International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 5 Issue 3, March-April 2021 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Design, Development, Fabrication and Testing of Small Vertical Axis Wind Turbine

Dr. Mukesh Kumar Lalji PhD

Vice-Principal, Department of Technical Education,
M.P. Govt. (S. V. Polytechnic College), Bhopal, Madhya Pradesh, India

ABSTRACT

An experimental investigation has been carried has been carried out on a design, Development, Fabrication, & Testing of small Vertical axis wind turbine. An extremely simple design, of a vertical axis wind rotor using two flat vertical Vanes, swinging vanes has been fabricated and tested to obtain its performance. The torque and power coefficient have been obtained and presented in this paper the result are highly encouraging and indicate the usefulness of the swinging vane rotor at low wind regions. This paper is presented on the basis of technology two blade vertical axis wind turbine system.

***KEYWORDS**: Wind mill vertical axis, low wind swinging vane. Drag and torque coefficient of stationary S- shaped rotor have been investigated by measuring the pressure distribution on the blade surfaces for various rotor angles. The experiments have been carried out at a Reynolds number of 1.1x105 in a uniform flow jet produced by an open circuit wind tunnel. The measurements indicate that the drag force, and hence the torque, varies with rotor angle. The maximum net static torque occurs at 450 of rotor angle and it becomes negative in the range of 1350 to 1650 of rotor angle. A quasi-steady approach has been applied for the prediction of the dynamic performance of the rotor using the static drag and torque coefficients*

***How to cite this paper**:* Dr. Mukesh Kumar Lalji "Design, Development, Fabrication and Testing of Small Vertical Axis Wind Turbinev" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-5 | Issue-3, April 2021, pp.478-481, URL: www.ijtsrd.com/papers/ijtsrd39817.pdf

IJTSRD39817

1. INTRODUCTION

A vertical axis wind Turbine It is known, Classical water wheels let the water arrive at a right (Perpendicular) to the rotational axis (shaft) of the water wheel. Vertical axis wind turbines (VAWTs) are bit like water wheel in the sense. The only vertical axis turbine which has been ever been manufactured commercially at any volume is the Darrieus machine, named after the commercially at any volume is the Darrieus machine, named after the commercially at any volume is the Darrieus machine, named after the French Engineer Gorge Darrieus who patented the design in 1931. the darrieus machine is characterized by its C-Shaped rotor blades, which make it, look like an eggbeater. It is normally built with two are three blades.

The basic advantages of a vertical axis machine are Generator, Gearbox etc may be placed on the ground and need not a tower for the machine .It does not need a Yaw mechanism to turn the rotor against the wind. The basic disadvantages are:

Wind Speeds are very slow close to the ground level so if the tower is saved then wind speed will be very slow on the lower part of rotor. The overall efficiency of the vertical axis machine is not impressive. The machines are not self-starting (e.g. a Darrieus machine will need a "push" before it start, This is only minor inconvenience for a grid connection turbine, however, since the generator may be used as motor current from the grid may used to start the machine.) The machine may need guy wires to hold it up, but guy wires are impractical in heavily framed areas. Replacing the main bearing for the rotor necessitates removing the rotor on the both a horizontal and a vertical axis machine. Description of various types of VAWTs

1. Cup anemometer:- this device rotates by drag force. The shape of this cup produces a nearly linear relationship between frequency and wind speed.
2. Savonius Rotor:- There is a complicated motion of the wind through and ground the two-curved sheet airfoils. The driving forces principally drag. The construction is simple and inexpensive. The high solidity produces high stating torque, so savonius rotors are used for water pumping.
3. Darries Rotor:- this rotor has two or three curved blades with an airfoil section. The driving forces are lift, with maximum torque occurring when a blade is moving across the wind at a speed. Uses are for electricity generation. The rotor is not usually self-starting. Therefore movement may be initiated with the electrical used as a motor.
4. Musgrove: - The blades of this form of rotor are vertical for normal power generation, but tip or turn about a horizontal point for control or shutdown. There are several variations, which are all designed to have the advantages of failsafe shutdown in strong winds.
5. Evans Rotor:-The vertical blades twist about a vertical axis for control and failsafe shutdown.

BETZ LAW:

In the undisturbed state, a column of wing upstream of the turbine, Kinetic energy passing per = $P_o = \frac{1}{2} (pA_oU_o)U^2 = 1/2pA_oU_o^3$ --- eq (i) (of undisturbed column)

Where
'Po' is the Kinetic energy per unit time

Uo is initial undisturbed wind velocity

P is air density

Considering constant velocity air streamlines passing through turbine.

