

Design of 5kw Pico Hydro Power Plant Using Turgo Turbine

Vipin Uniyal, Nikhil Kanojia, Kshitij Pandey

Shivalik College of Engineering Dehradun

Abstract— Hydro power plant is used hydraulic energy of water. the hydraulic energy is then converted in to mechanical energy using turbine and then further mechanical energy converted to electrical energy with the help of alternator. Hydro energy is widely used and useful in small, remote areas that require only a small amount of electricity. Pico hydro are widely used in rural areas electrification. The establishment cost of the pico and micro hydro is very low. So now a days pico and micro hydro widely used in the rural areas. The main advantage of micro and pico hydro plant is that its low cost and environment friendly. This paper represent the pico hydro installation in rural areas. The Turgo turbine is used for pico hydro power generation. The initial cost of the turbine is low and is similar to pelton wheel.

Keywords: Hydropower, Rural electrification, turgo turbine, Electricity, pico hydro, Turgo

1 INTRODUCTION

The hydro power plant widely used for electricity generation all around the world. But the size of hydro power plants is big. A Big catchment area is required for the reservoir. The big hydro plant is also effect the environment. So the small and pico hydro power plant is designed or established for rural electrification. This Paper will provide us a basic understanding of pico hydroelectric power generation. The pico hydro power plant is below then 5kw power generation plant. Pico hydro plants are basically used in rural areas and off grid power generation. There are thousands of micro-hydropower sites (up to 100kW) that could be developed to supply environment friendly renewable energy. The micro and pico hydro plants are easily established at low cost. So we can say that the micro and pico hydro power generation is the best method for rural electrification. With some special precautions, they can be used virtually year-round, summer and winter. The hydro power system can continuous produce electricity 24 hours in day. When the peak power required in the evening when the Sun is not shining and the wind is not blowing. The Batteries are completely drained by morning with a solar and wind system. The hydro system located on a year-round creek or river, power is produced continuously. These are the main benefits of the hydropower. Pico hydro power is widely used in those days for rural electrification. The main advantages of Pico hydro plants are that the low cost and easily established. Pico hydro power plants are easily operated by a low skill operator.

CLASSIFICATION OF HYDRO POWER PLANT

Classification based on plant capacity

Type	Capacity
Pico hydro power plants	<5kW
Micro hydro power plants	< 100 kW
Mini hydro power plants	100kW to 1MW
Small hydro power plants	1 MW to 25MW
Medium hydro power plants	25 MW to 1000 MW
Big hydro power plants	More than 1000 MW

Classification based on head

The available Head at the turbine inlet, the hydro plants are classified as

Type	Head
Low head power plants	< 15 m
Medium head power plants	15 – 70 m
High head power plants	70 – 250 m
Very high head power plants	More than 250 m

- Vipin Uniyal is currently pursuing masters degree program in Thermal engineering in Uttarakhand University Dehradun, India, PH-9997609271. E-mail: vipin.uniyalme@gmail.com
- Nikhil Kanojia is Master degree program in Thermal engineering in Uttarakhand Technical University Dehradun, India, PH -9557480165. E-mail: kanojianikhil12@gmail.com
- Kshitij Pandey is currently pursuing masters degree program in Thermal engineering in Uttarakhand University Dehradun, India, PH-7351645594. E-mail: kshitijpandey@gmail.com

1.3 INTRODUCTION TO HYDRAULICS TURBINES

1) The energy available at the inlet of turbine:

Impulse Turbine : The energy available at the inlet of turbine only kinetic e.g: Pelton wheel, Turgo wheel.

Reaction Turbine : The energy available at the inlet of turbine both pressure and kinetic . e.g: Propeller, Francis turbine

2) Direction of flow of water:

Tangential flow : In this turbine water flows in tangential direction,

Radial inward flow: The Water flows in radial direction : Francis turbine

Axial flow : The Flow of water parallel to the axis of the runner. Kaplan turbine.

Mixed flow : In this the water enter radially and leaves the runner axially : Modern Francis turbine.

3) Head available at the inlet of turbine.

High head, impulse turbine. : Pelton turbine.

Medium head, reaction turbine. : Francis turbine.

Low head, reaction turbine. : Kaplan turbine, propeller turbine.

