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Performance Improvement of Horizontal Axis Wind Turbine by Using Modified Blade of NACA 5510

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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 co_2 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 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

I. 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 create 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-speed-ratios. 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.

II. EXPERIMENTAL SETUP

Fig. (a) Assembled HAWT Model

A. MAIN PARTS OF WHOLE EXPERIMENTAL SETUP:

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

B. SPECIFICATION OF BLADE:

Length of blade	0.5 m Each
Twist angle	12 Degree
Chord length	5.5 cm

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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

III. EXPERIMENTAL METHODOLY

1. Calculation:

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

$$\text{Power}_{air} = \frac{1}{2}\rho A v_i^3 \quad (3.1)$$

Actual power, $\text{Power}_{air} = \frac{1}{2}\rho A\, v_a(v_i^2 - v_e^2)$ (3.2)

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

v_i = Inlet velocity at the blade in m/s

v_e = Exit velocity at the blade in m/s

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

A = Swept area of rotor blade in m2

Coefficient of Power, $c_p = \frac{Actual\ \ Power}{Theoretical\ \ Power}$ (3.3)

Rotor factor (b) = $\frac{v_e}{v_i}$[8] (3.4)

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

We get,

$$C_p = \frac{1}{2}\,(1 - b^2)(1 + b)[8] \quad (3.5)$$

IV. CASES OF EXPERIMENTED

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

Place of Experiment	Maharajpura Airfield, Behind Bhind complex on the hill
Date of Experiment	19/08/2015,22/08/2015,25/08/2015

(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

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V. RESULTS AND DISCUSSION:

A. Result for Smooth surface Blade

S.N.	Tower Height (m)	Wind Velocity (m/s)	Exit wind Velocity	RPM	Actual Power (W)	Efficiency (%)
1	0	2.5	2.0	70	2.384	32
2	20	3.4	2.7	90	6.134	33
3	35	4.0	3.1	98	10.68	35

B. Result for Roughened surface Blade

S.N.	Tower Height (m)	Wind Velocity (m/s)	Exit Wind Velocity	RPM	Actual Power (W)	Efficiency (%)
1	0	2.5	1.9	80	2.735	37
2	20	3.4	2.5	98	7.377	39
3	35	4.0	2.9	120	12.33	40

C. Results for Roughened Blade with Flap

S.N.	Tower Height (m)	Wind Velocity (m/s)	Exit Wind Velocity	RPM	Actual Power (W)	Efficiency (%)
1	0	2.5	1.84	104	2.94	39
2	20	3.4	2.49	114	7.43	40
3	35	4.0	2.88	130	12.48	41

D. Combined variation of RPM with respect to wind speed:

This graph shows that combined variation of RPM of wind turbine with respect to wind speed and it has cleared that RPM is Optimum for the case when flap are used with Rough surface blade.

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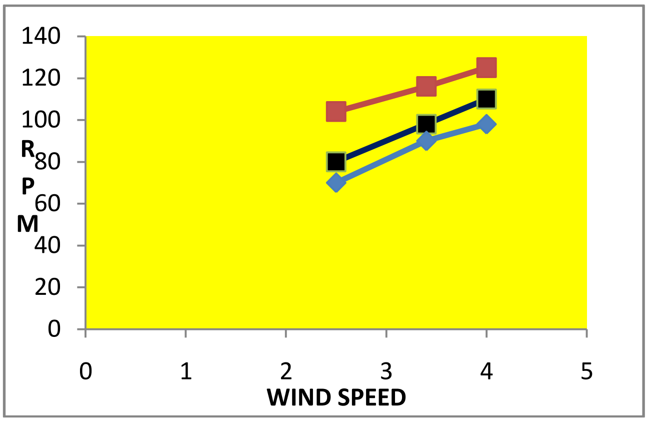

Fig. (b) Combined variation of RPM with wind speed

E.Combined Variation actual power with respect to wind speed.

This graph showed that combined variation of actual power of wind turbine with respect to wind speed and it has cleared that actual is optimum for the case when flap are used with rough surface blade.

