Design and Fabrication for Power Generation using Maglev Turbine

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ABSTRACT
This study represents about the history and global scenario of development of power generation. Indian scenario of power generation explained through tables and graph. Brief discussion about the Maglev turbine. Methodology and selection of turbine also discussed and presents the designs and fabrication of Maglev Turbine which is further used for power generation. In this paper, it is explained that miniature maglev turbine is divided in different sections to understand and fabricate it easily. Team has been made for design and fabricating blades, coils for connection, rotor. Members of team coordinated with each other to understand the design, concept and share the ideas under the supervision of guide.

Keywords: design and fabricating blades, maglev turbine**,** power generation

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INTRODUCTION
A vertical-axis wind turbine design called Darrieus wind turbine was patented by Georges Jean Marie Darrieus, a French aeronautical engineer. This type of wind turbine is still used today. Johannes Juul, a former student of Poul la Cour, built a horizontal-axis wind turbine with a diameter of 24 meters and 3 blades. The wind turbine had a capacity of 200 kW and it employed a new invention, emergency aerodynamic tip breaks, which is still used in wind turbines today. The first US wind farm was put online, producing enough power for up to 4,149 homes. Wind power becomes the No. 1 source of new power capacity in the US. 45,100 wind turbines were installed in the US this year, accounting for 42% of all new US power capacity. The world's first hybrid wind/current-powered turbine was installed off the coast of Japan. These demonstration were supported by the Ministry of New and Renewable Energy (MNRE). By year end 2015 India had the fourth largest installed wind power capacity in the world[1–5].

Overall Scenario of Power Generation
The development was occurred every year in power plants. The first power plant was hydroelectric type. After that, various types of power plants like wind, nuclear and thermal power plants came into existence. Now a day's renewable energy is being used widely. Figure 1.

Global Scenario
Table 1 shows most of power plants use non-renewable energy in present days. But in upcoming year, the share of non-renewable energy type power plant will decrease and share of the renewable energy type power plant will increase [6].

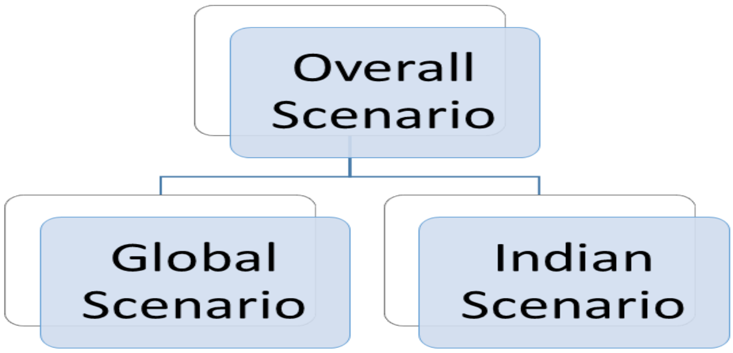


Fig. 1. *Different Scenario of Power Generation.*

Table 1. *Power plants use non-renewable energy in present days.*

Primary Fuel/Year	Power (TWhrs/year)								
	Jazz					Symphony			
	2010	2020	2030	2040	2050	2020	2030	2040	2050
Coal (with CCS*)	0	10	87	346	1007	41	301	1587	7100
Coal	8666	11920	14792	18565	19272	9289	7949	5280	1383
Oil	980	0	0	0	0	0	0	0	0
Gas (with CCS*)	0	2	31	140	558	11	113	789	2505
Gas	4777	7232	9734	11427	12869	6609	8127	9049	7012
Nuclear	2763	3255	3430	3395	3279	3651	4706	5888	6950
Hydrogen	0	0	2	12	69	0	5	32	155
Hydro	3,491	4003	4550	5146	5789	4337	5408	6530	7701
Biomass	337	287	390	884	1923	362	535	1056	1913
Biomass (with CCS*)	0	8	28	160	441	16	100	295	800
Wind	358	818	1435	3142	4513	1386	2418	2994	4003
Solar	34	302	462	732	2979	519	2054	5752	7741
Geothermal	69	125	257	504	949	94	182	346	654
Total	21475	27962	35198	44453	53648	26315	31898	39598	47917

Table 2. *Indian scenario of power generation.*

Primary Fuel/Year	Power (GW)					Shares		CAAGR*
	2000	2014	2020	2030	2040	2014	2040	2014 - 2040
Fossil fuels	84	204	280	419	576	71%	53%	4.1%
Coal	66	174	230	329	438	60%	41%	3.6%
Gas	11	23	41	76	122	8%	11%	6.6%
Oil	7	7	9	13	15	3%	1%	2.9%
Nuclear	3	6	10	24	39	2%	4%	7.6%
Renewables	27	79	147	304	462	27%	43%	7.0%
Hydro	25	45	58	83	108	15%	10%	3.5%
Wind	1	23	50	102	142	8%	13%	7.2%
Solar	0	3	28	100	182	1%	17%	16.4%
Other	0	7	11	18	30	2%	4%	5.5%
Total	113	289	436	746	1076	100%	100%	5.2%

