INTRODUCTION OF LOW PRESSURE ENERGY RECOVERY TESLA TURBINE AND ITS PUMP

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ABSTRACT

In many applications of process industry where the processing of a fluid stream (gas / air) requires its pressure to be reduced. This process is accomplished by using a device known as throttling valve. In this process energy of fluid stream is lost. Nowadays, awareness about effective energy usage is increased in process industries. Due to this awareness, areas in process industry where lost of energy of fluid stream are closely monitored and different methods of energy are being investigated. This problem creates challenge for developing of effective low pressure recovery system. Traditional wind turbines having high cost also requires high quality machinery set up to avoid structural damage. While bladeless wind turbines responded to vortices and oscillate accordingly, due to this risk of heavy structural damage is comparatively low. Bladeless wind turbine contains few parts. They emit less noise and also no risk to birds. This eliminating two of the major complaints that user have from conventional wind turbines. Less moving parts also make construction of the bladeless wind turbine more reliable than traditional ones. Bladeless wind turbines are less expensive than conventional wind turbines and also they are easy to install. These all factors are useful to drive the growth of global bladeless turbine market.

Keyword: - *Pressure reduction, low pressure recovery, bladeless turbine, reliable.*

1. TESLA TURBINE

The Tesla turbine is a bladeless centripetal flow turbine patented by Nikola Tesla in 1913. It is referred to as a bladeless turbine. The Tesla turbine is also known as the boundary layer turbine, cohesion-type turbine, and Prandtl layer turbine (after Ludwig Prandtl) because it uses the boundary layer effect and not a fluid impinging upon the blades as in a conventional turbine. Bioengineering researchers have referred to it as a multiple disk centrifugal pump. One of Tesla's desires for implementation of this turbine was for geothermal power, which was described in our Future Motive Power.

1.1 Description-

A Tesla turbine consists of a set of smooth disks, with nozzles applying a moving fluid to the edge of the disk. The fluid drags on the disk by means of viscosity and the adhesion of the surface layer of the fluid. As the fluid slows and adds energy to the disks, it spirals into the center exhaust. Since the rotor has no projections, it is very sturdy.

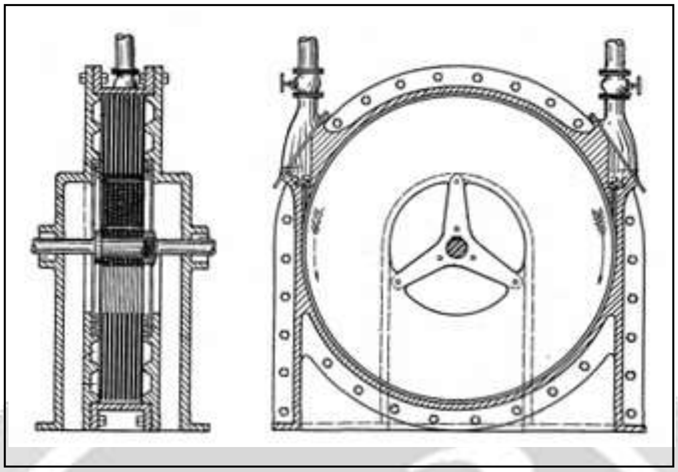


Fig-1 View of Tesla turbine "bladeless" design

Tesla wrote, "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. Minor departures from the turbine, as may be dictated by the circumstances in each case, will obviously suggest themselves but if it is carried out on these general lines it will be found highly profitable to the owners of the steam plant while permitting the use of their old installation. However, the best economic results in the development of power from steam by the Tesla turbine will be obtained in plants especially adapted for the purpose."

This turbine can also be successfully applied to condensing plants operating with high vacuum. In such a case, owing to the very great expansion ratio, the exhaust mixture will be at a relatively low temperature and suitable for admission to the condenser. Better fuel has to be used and special pumping facilities provided but the economic results attained will fully justify the increased outlay.

All the plates and washers are fitted on and keyed to a sleeve threaded at the ends and equipped with nuts and collars for drawing the thick end-plates together or, if desired, the collars may be simply forced onto it and the ends upset. The sleeve has a hole fitting snugly on the shaft, to which it is fastened as usual.

This 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. A larger active plate area and consequently more power is obtained for a given width, improving efficiency. Warping is virtually eliminated and smaller side clearances may be used, which results in diminished leakage and friction losses. The rotor is better adapted for dynamic balancing and through rubbing friction resists disturbing influences thereby ensuring quieter running. For this reason and also because the discs are not rigidly joined it is protected against damage which might otherwise be caused by vibration or excessive speed.

