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Design of Runner for Cross-Flow Turbine (10 kW)

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Abstract: Electricity demand is increasing worldwide. Water power is one of the major sources of energy. In hydro power plants, water turbine is one of the most important parts to generate electricity. This runner of Cross-flow, Banki-Mitchell turbine is designed to produce 10kW electric power from head of 14m and the flow rate of 0.123 m^3/s. For the given capacity, the dimensions of turbine diameter and width are 150 mm and 320 mm. According to these data, the important part of cross-flow turbine runner can be constructed.

Keywords: runner, microhydro-power, flow rate, cross-flow turbine,

1. INTRODUCTION

The hydroelectric power generation is the availability of a source of water with a very large amount of hydraulic energy. Hydropower is a clean, domestic and renewable source of energy. Hydropower plants provide inexpensive electricity and produce no pollution. Hydropower requires no fuel and the machine to produce is much simpler, and also simple to operate and maintain. The other sources of energy being developed by the fuels such as coal, oil etc, and nuclear power are used for energy. Hydropower development is essential to utilize the hydraulic power proceed by the water flowing in a stream and to develop from it electric power through water turbines coupled to electric generators. The Cross-Flow turbine is primarily impulse type. In the cross-flow turbine, the flow enters the runner from its circumferential direction, passes inside the runner and again passes through the runner blades toward the opposite direction before leaving the runner.

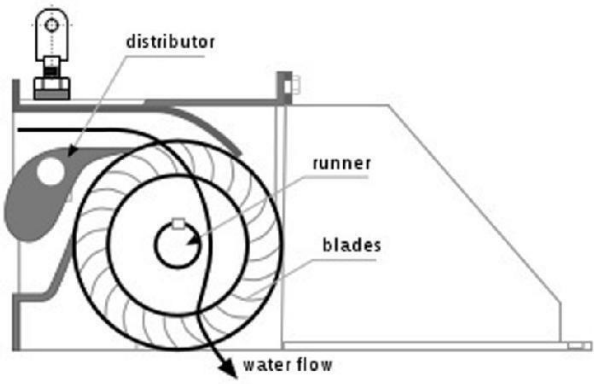

Figure.1 Working Principle of Cross-flow turbine

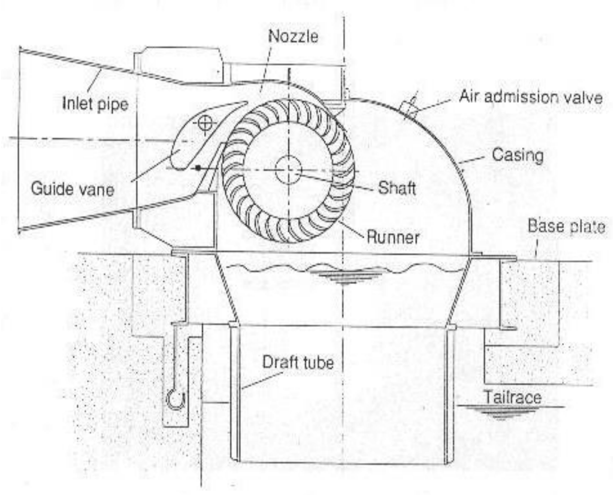

Figure.2 Cross-flow turbine

Also called a Michell-Banki turbine a cross-flow turbine has a drum-shaped runner consisting of two parallel discs connected together near their rims by a series of curved blades. A cross-flow turbine always has its runner shaft horizontal. In operation a rectangular nozzle directs the jet onto the full length of the runner. The water strikes the blades and imparts most of its kinetic energy. It then passes through the runner and strikes the blades again on exit, impacting a smaller amount of energy before leaving the turbine. High part-flow efficiency can be maintained at less than a quarter of full flow by the arrangement for flow portioning. At low flows, the water can be channeled through either two-thirds or one third of the runner, thereby sustaining relatively high turbine efficiency.

2. DESIGN CONSIDERATION OF RUNNER

The cross-flow turbine is primarily impulse type, the optimal speed of the runner primarily determined by the head. The runner speed of the cross-flow type is low as compared with other turbines. The heart of the turbine is the runner and is responsible for the conversion of water energy into mechanical energy. Cross-flow turbine runner is a cylindrical in shape with a long in axis direction and is built up of two parallel circular disks joined together at the rim with a series of curved blades as shown in Figure 2. Runner design is very critical for achieving good overall performance of the turbine.

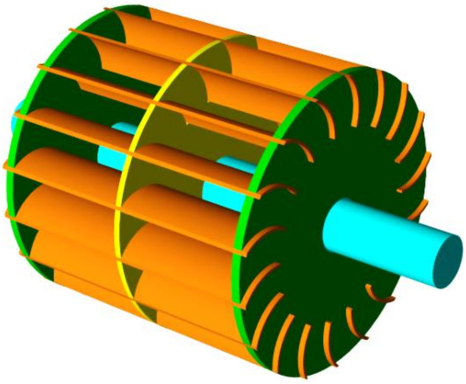

Figure.3 Cross-flow turbine runner[5]

The diameter of the runner is an important and basic factor for the design of the runner. It can be determined from the speed and water head. From the turbine speed, generator can be selected depending on the synchronous speed. In this paper, the inlet flow angle to the wheel is taken as 16° according to obtain the maximum efficiency. When considering the design of runner, the curvature of the blade, inlet blades angle, the value of pitch and the thickness of the runner. A cross-flow turbine has its runner shaft horizontal to the ground in all cases. Shaft transfers the generated torque to the generator or alternator. Bearing function is to hold the shaft rigidly on its position. At the same time it reduces the resistance to the rotation of the shaft and absorbs the axial forces on it. It includes one or two guide vanes depending on the inlet width. The function of the guide vane is to adjust and shut-off the water flow into the runner. A turbine with large maximum discharge has two guide vanes. The vanes lengths are 1/3 and 2/3 of the inflow width, respectively. When the discharge is small, only the shorter vane is used.

