"EVALUATION OF TESLA TURBO MACHINE AS TURBINE"

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ABSTRACT

Turbo-machine applications have a several alternatives, each of which emanates to help build the world of power. One of these ideas is 'The Tesla turbine', which is also referred to as a bladeless turbine or friction turbine. A turbine is a machine that transforms rotational energy from a fluid that is picked up by a rotor system into usable work or energy. The principle of Tesla turbine comes from two main rudiments of physics: Adhesion and Viscosity, instead of the conventional energy transfer mechanism in traditional turbines. It is referred to as a bladeless turbine because it uses the boundary layer effect and not a fluid impinging upon the blades as in a conventional turbine. In this Analysis by the means of changing mass flow rate and proper design of bladeless rotor the efficiency is to be calculated and the analysis of viscous fluid that can be transferred is to be measured. The Turbo machine will also be analyzed as a turbine for a viscous fluid transfer and will be compared with the previous cfd analysis.

Keyword: - *Boundary Layer, Momentum, viscosity, Flow regime, Rotor*

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1 INTRODUCTION

Ludwig Prandtl the German Engineer on August 12, 1904 first introduced the boundary layer concept. The fluid flow equation was simplified by dividing the flow field into two areas: Dominated by viscosity, one inside the boundary layer and hence the majority of drag is created which will be experienced by the boundary layer. Another will be outside from this boundary layer, neglecting the viscosity effects on the solution. By this there will be significant simplification of the Navier-Stokes equation for closed form solution for the flows in both the areas. Within the boundary layer heat transfer from a body and to a body also takes place which will again simplified the flow field equation outside the boundary layer. Normal to the surface direction pressure distribution throughout the boundary layer remains constant and is the same in as the surface itself.

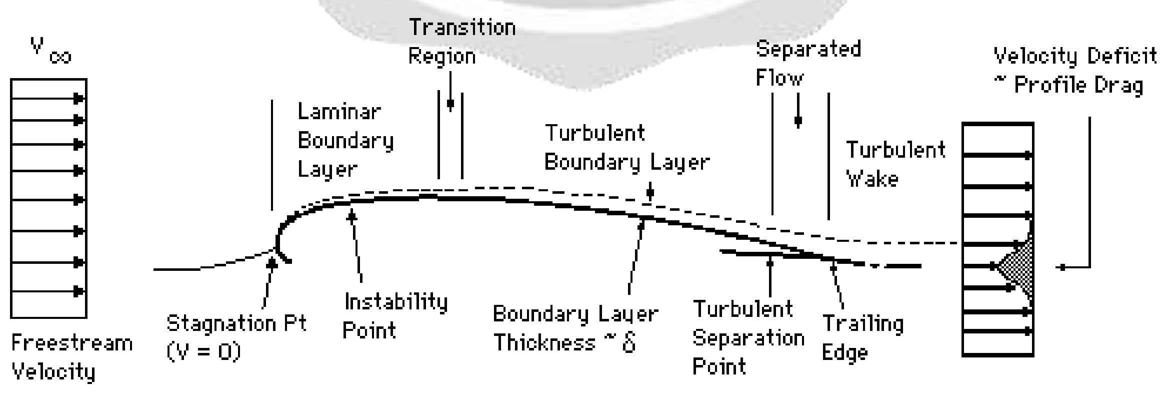

Figure 1.1 Boundary Layer concept

The thickness of the velocity boundary layer is normally defined as the distance from the solid body at which the viscous flow velocity is 99% of the free stream velocity (the surface velocity of an inviscid flow). Displacement Thickness is an alternative definition stating that the boundary layer represents a deficit in mass flow compared to inviscid flow with slip at the wall. It is the distance by which the wall would have to be displaced in the inviscid case to give the same total mass flow as the viscous case. The no-slip condition requires the flow velocity at the surface of a solid object be zero and the fluid temperature be equal to the temperature of the surface. The flow