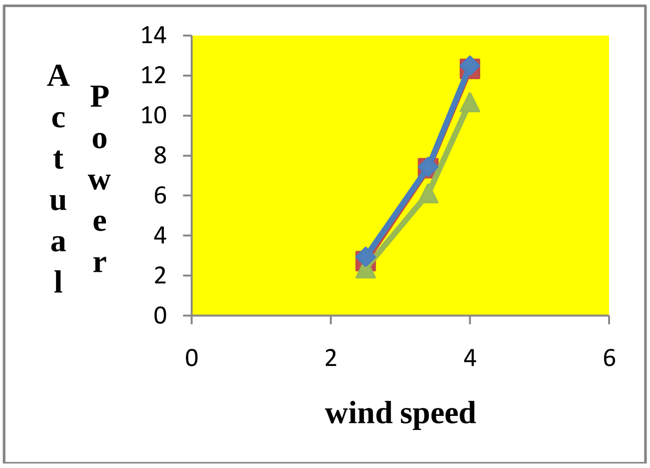

Fig. (c) Combined variation of actual power with wind speed

F. Combined variation of efficiency with respect to wind Speed:

This graph showed that combined variation of efficiency of Wind turbine with respect to wind speed and it has cleared *that* efficiency is optimum for the case when flap are used with rough surface blade

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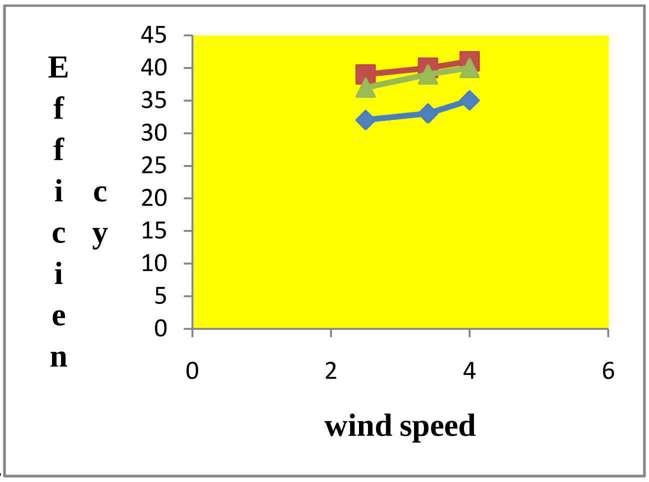

Fig. (d) Combined variation of Efficiency with wind speed

VI. 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.

REFERENCES

[1] http//www.bookboon.com,cited on Aug-2015.
[2] Rai, G. D., 2011, “A Text book of Non-conventional energy Sources” ISBN No.81-7409-073-8.pp.227-310.
[3] R., Rakesh and Agrawal, M., 2015,"Experimental Analysis of Blade Design, Power output and Efficiency of A Horizontal axis Wind Turbine on A working Model, “International Journal Emerging Technology and Advance Engineering, Vol., 4(12)
[4] Kale, A., Sandeep and Verma, N., Ravindra, 2014, “Aerodynamic Design of A Horizontal Axis Micro Wind turbine Blade Using NACA 4412 Profile” International Journal of Renewable Energy Research Vol.4 (1).
[5] Sarkar, Asis, andBehera, Dhiren, Kumar, 2012,”Wind Turbine Blade Efficiency and Power calculation with electrical Analogy” International Journal of Scientific and Research Publications, vol.2 (2).
[6] Kishore, A., Ravi, 2013,” A Small Scale Wind Energy Portable Turbine (SWEPT)” Virginia Polytechnic Institute (UK).
[7] Ismail, Farhad, Md., 2014,”Aerofoilprofile Modification Effects for Improved Performance of a Vertical Axis Wind Turbine”.
[8] Raghev, Magdi, and Adam, M., 2013,”Wind Turbine Theory-The Betz Equation and Optimal Rotor Tip Speed ratio.”www.intechopen.com, Cited on Aug 2015.
[9] Ridhwan, Razeen, Alshaleeh, Mohamed, and S, Arunvinthan, 2014 “Aerodynamic Performance Optimization oF Wind Turbine Blade by Using High Lifting Device” International Journal of scientific & Technology Research Vol.3 (12).