

Co Axial Rotor Wind Turbine

Milind Deotale, Abhishek Chavan, Abhishek Patil, Bhavesh Patil

¹Department of Mechanical Engineering, LokmanyaTilak College of Engineering,
Mumbai University, Navi Mumbai - 400073, India.

ABSTRACT

Electricity is basic need of modern world and now a day we are facing the electricity problems. From day to day life devices to industrial instruments we require electricity time to time. To fight energy crisis up to some extent wind turbines perform an important role. So it will be beneficial if we are able to generate more amount of energy by modifying conventional wind turbines.

This is the basic need of developing coaxial rotor wind turbine

I. INTRODUCTION

The energy demands are increasing day by day in almost all regions of world. Conventional energy sources are declining. As a solution for fulfilling demands we should use non-conventional sources to generate energy.

Wind turbine is better option to generate energy from natural wind currents with reasonable investment. For further modification in wind turbines it was the thought that if we are able to combine coaxial assembly with wind turbines to increase rate of power generation significantly. This combines various advantages. The aim of this project is to introduce coaxial assembly in wind turbines to increase efficiency and rate of power generation.

This paper shows the generation of electricity by wind turbine but by some modification. In this wind turbine we are using two sets of blades instead of one set as it is used in conventional wind turbines. This concept is actually taken from helicopter which has two sets of blades. This helicopter is driven by two engine and two sets of blades rotates in opposite direction to give more upward thrust to raise the helicopter. We took this concept in our wind turbine inversely. In this wind turbine due

to air velocity two sets of turbine blades rotates in opposite direction and this two blade sets are connected to two different generators thus producing more electricity from same amount of air flow.

The first section deals with the literature survey. Second section explains the construction of the system. The third gives the idea about the working of co axial wind turbine and the fifth section shows the calculations. The last section is the conclusion which explains the practical application of the system and the amount of electricity generated.

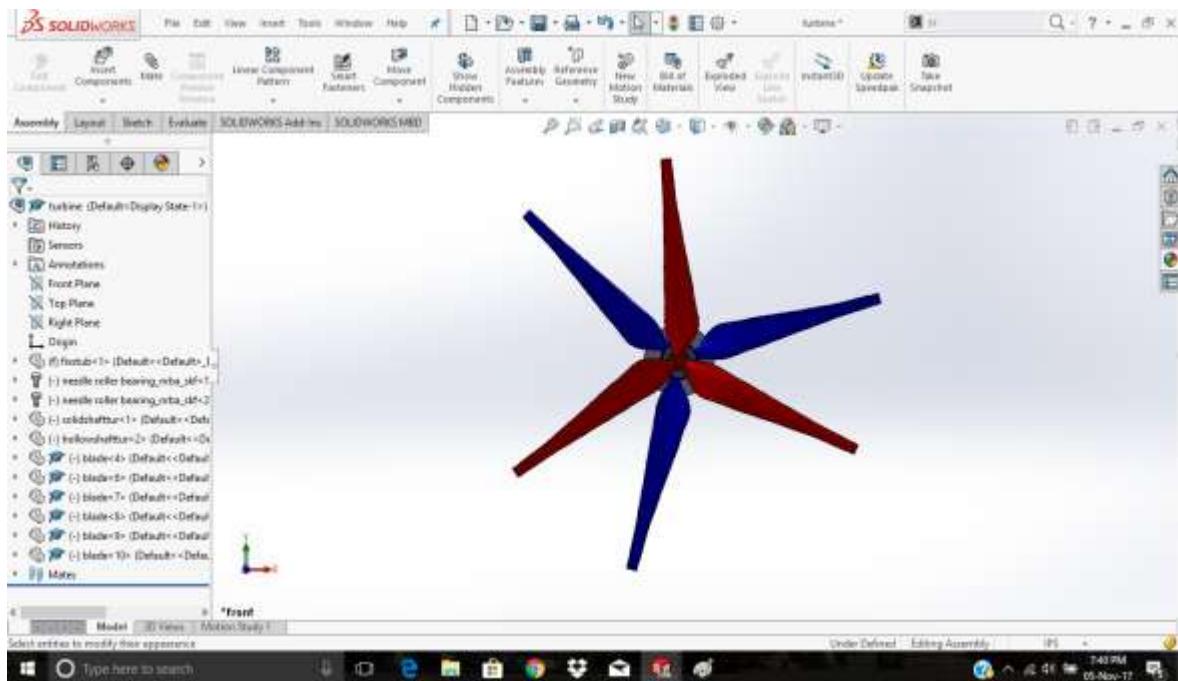
II. LITERATURE REVIEW

In 1859, the British Patent Office awarded the first helicopter patent to Henry Bright for his coaxial design. From this point, coaxial helicopters developed into fully operational machines as we know them today. The idea of coaxial rotor assembly is itself firstly initiated as a modification of helicopters. Till date it has sole application in helicopters only.

