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STUDY OF OPERATION OF TESLA TURBINE

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***Abstract:** Turbo-Machinery is one vast field to work in with. The conventional turbines used in practice have many problems associated with the blades of the rotor viz, blade failure, crack in blade, vibrations etc. The aim is to eliminate these problems by advancement in design i.e. a new bladeless turbine named as Tesla turbine. The turbine is also known as the boundary layer turbine and Prandtl turbine operating on the principle of the boundary layer. It uses the adhesion and viscosity of the fluid for its working thus avoiding friction. This paper gives the insight to the bladeless turbine called Tesla Turbine and the advancements till date. It also focuses on the critical dimensions of the turbine. The CAD drawings are also provided for the rotors of the turbine. The performance parameters study includes power output, torque transmitted and efficiency.*

Keywords-component; Turbomachinery, bladeless turbine, Performance analysis, Tesla turbine,

I. INTRODUCTION

All gas and steam turbines built to date have one thing in common. The Working fluid is propelled to and is expanded against the face of the turbine blades. This is true in both the radial inflow and axial flow turbines. The problems with both designs is the inability to handle particulates, contaminates and heavy moisture. Also, due to the frontal impact of the Working fluid, stresses are more pronounced and a much heavier and higher alloy material is needed. Nikola Tesla (1846-1943) in 1913 made an invention to overcome the drawbacks of the conventional turbine by outlining a turbine design with a rotor consisting of discs with openings in the central areas and separating star washers. The turbine is also known as the boundary layer turbine and Prandtl turbine operating on the principle of the boundary layer. It uses the adhesion and viscosity of the fluid for its working thus avoiding friction. The fluid entering tangentially to the rotor enter into the space between the discs and transfer its energy to the rotor by dragging the discs mounted onto the shafts and exits axial through the central exhaust ports. On its way passing through the discs and exiting centrally, the fluid follows the spiral path into the exit ports. The transfer of energy greatly depends on this paths i.e., higher the spiral turns of the fluid, higher is the energy transfer and thus higher is the rotational speed of the turbine. The main aspect of the Tesla type turbine is that it can handle the fluid with the particulate and the contaminants and still give the desired output.

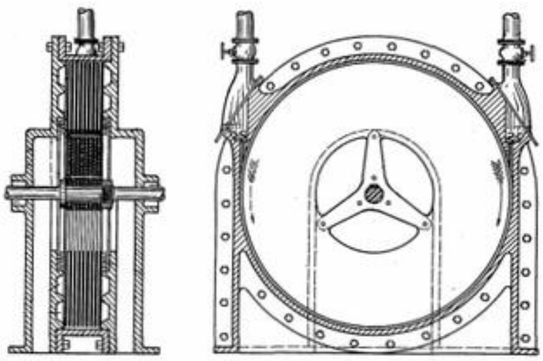

Fig. 1.1 Sectional view of Tesla turbine

Again the Tesla turbine is the reversible machine i.e., it can work as a pump too. If the inlet and outlet of the turbines are exchanged and the casing is made involute, the same system can work as pump. The fluid to be pumped is entered centrally and then the fluid is pumped out radially by spiral path. This type of pump can handle the highly viscous fluid, abrasive fluids, fluids with contaminants etc.

II. LITERATURE SURVEY

In order to overcome the drawback of the turbines, Nikola Tesla [1][10] made an effort and was found successful in doing so. In the year 1913, he was given a patent (US1061206) for his work. He established a turbine having identical multiple discs mounted on a shaft having equal distance between them. In his invention he showed how the fluid will transfer the energy to the discs and the turbine will operate to give the output. He also claimed in his other patent (US1061142) that the same turbine can also work as a pump if the inlets and the outlets are just exchanged working being the same.

Robert A. Oklejas et. Al. [2] in 1973-74 also did some useful work in the same field and got their work patented (US3899875) on 16 Jan. 1974. The work done was towards utilizing the waste heat carried out by the exhaust gases and also cooling the discs with the help of air. The invention gave an improved design of the rotor in which the spaces was given between the discs to pass the air for cooling purpose. The exhaust gases pass through the discs and transfer the energy as usual but the change in the design of the rotor allows the air to pass in between the discs. As a result, the air cools the discs that are hot due to the exhaust gases. Simultaneously, the air gets heated up. Now, this air can then be used in combustion chamber for combustion. Thus preventing the discs from getting melted due to the high temperature. The schematic diagram is as shown in the Fig. 2.1.

