# ENHANCEMENT OF WIND TURBINE ACCELERATION USING MAGNETIC ACCELERATING UNIT

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**Abstract**- The utilization of wind energy is not a new technology but draws on the rediscovery of a long tradition of wind power technology. Today, while energy production based on the burning of coal and oil or on the splitting of the uranium atom is meeting with increasing resistance, regardless of the various reasons, the re-emergence of wind power is an almost inevitable consequence. The work describes the methodology followed for the design and development of a new Magnetic Accelerated Wind Turbine. The set-up will overcome most of the conventional Wind Turbine problems. Conventional wind turbines rely on wind velocity only for its driving power requirement. No external force is applied for acceleration of wind turbines; it purely depends on wind velocity or wind cut. Thus there is need for a power source which is substantially pollution-free to operate, requiring no external power and is simple to maintain. The Magnetic Accelerated unit helps us to overcome the problem of low wind speed in several areas. It will generate the electrical power from low wind speed, thus enhancing the overall efficiency of windmill. After getting the initial torque to rotate, magnetic accelerated unit will start to accelerate the windmill for desired output.

**Keywords**— Betz law, Magnetic accelerated unit, Magnetic motor, Neodymium magnets

## I. INTRODUCTION

A wind turbine is a device that converts kinetic energy from wind into mechanical energy. Wind energy converters which have their axis of rotation in a horizontal position are realized almost exclusively on the basis of "propeller-like" concepts. The rotor blade shape can be aerodynamically optimized and it has been proven that it will achieve its highest efficiency when aerodynamic lift is exploited to a maximum degree [2]. All wind turbines work on the Betz's law which says that a wind turbine can extract a maximum of 16/27 (in other words 60%) of the energy from the wind [1].

P (Betz) = 16/27 * P (wind)

The Betz law implies that the efficiency of wind turbines can never be more than 59.3%. Magnetism is a property of materials that respond to an applied magnetic field. Permanent magnets have persistent magnetic fields caused by ferromagnetism. That is the strongest and most familiar type of magnetism. To eliminate the feedback power required for electro-magnets, permanent magnets were used. The magnetic accelerated wind turbine includes following main parts for enhancement:

a. Magnetic Accelerated Unit
b. Diffuser Duct
c. Rotor

## II. OBJECTIVE

- Output power and hence the overall efficiency of horizontal axis wind turbine is to be increased by using magnetic acceleration unit.
- The unit is to be made cost effective.
- To introduce a new product.

The set-up would be used in following scenarios:

1. Low wind velocity regions.
2. In rough terrain.
3. For all types of wind turbine.

## III. MAGNETIC ACCELERATION

The dynamics of magnetic acceleration relates to the magnetic repellent motion. There is a magnetic force between the stationary magnet and the incoming magnet. This magnetic force results in bonding energy between them. Much of the magnetic energy results into kinetic energy which accelerates the rotor [3].

The present invention in new product can overcome the conventional wind turbine problems by using magnet force to maintain the smooth rotation of wind mill even for small amount of wind velocity. The magnetic force will help to accelerate the windmill, after getting initial wind cut from minimum wind velocity.

## IV. DEVELOPMENT OF MAGNETIC ACCELERATION UNIT

There is a repulsive magnetic force between two same polarity facing magnets. This magnetic force results in bonding energy between them. Much of the magnetic energy results into kinetic energy which helps in accelerating the rotor of turbine [4].

Stored Gravitational Potential Energy + Stored Magnetic Potential Energy = Kinetic Energy

The best practical example of magnetic acceleration unit is magnetic motor [3].

