ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 2, Issue 5, May 2017

Design of tesla turbine and fabrication of model

[1] G. Sai Krishna Pranay, [2] Md Mujtaba Ahsan Ullah, [3] Md Faiz Ul Haque, [4]Dr U.S Vara Prasad
[1][2][3][4] Methodist college of engineering and technology

Abstract: -- Tesla turbine is a bladeless turbine; it is also called boundary layer turbine or cohesion type turbine or prandtyl layer turbine. It was invented by Nikola Tesla in the year 1908 and patented in the year 1913.It works on Boundary layer theory. The boundary layer is responsible for the rotation of discs with increase in the individual pressure in the cross section.

As the world is getting polluted more and more by harmful gases from the burning of fossil fuels example: IC engines, the need for the alternate way of getting the work output has to be the key goal of today's engineers. As tesla turbine can run on water, compressed air and steam. Hence these are all abundantly available resources which can be utilized to get the max efficiency from the turbine. Tesla turbine gives maximum efficiency when run on steam, as steam generation is difficult and not ideal for small scale projects we decided to go for compressed air. As stated by tesla the efficiency of this turbine is around 95%. Hence this turbine was chosen for the major aim of the project. In total two models where prepared from plastic practically and tested and final model is a computerized model in proportionate to the previous models. The input pressure, output pressure, input velocity, exit velocity, torque, actual work, isentropic work, experimental efficiency and power were calculated from the model and the designed turbine, when running on compressed air. The equations used for these calculations are the Navier-Stokes equation in cylindrical co-ordinate system, continuity equation, momentum equation. These were the theoretical calculations done on the model and the designed turbine. The Bernoulli's equation, continuity equation, torque equation in relation with fluid flow, angular acceleration are calculated manually for the values of torque, isentropic work, actual work and experimental efficiency.

Keywords: Boundary layer theory, Disks, Spacers, compressed air, transmission, work production

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 field. 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.
According to the 1913 patent of Nikola Tesla; the working fluid enters the chamber through a nozzle and flows along the surface of the disk through the disk spacing. The flow path spirals towards the center orifices, and 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 center 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 compressed air, 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 center.

AIM OF THE PROJECT:

The main aim of the project is that to show that the torque produced from the designed tesla turbine can run an automobile weighing 180kg (approx.) when coupled to its transmission".
Hence this project is an innovative idea into improving the future from pollution and extinction of natural resources

ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 2, Issue 5, May 2017

like petroleum, coal etc. And to improve the efficiency of the prime-mover as that of IC engines.

FABRICATION PROCESS AND EQUIPMENT

Machines used:

- Compressor:
  A 250psi compressor was used to produce the compressed air which will be used for rotating the disks which thus in turn drives the rotor.
- Drilling machine:
  A 1.5 HP bench drilling machine was used for drilling the holes on the compact disks and on the casing for providing holes for passage of air from one disc to the other and from the casing to the outlet.
- Grinding machine:
  A bench grinding machine was used to grind the disks so as to decrease the diameter of the disks such that the disks can easily rotate in the casing

Components Required:

- Plastic CD case
  This casing is made up of plastic thus drilling it is tricky as excess force may break it. The holes of 8mm were made on the front portion of the casing which is the exhaust. There is another hole on the outer periphery of the casing which is of approximately 10mm in size and this hole is connected to the nozzle by means of glue from hot glue gun. The casing is attached to the back cover by using the same hot glue from the hot glue gun.
- CD's
  These CD's basically works as the disks which are made of plastic. Holes of 8mm in diameter are drilled by using the bench drilling machine on its surface. The disks are also grinded by 1mm which is done by using bench grinding machine. The holes drilled are not arranged aligned to each other since the air might just pass through it which was tested. Now the holes are arranged angular to each other such that as the air passes through them it drives them and further the shaft.
- Plastic nozzle
  This is basically a plastic reducer which works similar to a nozzle the larger end is connected through a pipe to the compressor.
- Plastic washers
  The washers used are the pillar washers which are chosen based on the availability of the washers. These washers are used to connect the CDs with each other and create enough space between them such that the air drives the disks and the shaft.
- Rubber washers
  These washers are also used to attach the discs based on its availability.
- CD case's back cover
  This is required to close the casing from the back side by using a hot glue gun. This is done to not let the compressed air escape from the end and to ensure that there are no leakages.
- Plastic shaft
  This is the main part which is placed without a bearing in the model. Thus, supports are to be given to the shaft this is given by placing the shaft between the casing and the back cover. The end is constrained from the outer part such that the shaft is not allowed to move axially. Lubricating oil is used here to decrease the friction between the shaft and the parts in contact to it.
- Hot glue gun
  This is used in various parts to make them to attach each other. The main reason for using this is it produces leak proof joints. It is better for making plastic parts to adhere to each other.
- Liquid silicon solution
  This is used to make the washers and the CDs to stick each other.
- Valve
  This is used to operate the compressor at different discharges.

