ANALYSIS OF EFFICIENCY OF A HORIZONTAL AXIS WIND   TURBINE USING MODIFIED BLADE OF NACA 5510 AEROFOIL

Rakshapal Singh[1], Nitesh Rane[2]

[1]Research Scholar, CIIT Indore, M.P, India
[2]Assistant Professor CIIT Indore, M.P, India

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ABSTRACT- *In the present scenario, pollution has become the issue of prime concern. 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 CO_2 gas and pollutes the environment.*

In the current research 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. For consideration 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 conducting the experiment in all cases it was concluded that power of the wind turbine has increased by 5% when rough surface blade are used and 6% when flap at trailing edge are used while compared to the wind turbine using smooth surface blade.

KEYWORDS: Rotor Blade, Rotor Shaft, RPM, Flap, Support Block, Performance

1. INTRODUCTION

In the present years, the demanding of power increasing day by day. It is a well known that non-renewable source of energy is the best method to produce power as it is pollution free and involves less maintenance and manpower. In this situation wind power can be used to produce power. It is pollution free energy. The extraction of power as wind energy from the wind depends on creating certain forces and applying them to rotate a mechanism producing the two forces, lift and drag. The lift forces act Compression ignition engine a type of internal combustion perpendicular to the direction of the air flow while drag forces act in the direction of air flow. Lift forces are produced by the change in velocity of the air flow over either side of the lifting surface. The efficiency of wind turbine is primarily depend on the design of shape of the rotor blade rotor blade extracted the wind energy from the air to drive the shaft which is connected to a d.c.generator which creates the electrical energy Induction of the LED bulb. Design of blade of aerofoil section in basis of blade angle twist angle and angle of attack and obtained the performance of change of modification. Higher wind speed gives the higher R.P.M.of wind turbine by rotor blade. Researcher have experienced on various design of blade changes the angle of attack, blade angle and pitch angle.Roshan et al.[3] have been developed the small horizontal axis Wind turbine for experimenting in which flow straighteners are provided at leading edge of the turbine blade. These flow straighteners give the stream line flow to the air flow circulating the over Aerofoil and reduce the drag. In which blades are twisted about 12 to 13degree from root to tip. They have found the average mechanical efficiency of 39% and mechanical efficiency increases with increase in wind Speed. Kale and Verma [4] they have experimented on NACA 4412 aerofoil and developed the length of the Blade was 800 mm successfully for a horizontal axis micro wind turbine of 600 W power output through multiple.

Iterations to enhance its performance and the chord of optimized blade is reduced by 24% and thickness is reduced by 44%. They have found the efficiency of optimized blade is increased significantly up to 30% than that of normal blade. Sarkar and Behera [5] have been designed the wind turbine of 1 meter diameter with the support of software for 1kW @ 11m/s. The wind turbine blades power and efficiency has been measured at different tip-speed-ratios as well as calculated using software tool. The wind turbine blades power and efficiency has been measured at different tip-speedratios. They were recorded a maximum efficiency of 30% at a TSR of 11.6 was recorded, verified the blade calculator's accuracy. Kishore [6] in this studied he has provided the first systematic effort towards design and development of SSWTs (rotor diameter<50 cm) targeted to operate at low wind speeds (<5 m/s). An inverse design and optimization tool based on Blade Element Momentum theory is proposed. And his experiment has been carried out on a 40 cm diameter small-scale wind energy portable turbine (SWEPT) operating in very low wind speed range of 1 m/s-5 m/s with extremely high power coefficient. In comparison to the published literature,

SWEPT is one of the most efficient wind turbines at the small scale and very low wind speeds with the power coefficient of 32% and overall efficiency of 21% at its rated wind speed of 4.0 m/s. It has very low cut-in speed of 1.7 m/s among the other available wind turbines. Winds tunnel experiments revealed that SWEPT has rated power output of 1 W at 4.0 m/s it has produced very less power hence its utility is very limited

2. EXPERIMENTAL SETUP

Fig. (a) Assembled HAWT Model

3. MAIN PARTS OF WHOLE EXPERIMENTAL SETUP:

1	Rotor Shaft
2	Rotor Blade
3	.Flap
4	Support Block
5	DC Generator

SPECIFICATION OF BLADE:

Length of blade = 0.5 m Each

Twist angle = 12 Degree

Chord length = 5.5 cm

Camber area = 2.8 cm

Camber position 2.7 cm from Leading Edge

Blade thickness = 0.6 cm

Blade twisting 13 Degree

Blade nomenclature NACA 5510

4. EXPERIMENTAL METHODOLY

1. Calculation:

Theoretical power available at wind turbine in the form of Kinetic energy is,

$$\text{Power air} = \frac{1}{2}\rho AV^3 \tag{3.1}$$

$$\text{Actual power, Power air} = \frac{1}{2}\rho AV_a (V_i^2 - V_e^2) \tag{3.2}$$

Where, ρ = Density of the air = 1.2 kg/m^3

vi = Inlet velocity at the blade in m/s

ve = Exit velocity at the blade in m/s

va = (vi+ve)/2 = Average Velocity in m/s

A = Swept area of rotor blade in m^2

Coefficient of Power, cp = *Actual Power Theoretical Power*   (3.3)

Rotor factor (b) = ve/v$_i$ [8]   (3.4)

Putting the value of b in the original equation of power coefficient
We get,
$Cp = 1/2(1 - b2)(1 + b)$ [8]   (3.5)

5. CASES OF EXPERIMENTATION:

In the experiment we have taken the three cases of blade at different places and time and different velocities of Wind.

