

**INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES
& MANAGEMENT****AN EXPERIMENTAL ANALYSIS OF HORIZONTAL WIND TURBINE****Tushar Mittal¹, Nitesh Rane²**¹M.tech Research Scholar, ²Asst. Prof.^{1,2} Department of Mechanical Engineering, Dr. APJ Abdul Kalam University, Indore (M.P.)**ABSTRACT**

In the present global scenario, pollution has become the issue of prime concern. International community is holding meeting, after meeting to control the pollution and save the environment from pollution. The main factors which are responsible for the pollution are conventional method of power production by burning coal and other fossil fuels which emits an enormous amount of CO₂ gas and pollutes the environment. In the present work the power production by wind turbine has been emphasized and research has been carried out on design of rotor blade of wind turbine to have maximum mechanical power output and absolutely pollution free power produce. In this work the rotor blade of the wind turbine aerofoil section NACA 5510 has been roughened to have maximum drag at the lower face and to offer more and more lift on the rotor blade. Also to increase the blade area, a flap has been added at the end of blade trailing edge so that braking torque can be achieved at the lower wind speed. After taking the experiment in all cases it has concluded that power of the wind turbine has increased by 10% when rough surface blade are used and 21% when flap at trailing edge are used while compared to the wind turbine using smooth surface blade.

INTRODUCTION

Wind power comes with the sun and sun heats the ground which air around of ground warms up and rises. The hot air rises heavier or cool air rushes in to fill its place. The rush of air is wind which made of gas particles. Wind turbine absorbs kinetic energy or turning it into electricity. Wind power (P_w) is written the equation where ρ is the density of air or A is the area covered by the wind turbine blades and v is the wind speed.

$$P_w = \frac{1}{2} \rho A v^3$$

One of the most important parameter of wind turbines is wing because wind comes and strikes to the wings then energy of wind is transformed into the mechanical energy by wings. Wings profiles are known as Airfoils. Airfoil profile is the most important parameter for wing design because wing efficiency increases depend on Airfoil profile. The studies over the Airfoil profile as numerical and experimental in the literature [2]. The power produced by wind turbine can be find by multiplying the power available in wind by power coefficient, the power available in wind depends on air density, rotor swept area or cubic free stream wind velocity, thus the turbine power can be written as:[4].

$$P_w = \frac{1}{2} \rho A v^3$$

The subjects of this study is to develop a method using BEM theory for different airfoil profiles performance and aerodynamic design of the HAWT blades, also to build a computer program, finally to determine the aerodynamic characteristics and to create the performance. Wind turbine blade is divided into number of sections along the blade.

The demand for power is increasing day by day in the world .we are depend upon the traditional resources for power production but we know that our traditional recourses are something which are getting short day by day. Wind power is a renewable energy source which easily reduces the world's dependence on oil and natural gas, while not polluting the environment. Although there are many things that affect the efficiency of a wind turbine. Coming decade would be the glorious for the wind power industries. The cost of power production is increasing fastly day by day and it is going beyond the common people reach. While the power production by wind mill technology is very cheap or easy and pollution free too[5].

The advantage of this technology is electricity can be produced at any scale. Any individual can produce power for their own use. In this position wind power can be a very suitable replacement for power production. Particularly in rural area the domestic turbine or micro turbine can play an important role as it is cheaper than the other sources of power production which is pollution free and low maintenance require. The micro wind turbine

can produce low power even at low wind speed. Since minimum requirement of power or lighting can be achieved by this wind turbine[6].

Wind turbine is a device which converts kinetic energy from air into mechanical energy. Since mechanical energy convert into electrical energy. This energy conversion is the result of several phenomena. The wind is characterized by its speed and direction, which are affected by several factors, e.g., geographic location, climate characteristics, height above ground, and surface topography[2].

The subject of our project is to develop a wind turbine with drag increasing device on the lower face of the blade with arrangement to work at low air speed and produce power for domestic use.

