International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 06 | June 2020 www.irjet.net p-ISSN: 2395-0072

Vertical Axis Maglev Wind Turbine Design & Analysis for Power Generation

Shozab Hasnain Rizvi[1], Namita Sawant[2], Nabil Mahadik[3]

[1-3]Student Department of Mechanical Engineering, Rizvi College of Engineering, Bandra, Mumbai, Maharashtra, India.

Mohd Kashif A.R[4]

[4]Asst. Professor Department of Mechanical Engineering, Rizvi College of Engineering, Bandra, Mumbai, Maharashtra, India.

Abstract - *This project emphasizes on the use of magnetic levitation in wind turbines for the purpose of power generation. Energy is a prime factor which needs to be developed at the same time it must be a sustainable source like Wind, Solar etc. Maglev Levitation is a method by which an object is suspended without any support using the magnetic fields. This paper focuses on Vertical Axis Wind Turbine utilizing magnetic Levitation as an axial flux generator as well as an alternative to the conventional ball bearings.*

Vertically oriented blades of the wind turbine are suspended by the help of permanent magnets. Power is then generated by using an axial flux generator which has incorporated the utilization of permanent magnets and coils. The principle advantages of Maglev Windmill are elimination of the frictional losses, low starting wind speeds (upto 1.5 m/s) and also operable at higher wind speeds exceeding 40 m/s. These VAWT's can also be utilized in micro power generation on a domestic scale. The fluid analysis as well the modelling of the prototype has been performed using ANSYS 20 & SolidWorks respectively.

Key Words: Energy, Sustainable Power Source, Wind, Maglev, Turbines, Maglev Wind Turbine

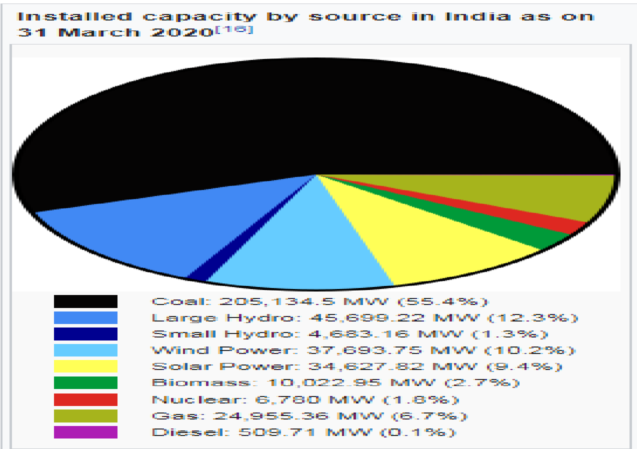
1. INTRODUCTION

Renewable energy is generally electricity supplied from sources, such as wind power, solar power, geothermal energy, hydropower and various forms of biomass. These sources have been coined renewable due to their continuous replenishment and availability for use over and over again. The popularity of renewable energy has experienced a significant upsurge in recent times due to the exhaustion of conventional power generation methods. India has a potential of 20,000 MW of wind power. Wind power accounts nearly 9.87% of India's total installed power generation capacity. Generation of wind power mainly account from southern state of India.

The aim of this project is to design and implement a magnetically levitated vertical axis wind turbine system that has the ability to operate in both high and low wind speed conditions. Our choice for this model is to showcase its efficiency in varying wind conditions as compared to the traditional horizontal axis wind turbine and contribute to its steady growing popularity for the purpose of mass utilization in the near future as a reliable source of power generation. Unlike the traditional horizontal axis wind turbine, this design is levitated via maglev (magnetic levitation) vertically on a rotor shaft. This maglev technology, which will be looked at in great detail, serves as an efficient replacement for ball bearings used on the conventional wind turbine and is usually implemented with permanent magnets. This levitation will be used between the rotating shaft of the turbine blades and the base of the whole wind turbine system. The conceptual design also entails the usage of spiral shaped blades and with continuing effective research into the functioning of sails in varying wind speeds and other factors, an efficient shape and size will be determined for a suitable turbine blade for the project. With the appropriate mechanisms in place, we expect to harness enough wind for power generation by way of an axial flux generator built from permanent magnets and copper coils. The arrangement of the magnets will cultivate an effective magnetic field and the copper coils will facilitate voltage capture due to the changing magnetic field.

