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RESEARCH ARTICLE OPEN ACCESS

Design & Development of Tesla Turbine Using Magnetic Bearing

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Abstract:

A Tesla turbine is bladeless centripetal flow type turbine. It is as well recognized as the boundary layer turbine, cohesion type turbine and Prandtl layer turbine because it is used boundary layer effect and not a fluid impinging upon the blades as in a convectional turbine. Tesla turbine has found wide ranging of application that include the handling of a mixture of solid, liquid and viscous fluid without damaging the part.

This research work is chiefly focused on implementation of magnetic bearing in Tesla turbine. Designing of magnetic bearing is done by suitable software. The development of Tesla turbine will carry out to influence the size of blade, blade gap, nozzle angle, appropriate magnetic field of magnetic bearing. New developed model imparts increase in efficiency and torque.

Keywords **—Turbine, boundary layer, blade.**

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I. INTRODUCTION

1.1 History and Background

Nikola Tesla invented the firstBladeless turbine in the year1913.Tesla turbine is distinguished by the fact that the rotor is composed of parallel rotating disks arranged normal to a shaft with very slight gaps. These disks are bladeless, thin and smooth. It is framed by a runner with thin spacers in between, shaft, housing, collar, nozzle and bearing. Tesla turbine is commonly practiced as the steam turbine to generate electricity. The high energy gasses like high pressure gaseous state and high velocity gas can be useful if it is able to convert to electrical energy [1]

Several closely-spaced flat disks were mounted on as haft. The working fluid flows between the disks spirally from the outer to inner radius and transfers energy to the rotating disks. When the fluid is in contact with a disk, the molecules adhere to the disk and resist departure. The force of the fluid will oppose the resistance of the magnetic disc. Therefore, the force of viscosity allows more fluid to act on the disk. As the fluid loses energy, it is discharged by the lower pressure in the turbine outlet [1].

Tesla stated that in order to gain the highest efficiency due to energy transfer, the changes in velocity and direction of movement of the fluid should be as gradual as possible [1]. This can be accomplished causing the propelling fluid moving in natural paths or streamlines of least resistance, free from constraints and disruptions caused by fans. Acrylic is used to fabricate housing, nozzle and vent plate.

Acrylic [1] is chosen attributable to its transparency, which benefits in observation of the rotating rotor when taking measurements of rotating speed. Aluminium rod is used to fabricate shaft and collar. Aluminum rod's lightweight is an advantage which helps in reducing the weight of the rotor. Lighter rod allows for quicker acceleration through the RPM range. Aluminum sheet of 0.001 mm thickness is used for disks and spacers. The main advantages of aluminum sheet are its lightweight and corrosion free. It is also easy to process. This aids in the process of laser cutting into disks and spacers. Ball bearing's function is to assist in the rotation of the shaft, disks and spacers. Ball bearing is chosen as it requires low starting torque. The turbine is an assembly consisting of a nozzle or stator, runner, and a shaft that collectively convert momentum and pressure in a water flow into rotational mechanical work.

1.2 Objective

- Tesla turbine is bladeless turbine we implement in blade design and simulation in software.
- To reduce the distance between disc and increase the efficiency.
- Use a magnetic bearing so increase the life of bearing.
- Made working model in with the help of machine workshop.

II. THEORY OF OPERATION

The working fluid enters the chamber through the inlet in the tangential direction and flows along the surface of the disk through the disk spacing. The flow path spirals towards the centre orifices, then exits axially through the outlet. Due to viscosity, the fluid adheres to the disks with the no-slip condition occurring directly adjacent to the disk surface and a velocity gradient forming throughout the working medium away from the surface. Through this phenomenon, some of the fluid energy is converted to mechanical work, causing the disks and shaft to rotate.[9].

Performance Parameters and Design Analysis

Since the original patented design by Tesla in 1913, while some researchers proposed modified designs to the original Tesla turbine design, some researchers showed interest on the modeling and numerical simulation studies aimed at achieving better performance of Tesla turbines. Many investigations have been carried out to determine the performance and efficiency of Tesla turbo-machinery. Most of these investigations had a certain limited application as the objective, with regard to size and speed as well as the nature of the operating fluid. However, some of the investigations have tried to establish the generalized performance of Tesla-type turbomachines. 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. But it has proved very difficult to achieve efficient nozzles in the case of turbines, and efficient diffusers for pumps and compressors.

