

# Design and Development of Low Cost Micro Hydro Power Station for Agro based Application

Hrishikesh. U. Patankar, Prof. Dilip. I. Sangotra.

**Abstract**— The aim of this study is to utilize the wastage of water energy supplied by the canals and hydraulic pumps in agriculture areas. In this study we will utilize the nozzle type of arrangement to discharge pipe to supply the water jet to drive pelton wheel then the revolution obtained from the wheel will be increased by the gear box and then it will be supplied to the alternator which will generate electricity to drive agro based application.

**Index Terms**— Micro Hydro power Station, fundamentals, turbine, gear box, alternator.

## 1 INTRODUCTION

**M**ICRO Hydro power is probably the least common of the three readily used renewable energy sources, but it has the potential to produce the most power, more reliably than solar or wind power. This means having access to a river or creek that has enough flow to produce useable power for a good part of the year. Many creeks and rivers are permanent, they never dry up, and these are the most suitable for micro hydro power production. Hydroelectric power plants convert the energy from flowing water in rivers and streams into electricity. Micro-hydro plants convert the energy from flowing water in rivers and streams into electricity. Micro-hydro plants producing less than 100 KW(0.1mw) have very low impact on environment. Micro-hydro power is recognised as a renewable source of energy, which is economic, non-polluting and environment sustainable and ideal for agro based application.

Currently 2 billion people have no access to modern commercial energy. Rural electrification is recognized as a necessary condition for alleviating poverty, satisfying basic human needs, stimulating productive employment and income generation.

## 2 NEED OF MICRO-HYDRO STATIONS.

We are not unaware of the present situation of acute power crisis, which our whole country is facing, besides the world. The power requirements have sharply sprung up. Here in India, the duration of load shedding is increasing every hour. The situation is even worst in rural areas where the power cuts-offs are even as large as 14 hours a day. This evidently shows the urgent need to find some new sources of power.

The difference between the required and actual power is 35% at normal times and 50% at peak working loads. The de-

mand growth is predicted to increase at an alarming rate of as high as 20% per year. The reasons of such a supply shortage can be listed as-

- Under investment in power projects in last 15 years.
- Drastic reduction in the rate of power generation from 2003.
- ghHydro-electric generation dropped by 65%.
- Thermal power generation shot above 120GW-hr. This is happened when oil prices rise by around 65%.

All these reasons have compelled us to find for some other alternatives of generating low cost, effective and clean sources of power, with minimum environment problems.

## 3 FUNDAMENTALS OF FLUID MECHANICS

### Impulse-Momentum Equation-

When liquid comes out from the nozzle in the form of Jet, it exerts a force on plates which is obtained by Newton's second law of motion or Impulse-Momentum equation; which states that-

"The impulse of the force  $F$  acting on a fluid mass  $m$  in a short interval of time  $dt$  is equal to the change of momentum  $d(mv)$  in the direction of force."

$$F = d(mv) / dt$$

The above equation can be written as-

$$F \cdot dt = d(mv)$$

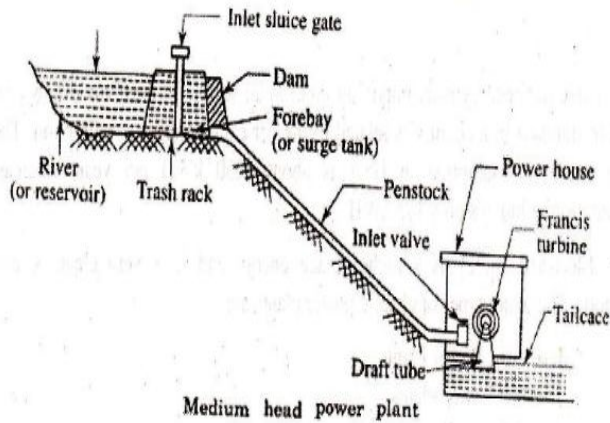
This is Impulse-Momentum equation.

## 4 TERMINOLOGY ASSOCIATED WITH HYDRAULIC MACHINES

Turbines are defined as Hydraulic Machines which convert hydraulic energy into mechanical energy. This mechanical energy is used in running an electric generator which is directly coupled to the shaft of the turbine. Thus the mechanical energy is converted into electrical energy. The electric power which is obtained from hydraulic energy is known as

- *Hrishikesh.U.Patankar. M.Tech (2<sup>nd</sup> year) Production engineering in Yeshwantroa Chavan College of Engineering, India, Mo-919673992082. E-mail: patankar.hrishikesh@gmail.com*
- *Dilip.I.Sangotra. Asst. Professor, Department of Mechanical Engineering, India, Mo-919326061219. E-mail: dilip\_0910@rediffmail.com*

hydro-electric power.



