© 2017 IJSRST | Volume 3 | Issue 3 | Print ISSN: 2395-6011 | Online ISSN: 2395-602X
Themed Section: Engineering and Technology

Fabrication and Study of the Parameters Affecting the Efficiency of a Bladeless Turbine

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ABSTRACT

Man always tried to extract as much energy as possible from the freely available energy sources in this world. One such attempt is the building of the turbine, which converts the fluid energy into mechanical energy, which is later converted into electrical energy. Due to the constant increase in the demand for this energy, the performance of these turbines mattered a lot and hence various types and designs of turbines were developed. One such turbine is the bladeless (Tesla) turbine. Many analytical studies have been carried out on this turbine but very limited information is available on the actual test results. In this paper, an attempt has been made to fabricate a turbine and study the effect of various parameters on the turbine's performance. The observations are plotted. Few parts and parameters are kept constant while the others are varied during the testing process. Maximum rpm which was 25,324 was observed at six bar pressure, two exhaust holes on each flange and operating with four-disc rotor assembly.

Keywords: Bladeless Tesla Turbine, Renewable Energy

I. INTRODUCTION

This current era is considered as the time with the highest development in science and technology, medicine and space exploration to name a few out of which industrialization plays a major role. With ever increase population and their needs, the need and importance of this industrialization has only increased. This progress came with its own merits and de-merits. The most important demerits being the excessive consumption of fossil fuels, release of high levels of greenhouse gases leading to ozone layer depletion, global temperature rise, melting of polar caps, extinguishing of species and others. It becomes very important to decrease our dependence on the fossil fuels and increase the use of renewable sources of energy. Tremendous progress has been achieved in the areas of solar, wind and hydroelectric power generation and up to some extent in harnessing geothermal and tidal energy. Generation of power from geothermal sources in the form of natural hot water geysers associated with steam could have good potential to generate power in smaller quantities for surrounding areas at least. The significance cannot be felt from one single source but cumulatively it could be very valuable.

The steam from the geysers can be used to generate power through turbines [1]. The steam rotates a turbine, which in turn when connected to a generator produces electric power. Placing a turbine in a very remote area constantly subjected to highly corrosive natural steam needs constant monitoring and maintenance. The usage of conventional turbines is not economically feasible. In this paper, an attempt is made to fabricate a bladeless turbine [2] and study the parameters affecting its performance.

Turbines can broadly be classified into impulse and reaction turbines [3]. Impulse turbines are driven by high velocity/pressure jets of water or steam from a nozzle directed onto vanes or buckets attached to a wheel. The resulting impulse spins the turbine. In the case of a reaction turbine, the torque is developed by reacting to the pressure or weight of the fluid. The nozzles discharging the fluid are embedded into the rotor. The force of the fluid leaving the nozzle produces a reaction force on the pipes resulting the rotor's rotation in the opposite direction. The differences are as shown in Figure 1.

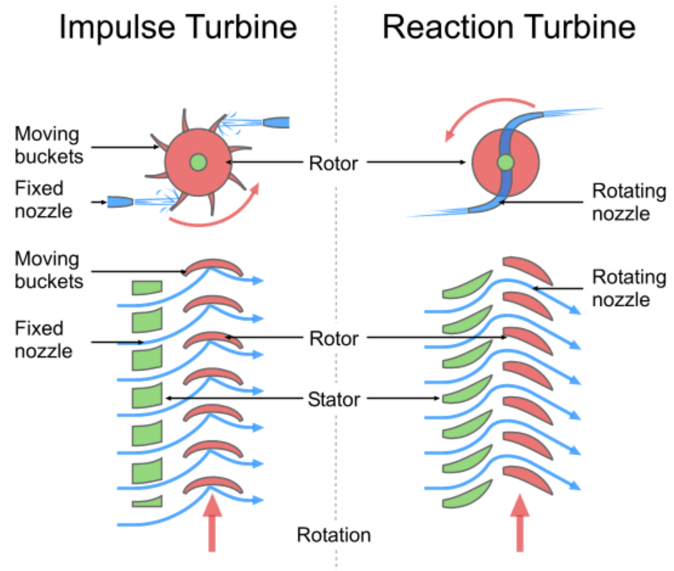

Figure 1: Working principle of an impulse and reaction turbine

Working principle

This device works by using viscous shear forces [4]. These forces act in the boundary layer of a fluid passing near a disk to transmit a torque to or from the fluid and the disk. In the gap between two closely spaced disks that are rotating about a central axis, any viscous fluid contained in that gap will be dragged around the axis by these viscous forces. Because the fluid is rotating, it is therefore subject to centrifugal forces. In the case of a pump, the flow of the fluid will generally follow a spiral pattern between the inlet and the periphery of the disks. In the case of a turbine, it will flow in the other direction. The turbine's rotor is composed of parallel co-rotating disks arranged normal to a shaft. These disks are flat, thin and smooth and spaced along the shaft with thin gaps as shown in Figure 2.