**CAAGR, compound average annual growth rate.*

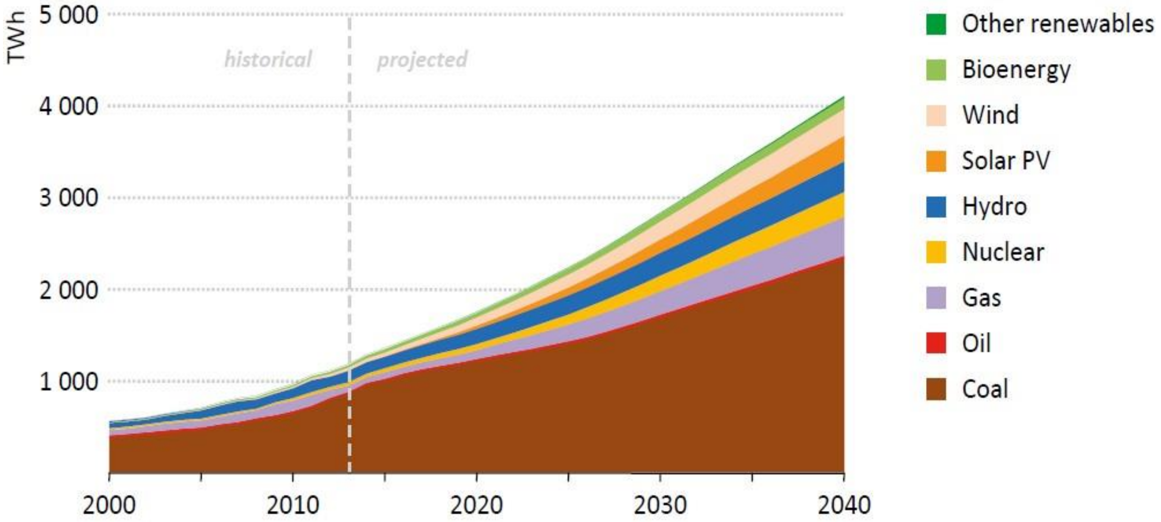


Fig. 2. *Power generation by source in India in the new policies scenario.*

Carbon Capture and Sequestration (CCS) through which waste carbon dioxide (CO_2) is captured from various sources like fossil fuel power plants then store it at storage site and depositing where it will not enter the atmosphere, normally an underground geological formation.

Indian Scenario

The Indian scenario of power generation can be understood by following Table 2 and Figure 2.

The content of Table 1 is plot in the Figure 2. This data shows the trend of power plants in India. In critical analysis of these data, it is found that the non-renewable energy type power plant has 71% share in 2014 but it become 53% in 2040. This shows that shares renewable energy type power plant increases day by day. This is also showing the awareness of the people about harms of use of non-renewable type energy [7].

Brief about Maglev Turbine

A Maglev turbine is a type of wind turbine in which there are no bearings. Maglev basically stands for Magnetic Levitation. In this turbine the whole turbine is levitated with the help of magnets [8].

This turbine operates on the principle that the similar poles of the magnets repel each other. The magnetic levitation makes it easy to rotate the blades by a breeze also because of negligible friction.

The main components of a Maglev turbine are shown in Figure 3. The function of each is described as below:

(1) Shaft: In this type of turbine, the shaft is stationary, and the blades rotate about the shaft. The magnets used for levitation are also inserted into this shaft.
(2) Blades: The blades of this turbine are the curved and parts of the circle. The blades are placed at between the upper and the lower disc.
(3) Magnets: In this turbine, the magnets are used for levitation as well as induction of EMF into the coils.
(4) Stand: It is a stationary part of the whole assembly, on which whole arrangement is placed.
(5) Copper Coils: An arrangement of copper coils is used so as to generate the electricity by changing the flux into the coil.

