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DESIGN AND FABRICATION OF VERTICAL AXIS WINDMILL TURBINE

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ABSTRACT

This paper addresses the betterment in vertical axis windmill turbine. Vertical axis windmill turbine uses a radically new approach to capturing wind energy. The device captures the energy of wind and converts it into mechanical form. As the wind passes over a turbine blades, the energy will be transferredto the alternator which will exert the force in the downward direction. The alternator connected is convert wind energy to mechanical energy . Naturally, the design of such device is completely differentfrom a traditional turbine i.e where we use in horizontal axis wind turbine we use blades, generator andgear which increases the initial cost of project instead of we use vertical axis windmill turbine puts thetechnology at the very low range of capital intensity of such project; it also makes it highly competitive not only against generations of alternative or renewable energy, but even compared to conventional technologies. This project increases the efficiency than Horizontal Axis Windmill Turbine.

Keywords : Wind energy, Efficiency.

1. INTRODUCTION

A vertical axis windmill turbine (VAWT) is a type of wind turbine where the main rotor shaft is set transverse to the wind (but not necessarily vertically) while the main components are located at the baseof the turbine. Vertical axis windmill turbine do not need to be pointed into the wind , which removes the need for wind-sensing and orientation mechanisms. Windmills that would provide safe quiet, simple,affordable and work on lesser wind speeds are need of the hour. A vertical axis windmill turbine has itsaxis perpendicular to the wind streamlines and vertical to the ground.

1.1. Wind

The wind is generated due to pressure difference of atmosphere. Because of the atmospheric pressure difference, air particles move high-pressure end to lower pressure end. During the air flowing air molecules are subjected to Coriolis effect except exactly on the equator. The winds are often referred toaccording to the direction from which wind blows and its force. Small bursts of high speed winds are called gusts. Strong winds of intermediate duration are called squalls. Long lasting winds have differentnames such as breeze, gale, storm, and hurricane.

1.2. Wind Power

Wind turbines produce electric power by using the power of wind to drive an electric generator. The generator generates electricity and moves from the tower to an available transformer and switches fromthe output voltage (usually about 700 V) to a nationwide grid (33000 V) or personal use (about 240 V).wind power is an attractive and alternative power source for both large scale and small scale and distributed power generation application. One of the most important advantages of wind energy is beingmodular and scalable. As a side effect of using wind energy , the dependency on fossil fuel also is reduced.

With largely untapped wind energy resources throughout the world and declining wind energy costs, people moving forward into the 21st century with an aggressive initiative to accelerate the progress of wind technology and further reduce its costs, to create new jobs, and to improve environmental quality.

1.3. Wind Turbine

Wind turbine blades use the kinetic energy from the wind and that energy is converted in mechanical energy for useful work or electrical energy. There are two types of wind turbines i.e. 1) Horizontal axiswind turbine(HAWT), 2) Vertical axis wind turbine(VAWT). But, horizontal axis wind turbine need high speed of air pressure to give it's output or maximum performance for the electricity generation. And also , moving wind turbine blade experiences the wind as the blade velocity increases to the tip,

the relative wind speed becomes more inclined towards the tip. Then generates tip vortices which are caused to high noise.

(a) HAWT

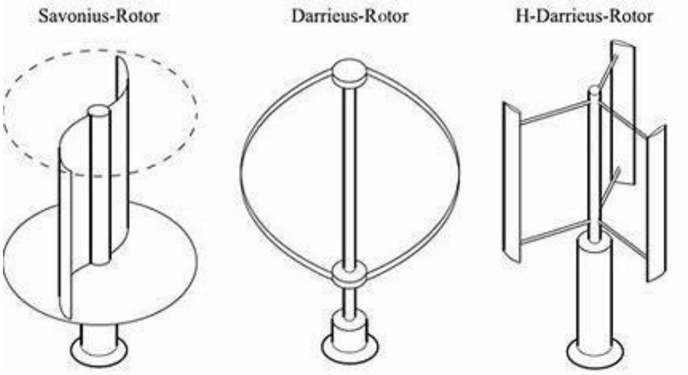
(b) VAWT

Above fig shows the two types of Windmill turbines.

1.4. Vertical Axis Wind Turbine

Vertical axis wind turbine offers a number of advantages over a traditional horizontal axis wind turbines.They can be packed closer together in wind farms, allowing more in a given space. They are quiet, omni-directional, and they produce lower forces on the support structure. They do not require as muchwind to generate power, thus allowing them to be closer to the ground where wind speed is lower. Because of they are closer to the ground easily maintained. The basic vertical axis designs they are,

i. Derrius - which has curved blades,
ii. Giromill - which has straight blades,
iii. Savonius - which uses scoops to catch the wind.



The main drawbacks of initial designs were (Savonius, Darrieus and Giromill) significant variations oftorque during each rotation and the huge bending moment on the blades. Subsequent projects addressedthe issue of torque ripple by sweeping the blades helically.

Power coefficient (Cp) is a measurement of the wind turbine efficiency. Cp is the ratio of actual powerproduced by a wind turbine divided by the total wind turbine blades at a specific wind speed. Power coefficients of different VAWTs as shown in below figure.