MICRO-HYDRO POWER STATION

Head;  $H=8\text{m}$   
 $V1 = \sqrt{2gh}$

$V1 =$  Velocity head available at turbine inlet  
 $= \sqrt{2 \times 9.81 \times 12}$   
 $= 15.34\text{m/s}$

Assume:  $u1 = 0.45 \times V1$   
 $= 6.903\text{m/s}$

Where  $u1 =$  Peripheral velocity of wheel

$u1 = \pi DN / 60$

Considering Diameter of wheel  $D = 0.503\text{m}$

$6.903 = (\pi \times 0.5 \times N) / 60$

$N = 263\text{rpm}$

$Vr1 = V1 - u1$   
 $= 15.34 - 6.9$   
 $= 8.44\text{m/s}$

$Vr1 = Vr2 = 8.44\text{m/s}$

$Vw1 = V1 = 15.34\text{m/s}$

$Vw2 = Vr2 \times \cos\phi - u2$   
 $= 8.44 \times \cos(20) - 6.903$   
 $= 1.03\text{m/s}$ .

Where  $Vr1 =$  Relative Velocity at inlet.

$Vr2 =$  Relative Velocity at outlet.

$Vw1 =$  Whirl Velocity at outlet.

$Vw2 =$  Whirl Velocity at outlet.

### 5 CLASSIFICATION OF HYDRO POWER STATION

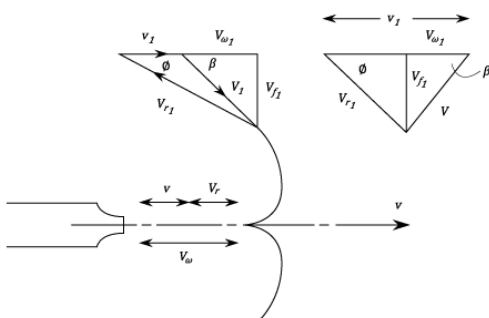
The Hydro Power System are classified based on the amount

Sr. NO	Type Hydro Power Station	Power Generation
1	Large Hydro Power System	>100 MW
2	Medium Hydro Power System	15 MW-100 MW
3	Small Hydro Power System	1 MW-15 MW
4	Mini Hydro power System	100 KW-1000 KW
5	Micro Hydro power System	5 KW-100 KW
6	Pico Hydro power System	300 W-5 KW

of power generated as under:

### 6 CALCULATION (PUMP BASED)

**Design of Pelton wheel runner**



Power developed by unit

$\therefore$  Assuming  $Q = 0.0208 \text{ m}^3/\text{sec}$ .

$P = \frac{\rho * Q * [Vw1 + Vw2] * U1}{1000} \text{ Kw}$

$P = (1000 * 0.0208 * [15.34 + 1.03] * 6.903) / 1000$

$P = 2.35\text{kw}$ .

Power developed by unit is 6.68kw

$$Q = a \cdot V^1$$

$$= (\pi/4(d_1)^2) \cdot V^1$$

Where a=Area of Nozzle.)

$$0.0208 = \pi/4 (d_1)^2 \cdot 15.34$$

$$d = 0.042m$$

Diameter of Nozzle is 42mm

Number of buckets is given by

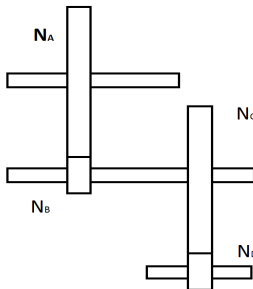
$$Z = 15 + D/2d$$

$$= 15 + 0.5/(2 \cdot 0.042)$$

$$= 20.98$$

No of Buckets;  $Z \approx 21$

### Design of Gears Box



Design of gear drive A-B

$$N_a = 263 \quad N_b = 1250$$

$$T_a = 95 \quad T_b = 20$$

Speed ratio = 4.75

$$D_a = 290mm \quad D_b = 61mm$$

$$\text{Module } (m) = D/T$$

$$= 290/95$$

$$= 3.05mm$$

$$V = (\pi \cdot D \cdot N) / 60$$

$$V = (\pi \cdot 0.61 \cdot 1250) / 60$$

$$V = 3.99m/s$$

Maximum power to be transmitted is  $P = 2.35Kw$

$$P = W_t \cdot V$$

$$W_t = P/v$$

$$= 2.35 \times [10]^{3/3.99}$$

$$= 588.97N$$

Where  $W_t$  = Tangential Load on gear  
Selecting commercially cut gear

$$C_v = 3/3 + 3.99$$

$$C_v = 0.43$$

Full depth involute teeth

Lewis form factor is

$$Y = 0.485 - 2.87 / T$$

For gear A

$$Y_a = 0.1444$$

For gear B

$$Y_b = 0.1084$$

We assume static stress for forged steel'

