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Analysis and development of vertical wind axis turbine using CFD techniques

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Abstract

The paper contains study of VWAT named analysis and development of vertical wind axis turbine using CFD techniques . The analysis and comparison of various types of blade in this research computational fluid dynamic (CFD) software ANSYS CFX 13 and CATIA were used. Due to its simple design and low construction cost this rotor is mainly used for water pumping as well as wind power on small scale. This investigation was carried out to find aerodynamic characteristics like torque and power of wind turbine rotor model without change in rotor diameter, rotor height and velocity of wind. The main goal of this research is to improve the torque of vertical axis wind mill on the basis of shape of blade , angle of blade and number of blades. Further study on based on angle of blades and number of blades on the curve type and bucket type blades which are effective as compared to other shape of blades. Afterwards results were compared for verification. Study end at the result bucket type shape of blades have angle 30^0 and 8 number of blades give high performance and torque compared to other blades about 5.86 Nm.

1. Introduction

They are a type of wind turbine where the main rotor shaft is set vertically .there are two categories of modern wind turbine namely horizontal axis wind turbine and vertical axis wind turbine which are used mainly for electricity generation . The principal advantages of vertical axis forms are their ability to accpect wind from any direction. The VWAT may be drag or lift type. The blades of VWAT may be uniform section and untwisted making them relatively easy to fabricate or extrude unlike the blades of HWAT which should be twisted and tapered for optimum performance .furthermore, almost all of the components requiring maintenance are located at ground level facilitating the maintenance work appreciably. However, its high torque fluctuations with each revolution, no self starting capability are the drawbacks. The design of VAWT blades, to achieve satisfactory level of performance; starts with knowledge of them aerodynamic forces acting on the blades.The structural design of VAWT blades is also as important as their aerodynamic design. The dynamic structural loads which a rotor will experience play the major role in determining the lifetime of the rotor. In this paper a brief discussion of experimental and numerical work on savonius (drag) wind turbines will be discussed.

2. Work strategy

Following are the performance controlling parameters for VAWT that we are going to vary to improve performance i.e.

a. Shape of blade
b. Angle of blade w.r.t. centroid
c. No. of blade

2.1 Geometric modeling

a. Shape of blades :

1 **Fan type blade:** This is the actual blade shape provided by sponsored. It is used in existing design.

Fig 1: Fan shape blade

2. S shaped blade: This type of blade is used in Savonious turbines designed in earlier times of development. The concave part facing air stream is responsible for rotation of turbine. The convex part at the same time resists the motion.

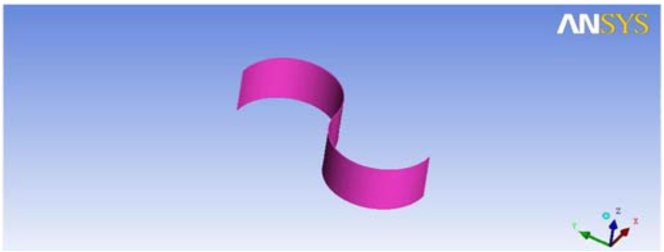


Fig 2: S shaped blade

3. Bucket type: These types of shapes with somewhat variations are widely used by many VAWT manufacturing firms. Its cost is higher because of its complex shape. The fibre composition is generally used for manufacturing this shape

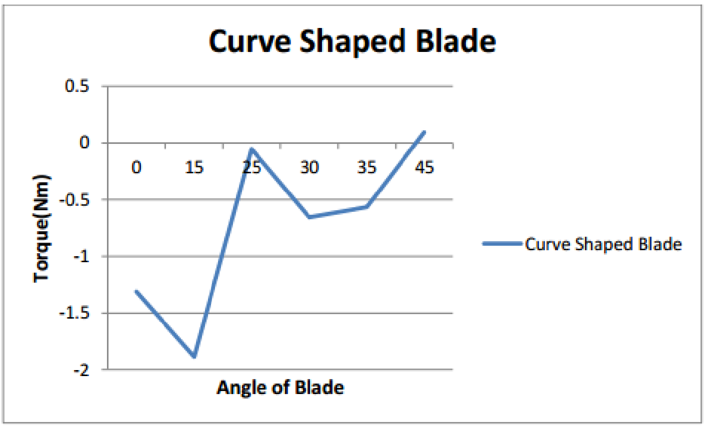
Fig 3: Bucket type blade

4. Curved shape blade : This shape is obtained from the geometry of stock blade. From cross section of stock blade, 3 corner points are used to extract a curve.
3.