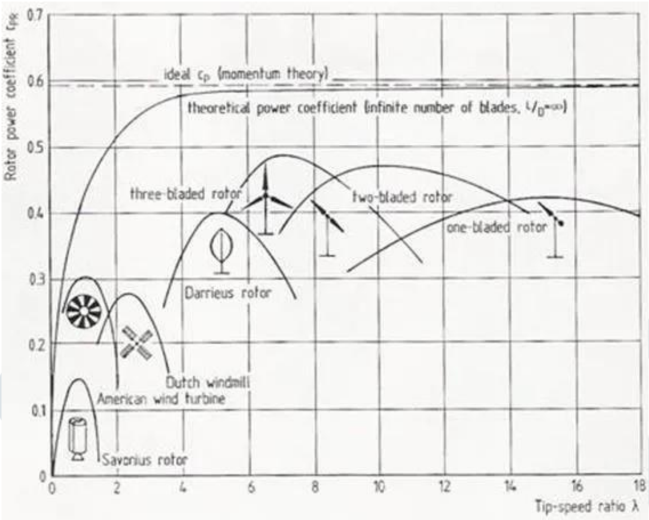


Fig. Power coefficient of different VAWTs.

From the last few years China is the leading researcher in this field. Following graph shows that theinterest of research on VAWT in European countries.

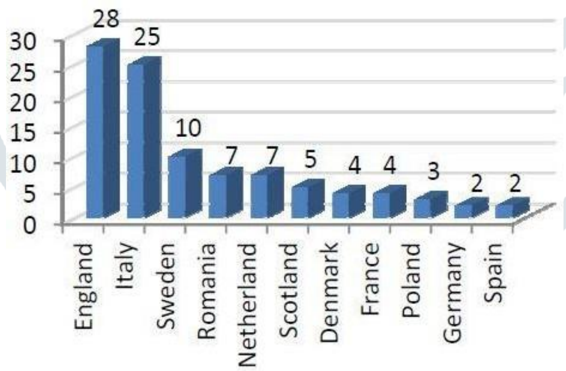


Fig. Research publications on VAWTs in European Countries.

1.4.1. Darrieus type Vertical Axis Wind Turbine

Darrieus wind turbine was invented by Georges Jean Marie Darrieus and first patented in 1927. Bladesare aerodynamically shaped, usually NACA style, with different layouts and with a certain distance from the rotation axis. There are so many challenges when protecting the Darrieus turbine from extreme wind conditions and making it as a self starter. This wind turbine is high speed and low torque turbine which suitable for generating alternative current (AC). The largest Darrieus wind turbine is Placed in Cap-Chat, Quebec. It is a 60 m wide and 100 m tall. It has a nameplate capacity of 3.8 MW.

Fig. shows that how Darrieus wind turbine moves with respect to the wind directions.

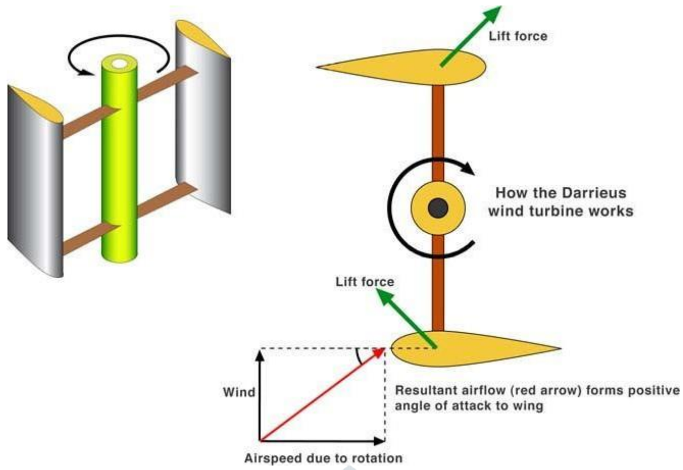


Fig. Darrieus wind turbine operating principle.

The original version of Darrieus designs was symmetrical and had zero rigging angles. This arrangement is equally effective regardless of the direction in which the wind is blowing. Darrieus type needs n electric support to start and its removal rate around 4-5 m/s , while the Savonius type starts at1 m/s or lower. By solving the starting problem of the Darrieus type turbine , the hybrid system has been power coefficient (Cp) then the Savonius type at high speed winds.

The angle of attack of the turbine blades should not exceed +20 or -20 since it becomes turbulent causingstall. The angle of attack in between zero and 20 requires sufficient high blade speeds. Generally lift forces as well as the drag forces increases with the angle of attack. Tangential component of lift forcesto blade rotation and drag force opposed to it. A wind turbine can give its maximum performance whenlift to drag ratio is maximum. This is happening when the optimum angle of attack. Airfoil cross sectionsshould be aligned with the optimum angle of attack. These are the points that researchers address rightnow. Present researchers are trying to improve the performance of Darrieus type wind turbine by introducing the wind deflectors. When the two flows meet from different angles, they create rapid mixing vortex. That means low pressure zone will be created by vortices, like a typhoon. It causes to reduce the downstream air pressure and increases the turbine efficiency.