2. Energy Consumption in India

There are various modes of power generation currently supplying energy in India including Renewable as well as Non-renewable sources.



3. Objectives

- To create new opportunities in low-speed areas, speed as 7m/s.
- By use of Magnetic levitation to reduces the friction & eliminates need of bearings in wind mill.
- To convert wind energy into electrical energy remarkably cheap with low operating cost.
- By use of Magnetic levitation due to absence of friction to convert energy with very less noise compared to existing conventional wind mills.
- To perform a fluid analysis on the turbine to get results for power actual power output
- To develop micro wind energy generators for domestic use.

4. WIND POWER

The power being generated can be calculated, however one should note that it is not possible to convert all power of the wind into power for generation. The power harnessed from the wind cannot exceed 59% of the overall power in wind. Thus several assumptions have been made while designing the turbine. The detailed calculations for the same is as follows:

We know:
Kinetic energy = $0.5\ mv^2$
The volume of air passing in unit time through an area A, with speed V is AV and its mass is equal to the Volume V multiplied by its density ρ so
M= ρAV
Substituting the value of M in equation 4.1 weget:
Kinetic energy = $0.5\ (\rho AV)V^2 = 0.5\ \rho AV^3$

5. MAGNETIC LEVITATION

Magnetic levitation is a method in which an object is suspended with no support other than magnetic fields. The magnetic force produced is used to counteract the effects of the gravitational force and lift up the object. There are many advantages for utilizing magnetic levitation that is to minimize friction, stress on shaft etc. Recently, this advance technology is applied into transportation system in which non contacting vehicle travel safely at very high speed while suspended, guided, and propelled above a guide way by magnetic fields. The concept of magnetically levitated vehicle stimulates the development of useful application in various fields such as the power generation.

6. MAGLEV WIND TURBINE

Unlike the conventional type, the vertically oriented blades of the wind turbine are suspended in air by using permanent magnet which produces magnetic force to lift up the blades. Since the turbine blades are suspended by magnetic force produce by the permanent magnet, there is no need of ball bearing to retain the blades. This allows the friction between the blades and ball bearing can be reduced significantly and thus, minimizes the energy loss. This also helps reduce maintenance costs and increases the lifespan of the generator. The Maglev wind turbine, which was first unveiled at the Wind Power Asia exhibition in Beijing, is expected to take wind power technology to the next level with magnetic levitation.

Calculations for Modelling:

To design and fabricate high performance maglev windmill which will be safe by ergonomically, economically and by all means safety considerations following main parameters were set before the designing; on which whole design process is carried out,

I. Power and power coefficient

Assuming minimum power generation from windmill as 100W:
P = 100 W
$P_w = {}^1/_2 \times \rho \times S \times V_o^3$ Watts
Where,
Vo is the velocity of the wind [m/s]
ρ is the air density [kg/m3] the reference density used its standard sea level value (1.225 kg/m^3 at 15ºC).
Note that available power is dependent on the cube of the airspeed. The power the turbine takes from wind is calculated using the power coefficient:
Cp = Captured mech Power by the blades
Cp value represents the part of the total available power that is actually taken from wind, which can be understood as its efficiency. The value of maximum power coefficient be usually ranges between 0.15 & 0.22.
Taking Cp as 0.2
$P_w = {}^1/_2 \times 1.225 \times S \times 7^3$
Pw = P/0.2 (Cp=0.2)
Pw = 500

$500 = {}^{1}/_{2} \times 1.225 \times S \times 7^3$
$S = 2.45\ m^2$

II. Swept area

The swept area is the section of air that encloses the turbine in its movement, the shape of the swept area depends on the rotor configuration, this way the swept area of an HAWT is circular shaped while for a straight-bladed vertical axis wind turbine the swept area has a rectangular shape and is calculated using:

$S = DL$
$2.45 = 2 \times 0.25 \times 0.5$
$D/H = 0.8$
$H = 1.7\ m,\ D = 1.4\ m$

Where S is the swept area [m2], D is the rotor diameter [m], and L is the blade length [m].The swept area limits the volume of air passing by the turbine. The rotor converts the energy contained in the wind in rotational movement so as bigger the area, bigger power output in the same wind conditions.