Date of Experiment	14/07/2017,23/07/2017,26/07/2017
Place of Experiment	Manpura (Bhind).

(a) Wind Turbine Rotor Blade with Smooth Surface
(b) Wind Turbine Rotor Blade with Roughened Surface Blade
(c) Wind Turbine Rotor Blade with Roughened Blade with Flap

6. RESULTS AND DISCUSSION:

A. 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

B. Result for Roughened 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

C. Results for Roughened Blade with Flap

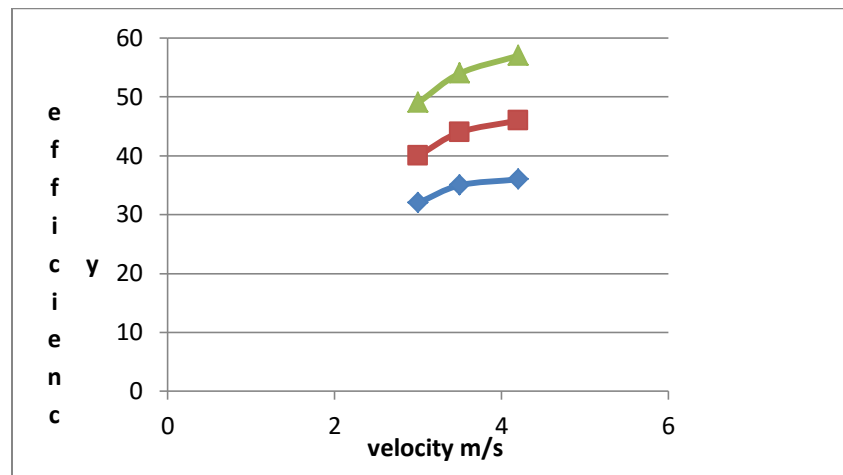| S.N.	Tower Height (m)	Wind Velocity (m/s)	Exit wind velocity (m/sec)	RPM	Actual Power (w)	Efficiency (%)
1.	10	3.0	1.89	100	6.265	49
2.	15	3.5	2.2	120	10.938	54
3.	25	4.2	1.86	130	20.24	57

1. Combined variation of RPM with respect to wind speed for all three cases:
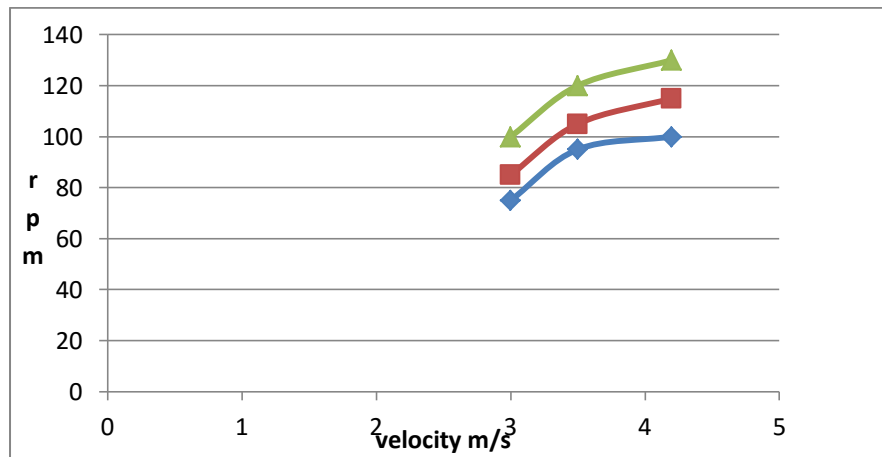
2. Combined Variation of actual power with respect to wind speed.
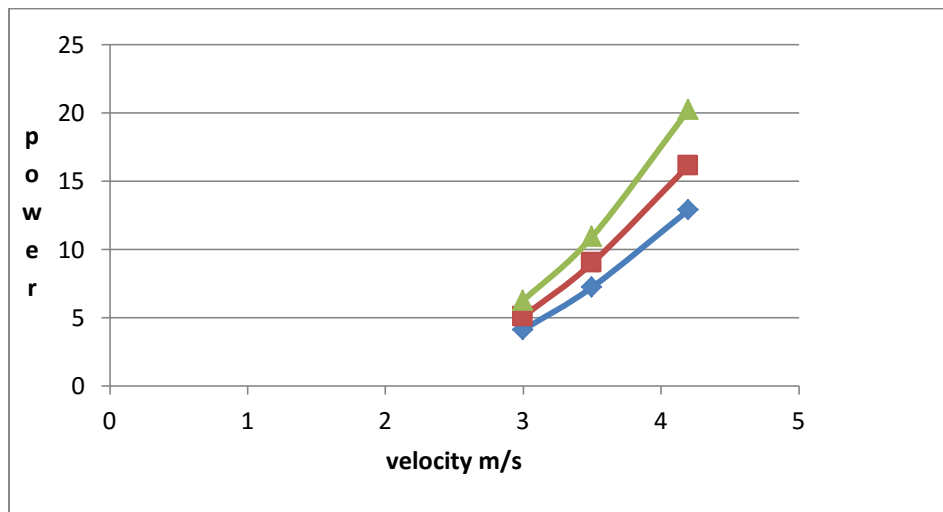
3. Combined variation of efficiency with respect to wind Speed:

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 parameters obtained from results as 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 5% when rough surface blade are used and 6% 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.

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