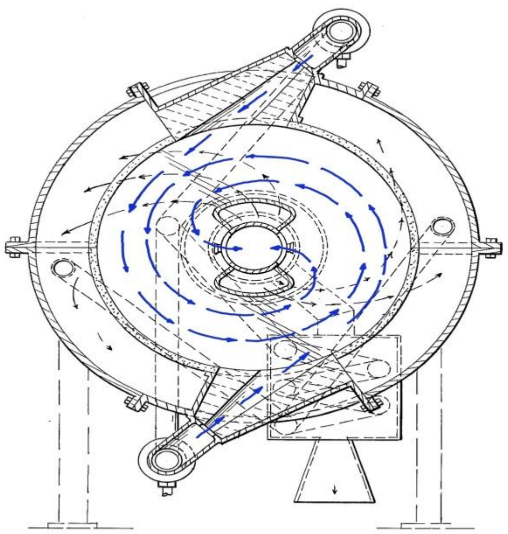

Fig. 2.1 Front view of the Robert Oklejas`s design [2]

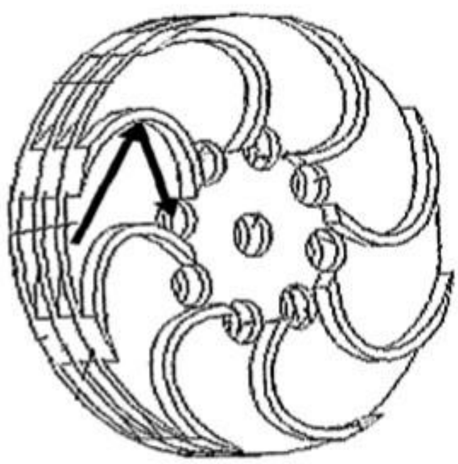

Fig. 2.2 Hybrid Pelton-Tesla Wheel[4]

Melvin L. Preuitt [3] in his patent (US20090260361) published on 3rd Oct. 2008 analyzed that if the process in the turbine is done isothermally instead of adiabatically, the work done is more than the previous case. It is also valid for the pump that, if the pump works on isothermal cycle, lesser amount of power/work is to be supplied for its working. In order to achieve the isothermal state during process, the heat is added to the system which is lost by the gases in case of the turbine. Similarly, in case of the pump, the heat is extracted from the system by supplying the air for the cooling purpose and thus maintaining the temperature.

In 1980 Marynowski et. Al. [7], patented their invention “radially staged drag turbine”, which claims an Improvement in friction turbine or drag turbine by employing a plurality of separate stages. The invention is particularly directed to application wherein a number of stages are required to achieve high efficiency operation.

In another patent (US20110027069) published by Heraldo da Silva Couto et. Al. [4] worked on improving the torque transfer capacity of the turbine. In their invention they combined the principles of the Tesla turbine as well as the Pelton wheel. Tesla turbine giving its property to rotate at higher speed and Pelton wheel being able to increase the torque transmitted by the rotor. In order to combine the effect, in between the Tesla turbine discs the Pelton bucket is introduced as shown in the Fig. 2.2.

III. OPERATION OF TESLA TURBINE

A. Ray Diagram

As quoted by the Nikola Tesla in his paper, the turbine needs the pressurized flow of gases or air for its working. If the working fluid is not at higher pressure, then the turbine might not give the satisfactory results. Again, in our work Convergent Divergent Nozzle is used which requires fluid at high pressure for its working. The main function of the C-D Nozzle is to reduce the pressure loss and increase the velocity of the fluid to supersonic speed before exposing it to the rotor. As shown in Fig. 5.1, the compressor takes in air from atmosphere. The compressed air is then passed to the C-D Nozzle. The air coming out of the Nozzle is at high velocity and is supplied to the turbine. Which is then rotated and it produces the power. In big industries this air can again be used in the combustion process by heating it in heat exchanger by the heat of hot exhaust gases. In our work we are not going to use the heat exchanger. The presence of heat exchanger in the figure is just for reference purpose.

