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DESIGN, FABRICATION AND ANALYSIS OF HYDRO OPERATED BLADELESS TURBINE WITH POWER GENERATION

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ABSTRACT

All the hydroelectric power plants are still using the conventional hydro turbines with the blades. This conventional turbines are very complex to manufacturing and do the maintenance work. So the result for this problem is producing the bladeless turbine with acceptable efficiency. This bladeless turbine is center petal turbine, which is running by the centripetal force and boundary layer effect of the fluid. This bladeless turbine can rotate at the both clockwise and counter clockwise directions. But conventional turbine can't do that, this turbines can only rotate in one direction. The bladeless turbine is designed, fabricated and analyze its properties and calculates its power generation.

Keywords: conventional hydro turbine, bladeless turbine, boundary layer effect.

I. INTRODUCTION

Turbines are defined as the hydraulic machines which converts hydraulic energy into mechanical energy. This mechanical energy is used in running an electric generator which is directly coupled to the shaft of the turbine. Thus the mechanical energy is converted into electrical energy. The energy obtained from hydraulic power (energy of water) is known as hydroelectric power. At present the generation of electric power from the hydraulic energy is the cheapest of all the power generation processes. As long day using the conventional turbine with blades that is very complex in design complex to manufacture it and complex to maintenance work.

II. HISTORY AND LITERATURE REVIEW

2.1 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 because it uses the boundary layer effect and not a fluid impinging upon the blades as in a conventional turbine. The Tesla turbine is also known as the boundary layer turbine, cohesion-type turbine, and Prandtl layer turbine (after Ludwig Prandtl). Bioengineering researchers have referred to it as a multiple disc centrifugal pump.

2.2 Introduction

The job of any engine is to convert energy from a fuel source into mechanical energy. Whether the natural source is air, moving water, coal or petroleum, the input energy is a fluid. And by fluid we mean something very specific -- it's any substance that flows under an applied stress. Both gases and liquids, therefore, are fluids, which can be exemplified by water. As far as an engineer is concerned, liquid water and gaseous water, or steam, function as a fluid.

At the beginning of the 20th century, two types of engines were common: bladed turbines, driven by either moving water or steam generated from heated water, and piston engines, driven by gases produced during the combustion of gasoline. The former is a type of rotary engine, the latter a type of reciprocating engine. Both types of engines were complicated machines that were difficult and time-consuming to build.

Consider a piston as an example. A piston is a cylindrical piece of metal that moves up and down, usually inside another cylinder. In addition to the pistons and cylinders themselves, other parts of the engine include valves,

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cams, bearings, gaskets and rings. Each one of these parts represents an opportunity for failure. And, collectively, they add to the weight and inefficiency of the engine as a whole.

Bladed turbines had fewer moving parts, but they presented their own problems. Most were huge pieces of machinery with very narrow tolerances. If not built properly, blades could break or crack.

Tesla's new engine was a bladeless turbine, which would still use a fluid as the vehicle of energy, but would be much more efficient in converting the fluid energy into motion.

2.3 Research Gaps

Tesla had several machines built. Juilus C. Czito, the son of Tesla's long-time machinist, built several versions. The first, built in 1906, featured eight discs, each six inches (15.2 centimeters) in diameter. The machine weighed less than 10 pounds (4.5 kilograms) and developed 30 horsepower. It also revealed a deficiency that would make ongoing development of the machine difficult. The rotor attained such high speeds -- 35,000 revolutions per minute (rpm) -- that the metal discs stretched considerably, hampering efficiency.

In 1910, Czito and Tesla built a larger model with discs 12 inches (30.5 centimeters) in diameter. It rotated at 10,000 rpm and developed 100 horsepower. Then, in 1911, the pair built a model with discs 9.75 inches (24.8 centimeters) in diameter. This reduced the speed to 9,000 rpm but increased the power output to 110 horsepower.

Bolstered by these successes on a small scale, Tesla built a larger double unit, which he planned to test with steam in the main powerhouse of the New York Edison Company. Each turbine had a rotor bearing discs 18 inches (45.7 centimeters) in diameter. The two turbines were placed in a line on a single base. During the test, Tesla was able to achieve 9,000 rpm and generate 200 horsepower. However, some engineers present at the test, loyal to Edison, claimed that the turbine was a failure based on a misunderstanding of how to measure torque in the new machine. This bad press, combined with the fact that the major electric companies had already invested heavily in bladed turbines, made it difficult for Tesla to attract investors.

