Power generation by using open type low head turbine

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Abstract

Despite that researchers and equipment manufacturers have paid less attention to the emerging field of open type low-head power turbines, open type low head turbines can provide innovative, environmental friendly and cost-effective solutions for energy production. Such turbine can has power generation capacity in the range 0.1kw to 0.5kw, the challenge is to provide new turbine designs, which can be customized and applied to existing water systems, characterized by low-head and nearly constant flow rates. Power generation capacity of Open type low head turbine is similar to the Micro hydro turbine. Such low head turbine schemes have good prospects for potential use in remote location. The geometry and configuration of the proposed turbine is suitable up to a head of 0.25m to 1 m and flow rate about 10-16 lit/sec. The analysis and documentation is done for good efficiency up to 47.8 %.

***Index Terms*— Power Generation, Design, Turbine.**

1. Introduction

Hydro power is the backbone of "Co_2 free" energy conversion; about 22% of the world's electricity production comes from hydropower installations, the simplest way to produce the volumes of falling water needed to make electricity has been to build a dam. A dam stops the natural flow of a river, building up a deep reservoir behind it. However, large dams and reservoirs are not always appropriate, especially in the more ecologically sensitive areas of the planet. For making small amounts of electricity without building a dam, the small-scale hydroelectric generator is often the best solution, especially where fast-flowing water available. During farming process for the growth of plant there is need of water, to supply this water farmer need water pump. After pumping this water from pump station the water have velocity, the aim is that, to use velocity of water for power generation by using open type low head turbine. Findings of this research were quite in harmony with theoretical and practically results which may be used for increasing the size of low head turbine along with a proportionate rise in generated power.

2. Experimental overview:

1) Define the scope of project.
2) To find out theoretical result and analysis of feasibility of the system.
3) Design the set up.
4) Compare the experimental result with theoretical result.
5) Find out the efficiency and losses of system.

3. General layout of the plant and design of plant components:

Fig .1.0 shows a general layout of a hydro-electric open type low head turbine which consist of
1) A well which store the large amount of water.
2) Pipes which carry the water under pressure from pump station to the turbines.
3) Turbines having vanes fitted to the wheels.
4) Tail race, which is a channel which carries water away from turbine and use this water for the growth of crop.

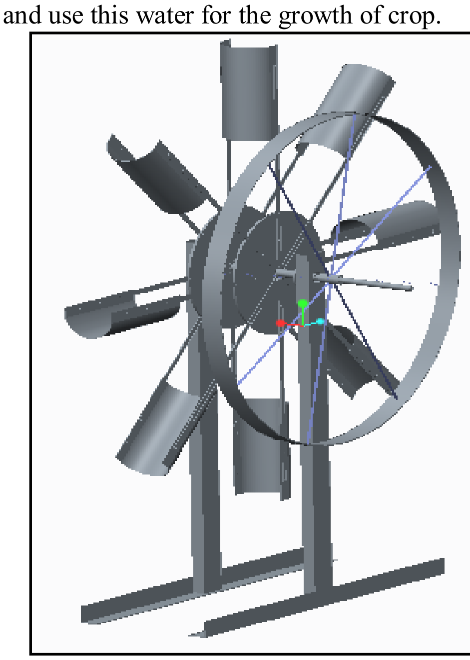

Fig .1.0 General layout of a hydro-electric open type low head turbine

4 .Design of prototype:

Assumption for finding out force exerted on blade consider semicircular vane and speed get from the rotor is 80 rpm and the diameter of turbine taken as 0.96 m because availability of

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space then, go for the calculation of force exerted by the jet of water .

Curved vane velocity u = 4.021 m/sec.

$Fx = \rho \times A \times V \times (V-u)(1+\cos \theta)$.

Where,

Fx = force exerted by jet of water.

ρ = Density of water.

A = Area of jet.

V = Velocity with which jet strikes the plate

u = Velocity of the plate in the direction of the jet

$Fx = \dot{m} \times (V-u)(1+\cos \theta)$.

Fx = 69.26 N.

Work done by the jet on the buckets per second

= Fx × Distance travelled per second in the direction of x

= 278.50 watt. (Theoretical, when jet strikes at centre of bucket)

5. Design of components:

There are number of components which is design for low head turbine are as follows.

1) Number of buckets on the periphery:

The number of bucket should be selected in such way that water no water goes as waste, also is no water leaves without striking at least one bucket of the runner.

