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Improvement of Performance and Efficiency Through the Use of Permanent Magnet Propelling Phenomenon in Traditional Vertical Axis Wind Turbine Systems

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***Abstract:** It is widely accepted that the energy we currently use will not be sufficient to fulfil the demands of all people on the globe in the future. As a result, cleaner and more abundant alternative energy sources—which may also take the form of hybrid energy—are needed. Renewable energy sources will certainly become more prominent. Modern civilizations needs cheap, plentiful energy to survive, therefore, it is crucial for human civilization to create a sustainable, affordable, and environmentally benign alternative sources of energy. The global energy dilemma may have an efficient solution in the form of wind power. In current state of affairs, the air could seems like insignificant to any or all. However we tend to all grasp that, the planet has shaped up with associate uneven surface, which suggest that the sunrays could strike these surface with variable intensities at numerous spot on its uneven surface. This creates associated degree of unequal degree of heating of the earth surface, that which causes variation in part of atmospheric pressure thereon. Then it leads to wind. The Kinetic energy of these air molecules is nothing but wind energy. A mechanical mechanism known as a wind turbine which transforms, kinetic energy which is there in the air around it into the required form of mechanical energy. Here in this research we focused on the repellent qualities of permanently magnetized objects with similar poles. These innate qualities of magnetic propulsion are used here as an energy sources. Due to the inclusion of this components like magnetic repulsion, our VAWT system will operate more effectively even at lower wind speeds circumstance also. This magnets will produce a repulsive force that will add various sorts of kinetic energies to the wind turbines as they convert wind energy's kinetic energy of into the necessary mechanical power when it's employed as an extra source of energy in a VAWT.*

***Keywords**: Magnet Propelling, Hybrid Energy, Wind Energy and Renewable Energy Sources*

I. INTRODUCTION

At the beginning of the 1980s, the energy sector saw a massive boom, with the wind energy sector standing out in particular.

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As a result, in the present property energy sector, they will furthermore play a significant part, inside a property energy bank, under the term of hybrid energy source, in addition to hydro power, alternative energy, and wind energy. The wind's mechanical energy is transformed into the necessary type of energy by the mechanical system that supports the turbine system [1]. Now, this mechanical power can be used to move or operate another system, or it can be used to turn the generator shaft to produce electrical energy. There are mainly two families of wind turbines; the majority of these have a horizontal shaft with connected blades. Moreover, a shaft-mounted electric generator, these wind turbines have a horizontal axis, thus the name. The most common configuration is three blades, and they spin "upwind" at the top of a tower so they can blades face the wind. The vertical axis machine is another sort of device that has a series of long, curved blades on a vertical shaft and is formed like an egg beater. The goal of our research is now the creation of a VAWT powered by a permanent magnet. This system can operate in a variety of wind-speed environment circumstances thanks to hybrid energy technology of permanent magnets. In this study, we evaluate the performance of vertical axis wind turbines in the PM design in comparison to the traditional VAWT system that they will eventually replace.

II. WIND SAIL DESIGN

In this instance, the wind turbines are mechanical structures consisting of a shaft, blade, and auxiliary parts. The air may come into contact with the revolving blades of the give system when it is mounted and exposed to a region where air is flowing, changing the pressure. As a result, the rotor starts to move in the carry's direction. Here, wind mechanical energy is then transformed into the required form of energy and delivered through the shaft to a generator. In our, both the investigation, we decided to use a vertical axis wind turbine system with magnetic propulsion [2]. In a VAWT configuration rotating plane and the rotating shaft are vertical. The rotating shaft itself then resembles a cylinder. The VAWT Systems are the oldest and least popular members of the family of turbines. The VAWT's Structure essentially has two subtypes, which are as follows:

- Darrieus Model.
- Savonius Model.

The drag-type VAWT structure used by the Savonius-based turbine system in the VAWT system family functions similarly to a pedal boat on water.

The inventor of this method is S.J. Savonius. Over time, a bucket, plate, or cup used as a propelling mechanism to create the drag-based Savonius Structure as shown in figure 1.

