ANALYSIS OF TWO BLADED VERTICAL AXIS WIND TURBINE USING CFD

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ABSTRACT: A vertical axis wind turbine (VAWT) is able to agreeable to fulfill the requirements of human needs. In adding up to life form eco-friendly, it is relatively very cheaper than as compared with conventional schemes of electricity generation at present. Kinetic energy i.e. wind velocity is used to generate electricity by converting the mechanical energy, which is accessible in profusion and unlimited. By using this kind of systems there are has no negative effects on the environment. As the maintenance cost and operating cost are negligible which is better than other conventional methods. The work aims in evaluating the performance of savonius vertical axis wind turbine at various speeds from 1m/s to 5m/s on NACA 8420 aerofoil profile blade and deflection of air flow as per the change of velocity (in rpm) with a blade angle 0^o and curvature of the blade at 15^o. The flow rate of air can be determined based on the streamlines.

I. INTRODUCTION ABOUT WIND POWER GENERATION:

Wind turbines convert the harnessed wind power into electricity. Wind turbine converts the wind's kinetic energy into power. Wind turbines are built in different type’s vertical and horizontal axis. Battery charging for Boats or traffic-power warning signs is the most popular applications of the smallest turbines. Whereas larger turbines are used in contributing the domestic power supply while the unused power is selling back to the supplier through electrical grid.

Therefore the arrangement of larger turbines in proper arrays is known as wind farms, which gained much importance in renewable energy and are utilized by many countries to reduce the reliability on fossil fuels.

II. VERTICAL AXIS WIND TURBINES:

In Vertical- axis wind turbines (VAWTs) type the rotor shaft is arranged such that it transverse directly to the wind, while the other components are arranged at the turbine base. Such type of arrangement provides convenient service and repair for the gear box and generator which is located near the ground level. In "transverse axis wind turbine" or "cross-flow wind turbine” the VAWT axis is always perpendicular to streamline wind and functions. Drag-type Vertical axis wind turbines i.e. Savonius rotor operate at very low tip speed ratios than the lift-based vertical axis wind turbine i.e. Darrieus rotors. The turbines which spin on vertical axis are known as vertical turbines which have different shapes, sizes and material. VAWT and HAWT mainly differ by its position of blades. The turbine in which blades are on top rotating in air is known as HAWT whereas the turbine in which blades are rotating around the shaft is known as VAWT.VAWT are designed such a way that it is practically economical , quiet and efficient. Two different types of VAWTs are there. They are:

Fig.1: Vertical Axis Wind Turbine

The Savonius model and the Darrieus model. The first type of VAWT look like 60 gallon barrel cut in two half’s placed on the shaft which is rotating. Whereas the second type is very small and looks like an egg beater. Nowadays priority is given for savonius type of VAWT.

A. *Savonius Wind Turbine:*

A savonius VAWT consist of two or more blades having high torque, rotate very slow utilized in high reliability and low efficiency turbines. Generally wind turbines use lift developed airfoil shape blades to rotate a rotor, whereas savonius type VAWT uses drag developed airfoil shaped blades; therefore it can’t be rotate faster than approaching wind speed. The savonius type of VAWT is more popular than other types. As it is having more drag it is known for less efficient turbine, moreover it needs manual start and these characteristics increases the cost of this type of wind turbine.

III. NACA AIRFOIL SERIES:

The airfoil shapes for the wings of aircraft which is known as NACA airfoils was developed by the National Advisory Committee for Aeronautics (NACA).NACA airfoils shapes are represented by the last series of digits following the “NACA” word. To develop the airfoil cross-section and estimate its properties the parameters which are in algebraic code are entered into the equations. Early series of NACA airfoil i.e., four, five and four/five digit, were developed by using the critical equations which describe the curvature of the mean-line of the section airfoil and thickness division along the airfoil length. Later, six series which are more complex in shapes developed using theoretical methods are included in the family of series. Before NACA designed these airfoil design series, it was just the past experimentation with well known shapes and experience with those modified shapes.

IV. METHODOLOGY & WIND POWER GENERATION CALCULATIONS:

A. *Wind Power:*

Wind power can be calculated using the formula $P=1/2*\rho*A*V^3$, where (P=Power, ρ=density, A= swept area, V= velocity of wind).

