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Development of Vertical Axis Wind Turbine Using Neodymium Magnets

Sagar Ganjale[1], Ketan Jain[2], Abrar Khot[3], Shivnesh Poojary[4], Prof. Gajendra Patil[5]
[1,2,3,4,5] *Mechanical Engineering Department, Pillai College of Engineering,* Mumbai University

Abstract: We incorporate the concept of VAWT with neodymium magnets to generate free power. In this case, we use repulsive force of magnet to rotate the blades of VAWT. Here the shaft is stationary and magnets are glued on the blades with respect to other magnets fixed to the support plates, thus VAWT rotates due to repulsive action of magnets. As VAWT rotates, the motor shaft which is coupled to the upper acrylic plate rotates which in turn produces power. This modified VAWT makes better use of NdFeB magnets by continuously driving the motor and brings about an increase in rpm which leads to more power generation. It can be either used for small scale application as well as large scale application based on its design.
Keywords: VAWT, Neodymium magnet, Repulsive force, Stationary, acrylic plate

I. 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 and increasing realization of its adverse effects on the environment.

This popularity has been bolstered by cutting edge research and ground breaking technology that has been introduced so far to aid in the effective tapping of these natural resources and it is estimated that renewable sources might contribute about 20% – 50% to energy consumption in the later part of the 21st century.

The project aims is to study various types of VAWT and check feasibility of neodymium magnet to generate free power as well as perform conventional and CAD design of VAWT and analysis of setup.

II. BASIC DESIGN

A. Parts

The main parts of setup that are used for power generation by using magnets are,

1) Axle
2) Spool
3) Bearing,
4) Neodymium Magnets,
5) Blades,
6) Flange,
7) Support,
8) Motor,
9) Wooden Base,
10) Nut.

B. Design of Various Parts

1) *Axle:* The axle is used to provide support to the entire assembly. It is mounted on wooden base with the help of nut. A bearing is mounted on axle to constraint relative motion between axle and acrylic plate. Here we used alluminium material for axle as it has low density as compared to mild steel and it is also corrosive resistance. The main reason we select alluminium is that it is dimagnetic. Consider axle as a cantilever beam which is subjected to bending.

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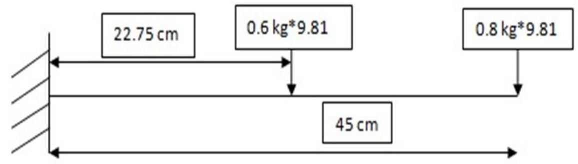

Max. BM. = (6*227.5) + (8*450) = 4965 N-mm
Select alluminium as material for shaft
$[\sigma_t] = 65$ N/mm2
$[\sigma_b] = \frac{65}{FOS} = \frac{65}{5} = 13$ N/mm2
$\sigma_b = (M_b) * \frac{y}{I} = \frac{13*4965}{\frac{\pi}{32}d^3}$
d = 15.72 mm
Let us select shaft of diameter 20 mm.
2) Bearing: Consider life Lhrs = 10000
Max. RPM = 50
Weight of plate = 0.5 kg
Weight of plate + flange = 0.7 kg
Radius of plate = 85mm
Fa*mg = 0.7*9.81 = 6.867 = 7 N
Now centripetal force acts as radial load on bearing
$Fx = mr\omega^2 = 0.7 * 0.085 * (\frac{2\pi*50}{60})^2$
Fx = 1.631 N
$L90 = \frac{L_{hrs}*60*N}{10^6} = \frac{10^4*60*50}{10^6} = 30$ mrev.
Pe = V*(x.*Fx + y*.Fa)
x = 0.56, y = 1.8………………………………… (PSG 4.4)
V = 1.2, Outer race rotates
Pe = 1.2*(0.56*1.631 + 1.8*5)*1.5
Pe = 17.84 N
C = 301/k * 17.84
Where k = 3 for DGBB
C = 301/3 * 17.84 = 55.43 N = 5.543 kgf
Since diameter of shaft is 20 mm. Let us select bearing with inner diameter 20mm.
Select SKF 6004 DGBB from PSG 4.12
Co = 450 kgf, C = 735kgf……............................... (PSG 4.12)

3) Spool: Spools are coupled at both ends of the axle. Both spools has center slot into which bearing is press fitted. No of curves are made on to the surface of plates with respect to blades so that blades can be fitted into it. Main reason we select acrylic material is that it is light in weight and easily available.