The first windmill used for the production of electricity was built in Scotland in July 1887 by Prof James Blyth of Anderson's College, Glasgow (the precursor of Strathclyde University).

III. DESCRIPTION

In the model, a pair of rotors, one mounted on the external hollow shaft & another on the inner solid shaft. A considerably small clearance is to be maintained within the space of the two shafts running parallel to each other. On the shafts, the hub made of plastic (for model purpose only) with the rotor blades on it, is to be mounted. The angle of attack of wind with respect to the blade of rotor at inside is exactly opposite to the angle of attack of the blade at outside. In other words we can say that, the airfoil



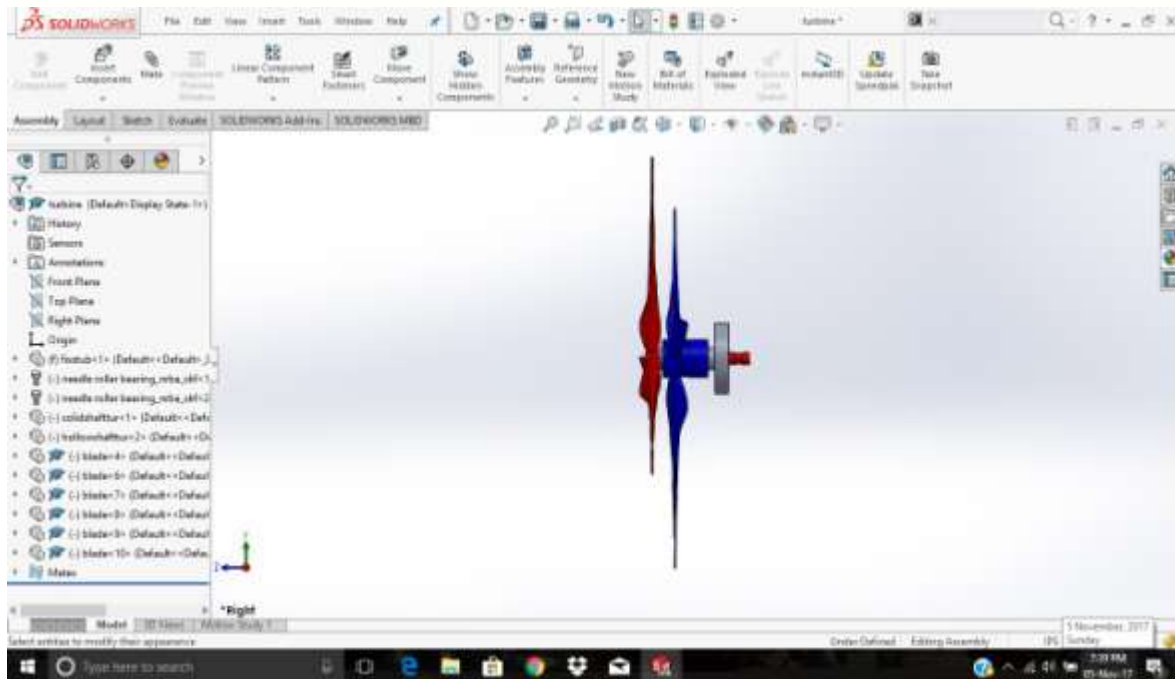


Fig. front and side view of co-axial rotor

shapes of the two blades will be vertically mirrored. The outside rotor is to be mounted on the solid shaft & the inside rotor is to be mounted on the outer hollow shaft.

The torque generated by kinetic energy of the wind on the turbine blades is transmitted to the gears through the shafts. For gearing assembly of the turbine power generation unit can be done in two ways either by coupling the each shaft to the separate generator or firstly combining the two shafts together & then coupling that single shaft with the single generator only. In the first option, the investment cost may increase due to employment of the two generators of same capacity in the single unit, but surely the losses occurring during transmission will be reduced in this option. For another option, to combine the two shafts together, a pair of bevel gears is used, but this assembly increases the mechanical parts in the power generation unit which may decrease the net power generation due to losses occurring in the bevel gears. In case of pair of bevel gears, the torque generated by rotor is also utilized to rotate the pair of bevel gears, this reduces the torque available for generator.