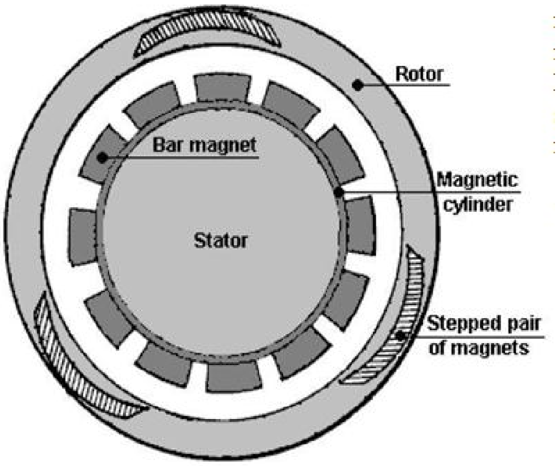


**Figure 1 Conceptual diagram of Magnetic Motor**

Following is a step wise implementation and development of magnetic acceleration unit.

Stage 1:

**Figure 2 Photo taken while testing the concept**

In the first stage, experiments were carried out to understand the concept of magnetic acceleration and test its effectiveness. Polypropylene sheet of 15mm thickness was selected for making a rotor disc. This sheet was machined to a circular disc having diameter of 180mm, 23 circular slots of 10mm diameter at an angle of 10° with the radial direction were drilled on the periphery. 23 neodymium magnets of 10mm diameter and 6mm thickness were press fitted in slots with all having their north pole facing outwards. This disc was fixed on the aluminum shaft of 10mm diameter which was coupled to the small alternator. A magnet of 25mm diameter and 10mm thickness was held stationary with its north pole facing parallel to the north pole of the magnets mounted on the disc. The disc magnets and the outer stationary magnet were placed in such a manner that they helped in accelerating the rotary motion of the disc. Observations were recorded by placing the stationary magnet at various angels and distances from the rotary magnets.

It was found that by placing the outside magnet stationary at a fixed distance with respect to rotating magnets, brake was been applied on the rotating disc.

Stage 2 :

**Figure 3 Magnetic acceleration unit at Stage 2 with slot made on the plate**

From the conclusions of stage 1 slider crank mechanism was implemented on the turbine to achieve reciprocating motion.

All peripheral magnets mounted on disc were removed as they were not helpful in reciprocating assembly and were providing braking force. Only one magnet on the periphery of the plate was kept. Rotating Circular disc was cut to square plate to reduce its inertia. A new slider was made from the polypropylene material to reduce its friction as it the material as very high surface finish. Connecting rod of 250mm length was made of polypropylene sheet of 10mm thickness.

It was found that the connecting rod of slider crank mechanism which was made from the polypropylene material for the initial disc of 250mm was too long and was not having sufficient strength to sustain the forces. Also the power output of the turbine reduced than its power output without magnetic acceleration unit.

Stage 3:

**Figure 4 Implementation of the reciprocating motions**

Stage 3 was the result of the conclusions made from stage 2. Standard MS slider was used for the slider crank mechanism. As it was found that the connecting rod of the slider crank mechanism was too long a shorter connecting rod of 150mm was made from polypropylene.

It was concluded that because of the reduced magnetic repulsion force, frictional losses and inertia effect the power output of the turbine reduced than its power output without magnetic acceleration unit. Though in this stage the power output was increased compared to the 2nd stage.

Stage 4:

**Figure 5 Two repelling magnets on the slider**

Due to the above results it was found that there was a necessity to increase the magnetic power. This was done by placing two magnets at the other end of the slider, with one fixed and the other sliding. They were arranged with their like pole facing each other so as to cause a repulsive force.

Tests were taken and observations were recorded. It was observed that the power output with magnetic acceleration unit was the same as the power output without magnetic acceleration unit.