1.1 TESLA TURBINE

The first bladeless turbine was designed and manufactured by a Serbian engineer and well known inventor Nicola Tesla in 1913, by turbine also known as a friction turbine. The boundary layer flow which produces the viscous effect is used to run this unusual turbo device. In our general classical bladed turbines, the viscous effects are the reason for the efficiency loss of this typical turbines therefore it is the undesirable source while opposite of this phenomena these viscous effects are the main driver enabling the rotational movement of the rotor. A set of n number of thin disks is attached with a shaft which is perpendicular to its axis of a revolution; “n” numbers of set depends on the size and design. According to the theory the individual each disk must be as thin as possible. The smaller the gap between the “n” number of disks and the distance between one another the higher will be rotation. The highest value of efficiency according to Rice [18] is achievable when the gap is approximately equal to the double boundary layer thickness. Therefore, with respect to the flow conditions and physical properties of the working fluid the gaps between the disks should be maintain. The technology of manufacture, material strength and its assembly has the impact on the thickness of the disks and the gap between them is also limited.

Figure 1.2Parts of the Tesla Turbine

2 CONSTRUCTION AND WORKING PRINCIPLE

The closely spaced disks, in Tesla Turbine are propelling by using the viscosity and adhesion of a moving medium. From the periphery the fluid enters the inner space between the disks and through the central holes located near the axles exists shown in the figure 2.1. To couple inertia forces there are no constraints or obstacles as in traditional turbines. The fluid entering tangentially at perpendicular to the axis of rotor at the periphery, it transfers momentum to the disks, during this process. If considering ideal conditions, then between the tangential velocity of the fluid entering the disk and the tip velocity of the rotating disk and the tip velocity of the rotating disk there will be no slippage at the nozzle exit. The efficiency of energy transfer is largely is governed by the following:

- From the nozzle the smoothness of the medium flow to the disks.
- The bearing effectiveness for reducing the friction los and
- For the transfer of the momentum the size of the active area.

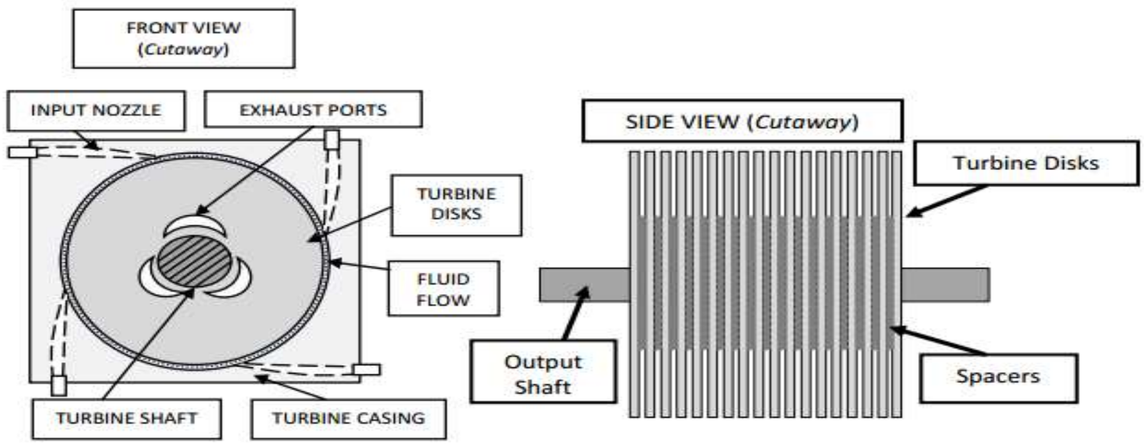

Figure 2.1Construction of Tesla Turbine [13]

From a manufacturing standpoint a most attractive feature of the Tesla turbine is its simplicity. The parts from the Tesla Turbine can be taken apart easily as assembly is very simple, as shown in figure. 2.2. The Tesla turbine designed by its use of flat, fixed and co-rotating disks equally spaced along the rotor shaft which can be seen in figure. 2.2. There is a metal casing by which the rotor is housed which contains the exhaust ports as well as inlet nozzle.

