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To Examine the Effect of Mass Flow Rate on Cross Flow Turbine using Computational Fluid Dynamics

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***Abstract*— The cross flow turbine is place for small water flow rate and low head application. In this paper evaluates the performance of cross flow turbine by changing the different mass flow rate using CFD software. For the analysis applying the inlet boundary condition of mass flow rate ranges from 70 kg/s to 150 kg/s. Here cross flow turbine having constant rotational speed 354 rpm. From the flow analysis the results shows that as the flow rate increase as torque increases ranges from 59.9686 Nm to 181.213 Nm, same as power increases ranges from 2.21kw to 6.71kw and also efficiency increases ranges from 67.1% to 95.08%.**

Keywords*— Cross flow turbine, computational fluid dynamics, mass flow rate, power

I. INTRODUCTION

A cross flow turbine gets its name from the way the water runs through, or more correctly 'across' the rotor as shown in Figure 1 below. The water flows over and under the inlet guide-vane which directs flow to ensure that the water hits on runner blade at the right angle for maximum efficiency. The water then flows over the upper runner blades, producing a torque on the runner blade, then through the center of the runner and back across the low runner blades producing more torque on the runner.

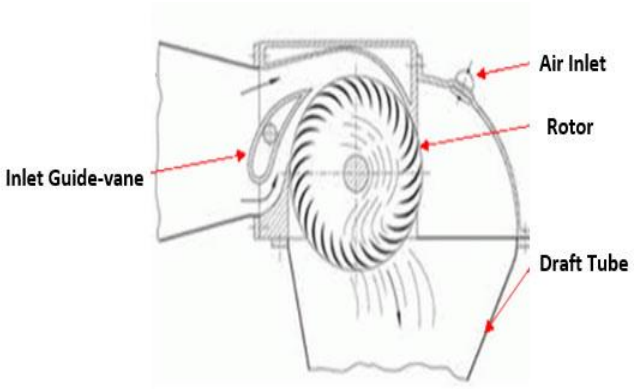

Fig.1 Cross flow turbine [1]

II. IMPORTANCE OF COMPUTATIONAL FLUID DYNAMICS

Computational fluid dynamics (CFD) is a useful tool to apply for fast simulation for the design of any hydro turbine and improve their efficiency. CFD analysis calculating the impact of gas or liquid and fluid force on performance of any product. A CFD is a powerful tool for resolving a broad assortment of industrial problems. Development work on solver algorithms, meshing, and user interface generation are ongoing, with the aims of improving accuracy, reducing solution time, and increasing accessibility.

A. Modelling of cross flow turbine

Given data is used for make a geometry for a cross flow turbine with the help of CREO software. Different parameters are given in table I.

TABLE I PARAMETER OF CROSS FLOW TURBINE [2]

Sr.no	Parameter	Specification
1	Runner dia.	230 mm
2	Runner width	200 mm
3	Head	3 m
4	Shaft speed	354 rpm
5	Guide vane angle	16
6	No. of blade	18

Geometric model of cross flow turbine is done in CREO software. CREO model file is converted into STEP file (.stp format). That STEP file is carried in ANSYS software for further process. In ANSYS, that model give meshing and boundary condition.

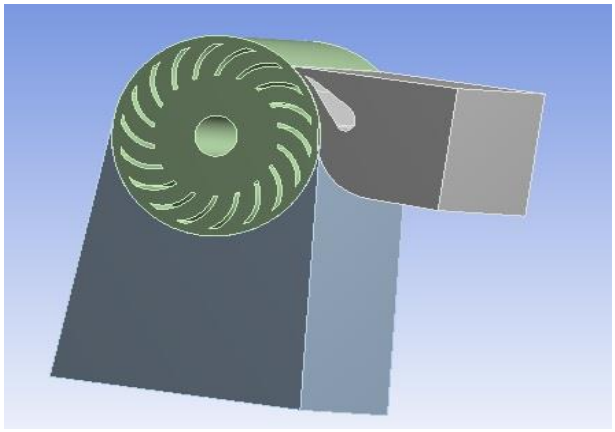

Fig. 2 Geometry model of cross flow turbine

After the geometry model of cross flow turbine mesh is generated in ANSYS. Meshing is used to obtain the acceptable level of solution. Meshing model is shown in fig. 3