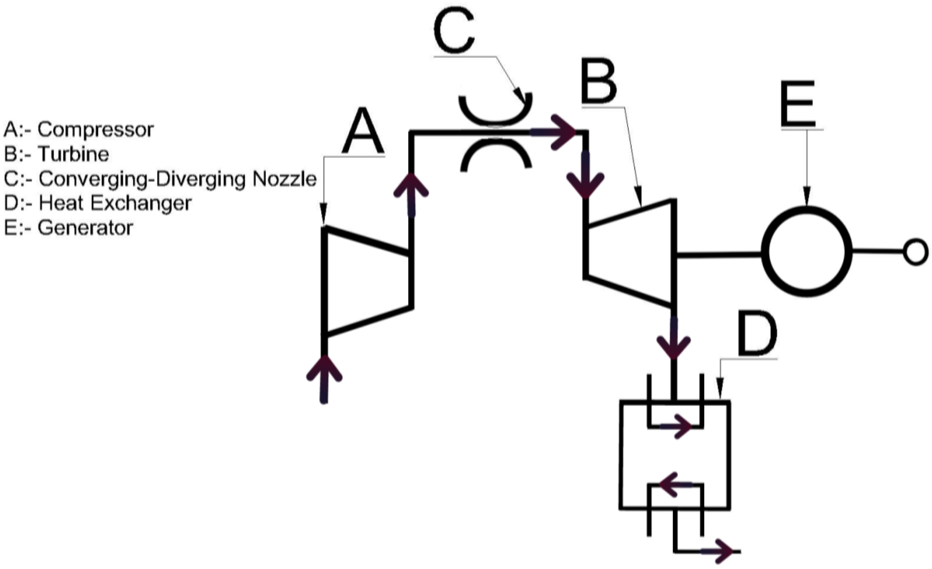

Fig. 3.1 Ray Diagram of Tesla Turbine

B. Operation of Turbine

As shown in the Fig. 4.1, The turbine needs pressurized fluid for its operation obtained by the compressor and air being the working fluid can be obtained from the atmosphere. As Tesla Turbine can be used with any kind of the fluid, the fluids with heavy particulates, contaminants, exhaust gases at higher temperature can be used as a working fluid. The compressor available is the Con-Air`s double acting piston compressor capable of producing 12 bar of pressure. The operating range of the pressure is 6-7 bar.

Once the air is compressed, it is passed through the C-D Nozzle to reduce the pressure losses and to increase the velocity of the air. The air from outlet of the compressor is at high pressure and temperature. The air coming out of the C-D Nozzle is at lower pressure compared to the air from the compressor. Then it is passed through the turbine. In turbine, the air as stated earlier passes over the discs and drags them with it. The air transferring its energy to the discs spirals out of the central exhaust provided onto the discs. In process of entering from the nozzle to leaving through the central exhaust, the air expands and as a result the temperature of the air reduces and thus the pressure. Generally, the shaft of the turbine is connected to the shaft of the generator as shown in Fig. 3.1 which converts the rotational (mechanical) energy into the useful electrical energy. The air coming out of the turbine is used again for the combustion purpose. In industries where the exhaust gases are the by-product, the air can be passed through the heat exchanger along with the hot exhaust gases. This will preheat the air and then it is used for the combustion purpose which is the working principle of Rankine cycle. Thus, the Rankine cycle is the basic cycle over which the whole industry works.

The components of the turbine mainly include the stator and the rotor. Like any other turbine, the stator part consists of the three different parts such as casing, nozzle and the exhaust ports. Similarly, in rotor part, there are mainly two elements viz, disc stacks and the shaft unlike the other turbines. Disc stack is one of the important part of the Tesla Turbines rotor. It is the no. of similar discs equidistant from each other. When this discs are mounted on the shaft and are used in actual condition, gives the very high rotational speed. There are number of concepts used for the discs stacks to be used. One of such is the hybrid Pelton-Tesla wheel. In this type of the stack, the distance between two successive discs is managed by introducing the extended surface which serves as a Pelton bucket and as a spacer too. The Hybrid Pelton-Tesla wheel is as shown in the Fig. 2.2. The disc stacks are as shown in Fig. 3.2.

