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RESEARCH ARTICLE OPEN ACCESS

Aruth Wind Turbine

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ABSTRACT
Adetailed review of designing and development of the Vertical Axis Wind turbine is presented including design of blade, gasket, washers, wheel hub, wind wheel pressure plate and selection of motor.Our intention is to design a wind turbine compact enough to be installed in between dividers of road and roof tops. The wind turbine designed to generate electricity sufficient enough for a domestic use. The electricity generated will be stored in the battery and then given to the load. This project emphasizes on electrification of streets and houses with minimum cost. This motive of this project is to provide electricity to street lights and make them self-sufficient without supply of electricity from outside.

Keywords: Blade design, Vertical axis wind turbine,Wind Turbine.

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I. INTRODUCTION

Energy is the primary and most universal measure of all kinds of work by human beings and nature. Energy is a crucial input in the process of economic, social and industrial development. As conventional energy sources are depleting day by day, utilization of alternative energy sources is the only solution. The increased power demand, depleting fossil fuel resources and growing environmental pollution have led the world to think seriously for other alternative sources of energy. Basic concepts of alternative energy resources are related to the issues of sustainability, renewability and pollution reduction.

Development of any country is directly related to the energy resources present since energy is the backbone of technology. To meet the necessary demands great pressures have been created on the natural energy resources. Thus it is essential for today's world to concentrate on renewable ones to satisfy the demand and conserve our finite natural resources for the generations to come. Since the major energy comes from the finite, non-renewable fossil fuels thus it becomes crucial to look for other renewable alternate energy sources such as Solar, Wind, and Biomass etc.

A vertical-axis wind 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 base of the turbine. This arrangement allows the generator and gearbox to be located close to the ground, facilitating service and repair.

Vertical-axis wind turbines come in one of two basic types: the Darrius wind turbine, which looks like an eggbeater, and the Savonius turbine, which uses large scooped cups.

Vertical-axis wind turbines were tested and used more extensively in the 1980s and 1990s because they were quieter and could operate without requiring yaw controls, regardless of the wind's direction.

The Vertical-Axis Wind Turbine (VAWT) is a wind turbine that has its main rotational axis oriented in the vertical direction.

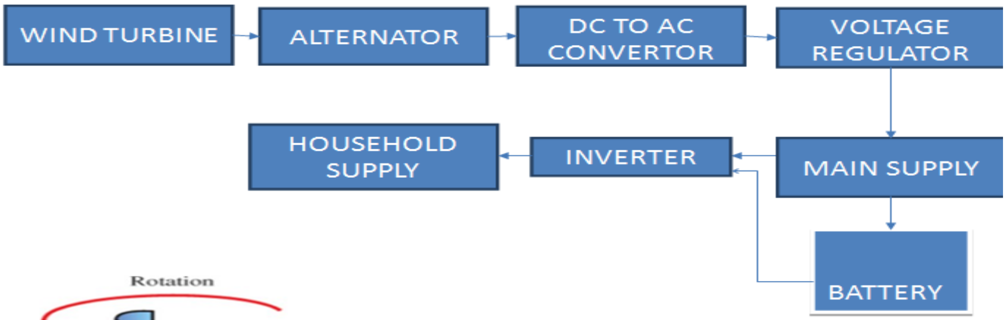
VAWTs were innovative designs that have not proven as effective in general as HAWTs, but they have a few good features, including quietoperation.

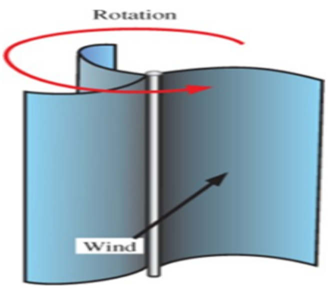
Because they are not as efficient as HAWTs, they are rarely used in large units. Most VAWTs are smaller units that can be located in residential and commercial locations because they are much quieter than the horizontal-axis turbines.

1.1 Working principle of Vertical Axis Wind Turbine

Wind turbines operate on a simple principle. The energy in the wind turns two or three propeller-like blades around a rotor. The rotor is connected to the main shaft, which spins a generator to create electricity. Wind is a form of solar energy and is a result of the uneven heating of the atmosphere by the sun, the irregularities of the earth's surface, and the rotation of the earth ,The terms wind energy or wind power describe the process by which the wind is used to generate mechanical power or electricity. Wind turbines convert the kinetic energy in the wind into mechanical power. This mechanical power can be used for specific tasks (such as grinding grain or pumping water) or a generator can convert this mechanical power into electricity.

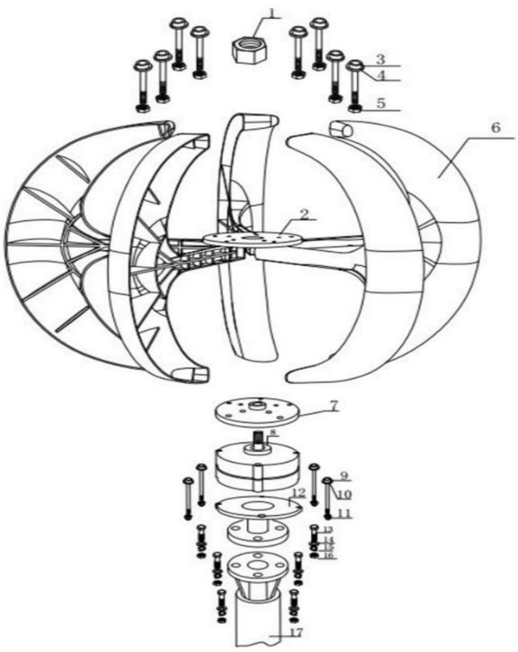
1.2 How does it work?