IV. WORKING

The wind conditions are not same as that of far away from turbine. The actual drag & lift produced on the turbine blades depends upon the relative velocity of the wind striking the turbine. The drag force tends the blades to bend in edgewise direction. The actual lift force is the force which produces the rotational torque in the rotor. The laminar flow of the wind over the aerofoil reduces the drag & increases the lift which is actually responsible for the maximum efficiency of the wind turbine. The coaxial rotor assembly will

perform the same role but it will extract the maximum of kinetic energy from the wind flow.

The torque is transmitted to the gearing system & then to the generator shaft by twisting of the shaft. The gear connected to the solid shaft is further connected to the pinion which increases revolutions of the shaft of the rotor through the reducing gear train. The increased rpm of the generator shaft tends to the generation of more and more power. Similarly the gears connected to the hollow shaft power the second generator & hence the more amount of power is generated using the same kinetic energy of the wind.

In actual, it helps to extract more & more power contained in the wind flow even at the small linear velocities.

Generators in the turbine are the simple alternators which convert the rotational energy to the electrical energy. The alternators simply work on the principle of Faraday's Law of Electromagnetic Induction. The energy generated can be stored in the batteries using inverter circuits or can be attached directly to the electrical circuit.

V. CALCULATIONS

The power that can be generated per rotor is assumed to be 0.5 Watt per rotor. Then the total power creation becomes 1 Watt from the whole system.

According to relation for power generated by a single rotor is,

$$P = \frac{1}{2} \times \rho \times \epsilon \times A \times v^2$$

Where, P = power generated

ϵ = efficiency of the blades

ρ = density of wind = 1 kg/m^3

A = blade area exposed to wind

v = speed of wind

now, as the above formula is applicable for the single rotor wind turbines,

$$1 = \frac{1}{2} \times 1 \times 0.5 \times A \times (9^2)$$

$$A = \frac{1}{20.25} = 0.0493 \text{ m}^2$$

By implying the rotors in the place of one single big rotor to generate the same power, the total area required per rotor becomes,

$$a = \frac{\text{total area required}}{\text{no. of rotors}} = \frac{0.0493}{2} = 0.0246 \text{ m}^2$$

Hence the diameters of rotors are,

$$a = \frac{\pi}{4} \times d^2$$

$$0.0246 = \frac{\pi}{4} \times d^2$$

$$d^2 = 0.0314 \rightarrow d = 0.177 \text{ m.}$$

Hence, required diameter of blade is 177 mm.

As according to convention, the maximum rpm that can be achieved by a wind turbine are taken as 10 rpm,

Hence the torque required to rotate the blades is,

$$P = \frac{2\pi \times N \times T}{60}$$

$$\therefore 1 = \frac{2\pi \times 10 \times T}{60}$$

$$\therefore T = 0.9549 \text{ N} - \text{m.} = 954.929 \text{ N} - \text{mm.}$$

this total torque is to be generated with the two rotors hence, torque generated by one rotor,

$$T_1 = \frac{\text{total torque}}{\text{no. of rotors}} = \frac{954.929}{2} = 477.464 \text{ N} - \text{mm.}$$

Now, the design of shaft to transmit the torque,

$$T_1 = \frac{\pi}{16} \times d^3 \times \tau$$

Assuming the safe stress for steel shaft as 42 MPa.,

$$\therefore 477.464 = \frac{\pi}{16} \times d^3 \times 42$$

$$\therefore d = 3.86 \text{ mm.}$$

Considering safety and available standard, the diameter of shaft is taken as,

$$d = 6 \text{ mm.}$$

Providing a bush of 1 mm. thickness, hence outer diameter of bush becomes,

$$d_1 = d + 1 + 1 \text{ mm.}$$

$$\therefore d_1 = 8 \text{ mm.}$$

As the hollow shaft is to be fitted over the bush, hence the inner diameter of shaft becomes,

$$d_i = d_1$$

$$\therefore d_i = 8 \text{ mm.}$$

The thickness of shaft available is 0.5 mm, hence the outer diameter becomes,

$$d_o = d_i + 0.5 + 0.5 \text{ mm.}$$

$$\therefore d_o = 9 \text{ mm.}$$

The design of gears to transmit power from shafts to the generators,

The available suitable sizes to transmit power are,

For spur gear, $PCD = 62 \text{ mm.}; d_o = 65 \text{ mm.}; d_i = 60 \text{ mm.}$

$$\text{no. of tooth} = 60$$

The tooth thickness becomes,

$$t = \frac{\pi \times D}{60} = \frac{\pi \times 62}{60} = 3.25 \text{ mm.}$$

force applied on the gear teeth,

$$\begin{aligned} T &= \text{force} \times \text{radius} = F \times r \\ 954.929 &= F \times 31 \\ \therefore F &= 30.80 \text{ N} \end{aligned}$$