FABRICATED MODEL:

The fabricated models were created by using simple CD's and its case and incorporating a nozzle in it. The CD case was drilled with a slanted hole tangentially to the

ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 2, Issue 5, May 2017

circumference to make a sloping hole where the nozzle would go in and can be fixed. The nozzle was also grinded such that the air flow was more linear. Then this assemble was sealed using a hot glue gun with a plastic mold. Then the whole case was drilled with 4 exhaust holes in the front. This process was same for both the models and then the CD's were drilled with 4 through holes and were glued together with spacers between them. The discs were glued together in such a way that the through holes were in a spiral format so that there is some turbulence near the holes. Then they were placed onto the shaft. The model without rotating shaft was made to understand the boundary layer flow and the rotation of the discs. The model with rotating shaft was the actual idea of the project, here the discs were reduced from 12 to 10 and even the casing length was reduced so that there is mode pressure in the chamber. All these illustrations can be found in the images in upcoming pages. The overall mass of the turbine is around 400g in which the disc is 16g each.

DESIGNED MODEL:

The designed model is in proportion with the fabricated model and was designed such a way that it would give enough torque to run a small automobile. The whole turbine is made of aluminum alloy 6061. The whole weight of the turbine comes to 14kgs. The discs with spacers weigh around 300g. Only the exhaust pipe is made of rolled stainless steel.

ALLOY 6061

CHEMICAL COMPOSITION IN %								
Element	Si	Fe	Cu	Mn	Mg	Zn	Cr	Al
Specified	0.40 to 0.80	0.70Max	0.15-0.40	0.15 Max	0.80 to 1.20	0.25 Max	0.04-0.35	Remainder
MECHANICAL & ELECTRICAL PROPERTIES								
	Ultimate Tensile Strength in			% Elong	Hardness in BHN			
Specified	27 kg/mm² (262Mpa)			8%	80			

Fig:1 Material specification table

DIMENSIONS:

Model with and without rotating shaft:

- Disc diameter: 118mm
- No of holes on disc: 4 and diameter: 8mm
- Thickness of disc: 1.5mm
- No of discs: 10 (with rotating shaft) & 12 (without rotating shaft)
- Spacer diameter: OD: 35mm & ID: 20mm
- No of spacers: 11 (with rotating shaft) & 13 (without rotating shaft)
- Spacer thickness: 2mm
- No of exhaust holes on disc: 4
- Mach no: 1(approx~0.9)
- Sonic flow throughout the nozzle
- Exhaust hole diameter: 8mm
- Shaft diameter: 15mm
- Shaft length: 60mm
- Casing outer diameter: 140mm
- Casing thickness: 2mm
- Casing length: 50mm (with rotating shaft) & 80mm (without rotating shaft)
- Pressure at inlet from the nozzle: 70 psi
- Chamber pressure: 13 bar(approx.)
- Nozzle diameter: Inlet diameter: 15mm & outlet diameter: 5mm. Nozzle chosen has 33% decrease in exit pressure and vice-versa of velocity

DESIGNED TURBINE:

- Disc diameter: 285mm
- Thickness of disc: 2mm
- No of discs: 10
- Spacer diameter: 50mm
- No of spacers: 11
- Spacer thickness: 3mm

ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 2, Issue 5, May 2017

- No of exhaust holes on disc: 8
- Exhaust cover diameter: OD:110mm ID:100mm
- Exhaust hole diameter: 20mm
- Mach no: 1(approx~0.9)
- Nozzle length: 50mm
- Nozzle diameter: inlet diameter: 25.4mm and outlet dia:10mm
- Exhaust pipe diameter: OD:25.4mm ID:24mm and length:100mm
- Shaft diameter: 20mm
- Shaft length: 100mm
- Bearing diameter: OD:40mm & ID: 20mm
- Bearing thickness: 5mm
- Casing outer diameter: 300mm
- Casing thickness: 3mm
- Casing length: 76mm
- Pressure at inlet from the nozzle: 150 psi
- Chamber pressure: 18 bar(approx.)
- Nozzle chosen has 40% decrease in exit pressure and vice-versa of velocity and it is made of copper for durability