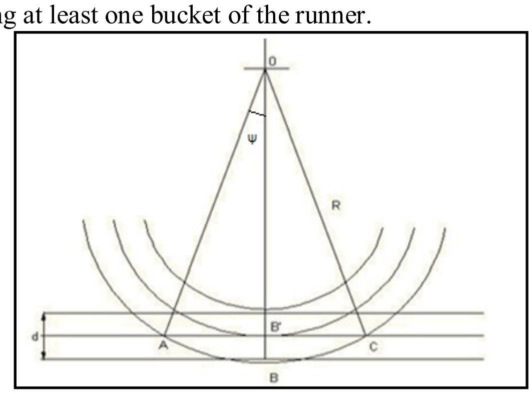


Fig. 2.0 Number of buckets.

by using angle made by bucket with each other and taking the diameter wheel and pipe we are select the number of bucket.

$\cos \Psi = (OB'/OA) = ((R+0.5d)/(R+0.6d))$.

let we know that diameter of rotor 0.96 m and pipe diameter 0.05 m putting this value and after calculating we get 8 number of bucket. The shape bucket is such way that the water flow fall down easily after sticking the bucket shown in fig.3.

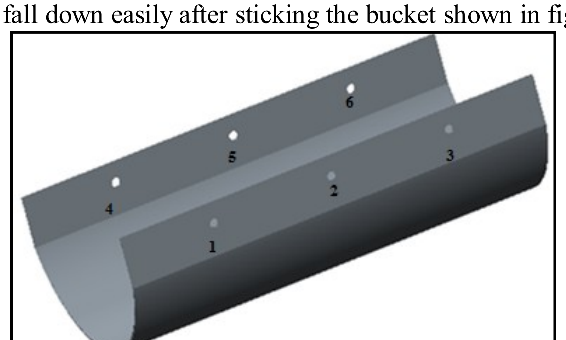


Fig.3 Shape of bucket.

6. Design of shaft:

For design of shaft both static and dynamic load is consider. The Static load is due to weight of the components fitted on the shaft and the dynamic load is due to rotary motion of shaft, that is both bending moment and torsional moment is consider.

In the static load consider weight of:

1) Weight of the Plate

2) Weight of the Disc

3) Weight of the bucket

4) Weight of the Nut and Bolts.

After calculating the weight of above the component is 60 N get, and the maximum bending moment we get 3900 N-mm and torsional moment we get 33970 N-mm from power. By applying formula

We get diameter of shaft is 15mm.

7. Design of bearing:

Bearing carrying the radial load of 60N

Assume maximum operating speed = 200rpm.

Consider life of bearing $L_{10}h$ = 30000 h

Dynamic load capacity

The bearing is subjected to pure radial load

Therefore P = Fr = 60 N

$L_{10} = (60 \times n \times L_{10}h)/10^6$

After calculation we get

= 540 million revolution.

Dynamic capacity of bearing

$C = P(L_{10})^{1/3}$

= 827.3 N

For C=827.3 N bearing are available 6000 but the diameter of shaft 15 mm hence for 15mm bore diameter 6002 bearing is selected.

Dimension of Bearing

Designation -6002

8. Design of Bush:

For mounting of the disc on shaft we need bush Design of hub for collar

D = 2×d = 2×15 = 30mm.

and length of the hub

L = 1.5×d = 1.5×15 = 22.5mm.

let us now check the induced shearing stress for the hub material 30 C8 and by considering it as a hollow shaft.

We know that the maximum torque transmitted (Tmax).

$Tmax = ((D^4-d^4)/D)) \times \tau_C \times (\pi/16)$.

$\tau_C = 6.89 \text{ N/mm}^2$

Since induced shear stress in the hub is less than permissible value of mild steel, therefore the design for hub is safe.

8.1 Design for collar:

the thickness of collar (t_f) is taken as 4mm.

let us now check the induced shearing stress in the collar by considering the flange at the junction of the hub in shear .

We know that the maximum torque transmitted (Tmax)

$Tmax = ((\pi \times D^2)/2) \times \tau_C \times t_f$.

After calculating we get.

$\tau_C = 3.37\ N/mm^2$

Since the induced shear stress in the flange is less than permissible shear stress therefore the design of collar is safe.

8.2 Design of bolt.

Let d1 = Nominal diameter of bolts.
Since the diameter of shaft is 15mm, therefore let us take the number of bolts,

n = 2.

The bolts are subjected to shear stress due to torque transmitted. We know that torque transmitted (Tmax).

$T_{max} = ((\pi\times d_1^2)/4)\times\tau_C\times t_f\times n.$

After calculating we get d_1=3.97mm.

Assuming coarse threads, the standard nominal diameter is 4mm.

9. Design of Belt Drive:

For transmitting the power from rim to the pulley cotton woven belt is select having a length of 3.15m, 0.03 m width and 0.002m thickness.

10. Alternator:

For power generation from the low head water turbine we select 3- phase alternator having generation capacity of 130 watt at 1000 rpm and get dc output rectifier is used.

11. Experimentation:

1) First stage of experimentation is to calculate the theoretical power. The theoretical power is calculated directly by using value of speed.
2) From theoretical power we know that as the speed of the turbine increases the power develop by turbine also increases.
3) From theoretical result we go for actual result. For calculating actual result we need some instrument for measuring speed, output voltage. For measurement of speed and voltage we require tachometer and digital multimeter.

