

Experimental Investigation of Tesla Turbine and its Underlying Theory.

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Abstract— Nikola Tesla is widely known for his outstanding achievements in generation transmission and utilization of power. The object of this paper is to experimentally verify one such method of extracting electrical power from fluid energy; devised by Tesla in his 1913 patent; known as Tesla Turbine. It is to be noted that almost no work has been done using water as the working fluid for the turbine so an attempt to reconstruct the turbine as per Nikola Tesla's patent has been made with positive results obtained by generation of useful electrical power using water as the medium which provides a new outlook towards our understanding of the turbines and the ways by which mechanical energy of the motive fluid can be converted into useful electrical output.

Keywords— bladeless turbine, boundary layer turbine, disc turbine, tesla turbine

I. INTRODUCTION

Intriguingly, the term 'turbine' can be deluding in explaining Tesla's innovation as it tends to create an image of something mounted on a shaft with fan-like blades. With the advent of 20th century two types of turbines were developed to harness the fuel/fluid energy and they were the 'bladed turbines' driven by moving water or steam from a head and the 'piston engines' driven by pressurized gases produced from combustion of the fuel. The former being a rotary engine and the latter a reciprocating engine had one thing in common – difficult and time consuming construction plus maintenance. Nikola tesla's 'bladeless turbine' built on entirely different mode of operation was a turning point in this regard. The turbine is the first of its kind to utilize the boundary layer effect of the propelling fluid over the rotor discs along with the fluid properties of adhesion and viscosity. The objective of this project is to construct the working model of a turbine based on Tesla's patent and investigate the theoretical basis of this turbine and its possible application in rural electrification by independent installation or as a hybrid.

II. THEORY

According to the 1913 patent of Nikola Tesla [1]; the working fluid enters the chamber through the inlet in the tangential direction and flows along the surface of the disk through the disk spacing. The flow path spirals towards the centre orifices, then exits axially through the outlet. Due to fluid properties of viscosity and adhesion it adheres to the disks with the no-slip condition occurring directly adjacent to the disk surface and a boundary layer velocity gradient forming throughout the

working medium away from the surface. As fluid slows down and adds energy to the discs, it spirals to the centre due to pressure and velocity, where exhaust is. As disks commence to rotate and their speed increases, fluid now travels in longer spiral paths because of larger centrifugal force. Fluid used can be steam or a mixed fluid (products of combustion). Through this phenomenon, some of the fluid energy is converted to mechanical work, causing the disks and shaft to rotate. Openings are cut out at the central portion of the discs and these communicate directly with exhaust ports formed in the side of the casing. In a pump, centrifugal force assists in expulsion of fluid. On the contrary, in a turbine centrifugal force opposes fluid flow that moves towards centre.

A. FORMULA USED

- i. Shaft power, $P_s = \frac{2\pi NT}{60}$
- ii. Velocity of the shaft, $V_s = \frac{\pi DN}{60}$
- iii. Power input by water from a head,
 $P_i = \text{Fluid Pressure} \times \text{Flow rate}$
- iv. Fluid Pressure (in Pascal), $p = \rho \times g \times h$
- v. Efficiency, $\eta = \frac{P_{\max}}{P_i}$
- vi. Motor Power ,
 $P_m = \text{Voltage (volts)} \times \text{Current (amperes)}$
- vii. Voltage for LEDs' in parallel,
 $\frac{1}{V_p} = \frac{1}{v_1} + \frac{1}{v_2} + \frac{1}{v_3} + \dots + \frac{1}{v_n}$
Voltage for LEDs' in series,
 $V_s = v_1 + v_2 + v_3 + \dots + v_n$
- viii. Torque, $T = I \times \alpha$

Where;

ρ = density of water

$$= 1000 \frac{\text{kg}}{\text{m}^3}$$

$$g = 9.81 \frac{m}{s^2}$$

h= water head in metres.

D= diameter of the shaft.

N= rpm of the shaft.

III. EXPERIMENTAL SET-UP

A. Material List

- B. The materials used to construct our water-driven experimental set up are very economical and easy to find. It includes stainless steel, aluminium, brass, P.V.C. pipe, and Acrylic (or Plexi) sheet.
- C. Stainless steel 202 for rotor discs.
- D. Brass for nozzle.
- E. Stainless steel washers as disc spacers.
- F. Aluminium for making 10mm diameter shaft.
- G. Acrylic sheet and P.V.C. pipe for making the rotor

B. Building Rotor

The rotor of the bladeless turbine consists of a series of circular discs with smooth & polished surface. The number of discs for the rotor depends on the head available as with increase in number of discs, initial torque of the turbine also increases due to increase inertia of the system.

C. Building Stator

Stator forms the most important unit of any turbo-machinery. It forms the part on which the rest of the unit i.e. rotor and the shaft rests. The following approach was made to build the stator of our turbine:

- The ease of availability and the cost formed our basis for material selection for the stator.
- P.P (polypropylene) 5"x5"x1 block was selected because it is light weight and it is relatively easy to perform mechanical operations like drilling on it.
- Exhaust holes were made on an acrylic sheet of standard thickness. It was ensured that these exhaust holes were made symmetrical to those present on the disc so as to make an easy outward flow of the exhaust water and also to reduce friction and stalling of water inside the casing resulting in the turbine to stop rotating further. The acrylic sheet was mounted on the casing.

