Micro Hydro Electricity Generation in S.T.P, A Case Study of S.T.P, Salawas-Jodhpur

Karan Bhandari[1], Ojas Pravin Rahate[2]

[1] *Department of Environment Engineering, K.I.T's College of engineering, Kolhapur, Maharashtra, India*
[2]*Department of Mechanical Engineering, K.I.T's College of engineering, Kolhapur, Maharashtra, India*

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Abstract–*With every human activity in progress, it's leading to a considerable threat on our environment. The environment is vigorously affected by activities like nonrenewable methods for electricity generation, vehicular emissions. One of the largest consumers of electricity is Sewage Treatment Plants (S.T.P).*
The aim of this paper is to highlight how Micro hydro power plant (MHPP) can be used to partly meet the high demands of electricity. MHPP in S.T.P is no new concept and has been practiced in many parts of the world. The paper outlines some of the advantages and disadvantages of installing a micro hydro power plant in S.T.P along with the components required in a MHPP. The paper showcases a theoretical case study in which MHPP has been installed in one of the S.T.P's in the Blue city, Jodhpur. Based on the flow and head available, a specific turbine is selected and the respective design is discussed. Results showcased that this methodology can produce 73,355 units annually, while the return on investment period being 1.5 years. A high benefit cost ratio of 9.53 is observed. It can be concluded that MHPP is an efficient and renewable source for energy generation and the implementation of this technology is expected to increase in the coming future.

Keywords: Micro Hydro Power Plant, Sewage Treatment Plant, Kaplan turbine.

1. Introduction

Micro hydropower system has emerged to be a popular renewable energy sources in the developing countries. Hydro-electricity is fundamentally the combination of water flow and vertical drop (commonly called "head"). Micro hydro is a type of hydroelectric power that typically produces from 5 kW to 100 kW of electricity using the natural flow of water. Micro hydro power is both an efficient and reliable form of energy, most of the time. With the right research and skills, micro hydro can be an excellent method of harnessing renewable energy from small streams and sewage treatment plant these days. The following table lists where MHPP are applied and the units produced annually.

Waste Water Treatment Plant	Turbine Output	Electricity production(Mwh/y)
Brussels (Belgium)	640	2100
Madrid (Spain)	180	1500
Bucharest (Romania)	426	3150

Table: 1 Various countries which have adopted MHPP in S.T.P

1.1 Micro Hydro Pros – Advantages

- Reliable electricity source.

  Hydro produces a continuous supply of electrical energy in comparison to other small-scale renewable technologies. The peak energy season is during the winter months when large quantities of electricity are required.

- Cost effective energy solution

  Building a small-scale hydro-power system can cost from $1,000 – $20,000, depending on site electricity requirements and location. Maintenance fees are relatively small in comparison to other technologies.

- Integrate with the local power grid

  If your site produces a large amount of excess energy, some power companies will buy back your electricity overflow. You also have the ability to supplement your level of micro power with intake from the power grid.

1.2 Micro Hydro Cons – Disadvantages

- Energy expansion not possible

The size and flow of small streams may restrict future site expansion as the power demand increases.

- Suitable site characteristics required

In order to take full advantage of the electrical potential of small streams, a suitable site is needed. Factors to consider are: distance from the power source to the location where energy is required, stream size (including flow rate, output and drop), and a balance of system components — inverter, batteries, controller, transmission line and pipelines.

2. Micro Hydro-Power v/s Hydro Power

Table: 2 Comparison between Micro Hydro power and Hydro power

Hydro Power	Micro – Hydro Power
• Large dam is required to generate hydro power. • Constant flow rate/ speed is required. • The concept is not much environmenta l friendly.	• Small run off river or any water flow with appreciable flow rate is required to generate power. • Variable speed/flow is permissible. • Low Carbon foot print. Hence nature is conserved.

3. Components of Micro Hydro Power Plant

Based on the parameters available the turbine selected is a Double regulated Kaplan turbine. The double regulated Kaplan turbine has a wider work field and it can work between 15-100% of the maximum design discharge

A. Turbine

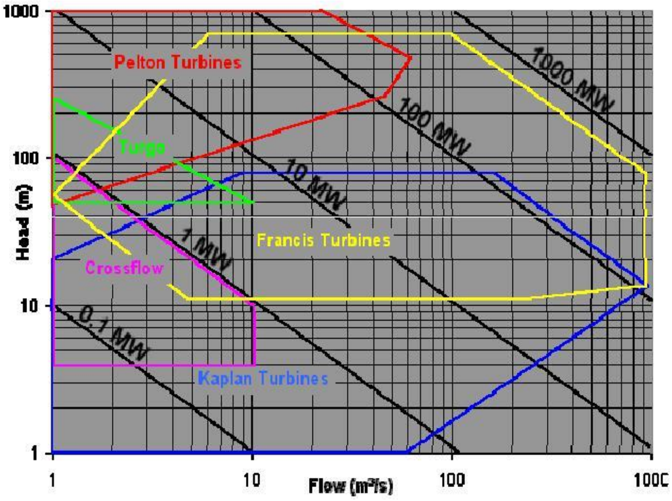
Water turbines are classified into two different groups-impulse turbines and reaction turbines. The first group includes Pelton, Turgo and Cross flow. In such turbines the water is accelerated prior to enter the turbine using its own pressure but, once the water is flowing over the turbine runner blades the
pressure is constant and all the work output is due to the change in kinetic energy of the water. Contrarily, reaction turbines such as Francis or Kaplan types have their functioning on the change in pressure experienced by the water as it moves through the turbine and gives its energy.