Stage 5:

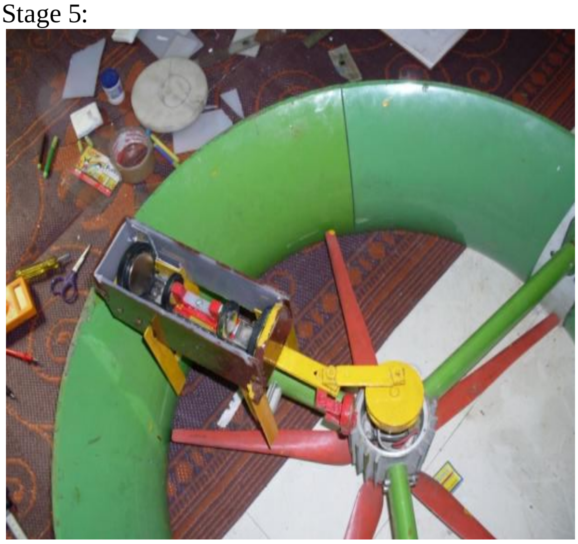

**Figure 6 Magnetic acceleration unit**

**Figure 7 Detailed view**

In order to increase the output more it was concluded that we needed to increase the number of magnets. Angular sockets relative to the circumference of rotor were made for magnets. A slider was connected to the rotor via crank whose end point was eccentric to rotor. The rotary motion of rotor resulted in linear motion of the slider. Two magnets were fixed, one at the end of the slider, the other at the circumference of rotor with their like poles facing each other. Four more magnets were placed co-axially on top of the slider (refer fig 5) in way that they repel each other.

It was found that the power output increased and was more than the turbine without the magnetic acceleration unit.

## V. MAGNETS

The magnets used in the setup were Neodymium magnets of grade N35. Neodymium magnets are a member of the Rare Earth magnet family and are one of the most powerful permanent magnets in the world. They are also referred to as NdFeB magnets, or NIB, because they are composed mainly of Neodymium (Nd), Iron (Fe) and Boron (B) [3]. They are a relatively new invention and have only recently become affordable for everyday use. The magnet has a high magnetic induction of around 1. 3tesla. This magnet has the potential for storing large amounts of magnetic energy (BHmax ~ 512 kJ/m3), considerably more than samarium cobalt (SmCo) magnets, which were the first type of rare earth magnet to be commercialized.

TABLE I. PRPERTIES OF NEODYMIUM MAGNETS

| | |
|---|---|
| Density | 7.4-7.5 g/cm3 |
| Compression Strength | 110 kg/mm2 |
| Bending Strength | 25 kg/mm2 |
| Vickers Hardness (Hv) | 560-600 |
| Tensile Strength | 7.5kg/mm2 |
| Young's Modulus | 1.7 x 104 kg/mm2 |
| Recoil Permeability | 1.05 µrec |
| Electrical Resistance (R) | 160 µ-ohm-cm |
| Heat Capacity | 350-500 J/(kg.°C) |
| Thermal Expansion Coefficient (0 to100°C) parallel to magnetization direction | 5.2 x 10-6 /°C |
| Thermal Expansion Coefficient (0 to100°C) perpendicular to magnetization direction | -0.8 x 10-6 /°C |

The force of repulsion exerted by the magnets (Grade N35) of dimensions Ø50mm and thickness 15mm on the other magnet at varying distances can be calculated by the following graph.

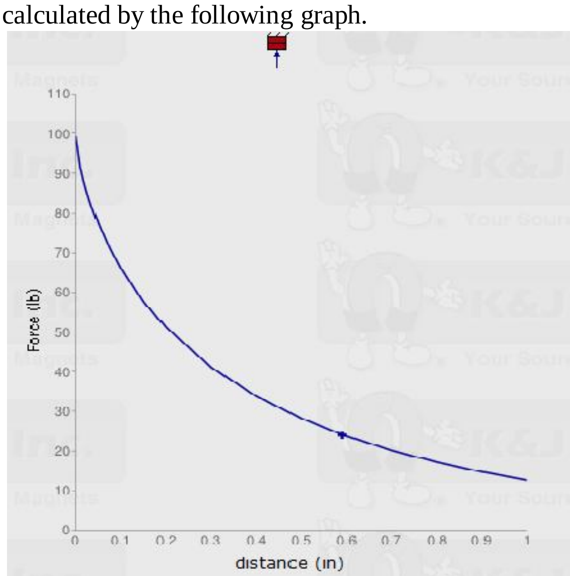


**Figure 8 Variation of magnetic force along the distance**

The force exerted when the magnets are 15mm apart is 24.07lb which is 10.917 kg which equals 109.17N. The force exerted when the magnets are 32mm apart is 8.93lb which is 4.05 kg which equals 40.5N.

