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Fabrication of Multirotor Windmill

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***Abstract:** Finding techniques to meet the growing power demand is the greatest challenge for industrialists, engineers and entrepreneurs of the country. Wind energy is emerging as one of the various renewable energy sources, which contributes to the appreciable energy demand in the world. This paper focuses on the fabrication of multirotor windmill, which has two sets of turbine blades, out of which, one set of blades rotates in the clockwise direction and the other set in the anticlockwise direction. Conventional method is used for the design of blades. The floor space required for both the windmills are same. The two sets of blades are coupled by a Bevel gear mechanism which in turn, produces a uniform torque. When compared to the normal windmill, the proposed windmill has higher efficiency due to the presence of second set of blades.*

***Keywords** : Bevel gear mechanism, Wind turbine, Multirotor, Two sets of blades, Wind speed*

I. INTRODUCTION

Nearly 1.5% of energy from the Sun that reaches the earth is converted into wind energy. Wind energy, being a renewable energy resource can solve energy crisis and environmental pollution problems. Earlier, the wind power was utilized by the human beings to sail boats, pump water, crush grains etc. Today, it is used in large scale wind farms and small standalone systems producing electricity either as horizontal axis wind turbine (HAWT) or vertical axis wind turbine(VAWT). HAWT has the main rotor shaft and electrical generator at the top of a tower, and they must be oriented in the direction of wind by yaw mechanism. Large wind turbines have a gearbox, which turns the slow rotation of the rotor into a faster rotation of the generator. Betz law defines the maximum power that can be extracted from the wind by a wind turbine in an open flow.

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[1] discusses about the design and analysis of a small scale HAWT highlighting the calculations of the total cost of turbine and the amount of generating electricity. [2] deals with the design and fabrication of of VAWT running at low tip-speed ratio and its simulation in computational fluid dynamics software. [3]

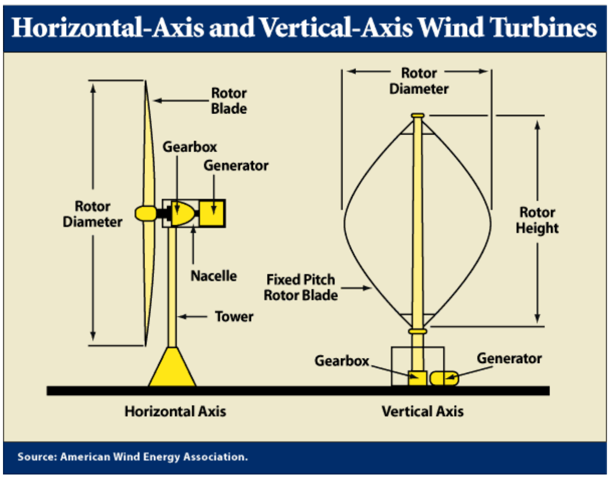

Fig. 1 HAWT and VAWT(Source: AWEA)

describes the wind turbine design of VAWT using NACA 2404 airfoil for improving its performance. Fig. 1 shows schematic diagram of HAWT and VAWT (Source: AWEA). This paper proposes a new multi rotor wind turbine having two sets of wind turbine blades, one running in clockwise direction and another in anticlockwise direction. Since it has two rotor shafts, the power generated will be more than that of conventional wind turbine having one set of turbine blades.

II. SYSTEM UNDER STUDY

Fig. 2 shows the schematic diagram of the proposed wind turbine system. In normal wind turbine, there are only one set of blades in one side of the head, but in the proposed wind turbine, there are two set of blades in each side of the head. The normal windmill rotates in clockwise direction, whereas in the modern windmill, the first set of blades rotates in clockwise direction and the other set of blades rotate in anticlockwise direction .The design of second set of blades are different from the first set. Due to the presence of wind direction indicator, the windmill head rotates in 360 degrees. The two set of blades were connected to star gear with help of shafts guided by the bearings. During the wind flow, both set of blades rotate. The power is transmitted from the star gear set-1 to the star gear set-2 through the horizontal shaft and from the star gear set-2, the power is transmitted to the flywheel which is coupled to the generator, where electrical power is produced.