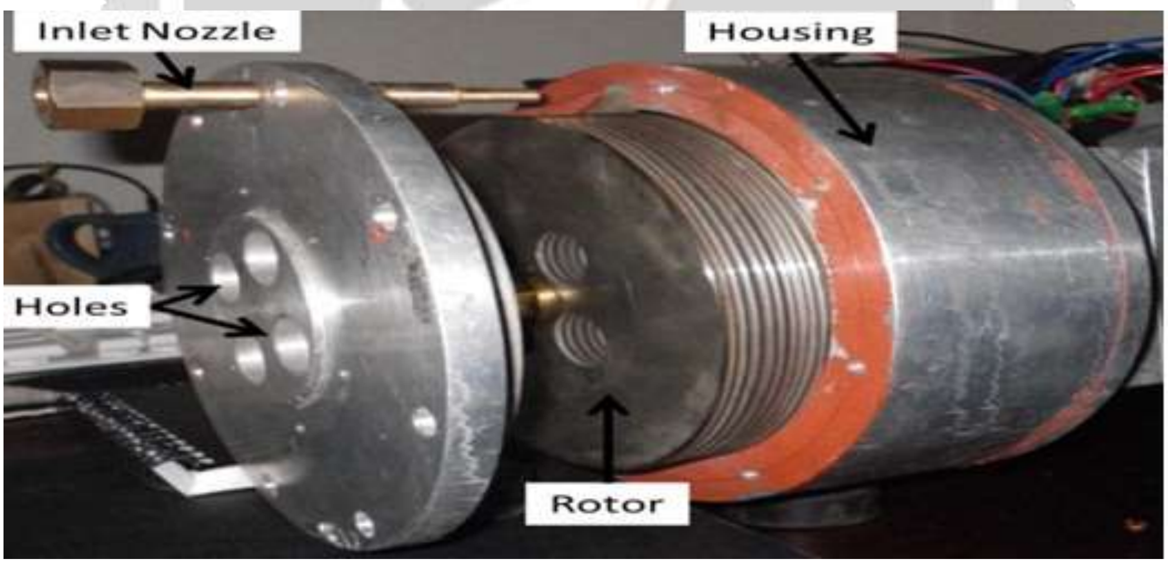

Figure 2.2Entire Tesla turbine assembly showing the rotor blades, housing, inlet nozzle and exhaust Ruler (cm) added for approximate size scale

The fluid velocity is significantly increased when a fluid is introduced through the nozzle and towards the outer edge of the disks it is ejected tangentially. The result in momentum exchange from the fluid to the disks is by the viscosity of the high speed fluid and no slip condition along disk surface power output and shaft torque.

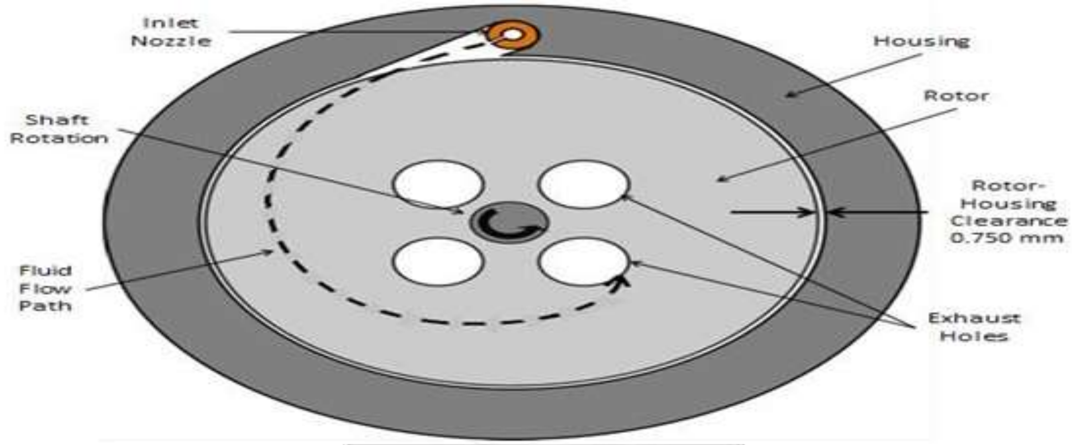

Figure 2.3Schematic of fluid flow through the Tesla turbine All major turbine components are shown and the actual rotor-housing clearance given [15]