Figure 1: S-Shaped Savories Type VAWT Model

In this article, the rotary blades of the S-model are called Savonius type rotor devices. When compared to lift-based systems, these pull-type VAWT systems have an especially strong starting torque and self-starting capabilities. When investigating the two main sub types of VAWT system rotor components, we eventually decided to base our foundation on the Savonius design with a few minor modifications. The addition of magnetic repulsion properties between the moving and stationary portions of turbines is the primary deviation from the basic Savonius subsystem idea [3]. The upper half of the blades of the turbine will experience scoops as a result of this repulsion, and it is necessary to remove these scoops from the turbine and to create a smoother torque as the rotor rotates [4].

Owing an inherent elasticity of aluminum sheet-metals, was used to create four triangular forms for this design, it was possible to twist the balde down to apex of axis shaft of base plane. Here a primary driving force behind our design is to eliminate the clogging on models upper half which formed due to magnetic propulsion.

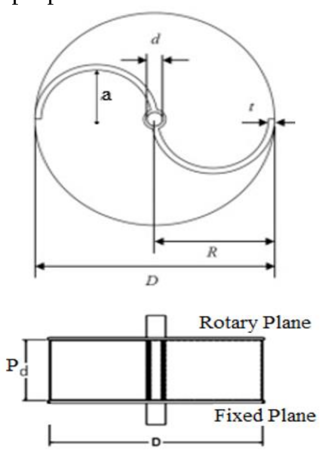

Figure 2: The Schematic Diagram of the Modified Savonius Wind Turbine

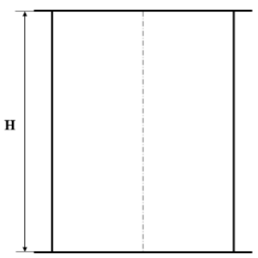

Figure 3: Sweep Area of Turbine

The design will take benefit of the repelling-characteristics associated with magnetic materials under this instance. Unlike normal vertical shaft turbines, this vertical shaft turbine design generates kinetic energy from magnetic repulsion by stacking a pair of magnetic material one above the other and separated with specific air gap. Here the comparable poles made coinciding each on, the resulting in repulsion-of-magnetic material were met by the rotor during rotation. This is built by joining the turbine's base to the frame created beneath the turbine. This magnetic repelling effect is also used to turn the power present in flowing air into mechanical power, which may subsequently be transferred into electrical power using a generator system. Design Specification were tabulated in table I, and visualized in figure 2 and figure 3.

Table I:-VAWT Design-Specification

Parameter	Value
Axis of rotation	Vertical
No of Blades	6
Rotational Speed range	60-150 RPM
Wind Speed Range	2m/s -6.5m/s
D = the rotor diameter,	400mm
R = Radius of the shaft	160mm
d = Shaft Diameter,	80mm
H = rotor height,	450mm
a = tip to blade distance	70mm
t = The thickness of blades	1mm
Swept Area, A	0.179 m^2
Mass of the turbine	3.7kg
Magnetic Flux Density	2 $Weber/m^2$
d = magnets installation periphery	350mm
P_D = Air Gap Between Rotary and Fixed Plane	45mm

We modified our design somewhat in contrast to our standard Savonius turbine model by altering the rotor blade's top to base's bending shape [3]. This is done by swirling, in accordance with our design criteria, a group of triangular faces cut from an aluminium sheet element from the top to the bottom of the rotor blade. The final modified Savonius design is shown in Figures 4.

Figure 4: A Prototype of Modified Turbine Model

III. MAGNETIC PROPELLING

The repelling properties of permanent magnets are ultimately drive these events. Magnetic repulsion can easily encountered with a set of magnet, such as neodymium-iron-boron magnets, and the strong supporting structure.

These repulsion of magnets will add some force to the rotating turbine when a set of magnet are stacked on each other with similar polarity magnetic pole pointing inward. Hence, force produced by this repulsion also serves while transferring the power available in moving air to rotational mechanical power. These technique were utilized in this project with the aim of reaching high turbine efficiency [5].

