DESIGN OF A BLADELESS WIND TURBINE

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ABSTRACT

Turbines that would provide a quiet, safe, simple and efficient alternative to our supposedly advanced bladed turbine aircraft engines are the need of the hour. One such turbine called the bladeless turbine that poses to be the ideal replacement for the conventional turbines was successfully designed. The design of such an unconventional turbine was conceived considering the catastrophic effects that conventional turbines may have on the machines they are incorporated. The turbine is designed in such a way that the blades of a conventional turbine are replaced by a series of flat, parallel, co-rotating discs spaced along a shaft. The discs are used to eliminate the expansion losses that are incurred in conventional turbines and also to reduce noise considerably at high RPMs. Furthermore, the design of the turbine ensures that the turbine rotates at high RPMs with total safety unlike a conventional turbine which explodes under failure due to fatigue. The engines making use of these bladeless turbines can run efficiently on any fuel, from sawdust to hydrogen. Bladeless turbines are also the greenest turbines with almost nil harmful effects on the environment. Another major advantage of this design is that this turbine has only one moving part, thereby reducing the vibrations to a minimum. Overall this design aims at bringing out a new age turbine with improved performance that can provide an engine that is economic, eco-friendly and reliable as the expensive, complicated and wear prone transmission is eliminated.

Key-Words: Bladeless turbine; Boundary layer; Conceptional design; Effects and Results; 3-D modeling; viscous effect

1. Introduction

In 1913 Nikola Tesla patented a bladeless centripetal flow turbine called the Tesla turbine. It is referred to as a bladeless turbine. The turbine is also known as the boundary layer turbine because it uses the boundary layer effect for its operation unlike a conventional turbine where a fluid impinging upon the blades drives it. Bioengineering researchers have referred to it as a multiple disccentrifugal pump[1].The performance of Tesla turbine is found to be influenced by a number of parameters including width of discs, number of discs, gap between discs, jet angle at inlet, inlet pressure, load applied, Mach number and Reynolds's number[2].

Tesla in his patent argued that for high efficiency devices changes in velocity and direction should be gradual. Tesla sought to design a device where the fluid was allowed to follow its natural path with minimal disturbance, both to increase efficiency and to reduce cost and complexity in the device. He pointed out several important factors affecting

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performance, including that increasing size and speed increases the efficiency, as does decreasing the disc spacing. He also mentions that centrifugal pressure gradients, increasing with the square of velocity, prevent the device from running away to high speeds and thus preventing the device from damage [3].

Conventional turbines suffer a major drawback in practical applications because of their low efficiencies. Their efficiency is lowered by the use of moving blades to generate shaft power. Thus failure of a single blade results in inadequate expansion which directly affects the overall efficiency of the turbine. On the contrary Tesla turbine consists of a set of smooth disks, with nozzles applying a moving gas to the edge of the disc. The gases drag on the disc by means of viscosity and the adhesion of the surface layer of the gas. As the gas slows and adds energy to the discs, it spirals into the center exhaust and causes rotation of the discs[4].Thus minimizing the expansion losses and increasing the efficiency of the prime mover.

2. Formula for determining torque

Tesla describes a dynamic relation between the disc and the fluid [3]. However the mass and viscosity of the fluid are essential in developing an equation that will work across fluid. The equations are:

Momentum = mass * velocity

Kinetic energy = $(\text{mass}*\text{velocity}^2) / 2$

Also engineers have developed a dynamic relation between torque and fluid viscosity as follows,

Torque = $(3uvr^2) / 2h$

Where

v = velocity of the fluid, in meters/second

u = viscosity of the fluid, in Pascal-second

r = radius of the disc, in meters

h = half of the distance between the discs, in meters

3. Design

Designing of the model was done using CATIA as this software provides an interactive function to design parts in a very intuitive way, taking manufacturing constraints into account on the basis of the dimensions given in the table below:

Parameter	Dimension
Thickness of each Disc	2mm
Outer diameter of the Disc	120mm
Inner diameter of the Disc	15mm
Hole diameter	20mm
Angle between each hole	60deg
Shaft length	76mm
Washer outer diameter	40mm
Washer outer diameter	15mm
Washer thickness	1.5mm
Outer casing thickness	17mm
Outer casing outer diameter	120mm
Outer casing inner diameter	15mm
Total number of discs	11
Total number of Washer	12

Using the design and drafting software CATIA V-5 R-20 the 2-D and 3-D view of the various components of the turbine are shown below:

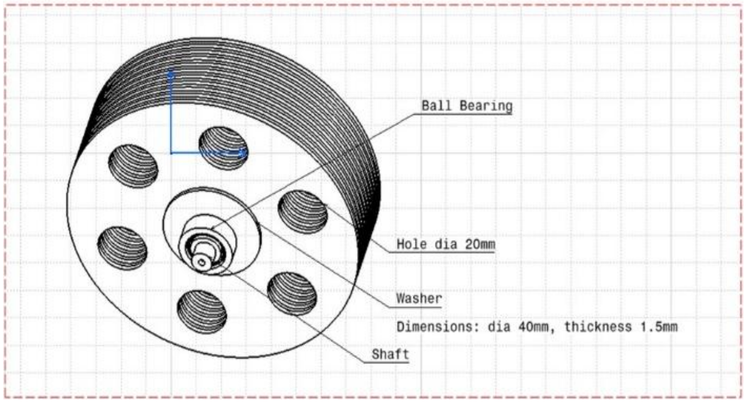

Fig 1.1 CATIA 2-D draft assembly of disc, washers, shaft and ball bearing

Fig 1.1 shows the 2-D draft of disc, washers, shaft and ball bearing assembly modeled in CATIA V5 R20. Each disc is separated by 1.5 mm thick washer. Eleven discs, twelve washers and two ball bearings are mounted on a 76mm long shaft.

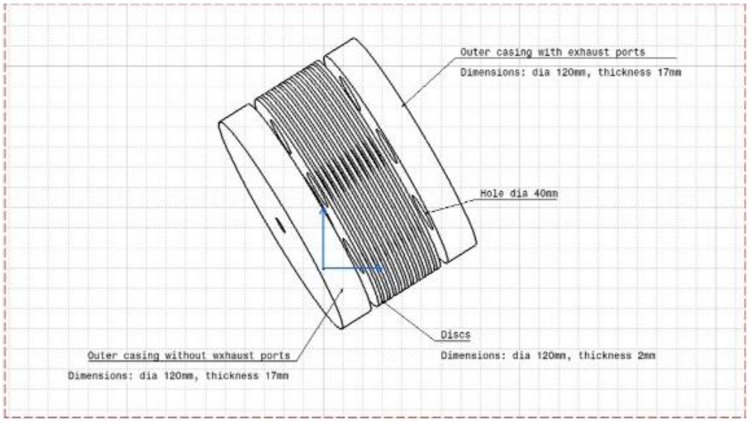

Fig 1.2 CATIA 2-D Draft assembly of disc, washer, shaft, ball bearing, and outer casing

Fig 1.2 shows the 2-D draft of disc, washer, shaft, ball bearing, and outer casing assembly modeled in CATIA V5 R20. The assembly has two casings at the extreme ends, one with exhaust ports and another without exhaust ports.