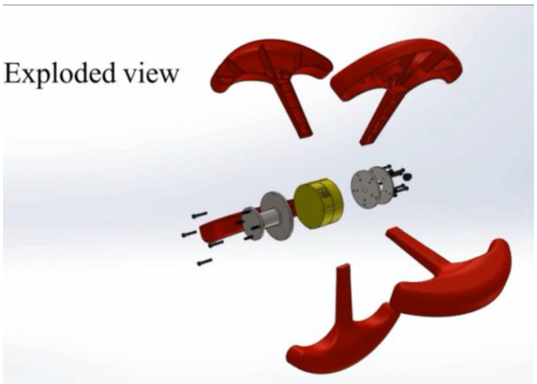


II. DESIGN AND DEVELOPMENT

2.1 Parts



1.loose nut；2. wind wheel pressure plate;3.bolts;4.flat washer5.loose nuts;6.wind blade
7.wind wheel hub;8.motor body;9.body bolts;10.flat gasket;11.nuts;12.flange base;
13.bolts14.flat gasket;15.elastic washers;16.nuts;17.steel pipe bracket (tower)



2.2.1 Selection of Parts

We tried to keep our prototype with simple design, so we selected few and basic parts with standard dimensions which are readily available in market. Keeping design simple and using standard parts reduces designing process and human efforts. Small parts like loose nuts bolts, washers can be readily selected from market. Here's a list of parts we selected directly from market:-

1. Loose nuts (M6)
2. Bolts (M6)
3. Flat washers (M6)
4. Gasket
5. Steel Pipe Bracket (tower)
6. Elastic Washers
7. Motor

Motor specifications are
IP Grade = IP65
Power rating = 400w
Rated Voltage = 12v
Rated wind speed = 13m/s
Net Weight = 12kg
RPM = 2400rpm

A motor should be selected according to the load of our design and the wind speed of the environment we are going to install our prototype.

2.2.2 Designing Parts

The main parts to be designed in our prototype are:-

1. Wind wheel pressure plate
2. Wind blades

1. Wind wheel pressure plate:-

Wind wheel pressure plate is the one on which the blades will be mounted from beneath at the circumferential holes with the help of bolts, nuts washers being fastened.

Design of wind wheel pressure plate:-

Formulas and steps to be followed

1. Power = Force * Velocity
2. Tensile stress acting on pressure plate (σ_t) = p/a
3. Shear stress acting on pressure plate ($\sigma_{s)}$ = p/a

Where
p = pressure
a = area

Therefore the same design procedure will be carried out for the wheel hub with comparatively smaller dimensions.

2. Wind blades

Wind turbine blades are airfoil-shaped blades that harness wind energy and drive the rotor of a windturbine. The airfoil-shaped-design (which provides lift in a fixed wing aircraft) is used to allow the blades to exert lift perpendicular to wind direction.

Wind blade depends upon the rotational velocity of the wind turbine and the free stream velocity of the component.

Here we are selecting 5 number of blades to be mounted beneath the wind wheel pressure plate. This number is decided according to our requirement, application and selection of motor. The material we choose for the fabrication of blades is plastic as it is cheaper in rate, easy to fabricate, light in weight and favourable to our application and environment we select to install our prototype.

Design of Wind blade:-

The wind blade design depends upon the operating tip speed ratio which is expressed by (λ)

$\lambda = \omega_r / V_\infty$

Where

ω_r= rotational velocity of the wind turbine

V_∞ = wind speed

By calculations, we got

$\lambda = 1.92$

After calculating λ,

Therefore the geometry of VAWT can be defined through dimentionless parameter Solidity which would be defined as (σ).

$\sigma = (N*C) / d$

Where,
N = number of blades
C = chord length of blades
d = diameter of rotor

The Solidity represents the fraction of the frontal swept area of the wind turbine that is covered by the blades.

After this, we predict the actual performance of the wind turbine. For this we need to determine force acting on each blade. This is done by the software named as CFD (Computational Fluid Dynamics simulation software).

III. LAWS

3.1 Betz Law:-

It states the maximum theoretical efficiencythatanywindturbinecanattain.Itstatesthat thereisamaximumpowerthatcanbe extracted from a flow of air. Because of conservation of momentum and of mass, energy can never be fully extracted from wind. Betz proved that the maximum kinetic energy that canbe extracted from the wind cannot exceed 16/27 (59.3%).

3.2 Tip speed ratio:-

The tip speed ratio (lambda λ) is the ratio of the speed of the tip of the blades to the speed of the wind. Asthetip speedratiovaries,sodoesthe powercoefficientandhencetheefficiencyof theturbine. An optimal value that will resultin themaximum Cp is desired.

3.3 Turbulence:-

It is defined "instability or disturbance" as well as unpredictability of the Turbulence presents a major challenge for wind turbines as it makes the generation profile inconsistent and decreases the lifetime of turbine blades because of the mechanical stresses. According to [10], predicting turbulence is as important as predicting the general weather conditions. The random and sudden changes in wind speed and direction pose many challenges on the turbine components. These components have to be able to accommodate shortdurationofpeakloadsattimesofhighturbulence, andhavetobemechanicallystrongto resist the vibrations generated from the turbulent flow.

IV. CONCLUSION

Wind is an inexhaustible energy source available all around the world.Thepotentialonshorewindenergyisofcourse notentirelyusable,as the wind might be too slow or too fast for practical applications. We here are trying to establish and set a new benchmark in this field of renewable energy with a sustainable product that can generate electricity. Therefore, with this project idea and our calculations for the VAWT, we think we might help the future generation for the same. Based on our design data and calculations we came to as close as calculating that almost 220 Watts of power would be generated from this design.

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