"COMPARATIVE ANALYSIS OF MECHANICAL EFFICIENCY OF DOMESTIC HAWT WITHOUT NOSECONE AND WITH NOSECONE"

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Abstract- *In this research a domestic wind turbine has been compared efficiency for experimenting the performance of a Horizontal axis wind turbine with varying wind speed first without nose cone and another one with the nose cone. To improve the performance, the nosecone which is provided at leading edge of the turbine blades. These nosecone give a streamline flow to the airflow circulating over the aero foil and reduce the dragging noise, vibration and give uniform RPM(rotation per minute of the rotor).We notice an improved value of Betz limit and hence efficiency. As per varying wind speed, RPM was noticed separately using without nose cone and with the nose cone. In this present research work, we obtained an average mechanical efficiency of 38.75% without nose cone and 40.38% with the nose cone. Also, it was noticed that the mechanical efficiency increases with increase in wind speed.*

Keywords—Wind turbine blades, Flow straightener Nosecone, Wind wheel shaft, camber Wind Wheel.

1.Introduction –

The demand of electricity is increasing day by day in India Or World. We majorly produce electricity by using the traditional fuel like coal for power production or work doing. As we know, our conventional fuel resources are not ample which is getting reduced day by day. In this condition, wind power can be a very suitable and also low-cost choice for power production. Majorly in remote area the domestic wind turbine or small wind turbine may be used for power production to fulfill the domestic usages. This method of producing power cheaper and requires less maintenance cost than the other sources of power production. Secondly, it is pollution free hence it is ecofriendly and requires low maintenance. The small or technically known as micro wind turbine produces low power even of at lower wind speed. Thus minimum output of power required for lighting can be achieved by this micro wind turbine. LED light induced which gives a momentum to this research work even at lower wind speed and the lighting work has been achieved efficiently. The objective of our this research work is to compare mechanical efficiency the domestic micro wind turbine model with various lift augmentation arrangements using the nose cone and without nose cone to work at low air speed and produce power for domestic use.

2. Literature Survey & Review-

In order to extract power from the wind, there are so many blade design of wind turbine and construction all work on the conservations of energy but there is loss also .Wind wheel captures the kinetic energy of the wind in the form of rotational energy , this rotational energy produces torque which drive the shaft which is coupled to an electrical generator(copper coil arrangement) which generates electricity this because of electromagnetic induction(Farady's Law Of Electromagnetic Induction)

As maximum the wind speed then the rotational speed of the wind wheel which is in RPM is also maximum and thus more energy would be extracted from the wind (kinetic energy) by the wind turbine blades.

The major designs of wind turbine is on two concepts. These two are decided and determined according to their arrangements of the rotor shafts and blades , which are either horizontal or vertical. If shaft axis is horizontal then Horizontal Axis wind turbines and if shaft axis of wind wheel is vertical then Vertical Axis Wind Turbine. Main advantage of HAWT is that there rotating shaft runs parallel with the ground. So due to horizontal axis to control over wind wheel and blade arrangement is very good . And controlling of pitch giving to the turbine blades is also optimum angle position with respect t to the wind speed. These are the advantages of HAWT over VAWT. Now mounting of wind wheel with rotor mounting of the wind turbine on tall towers requires more strength and good design methods which enables them to have obstruction free high speed wind flow.

The main most important thing in a HAWT is that the Betz limit is also comparatively good than VAWT. Betz limit is limits that describes about the maximum power produced by a wind turbine cannot be more than 59.3% of the wind power (rate of kinetic energy of wind). But actually even after so many research and the experiment carried out by different researcher cannot reach the value of 59.3% even though more far away from the that Betz constant . The actual value of the Betz limit varies between

25%-45%. So due to this reason a lot of research need to be going on this wind turbine .Because 33% of the air passing through the wind wheel is not doing any work on to the wind heel. Which can be achieved only by doing design change in the arrangement of flow nosecone and wind wheel blade. Research scholars have done many experiments on various blades designs and arrangements of wind turbine by changing angle of attack and many pitch angles. In this present work we have introduced a flow straightener which is technically known as nosecone over the rotor blade to reduce the drag force over the blade and thus increase the lift force which is required for our work. And introduction of nosecone also giving a streamline flow to the air passing over the blade camber area is increased to 60%. The value of Betz limit increased after completion of the experiment result as we compared.