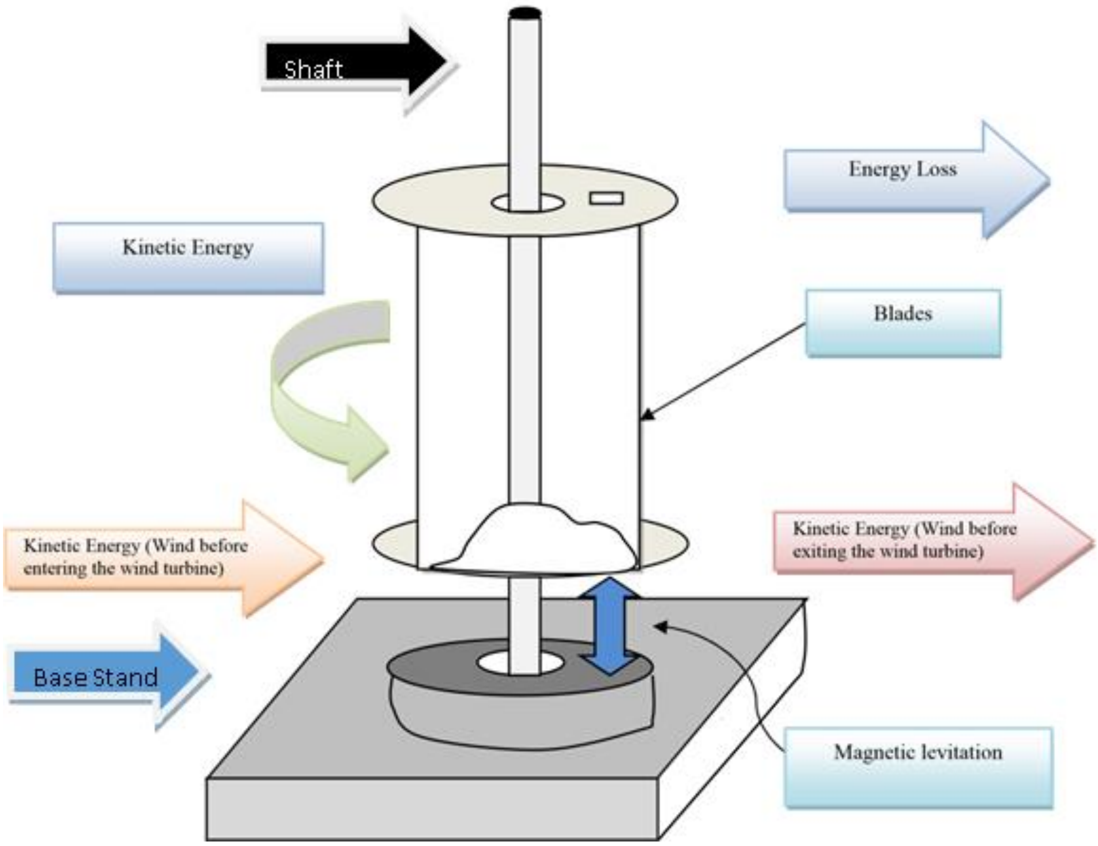


***Fig. 3**. Components of a Maglev turbine.*

METHODOLOGY

It includes the sequence, we have followed to make this design effective and without any drawback.

(1) Power to be generated
(2) Area of blade for power
(3) Design of blade
(4) Design of blade platforms
(5) Design of shaft required
(6) Design of generator
(7) Design of rigid base platform
(8) Analysis
(9) Fabrication

The first step for execution is to decide that which type of magnet should be used. For this we have done literature survey, from which we found that only permanent magnets are suitable for this purpose.

There are four types of permanent magnets:

(1) Neodymium Iron Boron (NdFeB)
(2) Samarium Cobalt (SmCo)
(3) Alnico
(4) Ceramic or Ferrite

From market survey it was confirmed that neodymium magnets were easily available and suitable for this because this type of magnet is composed of rare earth magnetic material and has a high coercive force. They have an extremely high energy product range, up to 50 MGOe. Because of this high product energy level, they can usually be manufactured to be small and compact in size. However, NdFeB magnets have low mechanical strength, tend to be brittle, and low corrosion-resistance if left uncoated. If treated with gold, iron, or nickel plating, they can be used in many applications. They are very strong magnets and are difficult to demagnetize [9–13].

For market survey we went to old Delhi and got some quotations which are listed below in Table 3:

(1) Second important step is to decide, which material is suitable for turbine blade. For this we had two options:
(2) To use aluminium sheet.
(3) To use polyvinyl chloride (PVC) plastic.

Table 3. *Quotations of market survey.*

S. No.	Diameter (cm)	Thickness (cm)	Price (₹)
Magnet 1	2.0	0.5	80.0
Magnet 2	2.5	1.0	150.0
Magnet 3	ID–1.4 OD–3.0	0.2	80.0

Aluminium sheet is costly and also it was not easy to symmetric blades out of aluminium sheet. For symmetricity we found a suitable solution. We used PVC pipe of 4-inch diameter and cut it into four parts of along its axis. It helps us to find the exact arc and symmetric shape which is an important consideration for blade design.