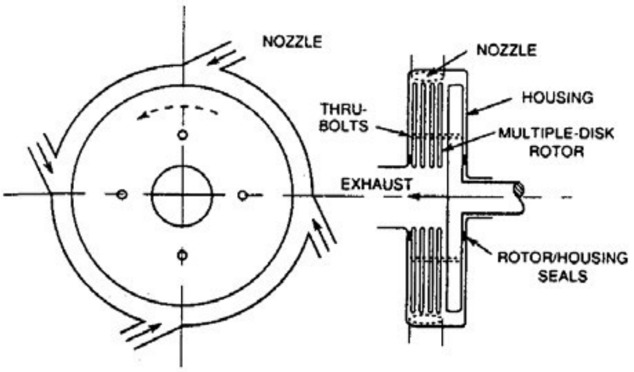

Figure 2: Schematic diagram of Tesla turbine

II. PROTOTYPING & EXPERIMENTATION

Prototype

This turbine has fewer and simpler parts compared to the conventional turbines. The main parts are the runner, shaft, casing, accessories such as valves and nozzles as shown in Figure 3. Runner consists of several flat discs set horizontally with gaps in-between using spacers. The shaft assembly consists of the shaft, collar, bearings and fasteners. The thickness of the spacers and the dimensions of the inter-disc space can be calculated using the depth of the boundary layer of the working fluid [5]. The inter-disc dimension which is the spacer's thickness used in this turbine is 1.016 mm.

Fluid enters the turbine through the nozzles and is injected into the spaces between the discs in a direction approximately tangential to the rotor periphery. The fluid follows a spiral path between the discs and finally exhausts from the rotor through the holes drilled in the discs near the shaft as shown in Figure 3 [6]. This turbine in general is a high-speed low-torque machine.

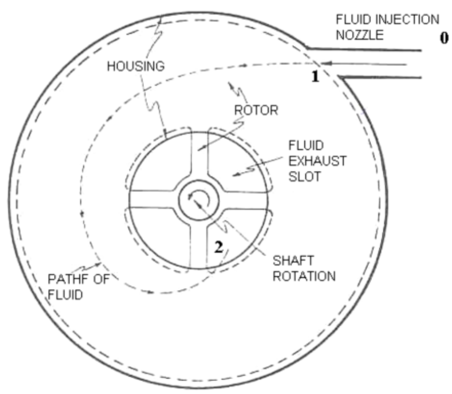

Figure 3: Schematic diagram of the fluid path inside the turbine

The shaft is made of aluminium which forms the base for the discs and the spacers. The discs are of 95mm outer diameter and 1.27 mm thick and are made of Al alloy coated with a cobalt alloy for high surface finish. The spacers are of mild steel. The discs and the spacers are laser cut for precision. A diametrical clearance of 02 mm is provided between the stator and the rotor. Nozzles of 06 mm diameter at 45˚ with 08 mm offset from the disc's centre. The weight of the shaft, ten discs with spacers and bearings was 437 g. This is the rotational mass of the turbine. Ten are the maximum number of discs that can be accommodated in the turbine. The parts of the turbine are as shown in Figure 4.