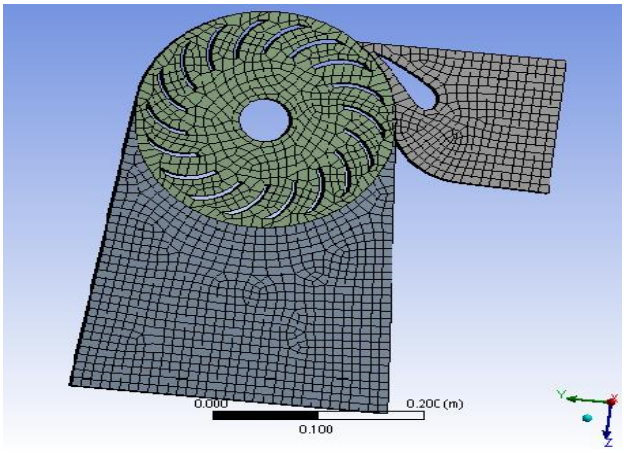

Fig. 3 Meshing of cross flow turbine

B. Boundary dondition of cross flow turbine

In cross flow turbine rotational speed of runner give 354 rpm. At inlet of cross flow turbine give static pressure 29430 pa and at outlet of cross flow turbine mass flow rate are given. Boundary condition of cross flow is shown in fig. 4

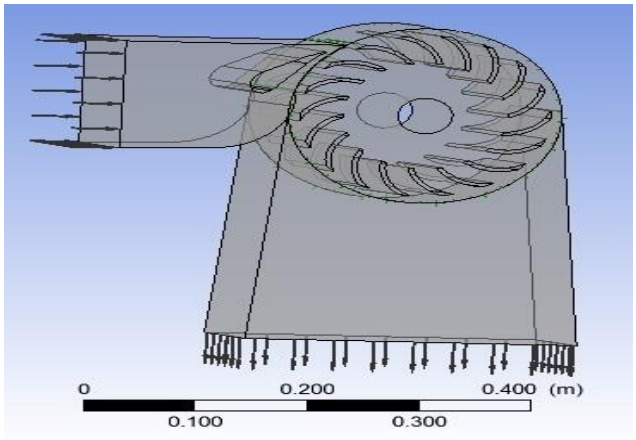

Fig. 4 Boundary condition of cross flow turbine

III. EFFECT ON CROSS FLOW TURBINE WITH DIFFERENT MASS FLOW RATE

On cross flow turbine apply different mass flow rate and then check the effect on efficiency. Mass flow rate is varies from 17 kg/s to 190 kg/s. know the effect on efficiency and power, when varies the mass flow rate on cross flow turbine. Fig.5 shows the effect on cross flow turbine efficiency.

TABLE II EFFECT ON POWER AND EFFICIENCY ON VARIOUS MASS FLOW RATE

Mass flow rate(kg/s)	Pressure (pa)	Torque (Nm)	Power (kw)	Efficiency (%)
70	29430	63.3421	2.34	71.05
79.928	29430	77.3237	2.8	74.46
90	29430	86.9375	3.22	76.05
100	29430	102.252	3.78	80.34
110	29430	116.633	4.32	83.47
120	29430	131.568	4.87	86.26
130	29430	144.779	5.36	87.64
140	29430	161.992	6	91.09
150	29430	184.147	6.82	96.64
160	29430	211.875	7.85	78.75
170	29430	252.215	9.34	78.71
180	29430	297.35	11.01	78.7
190	29430	349.081	12.93	78.69