Selection of Turbine

We have selected vertical axis wind turbine (VAWT). This turbine has been selected on the basis of following criteria Table 4:
(1) It has been selected because magnetic levitation is only possible for vertical axis wind turbine (VAWT).
(2) There is no yaw mechanism in case of VAWT.
(3) In this turbine shaft can be used for the support and stability of the rotors and generator.
(4) VAWT produce less noise in their operation.

Table 4. *Bill of Materials.*

S. No.	Parts	Material
1.	Shaft	Aluminium
2.	Wind Turbine	PVC Sheet
3.	Permanent Magnet	Neodymium Magnets
4.	Fixed Base	Wood
5.	Coil	Copper wire (32 gauge)

Testing

Test 1: The starting wind speed of wind turbine model

(1) The model is assembled to be the maglev wind turbine.
(2) A fan is placed in the direction parallel to the maglev wind turbine model.
(3) The fan is switched on and the wind produced is directed to the model.
(4) The model is replaced by anemometer and the fan is switched on again. The wind speed is recorded.
(5) The test is repeated by using conventional wind turbine model.

Test 2: The rotational speed of wind turbine model at constant wind speed

(1) The step 1 is until 4 of test 1 are repeated. The wind speed is measured by using anemometer.
(2) The reading of rotational speed of model is recoded after 1 minute for five times.
(3) The test is repeated by using conventional wind turbine model.

Test 3: The time taken by wind turbine model to stop rotation

(a) The step 1 is until 3 of test 1 are repeated.
(b) The fan is then switched off after 5 minutes and a card bock is placed in front of it.
(c) Steps 2 and 3 are repeated for two times.
(d) The test is repeated by using conventional wind turbine model.

RESULTS AND ANALYSIS

Test 1: The starting wind speed of wind turbine model in Table 5.

Table 5. *Test 1 results*

Wind Turbine Model	Starting Wind Speed (m/s)			Average (m/s)
Maglev	1.9	1.5	1.4	1.60
Conventional	4.2	4.5	4.6	4.59

Test 2: The rotational speed of wind turbine model at constant wind speed of 5.63 m/s shown in Table 6.

Table 6. *Test 2 results*

Wind Turbine Model			**Rotational Speed (RPM)**			**RPM (avg.)**
Maglev	666.00	666.00	630.00	618.00	630.00	640.80
Conventional	292.80	294.00	235.80	270.00	237.00	265.92

Test 3: The time taken by wind turbine model to stop rotation show in Table 7.

Table 7. *Test 3 results.*

Wind Turbine Model		**Time Taken (s)**		**Average (s)**
Maglev	14.1	15.7	13.7	14.5
Conventional	1.6	1.5	1.4	1.5

Analysis report shown in Table 8 and Figure 4-5.

Table 8. *Analysis Report.*

Object Name	Turbine blade
State	Meshed
Graphics Properties	
Visible	Yes
Transparency	1
Definition	
Suppressed	No
Stiffness Behavior	Flexible
Coordinate System	Default Coordinate System
Reference Temperature	By Environment
Behavior	None
Material	
Assignment	PVC sheet
Nonlinear Effects	Yes
Thermal Strain Effects	Yes
Bounding Box	
Length X	16.995 mm
Length Y	71.831 mm
Length Z	304.8 mm
Properties	
Volume	70798 mm^3
Mass	0.10266 kg
Centroid X	8.2883 mm
Centroid Y	111.48 mm
Centroid Z	152.4 mm
Moment of Inertia Ip1	832.72 $kg \cdot mm^2$
Moment of Inertia Ip2	790.07 $kg \cdot mm^2$
Moment of Inertia Ip3	46.57 $kg \cdot mm^2$
Statistics	
Nodes	8396
Elements	1139

