STUDY OF MICRO HYDRO POWER PLANT FOR RURAL ELECTRIFICATION

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Abstract: Energy generation through water is one of the most economic sources of power. Among the hydro-power plants, micro-hydro power plants are more preferred since they require lower heads and smaller flow rates to generate electricity. The main advantage of micro-hydropower plants is the combination of feasibility, ease of installation, efficiency and economy into a single source of power. In the category of micro-hydro power plants, gravitational water vortex power plants are emerging currently due to their ease of installation, reduced setup time and minimal expertise required for installation.

The Parabhani, Nanded, Jalna region in Maharashtra has water resources with low head and medium to high discharge conditions. Hence, the people of these region are not being able to utilize the water resources available near them due to the limitation of technology.
This study is intended to serve the purpose of further research of ultra-low head gravitational water vortex turbines useful for power generation in the these region.

Key Words: Gravitational vortex turbine, Micro hydropower plant, Electricity generation.

Introduction

Nowadays, the awareness about the importance of a sustainable environment is increasing, it has been recognized that traditional dependence on fossil fuel extracts a heavy cost from the environment. The role of renewable energy has been recognized as great significance for the global environmental concerns. Hydro-power is a good example of renewable energy and its potential application to future power generation cannot be underestimated.

The concept of micro hydropower system is promising technology in renewable energy. Micro hydro power systems are capable of generating electricity up to a capacity of 100 kW. The energy in rural, remote and hilly areas is inadequate, poor and unreliable supply of energy services, micro hydropower able to provide rural area where grid extension is too costly and consumers have low incomes.

Mini-hydro power generation could be planned on small-scale on existing small rivers ,canals etc. As it could be beneficial in utilization of all existing water reservoir and stream so as to generate hydro power which is renewable in nature.

The vortex turbine uses both kinetic (run-of-canal/river) and static potential energy (head) principles and promises to provide a power generation system resulting in minimum interference with the river and aquatic life. The gravitational water vortex turbine is an ultra-low head turbine which can operate in a low head range of 0.6 to 2 m. A maximum hydraulic output of 1 kW can be obtained with a flow rate of only 0.1 m^3/sec and a head of only 0.6 m. Mini hydropower plants have good potential for providing electricity to remote communities. GWVPP was first installed in Obergrafendorf, Austria. The turbine was patented by its inventor in 2004. The plant had a discharge of 1 m^3/s and a total head of 1.3m. The recorded efficiency of the plant was upto 80%. This plant was capable of generating power up to 10 kW.

Gravitational Water Vortex Power Plant is a type of green technology that falls in the category of micro hydro power plant. It is currently being categorized as micro hydropower because the maximum reported power generation had not exceeded 100kW. The main advantage of this power plant is the ultra-low hydraulic head requirement as well as environmental friendly. In this plant, the water passes through a large, straight inlet, which then passes tangentially into a round basin. The water will then form a powerful vortex, which exits the outlet at the centre bottom of the shallow basin. Due to its ultra-low hydraulic head requirement, the plant does not work on the pressure difference but on the dynamic force generated by vortex. Hence, the development and power generation costs are very low in the GWVPP compared to other hydro power technologies.

The gravitation water vortex power plant is a type of micro hydro vortex turbine system which is capable of converting energy in a moving fluid to rotational energy using a low hydraulic head of 0.7-3 metres (2 ft 4 in -9 ft 10 in).The technology is based on a round basin with a central drain, Above the drain the water forms a stable line vortex which drives a water turbine. The gravitational water vortex turbine is an ultra-low head turbine which can operate in a low head range of 0.7 to 2m which is often seen as too low for conventional hydroelectric turbines. In addition, there is positive environmental effect on the river as water passing through the turbine is aerated. The gravitational vortex is seen as a milestone in hydrodynamic development because was necessary in the past it to use energy to aerate water, but this technique uses a water, but this technique uses a water aeration process to produce electrical energy. The turbine does not work on pressure differential but on the dynamic force of the vortex. Systems range in size from <500 W to 100KW, and a series of units can be installed in a serial or parallel configuration along the river to increase power production .The limiting factors to the size of the unit are not clear but may be the formation of a vortex and the inlet and outlet size restrictions. The vortex may not form on larger basins and with larger outlets. The use of multiple controllable smaller units is probably a better option than a single large unit. The lower size limit is seen to be a minimum head of 0.7 m and flow rate of 1kl/s although several units work with lower flow rates.

Although vortex characteristics are well understood, the mechanism behind the formation of a gravitational vortex is not. The fully developed air core vortex is often attributed to the carioles effect but this is seen to be too weak at the scale of water vortices to have any affect .In the case of the GWVPP, the initial rotation is caused by the shape of the basin and is amplified by gravitational force.