Let,

A0 = rotor swept area at which velocity of wind = U1

A0 = Upstream swept air area at which wind velocity is U0

A2 = downstream swept air area at which wind velocity is U2

According to second law of Newton, rate of change of momentum will be equal to force on the turbine rotor

i.e. $F = mUo - mU2 = m(Uo-U2)$

where, m= air mass flow rate

Obviously power extracted by the turbine rotor is:

$Pt = FU1 = m\,(Uo - U2)\,U1$ ------------------- eq (ii)

Now, power extracted from the wind will be the loss of kinetic energy per unit time (Pw) i.e.

$Pw = ½\, mUo^2 - 1/2\, m\, U2^2 = 1/2m\,(Uo^2 - U2^2)$ ------------ eq (iii)

Equating eq (ii) and eq (iii),

$m(Uo - U2)U1 = 1/2m\,(U0^2 - U2^2)$

$U1 = (Uo + U2) / 2$ ------------------ eq (iv)

Mass of air streaming through the rotor during one second can be taken as

$m = pA1\,(Uo + U2)2$

Substituting this value of 'm' in eq (iii)

$Pw = ¼\,(U0^2-U2^2)\,(Uo + U2)p\,A1$

Now compare this result with the total power in the undisturbed wind streaming through exactly same area 'A1' wind no rotor blocking

$Po = ½\, Uo\, pA1$

The ratio between the power extracted from wind and power in the undisturbed wind is then:

$Pw/Po = (1/2)\,[1-(U2/Uo)^2]\,[1 + (U2/Uo)]$ ------------- eq (v)

This function of (U2/Uo).

To get the maximum factional power extracted from the wind, differentiating above equation with respect to (U2/Uo) and equating to zero.

$d(Pw/Po)/d(U2/Uo) = 0$

This follows,

$U2/Uo = 1/3$ (for maxima)

Putting this value of U2/Uo in eq (v)

$Pw/Po = 16/27 = 0.59$

Hence, only 59% of the total power of wind can be extracted at the most.

EXPERINATAL SETUP

Before collecting the data from the experimental setup. The system was tested for validity by experimentation on a small swinging vane wind rotor in constructed for testing in the laboratory. This is shown in fig 1 with dimension and a photograph is shown in fig. 2 Mainly aluminum is used for construction of this mini rotor to make it light. The center shaft is an aluminum tube of 18-mm diameter and 380 mm length. It is pivoted at top and bottom on a mild steel supporting structure fixed to a wooden base. Two wooden flanges are fitted on ths hsaft, one near the top and other near the bottom. Each flange can carry two or three radial arms symmetrically at 180^0 or 120^0 apart The arms are also aluminum tubes of 18- mm diameter and 168 mm length each. Aluminum sheets of 22 gauge cut to size and folded at the edges are used as vaens. Each vane is 168 mm by 210 mm in size. Pins and pivots are fitted to the ends of the arms and to one vertical edge of each vane respectively so that each vane can swing about its outermost vertical edge. The swing of each vane from its radial position is restricted by tying its inner vertical edges by a rope (thread) to the tip of the nearest arm. The length of the thread is so chosen as to restrict the swing of the vane. In one direction only from its radial position. A small pully is fitted on the vertical shaft near the top and one pulley on each side of the shaft is fitted to the supporting structure. These are used to guide a breaking rope (thread) whose vertical ends are connected to weights on one side and a spring balance on the other side. This arrangement provides a known and adjustable breaking torque on the rotor for experimental purpose. This wind rotor is tested in open wind flow coming out of a low speed forced flow wind tunnel. The wind velocity is measured by a Prandtl pilot static tube by traversing across the section and averaging over the area. The rotational speed of the rotor is measured by means of stroboscope. A tachometer is not used, as it requires direct contact. Which may affect the rotor speed. Experimental **DESIGN OF VERTICAL AXES WIND TURBINE** an approach to this design project, various component used are selected on basis of availability. **Cycle** rims used in this are having diameter of 65 cms. **Hub** are serving as the connection between shaft and fillet. They are having a diameter of 10 cms. They are also used to so as to increase the hollow sqace in between the rotor to pass the air. **Fillets** used to make a connection between cycle rim and hub. They are also used to keep blades in position. Fillets are made of mild steel and they are having width of 1 cms and thickness of 3mm **Blades** Used are having size of 1mx 30 cms. The are made up of galvanized iron sheet. **Shaft** used in this project is hollow, it is choosen hollow because of the weight consideration. It is welded to some extended portions of upper and lower parts Bearing's specification SKF-10. **Blade Sections** Air is a compressible fluid, but for design of the table section we will assume it as an incompressible fluid. Designing of blade section is based upon the design procedure of centrifugal pumps and blower. According to design centrifugal pump and blower, inlet angles 20 deg. And outlet angle 14.5 found to be satisfactory so it will be assumed here for design so for design of blade section following assumed here for design. So for design of blade section following assumption are made. 1. Air is a compressible fluid, but for design of the blade section we will assume it as an incompressible fluid. Designs of blade section is based upon the design procedure of centrifugal pumps and blower According to design of centrifugal pump and blower, intel angles 20 deg. And outlet angle 14.5 found to be satisfactory so it will be assumed here for design so for design of blade section following assumption are made. 1. Air is incompressible fluid. 2. Intel angles for blade for air: 20 deg **3. Outlet angles of blades for air: 14.5 deg.**

