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An Experimental Analysis and Comparison of the Mechanical Efficiency of Two Different Design Three Blade Wind Turbine NACA 4415 and NACA 5520 with Varying Camber Area, Camber Position and Blade Thickness

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***Abstract :** In the present era, the world is struggling for energy so lots of researches are being conducted to meet the demand. The wind energy is a renewable source of energy and it is clean and pollution free too. So it is necessary to optimize the wind power generation. In this research a small wind turbine with two different designs aerofoil section NACA 4415 and NACA 5520 was developed for experimenting the performance of a Horizontal axis wind turbine with varying wind speed. The blade thickness was taken 15% and 20% of chord length. Camber area is 4% and 5% of the whole area and camber position is at the 40% and 50% of the chord length. And tested for its mechanical efficiency. An improved value of efficiency was noticed for The blades of aerofoil section NACA 5520 is 39% as compared to NACA 4415 is 37% were twisted from root to tip about 12 to 13 degree and RPM was noticed. In the present research we obtained an average rotor efficiency of 39% .Also it was noticed that the mechanical efficiency increases with increase in wind speed.*

Keywords: Rotor blades, NACA5520, NACA4415, Rotor shaft.

I. INTRODUCTION

The demand for power is increasing day by day in India and over the Globe. We depend upon the traditional fuel for power production. We know that our traditional fuel resources are limited which is getting short day by day. Coming decade would be the glorious for the wind power industry. The cost of power production is increasing rapidly day by day and it is going beyond the common people reach. While the power production by wind wheel technology is very cheap and pollution free too. The main advantage of this technology is, electricity can be produced at any scale. Any individual can produce power for their own use.

In this condition wind power can be a very suitable replacement for power production. Particularly in rural India the domestic turbine or micro wind turbine can play an important role as it is cheaper than the other sources of power production. Secondly it is pollution free and requires low maintenance. The micro wind turbine produces low power even at lower wind speed. Therefore minimum requirement of power or lighting can be achieved by this wind turbine. The induction of LED light has given a momentum to this work as even at lower wind speed the lighting task can be achieved efficiently. The object of our project is to develop a wind turbine model with various lift augmentation arrangements to work at low air speed and produce power for domestic use.

An airfoil is the two dimensional shape of the wings of the wind turbine .the shape of the airfoil to be designed in the preliminary phase of based on the performance requirements and technical requirements. Blade design and aero foil shape are most important factors in the field of wind turbine technology. It depends upon the design of blade that how much lift would be generated. A thick blade would generate less lift than a thin blade .Camber area and chord length also affects the amount of lift produced by an aero foil shape. If the chord length is more and the chord length is not optimized properly the blade would generate more drag and finally lift drag ratio would be affected.A blade tapered from root to tip reduces the drag marginally. The blade cut the air stream affectively and experience less drag. theorem [1]. In Fig.1.1, the forces acting on an airfoil is shown.

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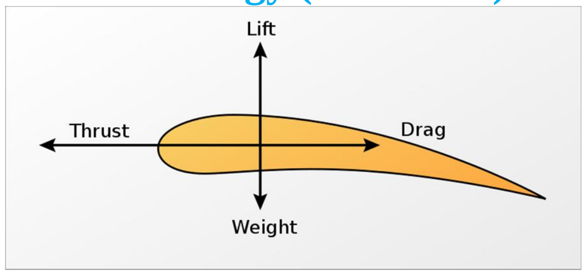
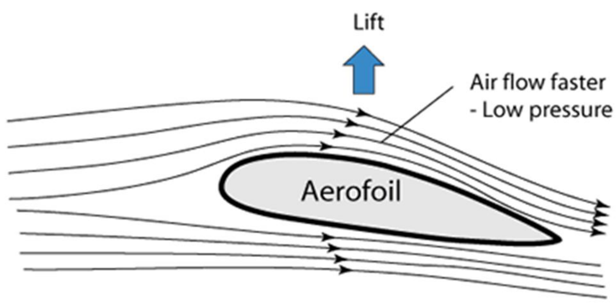


