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Small Scale Vertical Axis Portable Wind Turbine for Charging Electronic Gadget

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***Abstract*— With the increasing needs of human beings, energy consumption has also increased tremendously with the exploitation of mineral natural resources, leading to deficiency of energy resources in future. Wind, sun light, water are substitute of these problems. Wind is a sustainable and renewable source of energy with it's high abundance. Huge wind turbine installations are being developed in the world. The purpose of this project involves a fabrication of proto-type innovatively a small scale portable vertical axis wind turbine for charging cellular electronic gadgets. This would be light in weight with around 5 kg, would be operating at an average wind speed of 4.5 m/s and generating electric power of 12-15W. These portable turbines would bring change and evolution in wind turbine industry through bringing the general awareness regarding clean sustainable energy and increasing the overall efficiency, thus achieving the real motto of this technology.**

Keywords—*Rigging Angle, Renweable Energy, Yaw Control System, Omni-Dierction.*

I. INTRODUCTION

World is developing as well as the population of the world is also increasing. With the increasing development, energy consumption is also increasing. To meet the energy crises, new renewable and sustainable energy source technologies are being developed in the world. Wind turbine power is one of the options for this problem. Vertical axis wind turbines are being developed in the world. Vertical axis turbines are more preferable than horizontal axis due to its feature of being Omni-direction (accepting wind from all directions). Moreover it excludes yaw control system as compared to horizontal axis wind turbine. So focusing on this principle small scale portable wind energy turbine is being developed. It would be liable to be carried from one place to another. It would be light in weight with the material of high load bearing capacity viable to work under required conditions .This would increase the ease and efficiency of the user. Vertical axis darrieus wind turbine is discussed here. It consists of a rotor blades arranged in the symmetrical manner having zero rigging angle. Here the arrangement is omni-drection that is it can accept wind from all directions. It does not require yaw control system. When darrieus wind turbine is spinning, rotor blades move forward in a circular path creating positive angle of attack . Thus force created due to wind flow acts on the line of action. This force is projected inwards past the turbine axis giving the positive torque to the shaft, thus helping it to rotate. As the rotor blade move around the back of apparatus, the angle of attack changes to opposite direction but generated force is still obliquely in the direction of rotation because rotor blades are symmetric and rigging angle is zero. The rotor spins at the rate unrelated to wind speed. The energy arises from torque and speed, extracted and converted into useful power by using electric generator. Moreover the concept of lift and drag force is avoided due to symmetric arrangement and zero rigging angle.

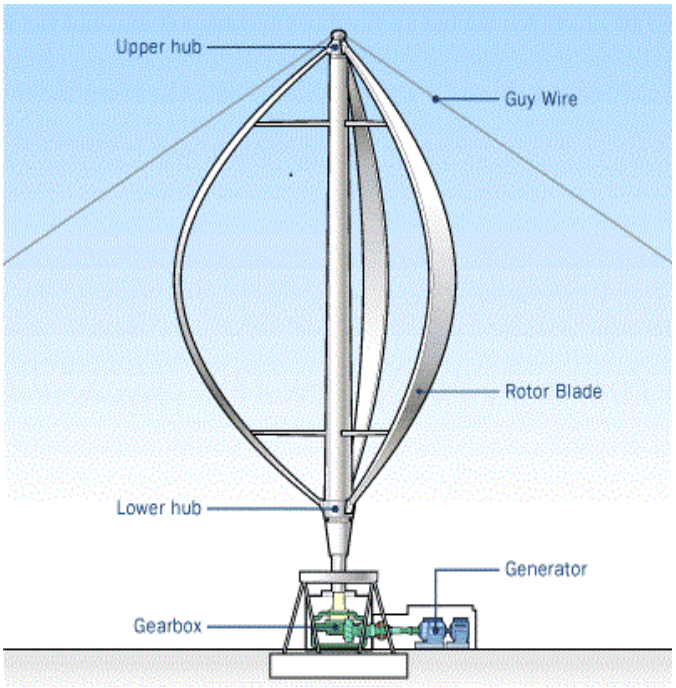

Fig 1. Darrieus wind turbine.