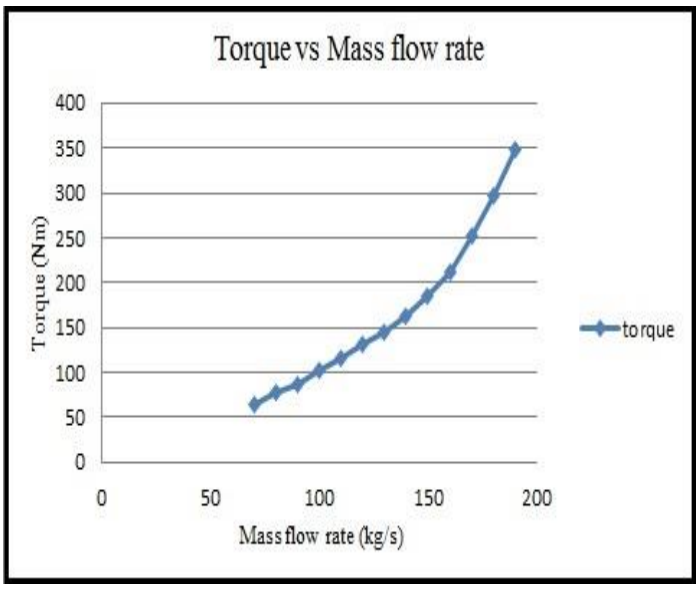

Fig. 5 Torque vs Mass flow rate

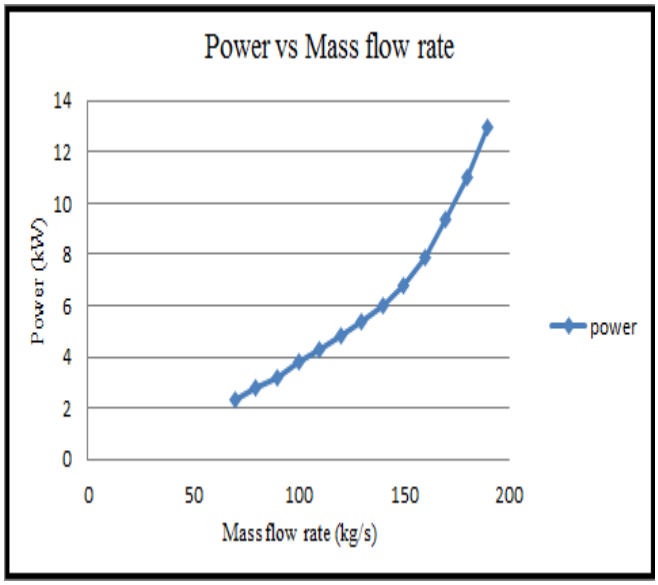

Fig. 6 Power vs Mass flow rate

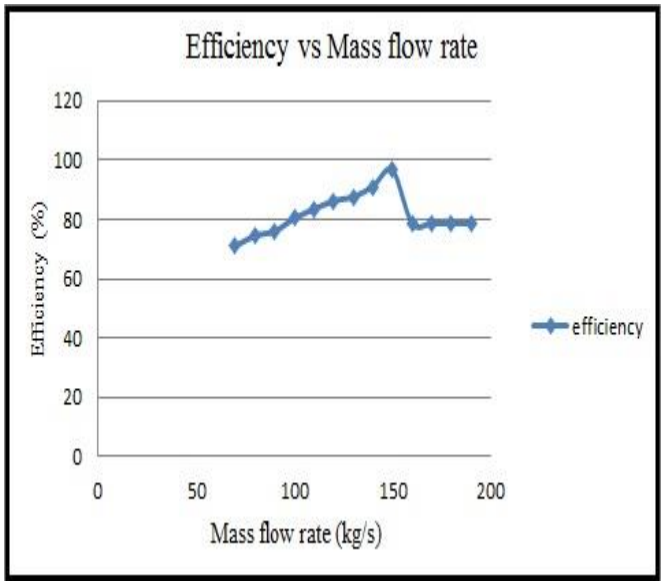

Fig. 7 Efficiency vs Mass flow rate

IV. CONCLUSION

Result of cross flow turbine on various mass flow rate with CFD simulation.

- The simulation was found mass flow rate varies ranges from70 kg/s to 190 kg/s as power increases and efficiency is increase for some time after that decrease.
- From figure 5 mass flow rate increase ranges from 70 kg/s to 190 kg/s as torque increase ranges from 63.3421 Nm to 349.081 Nm.
- From figure 6 mass flow rate ranges from 70 kg/s to 190 kg/s as power increase ranges from 2.34kw to 12.93kw.
- From figure 7 mass flow rate increases ranges from 70 kg/s to 190 kg/s as efficiency is increases ranges 71.05 % to maximum 96.64 % after that it going to decrease up to 78.695.

From the all CFD simulation result shows that mass flow rate increases with respect to torque and power are increases and also efficiency is increases for some time after that it going to be decrease. From the above all simulation get maximum power is 12.93kw and maximum efficiency is 96.64 %.

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