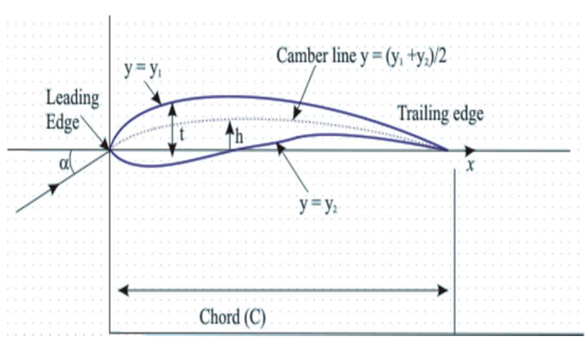
An aero foil shape

Newton's Third Law states that for every action, there is an equal and opposite reaction. In case of wind turbine air stream strikes to the lower face of the blade with some velocity. After striking to the blade lower face the velocity gets decreased, which creates an impact force onto blade. The reaction of which causes the rotor blade to rotate. But since wind turbine blades are set at an angle, the wind is redirected at an opposite angle, pushing the blades away from the reversed wind stream. This can be explained on a simple aero foil geometry exposed into the air stream [1]. In Fig 1.2 airflow passing over an airfoil section is shown.



The Bernoulli Effect tells us that the pressure decreases as velocity increases at the leading edge of the rotor blade. At the lower face of the blade due to blade angle the air stream strikes to the blade face and there is an increase of pressure at the lower face of the blade .Thus a pressure difference is generated across the rotor blade and the rotor blade experience a force which is called the lift force. This lift force only is responsible for the mechanical power output by wind turbine.

$$\frac{P}{\rho} + \frac{1}{2}V^2 + gZ = c$$



Chord length and blade thickness

II. LITERATURE SURVEY

Roshan et al. developed a small wind turbine experimenting the performance of a Horizontal axis wind turbine with varying wind speed. To improve the performance, he provided the flow straighteners at leading edge of the turbine blades. in this present research he obtained an average mechanical efficiency of 39%. Also it was noticed that the mechanical efficiency increases with increase in

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wind speed.

Kale experimented on NACA-4412 aero foil, chord of blade was reduced by 24% and thickness is reduced by 44% action with the objective to increase the power performance. The efficiency was found to be 30%.

Ravi did his Experiment on a 40 cm diameter small-scale wind energy portable turbine (SWEPT) operating in very low wind speed range of 2 m/s-5 m/s with extremely high power coefficient. It has the lowest cut-in wind speed (1.7 m/s) among all the other available wind turbines.

Deshmukh a wind turbine model was prepared with an air velocity enhancer was incorporated at the entry of wind flow. A considerable increase in power coefficient and thereby efficiency was noticed .

Sanchez described in his paper the experimental and computational (CFD) studies performed to investigate the performance of a small-scale windturbine. (HAWT) prototype with a simplified blade pitch mechanism was designed, and tested. The actual power coefficient of the turbine was approximately 23.5%, allowing a margin of 35% for improvements. The power coefficient obtained is 28.39%,.

The Soon paper presents the concept design of a modified airfoil blade for than efficient start-up mechanism. Hence changes were made in the airfoil blade design in order to enhance its tart-up mechanism..

Corbusin his report (NREL) shows the complex interaction of thrust, center of thrust, yaw rate, RPM, and how these variables relate to furl.

III. RESEARCH METHODOLOGY

To study the power output in terms of rotational kinetic energy of a wind wheel, a typical model of wind turbine is prepared and the experiment was carried out on the model at various wind speed.

A. Complete Setup

List of Components

S. No	Name of Components
1	DC Motor
2	Dc Led Bulb
3	Blade
4	Shaft
5	Ball Bearing
6	Hub
7	Stand
8	Anemometer
9	Tachometer

Specification of Blade

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1	NACA Profile	NACA 4415 and NACA 5520
2	Blade material	aluminum
3	No of blade	6
4	Chord length	4.5 cm
5	Blade length	0.4 m
6	Camber area	4 % and 5% of the total rotor blade area
7	Camber position	40and 50% of the chord length
8	Blade thickness	15 %and 20%of the chord length

IV. OBSERVATION

A. Overview

The whole wind turbine model by assembled as given in the figure and the experiment were performed at different location in the Gwalior (M.P.).