11.1 Procedure:

1) For finding the output, first start the motor and see where the water will be fall.
2) After that place the turbine model is place in front of pipe.
3) Turbine model place in such a way that maximum amount flow rate of water should be captured by turbine bucket.
3) Then take reading of speed and voltage by using tachometer and digital multimeter.
4) When the water is fall on the bucket of the turbine it exerts force on the turbine bucket which produce torque and generate and power by using alternator.
5) Same test procedure should be follow for different flow rate of pump.

12. Theoretical Result:

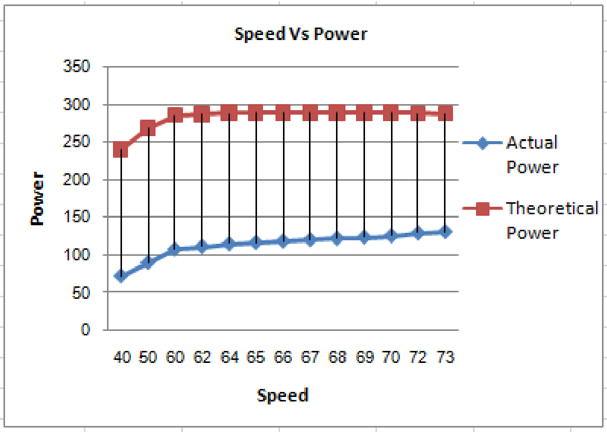
Table 1

Sr No	Wheel Speed	Force Exert On bucket	Theoretical Power Develop (Watt)	Theoretical Hydraulic Efficiency
1	40	119.3	239.9	75.165
2	50	106.9	268.5	84.154
3	60	94.4	284.7	89.221
4	62	91.9	286.4	89.763
5	64	89.4	287.7	90.149
6	65	88.2	288.1	90.283
7	66	86.9	288.4	90.378
8	67	85.7	288.6	90.434
9	68	84.4	288.6	90.451
10	69	83.2	288.6	90.428
11	70	82	288.4	90.366
12	72	79.5	287.6	90.125
13	73	78.2	287	89.945

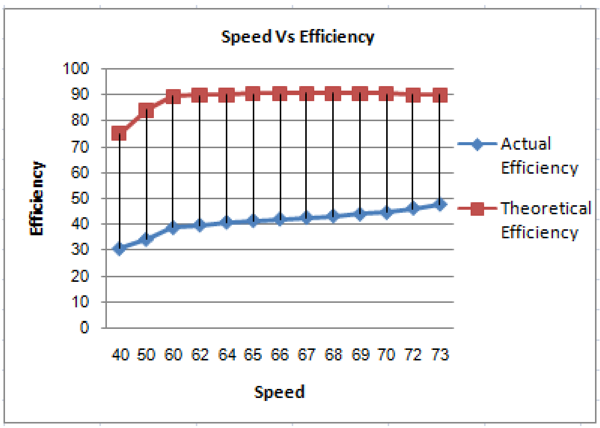
13. Experimental Result:

Table 2

Sr No	Wheel Speed N1=rpm	Pulley speed N2= rpm	Actual Power Develop (watt)	Actual Overall efficiency
1	40.0	553.2	71.9	30.6
2	50.0	691.6	89.9	34.2
3	60.0	829.9	107.8	38.7
4	62.0	857.5	111.4	39.7
5	64.0	885.2	115.0	40.8
6	65.0	899.0	116.8	41.4
7	66.0	912.9	118.6	42.0
8	67.0	926.7	120.4	42.6
9	68.0	940.5	122.2	43.2
10	69.0	954.4	124.0	43.9
11	70.0	968.2	125.8	44.5
12	72.0	995.9	129.4	46.2
13	73.0	1009.7	131.2	47.8



Graph 1 Speed Vs Power



Graph 2 Speed Vs Efficiency

efficiency obtain from theoretical was found of 90% while in actual result it was 47.8 % because of ɵ greater than 10^0 and above also consideration of losses like mechanical loss, volumetric loss etc

Fig. 4.1 Practical demonstration

14. Conclusion:

The report focuses on construction and working of low head water turbines. Such turbines could be used at regions where good storage of water is available and water is pumped from this station as per requirement for farming purpose. The analytical analysis was important to find techno-economically viability, all the investments made will otherwise become a waste exercise.. Project was found analytical feasible for further construction of plant and experimental analysis. The power generation form low head turbine up to131.2 watt and overall efficiency 47.8 % that is near about 50 % was obtained. This small power generation is sufficient to meet the requirement of one small family. Also the DC output power can be used for Ceiling fans, small pump, lighting purpose and battery charging.

15. References

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