The selection of turbine for a site can be determined by the following chart. Also the 2 parameters available at the site of installation are listed-

Flow available – 0.30-0.60 m^3/sec

Head available –1.5-2

Figure: 1 Type of turbine required on the basis of fflow and head available.



3.1 Design of Kaplan Turbine

Available Parameters

Discharge, Q = 0.57 m^3/s

Head, H = 1.8 m.

Density of Waste Water, ρ = 1250 Kg/ m

g = 9.81 m/s^2

*Considering Hydraulic efficiency of turbine, η = 90%

Power Developed –

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

$$P = 1250 \times 0.57 \times 9.81 \times 1.8 \times 0.90$$

= 11.32 kW

$$Net\ Head, N_h = H \times \eta$$

$= 1.8 \times 0.90$

=1.62 m

Specific Speed,

$$N_s = \frac{2.294}{N_h^{0.486}}$$

Rotational Speed,

$$n = \frac{N_s \times E^{\frac{3}{4}}}{\sqrt{Q}}$$

where, $E = NH \times g$

$= 1.62 \times 9.81$

$= 15.89$ J/ Kg

$$n = \frac{1.81 \times 15.89^{\frac{3}{4}}}{\sqrt{0.57}}$$

$= 19.08\ s^{-1}$

Runner Diameter,

$$D_r = 84.5 \times (0.79 + 1.62 + N_s) \times \frac{\sqrt{H_n}}{60 \times n}$$

$$= 84.5 \times (0.79 + 1.62 + 1.81) \times \frac{\sqrt{1.62}}{60 \times 19.08}$$

= 0.346 m

Hub Diameter

$$D_i = \left(0.25 + \frac{0.0951}{N_s}\right) \times D_r$$

$$= \left(0.25 + \frac{0.0951}{1.81}\right) \times 0.346$$

$= 0.102\ m$

3.2 Generator selection

Power generators are classified in two types-synchronous and induction generators. There are significant differences between them. In general, induction generators are simple, robust (requires least maintenance), present an inherent overload protection, and also a small size per generated kW (making them favourable for small power plants).However, they also involve some drawbacks. The main one is that they require reactive power to operate, which is usually fixed by adding a capacitors bank, but also that the small models have not such a good price per kilowatt as the larger central power plants models do (economy of scale). Conversely, synchronous generators are more efficient and can more easily accommodate load power factor variations. However, they present two big handicaps: they require rotor field dc excitation. Hence we have selected **Propeller - Induction Generator.**

4. Power Generation and associated economics–

No. of units generated per year = 300 × 24× 11.32kW

= 81,504 units

Savings per Year = 81,504 × 8.5

= 6,92,784 I.N.R

5. Estimation of Project Cost –

Cost of Kaplan turbine = 7,50,000

Intake structure and Penstock - 25,000/-

Power House -- 70000/-

Total Expenses =8,45,000

Annual Expenses Assumptions from other micro hydro power project.

1) Operation cost = 0. 2×790000 = Rs.8000

2) Malignance cost

a) 10 % of civil structure cost 0 .1 × 95,000= 9,500

b) Depreciation charges = 0.02 × 8,45,000 = 16,900

c) Miscellaneous Incidental charges = 0.02 × 8,45,000 = 16,900

Therefore Total annual expense Rs. 65,400

Consider 10% losses in the transmission and other losses of energy

Annual revenue = Total units Produced × Price saved per unit = 73,355 × 8.5

=Rs 6,23,517

Benefit cost Ratio = annual revenue / annual expenses

= 6,23,517 / 65400 = 9.53 (Considering all the units can run for 300 days.)

Pay Back Period = Total investment cost /Savings per year

= 9,10,400/6,23,517 =1.5 years

6. Conclusion

Installing micro hydro power plant in a sewage treatment plant is a very useful concept especially in the regions where there is significant shortage of electricity. The cost of installation is Rs. 9, 10,400. The Benefit cost ratio is 9.53 whereas the payback period is 1.5 years approximately. The installation of this concept will also result in annual savings of 6, 23,517. Thus it is concluded micro hydro power plants is a renewable, efficient and environmental friendly solution to partly meet the demands of electricity.

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