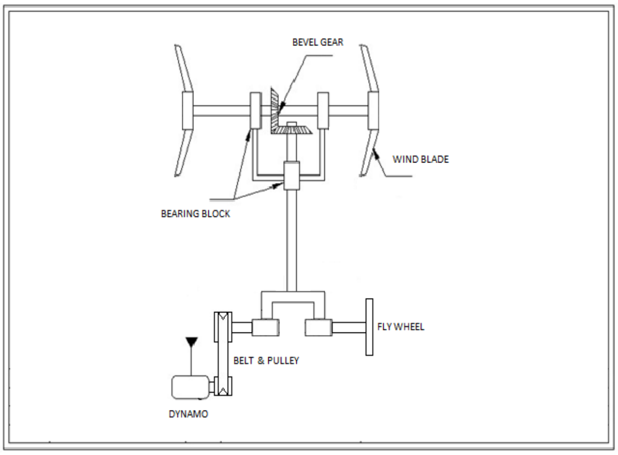

Fig. 2 Schematic diagram of the proposed turbine system

Bevel gears are the gears, where the axes of the two shafts intersect and are mounted on the shafts that are 90 degrees apart, but can be designed to work at other angles also. The pitch surface of bevel gears is a cone. By using dynamo, the direct current is produced from wind turbine. Electric dynamo makes use of rotating coils of wire and magnetic field to transform mechanical rotation into a pulsing direct electric powered current through faraday's regulation of induction and Lenz's regulation. A flywheel is a mechanical component specially designed to correctly store rotation power. As the flywheels angular speed is exaggerated, the produced energy increases and the stresses also increase. Thus, the tensile stress limits the quantity of electricity that a flywheel can keep. The shaft may be a rotating component, that transmits power from one part to another. A belt and pulley system is characterized by two pulleys in common to a belt. This enables for mechanical power, torque, and speed to be transmitted across axles. Fig.3 shows the drag and lift components of aerodynamic force acting on the wind turbine blades which converts kinetic energy of wind into mechanical energy and dynamo converts mechanical energy into electrical energy[6]. Fig. 4 shows the power curve of wind electric generator which shows the relationship of wind speed and the output power of wind electric generator.

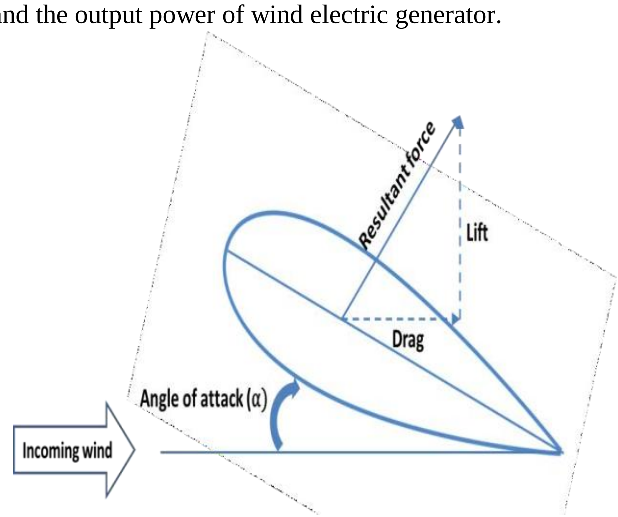

Fig. 3 Drag and Lift components of the aerodynamic force

The output power of wind electric generator is given by

$$Power = \frac{1}{2} \times \rho \times \pi \times r^2 \times C_p \times CF \times v^3 \times NG \times NB$$

P = power generated in Watts
v = velocity of the wind in m/s
ρ = density of the wind in kg/m^3
πr^2 = swept area, where r = blade length in m
C_P = Power Coefficient
C_F = Capacity Factor
N_G = generator efficiency
N_B = gearbox efficiency