1) *Experiment No. 1:* The whole wind turbine model was assembled as given in the fig. 1 .the model was positioned nose to wind and the RPM was noticed and registered for the further examination

B. Model Experimental Set Up

Experiments were carried at 25 meter tower height at five different wind speed, observation obtained from experiments are as follows:

1) *Experiment No 1:*

S.No	Wind Speed (m/sec)	Tower Height (meter)	Exit Velocity	
			NACA4415	NACA5520
1	3	25	2.4	2.3
2	3.6	25	2.7	2.6
3	4.2	25	3.5	3.3
4	4.5	25	3.8	4.0
5	5.5	25	4.1	3.9

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C. Mathematical Calculation

Let,

$$v_{i=}\ incident\ air\ speed$$

$$v_e\ = exit\ air\ speed$$

A= rotor swept area
M = mass of the air striking per sec
$= \rho. A. v_i$
ρ = density of air

K E of the air $=\frac{1}{2}$M $v_i{}^2$

$=\frac{1}{2}\ \rho. A. v_i. v_i^2$

$=\frac{1}{2}\ \rho. A. v_i^3$

Theoretical power = $\frac{1}{2}\rho A V^3$
Maximum Theoretical Power Developed By a Wind Turbine:
Theoretical maximum power = 0.59 $\frac{1}{2}\rho A V_i^3$
Actual power calculation: Actual power extracted by the rotor $=\frac{1}{2}\ \rho. A. v_a. (v_i^2\ - v_e^2)$
Where,
$v_a\ = (v_i\ + v_e)/2$

Mechanical efficiency = $\frac{Actual\ power}{Theoretical\ power}$= $\frac{1}{2}\ \rho. A. v_a. (v_i^2\ - v_e^2)]/[\ \frac{1}{2}\ \rho. A. v_i^3]$

V. RESULT AND DISCUSSION

In this chapter, mathematical calculation is carried out for both wind turbine on the basis of observation obtained from experimentation and result obtained from calculation are compared and discussed for both wind turbine.
Results –for NACA 4415
Max efficiency is 37%

sn	Wind speed m/sec	Exit velocity (m/sec)	Tower Height (meter	Theoretical power (watt)	Mechanical power (watt)	Efficiency (%)
1	3	2.6	25	13.5	3.38	25
2	3.6	3	25	23.30	6.03	28.4
3	4.2	3.6	25	28.5	9.05	31.3
4	4.5	3.7	25	36.6	12.3	34.5
5	5.5	4.1	25	42	15.6	37

Results –for NACA 5520
Max efficiency is 39%

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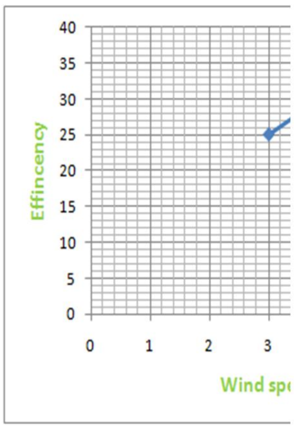
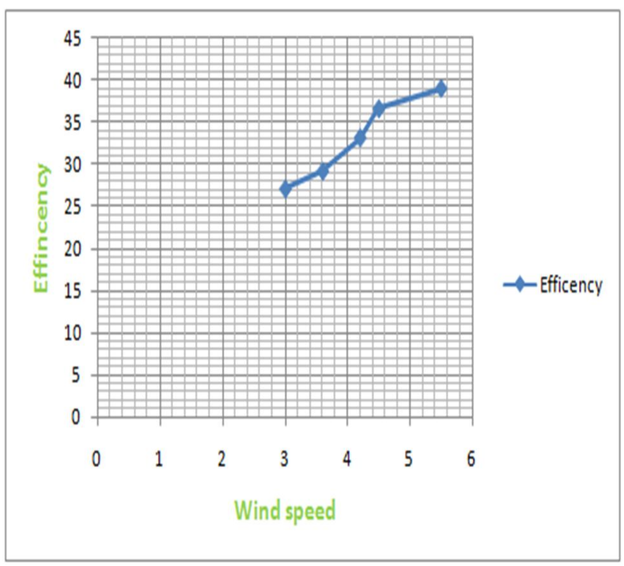
sn	Wind speed m/sec	Exit velocity (m/sec)	Tower Height (meter	Theoretical power (watt)	Mechanical power (watt)	Efficiency (%)
1	3	2.5	25	13.5	3.78	27.1
2	3.6	2.9	25	23.30	6.82	29.2
3	4.2	3.5	25	28.5	9.45	33.15
4	4.5	3.6	25	36.6	12.90	36.6
5	5.5	4.0	25	42	16.5	39