Ring No	R	R2	Racos	Rbcos	Rb2-	Ra2	e
1.	12.5	156.25	14.74	0.967			
2	20	400	16.62	0.958	7.07	243.25	17.25
3	27.5	756.25	18.55	0.948	6.91		356.25
4	35	1225.20	0.94	6.83	468.75	34.32	

This is the table which shows, length of arch for finding the blade section.

FABRICATION:-

For fabrication of Vertical Axis Wind turbine (VAWT) material are as follows

1. 2 cycle Rims
2. Hollow Pipe
3. 1 Dynamo
4. Frame
5. Gear Arrangement
6. Hub
7. 4 Bearing
8. G1 sheet
9. Miscellaneous Items

As it is clear from the design that cycle rims used are of 65 cms in diameter and the hub are of 10 cms diameter. These hubs are to be connected to the rims. So the connection is made by the means of fillet of 5 mm thickness and half inch width and linear length of these fillet are 30 cms but are made curved according to the design of the blade given earlier. This fillet serves two two specific purpose.

1. to connect hub with rim
2. to make a base for G1 sheet's blades so as to keep them position

According to different Scientists; it is better to use 2-4 blades in a wind turbine because if more blades are used then next blades will intercept the air coming in contact with earlier blades as hence whole of the energy will not be supplied to the blade and efficiency will be too less.

In this design, 2 blades are used. They are fixed at an angle of 1800 to each other so to make the drag force symmetrical on he assembly and also driving force to be at regular interval at same wind speed.

Both assemblies of hub, fillet and rim are welded on a shaft at a distance of 1m Here hollow shaft is used in spite of solid shaft so as to reduce the weight of whole assembly. Both rim and hub assemblies are fixed at perfect alignment so as to keep the blade straight so as to harvest maximum energy a possible from the following wind.

After fixing the hub on shaft blades are mounted on the fillet. For it blades are out in from the G1 sheet according to the dimensions and after that they are mounted on the fillet by means of nut and screw. Sizes of blades are 1m x 30 cms.

Frame is made by angle of mild steel. They are cut into desired length and them welded into the desired position they are giving support to the rotor by means of the ball bearings. They support on both upper and lower portions, VAWTs are different from HAWTs in mounting also. VAWTs are mounted on two bearings whereas HAWTs are mounted on single bearing which is between blades and generator.

Rotor is at a height if 55 cms from the ground. Soon the roof it will be at a height of nearly 5 m from the ground level.

TESTING

Design development Fabrication & Testing of small Vertical Axis Wind Turbine Two blade VAWT
Weighing machine for force measurement
Techometer/Stroboscope for rpm
Anemometer for wind velocity

The design and fabrication operations, we evaluate the performance of machine through the show experimental setup consists assembly of various component and equipment already described at initial phase. Blower, Anemometer and sensor are other equipment for facilitation of procedure. When we start the blower, the wind velocity strikes the blades or rotor, which start rotating due to its effect, Anemometer measures the speed of wind in meters per second. Sensor plays an important role in sensoring the velocity of wind.

Wind Velocity	RPM	Force (N)	Angular Velocity	Torque	Power
2.9	16	4.312	1.67	1.3798	2.3043
4	36	5.7232	3.768	1.8314	6.9007
4.2	40	5.978	4.186	1.913	8.0078
5	56	6.9972	5.86	2.239	13.1205
5.7	70	7.889	7.327	2.5245	18.497
6.3	82	8.6534	8.583	2.769	23.766
6.9	94	9.4178	9.839	3.0137	29.652
7.5	106	10.1822	11.095	3.2583	36.1508
8.1	118	10.9466	12.351	3.5029	43.2643
9	136	12.1912	14.235	3.9012	55.5336
9.7	150	13.083	15.7	4.1866	65.7296
10.4	164	13.9748	17.165	4.4719	76.76
11.4	184	15.2488	19.259	4.8796	93.976

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSION:-

Before going to conclude the topic it would be necessary to review the brief comparison of horizontal axis wind turbine and vertical axis wind turbine. Right from the origin of wind mill there has not been much attention paid on the development of vertical axis turbine. During the progress of civilization, horizontal axis wind turbine has suppressed the growth of vertical axis wind turbine. And not much appreciable work has been on its development Basic advantage incorporated with vertical axis wind mill is to be drag machine, that runs at lower speeds than driving wind, hence poor power coefficient and poor conversion factor results.