3. DESIGN CALCULATION OF CROSS-FLOW TURBINE RUNNER

The required design data for 5kW cross-flow turbine are as follow;
Net head, H = 14 m

Discharge, $Q = 0.123\ m^3/s$

Generator output, P_G = 95% of turbine output

Overall efficiency, $\eta_o = 0.65$

Design of water, $\rho = 1000\ kg/m^2$

Gravity, $g = 9.81\ m/s^2$

The required discharge can be calculated,

$$P = \rho\, g\, Q\, H\, \eta_o$$

The total area of jets can be calculated,

$$V_1 = C_V \sqrt{2gH}$$

$$A = Q/V$$

The periphery velocity is $u = \pi DN/60$,

the rande of specific speed for the cross-flow turbine is 40 to 200.

The number of blades ranges between 20 and 33. When the number of blades is increased, the manufacturing difficulties for small workshops become progressively more serve.

For this design, the specific speed is assumed $N_s = 80$ to calculated the rotational speed,

$$N_s = \frac{172.556}{H^{0.425}}$$

Where the wheel rotation is taken 400 rpm, thus the diameter of runner can be calculated as follows;

$$D_1 = \frac{60u}{\pi N}$$

So, Above the equation the runner diameter is used 25 mm.

Outer diameter of runner,

$$R_1 = D_1/2$$

Inner Radius ,

$$R_2 = 2 \times \frac{D_1}{3} \times \frac{1}{2}$$

Therefore, 28 blades are chosen for this design. Outer diameter D of runner is the basic parameter for design. Diameter of the blade stands for its inner surface. In this design, thickness of blade can be chosen 3.2 mm.

∴ the radius of blade shaped arc is 0.04 m.

So, $r = 0.16\ D_1$

The radial rim width (a) was graphically ascertained from the intersection of the two curves.

$$a = R_1 - R_2$$

The diameter of the shaft can be calculated as follow,

$$d_S = 150 \sqrt[3]{\frac{P}{N}}$$

So the diameter of the shaft is used 35 mm.

4. RESULT OF RUNNER CALCULATION

This table shows the calculated result for runner using above equation.

Table 1
Calculated result for 10kw cross-flow turbine for micro-hydro power plant

No.	Name	Symbol	Result (m)
1.	Outer radius of runner	R_1	0.75
2.	Inner radius of runner	R_2	0.05
3.	Diameter of runner	D	0.15
4.	Width of runner	B	320
5.	Radius of curvature	r	40
6.	Radial rim width	a	0.105
7.	Shaft diameter	d_s	0.249

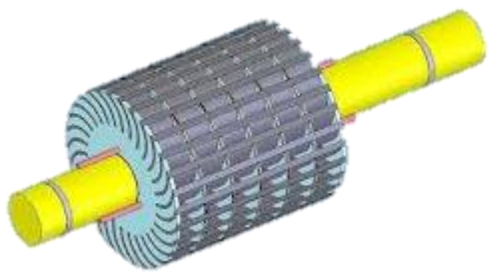

Figure.4 Two Dimensional Drawing

5. CONCLUSION

Water energy is renewable sources suitable technology needs to obtain these natural resources. In hydropower plant, turbine is one of the most important parts to generate electricity Cross-flow turbine is the best for low head to generate electricity. This type of turbine will be useful for micro hydro project because different sizes of turbine can be constructed easily for different kinds of require power. In this study, cross-flow turbines was designed a runner of 10 kW for micro-hydropower plant. The cross-flow turbine designed for 14 m of head and 0.53 m^3/s of flow rate to generate 10 kW. The diameter of the runner is 150 mm and length is 320 mm. For that turbine, a synchronous generator 6 pole is used with direct coupling. The attack angle at the runner is taken as 16 degree to get optimal efficiency. The number of blade is 28 and thickness is 3.2 mm, depending on the runner diameter.

6. REFERENCES

[1] L.A.Haimeral., 1956 The cross flow turbine. Deutche Miller-Zeitung.

[2] Seiroku Sajiki, Hitoshi Yamamoto., 1983. "Commercialization of Cross-Flow Hydraulic Turbines and Their Power Generating Systems", series No.68, No.2.

[3] Allen R. Inversin, 1986. Micro Hydropower Source Book.

[4] Modi, P.N., and Seth, S.M. 1982. Hydraulics and Fluid Mechanics. 5th Edition, University of Roorkee.

[5] Robert, L.Mott, P.E. 1985. Machine Elements in Mechanical Design. University of Dayton.

[6] http:// www.waterturbine.com

[7] http:// www.microhydropower.net/turbine.html

[8] http://www.home.carolina.rr.com/microhydro/turbine.html