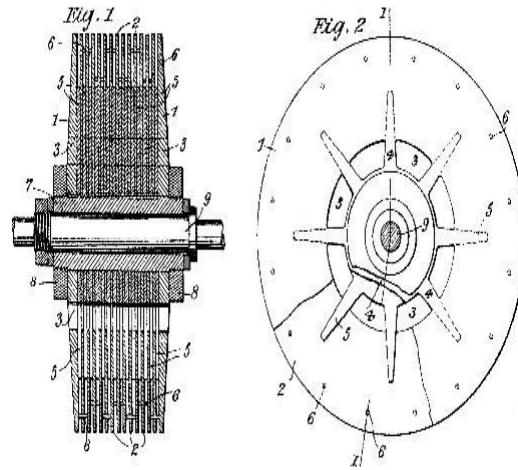


Fig1 represents the rotor disc; fig.2 represents the front view of the disc pack as viewed on N. Tesla's patent

D. Building Nozzle

A small copper pipe from the factory waste was used to design the nozzle for our turbine. The pipe was bent into the duck mouth shape nozzle.

E. WATER DRIVEN EXPERIMENT.

After the fabrication of rotor and stator, all the parts were assembled and the turbine was run on water on low head of 10-15 m. Different loads were connected to turbine and successful electrification of the loads marked the completion of the aim and objective of the turbine. The data from the experimentation is as follows:

TABLE I
NO LOAD VALUES.

Disc Spacing d (mm.)	Water Head h (m.)	Flow rate Q (m ³ /sec.)	Input Water Power. P _i (Watt)	R.P.M (N)
0.5	12.8	0.0001368	16	-
1	12.8	0.0001368	16	1500
1.5	12.8	0.0001368	16	860 – 910
2	12.8	0.0001368	16	750 – 800

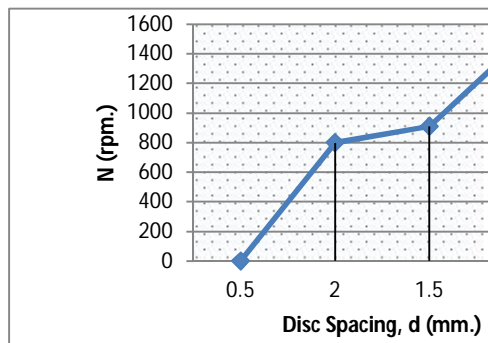


Fig.1 A plot of disc spacing v/s speed for 5 discs and water head approx. 12.8m.

On connecting with different loads (L.E.D bulbs) of following capacities

- 0.75 Watt
- 1 Watt
- 3 Watt
- 6 Watt

TABLE II
ON LOAD VALUES.

Disc Spacing, d (mm.)	Flow rate, Q(m ³ /sec.)	Input Water Power, P _i (Watt)	Load P _o (Watt) (LED Rating)	Efficiency, η̇ (P _o / P _i) %
1.5	0.00017	16.3	0.75	4.6
1.5	0.00017	16.3	1	6.13
1.5	0.00017	16.3	3	18.4
1.5	0.00017	16.3	6	36.8

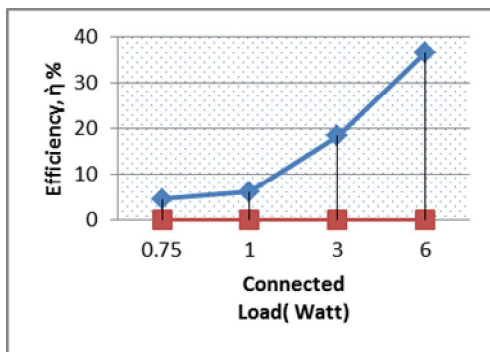


Fig.2 A plot of connected load v/s turbine efficiency for 5 discs and water head approx.12.8m.

IV. RESULTS AND DISCUSSION

The Fabricated tesla turbine was run at a very less flow rate of 0.0001368 m³/sec from a constant head of 12.8 m which makes our set up comparable to other high and medium head turbines like Pelton turbine, Turgo turbine and Cross-flow

turbines which work under a varying head of 7 – 60 m. The experimental results from Table I show the high speeds attained even at such low flow rate and varied disc spacing. The factor of disc spacing is of importance in the construction of the turbine as the spacing between the discs is responsible for boundary layer formation when water passes through discs tangentially.

After a series of experiments it was found that maximum speed attained by the turbine was at 1mm under no load conditions; increasing or decreasing the disc spacing from this value gave results as shown in Fig.1

The turbine was connected to varying loads consisting of household LED ceiling bulbs of different wattage and they glowed at full intensity with increasing efficiency as shown in Fig.2.

It is believed that Tesla type rotor disks are resistant to erosion [2] and are fit for rural electrification set up.

V. CONCLUSION

The analysis shows that our turbine had the flow rate of 100-1000 times lesser than the Pico-hydro's but the efficiency of our system outputs better results with an increase of 2.7% as compared to present Pico hydro set ups.

This analysis shows how with improved designs and better state of the art construction and increased flow rate at our disposal, the bladeless turbine can be a possible alternative for rural electrification especially for off the grid systems.

The above results from the experimentation reflect the vast implications of the bladeless turbine in the industry as well as other sectors such as rural electrification. The results prove and make a benchmark in our understanding of the fluids and their utilization at our disposal in the form of mechanical and electrical applications. The conventional turbines have long been trying to eliminate the losses due to viscosity and boundary layer formation but the present work experimentally proves the successful utilization of these two fluid properties into an altogether new system; namely 'Bladeless Turbines' with added benefits of reduced or no cost of blade maintenance, simple and cheap construction with compact units at use.

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