Design and fabrication of Portable Tesla Turbine

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Abstract- The present work of this research is to design and fabrication of portable Tesla disc turbine to generate electricity for domestic applications**.** In 1913, Nikola Tesla patented blade less turbine which is relatively simple in design and capable of achieving high speed upto 35,000 rpm. It is unique in design that replaces conventional blade of turbine with series of parallel discs mounted on shaft. Tesla turbine utilizes boundary layer effect to make it functional. A working fluid air is injected circumferentially and passes it over the disc, due to friction it propels the disc and air exit at the axis of rotation. The Turbine itself is environmental conscious in design and blades are totally replace with disc overcome the problem of blade failure.

Key words- Axial flow disc; Boundary layer theory; Compressed air; Flow efficiency; Tesla Turbine

1. Introduction

Tesla in 1909 filed a patent on turbine and got patented in 1913[1]. The design of Tesla turbine consists of parallel thin disc placed very close to each other separated by washer, assembled and mounted on shaft forming a rotor part which fitted in cylindrical housing(stator). In the central part of the disc, exhaust ports were opened which provide exit to the atmosphere [2]. A tangential bore at the casing through which working fluid enter and impinges on the disc results in rotation of rotor at high speed. The high speed is achieved due to viscosity and momentum change takes place between working fluid and disc, it moves in spiral fashion and exit it from center of the disc [3].Reynold's number is crucial to calculate as at low speed of the rotor, velocity of working fluid relative to disc surface is greatest. When the air enters between the disc separated by 2δ, the velocity profile in this case is as shown in Fig 1 which can be varied by changing the value of δ. Analysis of tesla turbine is based on Navier Stokes equations for parallel circular plates separated by distance 2 δ with inside radius r1 and outside radius is r2 as shown in Fig 2.

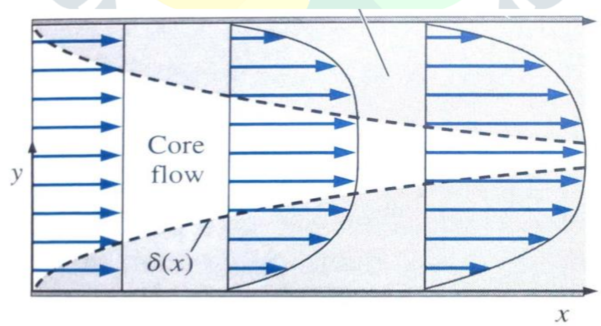

Fig 1: Boundary flow between two channels [4]

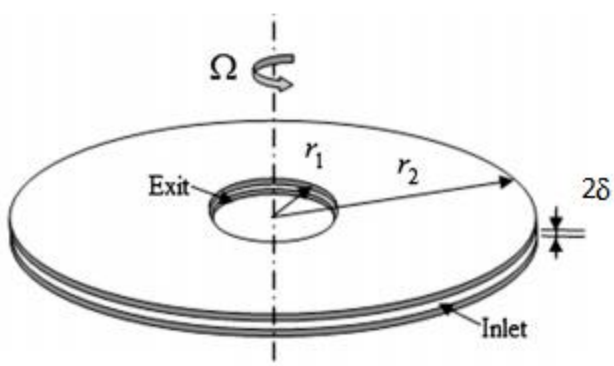

Fig 2: Two parallel circular discs are separated by distance 2δ

Torque(τ) exerted by fluid on the disc can be obtained by integrating the shear stress equation over the plate area through solving Navier stock equations proposed by Sengupta & Guha (2012) [5]. Thus, power generated by tesla can be calculated by multiplying torque with angular velocity(ω)

$$p = \tau\omega\text{--------}(1)$$

Modern turbines rely on principles of aerodynamics, where the air flow pushes the blades attached to an axle causing them to turn. Tesla's turbine however side steps friction and instead uses adhesion to power itself. This bladeless turbine is up to 95% efficient when using steam as the fuel, far exceeding any competition in its time. Pressurized gas entering at the inlet spirals its way to the center of equally spaced parallel discs and then exits through the middle holes, turning the discs at really high speeds in the process. A variety of fuels could be used such as steam and water. Thus, Tesla turbine is simple in construction and economic efficient. It does not provide harmful effect to the environment

Construction details of Tesla Turbine

- Take the metal discs and mount them on the threaded rod by layering one platter and one washer on top of each other, then screw the nuts on each side tightly to ensure the assembly does not rotate without rotating the rod as shown in Fig 3.

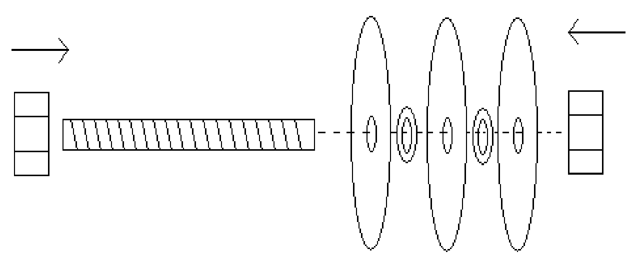

Fig 3: Arrangement of shaft and disks

THE CASING

Cut a block of acrylic or wood so that the platters can snuggly fit inside the casing. Also cut a hole on the side of the case to allow for the inlet of air as shown in Fig 4.