Infect, due to this disadvantage, vertical axis wind turbine has been ignored. But due to the economy and compactness; it is getting repose now a days and has become a subject of research.

Whatever work has been done infield of vertical axis wind turbine, is on darrieus eggbeater type. very negligible work is done for savonius rotor type wind turbine. as this project is based on savonius rotor type wind turbine. so, most of the work done in the design section is based upon the assumption so final results may vary from the expected results. Components used in fabrication are selected on basis of the availability and not designed according to strength. In the model construction, due to inaccurate welding extended portion of the shaft was tilted while cooling and shrinkage of the selded pool. Due to the interference of the tilted portion of shaft with bearing it is not rotating freely according to expectation

FUTURE SCOPE

There are considerably scope of harnessing wind power to meet part of growing energy of rural community demand.

In india today the bulk of energy needed to maintain various activities in our villages and to sustain agricultural production comes from human and animal muscle power. Villages from the core of India and if this core is to progress, it needs supplementary inputs of energy either supplied from central power plants or preferably, from within its own environment through the utilization of renewable local resources like wind, sunlight and agriculture wastes.

In spite of study progress, in the implementation of rural electrification schemes over 2,50,000 villages remain in the darkness in 1980. in definite monsoon, inadequate facilities for transportation of coal to thermal power plants and low load factor contributes to the unfavorable economics of distribution to the backward and remote areas of the country.

Unfortunately, the wind is neither stron or steady in india Gujart, rajasthan and South India states have better potential for wind power development particularly during March and September as the wind power can be developed economically only above the wind speed of 10 kms/hr.

As far as vertical axis wind turbine is concerned, it is vary useful in generation of electric power on small scale. As very small investment is required and it is very compact. Due to compactness of the machine it does not require much space to installation. It can be installed on roof of the house, from where it can harness energy, which can be used to light bulb of low power, It can also be installed in the farms for light there so as to ease of the security of the farm. At daytime it can be used to charge the rechargeable batteries known as kisan-torch which are used in the villages.

REFERENCES:

[1] Bakshi, Rakesh, wind Energy- India Overview, National Solar Energy Convention' 98, Nov, 30 – Dec2, 1998

[2] Saravanan, R. Sethumadhavan, R and Rao, A N. 2009,

[3] Heier, S. Grid Integration of Wind Energy Conversion Systems, John Wiley and Sons , 1998

[4] Moretti, P and Divone, L. Moderne Windkraftanlagen, Spektrum der wissenschaft, 1986.

[5] Lysen, E. H. Bos, H. G. and Cordes, E. H., Savonius Rotors for Water Pumping, SWD publication, Amersfoort, The Netherlands, 1978.

[6] Beurskens. H. J. M., Low Speed Water Pumping Wind Mills:Rotor Tests and Overall Performance, Proc. Of 3rd Int. symp. On Wind Energy systems, 26-29 Aug, 1980 Copenhagen. Denmark.

[7] Park, J., Simplified Wind Power System for Experimentry, Helion Inc. Californai, USA, 1975.

[8] Littler, R. D., Further Theoretical and Experimental Investigation of the Savonius Rotor, B. E. Thesis, University of Queensland, 1975.

[9] Huda, M. D., Selim, M. A., Islam, A. K. M. S. and Islam, M. Q., The Performance of an S- shaped savonius Rotor with a Deflecting plate,

[10] Islam, A. K. M. S., Islam, M. Q. Mandal. A. C. and Razzaque, M. M., Aerodynamic characteristics of a Stationary Savonius Rotor, RERIC Int. Energy journal, vol, 15. NO. 2 dec., 1993. pp 125-136.

[11] Bowden. G. J. and Mcaleese, S. A. The Properties of Isolated and Coupled Savonius Rotors, Wind Engineering, Vol. 8 No. 4, 1948, pp 271-288.

[12] Fusisawa, N., on the Torque Mechanism of Savonius Rotors J. of Wind engg. And Ind. Aero., Vol. 40. 1992, pp 277-292.

[13] Jones, C. N. Littler, R. D. and Manser B. L. , The Savonius Rotor-Performance and flow, 1st BEWA workshop, April 1979. pp 102-108.

[14] Sawada, T., Nakamura, M. and Kamada, s., Blade Force Measurement and Flow Visualisation of Savomius Rotor, s Bull USME, Vol, 15 1991. Pp 240-246