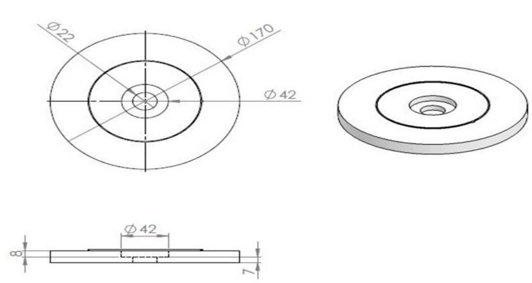

Fig.1: Drafted view of Spool

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4) Blades: We use the PVC pipe to make wind turbine blades, because the PVC pipe is very cheap and accessible materials. A wind turbine with 2 blades will rotate faster than 4 blades as it require more power to turn a larger generator. These blades are fixed between both acrylic plates.

Specification of Blades

Outer radius of curvature = 55 mm
Thickness = 2.5 mm
Height = 230 mm
Numbers = 4.

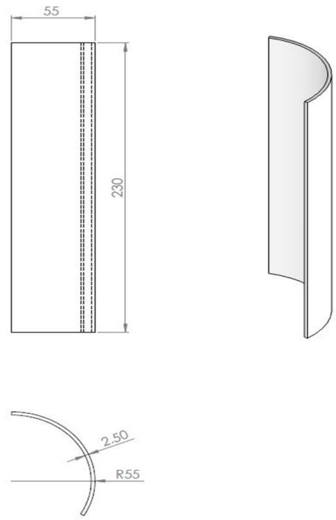

Fig.2: Drafted view of Blades

III. ANALYSIS

A. Axle

The axle of the VAWT is the part in the assembly which is subjected to torsion because of the motion of the blades of the turbine. Thus the axle is analyzed for the equivalent stress to indicate the actual stress acting on the axle. We have applied permissible torque of 1000 N-m which is the max. possible torque acting. We have used Auto mesh option. The boundary conditions are: The bottom part of the axle is fixed and torque is applied. We also calculate total deformation of shaft.