In Tesla's final attempt to commercialize his invention, he persuaded the Allis-Chalmers Manufacturing Company in Milwaukee to build three turbines. Two had 20 discs 18 inches in diameter and developed speeds of 12,000 and 10,000 rpm respectively. The third had 15 discs 60 inches (1.5 meters) in diameter and was designed to operate at 3,600 rpm, generating 675 horsepower. During the tests, engineers from Allis-Chalmers grew concerned about both the mechanical efficiency of the turbines, as well as their ability to endure prolonged use. They found that the discs had distorted to a great extent and concluded that the turbine would have eventually failed.

Even as late as the 1970s, researchers had difficulty replicating the results reported by Tesla. Warren Rice, a professor of engineering at Arizona State University, created a version of the Tesla turbine that operated at 41 percent efficiency. Some argued that Rice's model deviated from Tesla's exact specifications. But Rice, an expert in fluid dynamics and the Tesla turbine, conducted a literature review of research as late as the 1990s and found that no modern version of Tesla's invention exceeded 30 to 40 percent efficiency. This, more than anything, prevented the Tesla turbine from becoming more widely used.

2.4 Objectives of the experiment

According to Nikola Tesla, the three key efficiency points of his turbine are

1. Inlet nozzle
2. Outlet nozzle
3. Disc geometry
4. Distance between the turbine discs
5. Number and diameter of the turbine discs
6. Number of inlet nozzles to the turbine
7. Rotational speed of the rotor
8. Inlet pressure
9. Inlet temperature
10. Inlet velocity and inlet angle
11. Corrosion and erosion of turbine elements

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12. Constructional materials (composites, ceramic materials, bronzes, aluminum alloys)
13. Kind of medium flowing through the turbine (air, biogas, organic agents, exhaust gases, multiphase media, etc.)

2.5 Theoretical analysis

2.5.1 Construction

(1) Rotor
The rotor consists of series of smooth discs mounted on a shaft. Each disc is made with openings surrounding the shaft. These openings act as exhaust ports through which the fluid exits. Washers are used as Spacers; the thickness of a washer is not to exceed 2 to 3 millimeters.

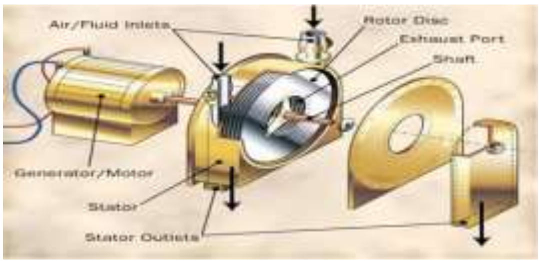

Fig. 2.1 Construction of tesla turbine

(2) Stator
The rotor assembly is housed within a cylindrical stator, or the stationary part of the turbine. Each end of the stator contains a bearing for the shaft.

The stator also contains one or two inlets, into which nozzles are inserted, which allows the turbine to run either clockwise or counterclockwise. To make the turbine run, a high-pressure fluid enters the nozzles at the stator inlets. The fluid passes between the rotor discs and causes the rotor to spin. Eventually, the fluid exits through the exhaust ports in the center of the turbine.

2.5.2 Working principle
Adhesion and viscosity are the two properties of any fluid, these two properties work together in the Tesla turbine to transfer energy from the fluid to the rotor or vice versa.

1. As the fluid moves past each disc, adhesive forces cause the fluid molecules just above the metal surface to slow down and stick.
2. The molecules just above those at the surface slow down when they collide with the molecules sticking to the surface.
3. These molecules in turn slow down the flow just above them.

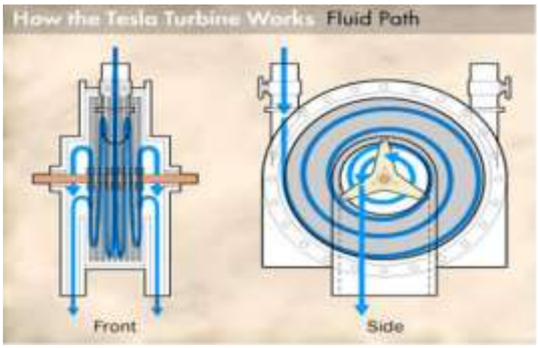

Fig. 2.2 Fluid flowing path of tesla turbine

4. The farther one moves away from the surface, the fewer the collisions affected by the object surface.
5. At the same time, viscous forces cause the molecules of the fluid to resist separation.

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6. This generates a pulling force that is transmitted to the disc, causing the disc to move in the direction of the fluid.

The thin layer of fluid that interacts with the disc surface in this way is called the boundary layer, and the interaction of the fluid with the solid surface is called the boundary layer effect. As a result of this effect, the propelling fluid follows a rapidly accelerated spiral path along the disc faces until it reaches a suitable exit.