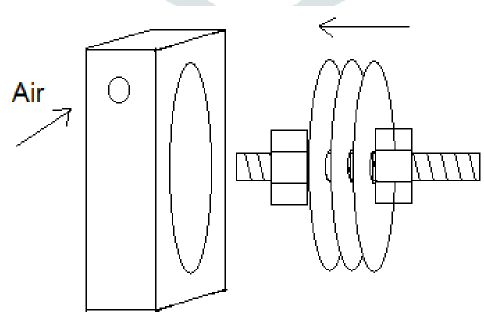

Fig 4: Arrangement inside casing

SIDE COVERS

Cut two identical pieces of acrylic to use as the side covers for the casing. Make a hole in the center of the pieces to allow for the rod to fit through it on each side. It is recommended to use ball bearings to minimize the friction between the acrylic and the rods while rotating as shown in Fig 5.

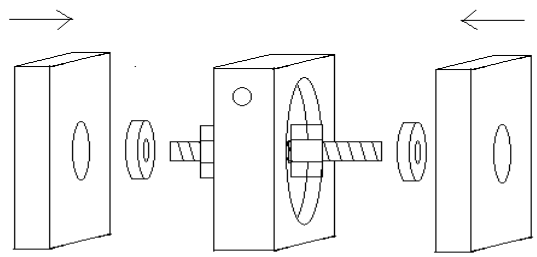

Fig 5: Side covers for casing

FINAL ASSEMBLY

Assemble the side covers and the casing to finish making the turbine.

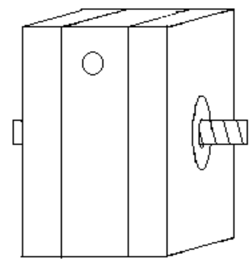

Fig 6: Assembled Tesla turbine

Analysis of tesla turbine

SPECIFICATION:
SIZES:

Casing diameter: 110mm
Turbine length: 204mm
Blade/disk diameter: 100mm
Blade/disk thickness: 2.0mm
Blade/disk gap: 0.7mm
Number of Blades/disks: 10
Total Weight: 1600g approximate

MATERIALS:

Casing: acrylic
Shaft: stainless steel
Disk Spacers: aluminum
Injector: plastic tube

Parameters obtained through Analysis:

$R_e = 4\rho va/3\mu$

ρ= density of air (0.929 kg/m^3) at 107 ^{o}C
v= velocity of air (m/s)
a= gap between disks (0.7 mm)
μ= dynamic viscosity of air (Pa-s)
R_e= Reynolds's number

$\omega = 2\pi N/60$

N= rpm of disk/flywheel
ω= angular velocity (rad/s)

$\upsilon = \mu/\rho$

υ= kinematic viscosity ($23.81*10^{-6}$m^2/s)

$I = (m_1r_1 - m_2r_2)/2$

m_1= mass of flywheel (1.6 kg)

r_1 = radius of flywheel (50 mm)

m_2= mass of holes (kg)

m_1/ ((area of disk) – (area of holes)) = m_2/ area of holes

m_2= 10.5 g

r_2 = radius of hole (5.75 mm)

I = mass moment of inertia (kg-m^2)

$\alpha = (\omega_2 - \omega_1)/t$

ω_1= angular velocity at N_1 (rad/s)

N_1= 7955 rpm

ω_2= angular velocity at N_2 (rad/s)

N_2= 8138 rpm

t= time gap between N_1 and N_2 (3 sec)

α= angular acceleration

$T= I\alpha$

T= Average torque (N-m)

$P= 2\pi N_{avg}\, T/60$

P= Power (watt)

N_{avg}= Average rpm of N_1 and N_2

Table 1: Result Obtained

$\omega = 2\pi N/60$ = 2*3.14*8500/60 = 890.11 rad/s	V = ωr = 890.11*.05 = 44.50 m/s	$R_e = 4\rho va/3\mu$ =4*0.929*44.50*0.7/3*22.12*10^{-6}*1000 = 1744.324
$I = (m_1r_1 - m_2r_2)/2$ =((1.6*0.05)–0.0105*5.75))/2 = 1.99*10^{-3} kg-m^2	$\alpha = (\omega_2 - \omega_1)/t$ = (852.20 – 833.04)/3 = 6.38 rad/s^2	T= Iα = (1.99*10^{-3})*6.38 = 0.0126 N-m $P= 2\pi N_{avg}\, T/60$ = 2*3.14*8046.5*0.0126/60 = 10.61 watt

Conclusion

In the present study, tesla turbine has been fabricated to generate energy for domestic applications as a replacement to batteries and generators. The prototype utilizes air as a working fluid. Air compressor is used to pump and deliver the air into the discs as working media which drives the turbine at high speed. This prototype can generate power upto 10 Watt. This study is useful efficiency matters a lot. It is easy to fabricate even with hard disc and available resources in economic rate.

References:

1. Tesla Nikola: „Turbine”. Patent no: 1,061,206., United States Patent Office, Nikola Tesla, of New York N. Y., Patented May 6, 1913
2. Couto, H. S., Duarte, J. B. F., & Bastos-Netto, D. (2006, October). The tesla turbine revisited. In 8th Asia-Pacific international symposium on combustion and energy utilization (pp. 1-6)

3. Podergajs, M. (2011, March). The tesla turbine. In *Seminar, University of Ljubljana, Faulty of Mathematic and Phsics*.
4. Cengel, Y., & Cimbala, J. (2010). *Fluid Mechanics, Fundamentals And Applications* (2nd ed.). New York, NY, USA: McGraw-Hill
5. Sengupta, S., & Guha, A. (2013). Analytical and computational solutions for three-dimensional flow-field and relative pathlines for the rotating flow in a Tesla disc turbine. *Computers & Fluids*, *88*, 344-353.