As can be seen in Figure 2.3, there is nothing complicated about the way a Tesla turbine works. The fact that the fluid flows parallel to the turbine disks gives this design a distinct advantage over traditional bladed turbine; abrasive particulates or even water droplets can be present in the working fluid without risking direct impacts which could cause additional wear and damage to the disks. Its ability to utilize a variety of fluids without damaging the blades and its extremely low manufacturing cost warrant a renewed interest in the design.

3 EXPERIMENTAL SETUP

This contains details of the experimental setup, scheme of instrumentations and experimental procedures. The description and specification of various instruments and components are described in this chapter. The specification equipment's used in the experimental setup are given in the later section.

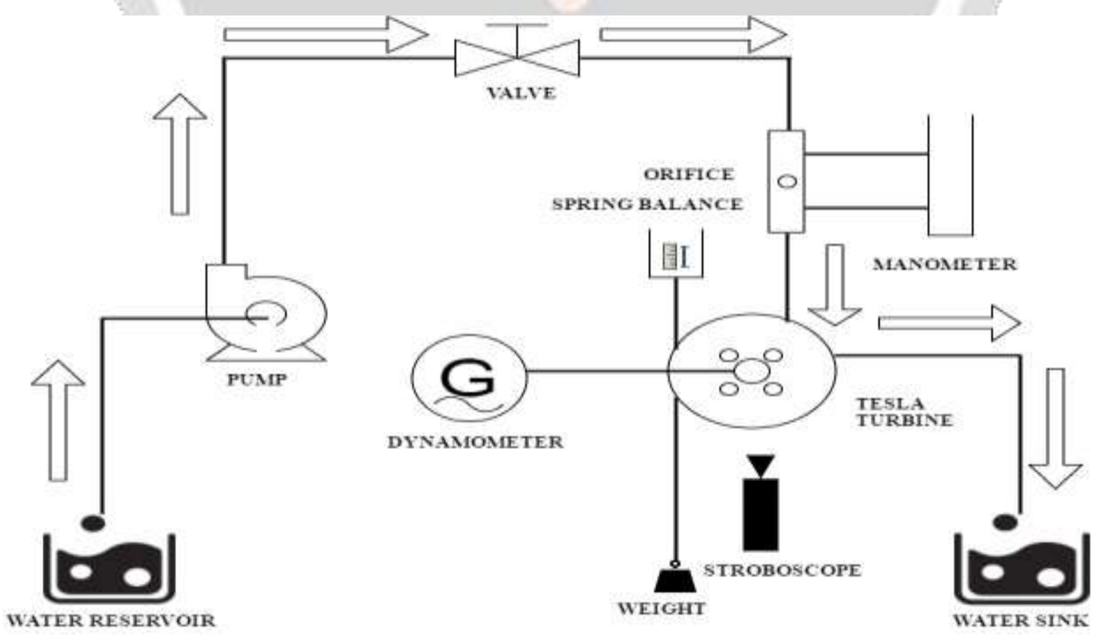

Figure 3.1 Schematic Diagram of Tesla Turbine Setup

PROCEDURE

1. The water is collected into the tank.
2. The pump will then take water from the tank for supplying to the turbine it will pass through the valve which is manually operated.
3. Closing and opening of the valve will give us the different readings.
4. From the orifice using u-tube manometer the velocity and mass flow rate will be measured.
5. Then water will pass through the turbine will it will give the rotation to the disc and using the stroboscope the RPM will be measured.
6. Finally the dynamometer is attached to this which will produce the current in volt which will be measured by the voltmeter.

