DESIGN OF A BLADELESS WIND TURBINE

[1]Soumya Ranjan Panda, [2]Kunal Dash, [3]Reetesh Ranjan, [4]Abhinash Bhoi, [5]Jayadev Das

Under Graduate students
Department of Mechanical Engineering
G.I.E.T Gunupur

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, conical shaped structure spaced along a shaft. The Structure is 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**

I. 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 affectingperformance, 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.

The Vortex Street effect was first described and mathematically formalized by Theodore von Kármán, the genius of aeronautics, in 1911. This effect is produced by lateral forces of the wind on any fixed object immersed in a laminar flow. The wind flow bypasses the object, generating a cyclical pattern of vortices, which can become an engineering challenge for any vertical cylindrical structures, such as towers, masts and chimneys. The issue is that they may start vibrating, enter into resonance with the lateral forces of the wind, and ultimately, collapse. One of such Bladeless Wind Power Generation examples is the collapse of three cooling towers of the power station Ferrybridge in 1965.
However, it is possible that the same forces can be captured to produce energy - the idea behind Vortex. When a semi-rigid structure enters into a horizontal laminar air flow, it begins to vibrate under the influence of the lateral forces generated by the vortex street. When the frequency of vortex occurrence in the atmosphere matches the natural frequency of the structure, it enters into resonance, maximizing the amplitude of vibration and coincidentally, the power generation capability we are interested in. The natural frequency of any object is limited and would only enter resonance and vibrate at certain wind speeds.

Bladeless Turbine buses a radically new approach to capturing wind energy. Our device captures the energy of vorticity, an aerodynamic effect that has plagued structural engineers and architects for ages (vortex shedding effect). As the wind bypasses a fixed structure, its flow changes and generates a cyclical pattern of vortices. Once these forces are strong enough, the fixed structure starts oscillating, may enter into resonance with the lateral forces of the wind, and even collapse. There is a classic academic example of the Tacoma Narrows Bridge, which collapsed three months after its inauguration because of the Vortex shedding effect as well as effects of flattering and galloping.

Instead of avoiding these aerodynamic instabilities our technology maximizes the resulting oscillation and captures that energy. Naturally, the design of such device is completely different from a traditional turbine. Instead of the usual tower, nacelle and blades, our device has a fixed mast, a power generator and a hollow, lightweight and semi-rigid fiberglass cylinder on top.

II. DESIGN CONSIDERATION OF THE MODEL

The model describes a dynamic relation between the disc and the fluid. 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 = (mass*velocity2) / 2 Also engineers have developed a dynamic relation between torque and fluid viscosity as follows, Torque = (3uvr2) / 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

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

Fig. 1. 2D And 3D View Of Vortex Bladeless Turbine

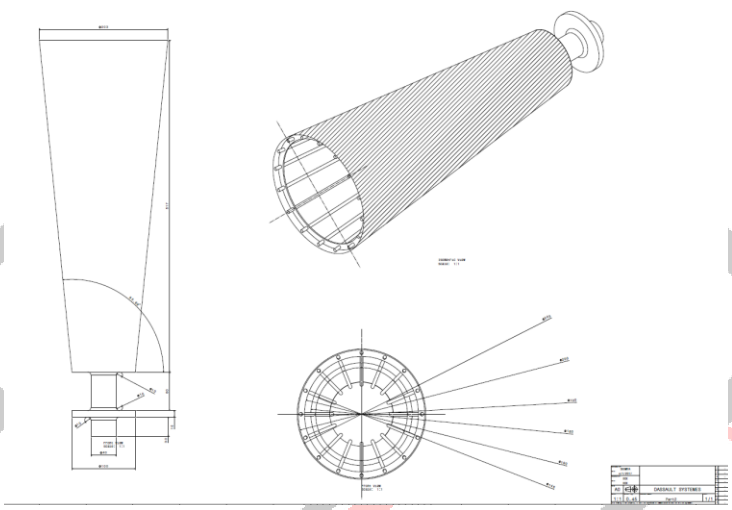

Table 1. Dimensions for the design of bladeless Turbine

Parameter	Dimension
Length of each Rod	517 mm
Upper diameter of the Disc	203 mm
Lower diameter of the Disc	100 mm
Angle between each rod with horizontal	96 deg
Outer casing thickness	17mm
Outer casing outer diameter	40mm
Total number of rods	18

