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Design and Development of Cross Flow Turbine for Agro Applications

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Abstract -- The cross flow turbine was gaining popularity in low head and small water flow rate, in established of small villages were there is shortage of electricity, due to simple structure and ease of manufacturing in the site of small canal. To obtain a cross flow turbine with maximum efficiency, the turbine parameter must be included in design. We have worked on design and fabrication of cross flow turbine for the agro applications.

Indexed Terms: cross flow turbine, design parameters, maximum efficiency

I. INTRODUCTION

Hydropower is an ancient technology that has been used throughout the world as a natural source of energy for several hundreds of years. The role of hydro plants becomes more and more important in today's global renewable energy. The small-scale renewable generation may be the most cost effective way to supply electricity to remote villages that are not near transmission lines there are various types of turbines for hydro power plants. The selection of the best turbine for any particular hydro site depends on the site characteristics, the dominant ones being the head and flow available. Selection also depends on the desired running speed of the generator or other device loading the turbine.

There are many sites which are suitable for low head hydro turbines. Low head hydro turbines include Kaplan Turbine which is axial inlet and axial outlet, Cross flow Turbine which is radial inlet and outlet of water is a cross the runner, etc. have been the main field of interest. Nowadays, the Cross-flow hydraulic turbine is gaining popularity in low head and small water flow rate establishments, because of its simple structure and ease of manufacturing in the site of the power plant. Cross-flow turbine is also called Banki-Mitchell turbine as they were the inventors and early developers of this turbine. Cross flow turbine is low head turbine which works with tremendous flow rate. Cross flow turbine is a two stage turbine and the contribution of power transfer in each stage has been a subject of theoretical and experimental investigation for some decades ago. The results significantly vary among investigators. Possibly the sources of variation may be the high levels of uncertainties associated with second stage power transfer, assumptions made during the theoretical analysis, different geometrical configurations of the Cross flow turbine testing models and the methodologies that were used. The main aim of the study is to enhance the design of a Cross flow turbine, as an appropriate technology for small-scale power generation. The Cross flow turbine, also known as Banki turbine, is simple to design and manufacture. The flow of water crosses the runner blades twice, from the periphery towards the centre, and after crossing the open centre space, from the inside to the outward periphery. This phenomenon is known as cross flow.

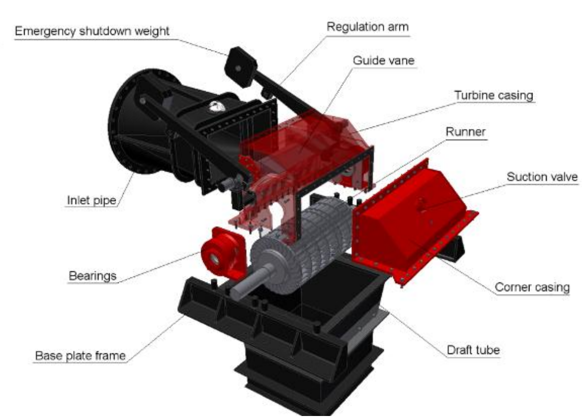

Fig. 1: Components of cross flow turbine

II. DESIGN PROCEDURE

The design procedure consist the different parameter associated with the turbine . they are as follow.

The design of the turbine is for the particular head and discharge

The head is 32 m

Discharge is 0.282m^3/sec

a. Net head

The net head is the differences between the gross head and the head equivalent of losses. The losses accounts for the losses in pipes, channels, trash rake, penstock, etc.

$$H_n = H_g - H_l$$
$$H_n = 30mm$$

H_g is the head equivalent for different losses which takes place in the pipes, channels, etc. This loss is approximately 6% of gross head. H_l is the gross head at the intake of the turbine. The head for the turbine was selected as 32m

b. Turbine efficiency

The maximum turbine efficiency can be calculated as

$$\eta = 0.5 * C^2 * (1+\psi) * (\cos\alpha)^2$$

c. Runner diameter

The outer diameter of the runner is the diameter of the outermost point of the runner from the shaft. Its selection depends upon the flow conditions Larger diameter turbine is selected for more flow and smaller diameter is selected for less flow.

$$D_o = 40 * (\sqrt{H}/N)$$
$$D_o = 300mm$$

From the given equation we can see that low value for angle of attack (α) is beneficial. It is seen that 16 degree for attack angle can be manufactured without inconvenience.