Let the velocity of wind be 5m/s, the radius of the swept area is assumed to be 0.5mts. On substituting we get,

$P = 1/2 * 1.125 * 0.19625 * 5^3$

$= 13.79 \text{ kg m}^2 /\text{s}^3$

or

13.79 watts.

Hence at a wind speed of 5m/s the power of wind is 13.79 or approx. 14watts.

Similarly for different wind speeds the power generated is:

For V=1m/s; P=0.110 watts.

For V=2m/s; P=0.883 watts.

For V=3m/s; P=2.980 watts.

For V=4m/s; P=7.068 watts.

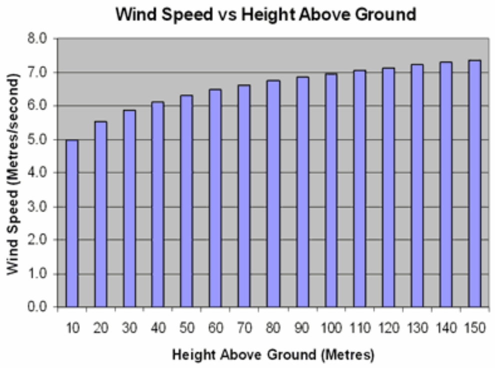

Fig.2 : Variation of Wind with Altitudes (Courtesy https://www.mpoweruk.com/wind_power.htm)

The variant of wind speeds with change of altitudes are shown in the above bar graph. From the graph it is observed that as altitude increases, the wind slowly increases to a greater valve. Therefore it is understandable that higher the altitude we have greater the wind power. That's why most of the turbines are installed at greater altitude for generating high power when compare to those located at lower altitudes. To analyze the performance of wind power production unit, following test is carrying out. In the beginning, the turbine rotor is made to drive for developing power and, in the next after one hour the battery is fully discharged. This same procedure is repetitive and for each hour the readings of power developed are noted. This data is shown in a bar chart.

- The subject, Design of windmill was very vast, therefore it depends on data analyze of different parts of windmill and its real drawings.
- This include the rotor assembly i.e. the blade and the hub, transmission shafts , the gear box, actuating pulley and the piston actuating mechanism, tail, turntable and the 2meters additional rig joined to the existing rig.
- To analyze the performance, the following steps should be carrying out. In the beginning the turbine with two blades prepared to rotate by applying different speeds utilizing a wind tunnel.
- The same results obtained by the field analysis are validated by conducting CFD analysis on the turbine blades, and the values of lift, drag, power etc., are verified.

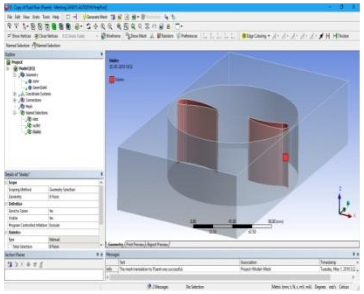

Fig.3: Modal in Fluid Flow Fluent

Now go to the meshing under the tree outline. Then specify the mesh size should be fewer than 512 k elements.

After the mesh was developed , go to the selection, then the front of the rectangle and right over it then select named selection. Under the named selected it as "inlet". Again go to the selection, and then the back of the rectangle and right over it then select named selection. Under the named selected it as "outlet".

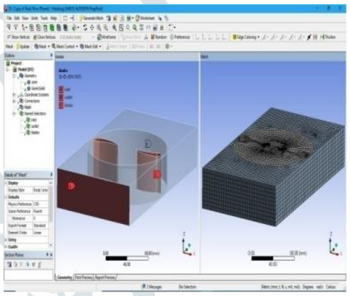

Fig.4: After The Name Selecting, Go To File And Select The Close Meshing.

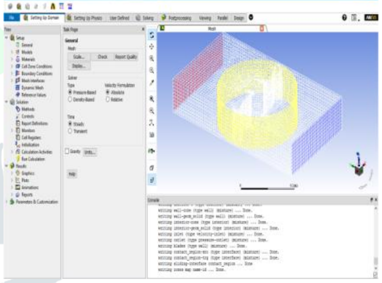

Fig.5: General Setting Under Fff Analysis

V. RESULTS & DISCUSSION:

For NACA 8420 blade profile with curvature of 15° with an angle of attack 0°, at different wind speeds i.e. 1m/s to 5m/s, the static pressure generated, velocity of the rotor shaft and stream line of the blades at different angles i.e. 0°, 90°, 180° & 270°. The results are shown in fig. 6 to fig. 17 and the consolidated results are shown in table 1 to table 4.

