Review paper on Maglev Vertical Axis Wind Turbine

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Abstract:
The present scenario indicates that the demand for electricity is increasing day by day and to meet it many research are going on. Electricity generation through renewable energy sources has gained attention in the last few decades due to depleting conventional energy sources and can help in reducing dependency on fossil fuels. The principal benefit of a vertical axis wind turbine using magnetic levitation in which the rotor is floating in the air due to levitation force which is generated using magnetic repulsion so that mechanical friction is totally eliminated. This new design comprises magnetic levitation phenomenon using rare earth permanent magnets between both rotors to reduce the losses. In the levitated generator design bearings and gears are absent which provides the frictionless flow of energy minimizing noise and hence friction losses are also reduced. At the same time the soft running of some moving component ensures minimum material wear, which reduce the maintenance cost. A VAWT rotor has two types such as savonius and darrieus. Savonius wind turbine produces high torque compare to other which is useful in self-starting. In other hand darrieus rotor has high tip speed ratio useful for electrical generation. So the combination of both type rotors are used over the individual savonius or darrieus rotor would have many advantages. so they are able to operate with starting speeds as low as 1.5 m/s. Also, they can operate at winds speed exceeding upto 40 m/s. That makes the rotation possible in very low wind speeds.

keywords- wind turbine, magnetic levitation, savonius and Darrius rotor,

1 INTRODUCTION

Renewable energy is generally energy 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 demand of renewable energy has increased at high rate in recent times due to the depletion of conventional power generation methods and increasing realization of its adverse effects on the environment. It is estimated that renewable sources might contribute about 20% – 50% to energy consumption in the former part of the 21st century. Wind is a natural power source that can be economically used to generate electricity. The way in which wind is created is the uneven heating of the sun, rotation of the earth and the rockiness of the earth's surface, winds are formed. Wind power is used to generate the electricity by means of using turbine which converts the kinetic energy of wind power into mechanical energy. This mechanical energy also can be used for pumping water or grinding grains further this mechanical energy converted into electrical energy by the generator. The wind strikes on blades which turns the blades of the rotor. Rotor is mounted on the shaft which spin a shaft, which connects to a generator and produce electricity. World Wind Energy Association estimates that the 250GW of wind power capacity is expected to be installed worldwide by 2020 which involves an expected net growth rate of more than 30% per year. Maglev Wind turbine has consist of permanent magnets which is instead of bearings and shafts so there is no mechanical linkages, no friction etc. Which minimize the noise and frictional losses. By reducing the damping in the magnetic levitation wind turbine, which makes the wind turbine start up with low wind speed and work with breeze. The Maglev wind turbine, which was first revealed at the Wind Power Asia exhibition in Beijing, is expected take wind power technology to the next level with magnetic levitation. Efficiency of turbine is directly proportional to increase in power generation. So that which leads the decreasing the need for expensive power generation processes that cause pollution.

2. LITERATURE REVIEW

Aravind CV et al.,[2012] carried design procedure and analysis of vertical axis wind turbine using magnetic levitation where gears were replaced with direct drive technology, thereby reducing the maintenance and power loss. Bearing were replaced with magnetic levitation. From the analysis he concluded that the introduction of maglev to the VAWT increases the efficiency and reduces the vibration with by 30% compared to that of the turbine without mechanical bearing.

Dinesh N Nagarkar et al.,[2013] carried out study on construction and working of magnetic levitation based power plant which has colossal structure where blades were placed vertically along the outer rim of the cylinder. Since the total assembly was levitated by permanent magnets so there was no friction due to bearings are replaced by the magnets they allowed the wind turbine to convert all the wind energy into electrical energy which results in increasing output and reducing cost. Due to magnetic repulsion betweem the magnets which seperates the turbine and the generator thus there is no friction as compared to traditional windmill so it increases the efficiency and power generation capacity by 20% compare to conventional as well. And also reduces the maintenance cost..

Minu John et al.,[2014] carried out an experimental study on vertical axis windmill working on maglev using Nd-Fe-B ring shaped permanent magnets of grade N-42 of outer diameter 40 mm, inner diameter 20 mm and thickness 10 mm placed at the center of the shaft by which the required levitation between the stator and the rotor was obtained. Similar disc type magnets of 30 mm diameter and 4mm thickness were arranged as alternate poles one after the other, along the periphery of the rotor made of acrylic of 40mm diameter. 26 gauge wires of 1000 turns each were used as coils for power generation. 12 sets of such coils were used in the prototype and were arranged in the periphery of the stator exactly in a line to the arranged disc magnets. The output voltage obtained from this prototype was a maximum of 45 volts DC.

B. Bittumon et al., [2014] carried out research on combined savonius and darrieus rotors which is very scarce. He designed and analyzed a Maglev VAWT using a combined savonius and darrieus vertical axis wind turbine would have many advantages over an individual savonius or darrieus rotor. A savonius produces high torque which would be useful in self-starting and darrieus rotor having a high tip speed ratio useful for electrical generation. This developed a two bucket savonius rotor and placed it on the central shaft of a traditional darrieus. Using a counter rotating wind turbine with a freely rotating generator can produce higher amounts of power than common wind generators.