With proper use of the analytical results, the rotor efficiency using laminar flow can be very high, even above 95%.

III. FABRICATION, CONSTRUCTION AND WORKING

3.1 Components used

1. Base with rolling wheels.
2. Reservoir.
3. Frame.
4. Casing.
5. Disc with shaft.
6. DC Generator with gear arrangement.
7. Pump.
8. Nozzle.
9. Pressure gauge.
10. Piping.

3.1.1 Base with rolling wheels

The base is the basic setup which carries the whole components of the turbine. A rolling wheel is used in order to move the turbine setup from one place to another. It is made up of cast iron.

3.1.2 Reservoir

This reservoir is used to store the water which is used to run the turbine disc. This reservoir is made up of sheet metal.

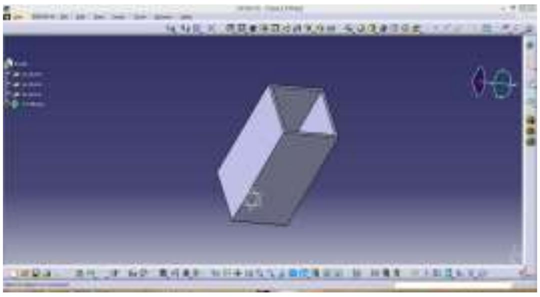

Fig. 3.1Reservoir

3.1.3 Frame

Frame is the basic set up of the stator which finds the space for the discs of the turbine to rotate. This frame is made up of cast iron.

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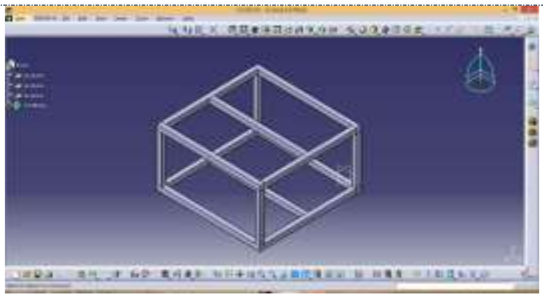

Fig. 3.2 Frame

3.1.4 Casing

Casing is made by the sheet metal in order to avoid spraying of water outside the stator.

3.1.5 Disc with shaft

The disc is the rotor and the main rotating element of the bladeless turbine. The disc is mounted on a shaft which is supported by two Plummer blocks on both ends of the shaft. It is made up of stainless steel.

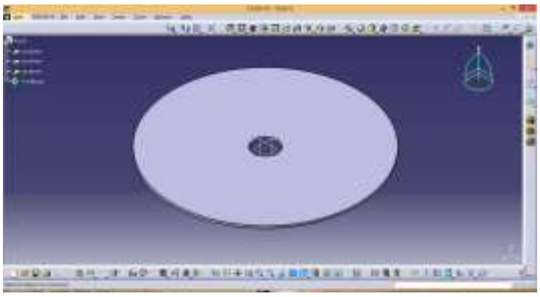

Fig. 3.3 Rotor disc

3.1.6 DC generator with gear arrangement

This DC generator with gear arrangement is the power generating source, which converts the shaft rotation into electrical energy.

Fig. 3.4 Gear

3.1.7 Pump

The pump is used to suck the water from the reservoir and send it through the hose to strike the rotor discs

3.1.8 Nozzle

The nozzle is used to spray the water with a high velocity on the discs of the turbine.

3.1.9 Pressure gauge

The pressure gauge is used to measure the inlet pressure.

3.1.10 Piping

Piping works are made with PVC pipes and a gate valve is used to control the rate of flow of water.

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3.2 Construction

There are mainly 2 parts in the turbine.

(1) Rotor

The rotor consists of series of discs mounted on a shaft. According to the need, we can increase the number of discs. The thickness of each disc is 3 mm.

(2) Stator/Frame The rotor assembly is housed within a frame, the stationary part of the turbine. Each end of the frame contains a bearing for the shaft.

The frame also contains an inlet, into which nozzle is inserted, which allows the turbine to run in clockwise direction. The fluid passes between the rotor discs and causes the rotor to spin. Eventually, the fluid is collected in the tank that is provided below the setup.

3.3 Working

Adhesion and viscosity are the two properties of water that work together in the bladeless turbine to transfer energy from the fluid to the rotor.

1. The water that is stored in the reservoir is sucked by the centrifugal pump.
2. At the delivery end of the centrifugal pump a ball valve arrangement is made to control the flow of water. A pressure gauge is fixed next to ball valve to measure the inlet pressure.
3. Then the water is directed to the rotor disc through the nozzle.
4. As the water moves past each disc, adhesive and viscous forces act together and make the water molecules stick to the surface.
5. This thin layer of fluid that interacts with the disc surface is called boundary layer and this interaction creates an effect called boundary layer effect. As a result a force is generated causes the disc to move in the direction of the water.