Neodymium Iron Boron (Nd-Fe-B), a magnetic alloy made of rare earth materials, possesses a potent coercive force. The high product energy level allows them to be manufactured often in small, compact quantities. Nd-Fe-B magnets have poor mechanical strength, are typically brittle, and have little corrosion resistance; nonetheless, if left uncoated, they will suffer from these drawbacks. If they get a nickel, iron, or gold plating treatment, they can be used in a variety of applications [6]. They are incredibly strong magnets that are difficult to demagnetize. One or more variables that might affect a magnet's stability include time, temperatures, reluctance changes, adverse stress, fields, shock, radiation and vibration. The Nd-Fe-B has a very attractive magnetic characteristic, offering better features like, it offers a high magnetic field flux density, provides high magnetic field strength in given condition, and also has the capacity to resist demagnetization in extreme conditions, according to the BH Curve of Magnet Materials. Consequently, it was decided to employ an Nd-Fe-B (Neodymium Iron Boron) magnet.

Permanent magnets may be utilised to capture kinetic energy from the magnetic propelling phenomena and other magnetic properties, such as the repulsion of like polarities of magnets, can be exploited as a supplementary energy source. Nd-Fe-B magnets can be classified as sintered or bonded depending on how they were made [7]. In many uses in modern goods that require strong permanent magnets, such as hard disc drives, magnetic fasteners, and electric motors in cordless tools, they have supplanted other types of magnets.

Permanent magnets constructed of the metal Neodymium-Iron-Born (Nd-Fe-B) were used in this experiment to produce magnetic repulsion. The magnets were arranged such that their comparable polarities faced one another. Using the mechanical energy produced by the magnetic attraction and transforming the mechanical energy of the wind into the necessary type of mechanical power.

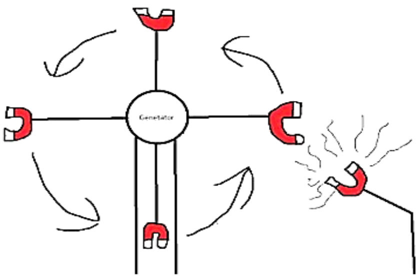

Figure 5: While Converting Wind Energy into Mechanical Energy, the Magnetic Repulsion will adds Some Sort of Kinetic Energy to Turbine in Circular Fashion.

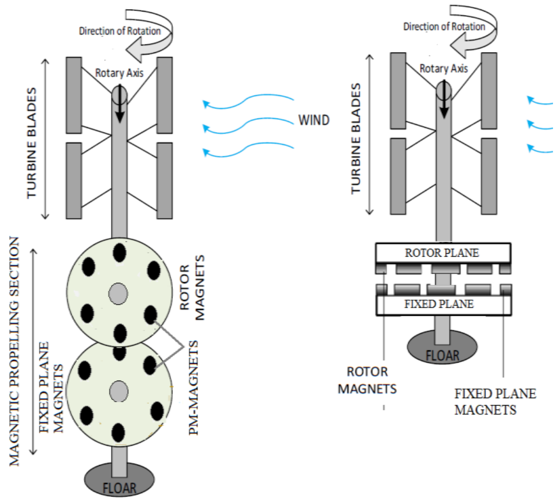

Figure 6: Schematic Diagram of Permanent Magnet Propelled VAWT

The repellent properties of magnets were contained throughout this study's attempt to include more kinetic energy in order to accomplish higher rotational structure potency [8]. Magnetic repulsion might also be sensed easily by squeezing this repellent feature in between the mounts and rotary planes. In contrast, VAWT converts the mechanical energy from wind into the necessary reasonably mechanical power, whilst the force provided by the permanent magnet can add some type of an acceptable kinetic power as shown in figure 5. The schematic diagram of PM Propelled VAWT shown in figure 6.