POWER	CLASS
>10mw	Large
<10mw	Small
<1mw	Mini
<100kw	Micro
<5kw	Pico

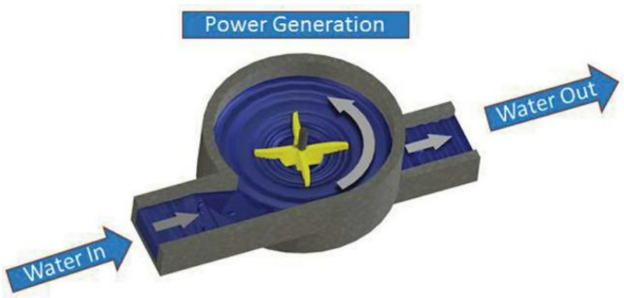


Figure 1 : Stream water flow in basin

Problem Statement:

Many villages in remote and hilly areas of Maharashtra have no power supply. But they have water resources with low head and medium to high discharge conditions. And the people of these region are not being able to utilize the water resources available near them due to the limitation of technology

Objective:

1. To provide electricity in remote areas using micro hydro power plant.
2. Analyze the power generation capacity of the Stream/ Canal flow.
3. To find alternative energy source which is environment friendly as well as cost effective, to reduce the load on fossil fuels.

Scope Of Project:

1. Energy consumption around the world is increasing; the global primary energy supply has more than doubled in last three decades. Furthermore there is a strong dependence on fossils fuel base energy. In 2012, 81.07 % of the total primary energy supply came from fossil fuels and only 13.5 % was from renewable sources. This rises security of supply issues or fossil fuel, the primary source in the current and predicted future fuel mixes are in limited supply. Increasing demand coupled with a limited supply has cause fossil fuel prices to soar in recent years so, due to increased demand and consumption of fossil fuel global CO_2 emission is increasing.
2. Renewable sources such as hydro offers on alternative source of energy to meet the growing demand the environment impact of hydropower generation is low, with zero greenhouse gas emission during the operation.

Research Methodology:

According to Literature review, Gravitational vortex Turbine works at minimum of 0.6 m. Identifying problem areas which is facing electricity crisis. Selection of appropriate site. Construction of diversion basin. Installation of turbine. Flow is further diverted into diversion basin. The induced circulation at the tangential entry influences strong vortex flow.

Potential energy is entirely converted to rotational kinetic energy at the vortex core.

This is then extracted by means of a vertical axis turbine. The water flows back into the stream.

Limitations of Study:

1. Instability in electricity generation, due to seasonal variation of flow.
2. A drought could potentially affect power generation.

Expected Outcome:

1. A maximum hydraulic output of 1 KW can be obtained with a flow rate of only 0.1 m^3 and a head of only 0.6 m.
2. Major benefit is that power is produced from water and the electricity produced is almost 97 % carbon free energy. Thus, a cleaner more sustainable and renewable energy production takes place.
3. Renewable sources such as hydropower offers an alternative source of energy to meet the growing demand, the environment impact of hydropower generation is low, with zero greenhouse gas emission during the operation.

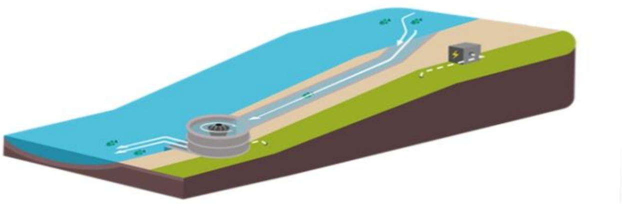


Figure 2: Diverted flow of flowing stream

Figure 3: Actual working prototype

CASE STUDY

Description about Site:

In the present work, Kinhola kh. , Tal. Parbhani, Dist. Parbhani and Bhardi, Tal. Ambad, Dist. Jalna is taken for the purpose of study. The available average velocity of canal is 0.75m/sec.

Jayakwadi dam is build across Godavari River which located in Paithan, Aurangabad district. Two canals are constructed from Jayakwadi lake A) Jayakwadi left canal B) Jayakwadi right canal.