3.1 Experimental setup and Equipment's that is used

Figure 3.2 Experimental Setup

1. Pump And Motor

Figure 3.3 Pump and motor for operating Machine

Power Range(HP)	0.25 HP(Single Phase Self Priming)
Speed	2850 rpm,50 Hz

Versions	230 V,50 Hz(Single Phase)
Types Of Duty	S1(Continuous)
Class of Insulation	F/B
Maximum Liquid Temperature	35 ^{0}C

2. U-TUBE MANOMETER

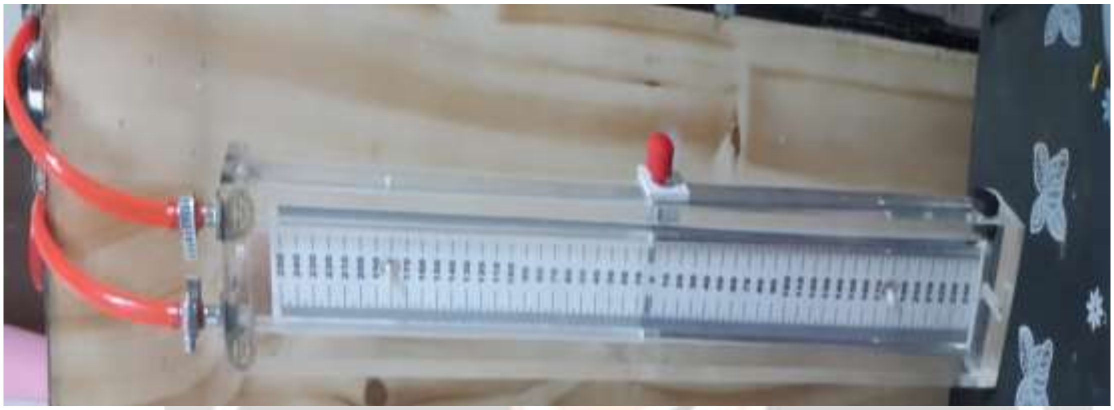

Figure 3.4 U tube Manometer for pressure difference

Body	Solid clear crystalc body
Subdivision	1 M.M W.C
Connection	House nozzle of PP
Scale	Black Anodized Aluminium Scale
Metering Tube	Finished glass coat
Range	250-0-250

3. DYNAMOMETER

Figure 3.5 Dynamometer for generating electricity

Item Weight	159 g
Product Weight	14.9*10.1*8.5 cm
Item model number	NTL-12VDCM
Weight	160 Grams
Colour	Silver

4. ORIFICE

Figure 3.6 Orifice

Diameter at inlet of orifice=0.028 m
Diameter at outlet of orifice plate=0.014 m
Area at inlet of orifice $=6.157\times10^{-4}$ m^2
Area at outlet of orifice$=1.539\times10^{-4}$ m^2

5. MULTIMETER

Figure 3.7Multimeter for measuring volt and current

Brand Name	Digital Multimeter Box
EAN	0740812318220
Item Weight	150 grams
LED	(2 red , 2 green, 2 yellow)
Resistors	1k,47k

6. STROBOSCOPE

Figure 3.8Stroboscope for measuring RPM

Brand Name	DT-315A Stroboscope
Design	durable properties and battery-powered motor
Features	internal power supply and portable structure
Battery	rechargeable internal batteries or AC line-power switched