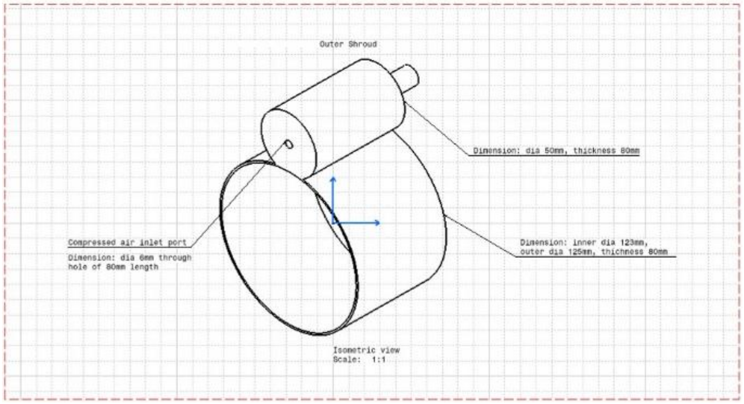

Fig 1.3 CATIA 2-D draft of outer shroud

Fig 1.3 shows the 2-D draft of outer shroud modelled in CATIA V5 R20. The shroud has an outer diameter of125mm and an inner diameter of 123mm. Air inlet is positioned on top of the shroud and a 6mm air inlet port is drilled through an 80mm length.

The air inlet is designed in such a way that the air comes in and hits the disc tangentially to convert the pressure energy to the kinetic energy [6]. The inlet port is designed in such a way that the efficiency in maximum. It has been found that the losses is increased when the air enters axially towards the disc. Clockwise and anticlockwise rotation of disk is made possible through the design of inlet valve.

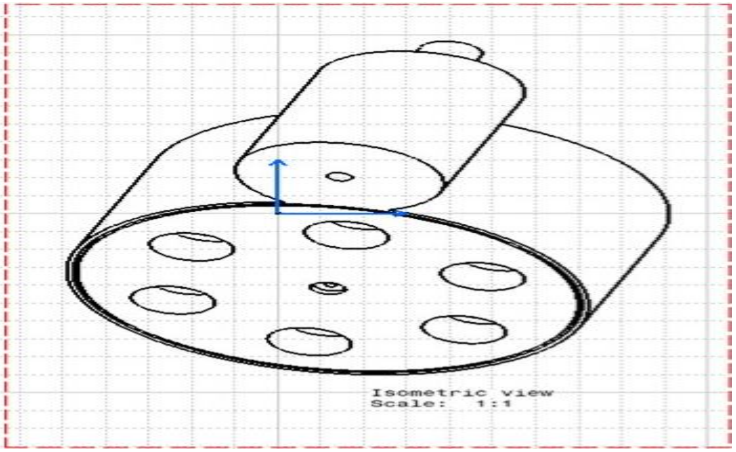

Fig 1.4 CATIA 2-D draft of final assemnbly

Fig 1.4 shows the 2-D draft of tesla turbine final assembly modeled in CATIA V5 R20.

The centrifugal forces generated within a Tesla turbine tend to push higher density compressible fluid toward the outer edges of the discs. This increased density increases the skin friction between the fluid and the discs. Tesla Turbine Engine can turn at much higher speeds with total safety. Even if itgoes critical, the failed component will not explode but implode into tiny pieces which are ejected through the exhaust while the undamaged components continue to provide thrust to keep the engine running. If a

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conventional bladed turbine engine achieves critical speed or fails, theexploding parts may cause serious damage to the engine leading to total failure.

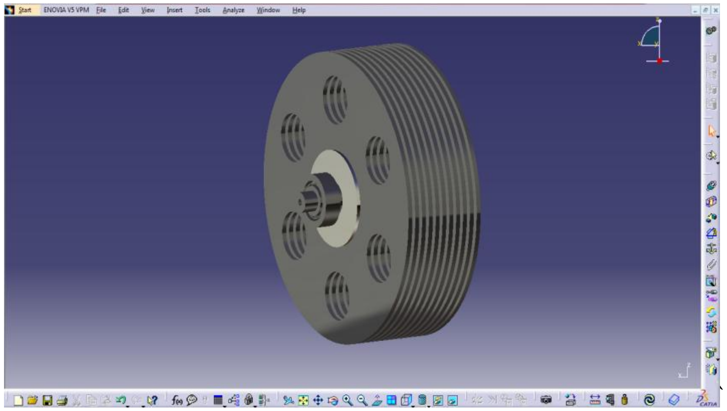

Fig 1.5 CATIA 3-D tesla turbine disc assembly

Fig 1.5 shows the disc, washer, shaft and ball bearing assembly of the Tesla turbine modeled in CATIA V5 R20.

