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DESIGN AND DEVELOPMENT OF LOW COST MICRO HYDRO POWER STATION FOR AGRO BASED APPLICATION

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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 utilizes 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.

I. INTRODUCTION

Micro 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 form 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 recognized 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.

II.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 demand 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.

III. Fundamental 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."

$$F = m\,X\,a$$

Here m is the fluid mass and a is the acceleration in the direction of F.

$$a=\frac{dv}{dt}$$

$$F = m\,X\,\frac{dv}{dt}$$

m is constant and can be taken inside the differential,

$$F = \frac{d(mv)}{dt}$$

The above equation can be written as

F.*dt=d(mv)*

This is Impulse-Momentum equation.

IV. 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 start of the turbine. Thus the mechanical energy is converted into electrical energy. The electric power which is obtained from hydraulic energy is known as hydro-electric power.

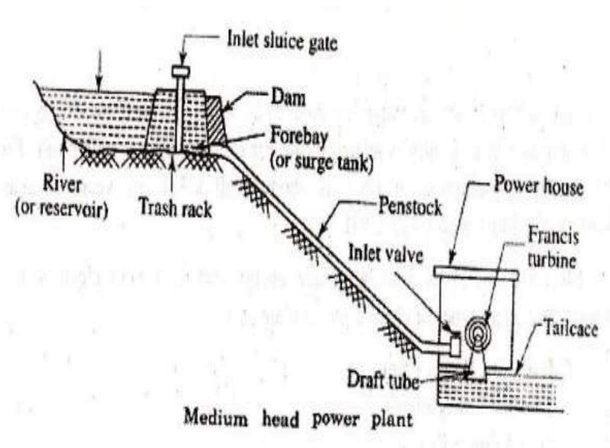


Fig1: Micro-Hydro Power Station

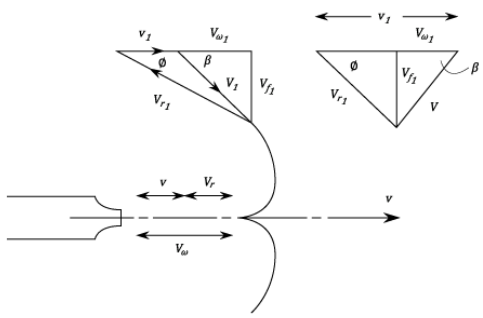
V. Classification of Hydro Power Station

Table1:

The Hydro Power System is classified based on the amount of power generated as under:

VI. Calculation (Pump Based)

Design of Pelton wheel runner



Head; H=8m

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

$$V1 = \sqrt{2gh}$$

V1= Velocity head available at turbine inlet

$=\sqrt{2x9.81x12}$

=15.34m/s

Assume: u1=0.45xV1

=6.903m/s

Where u1=Peripheral velocity wheel

$u1=\frac{\pi DN}{60}$

Considering Diameter of wheel D=0.503m

$6.903=\frac{\pi * 0.5 * N}{60}$

N=263rpm

Vr1=V1-u1

=15.34-6.9

=8.44m/s

Vr1=Vr2=8.44m/s

Vw1=V1=15.34m/s

Vw2=Vr2*cos∅-u2

=8.44*cos(20)-6.903

=1.03m/s.

Where Vr1=Relative Velocity at inlet.

Vr2=Relative Velocity at outlet.

Vw1=Whirl Velocity at outlet.

Vw2=Whirl Velocity at oulet.

Power developed by unit

∴Assuming Q=0.0.208 m3/sec.

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

$P=\frac{1000 * 0.0208 * [15.34 + 1.03] * 6.903}{1000}$

P=2.35kw.

Power developed by unit is 6.68kw

Q=a*V1

$=\frac{\pi}{4}(d1)2$*V1

Where a=Area of Nozzle.

$0.0208=\frac{\pi}{4}(d1)2 * 15.34$

d = 0.042m

Diameter of Nozzle is 42mm

Number of buckets is given by

$Z=15+\frac{D}{2d}$

$=15+\frac{0.5}{2 * 0.042}$

=20.98

∴No of Buckets; Z≈21

Design of Gears Box

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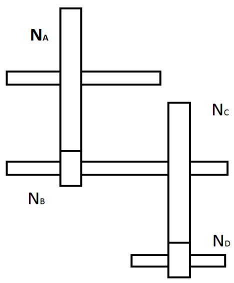

Design of gear drive A-B

Na=263 Nb=1250

Ta=95 Tb=20

Speed ratio=4.75

Da=290mm Db=61mm

Module (m)=D/T

=290/95

=3.05mm

$V=\frac{\pi * D * N}{60}$

$V=\frac{\pi * 0.61 * 1250}{60}$

V=3.99m/s

Maximum power to be transmitted is

P=2.35Kw

P=Wt x V

∴Wt=P/v

$=2.35 \times 10^3/3.99$

=588.97N

Where Wt=Tangential Load on gear

Selecting commercially cut gear

Cv=3/3+3.99

Cv=0.43

Full depth involute teeth

Lewis form factor is

Y=0.485-2.87 / T

For gear A

Ya=0.1444

For gear B

Yb=0.1084

We assume static stress for forged steel'

σ0=220 N/mm2

For gear A

∴σ0a x Ya =220 x 0.1444

=31.768

For gear B

∴σob x Yb= 220 x 0.1084

=23.848

Since (σob x Y) for pinion is less than for gear pinion is weaker

So we design for pinion

Wt=σob x Cv x b x π x m x Yb

=220x 0.43 x 25 x π x 3.05 x 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

Na=1250rpm Nd=5938rpm

Tc=95 Td=20

Speed ratio=4.75

Dc=290mm Dd=61mm

Module (m)=D/T

=290/95

=3.05mm

$V=\frac{\pi*D*N}{60}$

$V=\frac{\pi*0.29*1250}{60}$

V=18.98m/s

Maximum power to be transmitted is P=2.35Kw

P=Wt x V

∴Wt=P/v

=2.35 x 10^3/18.98

=123.81N

Where Wt=Tangential Load on gear

Full depth involutes teeth

Lewis form factor is

Y=0.485-2.87 / T

For gear C

Yc=0.1444

For gear D

Yd=0.1084

We assume static stress for forged steel'

σ0=220 N/mm2

For gear C

∴σ0a x Ya =220 x 0.1444

=31.768

For gear D

$\therefore \sigma ob \times Yb = 220 \times 0.1084$

=23.848

Since ($\sigma od \times Y$) for pinion is less than for gear pinion is weaker

So we design for pinion

$Wt = \sigma od \times Cv \times b \times \pi \times m \times Yd$

$= 220 \times 0.14 \times 25 \times \pi \times 3.05 \times 0.1084$

=799.78 N

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

So the Design is safe.

VII. 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.

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