Fig. 4: bucket shape blade

b. Angle of blade:

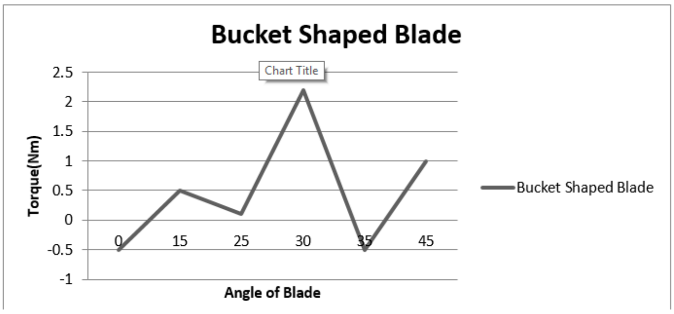
As no further modifications in Fan type and S shaped blade are possible, only the bucket shaped and curve shaped blades are tested for various blade angels, following are the results. 1. Curved blade: Curve shape blade is rotated around its centroid at angles of 10^0, 15^0, 25^0, 30^0, 35^0 and 45^0. The resulting torque values are presented in a graphical manner.



Graph 2.1: curve shape blade

2. Bucket shape blade

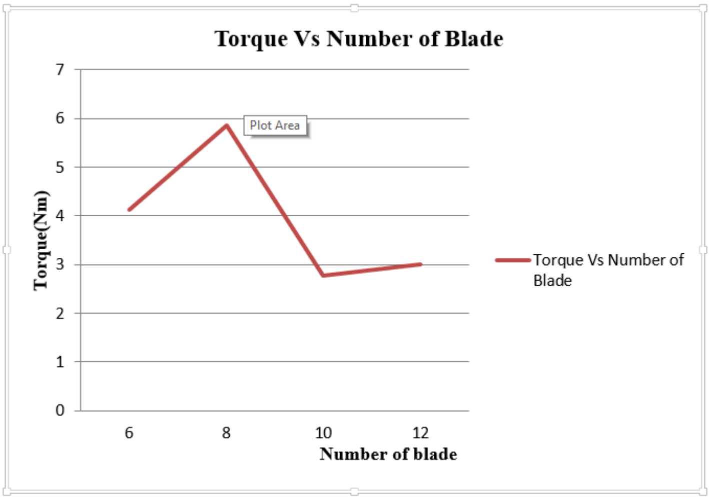
Bucket shape blade is rotated around its centroid at angles of 10^0, 15^0, 25^0, 30^0, 35^0 and 45^0.The resulting torque values are presented in a graphical manner.



Graph 2.2: bucket shape blade

3. Number of blades:

As until now, the Bucket shape blade at angle of 30^0 has given highest torque amongst all other cases analyzed, it is analyzed by varying the number of blades and following are the results obtained.



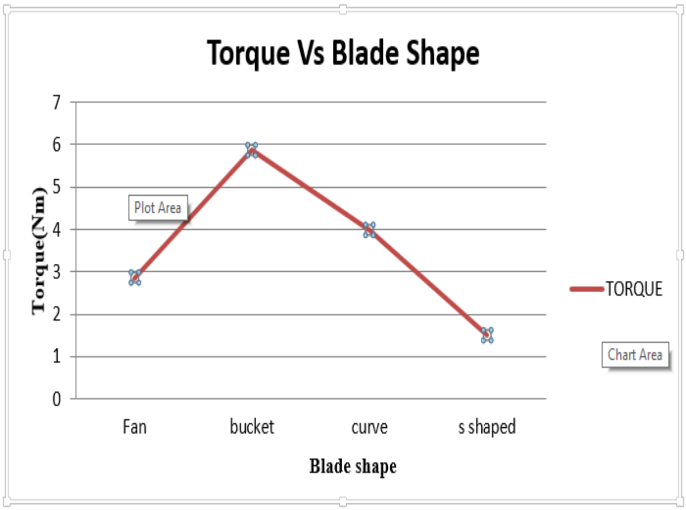
Graph 2.3: torque Vs number of blade

3. Results

For every case, the velocity of inlet air, angular velocity of rotor, boundary conditions, fluid properties and meshing parameters are kept constant. So the comparative study of various configurations of VAWT designs can be doneThe value of torque at blade surfaces predicted by software indicates the performance of the respective VAWT design. So the torque results are considered as a key parameter for comparison between different VAWT designs.As shown in previous chapter, some VAWTconfigurations have shown negative value of torque. i.e. the torque exerted by air at blade surface is negative. The significance of the negative value of the torque is that the specific design of VAWT cannot rotate at an angular velocity of 60 rpm when subjected to the wind velocity of 3 m/s. Similarly from the positive value of torque at blade surface we can interpret that the turbine will self start and rotate at 60 rpm.