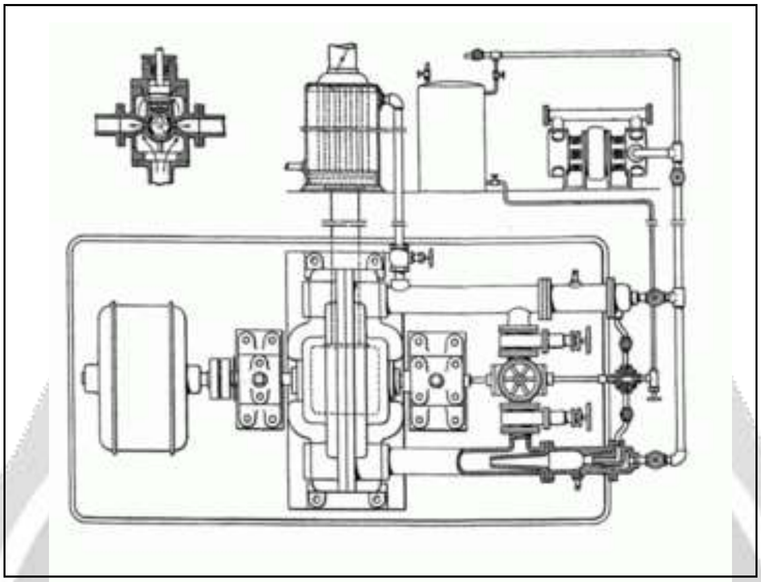


Fig-2 View of Tesla turbine system

The Tesla turbine has the trait of being in an installation normally working with a mixture of steam and products of combustion and in which the exhaust heat is used to provide steam which is supplied to the turbine, providing a valve governing the supply of the steam so that the pressures and temperatures can be adjusted to the optimum working conditions.

As diagrammed, a Tesla turbine installation is:
1. Able to start with steam alone
2. A disc type adapted to work with fluids at high temperature.

An efficient Tesla turbine requires close spacing of the disks. For example, a steam-powered type must maintain 0.4 millimeter (0.016 inch) inter-disk spacing. The disks must be extremely smooth to minimize surface and shear losses. Disks must also be very thin to prevent drag and turbulence at disk edges. Unfortunately, preventing disks from warping and distorting was a major challenge in Tesla's time. It is thought that this inability to prevent the disks distorting contributed to the commercial failure of the turbines, because metallurgical technology at the time was not able to produce disks of sufficient quality and rigidity.

2. PUMP

If a similar set of disks and housing with an involute shape (versus circular for the turbine) are used, the device can be used as a pump. In this configuration a motor is attached to the shaft. The fluid enters near the center, is given energy by the disks, then exits at the periphery. The Tesla turbine does not use friction in the conventional sense; precisely, it avoids it, and uses adhesion and viscosity instead. It utilizes the boundary layer effect on the disc blades.

Smooth rotor disks were originally proposed, but these gave poor starting torque. Tesla subsequently discovered that smooth rotor disks with small washers bridging the disks in ~12–24 places around the perimeter of a 10″ disk and a second ring of 6–12 washers at a sub-diameter made for a significant improvement in starting torque, without compromising efficiency.

2.1 Applications-

Tesla's patents state that the device was intended for the use of fluids as motive agents, as distinguished from the application of the same for the propulsion or compression of fluids (though the device can be used for those purposes as well). As of 2006, the Tesla turbine has not seen widespread commercial use since its invention. The Tesla pump, however, has been commercially available since 1982 and is used to pump fluids that are abrasive, viscous, shear sensitive, contain solids, or are otherwise difficult to handle with other pumps. Tesla himself did not procure a large contract for production. The main drawback in his time, as mentioned, was the poor knowledge of materials characteristics and behaviors at high temperatures. The best metallurgy of the day could not prevent the turbine disks from moving and warping unacceptably during operation.

In 2003 Scott O'Hearen took a patent on the Radial turbine blade system. This invention utilizes a combination of the concepts of a smooth runner surface for working fluid frictional contact and that of blades projecting axially from plural transverse runner faces.

Today, many amateur experiments in the field have been conducted using Tesla turbines which use compressed air, steam as its power source (the steam being generated with heat from fuel combustion, from a vehicle's turbocharger or from solar radiation). The issue of the warping of the discs has been partially solved using new materials such as carbon fiber. For example, both PNGinc and International Turbine and Power, LLC use carbon fiber discs in their Tesla turbine designs.