4) specific speed of the turbine:

Low specific speed, impulse turbine. : pelton wheel

Medium specific speed, reaction turbine. : Francis wheel

High specific speed, reaction turbine. : Kaplan and Propeller turbine.

2 LITERATURE REVIEW

The Turgo turbine are same as the Pelton turbine but the runner is split in half. Turgo turbines are used for medium and high head. The Turgo turbine works between the head 15 m to 300 m. The Turgo turbine is an impulse turbine; water not change the pressure as it moves through the turbine blades. The water energy is converted into kinetic energy with help of a nozzle. The high speed of water jet

then directed on to the turbine blades and after striking the water to the turbine blades the turbine is rotated at high speed. Then the shaft is rotated and the electricity is generated in generator. Water exits with a small energy. Turgo Turbine runner same as Pelton runner but it is split in half. For the same power output the Turgo turbine runner is one half the diameters of the Pelton runner, and the specific speed is twice the Pelton runner. The Turgo turbine can handle a greater water flow than the Pelton turbine because the exiting water doesn't interfere with buckets. The specific speed of Turgo turbine is between the Francis and Pelton. In this single and multiple nozzle can be used. If the number of jets are increased the specific speed of the turbine is also increased. The Pico hydro plants are below then 5kw power generation shown in fig 1 widely used in rural areas electrification. Pico hydro can easily be established in small canal and a small water stream. Pico hydro scheme is only for a small group, small village and a house. It is totally off grid electricity generation. Electricity is generated on the load demand.

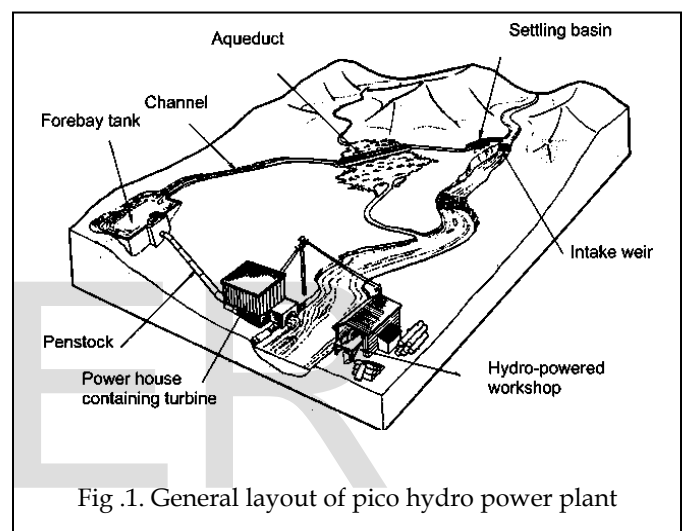


Fig .1. General layout of pico hydro power plant

DIFFERENCE BETWEEN PELTON AND TURGO TURBINE

PELTON WHEEL:

The Pelton turbine is an impulse turbine shown in fig 2. The water strikes the bucket in the tangent direction so it is also called tangential flow turbine. The energy available at the inlet of the Pelton turbine is the kinetic energy. The pressure at the inlet and outlet of the turbine is atmospheric. This turbine is used for high heads. The availability of Head should be more than 250 m. Fig shows the runner on which periphery number of buckets are fitted. The water flows from the reservoir through the penstock. At the outlet of the penstock a nozzle is fitted which increases the kinetic energy of the water flowing through the penstock to the runner. At the outlet of the nozzle, the water comes out in the form of a jet which forcefully strikes the buckets of the turbine.



Fig 2. PELTON WHEEL RUNNER

TURGO TURBINE:

The Turgo turbine is an impulse turbine shown in fig 3. The runner of turgo turbine look like a Pelton runner split in half. This turbine is used in medium head and high head of water. This is widely used in pico hydro power plant because the cost of the turbine is low. It can be easily manufactured in minimum cost. Turgo turbines are mostly used in those days in rural areas electrification in pico hydro power plants



Fig 3. TURGO TURBINE RUNNER

3. ESSENTIAL DATA FOR HYDRO POWER PLANT

HYDRO POWER BASICS

Power is measured in watts or kilowatts.

$$1\text{kW} = 1000\text{Wt}$$

$$\text{Flow: } 1 \text{ m}^3/\text{s} = 1000 \text{ l/s.}$$

Gross head: head of the water

Net head: Deducted the energy loss from forebay through penstock to hydro turbine, a little smaller than gross head.