As a result, only modest machine efficiencies have been demonstrated. Principally for these reasons the Tesla-type turbo-machinery has had little utilization. There is, however, a widespread belief that it will find applications in the future, at least in situations in which conventional turbo-machinery is not adequate.

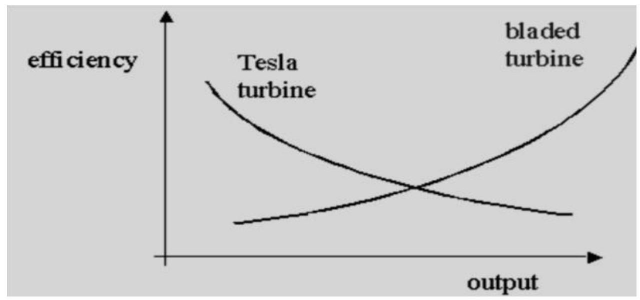


Figure 1.2: Graph showing the performance of Tesla turbine

Figure. Illustrates a comparison of performance of conventional bladed turbines and Tesla turbines. It can be seen that the performance of one is the inverse of the other and each has a certain point beyond which a switch over between the two is sought. While Tesla turbines are found to be more efficient at smaller power output, conventional bladed designs are better when higher output power is the requirement.

The performance and efficiency of the rotor of Tesla-type turbomachinery is found to be dependent on the combination of not only parameters related to the rotor assembly, but also on the efficiency of the nozzles and the nozzle-rotor interaction. The performance of the pump is also strongly dependent on the interaction of the fluid leaving the rotor with that in the volute and on the efficiency of diffusion in the volute.

III. DESIGN AND DEVLOPMENT

3.1 Design Parameter

Sr.No.	*Parameter*	*Dimension(mm)*
1.	Discouterdiameter	120
2.	Discinnerdiameter	25
3.	Discthickness	5
4.	Casinginnerdiameter	150
5.	Casingthickness	15
6.	Nozzleinletdiameter	5
7.	Nozzleoutletdiameter	2

8.	Nozzleangle(degree)	10°
9.	NumberofNozzle	6
10.	Shaftlength	700
11.	Shaftdiameter	20
12.	NumberofDisc	9
13.	MaterialofDisc	Aluminium
14.	Materialofcasing	Acrylic
15.	Spacingbetween twoDisc	3

Table No.1 Design parameter[12]

Calculation

Nomenclature:

$d = S\square aftdiameter(mm)$

$d_1 = Bus\square\ innerdiameter(mm)$

$d_2 = Bus\square\ outerdiameter(mm)$

$d_i = Discinnerdiameter\ (d_2 = d_i)\ (mm)$

$d_0 = Discouterdiameter(mm)$

$T = Twistingmoment(N.mm)$

$J = Polarmomentofinertia(N/mm^4)$

$r = S\square earstress(N/mm^2)$

3.2 Design of Shaft:

$$P = \frac{2\pi NT}{60000}$$

Pressure PSI	RPM	No. Nozzle
20	2500	3
35	2950	3
50	3300	3

$$8700 = \frac{2\pi 1000T}{60000}$$

$$T = 8308\ N.mm$$

$$\frac{T}{J} = \frac{\tau}{r}$$

$$\frac{T}{\frac{\pi}{32}d^4} = \frac{\tau}{r}$$

$$\frac{8308}{\pi} \times d^3 = 2 \times \tau$$

$$\frac{8308}{\pi} \times d^3 = 2 \times 5.4$$

$$d = 19.86\ mm$$

$$d = 20\ mmm$$

3.3 Design of Bushing:

$$d = 20\ mm$$
$$d = 1.5d_1$$
$$d_1 = \frac{d}{1.5}$$
$$d_1 = 13.33mm$$
$$d_2 = 13.33 \times 2$$
$$d_2 = 26.66\ mm$$

3.4Outer diameter of Disc:

$$\frac{d_0}{d_i} \geq 4.5$$
$$d_0 = 4.5 \times d_i$$
$$d_0 = 119.97\ mm$$
$$d_0 = 120\ mm$$