3. Problem Statements-

As know that the maximum theoretical power produced by a wind turbine is not more than 59% as per law given by Betz . But experimentally Betz Limit ranges between 25% to 40%of the wind power. Because most of the air passes over the turbine blade exits without doing any work on the blade so this problem exist. Therefore the efficiency of wind turbine can be improved by reducing drag force component and increasing lift force component by introducing some drag reducing device like flow straightener, nosecone. And also camber area increased value and appropriate camber position can also play a role in utilizing more and more air for power production. In the current research we have introduced a flow straightener on the leading edge of the blade camber. Thus camber area is taken 60% of chord length and the camber position is exactly at the aero foil section center and experimented for the power output at given wind speed.

4 Basic Theory-

Wind turbine is a device which converts kinetic energy of wind into electrical energy. Kinetic energy of wind first converted into mechanical energy then via a generator converted into electricity. Wind results from the movement of air due to atmospheric pressure gradients.
Wind flows from of higher pressure location to lower pressure lower pressure location.

Wind energy is a renewable source of energy which came from air current flowing across the earth surface. Wind energy is best growing sources of electricity generation in the world now a day. Actually wind energy is a inter conversion form of solar energy. And solar energy is produced by the nuclear fusion of hydrogen (H) into helium (He) in core of the sun. The H ,He fusion process produces heat and electromagnetic radiation streams out from the sun into space in all directions. And this way wind energy comes into picture.

Various concepts of Fluid mechanics used some are as following.

4.1 Principle Of Conservation Of Mass-

Mass neither be created nor be destroyed. Mathematically it is written as $dM/dT = 0$

4.2 Ideal Power Estimation Of Wind-

Wind Power depends on desnsity(ρ), area(A) and velocity(v) of air. Mathepatically $P = \frac{1}{2} * \rho * A * V^3$ Area $A = \pi r^2$

4.3 Bernoulli's Theorem-

Sum of kinetic head (kinetic energy per unit weight) , pressure head (pressure per unit weight) and potential head (potential energy per unit weight) is constant at any point of the system. Mathematically

$$\underbrace{\frac{p}{\rho g}}_{\text{pressure head}} + \underbrace{\frac{V^2}{2g}}_{\text{velocity head}} + \underbrace{z}_{\text{static head}} = \underbrace{H}_{\text{total head}} = \text{constant}$$

4.4 Dimensionless Numbers-

This concepts used for model testing which are Reynols Number, Euler Number, Froud Number and Mach nuber etc. Reynolds Number tell about flow tye. Euler number tell about tells how pressure varies along the parts of the system. Froude number tells about model is geometrically similar or not. And Mach number tells about speed achieved is subsonic ,sonic or hypersonic.

5 Research Methodology-

Study of the power output in parameters of rotational kinetic energy of a wind wheel or rotor of a typical wind turbine model is manufactured and the experiment analysis is carried out on the model as varying wind speed and thus resulting rotational speed of rotor in (RPM) of the wind turbine is registered for analysis.

5.1 Specifications Of Wind Turbine-

Length of blade = 0.62 m
Weight of the blade = 0.51kg each
Twist angle = 12 degree
Chord length = 6.52 cm
Blade thickness = 0.71 cm
Camber = 4.25 cm

Camber position = 2.35cm. from leading edge
Blade twisting = 13.2 degree
Blade nomenclature = NACA -6512

Fig.1- HAWT with generator with flow straightener over the leading edge.