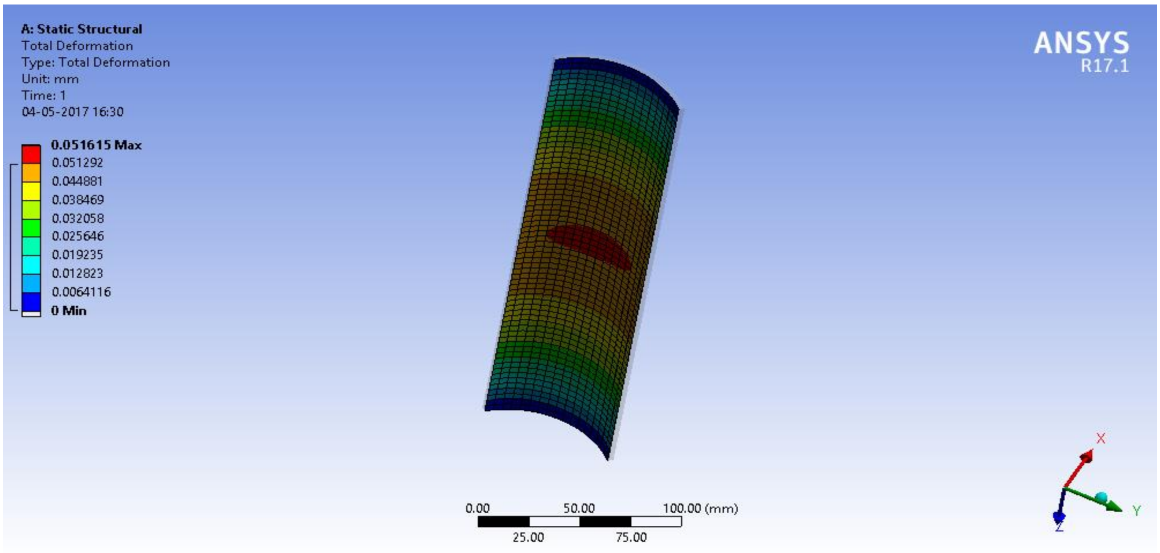


Fig. 4. *Total Deformation of Blade.*

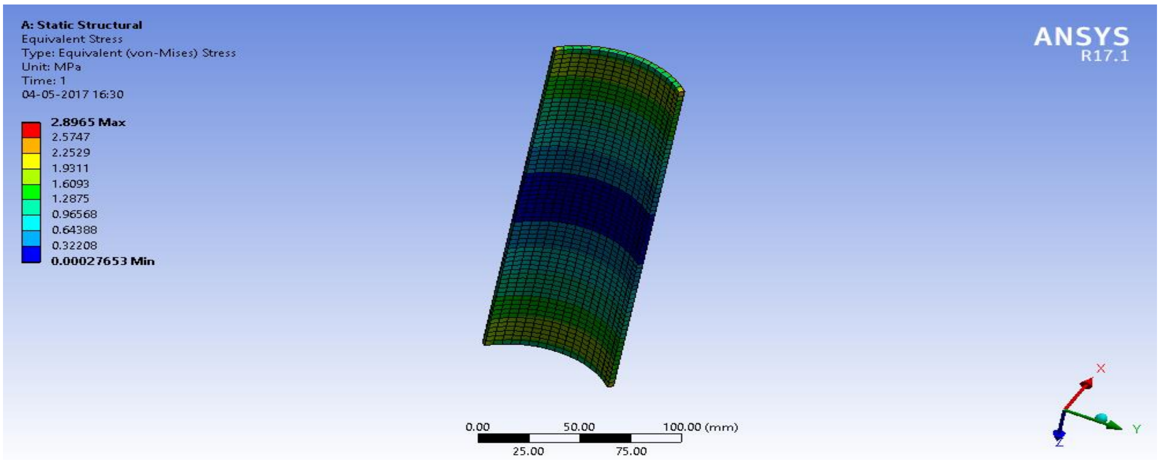


Fig. 5. *Equivalent Stress of Blade.*

Calculations

Power of Wind

The wind power increases as a function of the cube of the velocity of the wind and this power is calculable with respect to the area in which the wind is present as well as the wind velocity. Figure 6-8.

Kinetic energy (K.E.) = $\frac{1}{2} mv^2$

Amount of air passing is given by

$$m = \rho\, AV \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \ (1)$$

Substituting this value of the mass in expression of K.E.

$$K.E. = \frac{1}{2} \rho\, Av^3 \text{ watts} \quad \ldots\ldots\ldots\ldots\ldots\ldots \ (2)$$

To convert power to kilo watt a non-dimensional proportionality constant k is introduced where, k = 2.14 X 10-3

Therefore

$$\text{Power in KW (P)} = 2.14\, \rho\, Av^3 \times 10^{-3} \quad \ldots (3)$$

Where m = mass of air traversing

Air Density (ρ) = 1.2 kg/m3

Area (A) = area swept by the blades of the turbine

Velocity (V) = wind speed

With equation above, the power being generated can be calculated, however one should note that it is not possible to convert all the power of the wind into power. The turbine absorbs the wind energy with their individual blade will move slower that the wind velocity. The different speed generates a drag force to drive the blades. The drag force acting on one blade is calculated as

Fw

$$Fw = Cd2A\left(\frac{Uw-Ub}{2}\right) \ldots\ldots\ldots\ldots\ldots\ldots (4$$

Where,

A is swept area of the blade

ρ is air density (about 1.225kg/m3)

U_w is wind speed

C_d is the drag coefficient (1.9 for rectangular form)

U_b is the speed on the blade surface.