FORMULAE USED:

- $m = \rho A v$
- $P/\rho + zg + v^2 = \text{Constant}$
- $Av = \text{Constant}$
- $W_{isentropic} = mC_p\Delta T$
- $W_{actual} = W_{isentropic} - W_{losses}$
- $\text{Power} = W_{actual} / \text{Time}$
- $\text{Power} = (2*\pi*N*\text{Torque}) / 60$
- $\text{Torque} = W_{actual} * 60/2*\pi*N*\text{Time}$
- $\eta = W_{actual} / W_{isentropic} * 100$

DESIGN AND IMAGES OF TURBINE:

Turbine with and without rotating shaft:

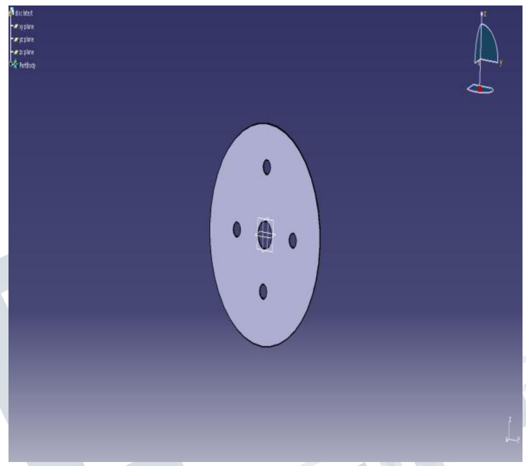

Fig 2: Disc of the turbine

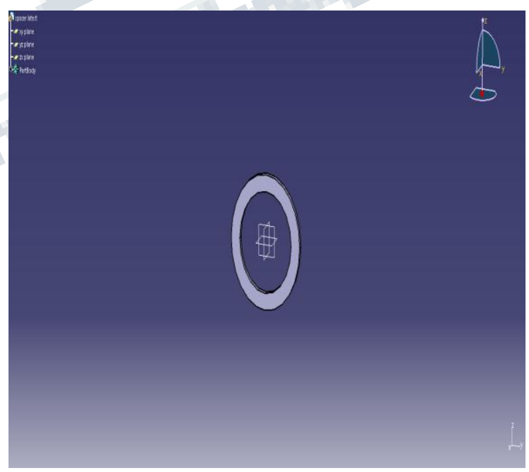

Fig 3: Spacer between the discs

ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 2, Issue 5, May 2017

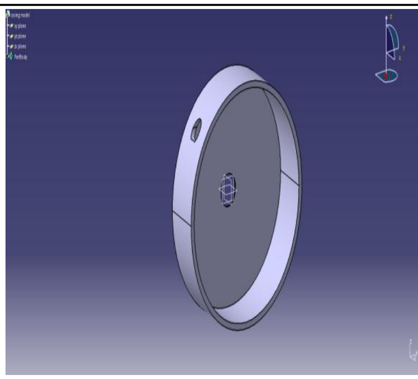

Fig 4: Casing of the turbine

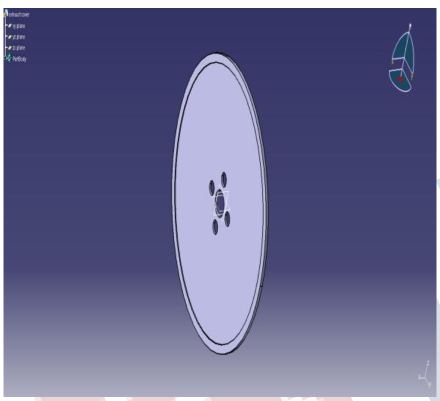

Fig 5: Exhaust cover of the turbine

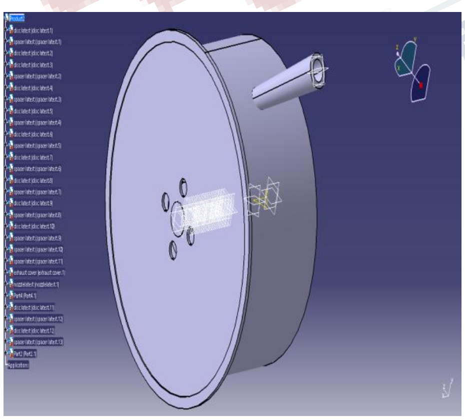

Fig 6: Assembled turbine

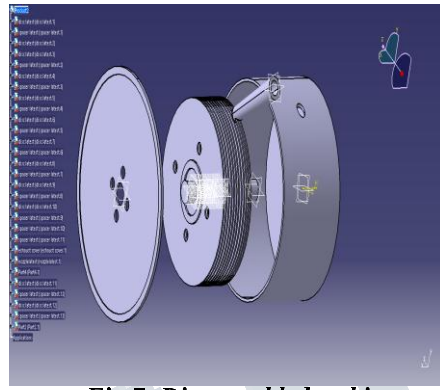

Fig 7: Disassembled turbine

Images of the turbine with and without rotating shaft:

Fig 8: Assembled Turbine without rotating shaft

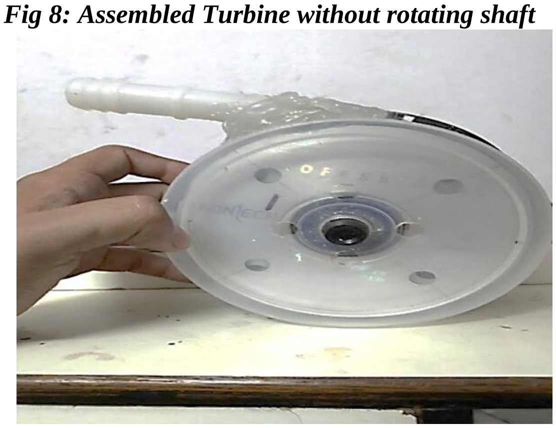

Fig 9: Assembled Turbine with rotating shaft

ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 2, Issue 5, May 2017

Designed turbine

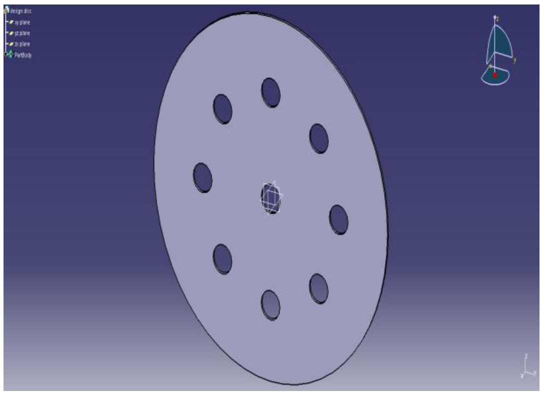

Fig 10: Disc of the designed turbine

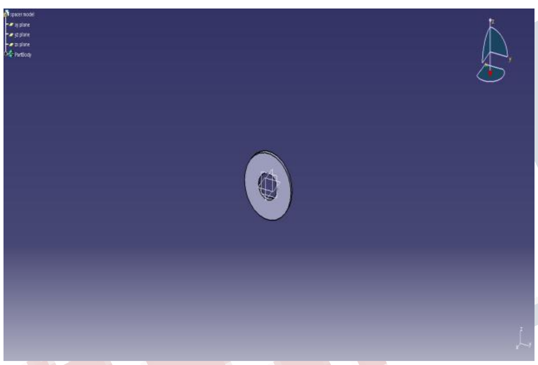

Fig 11: Spacer between the discs of the designed Turbine

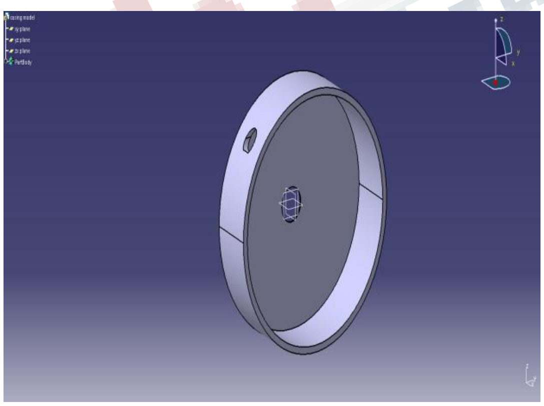

Fig 12: Casing of the designed turbine

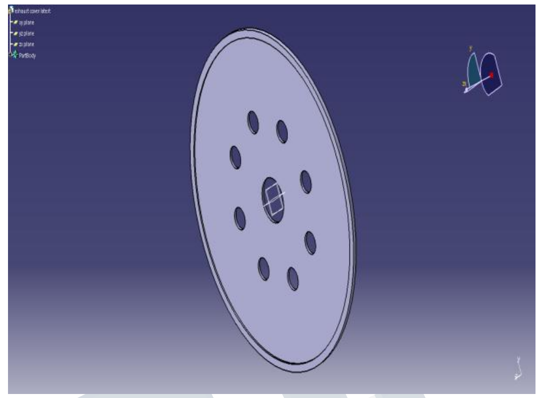

Fig 13: Exhaust cover of the designed turbine

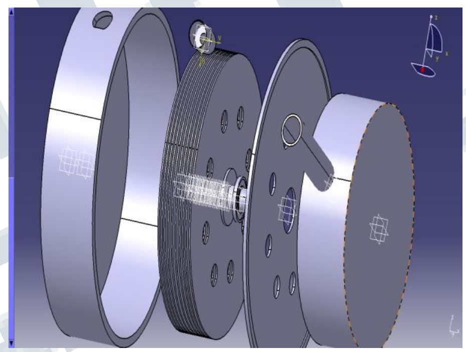

Fig 14: Disassembled designed turbine

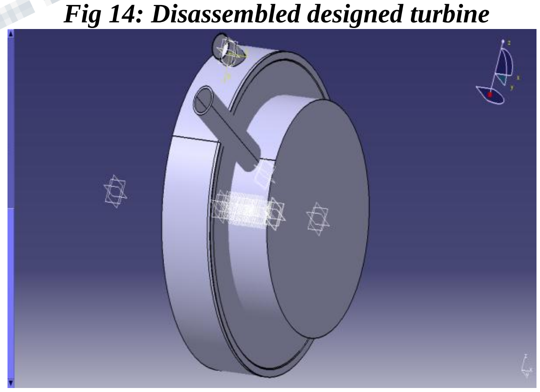

Fig 15: Fully assembled designed turbine

ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 2, Issue 5, May 2017

RESULTS AND DISCUSSIONS:

Model with rotating shaft:

Maximum speed	4000 Rpm
Torque produced	1.83 Nm
Time taken to achieve the max speed	23 seconds
Exit pressure	13 bar
Exit velocity	35.34 m/sec
Isentropic work done	35279.06 Joules
Actual work done	17639.5 Joules
Initial Velocity	360 m/s
Overall losses	50%
Theoretical efficiency	50%
Average speed	2500 Rpm
Power	1 HP

Table 1

Designed turbine

Maximum speed	8000 Rpm
Torque produced	9.2 Nm
Time taken to achieve the max speed	45 seconds
Exit pressure	18 bar
Exit velocity	12.54 m/sec
Isentropic work done	433685.57Watts
Actual work done	346948.4 Watts
Initial Velocity	400.6 m/s
Overall losses	20%
Theoretical efficiency	80%
Average speed	4000 Rpm
Power	10 HP

Table 2

ASSUMPTIONS:

- Pressure is constant throughout the pipe.
- It's a sonic flow in the nozzle.
- The axial velocity is negligible.
- The flow is laminar in the turbine.
- The temperature in the tank and at the inlet of the nozzle is constant and approximately equal to ambient temperature.
- The slip is negligible and there is no relative velocity between the disc and the shaft.