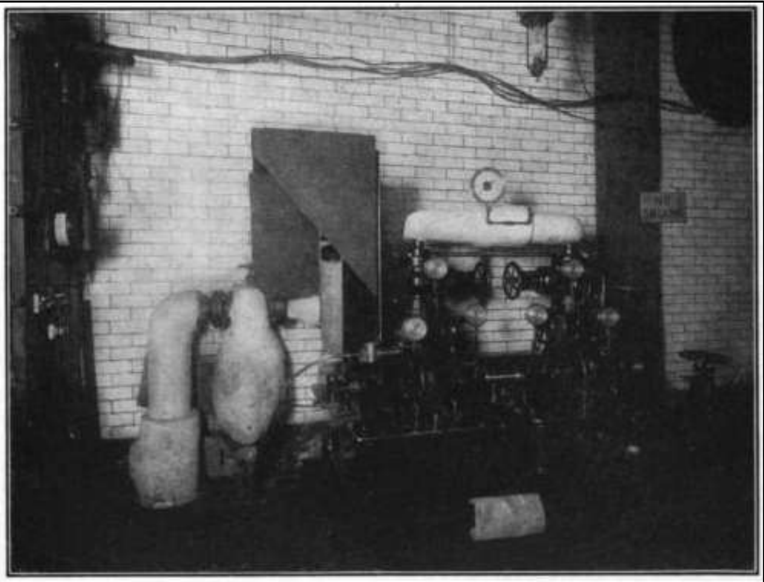
One proposed current application for the device is a waste pump, in factories and mills where normal vane-type turbine pumps typically get blocked.

Applications of the Tesla turbine as a multiple-disk centrifugal blood pump have yielded promising results. Biomedical engineering research on such applications has been continued into the 21st century.

In 2010, U.S. Patent 7,695,242 was issued to Howard Fuller for a wind turbine based on the Tesla design.

In Tesla's time, the efficiency of conventional turbines was low because the aerodynamic theory needed for effective blade design did not exist and the low quality of materials available to construct those blades put severe limitations on operating speeds and temperatures. The efficiency of a conventional turbine is related to the pressure difference between the intake and the exhaust. The Tesla turbine's ability to run on higher temperature gases than bladed turbines of the time contributed to its greater efficiency.

As time went on, competing axial turbines became dramatically more efficient and powerful, a second set of reduction gears was introduced in most cutting edge U.S. naval ships of the 1930s. The improvement in steam technology gave the U.S. Aircraft Carriers a clear advantage in speed over both Allied and Enemy aircraft carriers, and so the proven axial steam turbines became the preferred form of propulsion until the 1973 oil Embargo took place. The oil crisis drove the majority of new civilian vessels to turn to Diesel engines. Axial steam turbines still had not exceeded 50% efficiency by that time, and so civilian ships chose to utilize diesel engines due to their superior efficiency. By this time, the comparably efficient Tesla turbine was over 60 years old.



TESTING THE SPEED, POWER, AND STEAM PRESSURE OF A TESLA TURBINE
THE PICTURE SHOWS TWO ENGINES, EACH CAPABLE OF PRODUCING 330 HORSE-POWER, WORKING AGAINST ONE ANOTHER FOR TEST PURPOSES, THE TORSION SPRING CONNECTING THE TWO BEING USED TO INDICATE THE AMOUNT OF POWER DEVELOPED

Fig-3 Setup for testing Speed, Power and Pressure of a Tesla Turbine

Tesla's design attempted to sidestep the key drawbacks of the bladed axial turbines, and even the lowest estimates for efficiency still dramatically outperformed the efficiency of axial steam turbines of the day. However, in actual testing the Tesla Turbine had expansion efficiencies far below contemporary steam turbines and far below contemporary reciprocating steam engines. It does suffer from other problems such as shear losses and flow restrictions, but this is partially offset by the relatively massive reduction in weight and volume. Some of Tesla turbine's advantages lie in relatively low flow rate applications or when small applications are called for. The disks need to be as thin as possible at the edges in order not to introduce turbulence as the fluid leaves the disks. This translates to needing to increase the number of disks as the flow rate increases. Maximum efficiency comes in this system when the inter-disk spacing approximates the thickness of the boundary layer, and since boundary layer thickness is dependent on viscosity and pressure, the claim that a single design can be used efficiently for a variety of fuels and fluids is incorrect. A Tesla turbine differs from a conventional turbine only in the mechanism used for transferring energy to the shaft. Various analyses demonstrate the flow rate between the disks must be kept relatively low to maintain efficiency. Reportedly, the efficiency of the Tesla turbine drops with increased load. Under light load, the spiral taken by the fluid moving from the intake to the exhaust is a tight spiral, undergoing many rotations. Under load, the number of rotations drops and the spiral becomes progressively shorter.[citation needed] This will increase the shear losses and also reduce the efficiency because the gas is in contact with the discs for less distance.

Efficiency is a function of power output. A moderate load makes for high efficiency. Too heavy a load increases the slip in the turbine and lowers the efficiency; with too light a load, little power is delivered to the output, which also decreases efficiency (to zero at idle). This behavior is not exclusive to Tesla turbines.

3. ACKNOWLEDGEMENT

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