Fig .2- Frontal areas with nose cone

6 Mathematical Calculation –

ρ = Density of air **kg**/m^3
ω= Angular velocity of wind wheel blade (rad/(sec.)
M= Mass of the wind wheel blade blade (kg)
I = Moment of inertia of the wind wheel blade
A = Area swept by wind wheel blade
v_i = Initial velocity of air
v_e =Exit velocity air over the blade
v_a= Average velocity of wind wheel

$$= \frac{v_{i+v_e}}{2}$$

D = Dia. Of the wind wheel

C_p = Coefficient of performance of wind turbine
=(Actual Power Developed/Theoretical Power)

Theoretical Power $P = \frac{1}{2} * \rho * A * V^3$

6.1 Actual Power Developed-

We know that,
Torque = Iα
α = Angular Accleration
I = Moment inertia of the wind wheel blade,

Power developed by the wind turbine is,

Mechanical Power = Torque × angular velocity
$= \int Iwdw$

Power = $\frac{1}{2} I\omega^2$

P = $\frac{1}{2} I\omega^2$ Therefore Mechanical power developed by the wind turbine is,
Power = $\frac{1}{2} I\omega^2$ Where I= moment of inertia of the rotor blade and w= rotational speed of the blade.

7 Experimental Results And Graphs-

7.1 Observation table For Without Nose Cone –

S. N	WIND SPEED (m/s)	RPM	Rotational Power of the wind wheel (watt)	Theoretical power of the wind (watt)	Betz Limit	Mechanical efficiency
1.	2.2	69	9.72	3.5	0.36	36%
2.	3.7	140	36.84	14.0	0.38	38%
3.	4.2	160	61.10	24.44	0.40	40%
4.	4.3	172	65.71	26.94	0.41	41%

As the average efficiency obtained is 38.75% as without nose cone arrangements.

7.2 Observation table For Without Nose Cone Arrangement-

S. N	WIND SPEED (m/s)	RPM	Rotational Power of the wind wheel (watt)	Theoretical power of the wind (watt)	Betz Limit	Mechanical efficiency
1.	2.2	75	10.81	4.0	0.37	37%
2.	3.7	150	40.51	16.0	0.395	39.5%
3.	4.2	170	63.33	26.69	0.42	42%
4.	4.3	182	67.79	29.15	0.43	43%

As the average efficiency obtained is 40.38% as per with cone nose arrangement.

7.3 Graph-

Comparison of efficiency with respect to varying wind speed without nose cone and with nose cone arrangement.

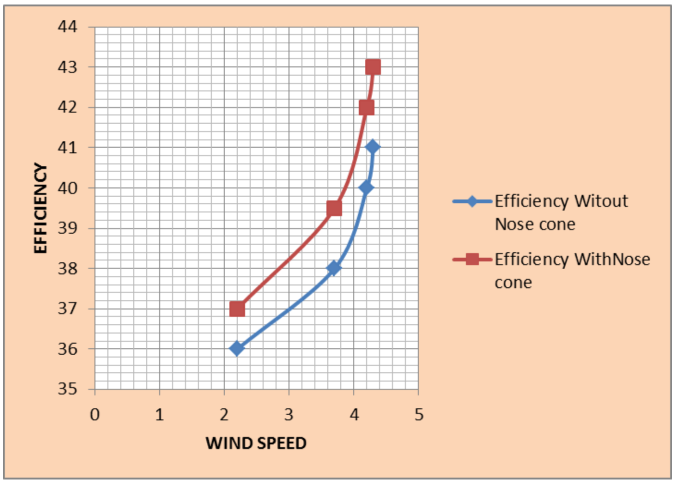

Chart – Wind Speed Vs Efficiency

8. CONCLUSIONS-

In a horizontal axis wind turbine there is change in the power output with the change in the value of Betz limit and this limit depend upon the attack of wind on the blades of the rotor. If we add lift augmentation devices like flow straightener and nose cone and optimum camber area is taken into account t the value of Betz limit is increasing hence mechanical efficiency increases also noise and vibration going to reduces . And one major observation is that angle of twisted also has a great impact on power output. If the angle of twist range is kept within the optimized limit then angle of attack of wind stream to the turbine blade would be more sensitive to change in wind speed.

Future scope:

As mainly the mechanical efficiency of a horizontal axis wind turbine depends upon the exit velocity of the wind past over the wind wheel i.e blade of the wind wheel. The efficiency going to increase with the appreciable decrease in exit wind speed. Hence more experiments can be carried out with different camber area and position and blade twist angle introducing various lift augmentation arrangements.

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