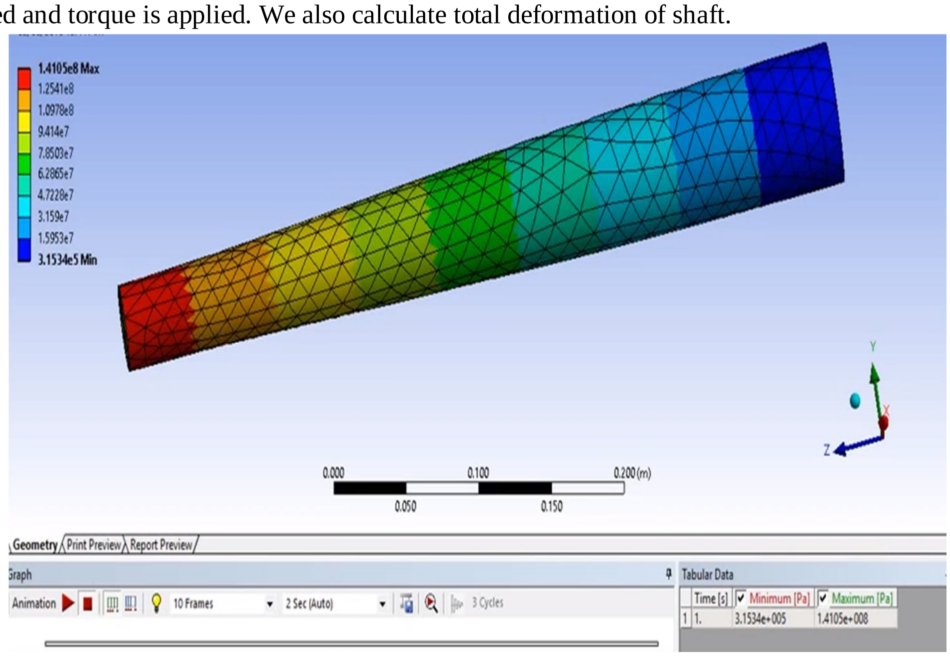

Fig.3: Von-Misses Stress

B. Spool

Here we did flow analysis of spool without considering effect of magnet. First we import geometry of spool in Ansys and edited such that rectangular boundary for air flow conditions is formed. The circular and rectangular domains are two different domains (both are fluids) with a small gap (0.0001 m) in between. Next step is meshing the geometry with including inflation at critical location such that at the edges of blades. Externally applied load of 14 N and self weight of 3 N (approx). We assume velocity of air acting on blade at different instant as 0, 0.5, 1, 2, 3 etc. m/s.

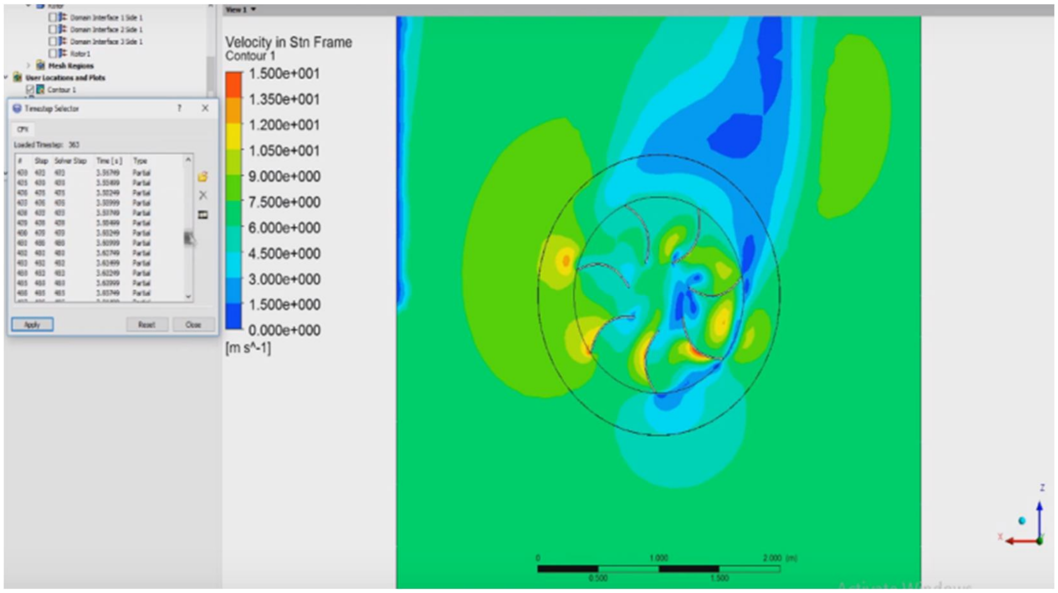

Fig.4: Analysis of Spool

IV. FABRICATION

A. Spool

The spool was made from 15 mm thick acrylic sheet. A circular plate of 170 mm diameter was generated with the help of CNC router from a rectangular acrylic sheet whose dimensions were greater than the circle's diameter. A through hole of 20 mm diameter was made in the circular sheet with the help of same router. A hole of 42 mm diameter to a height of 8mm was made in the sheet by the lathe machine to place the bearing. The slots for blades on the sheet up to a height of 2.5mm were later established with the help of carbon dioxide laser engraving machine. On one spool, a 4mm through holes were drilled to place the modified flange.In order to increase the cooling rate to achieve optimum lowest temperature for the pot we search for various methods.