- We are given the following data:
- Blade length, *h*= 0.304 m
- Wind speed, *v*= 10 m/sec
- Air density, ρ= 1.225 kg/m^3
- Power Coefficient, C_p= 0.6 and 0.9
- Radius of rotor, r= 0.15 m

A = 2πrh

= 2 × 3.14 × 0.15 × 0.304

= 0.2863m^2

We can then calculate the power converted from the wind into rotational energy in the turbine using equation:

Pavail= $\frac{1}{2}$ρAv3Cp

Case I: When C_p = 0.6

Pavail= $\frac{1}{2}$×1.225×0.2863 ×10^3 ×0.6

= 105.2 W

Case II: When C_p = 0.9

Pavail= $\frac{1}{2}$×1.225×0.2863 ×10^3 ×0.9

= 157.8 W

Magnet Calculation

Formula used: Voltage = -N Δ(BA)/Δt

N= Number of turns in one coil= 1400

Number of coils= 10

B= 0.2407 T

R_{coil}= 1.6 cm

R_{coil}= 1.4 cm

A= 0.0002 m^2

Table 9. *Theoretical results at different RPM.*

S. No.	RPM	Voltage (V)
1	10	4
2	20	8
3	50	20
4	100	40
5	150	60.6
6	200	80.9
7	300	121.3

Fig. 6. *Fabrication of stand.*

Fig. 7. *Fabrication of rotor and blade.*

Fig. 8. *Fabrication of generator.*

Design and Fabrication

There were limitations for the available energy to rotate the working maglev wind turbine, because of budget, balancing, losses, and types of material available. Also, the requirement of high strength magnets for the rotor was a major problem. After considering these parameters fabrication took place.

Design and Fabrication of Turbine

The turbine was designed in the Autodesk Inventor. First of all, a disc was made using the extrude command. Then blades are modelled using arc and extrude command. This model is designed according to the final fabrication of turbine. The front view and isometric view of model shown in the Figure 9 and 10 respectively.

Fig. 9. *Turbine model in inventor.*

First, the requirements were discussed for turbine like blade shape, wind speed for rotating the turbine. Accordingly, PVC blade was chosen for turbine. Rotating of blades at minimum speed depend upon the friction produce in rotor and shaft. So, it was decided that we use magnetic levitation in place of bearing system. Since, we required magnet with high strength head storming so, market survey was done to full the requirement. Ultimately, we got the magnet with required specifications. The magnets are shown in the Figure 11. The magnets were fixed with glue on the base.

Fig. 10. *Isometric View of turbine.*

Fig. 11. *Neodymium magnets.*

Design and Fabrication of Blade and Magnetic Levitation

Undoubtedly, its ability to function is solely dependent on the power of wind and its availability. Wind is known to be another form of solar energy because it comes about as a result of uneven heating of the atmosphere by the sun coupled with the abstract topography of the earth's surface. Figure 12

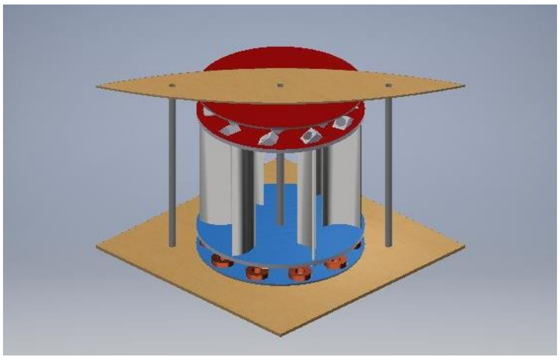


Fig. 12. *Complete maglev turbine Picture.*

Magnetic levitation operates on the repulsion characteristics of permanent magnets. This technology has been predominantly utilized in the rail industry in the Far East to provide very fast and reliable transportation on maglev trains and with ongoing research its popularity is increasingly attaining new heights. Using a pair of permanent magnets like neodymium magnets and substantial support magnetic levitation can easily be experienced.

By placing these two magnets on top of each other with like polarities facing each other, the magnetic repulsion will be strong enough to keep both magnets at a distance away from each other. The force created as a result of this repulsion can be used for suspension purposes and is strong enough to balance the weight of an object depending on the threshold of the magnets; we expect to implement this technology for the purpose of achieving vertical orientation with our rotors as well as the axial flux generator.