Considering shearing failure of the tooth,

$$\begin{aligned} F &= \text{gear thickness} \times \text{tooth thickness} \times \tau \\ \therefore 30.80 &= 6 \times 3.25 \times \tau \\ \therefore \tau &= 1.579 \text{ MPa.} \end{aligned}$$

Considering crushing stresses,

$$\begin{aligned} F &= \frac{d_o - d_i}{2} \times \text{gear thickness} \times \sigma_c \\ \therefore 30.8 &= \left[\frac{65 - 60}{2} \right] \times 6 \times \sigma_c \\ \therefore \sigma_c &= 2.053 \text{ MPa.} \end{aligned}$$

For pinion gear, $PCD = 23 \text{ mm.}; d_o = 27 \text{ mm.}; d_i = 22 \text{ mm.}$

$$\text{no. of tooth on gear} = 24$$

Tooth thickness becomes,

$$t = \frac{\pi \times D}{60} = \frac{\pi \times 23}{24} = 3.01 \text{ mm.}$$

force applied on the gear teeth,

$$\begin{aligned} T &= \text{force} \times \text{radius} = F \times r \\ 954.929 &= F \times 11.5 \\ \therefore F &= 83.04 \text{ N} \end{aligned}$$

Considering shearing failure of the tooth,

$$\begin{aligned} F &= \text{gear thickness} \times \text{tooth thickness} \times \tau \\ \therefore 83.04 &= 6 \times 3.01 \times \tau \\ \therefore \tau &= 4.617 \text{ MPa.} \end{aligned}$$

Considering crushing stresses,

$$\begin{aligned} F &= \frac{d_o - d_i}{2} \times \text{gear thickness} \times \sigma_c \\ \therefore 30.8 &= \left[\frac{27 - 22}{2} \right] \times 6 \times \sigma_c \\ \therefore \sigma_c &= 5.536 \text{ MPa.} \end{aligned}$$

gearing ratio,

$$\frac{N_1}{N_2} = \frac{n_1}{n_2}$$
$$\frac{N_1}{N_2} = \frac{60}{24} = 2.5$$

The gearing ratio is 2.5 : 1

VI. FUTURE SCOPE

Coaxial rotor wind turbine can find the application in the field of power generation in future as it is totally pollution free method of power generation at increased rate. The advantages of system may not be seen right after installation of system due to increased complexity of mechanism and due to more promptness towards maintenance, but as a system generates more energy than conventional wind turbine, installation cost incurred on system may be procured in the form of electricity.

VII. CONCLUSION

The efficiency of overall system is maximum at higher speeds with 60% but goes on reducing drastically to 28 to 30% at lower wind speeds. But at optimum speeds the average efficiency is 45%. This percentage is appreciable. Thus, the project concludes that the additional power generation with the help of more than one rotor in single assembly i.e. COAXIAL ROTOR WIND TURBINE is practically possible.

REFERENCES:

A reference list must be included using the following information as a guide. Only cited text references are included. Each reference is referred to in the text by a number enclosed in square bracket. References must be numbered and ordered according to where they are first mentioned in paper, not alphabetically.

Examples follow:

Journal papers:

[1] James P. Cycon, Fred W. Kohlhepp, Vincent F. Millea, 1994, "COAXIAL TRANSMISSION/CENTER HUB SUBASSEMBLY FOR A ROTOR ASSEMBLY HAVING DUC'ED, COAXIAL COUNTER-ROTATING ROTORS", Patent Number: 5,351,913.

[2] Putman P. C., 1941, "Wind Turbine", Patent Number: 2,360,791

Books:

[3] T. Gerhard, T. H. Carolus, 2010, "SMALL HORIZONTAL AXIS WIND TURBINE: ANALYTICAL BLADE DESIGN AND COMPARISON WITH RANS PREDICTED FLOW FIELD AND PERFORMANCE DATA", University of Siegen, Institute for Fluid- und Thermodynamic

- [4] Counter rotating wind turbine development Oprina G., Chihaia R. A., EL-Iethey L.A., Nicholia S., Babutanu C.A., Voina A.
- [5] A Novel Dual-Rotor Turbine for Increased Wind Energy Capture A Rosenberg, S Selvaraj, and A Sharm
- [6] Debleser, Y., Jeumont Industries, Wind turbine with counter rotating rotors, US Patent No. 6504260, 2003.
- [7] Jung, S.N., No, T.-S., Ryu, K.-W., Aerodynamic performance prediction of a 30 kW counter-rotating wind turbine system, in Renewable Energy 30, 2005, pg. 631– 644.