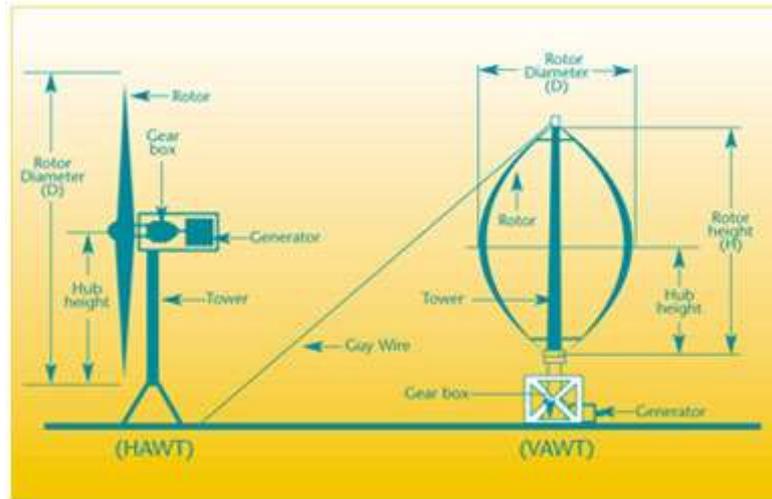


Fig. 1 Horizontal & Vertical axis Wind Turbine

EXPERIMENTATION AND OBSERVATION

a typical modal of wind turbine is made and experiment was performed on the modal at the different tower height and the different wind speed and obtaining the RPM of the wind is registered for further analysis. Also analysis effect of RPM in term of efficiency. The major component of the model are discussed below.



Fig. 2 Assembled HAWT

| | |
|----|---------------|
| 1. | DC Generator |
| 2. | Support Block |
| 3. | Flap |
| 4. | Rotor shaft |
| 5. | Rotor Blade |

Table1 Description of parts

Dc Generator of experimental setup

A 12 Volt DC generator has with modal no. UPH566H-A-A5 and its 2.26 ohms resistance and 1.4 ampere. It is coupled to the rotor shaft of the wind turbine and it observes the voltage developed by the wind turbine at different wind speed.



Fig. 3 Dc Generator

Support Block of experimental setup

The whole rotor assemblies are Supported by PVC Tee block and encloses two ball bearing. Two circlps are provided at the end the Tee block in their grooves to stop bearing from coming out the hub.



Fig.4 Support Block

Flap of experimental setup

Flaps are joint at trailing edge of the rotor blade. Its length is 6.2 cm and width is 0.6cm. This increase surface area of the blade.



Fig.5 Flap at Trailing Edge.

Rotor Shaft of model

Rotor shaft is made by stainless steel material and its diameter is 1.5 cm, length is 20 cm. Two hole mounting provided in Two rotor blades into the rotor shaft by the rivet. Mounting are welded on the rotor shaft. Rotor shaft is internally threaded to take the DC generator. Wind stream rotated the rotor blade; rotor shaft transmits drive to the generator shaft.



Fig.6 Rotor shaft

Rotor Blades

Rotor blades are made of light aluminum alloy. This blade are painted with anticorrosive paint to avoid the corrosion to due moisture other corrosion prone elements.



Fig. 7 Rotor Blades with roughened surface on the lower face

| | |
|--------------------|--------------------------|
| Length of blade | 0.5 m Each |
| Chord length | 5.5 cm |
| Blade twisting | 13 Degree |
| Twist angle | 12 Degree |
| Blade thickness | 0.6 cm |
| Camber area | 2.8 cm |
| Camber position | 2.7 cm from Leading Edge |
| Blade nomenclature | NACA 5510 |

Table 2 Specification of the Blade

CALCULATION FOR POWER

According to the Betz Limit theory in the form of kinetic energy,

Theoretical power of wind turbine is,

$$\text{Power}_{\text{air}} = \frac{1}{2} \rho A v_i^3$$

$$\text{Actual power, Power}_{\text{actual}} = \frac{1}{2} \rho A v_a (v_i^2 - v_e^2)$$

Where, ρ = Density of the air = 1.2 kg/m³

v_i = Inlet velocity at the blade in m/s

v_e = Exit velocity at the blade in m/s

A = Swept area of rotor blade in m²

$V_a = (v_i + v_e)/2$ = Average Velocity in m/s

Coefficient of Power, $c_p = \text{Actual power} / \text{Theoretical power}$

Rotor factor (b) = v_e/v_i [22]

Putting the value of b in the original equation of power coefficient,

We get, $c_p = \text{Actual power} / \text{Theoretical power}$

$$c_p = \frac{1}{2} \rho A v_a (v_i^2 - v_e^2) / \frac{1}{2} \rho A v_i^3$$

$$c_p = v_a \cdot v_i^2 (1 - v_e^2/v_i^2) / v_i^3$$

$$c_p = v_a / v_i (1 - b^2)$$

$$c_p = (v_i + v_e)(1 - b^2) / 2v_i$$

$$c_p = v_i (1 + v_e/v_i)(1 - b^2) / 2v_i$$

$$c_p = (1 - b^2)(1 + b) / 2$$

$$c_p = \frac{1}{2} (1 - b^2)(1 + b) [22]$$

RESULTS AND DISCUSSION

The results are calculated on basis of observation data the result obtained are listed below in table;

Result obtained from observation for smooth blade surface (refer to article 3.6.1)