Fig.5: Spool

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B. Blades

First a pipe of 20 mm diameter and 2.5 mm thick of polyvinylchloride material was selected to obtain a larger curved surface area. Then the pipe was cut into three pieces (blades) in the longitudinal axis direction. Each blade subtends an angle of 120 degree at the centre of the curvature of the curved surface.

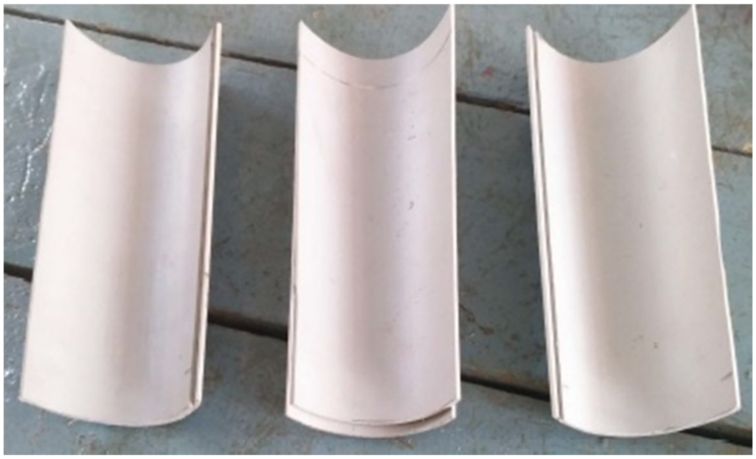

Fig.6: Blades

V. EXPERIMENTAL SETUP

This is the final phase of this project. The assembled spools and bearings is first fixed on the stationary alluminium shaft. Thus the project was assembled using the above shown means and the total setup is shown in Figure.

Fig.7: Experimental Setup of VAWT to generate free power

VI. RESULT

After the complete setup is done it is checked for operation under normal condition.

First we placed contact type digital tachometer on flange and measure the speed of rotating spool in RPM and noted down. Then we attached motor on flange and terminal wires of motor are connected with multimeter and corresponding power is obtained. Theoretical power is to be calculated by determining speed of motor (equal to speed of spool) and its specifications. Calculated values are frame in tabulated format and theoretical and experimental values compared. Then we calculate the percentage error.

Speed (RPM)	Power (watt) (Theoretical)	Voltage (v)	Current (mA)	Power (watt) (Experimental)	Error %
5	0.0261	1.53	14.81	0.0226	13.40
10	0.0523	1.61	30.73	0.0494	5.54
15	0.0785	1.68	40.49	0.0680	13.37
20	0.1047	1.76	55.32	0.0974	6.97
25	0.1309	1.78	70.11	0.1248	4.66
30	0.1570	1.86	80.08	0.1489	5.15

Sample Calculation

$$P_{th} = \frac{2\pi NT}{60}$$
$$= \frac{2\pi * 20 * 0.05}{60}$$
$$= 0.1047$$
$$P_{act} = V*I$$
$$= 1.76*55.32$$
$$= 0.0974$$
$$\text{Percentage Error} = \frac{P_{th} - P_{act}}{P_{th}} * 100$$
$$= \frac{0.1047 - 0.0974}{0.01047} * 100$$
$$= 6.97\ \%$$

VII. CONCLUSION

In this paper, we studied various types of VAWT and feasibility of neodymium magnet to generate free power. This project uses repulsive force of neodymium magnets to generate power. We have designed and developed experimental setup of VAWT successfully. The setup was analyze under normal working conditions of its operation. After the analysis was done successfully, we fabricated the setup of VAWT. The results obtained through theoretical and experimental analysis were compared and percentage error was calculated. The percentage error was observed to be between 5 % - 20 % which is acceptable.