FIG-1: No. of Blades

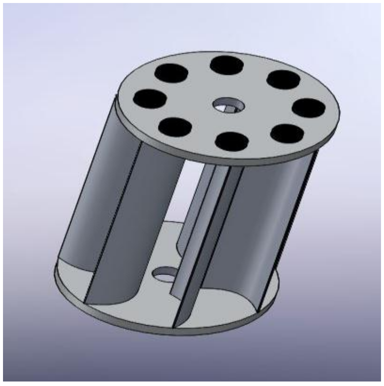


FIG-2: Rotor

FIG3: Stator

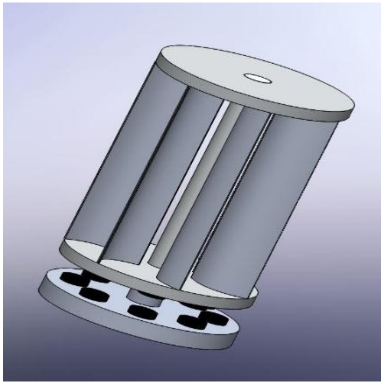


FIG4: Assembely

7. Analysis of Air flow using CFX solver:

A Computational Fluid Dynamics Analysis was carried out using CFX solver in ANSYS.

Analysis was carried for finding Momentum & Mass, Turbulence, Power generated, Velocity flow, Wind flow, Pressure flow, for wind speed of 7m/s and rpm of the rotor was taken as 100 rpm.

The Analysis was successful and the desired output value of power were received.

The steps for performing Analysis are as follows:

1. First an interface was created around the rotor of the windmill for reference.
2. A separate model was created using the interface for distribution of airflow.
3. Meshing of these two models was done using Ansys Mechanical using CFX solver.
4. The final model was solved for rotor speed as 100 rpm, wind speed of 7 m/s and temperature of 25°C in CFX solver for 800 timesteps using transient blade row model.
5. An additional output for power was evaluated using an expression:
   Power= Moment (Rotor)*pi* n/2 (n = speed of rotor)
6. Final Results were evaluated.