$$\sigma_0 = 220 \text{ N/mm}^2$$

For gear A

$$\therefore \sigma_0 a \times Y_a = 220 \times 0.1444$$

$$= 31.768$$

For gear B

$$\therefore \sigma_0 b \times Y_b = 220 \times 0.1084$$

$$= 23.848$$

Since  $(\sigma_0 b \times Y)$  for pinion is less than for gear pinion is weaker

So we design for pinion

$$W_t = \sigma_0 b \times C_v \times b \times \pi \times m \times Y_b$$

$$= 220 \times 0.43 \times 25 \times \pi \times 3.05 \times 0.1084$$

$$= 2456.46N$$

As the actual load 588.97N is less than the maximum permissible 2456.46 N

So the Design is safe.

Design of gear drive C-D

$$N_a = 1250rpm \quad N_d = 5938rpm$$

$$T_c = 95 \quad T_d = 20$$

Speed ratio = 4.75

$$D_c = 290mm \quad D_d = 61mm$$

$$\text{Module } (m) = D/T$$

$$= 290/95$$

$$= 3.05mm$$

$$V = (\pi \cdot D \cdot N) / 60$$

$$V = (\pi \cdot 0.29 \cdot 1250) / 60$$

$$V = 18.98 \text{ m/s}$$

Maximum power to be transmitted is  $P = 2.35 \text{ Kw}$

$$P = W_t \times V$$

$$W_t = P / v$$

$$= 2.35 \times [10]^3 / 18.98$$
$$= 123.81 \text{ N}$$

Where  $W_t$  = Tangential Load on gear

Full depth involute teeth

Lewis form factor is

$$Y = 0.485 - 2.87 / T$$

For gear C

$$Y_c = 0.1444$$

For gear D

$$Y_d = 0.1084$$

We assume static stress for forged steel'

$$\sigma_0 = 220 \text{ N/mm}^2$$

For gear C

$$\sigma_a \times Y_a = 220 \times 0.1444$$
$$= 31.768$$

For gear D

$$\sigma_b \times Y_b = 220 \times 0.1084$$
$$= 23.848$$

Since  $(\sigma_{od} \times Y)$  for pinion is less than for gear pinion is weaker

So we design for pinion

$$W_t = \sigma_{od} \times C_v \times b \times \pi \times m \times Y_d$$
$$= 220 \times 0.14 \times 25 \times \pi \times 3.05 \times 0.1084$$
$$= 799.78 \text{ N}$$

As the actual load 123.81N is less than the maximum permissible 799.78N

So the Design is safe.

## 7 FUTURE SCOPE

In this project the theoretical calculation of turbine and gear box design is done. Further the calculation of the design of shaft will be done. Also the calculation will be done according to the power required by the applications and the working efficiency of the mini hydro electric plant. After that the design will built up in the cad modeling software and then it will be analyzed and tested and then the final design parameters will finalized.

## REFERENCES

- [1] Study of the regulation of a Micro Hydroelectric Power Plant Prototype (M. Chennani, I.Salhi, S. Doubabi)-Laboratory of Electric Systems and Telecommunications (LEST)
- [2] Micro-Hydro electric power plant (Agustin Rojo, Jr., Terrazas de Tintillo #16, Guaynabo, P.R.00657)- United States patent Office.
- [3] Micro Hydro electric system (Timothy Michel Toal, Sr., 2936 Noonan St., Honolulu, Hi. 96818)- United States patent Office
- [4] Mini Hydro electric plant. (filemon E. Estilogy) – United states patent office.
- [5] Low Cost Inspection for Improved Blade Reliability (Douglas S. Cairns)-Montana State University, Bozeman, MT 59717
- [6] Hybrid wind-hydro Power Plant-(Wasfi Youssef)- United states Patent Office.
- [7] Regulation of a micro hydroelectric power plant – M.Chennani, I.Salhi.
- [8] Fluid Mechanics and hydraulic machines by-R.K.Bansal
- [9] Theory of Machines-R.S.Khurmi
- [10] Introduction to machine Design V.B.Bhandari.
- [11] MASE Generators North America.