First of all, we make turbine blade from 4-inches PVC pipe by cutting it with their axis in four parts. For better surface finishing we grind it on grinding machine. After that we prepare base for blade support by grooving the PVC sheet.

Some factors need to be assessed in choosing the permanent magnet selection that would be best to implement the maglev portion of the design. Understanding the characteristics of magnet materials and the different assortment of sizes, shapes and materials is critical. There are four classes of commercialized magnets used today which are based on their material composition each having their own magnetic properties. The four different classes are Alnico, Ceramic, Samarium Cobalt and Neodymium Iron Boron also known NdFeB. NdFeB is the most recent addition to this commercial list of materials and at room temperature exhibits the highest properties of all of the magnetic materials which offers high flux density operation and the ability to resist demagnetization. This attribute will be very important because the load that will be levitated will be heavy and rotating a high speed which will exhibit a large downward force on the axis. Figure 13

Fig. 13. *Fabricated turbine.*

Table 10. *Specification of turbine.*

Title	**Detail**
Number of Blades	6
Height of Blade	12 inches
Material of Blade	PVC
Width of blade	2.9 inches
Width of rotor	12 inches
Thickness of Blade	3 mm
Rotor Outer Diameter	12 inches
Shaft Outer Diameter	13 mm
Material of shaft	Steel

After this the assembly made was fixed to a rigid stand by journal bearing at the two ends of the rotor shaft. Ultimately the casing was made to cover the assembly and utilize maximum of the steam. Specification of turbine and magnet shown in Tables 10 and 11.

Table 11. *Specification of magnet used.*

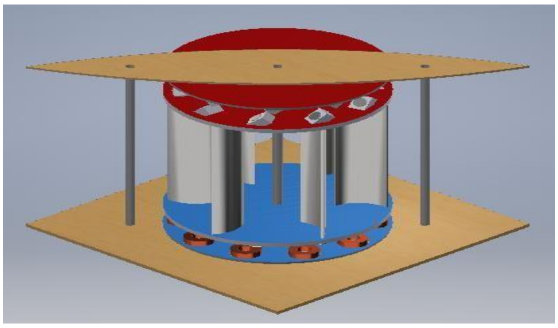
Title	Detail
Type	Neodymium Magnet
Material Used	N42
Composition	Nd- Neodymium, Fe- Iron, B- Boron
Residual Flux Density (Br)	176°F (80°C)
Coercive Force (Hc)	>11.4 KOe
Intrinsic Coercive Force (Hci)	>17 KOe
Max. Energy Product (BH)max	40–42 MGOe
Maximum Operating Temperature	176°F (80°C)

DESIGN AND FABRICATION OF TURBINE MODEL

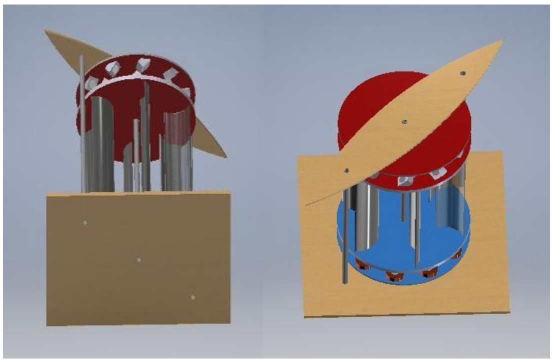
The turbine is designed on the software before the fabrication to observe and get a clear understanding of the working of the turbine operating in multistage. This minimizes the time, cost and error of prototype. So, it is very economic and effective to design an efficient model before the manufacture of working piece.

It was fabricated in following sequence:

- First the model was designed to get the understanding of each part of the turbine. The model was designed in Autodesk Inventor. The commands like revolve, extrude, extrude cut were majorly used in the preparation of this model. These different views of turbine model represent the complete construction of turbine in the 3D modelling using Autodesk Inventor. The different views of this turbine are shown in the Figure 14(a) to (c).
- The first step in fabrication has been the fabrication of rotor disc, rotor, shaft and the blades. The rotor disc has been made from PVC. The shaft has been taken of steel (Figure15).



(a)
Fig. 14. (a) *Isometric view.*



(b) (c)
Fig. 14. (b) *Bottom* View, ***(c)*** *Top view.*

Fig. 15. *Making of coil*

- After this, blades have been made from PVC pipe of 4-inch meter in diameter by cutting through hand hacksaw and then finishing with power grinder. After that the blades were assembled on the rotor disc. Figure 16
- These blades have been attached on the grooved rotor disc with the help of glue. Figure 17

This assembly was then inserted into the shaft with levitated magnets fixed to a frame. Figure 18-19


Fig. 16. *Making of Rotor disk.*


Fig. 17. *Arrangement of coil*


Fig. 18. *Arrangement of magnet.*


Fig. 19. *Assembly of turbine*

Axial Flux Generator

Alternator is a device which coverts mechanical energy into electrical energy. In present setup, turbine shaft was coupled with an alternator to convert the power at shaft into electrical power. Alternator is rated at power output of 500W with speed of 400 R.P.M.

