Development of vertical axis wind turbine by Maglev suspension – An innovative approach

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Abstract. Renewable energy sources like wind turbines are gaining more importance in recent years as apprehension of environment pollution has increased. Many developments have taken place to utilize solar and wind energy. Wind is present everywhere at all time but wind turbines are present in few places to generate power. An attempt has been made to make use of wind even from small regions by developing prototype of vertical axis wind turbine using maglev suspension to harness power. PVC pipes were used as wind turbine blades; simple and economic materials were also used in making this wind turbine. A new approach of having placed the magnets (double ended arrangement) has been experimented in this work. The voltage generated in double ended arrangement for different wind speeds was twice the voltage as that of single ended arrangement. The aim is to use simple low density material as wind turbine blade and generate power by magnetically levitated system. A new way of placing the neodymium permanent magnet and coils were deployed on the wind turbine plates and experimented in this work. On rotation of the wind turbine the magnetic arrangement would create axial flux while passing over copper coil arrangement.

1. Introduction

In favourable sites wind turbines are preferred over fossil fuels [1].Along with growth of power generated through solar energy, power generated through wind energy is growing rapidly worldwide [2]. Wind energy can be utilized effectively to generate power predominantly and also for other purposes. It is a reliable source of renewable energy as it's available at all altitude and at all seasons. Horizontal wind turbine is installed as gigantic structures to generate high power. However horizontal wind turbines are not preferred for medium to compact area as they occupy more space. On the other hand vertical axis wind turbines are chosen as they occupy less space and generate reasonable power. Vertical axis wind turbine (VAWT) accepts wind from any direction without any yawing mechanism as they are omnidirectional [3]. Shienbein et al presented their findings on mechanical and control systems of turbine for 50KW and 500KW darrieus wind turbine models [4].
Complex geometry of blades being used in VAWTs lead to manufacturing difficulty and associated cost has led to production limitation as mentioned by Eriksson S et al [5]. Savonius rotor has 20% less flow energy utilization than darrieus rotor [6]. Savonius rotors have the ability to self-

start when compared to other “lift type” Vertical axis wind turbines [7]. Efficiency can be improved by adding discs at both ends of the turbine as suggested by Muller et al [8]. Magnetic vertical axis wind turbine used by James A Rowan et al [9] in which foils were placed vertically and mounted are magnetically levitated above the turbines base; thereby reducing friction within the system. Cost is significantly low with smaller size generator in Maglev VAWT. Aravind C V et al [10] proposed the novelty of levitation concept which shows vertical axis wind turbine can be designed to work under low speed to produce power at 1 m/s.

2. Materials and Methods

Two O-ring neodymium magnets are arranged in the dimensions 40 mm, 20mm and 10mm of outer diameter, inner diameter with thickness respectively on the shaft which levitates non-rotating plate (stator) and rotating plate (rotor) due to the repulsive forces of the magnet. Ten disc type magnets of diameter 30mm and 4mm thickness were placed on the periphery of the rotor. Ten copper coils of 42 gauge having wire diameter of 0.102mm and 2000 turns in each coil of stator and magnets present on rotor are arranged on to the exterior in line with periphery. Arrangement of coils was in circumferential pattern to a radius of 10 cm and was connected serially in order to obtain maximum output voltage. For double ended; same set of arrangement is made on the other end of turbine blade. The repulsive force from the O-ring magnet give rise to the gap between the stator and rotor discs. Due to this magnetic levitation; rotor is free to rotate without much frictional forces and give rise to rotation of the wind turbine even at low wind speed. Magnetic levitation between the stator and rotor with the arrangement of magnets and coils are illustrated in the Fig 1.below as shown.

Figure 1. Levitation between Stator and Rotor

PVC pipes were used as wind turbine blades which were cut into two half forming a semicircular blade profile having a radius of 4.5cm and height 60cm. Fig.2 represents the wind turbine structure pictorially. The profile blades are attached to the rotor by using simple L clamp. This type of arrangement helps in fixing blades to the stator easily and also various blade profiles can be fixed to this setup in turn carrying experiments without changing the other components.

2.1. Single ended arrangement

In single ended arrangement type of experiment; ten copper coils were mounted on the base plate (stator) and ten neodymium magnets were mounted on the bottom end of the lower disc (rotor) of the wind turbine wherein the rotor and stator are separated by the magnetic levitation generated by the O-ring magnet placed on the shaft.

