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An Experimental Study on the Various Parameters of Tesla Turbine Using CFD

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Abstract: Conventional turbines are mainly of two type's reaction or impulse. Often a lot of technical challenges are faced by conventional turbines by sediment erosion. Financial feasibility of power plants is depended mainly on innovations to prevent wear and tear of mechanical equipment's or some new alternatives which can handle these conditions in a better way. Tesla turbine is one among an unconventional turbine that uses mainly fluid properties like boundary layer and adhesion of fluid on f smooth discs which are serially keyed in to a shaft. It has been gaining interest. It provides a simple design which can be produced easily and maintained at low cost. It can be useful in plants for pumping of water and other viscous fluids. Tesla Turbine pump can been used as a blood pump. This paper is presented in context of project by final year mechanical engineering students of Viswajyothi College of Engineering and Technology, Vazhakulam, Kerala to understand working of Tesla Turbine. For this design and computational fluid dynamics (CFD) analysis of a tesla turbine was carried out. The models thus created were used for computational analysis.

Keywords: Tesla Turbine, Boundary layer, Tesla pump, CFD

I. INTRODUCTION

Tesla Turbine is a bladeless turbine comprises of a progression of discs with spout through which gas or fluid enters towards the edge of the disc. Energy exchange in the middle of liquid and disc happens because of liquid properties of viscosity and adhesion. discs and washers, that different discs, are fitted on a sleeve, strung toward the end and nuts are utilized to hold thick end-plats together. The sleeve has an opening that fits firmly on the pole. Openings are removed around focal point of the plates to speak with fumes ports framed in the side of the packaging. Consequently tesla turbine is depicted as a multi disc; shear force or boundary layer turbo machinery that works with compressible and incompressible liquid. Liquid enters radially and exits pivotally through the ports. Tesla turbine has points of interest of simplicity of creation, adaptability and low upkeep. Liquid utilized can be steam or water. It is unaffected by residue disintegration because of absence of vanes. A test identified with Tesla turbine is low productivity. Tesla turbine guarantees high rotor effectiveness for ideal configuration, yet tentatively numerous challenges has been found to accomplish high efficiencies in spouts and rotors. The outline of a Tesla turbine was conveyed utilizing iterative procedure for head and release for principle measurements of the turbine.

II. PREVIOUS WORK

Tesla Turbine was patented by Nikola Tesla in 1903.His turbine utilized 22.5 cm disc and the whole rotor was 5 cm thick creating 110 Horsepower and utilized steam as propulsive liquid. Tesla pump was patented in 1909 which utilizes smooth turning discs on volute packaging. Tesla led trials of his turbine somewhere around 1906 and 1914, and afterward there was little movement on this field until a restoration of interest started in the 50's [1].

Rice [2] built up a basic introductory examination utilizing channel stream hypothesis with mass coefficients for erosion that gives some subjective comprehension through diagrams as it is appeared in Figure 1 and Figure 2. With this diagrams it is conceivable to acquire inexact estimations of efficiencies for various stream rates, yet for the predetermined geometry ro/b=50

$r0$= outer radius of disc

b= disc spacing between two discs

Ω= angular velocity of fluid

Q= volumetric flow rate for single disc spacing

Figure 2 demonstrates that high efficiencies is acquire for low stream rates at estimations of $Q/\omega r_o^3$=0.0001 and the second turbine tried by Rice has an estimation of $Q/\omega r_o^3$= 01256.03 then, the efficiencies are required to be under 40% as it is appeared in Figure 1. Figure 2 portrays the change of weight, for higher tangential speeds, the change of weight is higher, and for higher stream rates the change of weight is lower, this is on the grounds that the change of weight happens just in the limit layer because of the impacts of consistency and with the expansion of stream rate, the speed increment and the thickness or area of the limit layer reduces [3].

Allen accompanied a analytical model for liquid stream between parallel, co-rotating annular discs from

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preservation of mass and discussion of force standards. Through the suspicion of completely created limit layer stream a shut structure arrangement is found for the parts of speed and the weight. The model can be utilized to break down the liquid plate framework in either a turbine or pump design. The exactness of result enhances in both cases as the dimensionless parameter R* increments. A R* on the request of 1 or more noteworthy than shows that the thick impacts are vital and the model is exact [4].