Figure 4: Kinhole Kh. Villege, Parbhani, Parbhani

Figure 5: Bhardi villege, Ambad, Jalna

Properties of Flow :

1. Base Width : 1.5m
2. Top Width : 3m
3. Depth Of Flow : 0.8m
4. Height of section : 1.3m

Design calculations:

P = ρηgQH

Where,

P = Power (W)

g = Acceleration due to gravity (m/s^2)

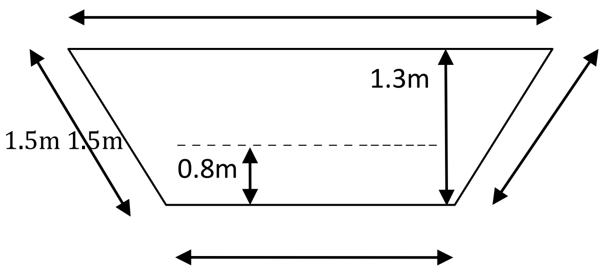
H = Head (m)

Q = Discharge (m^3/s)

ρ = Density of water (kg/m^3)

η = Overall efficiency of turbine, generator & gear box. (80 to 90%)

3m



1.5m

Canal Section

Sample Calculations:

Assume,

Head available = 1.0m

Depth of flow = 0.8m

1. **B** = 1.5 + 2 x (1/2) x 0.8 = **2.3m**

2. **Area of flow** = ½ × (B+b) ×y

½ × (2.3+1.5) ×0.8

Area of flow = 1.52 m²

3. $l = \sqrt{y^2 + (yz)^2}$

$\sqrt{(0.8)^2 + (0.8 \times 0.5)^2}$

***l* = 0.89m**

4. **P** = b+ 2 *l*

P = 3.28m

5. **R** = A/P

R = 0.46

6. **V** = (1/n) x $R^{2/3}$ x $S^{1/2}$

V = 0.79 m/sec.

Discharge (Q) = A × V

= 1.52 × 0.79

Q = 1.2 m³/s

Assume, efficiency = 80%

Power generation (P) = ρ η gQH

= 1000 × 0.8 × 9.81 × 1.2 × 1.0

= 9424 W

= **9.424 KW**

Energy generation for different depth of flow in the canal section are,

Sr. No.	Depth of flow (y) m	Area (A) m²	Velocity (V) m/s	Discharge (Q) m³/s	Power (P) Watt
1.	0.2	0.32	0.08	0.0256	200
2.	0.4	0.68	0.57	0.3876	3042
3.	0.6	1.08	0.69	0.7452	5848
4.	0.8	1.52	0.79	1.2008	9424

Energy Requirement:

(A) Domestic load:

On preliminary survey with the local people and authorities, for 111 houses; the

domestic load considered as, 2 numbers of 11 W CFL, 1 number of 50-120 W fan and a mobile charger load of 10 W.

CFLs: 2 x 11 x 111 = 2442 W or 2.44 kW

Fan Load: 1 x 50 x 111 = 5550 W or 5.55 kW

Mobile Charger Load: 1 x 10 x 111 = 1110 W or 1.11 kW

Total = 2.44 + 5.55 + 1.11 = 9.1 Kw.

(B)Public lighting load:

Number of lights = 20

Type of load = 18 W CFL

Lighting hours = 4

Total load = 18 W x 20 = 0.36 kW

(C)Total Consumption:

Assuming the losses in the power house and line to be 10% and taking 20% future growth as 20 %, the consumption is worked out below,

Domestic load = 9.1 KW

Public lighting = 0.36 KW

Future load growth = 0.2 x (9.1 + 0.36) = 1.89 kW

Power house consumption and line losses =

0.1 x (9.1 + 0.36 +1.89) = 1.13 kW

Total load = 9.1 +0.36 +1.89 +1.13 kW = **12.48 kW**

Say, 15kW

It is inferred from the data available that a discharge of 1.2 m^3/s can produce 9.424 KW which is about half the load requirement. Hence 2 units of 9.4 kW are proposed. The electricity generated will be further stored in Power House.

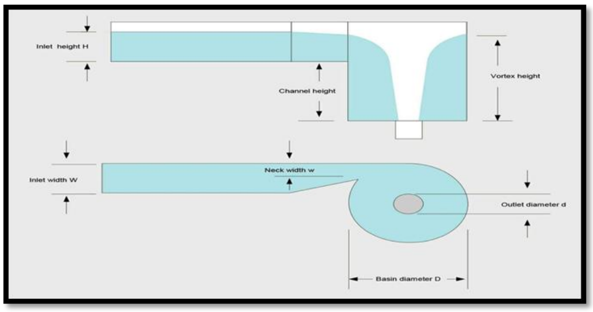


Figure 6 : Diverted Section And Turbine Basin

Conclusion:

In the project work, vortex pool system, which is capable of generating energy from low head of 0.7 m to 3m. The GWVPP is an efficient power plant that can be used to generate power easily using a low head. The micro hydro power plant is technically and economically viable and it not only meets the energy demand of tribal families in the locality but also improves their living standards as the operation and maintenance of the plant is very low.

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