Figure 2. Levitation between Stator and Rotor

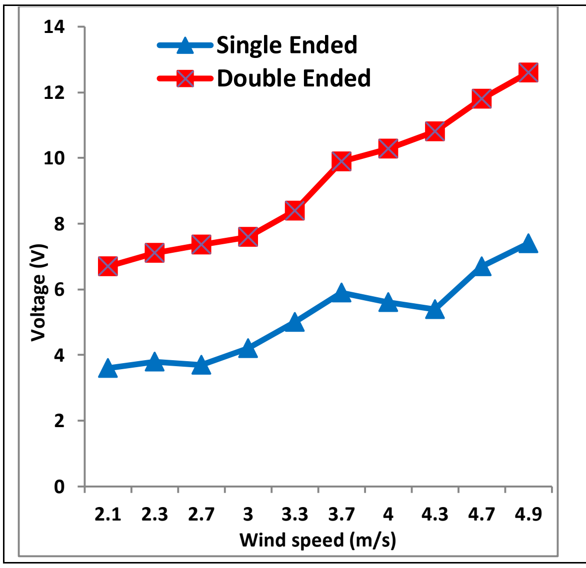
2.2. Double ended arrangement

In order to generate more voltage a similar set of magnet and copper coils were arranged on the top end of the wind turbine blades. The coils present at both ends of the blade were connected in series and voltage generated was recorded using a multimeter during the rotation of wind turbine at various speeds.

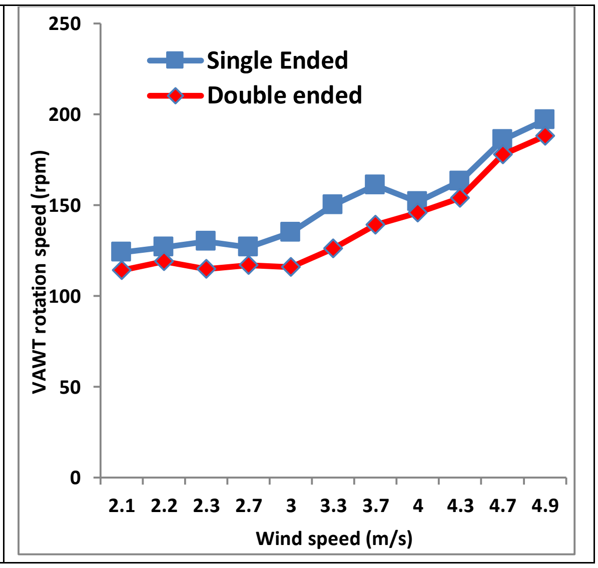
3. Results and Discussion

VAWT was fabricated as described in material and methods. Testing was carried by placing the setup on house roof top which is about 60 feet above ground level. Anemometer was used to measure wind speed and output voltage caused due the rotation of wind turbine blades for both single and double ended arrangement was measured using multimeter. The experimental results are as shown in Table 1. It is observed from graph 1 that higher voltage is developed for double ended setup which almost 50% greater than the voltage developed in single ended setup at all wind speeds. This is due to the increase number of coils and magnet in double ended setup which cut more flux generating higher voltage.

On comparing with the speed of VAWT for single ended and double ended setup, rotation speed of double ended setup is lesser than that of the single ended setup. This may be due to the resistance to rotation caused by magnetic force created as the magnet passes over the coils. Table 1(b) and graph 2 indicates the speed of VAWT for single ended and double ended setup with respect to wind speed.



Graph 1: Voltage v/s Wind speed



Graph 2: Rotation speed v/s Wind speed

Table 1. Experimental Data

Sl. No	Wind Speed (m/s)	VAWT Speed (rpm)	Voltage (V)	
			Single Ended	Double Ended
1	2.1	124	3.6	6.7
2	2.3	130	3.8	7.1
3	2.7	127	3.7	7.4
4	3	135	4.2	7.6
5	3.3	150	5	8.4
6	3.7	161	5.9	9.9
7	4	152	5.6	10.3
8	4.3	153	5.4	10.8
9	4.7	186	6.7	11.8
10	4.9	197	7.4	12.6

(a)

Sl. No	Wind Speed (m/s)	VAWT Speed (rpm)	
		Single Ended	Double Ended
1	2.1	124	114
2	2.3	130	115
3	2.7	127	117
4	3	135	116
5	3.3	150	126
6	3.7	161	139
7	4	152	146
8	4.3	163	154
9	4.7	186	177
10	4.9	197	187

(b)

4. Conclusion

VAWT rotated at low wind speed even with simple blade geometry and as the density of blade material (PVC) is less. In double ended setup VAWT rotation speed is lesser than single ended setup which might be due to the resistance caused by the pulling magnetic force as the magnet is about to leave the coil surface. Voltage produced in double ended setup is twice that of single ended arrangement, even though rotation speed is less in double ended arrangement compared to single ended arrangement for same wind speeds due to the high magnetic flux density.

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