3.1 Effect of shape of blade –

We designed 4 different types of blades and analyzed their performances. So the comparative study is done to study the effect of blade shape on torque produced on rotor blades. Following graph gives the comparison between all four blade shapes.

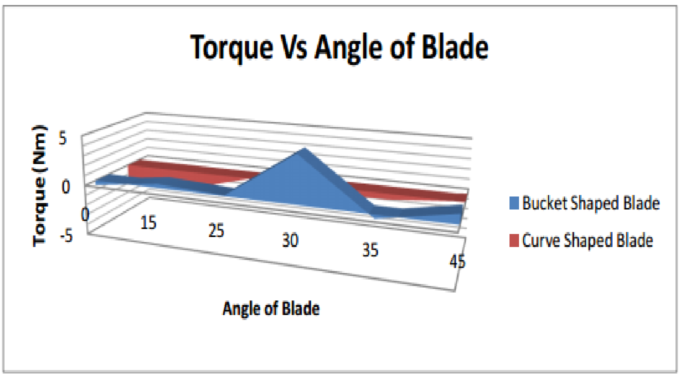


Graph 3.1: torque Vs blade shape

It can be seen from the graph that Bucket shape blade gives higher torque as compared to otherblade shapes. Curved and S shape blades also show good results than the fan type blade.

3.2. Effect of angle of blade :

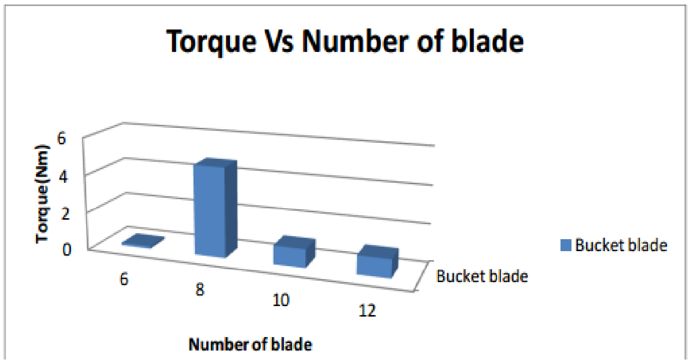
As no further modifications in Fan type and S shaped blade are possible, only the bucket shaped and curve shaped blades are tested for various blade angels, following are the results. From the graphs, it is observed that VAWT designs are very much sensitive to the angle of blade. Even a 5^0 change in the blade angle which is actually very negligible considering size of the blade and rotor, shows significant variation in torque produced on blade surface.Amongst all the configurations tested for variation of blade angle, bucket shape blade at angle of 30 degree gives best results.



Graph 3.2: torque Vs angle of blade

3.3Effect of Number of blades:

As the Bucket shape blade has proven better than other blades so far, bucket shape blade at angle of 30^0 is analyzed by varying the number of blades mounted on rotor and following are the results obtained. So from the graph it is observed that there is no linear relationship between the number of blades and the torque produced on blade surface. The VAWT gives good results only when specific numbers of blades are used. As the variation is very random, we cannot derive any specific relation between the torque produced and the number of blades used. we can only conclude that bucket shape blade with angle 30^0 gives best results when 8 numbers of blades are used amongst all other cases considered in this project.



Graph 3.3: Torque Vs number of blade

Conclusion

- Vertical Axis Wind Turbines (VAWT) are very sensitive to the parameters considered in this project, those are shape of blade, angle of blade and number of blades.
- The relationship between the performance of VAWT and these design parameters is non linear and very random so, any kind of empirical relation or equation cannot be established.
- Amongst all the configurations analyzed, the bucket shaped blade at blade angle of 30^0 (w.r.t.centroid) with 8 no. of blades gives best results for the current design of VAWT considered.

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