IV. EXPERIMENTAL METHOD

Although MATLAB is primarily intended for numeric calculation, an optional toolbox uses the MuPAD symbolic engine to give access to symbolic computing features. Simulink is a standalone application that improves multi-domain graphical simulation and model-based design for dynamic and embedded systems. The Mathwork Team developed a program called MATLAB along with add-on features like Simulation and Linking. Users of this application may utilize a graphical computer program to model, simulate, and analysis a system in a highly dynamic environment. By selecting an option from the drop-down menu, the user may create a multi-domain dynamic system that is then planned and evaluated on graphs using the array and matrix operations of a modified library block. This is frequently the reason why we choose for the MATLAB App models as shown in figure 7 [4].

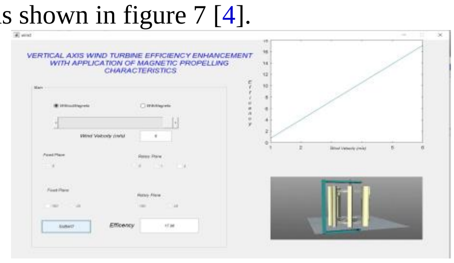

Figure 7: MATLAB for Validation Work

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The sweptwing front cross section area of turbine constructions, which is perpendicular to air density, air flow, and wind speed, can all be proportional to the overall power of wind flow in this situation [8][9][10][11][12][13]. It is also possible to write as follows:

$$P_W = x = \frac{1}{2}\rho AV^3$$

P_W=Total Power in Wind (W/m^2)
A =Rotary Turbine sweptwing area perpendicular to the air flow (m^2) =0.173m^2.
ρ= Density of air for given condition (kg/ m^3)
V= Wind Speed Condition (m/sec)

Table II: Power available in Wind at Various Wind Speed Conditions is Calculated the Oretically

Sl. N	V= Avg. Wind Speed in m/sec	$P_W = x = \frac{1}{2}\rho AV^3$ W/m^2
1.	6.0	22.54
2.	4.50	9. 52
3.	3.20	3. 4
4.	2.80	2. 28

Mechanical Power (PT) is obtained from the rotary turbine system, is nothing but the tangential forces (F) & rotary turbine movement speeds in rotation per minute (RPM) provide by Nr of the rotary shaft.

$$P_T = \frac{1}{60} 2\pi NrF$$

Force (F) = Angular Acceleration X rotary Turbine Mass.
Nr = Revolution/minutes of The Rotary Turbine Angular Acceleration = (acceleration / radius of the turbine) revolution /m^2 Total mass of the Turbine = 3.12 kg
Mechanical output powers PT is divided by the highest volume of total kinetic energy felt by the area of a particular wind turbine can be represented as power coefficient CP,

$$C_P = \frac{PT}{PW}$$

When magnets were positioned at a 180-degree or parallel angle to one another on both the rotary and fixed planes as shown in Figure 8, a little blockage to the turbine's spinning was noticed. The magnetic field produced by the permanent magnet will resist similar polarity magnets when they are placed parallel to one another and will hinder the spinning of the turbine as a result.

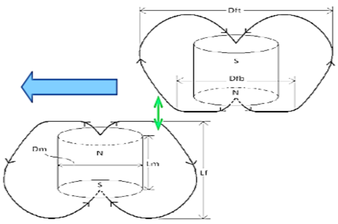

Figure 8: There Were Two Magnets Parallel to One Another

The challenge was to reduce the magnetic repulsion that adds some sort of resistance when rotary plane magnets coincide with fixed plane magnets while rotating. Magnetic repulsion of permanent magnets adds some sort of kinetic energy to the turbine while transforming the kinetic energies available in the wind into mechanical energy.

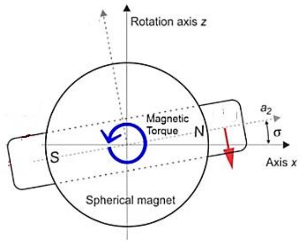

Figure 9: Magnets Orientation Visualization Top View

By rotating the magnets' installation orientation to 45 degrees, as shown in Figures 9, the resistive repulsive force was lowered. Therefore, the resistive force produced by magnets when they coincided was lower than the repulsive force produced when they separated from the magnetic field. As a result of adding these repulsive forces, wind kinetic energy is converted into the necessary type of mechanical energy. The goal of the tests was to determine the best positioning and orientation for magnet sets under different wind speed conditions as shown in figure 10.

