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A REVIEW OF TESLA TURBINE

Aniket Raje, Bikramjeet Singh, Ronak Churai and Pranav Borwankar
Department of Mechanical Engineering
SIES Graduate School of Technology, Mumbai University, India

ABSTRACT

The Tesla turbine, patented by Nikola Tesla in 1913, is a non-conventional bladeless turbine which works on the principle of boundary layer. It consists of a number of parallel discs fixed on a shaft with gaps between the discs. The fluid is made to flow tangential to the discs inside a casing. Momentum is transferred from the fluid to the discs due to viscous and adhesive forces. Not much work has been carried out in the first half of twentieth century but decent amount of published research and study has been done in the latter half. Some papers suggests modifications while some provide explanations for different performances and efficiencies at various parameters. This paper intends to review the principle, working, design modifications and the factors affecting the performance of Tesla turbine.

Keywords: Bladeless turbine, Boundary layer, Disc turbine, Tesla Turbine, Turbo machine.

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1. INTRODUCTION

Turbomachines are machines which convert fluid energy into rotational motion. Tesla turbine, also called as Prandtl turbine and boundary layer turbine, is a non-conventional turbomachine which operates on the principle of boundary layer. It does not use friction for its working, instead it uses adhesion (the Coanda effect) and viscosity for its functioning. Energy is transferred from fluid to the rotor by dragging discs mounted on the shaft due to boundary layer effect. Fluid flows tangentially towards the discs, follows a spiral path towards the centre and exits axially. The fluid loses its kinetic energy to the discs, thus causing the rotation of rotor. Both compressible and incompressible fluids can be used. The manufacturing of Tesla turbine is much easier compared to the conventional turbines. Also, the turbine is unaffected by the quality of the fluid, thus can be used with fluids containing particulates. A tesla turbine is a reversible turbomachine therefore it can be used as pump. In a pump configuration, the fluid enters axially near the centre. The discs provide energy to the fluid, following a spiral path and thereby exiting from the periphery.

After its invention by Nikola Tesla in 1913, not much research was performed. But decent amount of study has been carried out after 1950s. High amount of literature was published in the last few years. Commercialization has been attempted but has had little success due to its low efficiency at high power applications. Low power applications [1] [2] [3] have been proposed to be efficient than conventional turbomachines.

2. PRINCIPLE

The Tesla turbine works on the boundary layer principle. It was defined by Ludwig Prandtl. According to this principle, when the fluid passes over the discs the fluid particles adhere to the disc thus causing a condition of no slip. Thus, the velocity of the fluid near to the disc will be equal to that of the disc. In case of the disc being stationary, its velocity will be zero. The fluid velocity gradually increases as we move away from the disc surface, thus a velocity gradient is observed. This gradient exists in a direction normal to the surface, in a narrow region in its vicinity. This region is called boundary layer.

The boundary layer consists of two major regions: Laminar boundary layer and turbulent boundary layer. If U is the velocity of the fluid, in the laminar boundary layer, the velocity gradient dU/dy exists. Thus flow in this region is perfectly laminar. In the region between the laminar and turbulent boundary layers, the flow transitions from laminar flow to turbulent flow and hence its name. In turbulent boundary layer, the flow is completely turbulent.