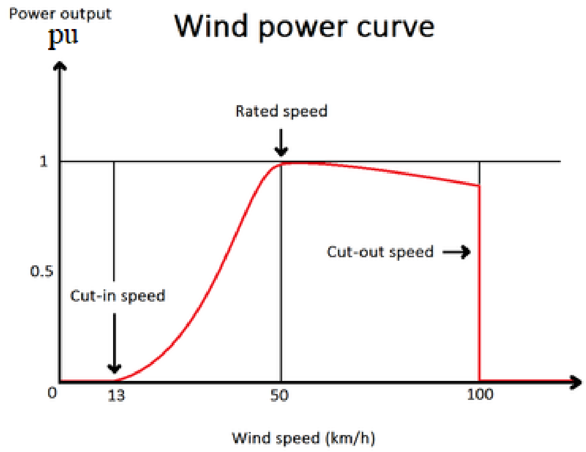

Fig. 4 Power curve of wind electric generator

III. DESIGN CALCULATIONS

Wind turbine blade design is similar to the conventional design and it is carried out for both clockwise and anticlockwise rotating set of blades[4][5]. Table I shows the dimensions of wind turbine and generator rating.

Table- I: Details of proposed wind turbine

Length of the blade	47 cm
Width of the blade	5 cm
DC Generator	12V, 30A

A. Shaft

Following stresses normally act on the shaft:
Max tensile stress = 60 N/mm^2
Max shear stress = 40 N/mm^2
Considering 25 % overload and shaft is subject to the pure torsional stress
T= 3. 14/16 x f s x d3
15250 = 3. 14/ 16 x 70x d3
D =10.20mm
FOS= 1.5
10.20*1.5=15.3mm
Diameter of the shaft=15mm(STANDARD)

B. Bevelgear

No. of teeth, T = 16
Diameter of the circle, D = 40 mm
Circular pitch, Pc =πD/T = 3.14*40/16 = 7.85mm
Diameter of the pitch, Pd=T/D =16/40 = 0.4mm
Module, m = D/T = 40/16 = 2.5

C. Ball Bearing

Radial load of roller bearing (Fr) = 700 N
Thrust load of bearing (Fa) = 300 N
Service factor (s) = 1.2
Hours in use per week = 35
Number of years = 3
Speed N = 500 rpm
Diameter of Shaft = 15 mm
Total lifetime of bearing = 35 x 3 x 52= 5460 Hours
Load factor = x = 0.56
Thrust factor = 1.4
(FROM PSGDB 4.4 AND 4.6)
P = (0.56 X 700 + 1.4 x 300) 1.2 = (812*1.2) = 974.4 N
C = 6039
Loading ratio = 10/1.8 = 5.5 ; 5.5=C/974.4
C=5.5*974.4= 5359.2 N
Dynamic Capacity in (kg F) -880 Kg F (In 8800 N)
Since C = 8800 > 5359.2 PSG DB -4.14
Chosen bearing = SKF6302

IV. HARDWARE RESULTS

Fig. 5 and Fig. 6 show the hardware of Bevel gear and Flywheel used in the proposed system. Fig. 7 and Fig. 8 show respectively DC generator and belt- pulley arrangement of the system. Fig. 9 shows the whole setup of wind turbine system under stationary and running conditions. Table II shows the readings taken during the running conditions of wind turbine.

Fig. 5 Bevel gear

Fig. 6 Flywheel

Fig. 7 DC Generator

Fig. 8 Belt-pulley arrangement

Fig. 9 Proposed wind turbine system under stationary and running conditions

Table- II Readings taken during running conditions of wind turbine

S.No	Rotor Speed (rpm)	Generated Voltage (V)
1	100	2..67
2	200	4.98
3	300	5.56
4	400	6
5	500	8.12
6	800	9.45
7	1000	8.98

V. CONCLUSION

This paper proposes a modern windmill that provides flexibility in operation, smoother and noiseless operation. Here two sets of blades are used and hence the output of the proposed wind turbine system is more compared to conventional system. This can be very much economical and helpful to many industries, workshops, households, educations institutions etc.

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