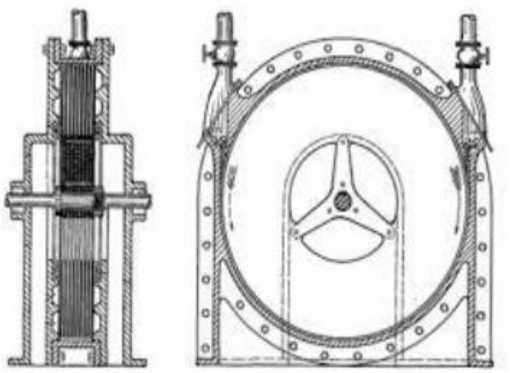

Figure 1 Original sketch of Tesla turbine [1]

Conservation of Mass:

$$\dot{\rho} + \vec{\nabla}(\rho\vec{u}).(\rho\vec{u}) = 0 \quad (1)$$

Conservation of Momentum:

$$\dot{\vec{u}} + (\vec{u}.\vec{\nabla})\vec{u} = -1/\rho\,\vec{\nabla}P + g + v\nabla 2\vec{u} = 0$$

u = Radial velocity
P = Pressure
v= Tangential Velocity
∇ =Gradient Function

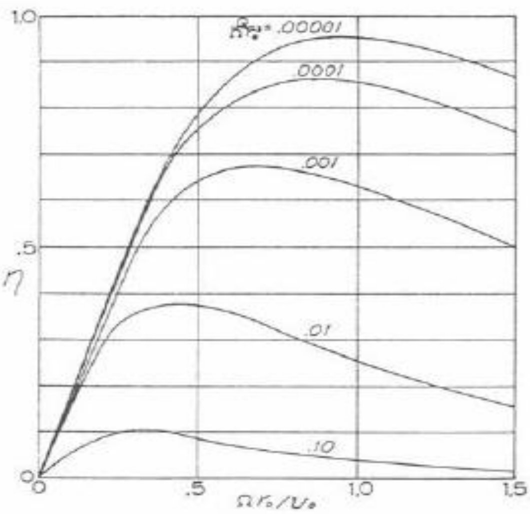

Figure 2 Typical results for maximum efficiency as a function of flow rate and parameter. Plotted for f=0.05 ro/b= 50[3]

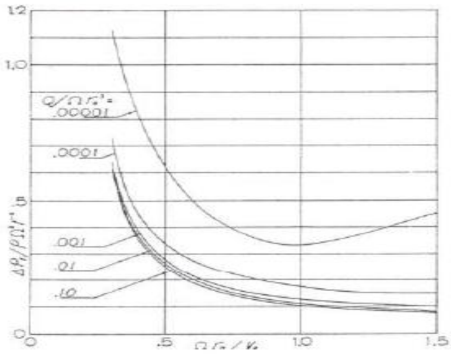

Figure 3 Typical results for pressure-change parameter as a function of flow rate and speed parameters. Plotted for f= 0.05, ro/b= 50[3] (2)

III. CALCULATIONS

A. Design parameters

Flow rate was chosen as 0.0001.Iteration of ro and Ω was completed to discover volumetric flow rate Q for single disc separating. Q was increased by aggregate number of disc n to discover aggregate volumetric stream rate Q' the disc design can deal with giving satisfactory estimations of productivity and torque.

Head and stream rates were iterated. Liquid enters turbine through the nozzle and is coordinated in the middle of the disc. The liquid strikes the disc tangentially at an edge to the rotor outskirts. This was utilized to discover supreme and outspread speed of plane. Torque and force delivered was computed. Finally efficiency of rotor get together was calculated.

Absolute velocity: $V = \sqrt{(2gH)}$
Radial Velocity: U= $\pi DN/60$
Torque: $(u_0v_0 - uivi)Q'\rho$
Efficiency: = $T\omega/QgH$

Table 1 defines the rotor configuration of the turbine. Values of power output and efficiency are provided. Figure 5 and 6 represent Tesla disc and rotor assembly respectively.

TABLE 1
DESIGN PARAMETERS

Parameters	Values
Angle of nozzle α	15^o
Outer radius ro	129 mm
Inner radius ri	36 mm
Disk spacing δ	2.6 mm
No of discs n	10
No of spacers	11
Revolution	800 rpm
Total length	44.698 mm
Torque T	9.4Nm
Power P	777.16 W
Efficiency	78.7 %

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Figure 4 Tesla disc

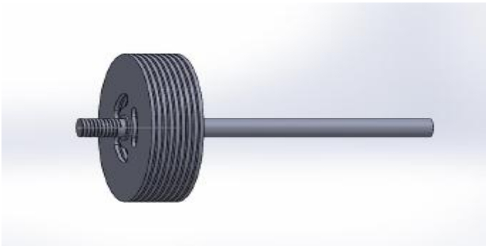

Figure 5 Tesla turbine rotor assembly

B. Analytical Model

The fluid model described by Allen uses the differential forms of the conservation of mass and the conservation of momentum principles only.

$$R=(-\lambda 3*\nu)/2\lambda 1*\delta^2 rU$$

υ= kinematic viscosity

r= radius of disc

R* is dimensionless system constant which is ratio of rotor configuration to the viscous/momentum force balance. A R* on the order of 1 or greater than indicates that the viscous effects are important and the model was accurate.

