Relative Study of Power Output of Domestic Wind Turbine without and With Nose Cone

Raghuwendra Kumar[1], Dr. M.K. Chopra[2]

[1]*Research Scholar Department Of Mechanical Engg. R.K.D.F. Institute of Science and Technology Bhopal Under SRKU Bhopal MP, India*
[2] *Principal & H.O.D. Department Of Mechanical Engg. R.K.D.F. Institute of Science and Technology Bhopal Under SRKU Bhopal MP, India*

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Abstract – *For improvement of performances of our model, domestic horizontal axis wind turbine the flow straightener is assembled at the leading edge of the wind turbine blades. The flow straightener distributes stream line flow of air striking and circulating over the wind turbine blade and thus reduces the drag, noise, vibration and gives uniform RPM (rotation per minute of wind wheel). To improve the performances of the wind turbine at frontal position nose cone is provided which results increase in the efficiency. In the present research we obtained an average rotor efficiency of 40.38% by the wind turbine with nosecone where as 38.75% without the nosecone arrangement.*

Key Words: *Wind Turbine Blade, HAWT, Anemometer, Shaft*

1.Introduction -

A small scale wind turbine or micro wind turbine may produce some little amount of power even though of low wind speed. The objective of our research work is to compare mechanical efficiency the domestic micro wind turbine model with various lift augmentation arrangements using the nosecone. 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. 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. Mainly in remote places like villages the domestic wind turbine or small scale wind turbine may play an important agent for the supply of power for domestic usages. It is cheaper also a cheaper method of producing power than other methods. Secondary but essential that it is pollution free and need very low maintenance. Thus minimum output of power required for lighting can be achieved by this micro wind turbine. After installation of experimental set up we lighten a low voltage led bulb which motivates us for further improvement of the performances. 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. The objective or purpose of our project work is to compare efficiency the small scale wind turbine model with two different arrangements in one case frontal position is not containing any type of flow straightener devices while in second case we provide a nose cone which distributes the wind flow and also lift component value of force improved.

2. Literature Survey & Review -

Wind has ample amount of energy in the form of kinetic energy which must be extracted for power production in order to extracting power from the wind there is lot of research are going on and completed. Some research on optimizations of blade thickness and blade design. Here our main concern is problem which aroused due to flow separation is short out. During design and construction of flow straightener and blade design all work based on the conservation of energy. But there is frictional loss so to minimize the frictional loss following researches are going. Actually wind wheel rotates this rotation of wind wheel because kinetic energy of wind transforms into rotational energy this rotational kinetic energy produces torque. And we know with help of torque we derive the shaft. Turbine shaft in short we say as shaft drives with torque produced which is coupled form the generator which generates electricity this because of law of electromagnetic induction given by Faraday. The only construction, design and manufacturing of blade and flow straightener necessarily able to provide the best power performances under practical condition so needs to be proper arrangement and modifications.

3. Problem Statement-

According to Betz the maximum power produced by wind turbine cannot crossed the figure of 59% of available kinetic energy of the wind. But experimentally value achieved ranging from 25% to 42% of the available wind power i.e. the efficiency is not more than the 42% till the date. But we try to increase the value for this various research rare going on and many of them completed. Because of less efficiency achieved main reason is friction exit in the blade, flow separation over turbine blades, and non-uniform distribution of wind attack over the blade. The whole problem is like due to that. Therefore the efficiency of the domestic H.A.W.T. (horizontal axis wind turbine) can be improved by reducing the drag force component as minimum as possible and increasing the lift component of force as maximum as possible by introducing lift augmentation devices and flow straightener like nosecone and also increased value of camber area and the position of camber may play very effective role in increasing the efficiency. These modifications help the wind turbine rotor to extract more power from the wind energy available in the form of kinetic energy. In this research we provide a flow straightener at the frontal positon of the wind turbine rotor shaft and blade assembly. Also to reduce the drag factors in this work we have minimized the number of blade to two. Second problem is considered the even distribution of wind stream over the rotor blade. For this purpose we have added the nose cone and experimented at the various wind streams.

4. Basic Theory-

Wind turbine is a device which converts kinetic energy of air into mechanical energy in the form of rotational energy which produces torque in the rotor shaft. And the rotor shaft connected to generator which produces electrical energy. At first kinetic energy of the wind stream converted into mechanical energy and then via generator converted into electricity.

It has been analyses and calculated that the total amount of solar energy emitted from the sun and absorbed by the earth is approximately $1.8 * 10^{11}$ MW. This huge amount of solar energy input of which only 2% is converted into the wind energy which is required for our purpose and is approximately$1.26 * 10^{9}$ MW. Because of this appreciable less value indicates that almost 20 times the rate of present global energy requirement. In practical wind energy can meet entire energy need of the world. Now comparing with the traditional energy sources wind energy has numbers of benefits and advantages. Not like fossil fuels that emits harmful gases which called pollutants and nuclear power which emits harmful radiations once this leakages takes place there is huge effects on the health issues of living beings and for environment. As we know wind power is a very clean and environment friendly energy resources of power production. i.e. rate of kinetic energy of wind would help to reduce the dependency of power production by fossil fuels minimized in this century. According o the present demand wind power is more used for power generation. Furthermore, the cost per kWh of wind power is much lower than that of solar power. Hence as the most ideal energy source is wind energy thus wind energy is believed to play a major role in global power production and supply in the 21st century.