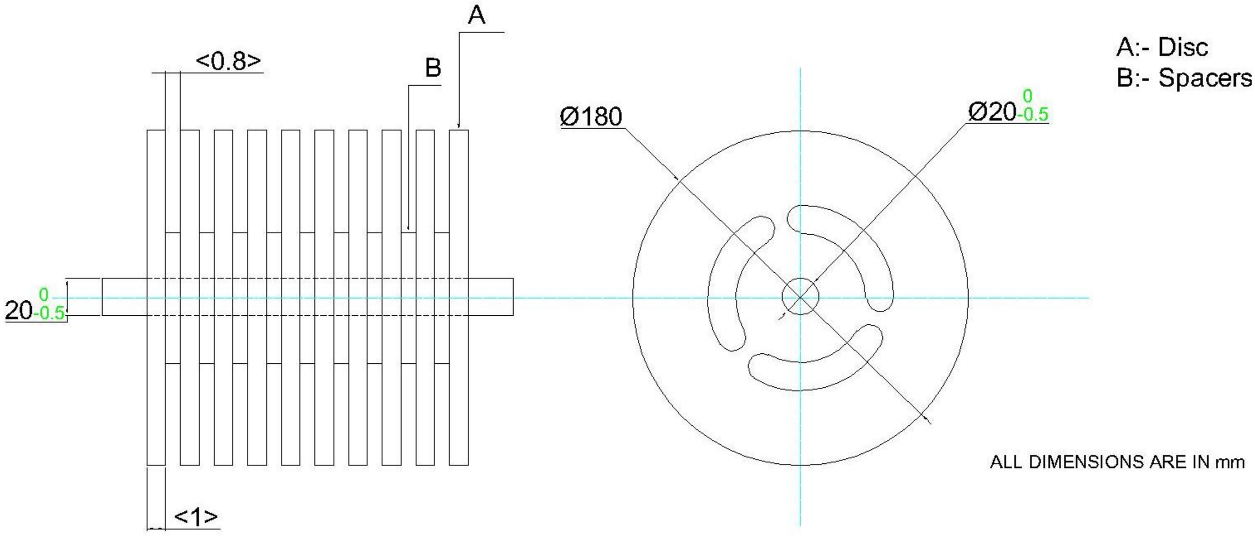

Fig. 3.2 Rotor disc stack

The disc stacks are made of mild steel material. The specifications of our rotor are as shown in the table 4.1.

Table 3.1 specifications of the rotor

Specifications	Dimensions
Disc Outer Diameter (mm)	180
Disc Inner Diameter (mm)	20
No. of Discs	10
Gap between successive Discs (mm)	8
No. of exhaust holes	3

The dimensions of the shaft to be used and the rotational speeds obtained can be known from the specification of the bearings that are to be used. The data can be obtained from the bearings because bearings have the limiting value of rotations according to their dimensions/specifications. For the specifications of the bearing as shown in the Table 3.2, the permissible rotational speed is 10000rpm. Thus our operating range will be from 6000-8000 rpms for around pressure range of 6-7 bars.

Table 3.2 Specifications of the bearings

Specifications	Dimensions
Bearing Inner Diameter (mm)	20
Bearing Outer Diameter (mm)	42
Bearing Width (mm)	12
Dynamic Load Carrying Capacity (kN)	9.9
Static Load Carrying Capacity (kN)	5
Permissible Speed (rpm)	11000

IV. FACTORS AFFECTING PERFORMANCE OF TESLA TURBINE

1. Spacing between the discs

One of the important factors affecting the performance of the turbine is the spacing between the discs. As the spacing between the discs increases, the speed of turbine decreases and so the efficiency of the turbine also decreases. Again the power output also decreases considerably.

2. Mass flow rate

As the mass flow rate to the turbine increases the power output from the turbine increases and hence the enhancement of the efficiency of the turbine can be achieved. The mass flow rate can be increased by increasing the number of supply nozzles to the turbine.

3. No. of discs

The increase in the no. of discs of the rotor increases the torque of the turbine and as result the efficiency of the turbine increases. The increase in no. of discs increases the surface area being in contact with the fluid as a result the power increases.

4. Diameter of the rotor

On increasing the diameter of the rotor, the surface area of contact increases and thus the power output and the speed of the rotor increases. The condition of increasing the diameter of the discs is that the inlet fluid must be at sufficient high pressure to flow through the central exhaust.

5. Nature of the inlet fluid

As the temperature of the inlet fluid increases, the power output of the turbine increases. One of the main factor to be considered is that if the fluid contains the particulate, the power output as well as the speed of the turbine reduces and the particulates damage the discs.

V. CONCLUSION

Tesla turbine is an important invention in the field of turbo machinery. It can be used in the geothermal power plant very efficiently. It can also be used as a pump and is being used in medical industries for pumping blood. The important conclusions drawn from the studies includes that it has an ability to provide high rotational speeds in comparison with the conventional turbine for the same input. Again, it gives good performance at lower speed which the conventional turbines fail to provide. It can also handle the fluid with heavy particulates without damaging the rotor. The cost of its construction in also very less as it does not include the blades. Thus, Tesla turbine is one very promising invention in power generation field.

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