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Rigging angle

It is the angle in which the rotor blades are set relative to the adjoining structure.

Yaw control system
It is a system used in horizontal axis wind turbine to adjust the direction of wind turbine blades in the direction upcoming wind. Vertical axis wind turbine offers the greater advantage in safety and operation when it comes to their application with the urban environment due to no requirement of yaw control mechanism [1].

Rotor Blades
Rotor blades are robust in construction, connected from tip to bottom in adjoining assembly. These rotor blades are symmetric in shape. Due to symmetricl nature oncoming air flow is added vectorily with direction of rotation of blades so that resultant air flow can create positive angle of attack to the blades.

Electric generator
It obtains the mechanical work from rotation of rotor blades due to wind speed. This torque and speed extracted is converted into useful electric power.

II. MATERIALS USED IN VERTICAL AXIS WIND TURBINE

Wind turbine rotor captures the wind and develops the required force for the generation of power. The materials mostly used in wind turbine components are steel, aluminium, copper, glass reinforced plastic, wood epoxy, pre-stressed concrete, carbon filament plastic. A rotor blade is mostly made up of wood but becomes fragile and weak due to its sensitivity to moisture. Modern materials such as PP Plastic, carbon fibre, PVC are replacing the traditional wooden units. Moreover steel with the alloy of iron and carbon are also used. Nickel alloy has good corrosion resistance and oxidation resistance with high fatigue strength and high specific gravity [2].

Moreover aluminium is also used which is ductile and good heat conductor. Aluminium possesses light-weight property but is weaker and less stiff than steel. Polyester resin possesses better water resistance ability hence it can be used for small scale wind turbine blades however is strongly competed by other resins for larger wind turbine blades. PMC (polymer matrix composite) is also used which is composed of matrix and fibre to improve the mechanical properties. Carbon fibres are also used because of its high stiffness, high strength, light weight and low density [3].

III. HIGH SUITABILITY OF POLYPROPYLENE MATERIAL

PP Plastic has high chemical and corrosion resistance, light weight and rigid, high tensile strength, excellent abrasion resistance, low moisture absorption ,easy to machine and cut, easy to maintain and clean, excellent thermal insulation properties, excellent dielectric properties, flame retardant, long life span. Hence due to all these excellent properties it would be most suitable material for small scale vertical axis portable wind turbines.

IV. SMALL SCALE VERTICAL AXIS PORTABLE WIND TURBINE

A. *Performance Parameters*

Rotor power efficiency can be calculated by

$$\eta = \frac{P_t}{P_w} \quad (1)$$

Power available in the wind

$$P_w = 0.5\rho A v^3 \quad (2)$$

Power of a wind turbine

$$P_t = 0.5\rho A v^3 \eta \quad (3)$$

The tsr (λ) is the ratio of the wind at the tip of the blade to the wind speed

$$\lambda = \frac{\omega * R}{v} \quad (4)$$

The mechanical power of the turbine due to rotation with the wind power that captured by the turbine is given by

$$P_m = 0.5 * I_s * \omega \text{^} 3 \quad (5)$$

The torque produced by the turbine is then determined from the power and the rotational speed

$$T = \frac{P}{\omega} \quad (6)$$

Where

η = Rotor power efficiency
Pt = The turbine rotor power
Pw = Power in the wind
ρ = The air density [kg/ kgm$^{3]}$
A = Swept Area [m$^{2]}$
v = Air Velocity [m/s]
ω = Wind turbine rotational speed

T = Torque produced by the turbine
P_m = Mechanical Power of the turbine due to rotation
I_s = Moment of inertia of the shaft due to rotation

B. Blades

Blades are made up of hollow corrugated polypropylene sheet and riveted with help of aluminium foil. Further the curve shape is given to the blades with corrugated finishing to capture maximum required wind so as to develop required force to generate the torque being transmitted to the shaft of the assembly. Normally while giving curve shape there is possibility to develop crack or fatigue in centre portion of the blade. Hence to avoid these upcoming circumstances aluminium foils are attached at the back portion of the blades. With the given modification, resistance of these blades improves against the strong and uncertain high velocity wind flow.