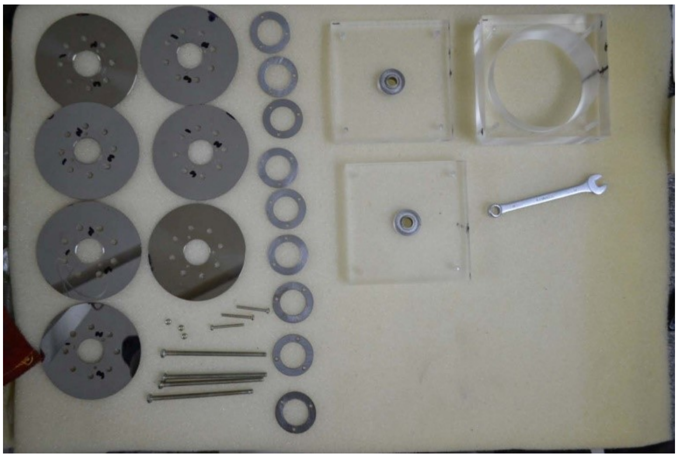

Figure 4: Parts of the turbine

Experimental setup

The turbine was operated using compressed air with a maximum input pressure of 6 bar at $5m^3/sec$ flowrate. The compressed air is fed through the nozzle. Though multiple parameters effect the performance of the turbine, in this study few of them are kept constant.

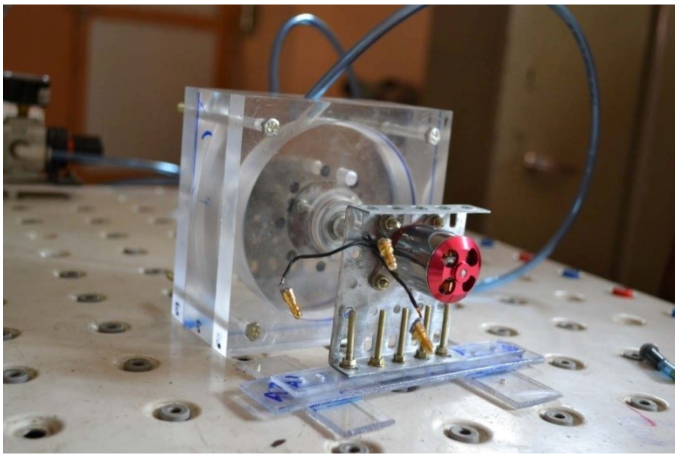

Figure 5: Experimental setup

Parameters effecting the turbine's performance [7]:

1. Number of discs
2. Diameter of the discs
3. Material of the rotor
4. Number of exhaust holes in the flanges
5. Interspacing distance between discs
6. Distance between stator and the discs
7. Nozzle diameter and type of nozzle
8. Pressure
9. Flow rate

In this study, diameter and material of the discs, interspacing distance of discs, clearance between the stator and the rotor and nozzle diameter and type are kept constant. The turbine was tested for all combinations of the number of discs, air pressure, flowrate, number of exhaust holes in the stator.

Procedure

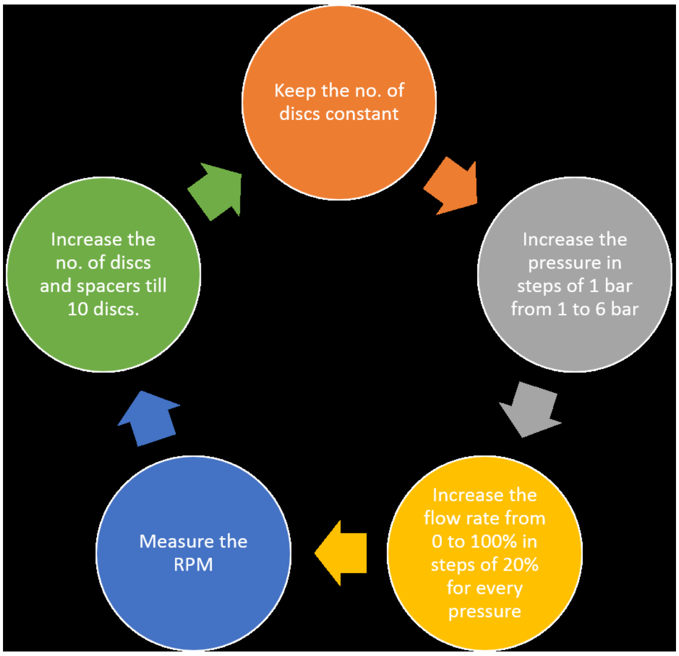

Figure 6: Procedure

III. RESULTS AND DISCUSSION

All the results obtained from testing the turbine for multiple combinations of number of discs, pressure, no. of nozzles and others when plotted into a single graph is as shown in Figure 6.