Figure 10: PM-VAWT Model vs. Conventional VAWT Model

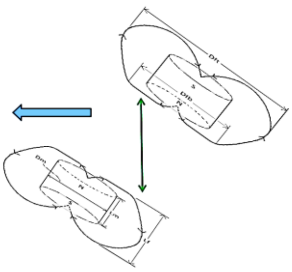

Figure 11: The Turbine Will Encounter Less of the Resistive Force Produced by Magnetic Repulsion

Figure 11 serves as an example. Due to the 45 degree orientation, which increased the distance between the magnetic flux density produced by magnets of the same polarity when they were coincident, the restive force created by magnetic repulsive force will be reduced.

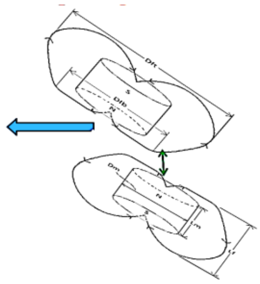

Figure 12: A kind of Kinetic Energy Will be Applied to the Turbine by the Resistive Force Caused by Magnetic Repulsion

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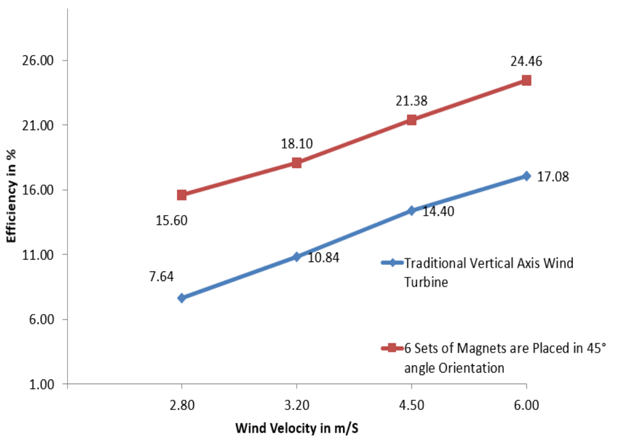
Figure 12 shows that there will be a stronger restive force created by the magnetic repulsive force because the magnetic flux density produced by the same polarity magnets exiting the field will be less separated owing to the 45 degree orientation. As a result, the mechanical energy from the wind will be converted into kinetic energy, which added with kinetic energy produced by magnetic repulsion.

Table- III: The Optimal Orientation and Position for Magnet Installation in A Pm-Propelled Vawt Under Varied Win Speed Circumstances to Obtain Greater Kinetic Energy and Smother Operation Were Determined Through Experimentation

S. No	Orientation of Magnets Placement	Wind Speed in m/s	Turbine RPM	$P_T = \frac{1}{60} 2\pi N_r F$	$.C_P = P_T/P_W$
Conventional-VAWT					
1.	Conventional Turbine Without Magnets	6	88.00	385. 24	**17.08**
2.		4. 5	76.00	137. 00	**14.40**
3.		3. 2	72.00	37. 08	**10.84**
4.		2. 8	68.00	17. 51	**7.64**
Permanent Magnet-Propelled VAWT					
1.	Six magnets were placed 180 degrees apart from one another or parallel to one another.	6	87.00	425. 67	**18.88**
2.		4. 5	79.00	162. 75	**17.11**
3.		3. 2	70.00	36. 05	**10.54**
4.		2. 8	61.00	15. 71	**6.85**
5.	Six permanent magnets are inserted into the fixed component, and one magnet is oriented 180 degrees on the spinning portion.	6	89.00	389. 62	**17.28**
6.		4. 5	78.00	140. 60	**14.78**
7.		3. 2	71.00	36. 57	**10.69**
8.		2. 8	66.00	17. 00	**7.42**
9.	6 PM were mounted on stationary section & 3 magnets were positioned in the spinning component with a 180° orientation.	6	92.00	426. 44	**18.91**
10.		4. 5	76.00	137. 00	**14.40**
11.		3. 2	70.00	18. 03	**5.27**
12.		2. 8	43.00	11. 07	**4.83**
13.	Six magnets were inserted on the stationary component in a 180° orientation, and one was positioned in the rotating segment at a 45° angle.	6	90.00	394. 00	**17.47**
14.		4. 5	82.00	147. 81	**15.54**
15.		3. 2	71.00	36. 57	**10.69**
16.		2. 8	65.00	16. 74	**7.30**
17.	Both the spinning component's three permanent magnets and the stationary part's six were put at a 45° angle.	6	91.00	398. 37	**17.67**
18.		4. 5	78.00	160. 69	**16.89**
19.		3. 2	73.00	37. 60	**10.99**
20.		2. 8	70.00	18. 03	**7.87**
21.	A 45-degree angle was made between the placement of three permanent magnets and six permanent magnets in the spinning component.	6	94.00	435. 71	**19.32**
22.		4. 5	85.00	175. 11	**18.41**
23.		3. 2	73.00	56. 40	**16.49**
24.		2. 8	64.00	32. 96	**14.38**
25.	The six magnet sets were angled at 45 degrees.	6	102.00	551. 59	**24.46**
26.		4. 5	82.00	211. 16	**22.20**
27.		3. 2	78.00	60. 26	**17.61**
28.		2. 8	71.00	36. 57	**15.96**