- The lateral fluid flow in the turbine is not considered for the calculations as the calculations have to be done on the cylindrical co-ordinates.

VARIOUS LOSSES IN THE TURBINE:

- Losses due to uncontrolled diffusion in the exhaust process.
- Losses due to partial admission of fluid.
- Leakage loss occurs due to the leakage flow through the bearing, seals and the clearance gaps between the rotor and the housing.
- Wind age loss is due to the first and last disc rotating within a nearly stagnant fluid.
- Loss due to partial admission is caused because of finite thickness of the discs and the interference of the edges of the discs.
- Bearing friction losses and uncontrolled varying pressure losses.

And when the whole turbine is manufactured then due to mechanical losses and ambient temperature variations the efficiency may go down to 75% that's when considered to the bare minimum.

FINAL VERDICT:

The overall observations for the designed turbine is done by comparing the torque and speed figures with the speed and torque figures of an existing automobile named "Hero Splendor – 100 CC engine".

ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 2, Issue 5, May 2017

Specification	Designed tesla turbine	Hero splendor 110cc
Weight	180kg (Including chassis)	110 kg
Max torque	9.2 Nm	7.95 Nm
Speed (Rpm)	8000 Rpm	8500 Rpm
Power	10 HP	7.4 HP

Table 3: comparison of designed tesla turbine and existing automobile

(This is just a theoretical comparison not practical, the practical data may vary)

The whole aim of our project was to create a turbine which could be used as an alternative for the conventional IC engines. And this turbine would run at a much higher efficiency than the IC engines.
Hence, we were successful in achieving that aim(objective) of our project thereby creating a turbine which could run at 75% efficiency depending on the type pf the fluid used in the turbine. We got the optimum torque of 9 Nm which is enough to run a small capacity automobile weighing around 180 kg and would propel it to the speed of around 30kmph.

