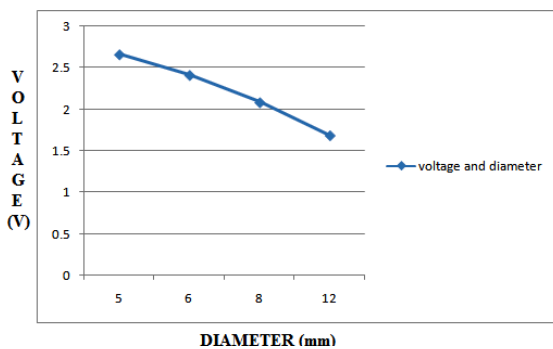


Fig 8(a): Graph b/t Voltage and Diameter (tap)

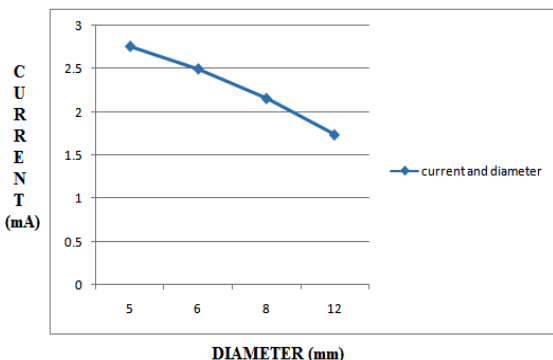


Fig 8(b): Graph b/t Current and Diameter (tap)

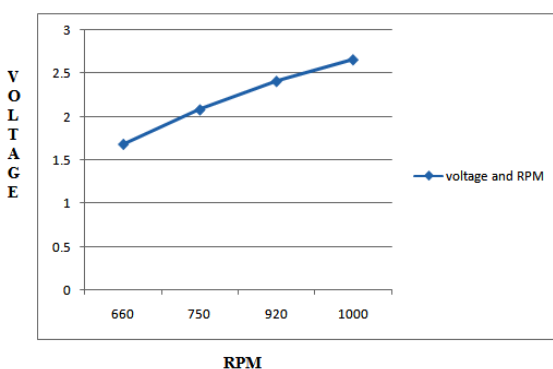


Fig 8(c): Graph b/t Voltage and RPM

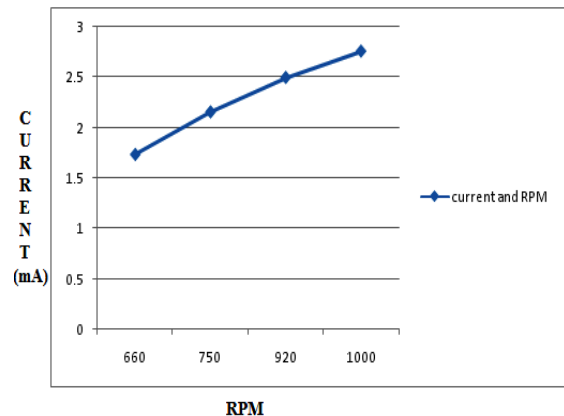


Fig 8(d): Graph b/t Current and RPM

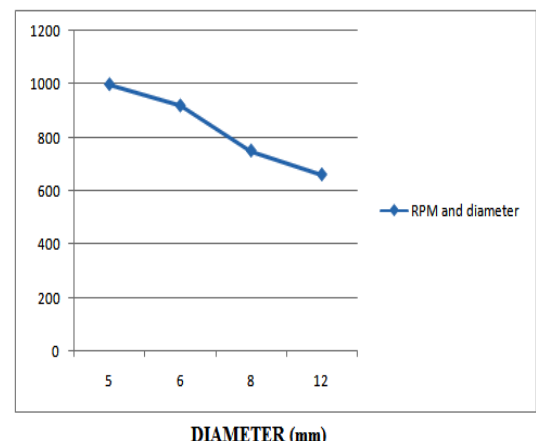


Fig 8(e): Graph b/t RPM and Diameter (tap)

Fig 8 Graph between different parameters (current, voltage, and diameter and RPM × 10) at 10 feet

From table 2 and figure 8 we concluded the following result

- From graph 8(b) and 8(d) we see that current increases when RPM increases and decreases when diameter of the tap increases but values of current in 10 feet are less than 20 feet for the same value of the diameter of the tap.
- From graph 8(a) and 8(c) we see that voltage increases when RPM increases and decreases when diameter of the tap increases but values of voltage is also in 10 feet is less than 20 feet for the same value of the diameter of the tap.
- From graph 8(e) we see that RPM increases when diameter of tap decreases but values of RPM are also in 10 feet are less than 20 feet for the same value of the diameter of the tap.

Hence from both the cases it is concluded that head and flow rate are the major parameter while designing a Pico micro hydro system.

In this proposed system 20 feet head and 5 mm diameter of tap correspond to the maximum value of Power, Current, Voltage and RPM which is **8.408W**, **6.87mA**, **5.646V** and **1500** respectively.

4. CONCLUSIONS

This project is a simple, save and cost effective project which provides basic needs to the developing countries. By using this system one can charge batteries through which many electric applications can be run. This system can not only be a solution for India, where this study was performed, but could be an option for many regions worldwide.

In this research paper we see that the current, voltage and RPM are inversely proportion to the dia. of tap and directly proportional to the head. Hence it is concluded that there are two main input parameters which are very important in ensuring the developed Pico micro hydro system to function as an alternative electrical power generator for residential use. The parameters are the pressure of the main pipeline water supply that representing the head (falling water) and the water supply flow rate. These parameters vary between residential areas. Hence, it is essential to determined both parameters at early stage for potential output power estimation.

The power developed in the proposed system is **8.408 W**. The maximum value current, voltage and RPM are **6.87 mA**, **5.646 V** and **1500**. This system efficiently capable of charging a **6 V** battery which is used for various purposes, in this system it is used to light up a **5 W CFL**.

In addition, since the turbine and generator are manufacture locally, so the selection of turbine and generator in terms of their type and size or capacity is also important in designing and developing the proposed Pico micro hydro system. Wrong type and improper sizing of these components would cause the system to operate at undesirable performance.

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