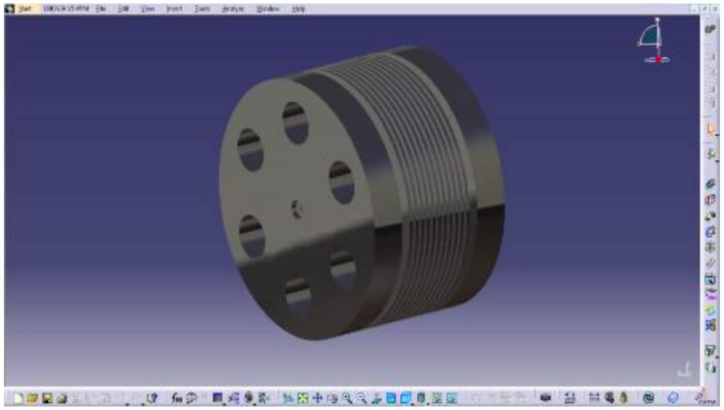

Fig 1.6 CATIA 3-D tesla turbine assembly

Fig 1.6 shows the discs, washer, ball bearing, shaft and outer casing assembly of Tesla turbine modeled in CATIA V5 R20.

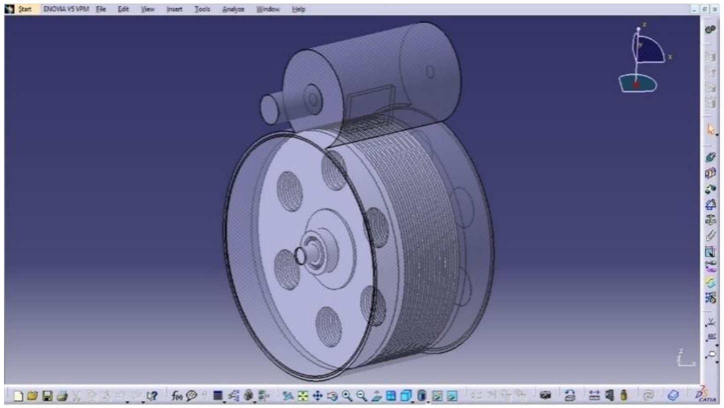

Fig 1.7 CATIA 3-D tesla turbine final assembly

Fig 1.7 shows the final assembly of tesla turbine modeled in CATIA V5 R20.

4. Conclusion

The concept of a boundary-layer turbine originated about a century ago, in the research of Nikola Tesla.Fluid parameters describing the interaction of disc with fluid is studied [4].A high-velocity of fluid is injected tangentially into the spaces between a stack of closely spaced discs, flowing inwardly in a spiral toward a centrally located exhaust. The drag between the surface of the discs and the fast moving fluid results in the conversion of fluid flow to mechanical power. This turbine was invented in response to the problems with bladed turbines and also with the intent to use it to help generate electricity from steam from geothermal sources. The construction permits free expansion and contraction of each plate individually under the varying influence of heat and centrifugal force and possesses a number of other advantages which are of considerable practical importance[5]. This turbine directly converts kinetic motion of the fluid into rotary motion via the boundary layer effect and adhesion.

The boundary layer turbine is simple to build, maintain and modify. This turbine is safer in the case of disc/blade failure or other parts failure, since the housing compartment or casing can be made strong enough to contain broken or cracked discs and often the failure of one or more discs will not necessarily lead to the failure of the entire turbine. This design is very sturdy because the discs and rotor are bolted together and there is minimal wear except on bearings. Also it does not suffer from cavitation or particulate problems that many turbines and fans must deal with andcan work with a wide variety of working fluids and over a wide range of temperatures.

This turbine is an efficient self-starting prime mover which may be operated as a steam or mixed fluid turbine at will, without changes in construction and is on this account very convenient [4].

In spite of all the above mentioned advantages the boundary layer turbine is limited to small scale application. However this turbine has the potential to eliminate all the disadvantages of the present day conventional turbines in the near future. In order to achieve this the design of the turbine will be modified slightly and an optimum design will be arrived at.

5. References

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