CONCLUSION:

The whole aim of our project was to create a turbine which could be used as an alternative for the conventional IC engines. And this turbine would run at a much higher efficiency than the IC engines.
Hence, we were successful in achieving that aim(objective) of our project thereby creating a turbine which could run at 75% efficiency depending on the type pf the fluid used in the turbine.
We got the optimum torque of 9 Nm which is enough to run a small capacity automobile weighing around 180 kg and would propel it to the speed of around 30kmph.
This speed may not be at the higher size but considering the size of the turbine which is very moderate and would fit into any kind of automobile in the place of the engine, hence this would open a new way of customizing the automobiles with this technology.

This technology can protect the damage further caused by the pollutants from the IC engines.

This technology will also lead a new way into the future with less eco-friendly engines and running on high efficiency. This would also help in improving the way to accommodate this technology in today's world.

We always wanted to change the way the automobiles being manufactured and the technology used in the current vehicles so we came up with this idea and as stated by Nikola Tesla that this turbine was his best invention from all time, we thought of putting this technology to use and hence we succeeded.

We hope that this project would help the automotive technology to go in an eco-friendly way and not compromising on power and the fun from an automobile.

APPENDICES:

- m = Mass flow rate or discharge of air leaving the compressor
- ρ = Density of air = 1.793 kg/m^3
- A = Area in m^2
- V_1 = Velocity of air entering the nozzle in m/s = 300 m/s
- V_2 = Velocity of air entering the turbine or leaving the nozzle in m/s
- V_3 = Velocity of air leaving the turbine in m/s
- P_1 = Pressure of air at the nozzle exit in kg/m^2
- P_2 = Pressure of air entering the turbine or leaving the nozzle in kg/m^2
- P_3 = Pressure of air leaving the turbine in kg/m^2
- T = Temperature of air at room conditions in ^oK
- g = Acceleration due to gravity in m/s^2
- μ = Dynamic viscosity of air at 25^{o}C = 0.0000179 kg/ms
- $C_{p=}$ Specific heat at constant pressure in J/kg k
- ω =Angular velocity of the discs in Rad/s
- Wisen= Isentropic work done in Joules
- Wact = Actual work done in Joules

ACKNOWLEGDEMENTS:

On the outset of the successful completion of the project titled "DESIGN OF TESLA TURBINE AND FABRICATION OF A MODEL".

It gives immense pleasure to express our deepest sense of gratitude and sincere thanks to our Dr.A.RAJASEKHAR (H.O.D) Department of mechanical engineering for their valuable guidance encouragement and help for completing this project work.

We are thankful to our internal project guide Dr. U.S VARA PRASAD Professor in mechanical engineering department for his valuable help and guidance in completing the project.

We would also like to the mechanical department laboratory for providing us the necessary equipment for testing our project.

We express our profound gratitude to principal of our college for allowing us to carry out this project.

We once again like to thank each and every person who helped us directly or indirectly for the successful completion of our project with all efforts.

We would like to thank our parents for their moral support and impeccable faith in us.

REFERENCES:

- A theory of Tesla disc turbines Sayantan Sengupta and Abhijit Guha Proc IMechE Part A: J Power and Energy 226(5) 650–663! IMechE 2012 Reprints and permissions: sagepub.co.uk/journalsPermissions.nav

  DOI: 10.1177/0957650912446402 pia.sagepub.com
- Lawn MJ and Rice W. Calculated design data for the multiple-disk pump using incompressible fluid. J Fluid Eng 1974; 96: 274–282.
- Lemma E, Deam RT, Toncich D, et al. Characterisation of a small viscous flow turbine. Exp Therm Fluid Sci 2008; 33: 96–105.
- Guha A and Smiley B. Experiment and analysis for an improved design of the inlet and nozzle in Tesla disc turbines. Proc IMechE, Part A: J Power and Energy 2010; 224: 261–277.
- North and Charles R. An investigation of the Tesla turbine. Neurol Sci 2015; 36: 1–2.
- Fundamentals of Compressible Flow with Aircraft and Rocket propulsion , Former Professor & Head, Deptt. of Mechanical Engg., I.I.T. Delhi, New Delhi.
- Fluid Mechanics and Hydraulic Machines by R.K. Rajput.