$R*=Rr^2$

Reynolds number based on disk spacing

$Re_\delta=Ur/\nu$

Radial Reynolds number

$Rer=U\delta/\nu$

a is radial constant dependent on boundary conditions.

$U= ar$

In a turbine configuration the flow is radially inward, the radial velocity is negative hence a is negative.

TABLE 2 DESIGN PARAMETER VALUES

Parameters	Values
Laminar Flow coefficient value $\lambda 1$	8/15
Laminar Flow coefficient value $\lambda 2$	2/3
Re_δ	1.31e04
Re_r	4.39e05
Mass flow rate m	7.28 kg/s
a	-0.456
$R*$	-0.048
Specific speed	26.23

C. CFD Analysis

Two domains were made in Solidworks2013. Pivoting domain comprised of rotor assembly and the stationary area comprised of external packaging with a streamlined spout [5]. Table 3 demonstrates the lattice information for the area made. Table 4 presents parameters chose for CFD examination. Figure 6 demonstrates the setup of two domains.

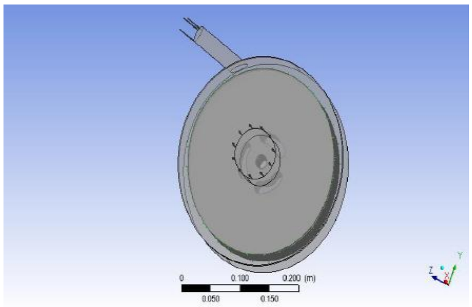

Figure 6 Inlet and outlet conditions

TABLE 3 MESHING DATA FOR DOMAINS

Meshing data	
Rotating domain	
Nodes	483462
Elements	2011811
Stationary domain	
Nodes	244141
Elements	1282278

TABLE 4 CFX PRE PARAMETERS

Flow State	Transient
Boundary Conditions	Mass flow rate as inlet Atmospheric pressure at outlet
Turbulence model	K-epsilon
Static atmospheric pressure	1 atm (Outlet condition)
Mass flow rate	7.3 kg/s
Phase	Single(water)
RPM	850

TABLE 5 SOLVER CRITERIA

Coefficient loop	
Min Iteration	1
Max Iteration	10
Residual Type	RMS
Residual Target	1e-4

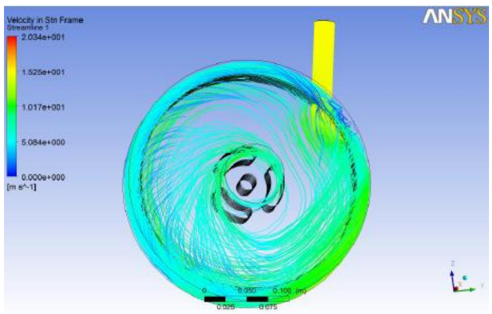

Figure 7 Velocity streamline in stationary domain

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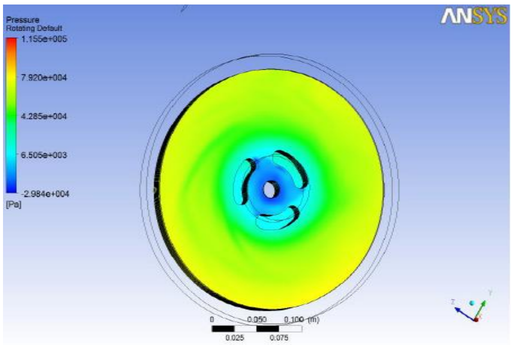

Figure 8 Pressure gradient in rotating domain

IV. RESULTS

Liquid parameters depicting the cooperation of disc with water were given. Estimation of dimensionless framework consistent $R*$ was observed to be - 0.048 which indicates worthy exactness of model and that gooey impacts are critical. Productivity considering improved spout was 78.7%.Figure 7 and 8 demonstrates the velocity streamlines and pressure gradient angle respectively.

V. CONCLUSION

Tesla turbine is a flexible turbine. It can be utilized as a part of Pico hydropower which can be privately created and oversaw by village communities. It can be utilized as pumped stockpiling frameworks. It can be utilized as spiral ventricular gadgets which may be "delicate" on blood pumps and doesn't causes loss of platelets because of its energy transfer mechanism. Tesla pump has been accounted for to handle various types of modern and horticultural and waste liquids [6]. It can likewise be different option for Improved Water Mill (IWM). It can be reasoned that the study on Tesla turbine has yielded critical comprehension of the turbine. There are still numerous spaces for development which makes it interesting point for further research.

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