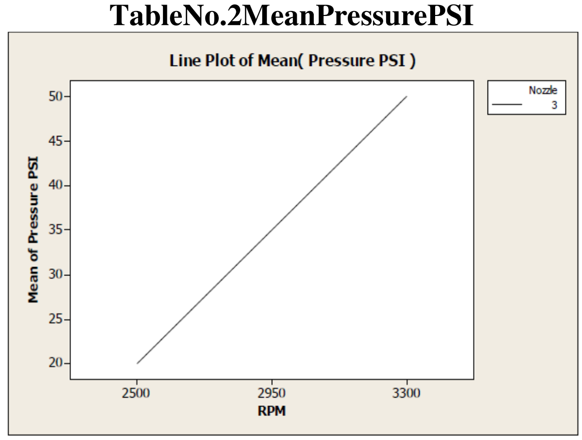
3.5Torque and Power Calculation:

$$\text{Pressure} = 22\ \text{Psi} = 0151684\frac{N}{mm^2}$$
$$P = \frac{F}{A}$$
$$F = P \times A$$
$$F = 3.89\ N$$
$$\text{TORQUE}$$
$$T = F * R$$
$$T = 233.92\ Nm$$
$$P = \frac{2\pi NT}{60}$$
$$P = 25.86\ \text{Watt}$$

IV. PERFOMANCE AND RESULT

4.1 Mean Pressure PSI Graph for 3 Nozzle:

TableNo.2MeanPressurePSI

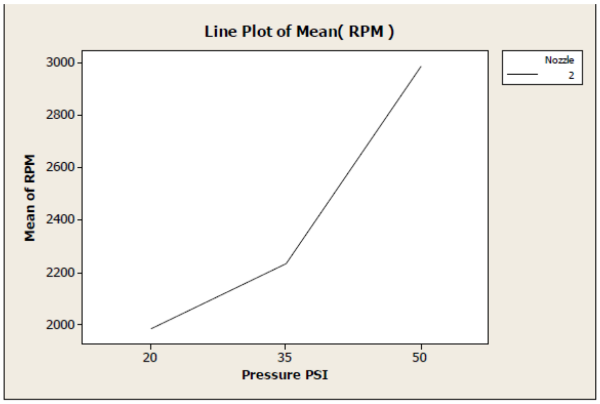


(Graph 1)

4.2 Mean RPM Graph for 2 Nozzle:

PressurePSI	RPM	No. Nozzle
20	2000	2
35	2360	2
50	3000	2

TableNo.3MeanRPM

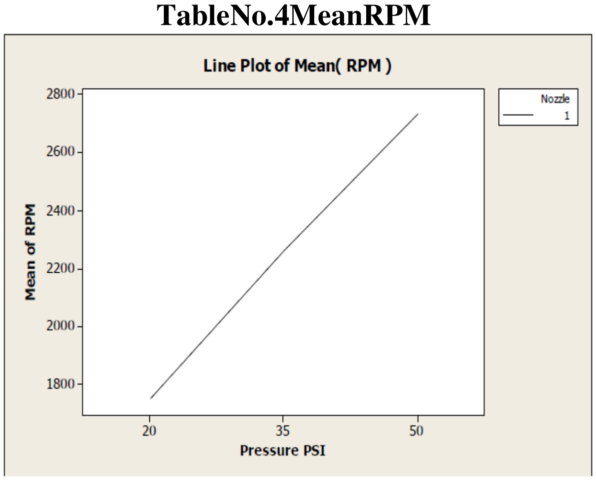


(Graph 2)