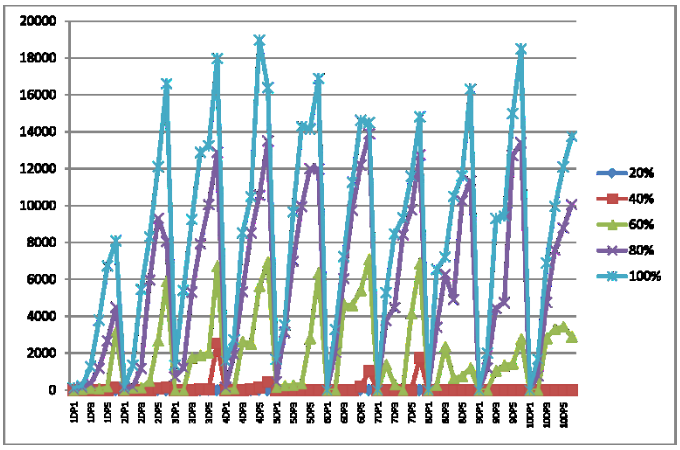

Figure 7: Performance characteristics obtained

The conclusions that can be made from the above graph are as follows:

1. At 1 bar pressure and 100% flow rate, the turbine was showing significant RPM when the number of discs was 3, 4 and 5 only.
2. 20% flow rate is not sufficient to operate the turbine.
3. With the increase in the flow rate, the RPM is increasing.
4. Increase in pressure increases the RPM.
5. With the increase in the number of discs till 4, the RPM increased and then decreased.
6. Maximum RPM was attained when the turbine was operating at 5 bar pressure with 4 disks.
7. Exponential increase in the RPM with the increase in the flow rate is observed.
8. At 40% flow rate, the turbine with three discs and at 6 bar pressure was showing the maximum RPM.

Few of the important results have been plotted as shown in Figure 7 to Figure 11.