Table 3 Result for Smooth surface Blade

| S.N. | Tower Height (m) | Wind Velocity (m/s) | Exit wind velocity (m/sec) | RPM | Actual Power (w) | Efficiency (%) |
|------|------------------|---------------------|----------------------------|-----|------------------|----------------|
| 1. | 10 | 3.0 | 2.4 | 75 | 4.1203 | 32 |
| 2. | 15 | 3.5 | 2.7 | 95 | 7.242 | 35 |
| 3. | 25 | 4.2 | 3.2 | 100 | 12.89 | 36 |

Results obtained from observation for Roughened Blade (refer to article 3.6.2)

Table 4 Result for rough surface Blade

| S.N. | Tower Height (m) | Wind Velocity (m/s) | Exit wind velocity (m/sec) | RPM | Actual Power (w) | Efficiency (%) |
|------|------------------|---------------------|----------------------------|-----|------------------|----------------|
| 1. | 10 | 3.0 | 2.2 | 85 | 5.094 | 40 |
| 2. | 15 | 3.5 | 2.4 | 105 | 9.0175 | 44 |
| 3. | 25 | 4.2 | 2.8 | 115 | 16.1553 | 46 |

Results obtained from observation for Roughened Blade with Flap (refer article 3.6.3)

Table 5 Result for Roughened Blade with Flap

| S.N. | Tower Height (m) | Wind Velocity (m/s) | Exit wind velocity (m/sec) | RPM | Actual Power (w) | Efficiency (%) |
|------|------------------|---------------------|----------------------------|-----|------------------|----------------|
| 1. | 10 | 3.0 | 1.89 | 100 | 6.265 | 49 |
| 2. | 15 | 3.5 | 2.2 | 120 | 10.938 | 54 |
| 3. | 25 | 4.2 | 1.86 | 130 | 20.24 | 57 |

DISCUSSION OF RESULTS

Variation of RPM with respect to wind speed for Smooth surface Blade.

when the tower height increase from ground level to 25 m. Then wind velocity varies from 3.0 m/sec to 4.2m/sec. which RPM varies from 75 rpm to 100 rpm.

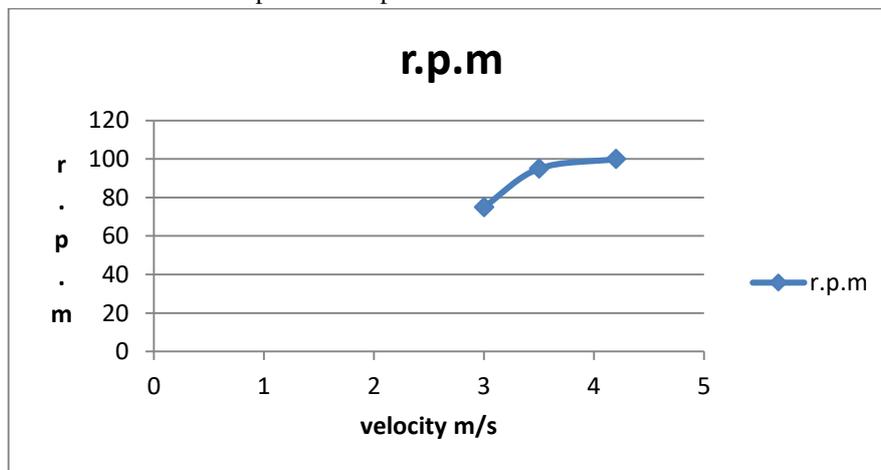


Fig. 8 Variation of RPM with Wind Speed

Variation of Actual Power with respect to wind speed for Smooth Surface Blade.

when the tower height increase from ground level to 25m. Then wind velocity varies from 3.0 m/sec to 4.2m/sec. which actual power varies from 4.1203w to 12.89w.

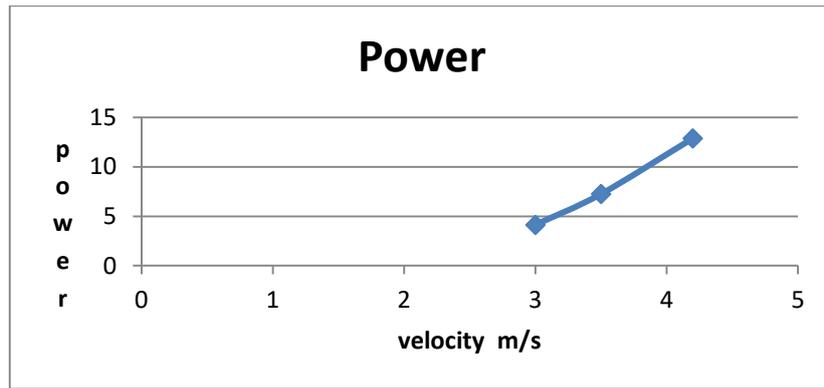


Fig 9 Variation of actual power

Variation of Efficiency with respect to wind speed for Smooth Surface Blade.

when the tower height increase from ground level to 25 m. Then wind velocity varies from 3.0 m/sec to 4.2m/sec. which efficiency varies from 32% to 36%.