Graph 1: Graph Comparing the Effectiveness of PM-Propelled VAWT vs Conventional VAWT

In this investigation, it was found that the PM-driven VAWT had a greater rotation speed than our conventional VAWT. Although the traditional VAWT only achieved 17.08 percent efficiency, the Permanent magnet powered VAWT obtained an efficiency of 24.4 percent for the same wind speed scenario as shown in graph 1.

V. RESULT AND DISCUSSION

After analysing the data, we found that magnetic qualities were used as power banks, particularly their ability to attract and repel. In this instance, the force generated by the magnets of opposing polarity was used to further activate the turbine and transform the wind's kinetic energy into the necessary kind of mechanical power. There hasn't been much research done with hybrid power technology, other from the synchronization of solar and wind power. So, using the magnetic propulsive phenomenon as a source of energy, research and development were done to construct a permanent magnet-driven vertical axis wind turbine. In this case, the rotary blade structure can get some dynamic power from the force generated by the permanent magnets, which also converts alternative energy into the required kind of mechanical power.

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The shaft rotational speed of the static magnet propelled-turbine VAWT was found to be higher in this performance evaluation when compared to our conventional VAWT. Conventional VAWTs had an efficiency of around 17.081 percent, whereas the static magnet driven VAWT has an efficiency of 24.466 percent for the same wind speed situation. Additionally, potency was said to have improved in conditions with slower wind speeds. As a result, when static magnet dynamical features are used, it will also perform more effectively when there is less wind. For the aforementioned reasons, we think that PM Propelled Wind Turbine is significantly more efficient than the hybrid idea of solar energy and wind energy.

VI. CONCLUSION

Renewable energy comes from natural resources that refill more quickly than they run out. The sun and the wind are two examples of such cyclically renewing sources. As we are aware of the fundamental fact that wind is produced as a result uneven heating, which results in temperature changes between day and night. Heated atmospheric air will rise near the equator and progressively spread toward the poles of the globe, producing wind. It seems obvious that employing wind power as a long-term solution to the current global energy issues may be feasible. Wind energy is the kinetic energy that these winds produced.

In order to build a permanent magnet-driven vertical axis wind turbine, research and development were conducted employing the magnetic propulsive phenomenon as an additional source of energy. Due to climate change and global warming, which contribute to the production of wind energy will not be restricted in the future. Additionally, by including the fundamental properties of magnets, such as their attractive and repulsive forces, the world's energy requirements with this hybrid energy notion of wind energy already feels incredible. Hence even in conditions of low wind speed, our turbine's efficiency was improved by the magnetic repulsion feature.

DECLARATION STATEMENT

We all the authors take public responsibility for the content of the work submitted for review and we all authors have a equal level of participation in this research article.

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Availability of Data and Material	Not relevant.
Authors Contributions	All authors have equal participation in this article.

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