Amit D. Patil et al., [2015] designed a prototype model of a VAWT using magnetic bearing. The rotors that were designed harnessed enough air to rotate at low and high wind speeds while keeping the centre of mass closer to the base yielding stability. The wind turbine rotor levitated properly using permanent magnets, which allowed for a smooth rotation with negligible friction. The no. of blades hub is 4 selected to use in project. (Width= 0.1cm, breath= 10cm, height= 26cm.)Other component which is mounted on the base are emf generator, charging circuit, battery. (Model: Height= 45cm, length= 38cm, width=1.5cm. The output voltage obtained from this prototype is measured using a multi-meter and a maximum of 5volts DC was obtained.

2 PRINCIPLE OF MAGLEV

Magnetic levitation, maglev, or magnetic suspension is a method by which an object is suspended above another object with no support other than magnetic fields. The electromagnetic force is used to counteract the effects of the gravitational force.

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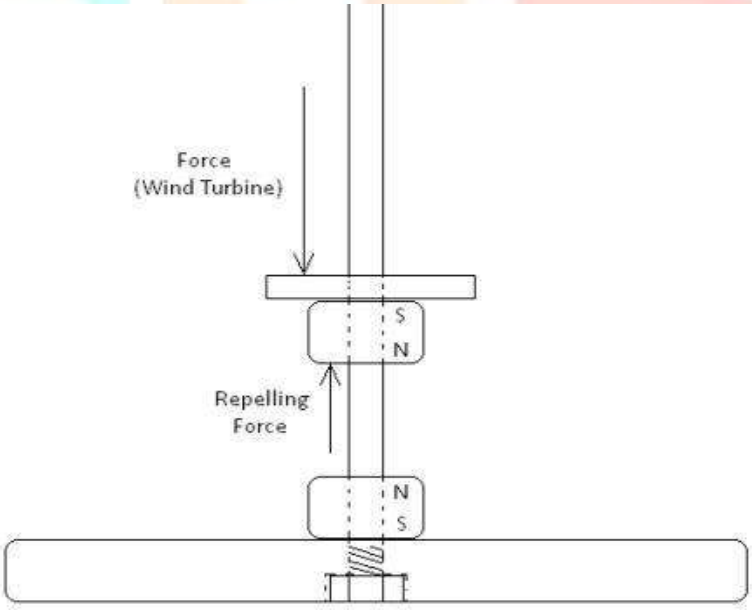

Fig.no.1 principle of maglev

3. VERTICAL AXIS WIND TURBINE

the axis of rotation of VAWT is perpendicular to the ground. The major difference is the orientation of the rotors and generator, which are all vertically arranged, and usually on a shaft for support and stability. This also results in a different response of the turbine blades to the wind in relation to that of the horizontal configurations. Their design makes it possible for them to utilize the wind power from every direction unlike the HAWTs that depend on lift forces from the wind similar to the lift off concept of an airplane. Vertical axis wind turbines are further subdivided into two major types namely the Darrius model and the Savonius model.Darrius Model was named after designer and French aeronautical engineer, Georges Darrius. The form of this design is best described as an eggbeater with the blades, two or three of them bent into a c-shape on the shaft. It has the high tip speed.

Fig.no.2 Darrius VAWT

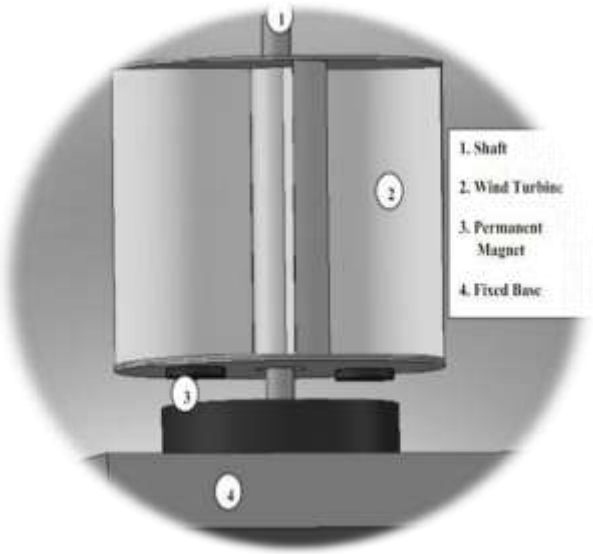

Fig.no.3 Savonius VAWT

Finnish engineer Sigurd Savonius invented the Savonius model. The functioning of this model is dependent on drag forces from the wind. This drag force produced is a differential of the wind hitting by the inner part of the scoops and the wind blowing against the back of the scoops. Like the Darrius model, the Savonius turbines will work with winds approaching in any direction and also work well with lower wind speeds due to their very low clearance off the ground. It can produce high torque.