CALCULATIONS

Formula used: Voltage = -N $\Delta(BA)/\Delta t$

N= Number of turns in one coil= 1400

Number of coils= 10

B= 0.2407 T

R_{coil}= 1.6 cm

R_{coil}= 1.4 cm

A= 0.0002 m^2

Table 12. *Theoretical results at different RPM.*

S. No.	RPM	Voltage (V)
1	10	4
2	20	8
3	50	20
4	100	40
5	150	60.6
6	200	80.9
7	300	121.3

CONCLUSION

The rotors keeping the centre of mass closer to the base yielding stability because of its designed harnessed enough air to switch the stator at low and high wind speeds while. Permanent magnets in wind turbine rotors and stator levitated helps for a smooth rotation with negligible friction.

Some shortcomings were there like generator itself had some design flaws which we feel limited the amount of power it could output. These flaws start at the coils which were initially made too thick and limited how close the magnets attached to the stator could be positioned from each other. The magnetic field density would be much greater if the magnets were pulled in closer to one another, due to which more power to be induced into the coils. Another limitation occurred in wire that was used to wrap the coils was 30 AWG due to its small cross section it limits the amount of current that could be drawn from the generator.

Vertical axis wind turbines have not been known to be suitable for large scale power production. Vertical axis wind turbine need to scale it up to a size where it could provide the amount of power to satisfy a commercial/industrial park or feed into the grid would not be practical. The large size of the rotors would cost too much to make. Aside from the cost, the area that it would consume, and the aesthetics of the product would not be desired by this type of consumer. Horizontal axis wind turbines can be used for this purpose because they need less space and having high positioned due to which they can obtain higher wind speeds and provide an optimum power output.

REFERENCES

[1] Cancino-Solórzano Y, Gutiérrez-Trashorras AJ, Xiberta-Bernat J. Analytical methods for wind persistence: Their application in assessing the best site for a wind farm in the State of Veracruz, Mexico. Renewable Energy. 2010 Dec 1; 35(12): 2844-52p.

[2] American Wind Energy Association. (2008). Installed Wind Capacity Surged 45% in 2007: AWEA Market Report. [Online] American Wind Energy Association. Available from http://www.awea.org/newsroom/releases/AWEA_Market_Release_Q4_011708.ht ml. [Access date 29 Apr. 2009].

[3] National Renewable Energy Laboratory. (2008). Wind and Hydropower Technologies Program: How Wind Turbines Work. [Online] U.S. Department of Energy Wind and Hydropower Technologies. Available from http://www1.eere.energy.gov/windandhydro/wind_how.html. [Access date 29 Apr. 2009].

[4] Yadav, V.P.D.V.A, Electricity Production by Magnet (Maglev Mill), 2017.

[5] "Wind Turbine FAQ." Rainbow Power Company. 29 Apr. 2009 http://www.rpc.com.au/products/windturbines/wind_faq.html.

[6] “Magnet Design”. 2000 Magnet Sales & Manufacturing Company, Inc. http://www.magnetsales.com/Design/DesignG.htm.

[7] Hunt Daniel V. *Wind power: A Handbook on Win Energy Conversion Systems*. New York: Van Nostrand Reinhold, 1981.

[8] Samaan N, Zavadil R, Smith JC, Conto J. Modeling of wind power plants for short circuit analysis in the transmission network. In Transmission and Distribution Conference and Exposition, 2008. T&D. IEEE/PES 2008 Apr 21; 1-7p.

[9] Richard F. Post. Inventor of inductrack passive magnetic levitation, Maglev: A New Approach. *Scientific American.* Jan 2000.

[10] National Maglev Initiative. *Final Report on the National Maglev Initiative*. Washington, D.C: National Maglev Initiative (NMI).1993.

[11] Minu J, Rohit J, Syamily PS, Vyshak PA. Maglev windmill. *International Journal of Innovative Research in Advanced Engineering*. 2014; 1(7); 111-114p.

[12] Ingle Amratan R Pankaj. Report on maglev VAWT. *IBSS College of Engineering, University-Mardi Road.* 2014; 2(9): 278–282p.

[13] Wang N, Hu Y, Wu H, Zhang J, Song C. Research on forces and dynamics of maglev wind turbine generator. Journal of Magnetics. 2013; 18(4): 443-53p.