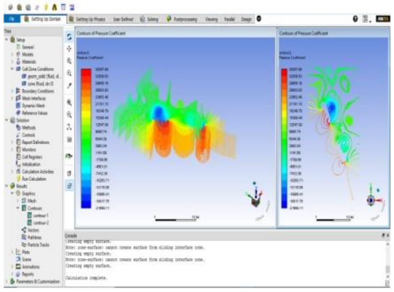

Fig.6: Contours- Pressure At Velocity 4 M/S

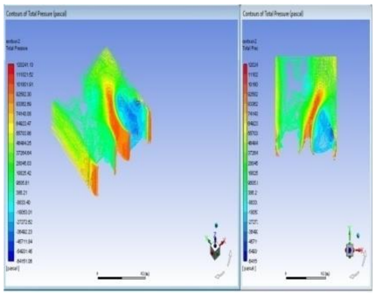

Fig.7: Contours- Pressure At Velocity 5 M/S

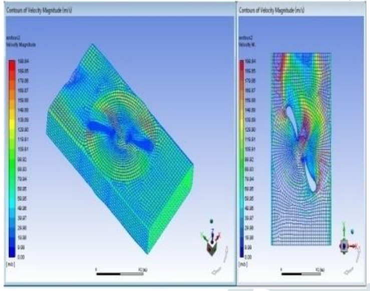

Fig.8: Contours – Velocity At Velocity 4 M/S

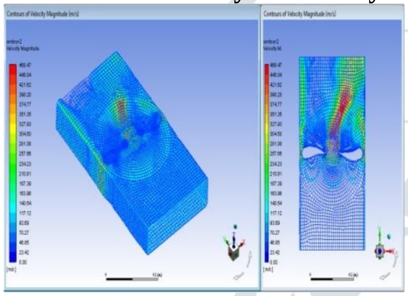

Fig.9: Contours – Velocity At Velocity 5 M/S

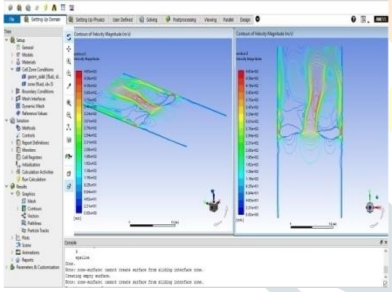

Fig.10: Contours – Velocity At Plane At Velocity 1 M/S

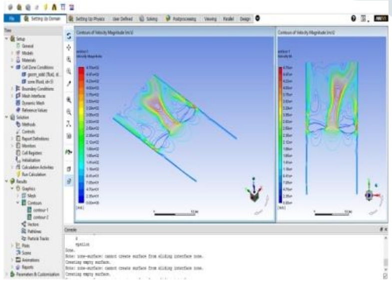

Fig.11: Contours – Velocity At Plane At Velocity 2 M/S

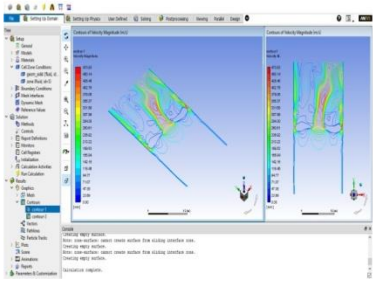

Fig.12: Contours – Velocity At Plane At Velocity 3 M/S

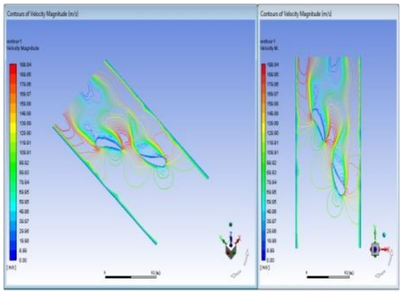

Fig.13: Contours – Velocity At Plane At Velocity 4 M/S

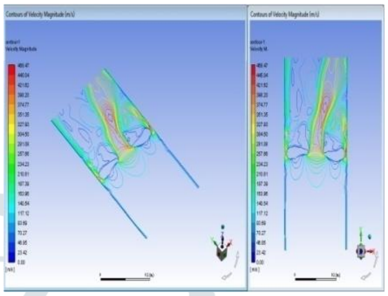

Fig.14: Contours – Velocity At Plane At Velocity 5 M/S

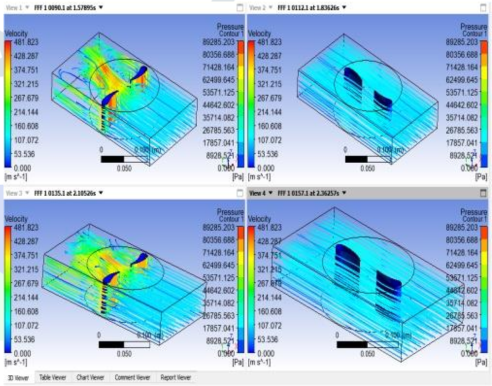

Fig.15: Stream Line- Air Flow At 1m/S At 0°, 90°, 180° And 270°

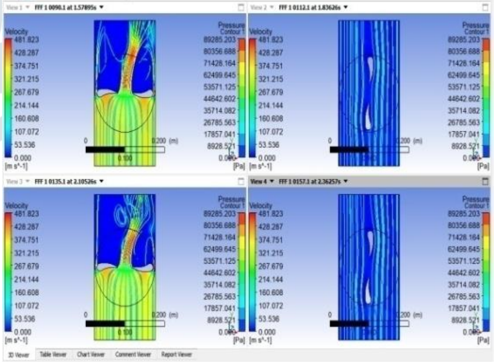

Fig.16: Contour- Pressure In Vertical At 1m/S At 0°, 90°, 180° And 270°

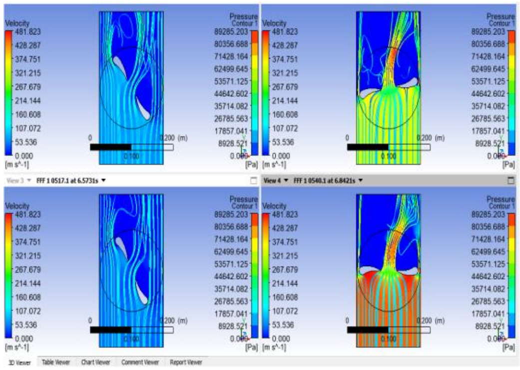

Fig.17: Contour- Pressure In Vertical At 5m/S At 0°, 90°,180° And 270°

Table 1: Theoretical calculated RPM at different wind speeds

Radius of zone (m)	π	Velocity (m/s)	ω (rad)	Speed of Turbine (Rpm)
0.5	3.14	1	0.3181	19.09