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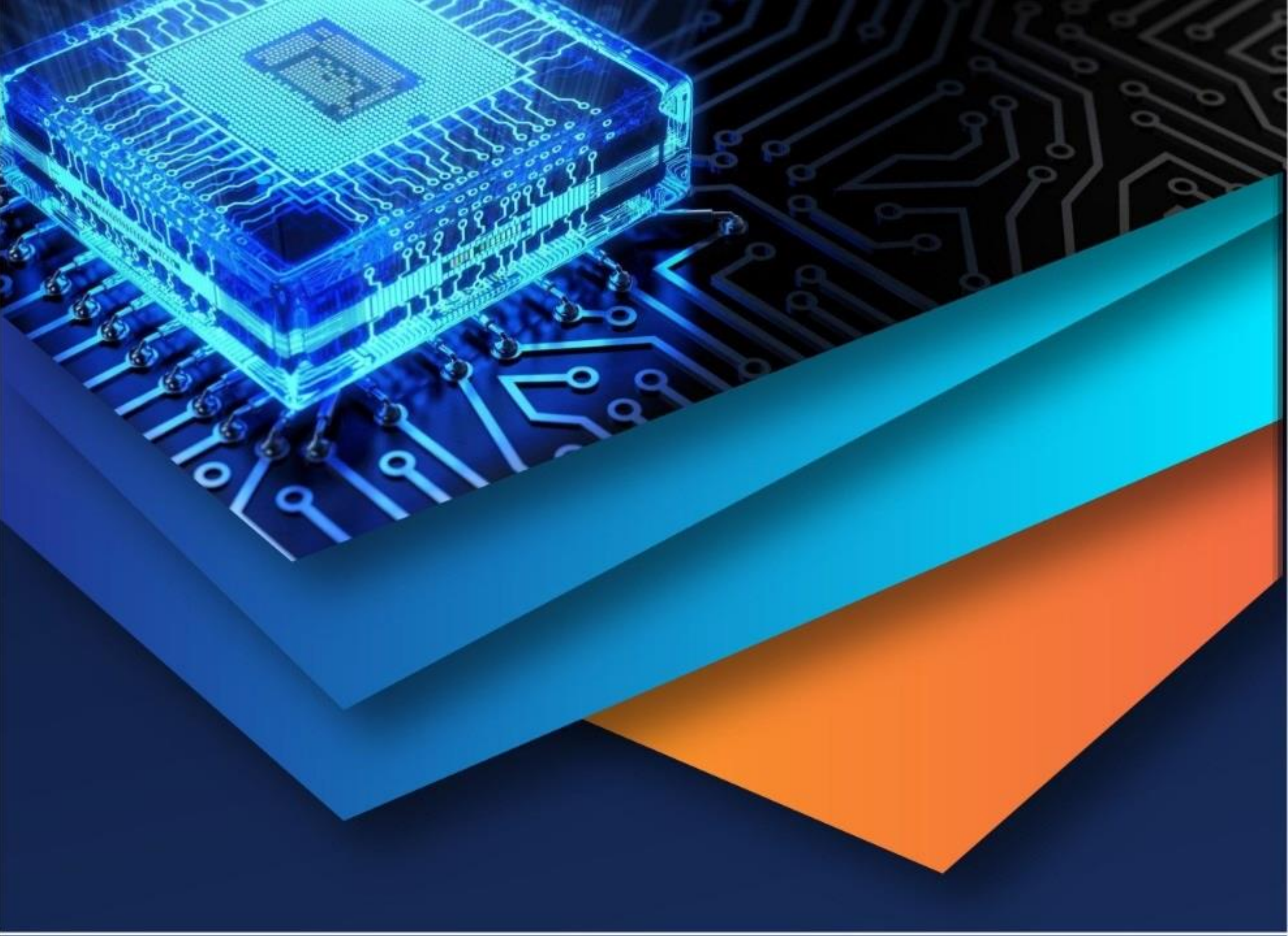

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