A. Discussion of Results

1) Variation of Efficiency with Wind Speed for NACA4415:



5.2 Variation of Efficiency with wind speed for NACA5520



5.3 Variation of Efficiency with wind speed for both wind turbine

Here it is clear that at same wind speed, wind turbine with 5520 shows more efficiency than that of with 4415. So it is clear that wind turbine NACA5520 blade is more efficient.

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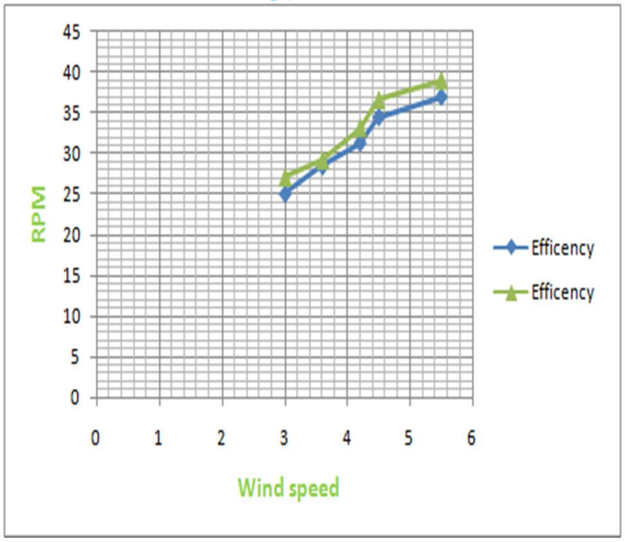