		2	0.6363	38.18
		3	0.9545	57.27
		4	1.2727	76.36
		5	1.5909	95.45

Table 2: Static Pressure at different wind speeds

Velocity (m/s)	Static Pressure (Pa)
1	9.24e4
2	8.15e4
3	141668.69
4	35357.88
5	120241.23

Table 3: Velocity of the rotor shaft at different wind speeds

Wind speed (m/s)	**Rotor shaft Velocity (m/s)**
1	463
2	470
3	473
4	199.84
5	468.47

Table 4: Available power generated at different wind speeds

Wind speed (m/s)	**Wind power generated (W)**
1	0.110
2	0.883
3	2.980
4	7.068
5	13.790

CONCLUSION:

For steady state simulation of NACA 8420 aerofoil 2 bladed using analytical software, the results concludes that at 5m/s the maximum power generated by aerofoil blade was 13.7W with rotor speed of 468.47m/s. Pressure distribution across the turbine blade is found to maximum of 9.24×10^4 Pa when the wind speed is at 1m/s. And the minimum pressure of 35357.88Pa at 4m/s. Maximum velocity of the rotor blade at wind speed of 3m/s is 473m/s. Streamline velocities at 1m/s to 5m/s at different angle positions of the blade at 0º, 90º, 180º, & 270º is 481.82m/s and their correspond pressure is 9285.203Pa. VAWT performance if it is enhanced it will be an immense improvement designed for the establishment of plant in all over the countries.

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