CALCULATION OF HYDRO POWER

The hydro power can be calculated as follows:

$$\text{Hydro Power } P \text{ (kW)} = \text{Net Head } H \text{ (m)} \times \text{Flow } Q \text{ (m}^3/\text{s)} \times g$$

For example, if the available water flow is 0.25 cubic metres per second and the available Net head is 5 metres, the hydro power is $5 \times 0.25 \times 9.81 = 12.26\text{kW}$

4. DESIGN OF 5KW PICO HYDRO POWER PLANT BASED ON TURGO TURBINE:

4.1. Preparing the site data of power plant

a. Calculation of the Net Head

For the pico-hydro scheme, hydraulic head H can be calculated at any location where elevation z , pressure p , and velocity v are known using

$$H_g = \frac{p}{\rho g} + \frac{v^2}{2g} + z$$

The net Head

$$H_n = H_g - H_f$$

H_g = The gross head which is the vertical distance between water surface level at the intake to the turbine

H_f = Total Head losses due to open channel. These losses are approximately equal to 6% of gross head

The jet Head

$$H_j = C_v^2 H_n$$

b. Calculation of water flow rate

The water flow rate can be calculated by the measuring the river or stream flow velocity and its cross sectional area, then

$$Q=A \times V$$

A= Area of channel

V=Velocity of stream

c. Calculation of Power

$$P= \rho \times g \times Q \times H_j$$

Where ρ is the density of the fluid and g is gravity.

d. Calculation of the Turbine Speed (N)

The Correlation between the specific speed (N_s) and the Net Head H_n is given

$$N_s = 85.49 \times \sqrt{N_j} / H_n^{2/3}$$

Where $N_j = N_o$. of jet
 $N = N_s \times H_n^{5/4} / \sqrt{P}$

e. Runner Design:

The mean velocity of the free jet emerging from the nozzle of the turbine is determined from the net head, by the equation

$$V_j = C_v \sqrt{2gH_n}$$

At the best efficiency point the circumferential speed of the runner is connected with the jet velocity via the relation.

$$U = (0.46-0.47) \times V_j$$

Hence the Diameter of runner is

$$D = 60 \times U / \pi N$$

Where N is the speed of runner in rpm .