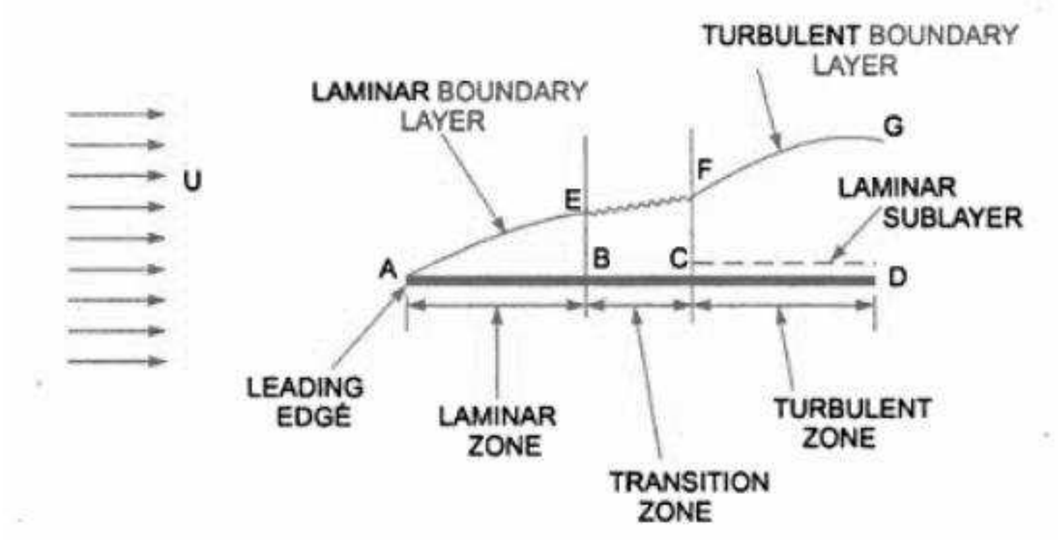

Figure 1 Boundary layer [4]

3. CONSTRUCTION AND WORKING

The Tesla turbine consists of a number of discs mounted parallel to each other on a shaft. Nozzles are located at the periphery of cylindrical casing and tangential to the shaft, pointing toward the inside. The discs are separated by thin gaps for the fluid to pass through it. Exhaust ports are located near the centre of the turbine.

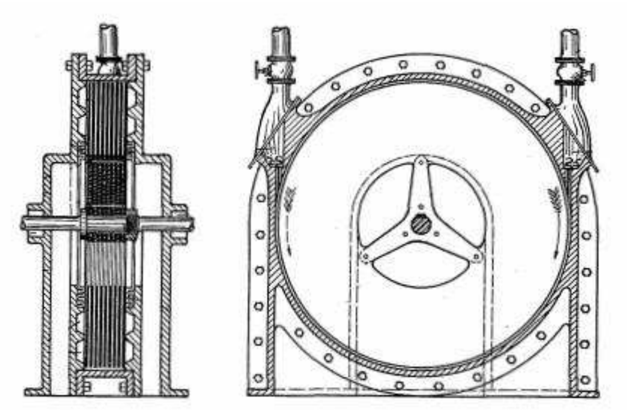

Figure 2 Tesla turbine from original patent [5]

Fluid enters tangentially into the turbine from the periphery. It is made to enter the gap between the discs. The moving fluid drags the discs in the direction of the flow. Due to this there is a transfer of kinetic energy from the fluid to the discs. This transferred energy causes the discs to rotate with the shaft. The fluid thus slows down as it moves towards the centre in a spiral path exiting from the exhaust ports.

4. FACTORS AFFECTING PERFORMANCE

Performance of tesla turbine is affected by various parameters. Few of them are:

4.1. Number of discs

The number of discs can be increased to increase the torque obtained. [6]

4.2. Dimension of the discs

The inner and outer radius determine the length of the spiral path followed by the fluid. The more the area of the discs the longer path will be travelled by the fluid.

4.3. Size of the gaps between the discs

The thickness of the gap should be equal to twice the boundary layer thickness. [7]

4.4. Number of nozzles

The torque obtained will be increased if the number of nozzles are increased.

4.5. Reynolds number

The laminar boundary layer thickness depends upon the Reynolds number. [4]

4.6. Velocity of the flow

The velocity of the fluid causes the kinetic energy which is transferred in the turbine.

5. APPLICATIONS

Tesla turbine was designed to use fluids as motive agents to rotate the rotors. It is found to be useful in low power applications but lacks in performance in high power applications [8]. Many experiments have conducted using tesla turbines for various applications such as steam turbines, turbo for automobiles. One of the most important applications of Tesla turbine is that it can be used where the working fluid contains particulates such as salt water or impure water. It also has applications when working with low and high viscous fluids.

Though Tesla turbine has not been successful in finding commercial utilization since its inception, Tesla pump on the other hand has been widely used in applications which require pumping abrasive fluids such as industrial waste etc. Tesla pumps for blood transfusion have become widespread.

6. CONCLUSION

The tesla turbine is a nonconventional promising technology that is yet to be fully researched and optimized. More applications are yet to be studied and developed. Complete optimization of tesla turbine performance is beyond the scope of this paper.

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