3.4 Dimensions of the components

Tank
Length = 40 cm
Breadth = 40 cm
Height = 50 cm 21
Frame
Length = 45 cm
Breadth = 20 cm
Height = 40 cm
Mass = 5 kg (approx.)
Disc
Diameter = 20 cm
Center hole = 2.54 cm
Thickness = 3 mm per disc.
Mass = 2.96 kg (two discs)
Shaft
Diameter = 2.54 cm
Length = 50 cm
Gear arrangement
Larger gear teeth = 57 teeth
Smaller gear teeth = 22 teeth
Gear ratio = 1: 2.59

IV. CALCULATION

Specifications of the pump
Phase = 1Ø
Voltage = 220V
Frequency = 50Hz
Input power = 0.37 kW / 0.5 HP
Rated speed = 2820 rpm

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Calculations
Inlet pressure = 2.7 kg/cm2
= 2.6487*105 N/m2

Contact Area on the disc = 6 mm * 6 mm
= 36 mm2
= 36*10-6 m2

Load acting on the disc = Inlet pressure * Contact area
= (2.6487*105) * (36*10-6)
= 9.53532 N

Speed of the shaft = 722.7 rpm

Maximum Voltage = 19.9 V

Maximum Current = 0.25 A 23

Power = Voltage * Current
= 19.9 * 0.25
= 4.97 W

Power = (2πNT) / 60 W

Torque, T = (P*60) / (2πN)
= (4.97*60) / (2π*722.7)
= 65.67 * 10-3 N-m

Efficiency of the turbine = shaft rotation per minute /rated rpm of the pump
= 722.7 / 2820
= 25.63 %

If the turbine with precise dimension is employed in conventional hydro power plant it is expected to produce somewhat higher efficiency than the bladed turbines which are in use.

V. ANALYSIS OF TURBINE ROTOR

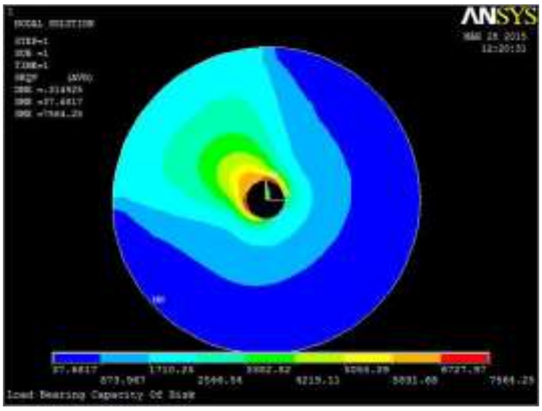

Fig. 5.1 Analysis of the turbine rotor

The following are the values that are analyzed for the applied load of 2000 N.
Maximum deflection = 0.31 mm
Minimum stress = 37.6817 N/mm2
Maximum stress = 7564.25 N/mm2

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VI. ADVANTAGES, DISADVANTAGES AND APPLICATION

6.1 Advantages

1. Pollution free.
2. Simple in construction.
3. Low cost to produce and maintain.
4. Low friction (uses boundary layer effect, adhesion + viscosity rather friction).
5. Can be powered by air, steam, gases or liquids.
6. This turbine can be adjusted to different circumstances by applying a few cross section changes to the actual demand, which is an interchangeable part of the equipment.

6.2 Disadvantages

1. Often not suitable for a direct replacement for conventional turbines and pumps, without changes to the machinery it is interacting with.
2. Proof of its efficiency compared to conventional turbines is still questionable and needs more research.
3. It has remained underdeveloped and hence design improvements are still being made.

6.3 Applications

1. With fewer design changes, it can be applied for power generation by replacing conventional turbines.
2. It can be applied where the space is less.

VII. CONCLUSIONS

The commonly used turbines are bladed turbines. Our aim is to eliminate the rotor runners of the conventional turbines. So we came up with a new idea called hydraulic bladeless turbine which does not have blades. By implementing this concept we can eliminate the complexity in manufacturing the turbine blades. This can also work efficiently as like the conventional bladed turbines. So it can be used easily and effectively with less maintenance.

VIII. REFERENCES

[1] Bansal, R.K., "Fluid Mechanics and Hydraulic Mechanics"
[2] Yahya, S.M., 2010, "Turbines, Compressors and Fans"
[3] http://en.wikipedia.org/wiki/Tesla turbine.
[4] http://auto.howstuffworks.com/tesla-turbine.htm/printable

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