4.1 Continuity –

Mass is undestructible mathematically it is written as
dM/dT =0

4.2 Ideal Power Estimation-

Wind poer is directly related with density area and velocoity mathematicaly,

P= 0.5 *density *area* cube of velocity

4.3 Bernoullis Theoram –

Sum of kinetic energy , potential energy and pressure energy is constant at any point. Mathematically it may be given as

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

4.4 Dimensionless No-

Various dimensionless numbers are in fluid mechanics but here we have use of following-
Reynolds Number(Re)
Euler's Number (Eu)
Froude's Number(Fr)

5. Research Methodology-

Study of power output in the terms of rotational kinetic energy. speed in rpn i.e. rotation per minute .Turbine midel is carried out on the model as varying rpm.

Fig.1- Turbine Blade

5.1 Specifications of The model-

Length of blade = 0.62 m
Weight of the blade = 0.51 kg each
Twist angle = 12.0 degree
Chord length = 6.52 cm
Blade thickness = 0.71 cm
Camber = 4.25 cm
Camber position = 2.35 cms from leading edge
Blade twisting = 13.2 degree
Blade nomenclature = NACA -6512

ρ = Density of air (kg/$m.^3$)
ω = Angular velocity of rotor blade (rad/(sec.)
M = Mass of the wind wheel blade (kg)
I = Moment of inertia of the wind wheel blade
A = Swept area of the wind wheel blade
v_i = Initial velocity of air
v_e = Exit velocity of blade
v_a = Average velocity of rotor
$= \frac{v_{i+v_e}}{2}$
D = Dia. Of the rotor blade
c_p = Coefficient of performance of wind turbine

Fig. 2- Nosecone

6. Mathematical Calculation-

Mathematical calculation involves many steps which are as follow

6.1Moment of Ineria Calculation-

To calculate the moment of inertia of the turbine blade the whole blade assembly is assumed to be a cylindrical rod and the M.I is calculated by rectangular section about their fixed end not about their neutral axis following formulae,

$$M.I = \frac{(mass)(length)^2}{3}$$

6.2 Actual Power calculation –

We know that torque is the product of moment of inertia and the rotational acceleration. Knowing the value of moment of inertia and the time derivative of angular velocity, we can find the torque exerted onto the rotor blade due to momentum of the fluid flow. Mathematically,
We know that,
Torque =Iα
α = Angular Accleration
I = Moment inertia of the rotor blade,

= 0.0653 kg-m^2

Power developed by the wind turbine is,

Mechanical Power = Torque × angular velocity
$= \int I\omega d\omega$
Power $= \frac{1}{2} I \omega^2$
P $= \frac{1}{2} I \omega^2$
Therefore,
Mechanical power developed by the wind turbine is,
Power $= \frac{1}{2} I \omega^2$
$= \frac{1}{2} 0.6053 * 7.225^2$
= 3.50 Watt.

7 .Experimental Result and Graphs-

7.1 Observation Table For without nosecone

S. N	WInD SPEED (m/s)	RPM	ROTATIONAL POWER(Ideal) (watt)	MECHANICAL POWER OUTPUT (watt)	C_p	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 Power output is equal to 17.125 watt using no nosecone.

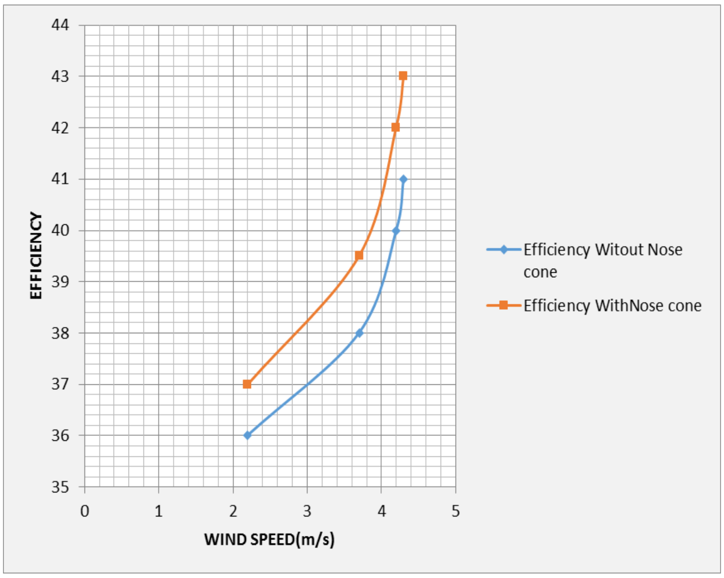
7.2 Observatio table for with nose cone-

S. N	WIND SPEED **(m/s)**	RPM	ROTATIONAL POWER **(watt)**	MECHANICAL POWER OUTPUT **(watt)**	C_p	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	26.6	0.42	42%
4.	4.3	18	67.79	29.15	0.4	43%

AS the average power output obtained is 19.5 watt using the nosecone.

7.3 Graph-

Relative analysis on power output with respect to varying speed without nosecone and with nosecone.



Graph- Wind Speed vs Power.

8. Conclusion-

In the present research we obtained an average rotor efficiency of 40.38% by the wind turbine with nose cone where as 38.75% by the wind turbine without nose cone .Also it was concluded that the mechanical efficiency increases with the increase in the wind speed. A conical nose cone distribute the air flow uniformly on to the rotor blade even at low velocity of air.

Future Scope-

The present experimental study has shown many interesting results regarding power coefficient, Betz limit, lift, drag and flow separation. However it has opened up many possibilities for extending the present work .based on different literature survey carried out here and result obtained from the present experimental study the following scope for future work is present.

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