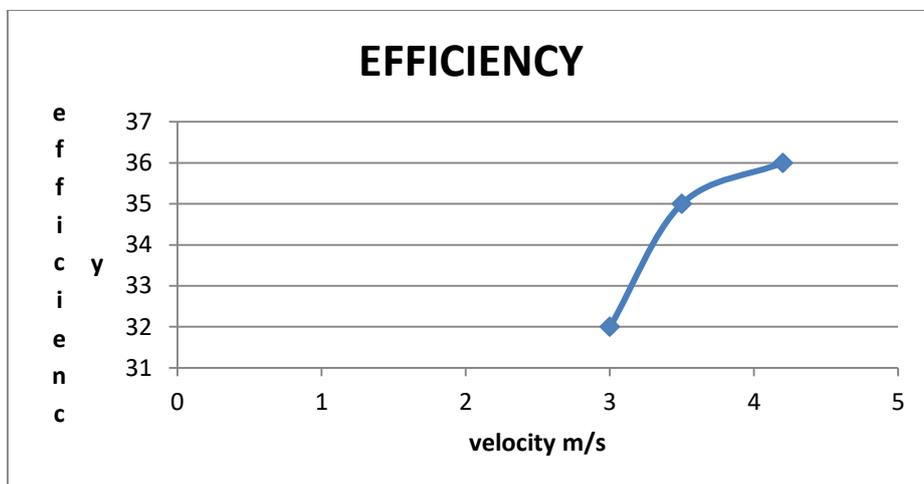


Fig. 10 Variation of Efficiency with wind speed

Variation of RPM with respect to wind speed for Roughened Blade.

when the tower height increase from ground level to 25 m. Then wind velocity varies from 3.0 m/sec to 4.2m/sec. which rpm varies from 85 rpm to 115 rpm.

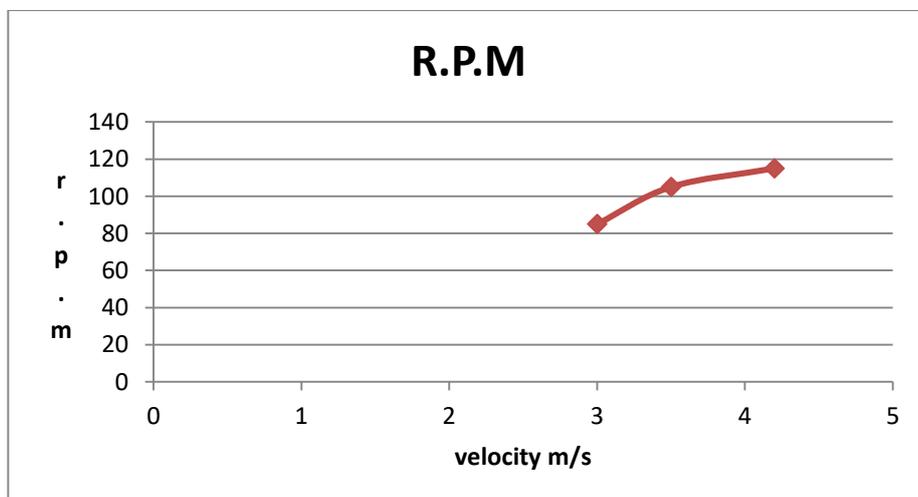


Fig.11 Variation of RPM with wind speed

CONCLUSION

On the basis of results obtained by horizontal axis wind turbine by using blade of NACA 5510 aerofoil with modified design of lift increasing techniques, following conclusion have been drawn.

The results obtained from parameters. The actual power and efficiency of wind turbine were found optimum for the case while using flap with roughened surface blade when compared to the cases of roughened surface blade and smooth surface blade.

The efficiency of the wind turbine has increased by 10% when rough surface blade are used and 21% when flap at trailing edge are used while compared to the wind turbine using smooth surface blade then It has also concluded that the efficiency of the turbine using the flap with roughened surface blade found optimum.

Case-1 Improvement of efficiency for smooth surface blade is 32% to 36%.

Case-2 Improvement of efficiency for rough surface blade is 40% to 46%.

Case-3 Improvement of efficiency for rough surface blade with flap is 49% to 57

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