4.3 Mean RPM Graph for 1 Nozzle:

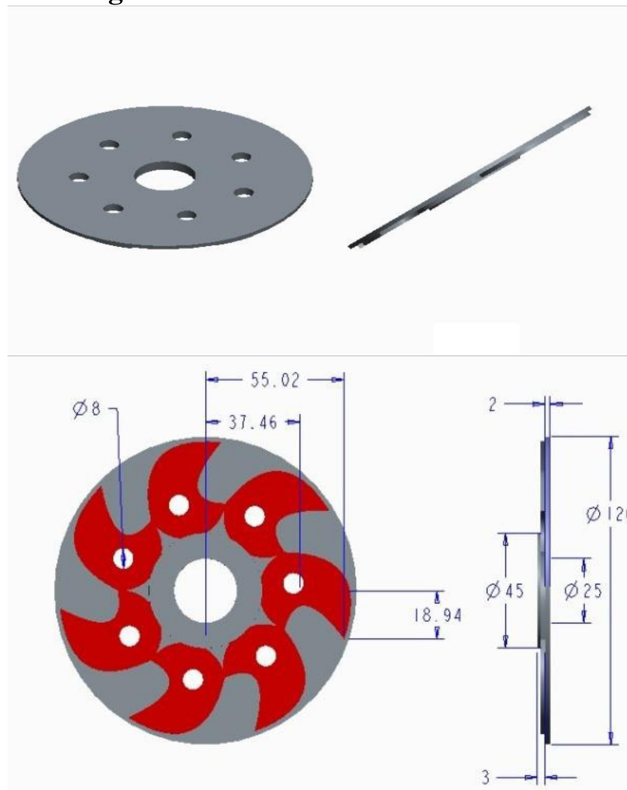
PressurePSI	RPM	No. Nozzle
20	1790	1
35	2100	1
50	2785	1

TableNo.4MeanRPM

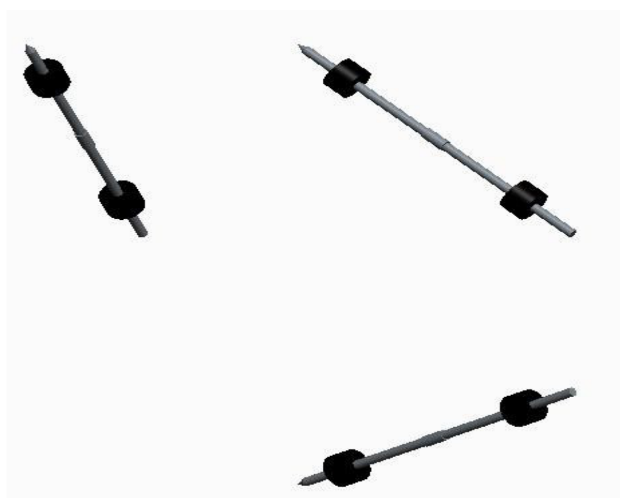


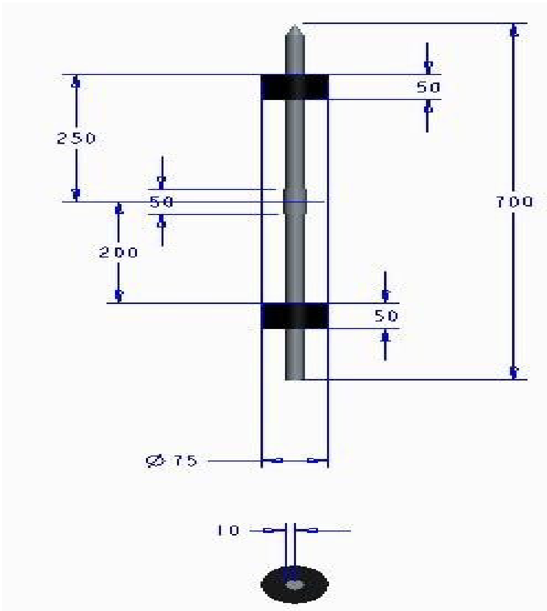
(Graph 3)

