International Journal of Science and Engineering Applications
Volume 8–Issue 08,272-274, 2019, ISSN:-2319–7560

Design of Cross-Flow Turbine for Hydro-power Plant (Runner)

Cho Nwe Tun
Lecturer
Department of Mechanical Engineering,
Technological University (Thanlyin),
Yangon, Myanmar

Khin Nwe Zin Tun
Lecturer
Department of Mechanical Engineering,
Technological University (Thanlyin),
Yangon, Myanmar

Mya Thet Hnin
Lecturer
Department of Mechanical Engineering,
Technological University (Dawei),
Yangon, Myanmar

Abstract: In hydro-electric plants, water turbine is one of the most important parts to generate electricity. Cross-flow turbine is one of the simplest radial impulse turbine. In this paper, cross-flow turbine is designed to produce 5kW output power from head of 7m and the flow rate of 0.102 m^3/s. For the given capacity, the dimensions of turbine diameter and length are 250 mm and 408 mm. The number of blades are used 28 blades, the thickness of each blades is 4.5 mm, the inner diameter of the runner is 166mm.According to these data, the important part of cross-flow turbine runner can be constructed. The detail design calculation of the runner is described in this study. And then detail drawing of 5kW cross-flow turbine is illustrated.

Keywords: cross-flow turbine, runner, hydro-power, flow rate, diameter.

1. INTRODUCTION

Nowadays, compact metal water turbines tend to be used instead of traditional water wheel. Water power is one of the major sources of energy. 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 hydraulic (water) turbines coupled to electric generators. A hydropower plant requires no fuel and it is much simple to operate and maintain. So, the position of hydro-power plants becomes more and more important in today's global renewable technologies.

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 Cross-flow turbine runner

It is called cross-flow, since the water passage through the runner. The turbine consists of two parts, a nozzle and a turbine runner, Cross-flow is suitable for heads from 5 to 80 meters. The drum shaped runner of a cross-flow turbine is built of two parallel disks connected near the rim by a series of curved blades. The number of blades ranges between 26 to 30. This turbine is always installed with the shaft horizontal.The objective of this study are to study the about of micro hydropower plants thoroughly and to study the theory of cross-flow turbine. And then, it can be constructed the runner of cross-flow turbine by local material at small machine shop and to reduce the use of non renewable energy.

2. DESIGN CONSIDERATION OF RUNNER

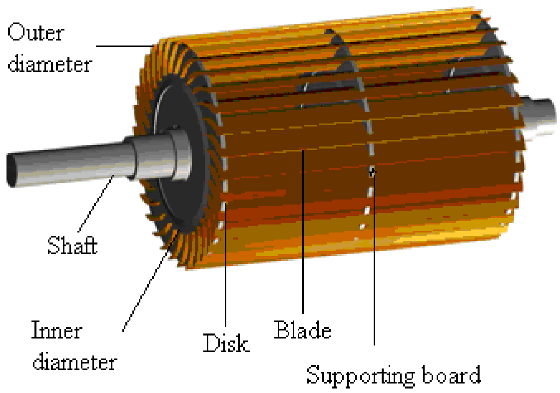

Figure.2 Cross-flow turbine runner[2]

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. 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. THEORETICAL CALCULATION OF CROSS-FLOW TURBINE RUNNER

The required design data for 5kW cross-flow turbine are as follow;
Net head, H = 7 m

Generator output, P_G = 95% of turbine output

Overall efficiency, $\eta_o = 0.75$

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

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

$C_v = 0.92 – 0.99$

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.

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

$$N_S = \frac{N\sqrt{P}}{H^{5/4}}$$

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 ,

$$R_2 = D_1/3$$

Radius of blade shaped arc r,

$$r = \frac{\left(R_1^{\ 2} - R_2^{\ 2}\right)}{2R_1\cos\beta_1}$$

∴ the radius of blade shaped arc is 0.04 m.

$$\text{So,} \quad r = 0.16\, D_1$$

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.

The efficiency is equal to the ratio of the output and input power.

$$\text{Efficiency} = \frac{\text{output power}}{\text{input power}}$$

4. RESULT OF RUNNER

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

Table 1. Calculated result for 5kw cross-flow turbine

No.	Name	Symbol	Result (mm)
1.	Outer radius of runner	R_1	125
2.	Inner radius of runner	R_2	83
3.	Diameter of runner	D	92
4.	Width of runner	B	408
5.	Radius of curvature	r	40
6.	Radial rim width	a	42
7.	Shaft diameter	d_s	34.8
8.	Efficiency	η	87 %

Figure 3 shows the result drawing of 5kW cross-flow turbine runner. In the cross-flow turbine, runner is the important part for the whole part of the turbine .

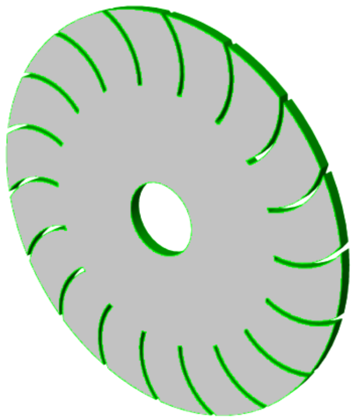

Figure.3 Drawing of runner (front view)

5. CONCLUSION

Hydroelectric power has been important in the provision of electricity. The future of hydroelectric power will depend on the demand of electricity and the provision of this using the most economical and environmental source available. In hydropower plant, turbine is one of the most important parts to generate electricity. The author has designed a runner of 5 kW cross-flow turbines for micro-hydropower plant. Unlike the other turbines, according to the water passes through the runner which is called cross-flow.

The cross-flow turbine designed for 7 m of head and 0.102 m^3/s of flow rate to generate 5 kW. The author has designed the runner of this turbine and drawn the working drawing of turbine runner. The diameter of the runner is 92 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 inlet blade angle is 30 degree. The number of blade is 28 and thickness is 4.5 mm, depending on the runner diameter.

6. ACKNOWLEDGMENT

The author is deeply grateful to her teachers, parents and friends for their noble support, encouragement, and guidance throughout her entire life.

7. REFERENCES

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

[2] Pa Pa Min. 2007 Design and construction of 300W cross-flow turbine.

[3] Nakase, Y., (1982): A study of Crossflow Turbine, Small Hydro Power Fluid Machinery, p. 13-18.

[4] Khosrowpahan, S., (1984): Experimental Study of the Crossflow Turbine, Ph.D. Dissertation, Colorado State University, Fort Collins, CO.

[5] Javed A. Chattha et. al. (2010): Design of a cross flow turbine for a micro-hydro power Application, Proceedings of the ASME 2010 Power Conference, July 13-15.

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

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

[8] http:// www.energymanagertraining.com

[9] http:// www.hypo-into, "Hydropower".