3.2 Experimental Reading Calculation

1) $h = 17.5cm = 0.175m \therefore H = 12.6 \times 0.175 = 2.205m$

$$Q_{th} = \frac{a_1 a_2 \sqrt{2gH}}{\sqrt{a_1^2 - a_2^2}} = \frac{(6.157\times10^{-4})(1.539\times10^{-4})\sqrt{2(9.81)(2.205)}}{\sqrt{(6.157\times10^{-4})^2 - (1.539\times10^{-4})^2}}$$

$$= \frac{(9.47\times10^{-8})\sqrt{2(9.81)(2.205)}}{0.000596}$$

$$= 10.4\times10^{-4}\ \frac{m^3}{\sec}$$

2) $Q_{act} = \frac{A \times R}{t} = \frac{0.1 \times 0.12}{20} = 6\times10^{-4}\ \frac{m^3}{\sec}$

$$3) C_d = \frac{Q_{act}}{Q_{th}} = \frac{16\times10^{-4}}{10.4\times10^{-4}} = 0.576$$

$$4) \dot{m} = \rho \times Q = 0.6 \frac{Kg}{Sec}$$

$$5) P = V \times I = 9.5\times1.69 = 16.126 watts$$

$$6) I.P = \frac{\rho QgH}{1000} = \frac{1000\times 6\times10^{-4}\times9.81\times4.60}{1000} = 0.027kw$$

$$7) \eta = \frac{O.P}{I.P}\times100 = \frac{0.01612}{0.027}\times100 = 59\%$$

Table 3.1 Result Table

SR. NO	Pressure difference (cm)	Rise Of water level R(cm)	Time taken for R t(sec)	Discharge $\left(\frac{m^3}{\sec}\right)$	Mass flow rate $\left(\frac{Kg}{\sec}\right)$	Power (Watt)	(%)	(%) CFD
1	17.5	12	20	6×10^{-4}	0.6	16.14	59	70
2	16.4	11.2	20	5.6×10^{-4}	0.56	15.18	60	66
3	14	10.8	20	5.4×10^{-4}	0.54	14	55	62
4	12	10	20	5×10^{-4}	0.5	12.5	53	58
5	10	8.5	20	4.2×10^{-4}	0.42	11	55	54
6	8.3	7.9	20	3.9×10^{-4}	0.39	9	47.37	50
7	6.5	6.8	20	3.4×10^{-4}	0.34	7	43.75	46

4 RESULT AND DISCUSSION

After the experimental reading and the CFD analysis the comparison between the results of both the approach is carried out. So the evaluation can be done. The fig-4.1 and the fig-4.2 are showing the results for the Torque and Power output with respect to the Mass flow rate