ψ = Blade roughness coefficient 0.98

C = nozzle roughness coefficient 0.98

$$\eta = 88\%$$

d. Turbine power

It is the output power that is produced by the turbine

$$P = \delta * g * Q * H_n * \eta$$
$$P = 73.03kw$$

e. Turbine speed

The turbine speed is the rotational speed at which the runner of the turbine rotates. The turbine speed can be calculated from below mentioned formula

$$N = 513.25 * (H_n^{0.745}/\sqrt{P})$$
$$N = 756rpm$$

f. Blade Spacing

The tangential blade spacing can be given as

$$t_b = 0.174 * D_o$$
$$t_b = 52mm$$

g. Radial width

It can be defined as the difference between the outer and the inner radius of the runner of the turbine. It can be given as

$$W = 0.174 * D_o$$
$$W = 52mm$$

h. Number of blade

The number of blades in turbine should be optimum because if number of blades is excess than it would cause pulsating power and reduce the turbine efficiency and if it is less, it would result in incomplete utilization of water. The number of blade can be determine as

$$n = \pi D_o / t_b$$
$$n = 8$$

i. Runner length

It is the length of the runner along the axis of turbine.

It can be calculated as

$$L = [(210 * Q)/D_o * \sqrt{H}]$$
$$L = 600mm$$

j. Blade radius

It is defined as the radius of the curvature of the curved blades of the turbine. The radius is very important for efficient working of the turbine. It varies directly with the size of turbine.

$$r_b = 0.163 * D_o$$
$$r_b = 50mm$$

d. Diameter of shaft

The diameter of shaft should be capable of carrying the load of the turbine. The size should be optimum for better flow of water across turbine.

$$D_s = 0.22 * D_o$$
$$D_s = 66mm$$

l. Design data table

PRAMETERS	UNITS	DATA
H_n	Mm	30
η	%	88
P	Kw	73.3
N	Rpm	756
D_O	Mm	300
t_b	Mm	52
W	Mm	52
n	-	8
L	Mm	600
r_b	Mm	50
D_S	Mm	66

Table 1: Design data

III. FABRICATION MODEL OF CROSS FLOW TURBINE ACCORDING TO CALCULATION

Fig. 2: Whole turbine

Fig. 3: Rotor

IV. DISCUSSION

The cross flow turbine design is very unique from conventional turbine as it is designed in such a way to give maximum efficiency as stated in theory. It is dependent on several factors such as runner diameter, runner speed, runner length, turbine power, blade spacing, radius of blade curvature, attack angle and the blade and exit angles. These parameters play very important role in attaining the desired efficiency.

The Angle of attack is kept 16°. The dimension for outer and inner diameter plays an important role. If the ratio of outer diameter to inner diameter is increased then, there will be more curvature of the blade and energy will be transferred in shorter distance. The optimum diameter ratio is 0.68 for design of high efficiency of turbine. The inner discharge angle recommends keeping at 90^0. As it will also help the water to move in radial direction.

V. CONCLUSION

Thus, we can see from the observations that Cross-flow turbine is suitable for very low head and a large flow. The maximum efficiency was found to be 88% for different values of head and water flow rate. The different design parameters such as water jet thickness, runner diameter, runner length, blade spacing, and radius of blade curvature, turbine speed, turbine power and number of blades were determined at maximum turbine efficiency.

In future, the scope of small scale plant is high as there is very much need of energy at mobile places like hilly areas or some rural villages where there is power cut or maybe no electricity in today's developing age.

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