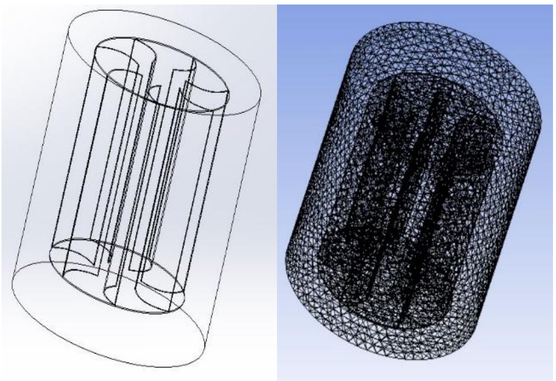


FIG-5: Interface Mesh Model

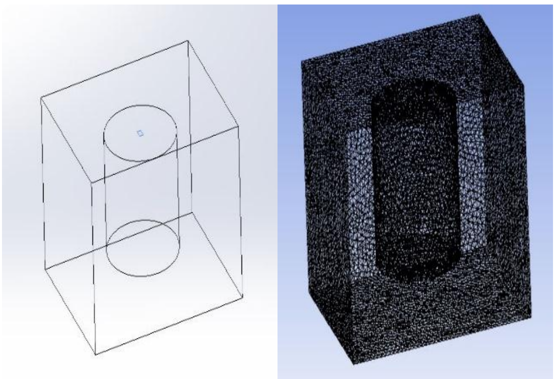


FIG-6: Airflow Reference Mesh Model

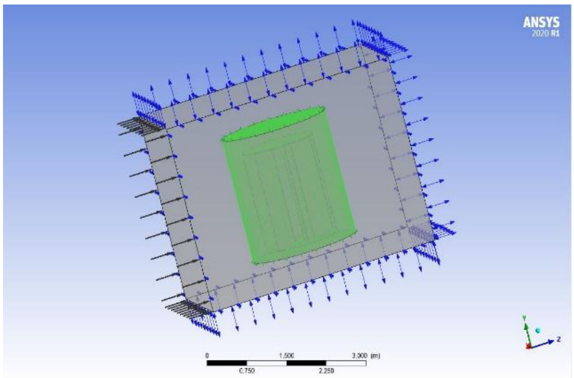


FIG-7: Airflow Reference Mesh Model

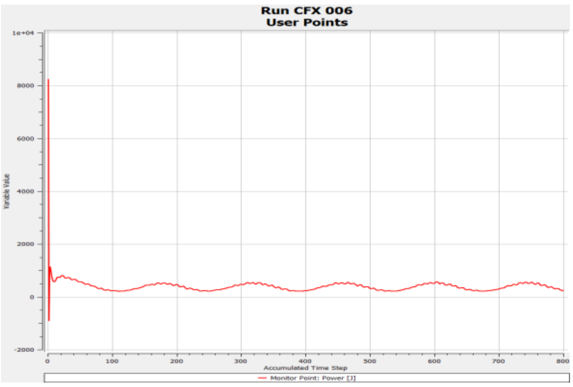


FIG-8: Power Output for 800 Time steps

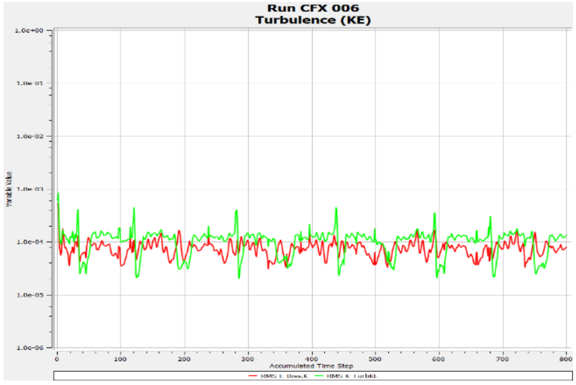


FIG-9: Turbulence for 800 Time steps

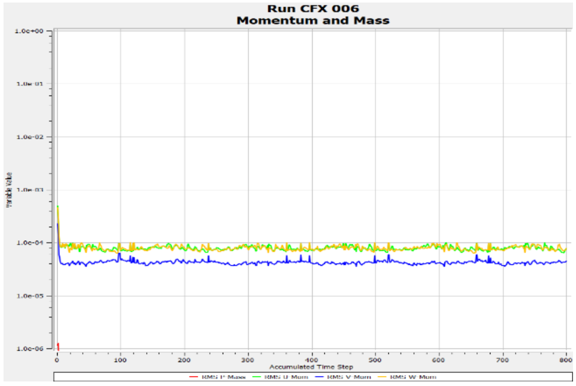


FIG-10: Momentum & Mass Values for 800 Time steps

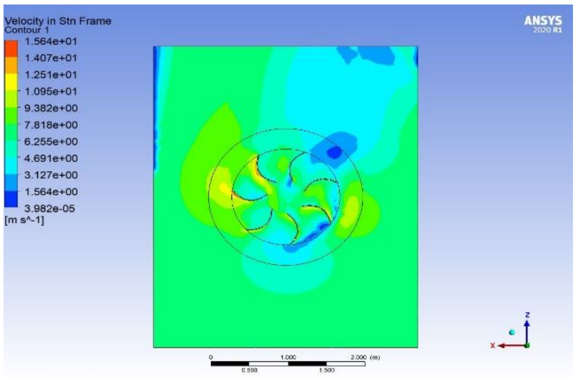


FIG-11: Velocity Flow

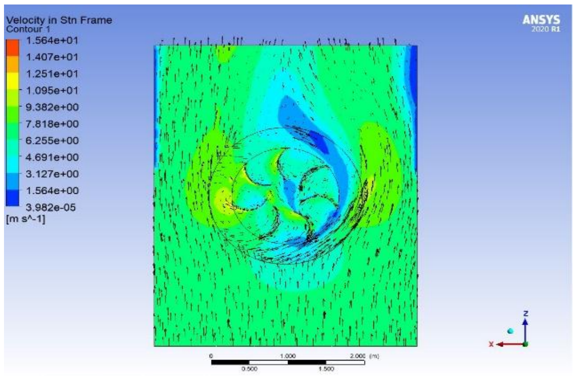


FIG-12: Velocity & Air Flow

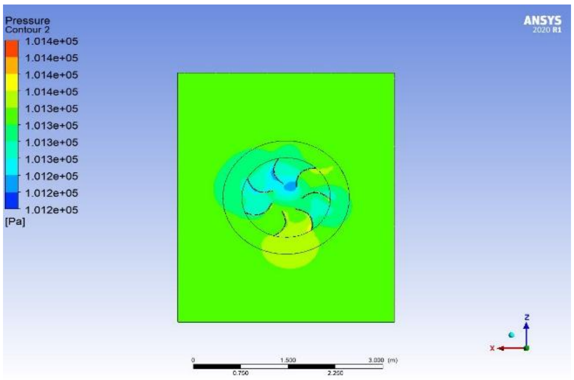


FIG-13: Pressure Flow

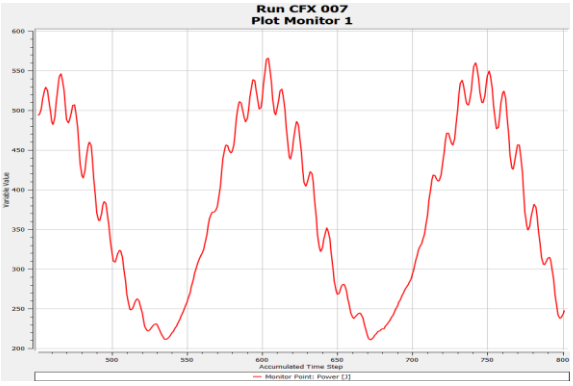


FIG-14: Power Output

8. Conclusion:

The home for the attractively suspended vertical hub wind turbine would be in local locations. Here it can be mounted to a rooftop and be extremely proficient and pragmatic. A mortgage holder would have the capacity to remove free clean vitality in this way encountering a lessening in their utility cost and furthermore add to the "Environmentally friendly power Energy" mindfulness that is progressively picking up fame.

The model of maglev windmill given above was successfully analyzed for a minimum output power of 100W.The model can be fabricated and be used for power generation of 100W at a minimum wind speed of 7 m/s.

9. RECENT DEVELOPMENTS:

Indian Renewable Energy Development Agency (IREDA) and the wind business are cooperating to achieve the changes through different innovative work programs.

REFERENCES:

1. Dinesh N Nagarkar and Dr. Z. J. Khan, "*Wind Power Plant Using Magnetic Levitation Wind Turbine*", International Journal of Engineering and Innovative Technology (IJEIT) Volume 3, Issue1, July 2013

2. Piyush Gulve, Dr. S.B.Barve, "Design And Construction Of Vertical Axis Wind Turbine", International Journal of Mechanical Engineering and Technology (IJMET), Volume 5, Issue 10, October (2014), pp. 148-155.

3. Vishal D Dhareppgoal and Maheshwari M Konagutti, "*REGENEDYNE Maglev Wind Power Generation*", SARC-IRAJ International Conference, 16th June 2013, Pune, India.

4. The maglev: The Super-powered Magnetic Wind Turbine, 02 2016, [online] Available: http://inhabitat.comisuper-powered-magnetic-wind-turbine-maglev/.

5. Study on the Bearing Resistance in a Wind Turbine Generator System", Wind engineering, vol. 39, no. 1, pp. 113-128, 2015.

6. Dr. Aravind CV, Dr. Rajparthiban, Prof. Rajprasad R,"A Novel Magnetic Levitation Assisted Vertical AxisWind Turbine–Design Procedure and Analysis", 8th International Colloquium on Signal Processing and its Applications, (IEEE) in 2014.

BIOGRAPHY:

Shozab Hasnain Rizvi
Student
Rizvi College of Engineering.

Namita Sawant
Student
Rizvi College of Engineering.

Nabil Mahadik
Student
Rizvi College of Engineering.

Mohd Kashif A.R
Asst. Professor
Rizvi college of Engineering.