## VI. DIFFUSER DUCT

It is more effective for small turbines to place the rotor in a duct in the shape of a reversed funnel, a diffuser. The power coefficient of the rotor rises to values of 2.0 to 2.5 relative to the rotor-swept area but, to obtain fair results, the power coefficient must be related to the maximum cross-sectional area of the diffuser. This reduces the power coefficient to about 0.75, which is still a modest gain compared to the free-stream rotor [1].

It is possible to exceed the Betz limit by placing the wind turbine in a diffuser. If the cross-section of the diffuser is shaped like an aerofoil, a lift force will be generated by the flow through the diffuser as seen in figure 7.

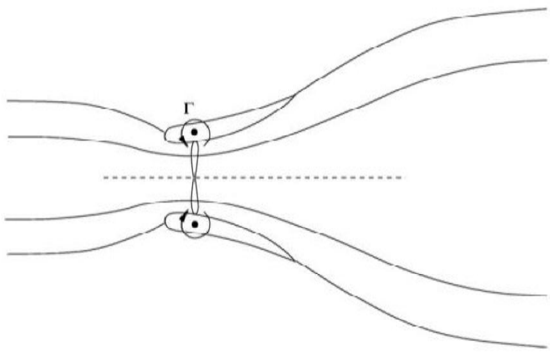

**Figure 9 Ideal flow through a wind turbine in a diffuser**

**Figure 10 Turbine with diffuser**

The diffuser having diameter of 1200mm and standard aerofoil structure was selected to improve the coefficient of power, to reduce the overall size and to make turbine work effectively in region of turbulent wind flow.

## VII. ROTOR

The power coefficient increases with increasing numbers of rotor blades. While the power increase from one to two blades is still a considerable 10 percent, the difference from two to three blades amounts to only three to four percent. The fourth blade only produces a power increase of one to two percent [1].

Hence the number of blades selected was 5 having rotor diameter of 750mm. Rotor blade tip shape and tip vane was selected of standard type. Material used for the blades was carbon fiber. Carbon fiber stands out due to the fact that it has the longest braking length as well as a high modulus of elasticity. The stiffness of carbon-fiber components is comparable to that of steel structures. Their fatigue strength properties are good [2]. It is only the price of carbon fibers, which continues to remain high, which speaks against it. Carbon fiber has virtually no corrosion problems but needs special precautionary measures for protection against lightning when used in rotor blades.

## VIII. TEST RESULTS

All tests were taken indoor with providing air of constant velocity (6m/s) using an industrial fan and observations were taken using voltmeter, ammeter and anemometer.

Power Output without Magnetic Accelerating Unit:
Voltage = 3.4 V
Current = 4.4 Amp
Power Output = 70 Watt

Power Output Using Magnetic Accelerating unit:
Input power = 126 watt

TABLE II TEST RESULTS

| Trial | Volts (V) | Current (Amp) | Output Power (Watt) | % Change in Power Output | Remarks |
|---|---|---|---|---|---|
| 1 | 2.6 | 4.3 | 52 | -26 | Decrease |
| 2 | 2.7 | 4.4 | 54 | -23 | Decrease |
| 3 | 3 | 4.5 | 64 | -9 | Decrease |
| 4 | 3.5 | 4.6 | 75 | 7 | Increase |
| 5 | 3.6 | 4.6 | 79 | 13 | Increase |

## CONCLUSION

- The output power of the turbine was more by the use of magnetic accelerated unit, than it was for the conventional model of the turbine.
- Fluctuation in the electric power output was reduced in spite of variable wind velocity.
- The objective of making the product cost effective is achieved successfully.
- The product is compact, easy to assemble and transport.
- The maintenance requirement of the product is low.

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