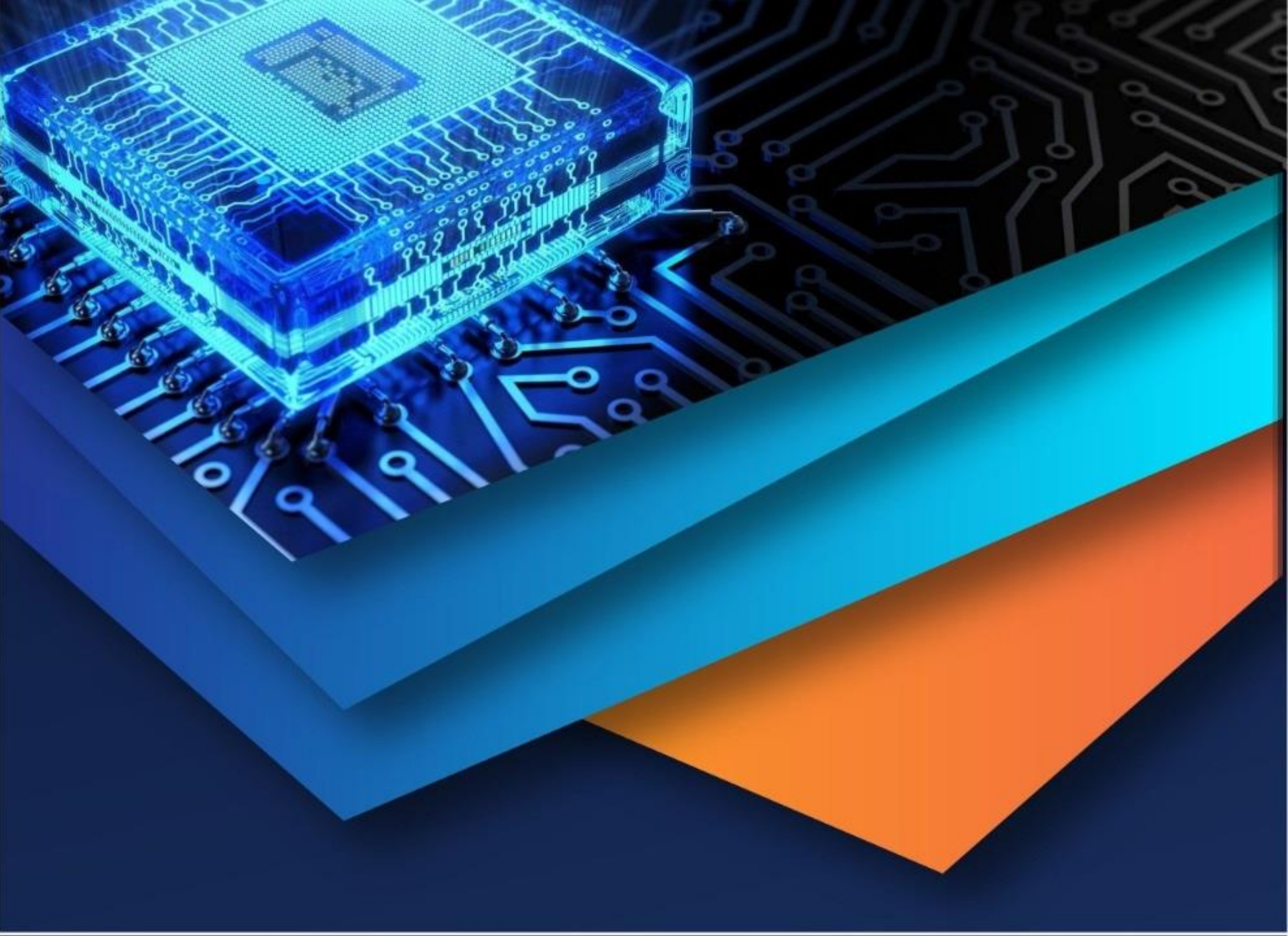
VI. CONCLUSION

The detailed experimental study of power coefficient and flow separation in the wind turbine is described here the main observation from these experiments can be broadly summarized below

A. The aerofoil section NACA5520 extracts more air from wind stream and RPM comparing with NACA4415.
B. The initial torque of the wind turbine aerofoil section 5520 was more hence the cutting speed of the aerofoil section 5520 is less than aerofoil section 4415.
C. The mechanical power output of wind turbine with aerofoil section 5520 was more than aerofoil section 4415.
D. An average efficiency of 39% was achieved by aerofoil section 5520 so aerofoil 5520 is more efficient with aerofoil 4415.

REFERENCES

[1] Roshan, R. and Agrawal, M.K., 2015 "Analysis of Blade Design, Power Output and Efficiency of A Horizontal Axis Wind Turbine on A Working Model", International Journal of Emerging Technology and Advanced Engineering ISSN 2250-2459, Volume 4 (12)
[2] Ravi, A K., 2013, "A Small-scale Wind Energy Portable Turbine (SWEPT)"Virginia Polytechnic Institute (UK).
[3] Deshmukh, N. R., Deshmukh, S.J., 2013, "Development of a modified Wind Turbine. ISSN 2278-018, Vol. 2, No. 6.
[4] Sanchez,C.V.,2013,"Blade performance Analysis and design improvement ofaSmallWind turbine," Diploma thesis at Purdue University, West Lafayette.0974-3154 Volume 6, Number 1 (2013), pp. 105-113.
[5] Moble, B., Lakshmi Narayan, V. Jonathan. 2013, "Fundamental Turbine with Dynamic Blade Pitching",International Journal of Engineeringresearch and a technology, AIAA 2013-1553, pp.1-21.
[6] Breuer, B.,Jovicic, K., 2009, "Separated Flow past an Airfoil at High Angle of Attack", High performance science and engineering journal, Munich pp. 93-105 Small Wind research turbine,2005,TechnicalReport, National Renewable Energy Lab (NREL). Stella, M., Tehsoon C., 2013, "Concept Design of a Modified Airfoil Blade".Internation
[7] Journal of Engineering Research and Technology. ISSN 0974-3154. Volume 6, Number 1 (2013), pp. 105-113.
[8] Corbuset, A.K., 2005, "Small Wind Turbine Research (Technical Report)" NREL/TP-500- 38550, turbine Final Report.



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