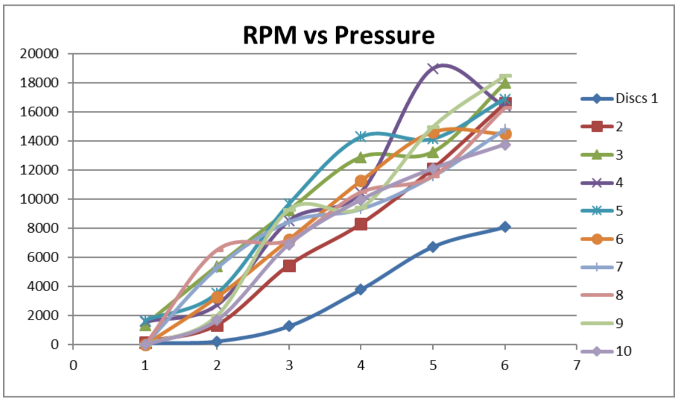

Figure 8: RPM vs Pressure for multiple no. of discs

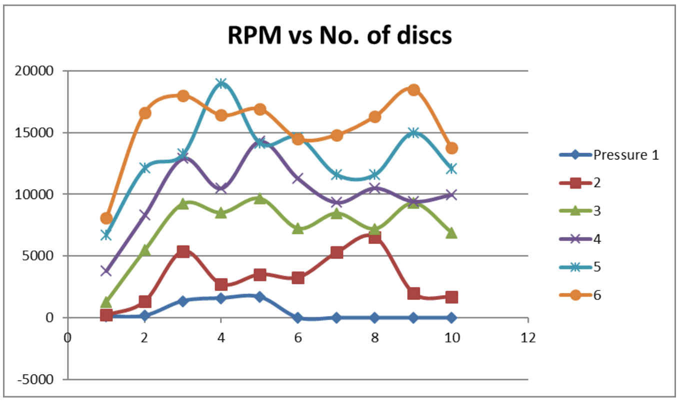

Figure 9: RPM vs No. of discs at multiple pressures

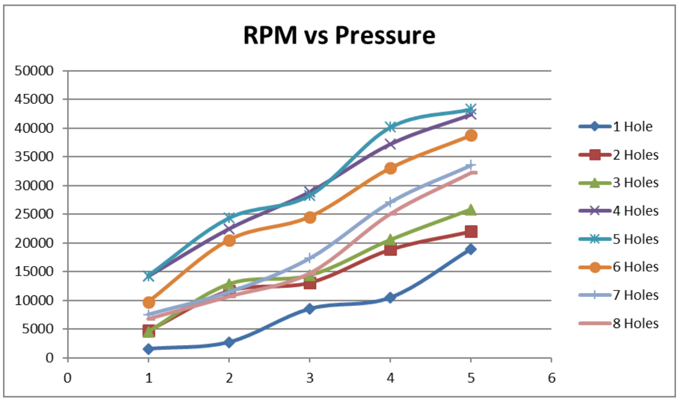

Figure 10: RPM vs Pressure for multiple no. of exhaust holes

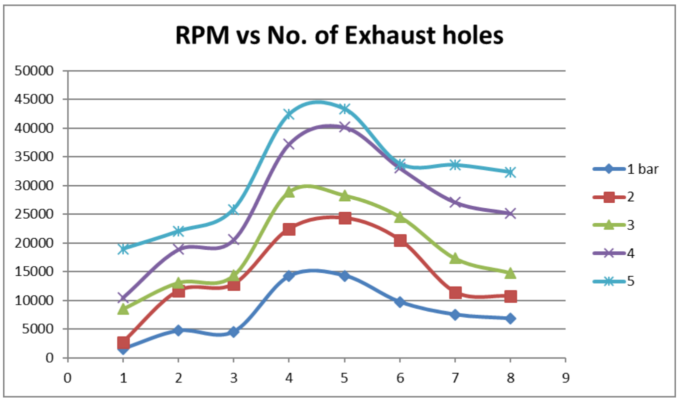

Figure 11: RPM vs No. of exhaust holes at multiple pressures

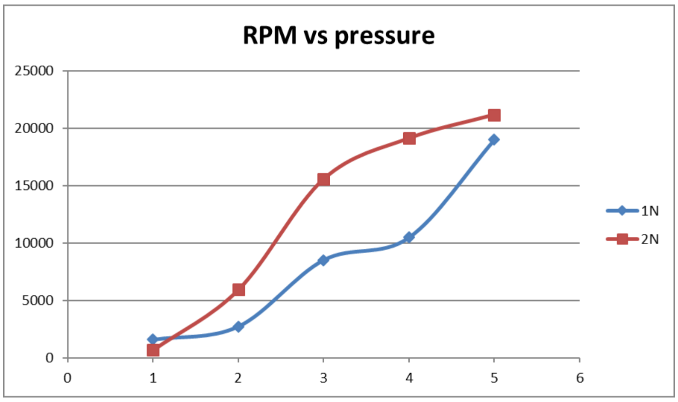

Figure 12: RPM vs Pressure for 1 and 2 Nozzles

The following observations can be made from the above-obtained characteristic curves:

1. With the increase in the pressure, the RPM mostly increased as more energy is available.
2. Maximum RPM is obtained for the turbine operating with four discs. The Nozzle diameter was equal to the gap between four discs, thus providing the maximum drag and weight combination.
3. The maximum RPM for increase in number of discs is not always at the same pressure. This is due to the increase in the back pressure of the air inside.
4. The slope of the curve increases with the increase in the pressure and the flow rate.
5. The RPM is decreasing when the number of discs is increased from four. This is due to inadequate air passing though the gaps of other discs as the nozzle diameter is lesser than the total gap between the discs; also, the increase in weight decreases the RPM.
6. Different combinations of pressure, flow rate and number of discs give the same RPM.
7. For increasing number of discs, the rate of increase in RPM varies.
8. The maximum RPM is different for different flow rates with different number of discs.
9. The increase and the decrease in the slope of the curve are almost constant for a set of pressure, flow rate and number of discs.
10. The maximum RPM for n set of discs at a constant pressure and flow rate need not be greater than the maximum RPM obtained for n+1 set of discs where n is a real number.

IV. SUMMARY

As not much work has been done on the development of the Tesla Turbine, this project has been undertaken to study the effect of the parameters affecting the performance by varying the number of discs, pressure, flow rate and number of exhaust holes in the flanges and keeping the other parameters like nozzle diameter, number of nozzles, clearance between the stator and the periphery of the discs, material of the discs, diameter of the rotor discs and others being constant. The performance was improved when the number of exhaust holes on the flanges was increased from one to two as the backpressure was decreased. Maximum RPM was observed at 6-bar pressure with four discs. The performance was maximum when the turbine was operated with four discs, as the width of the rotor assembly was almost equal to the inner diameter of the nozzle.

V. CONCLUSION

All the results obtained are plotted as shown above. Study of the effect on only a selected few parameters has been done due to time and facility limitation and a significant effect of each parameter on the turbine is observed. More tests should be performed to completely study the turbine's characteristics.

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