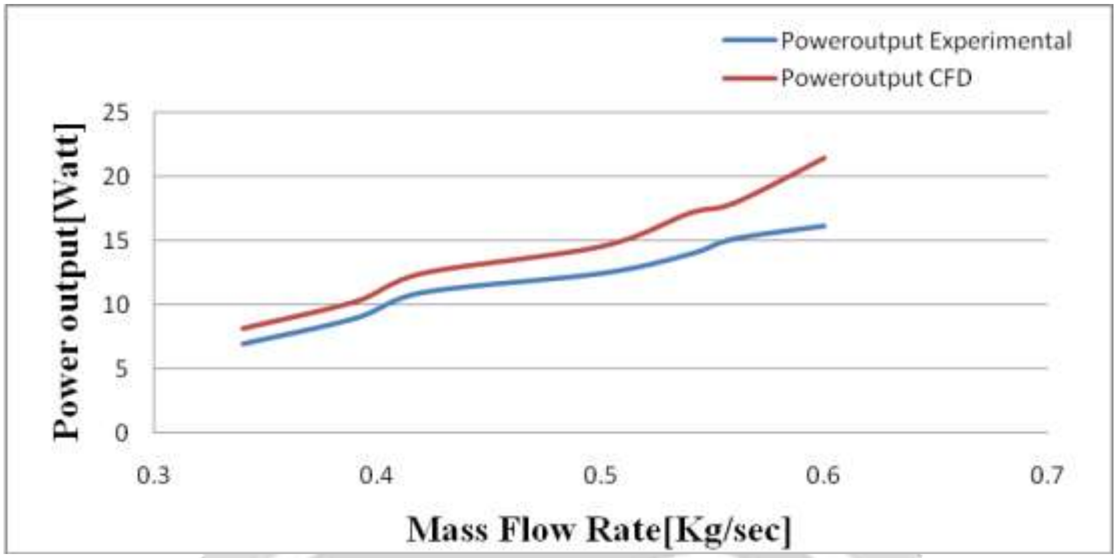

Figure 4.1 Power output respected to Mass Flow rate

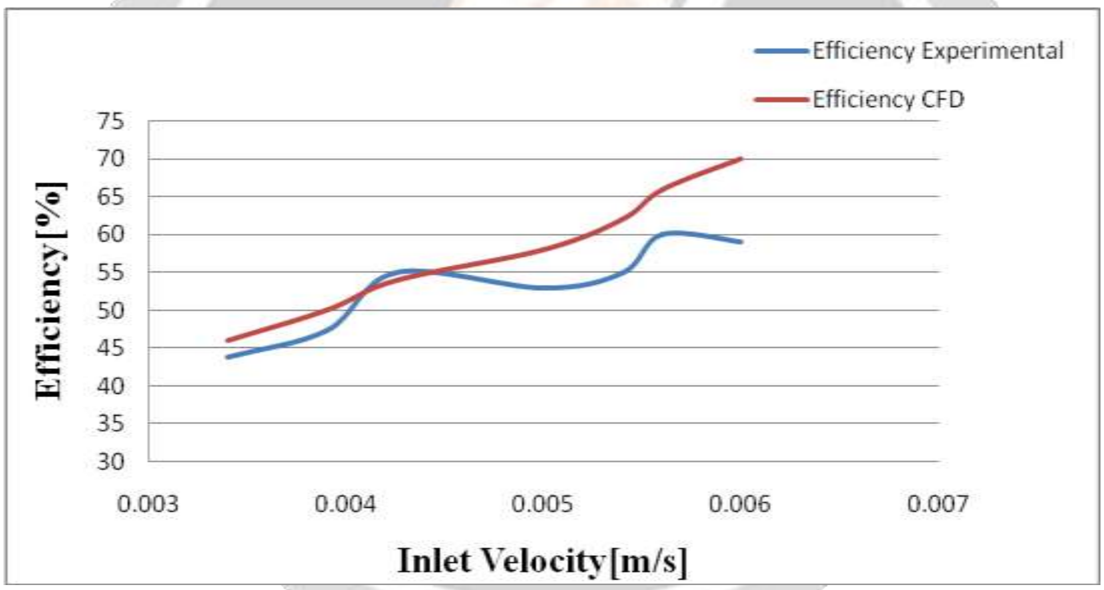

Figure 4.2 Efficiency with respected Inlet velocity

It was found out that the due to the pressure loss in the pipe of the experiment setup and the various others factor effecting the flow of the fluid is reason of loss of torque and the power output yet it is sufficient for providing the work to the generator. Though there are some improvement yet can be done for improving the output.

5 CONCLUSIONS

It is worth mentioning that the Tesla turbo machinery as a turbine especially fits into those instances where compacted unities are required for generating electrical power are required as in the case of isolated areas. It should be noticed that, as a unique source of rotating motion of this type, Tesla machines can run under a very wide spectrum of not only fuels but also fluids in general.

Tesla-type turbo machinery probably cannot prove competitive in an application in which more conventional machines have adequate efficiency and performance. Thus, it cannot be expected to displace conventional water turbines or gas turbines. Tesla-type turbo machinery can be considered as source of standard in applications in which conventional machines are inadequate. This includes applications for small shaft power, or the use of very viscous fluid or non-Newtonian fluids. It is an advantage that multiple-disk turbo machines can operate with abrasive two-phase flow mixtures with less erosion of material from the rotor.

In general, it has been found that the efficiency of the rotor can be very high, at least equal to that achieved by conventional rotors. With the increase in the velocity of the fluid and the decrease in pressure shows the increase in the efficiency of the turbine. Mass flow rate plays the important part in it. The CFD and Experimental readings shows the minor difference providing the losses in the turbine.

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