3. WIND POWER GENERATION

As mentioned earlier the effective functioning of a wind turbine is dictated by the wind availability in an area and if the amount of power it has is sufficient enough to keep the blades in constant rotation. The wind power increases as a function of the cube of the velocity of the wind and this power is calculated with respect to the area in which the wind is present as well as the wind velocity. When wind is blowing the energy available is kinetic due to the motion of the wind so the power of the wind is related to the kinetic energy.
We know,

$$\text{Kinetic Energy} = 1/2\ MV^2$$

The volume of air passing in unit time through an area A, with speed V is AV and its mass M is equal to the Volume V multiplied by its density ρ so:

$$M = \rho AV$$

Substituting the value of M in above equation we get:

$$\text{Kinetic Energy} = 1/2\ \rho AV^3$$

To convert the energy to kilowatts, a dimensionless proportionality constant k is introduced where,

$$K = 2.14\times10^{-3}$$

Therefore,

$$\text{Power in KW (P)} = 2.14\rho AV^3\times10^{-3}$$

Where:
Air Density (ρ) = 1.2 kg/m^3
Area (A) = Area swept by the blades by the turbine
Velocity (V) = wind speed in m/s
With the above equation, the power being generated can be calculated, however one should note that it is not possible to convert all the power of the wind into power for generation. The power harnessed from the wind cannot exceed 59% of the overall power in the wind. Only a portion can be used and that usable portion is only assured depending on the wind turbine being used and the aerodynamic characteristics that accompany it.

4. WORKING OF MAGLEV WIND TURBINE

It is the vertical axis wind turbine working on the principle of magnetic levitation effect i.e bearings are replaced by permanent magnets which reduces the frictional losses and allows turbine to rotate on low wind speed.

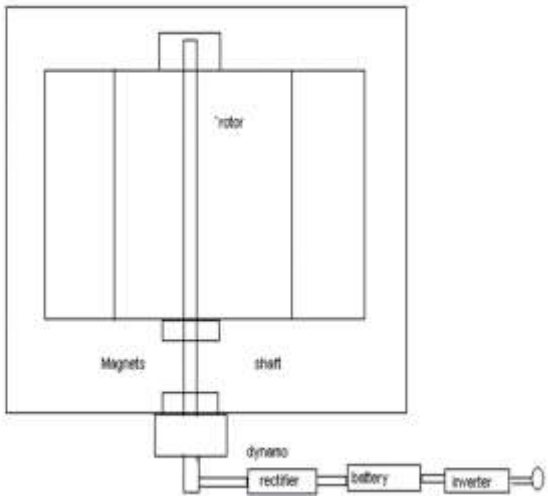

Fig.no.4 Block Diagram of Maglev Windmill

Figure gives an idea of Maglev Wind Turbine. This phenomenon operates on the repulsion characteristics of permanent magnets. This technology has been predominantly utilized in the rail industry in the Far East to provide very fast and reliable transportation on maglev trains and with ongoing research its popularity is increasingly attaining new heights. Using a pair of permanent magnets like neodymium magnets and substantial support magnetic levitation can easily be experienced. By placing these two magnets on top of each other with like polarities facing each other, the magnetic repulsion will be strong enough to keep both magnets at a distance away from each other. The force created as a result of this repulsion can be used for suspension purposes ands strong enough to balance the weight of an object depending on the threshold of the magnets. Power will then be generated with an axial flux generator, which incorporates the use of permanent magnets and a set of coils. The generated power is in form of DC, stored in battery, this can be used to directly supply the DC loads and can also be converted to AC using inverter to supply AC loads. It can be used as OFF grid and ON grid as shown in above figures. Wind power is a proven and highly effective way to generate electricity. Maglev technology is the most efficient means of transferring kinetic energy to generate electricity. The vertical axis wind turbine platform floats on a magnetic cushion with the aid of permanent- magnet suspension and a companion linear synchronous motor. This technology eliminates nearly all friction and delivers maximum wind energy to the downstream linear generator. Vent which allows for a different type of rotational support rather than the conventional ball bearing system found in horizontal wind turbines. This figure shows a basic rendition of how the maglev will be integrated into the design. If the magnets where ring shaped then they could easily be slid tandem down the shaft with the like poles facing toward each other. This would enable the repelling force required to support the weight and force of the wind turbine and minimize the amount of magnets needed to complete the concept.

9. ADVANTAGES

- •A massive tower structure is not required, as VAWT's are mounted closer to the ground.
- •These are located closer to the ground and hence easier to maintain.
- •Requires no lubrication.
- •Capable of generating power from wind speeds as low as 1.5 m/s and reported to operate in winds reaching 40 m/s.
- •Producing 20% more energy than a conventional turbine, at the same time decreasing operational costs by 50% over the traditional wind turbine.
- •Accepts wind from any angle.
- •Better answer to rapidly changing winds.
- •Lighter weight towers

FUTURE SCOPE

Future work could entail investigation of the effect of following perspectives discussed below on the performance of the present rotor.

- By using aerodynamic blades for Savonius rotor, the torque of the rotor can be increased to produce more power at even low speeds.
- Design related to self-adjustable End Plates can be developed to attract more air to pass through the blades by automatic creation of pressure differential across inlet and outlet.
- Future work in the field of suitable alternator or generator can also be proposed for efficient generation of electricity at lower speeds.
- In this design we can place Solar Plate and can get doubled electricity with the same place in use.

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