f. Diameter of Nozzle or Jet

$$d = \sqrt{4Q/\pi V_j}$$

g. Number of Buckets

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

h. Efficiency of turbine

$$\text{Torque } T = Q \times D \times (V_j - U)$$

Power transferred by the turbine shaft

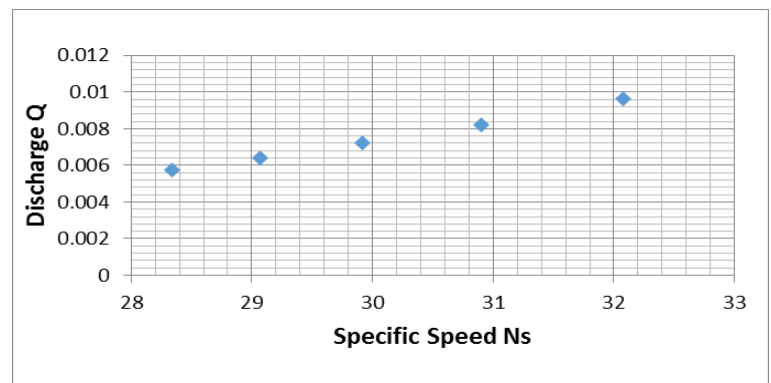
$$P_s = 2\pi NT/60$$

$$\text{Efficiency } \eta_t = P_s/P_j$$

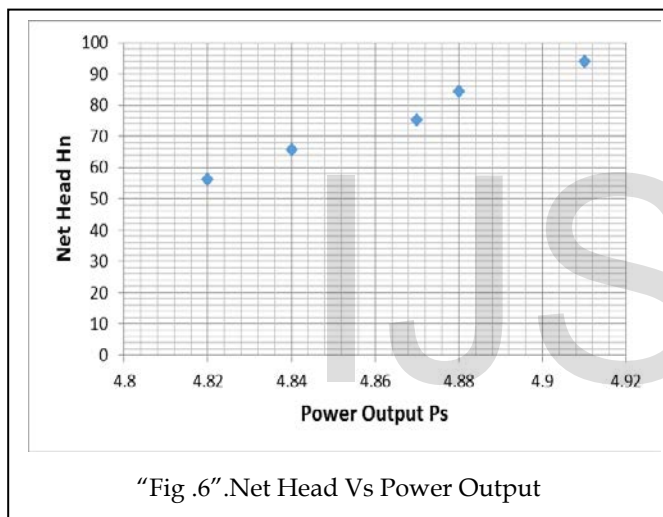
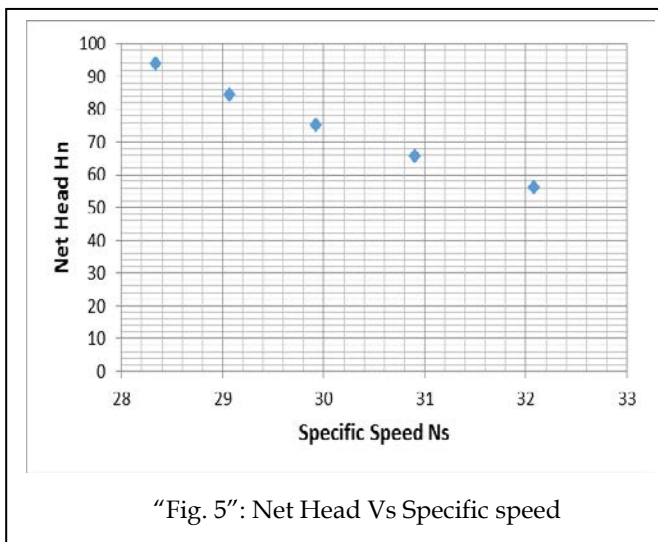
5 RESULT DISCUSSION

Table 1 represent the varous data for 5kw pico hydro power plant Design. The available Heads are 60m 70m 80m 90m 100m

H_o (m)	H_n (m)	Q (m ³ /s)	N_e (rpm)	U (m/s)	V_j (m/s)	D(m)	d(m)	N_b	T (N-m)	P_s (kw)	η_t (%)	
60	56.4	.0096 4	32.08	14.84	32.26	.128	.0195	18	.0215	5	4.82	.96
70	65.8	.0082 3	30.90	16.03	34.85	.118	.0173	18	.0183	5	4.84	.96
80	75.2	.0072 4	29.92	17.13	37.25	.111	.0157	18	.0162	5	4.87	.97
90	84.6	.0064 0	29.07	18.17	39.51	.104	.0143	18	.0143	5	4.88	.97
100	94	.0057 6	28.34	19.16	41.65	.098	.0132	18	.0127	5	4.91	.98



“Fig.4”: Discharge Vs Specific speed



6. CONCLUSION

Pico Hydro is best for the rural electrification. The cost of the pico hydro power plant establishment is very low as compared to other source of energy. The pico hydro as we know is below 5kW so it is useful only for rural electrification for a village or a house. The above discussion shows the selection of a turgo turbine for a 5kW pico hydro power plant. Fig 4 represent when the discharge is increased the specific speed is also increased. Fig 5 shows that when the Net Head is increased the specific speed is decreased. Fig 6 shows that when the Net Head is increased the power output is also increased. Thus the turgo turbine is best for the pico hydro power generation for rural electrification.

Nomenclature:

H_g	=	Gross Head
H_j	=	Jet Head
H_n	=	Net Head
P	=	Pressure
ρ	=	Density of water
V_j	=	Velocity of Jet
D	=	Dia of runner
d	=	Dia of jet
H_f	=	Loss of Head
Q	=	Discharge of stream
U	=	Circumferential velocity
N_s	=	Specific Speed of turbine
g	=	gravity
η_t	=	efficiency
P_j	=	jet power
P_s	=	shaft power (power output)
C_v	=	coefficient of velocity
N	=	speed of runner (rpm)
T	=	Torque

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