The power in the wind is proportional to the cubic power of the wind velocity approaching a wind turbine. This means that even small amount of its acceleration gives a increase in energy generation. Therefore many research groups have tried to find a way to accelerate the approaching wind velocity effectively. This upstream deflectors system generates large size of separation behind it, where a very low pressure region appears to draw more wind compared to a wind turbine without deflectors owing to this effect, the flow coming into deflectors will be effectively concentrated and accelerated.

1.4.2. Giromill type Vertical Axis Wind Turbine

The several limitations of the Darrieus wind turbine, several modifications have made to improve productivity, efficiency and design downtime. Giromill is a subtype of Darrieus turbine with straight blades, as opposes to the curves. It uses 2 or 3 straight blades, as individually attached of this type are,it has higher starting torque, torque curve with curve with less fluctuation and higher coefficient of performance. The blades are in lower bending stresses due to a lower bending stresses due to a lower speed.

Fig. Giromill type wind turbine

1.4.3. Savonius type Vertical Axis wind Turbine

This is another type of Vertical Axis Wind Turbine was invented in 1922 by Sigurd Johannes Savoniusfrom Finland. It is known as Savonius type VAWT. It is a drag based VAWT Which operates in the sameway as cup anemometer. However, Savonius wind turbine efficiency is around 15%. That means just 15% of the wind energy hitting the rotor is turned into a mechanical energy. It is less than Darrieus type.

A Savonius type wind turbine cannot rotate faster than the speed of the wind and it has tip speed ratio in between 0 – 1. That means the Savonius type will rotate slowly but generate a high torque. Thereforea Savonius type is not suitable for electricity generation, because turbine generators need to be turned into hundreds of RPM to generate high voltages and currents. A gearbox can be used to reduce and increase generator RPM.

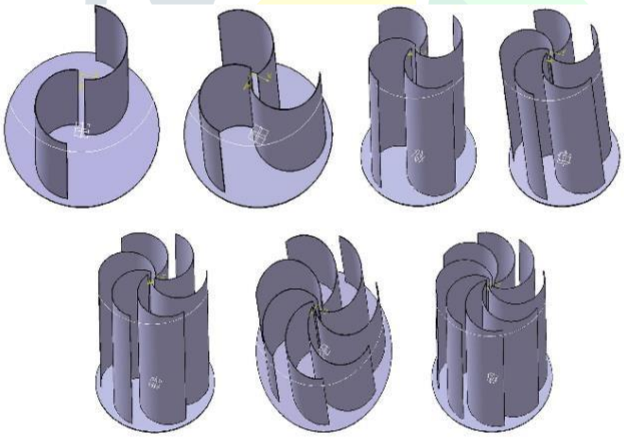


Fig. Savonius type Vertical Axis Wind Turbine

As Savonius type has low efficiency, many researchers are focused on the improvement of turbineefficiency, because it gives more advantages as compare to other types of turbines.

1.5. Future trends of Vertical axis wind turbine's

Although predicting the future, based on the presently available data is not fully accurate, so we can getsome idea where the vertical axis wind turbine technology goes.

A major problem encounters during the operation of VAWTs is low air capture, because it's very closeto the ground level. The deflector system that guides the wind towards the turbine blades will be solvedthat problem. It increases the power, speed and torque in these sorts of environments. A lot of researchersare on going at present in this level.

A lot of researchers have developed basic wind turbines, and discover significant parameters that directly involve to changing performances of turbines. Some of them blades has solidity, lift force, dragforce and angle of attack. Furthermore, so many researchers have done with considering blade profile. The latest VAWTs occupied blades that developed by NACA which has the ability to self-start. However, researchers are involved to modify common VAWT and increase its efficiency while globalattention on it. Most popular self-starting NACA blades are NACA 4415 NACA 4418.

Because of the low self-starting capabilities of the Darrieus type turbine, integrate the Savonius type blades by making a hybrid system. This will be very popular use in small generating installations, especially in urban environments that currently have winds that are not exploited.

It has been verified by simulations that helical arrangement of the turbine blades increases the power coefficient in comparison with the straight arrangement of the blades from 33% to 42% under same operation conditions. Lot of researchers are on going through the modelling work in this category.

The VAWT application of the offshore conditions for the major productions is discarded, but once canbe designed to supply weather buyo and boats, either individually or through a wind / PV hybrid system.

1.6. Conclusion

Local authorities in India, as well as the foreign authorities, will face, lots of problem in the near futuredue to lack of non-renewable energy sources. So, they are moving for the renewable energy sources likewind, solar energy, tides, rain, sea waves, geothermal heat, etc.

If we can improve the performance of the Vertical Axis Wind Turbine (VAWTs), it's huge advantage forthe authorities. They can implement the VAWTs every possible place and generate the electricity whilecontributing to the reduction of CO2 production and economic growth.

Thus, by the researches related to the VAWTs, it is accepted to substantial step forward in this field inthe foreseeable future. By introducing there search out comes to the country, it would gain for the national development.

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