C. Shaft

Mostly iron steel and its alloys containing nickel, copper etc. are used as material for the design and fabrication of the material. These prove to be heavy and robust constriction for the required shaft. But with the light weight of the portable wind turbine, huge inertia forces would be required to rotate this heavy material shaft. So to avoid these circumstances light weight material with high rigidity is preferred for the shaft material. Moreover these shaft materials should possess high abrasion resistance, less wear and tear, corrosion resistance, chemically stable. So to achieve these parameters for small scale vertical axis portable wind turbines, most preferable material would be hollow aluminium pipe. Aluminium can be easily fabricated and modified to achieve the required assembly.

D. Coupling

Here coupling is provided in the wind turbine assembly between the rotating shaft and the alternator. The extracted torque and speed from rotating shaft is transmitted to the shaft of alternator via coupling mechanism. Coupling reduces the probability of friction, wear and tear, abrasion between the adjoining parts that are the hollow shaft and the alternator. Thus it replaces traditional and conventional method of transmitting the motion between the assembly.

E. Alternator

Huge capacity alternators along with the generator and storage batteries are used in high purpose commercial turbines. Here with the small size of portable wind turbine alternator size and capacity has also decreased. Alternator receives the torque and speed extracted by the rotation of hollow shaft via coupling in the form of mechanical energy. With the received mechanical motion the shaft of alternator rotates. Electromagnetic flux is generated with the rotation of the shaft and further induces electromotive force leading to generation of required electric power.

F. Hand Crank

Crank is attached to the wind turbine assembly as external member for the rotation of the turbine blade. Sometimes there might be the possibility of the absence of wind. So the required pressure for the rotation of turbine is not developed due lack of wind. Under these circumstances the required power output could not be obtained. So to overcome this problem physical motion could be given to crank manually leading to rotation of turbine blades and to use the obtained power under required conditions.

G. Tripod

There might be low intensity of air at ground level or lower altitude so the required force for rotation of turbine blades is not developed. Intensity of wind increases with the increase in an altitude, So some height need to be provided to the assembly to develop the required force. So tripod in the form of stand to provide the required height is provided.

H. Battery

A rechargeable lead-acid battery for the storage of the electric energy produced from the alternator is provided.

I. Bearing

Bearing is an important component for transmission of torque in turbine assembly. Bearing plays an important role for the rotor to take self-starting action. Hence bearing improves the friction reducing capacity and overall efficiency of the turbine.

J. USB plug

USB plug for output to charge the electronic gadgets is provided in assembly .

V. RESULT

From the required analysis and fabrication of the small scale portable wind turbine assembly, most preferable and suitable material from the design consideration point of view satisfying all the optimum conditions and requirement is found to be corrugated polypropylene sheet materials.

Moreover considering the average wind speed of 4.5m/s, the optimum power would be obtained.

Table 1 Thermo composite properties

Material / parameter	PP Plastic	Polyester resin	Al sheet	Carbon fiber	PVC
Specific gravity (g/cm^2)	0.9	1.28	**2.7**	1.7-1.8	1.34
Strength (psi)	4500-6000	12000-25000	28000-48000	820000	1000-2700
Cost (Rs)	1000-1500	2000-3000	7000-8000	18000-20000	600-1000

CONCLUSION

The goal of the project is accomplished by developing a prototype that is small scale vertical axis portable wind turbine to work under low intensity of air under various condition, eliminating yaw control system being omni-direction in nature.

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