4.4 Design of Disc

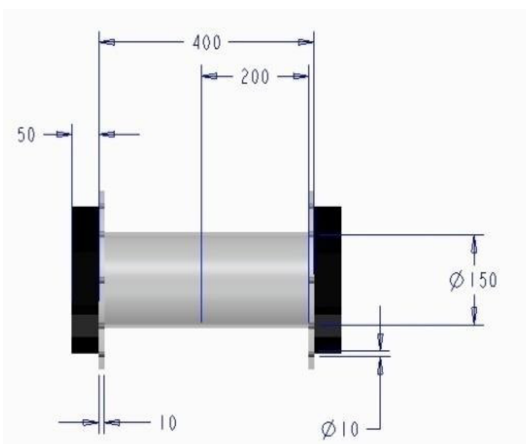


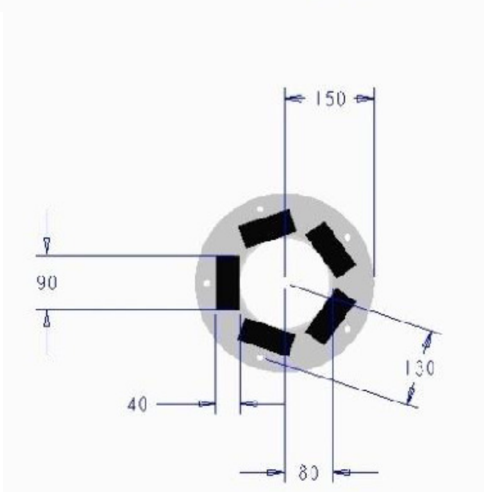
4.5 DesignofShaft

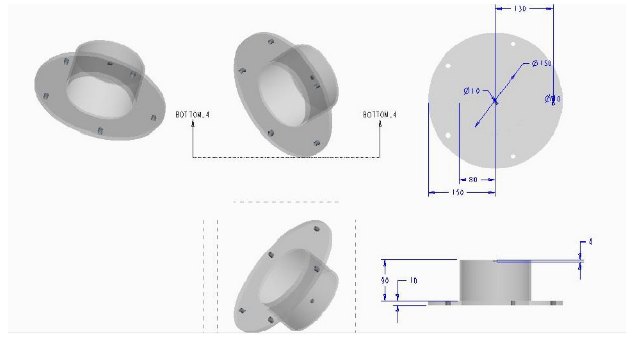


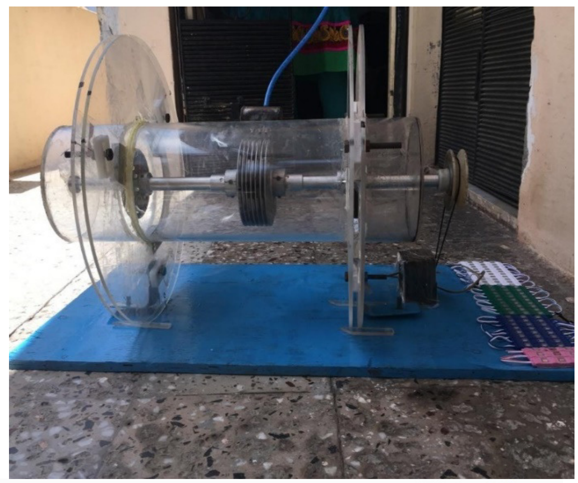


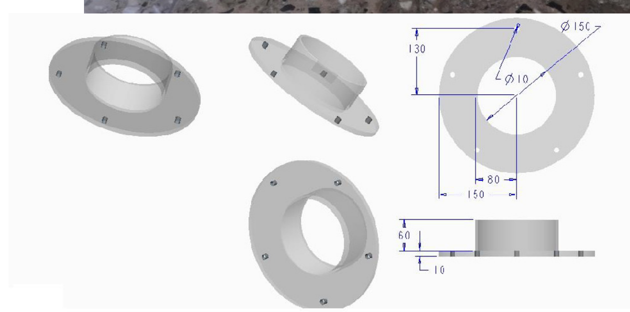
4.6 Design of Casing:



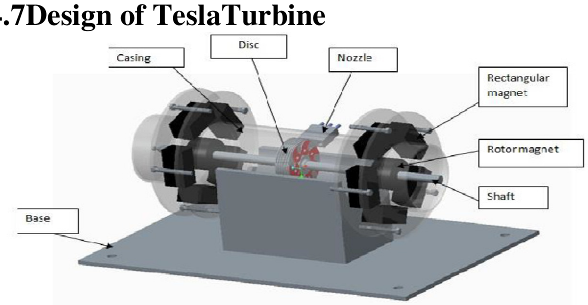








4.7Design of TeslaTurbine



1. Base
2. Casing
3. Disc
4. Nozzle
5. Rectangular magnet
6. Rotor magnet
7. Shaft

CONCLUSION

While using a magnetic bearing on behalf of other convectional bearing we found that a friction is reduce and turbine rotate freely. The initial efficiency increase and the increase in blade efficiency due to modification of blade design.

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