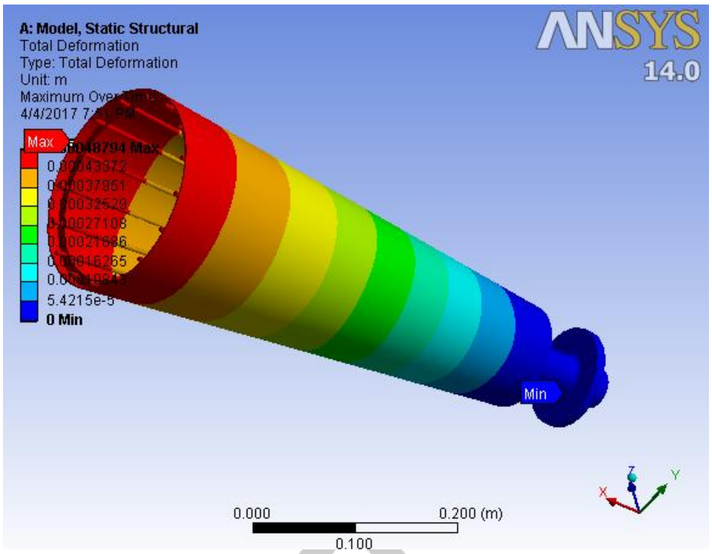

Fig 2 Structural design and Total deformation stress of the model in ANSYS.

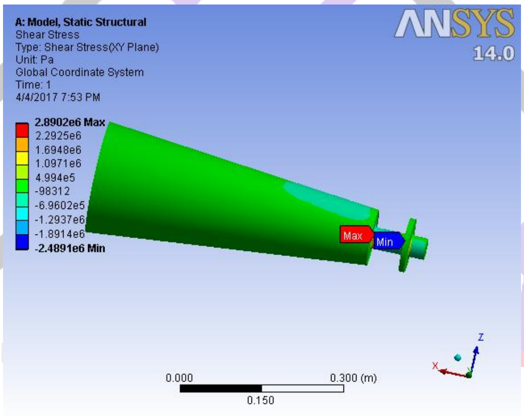

Fig 3 Structural design and Shear stress distribution of the model in ANSYS.

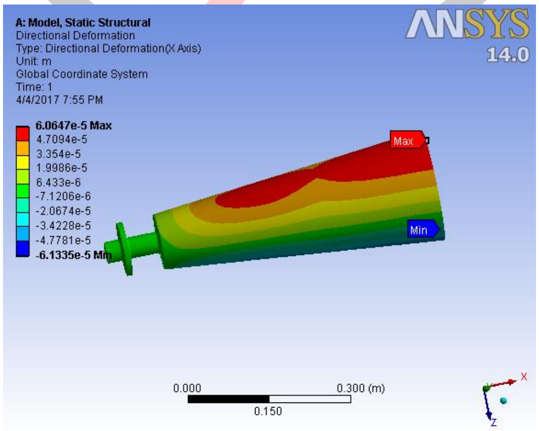

Fig 4 Structural design and Directional deformation due to Shear stress distribution of the model in ANSYS.

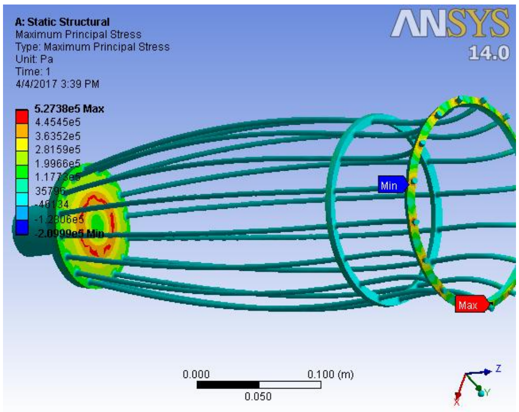

Fig 5 Structural design and Maximum Principal stress distribution of the model in ANSYS.

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. 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.

The centrifugal forces generated within bladeless 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. Bladeless Turbine Engine can turn at much higher speeds with total safety. Even if it goes 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 conventional bladed turbine engine achieves critical speed or fails, the exploding parts may cause serious damage to the engine leading to total failure 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 and can 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. 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 the design of the turbine will be modified slightly and an optimum design will be arrived at.

III. 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. 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. 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

REFERENCES

[1] Miller, G. E.; Sidhu, A; Fink, R.; Etter, B. D. (1993). "July. Evaluation of a multiple disk centrifugal pump as an artificial ventricle"

[2] Harikishan Gupta E.: “Design and Operation of Tesla turbo machine”, International Journal of Advanced Transport Phenomena, Vol. 2, No 01, Jan Dec 2013.

[3] Nikola Tesla, 1913 Tesla patent 1,061,142 Fluid Propulsion.

[4]Nicola Tesla in British Patent 179,043

[5] Raunak Jung Pandey.: “Design and Computational Analysis of 1KW Bladeless Turbine”, International Journal of Scientific and research Publication, Vol. 4, Issue11, November 2014, ISSN 2250-3153

[6] Rice, W.: “*An Analytical and Experimental Investigation of Multiple-Disk Turbines*”, Journal of Engineering for Power, Trans. ASME, series A, Vol. 87, No. 1 Jan. 1965, pp. 29-36