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Effect of Tail Shapes on Yawing Performance of Micro Wind Turbine

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Abstract: Wind energy is one of the most widely used renewable energy resources. Large amounts of research and resources are being spent today in order to harness the energy from wind effectively. Large wind turbines are erected at windy site and delivering satisfactory performance. Small wind turbines are erected in low wind regions and are in development stage. Research activities are increasing at a significant rate in the field of small wind turbines. World wind energy association forecast considerable development in this field. To face the wind directions, small wind turbines are using mechanical systems in the form of tail. The conventional tail changes the direction of the wind turbine to accommodate the variation of the incoming direction of winds. Quick and steady response is important as per change in wind directions. It has considerable effect on the wind turbine performance. The tails are having different shapes, but literature is not available about it. Different manufacturers used different tail shapes for their model, but the effect of tail shapes has not been studied yet. Hence, it is necessary to study the effect of tail shapes on the performance of wind turbine. This paper presents the effect of tail shapes on the performance of wind turbine. In this work three different tail shapes; rectangular, trapezoidal and triangular are considered. The yawing performance for these tail shapes using CFD analysis is carried out and presented in this paper.

Keywords: CFD, Small Wind Turbine, Tail Shape, Yawing

1. Introduction

Due to the increase in energy consumption and depletion of non renewable sources; there is need of clean renewable energy sources. Renewable energy devices such as wind turbines are playing a tremendous and significantly increasing role in the generation of electric power, in worldwide [1-4]. Countries in Europe and Asia are putting massive effort in the development of wind energy technology. At the end of 2013; the recorded small wind capacity installed worldwide has reached more than 755MW. This is nothing but the growth of more than 12% compared with 2012, when 678MW were registered. The technology of large wind turbines has been developed well; while small wind turbine technology is in development stage. The market for small wind turbine technology is encouraging in India also [2].

Generally, wind turbines, which are producing power in the range of 1-100kW, are called as small wind turbines. This definition of small wind turbines is found different for different countries [2]. Small wind turbines operating at low wind speeds regularly face the problem of yawing performance due to the uneven nature of wind. Because of this uneven nature of wind, the rotor axis of a wind turbine rotor is usually not aligned with the wind [11]. Due to which the rotor is not capable of following the variability of wind and so spends most of its time in a yawed condition. The yawed rotor is less efficient than the non-yawed rotor and so it is important to assess the efficiency for purposes of energy production estimation. In order to ensure the extraction of maximum wind potential even at lower wind speeds, most of the small wind turbines point into the wind using a tail assembly [5-6].

Presently, most of the leading small wind turbine manufacturers use different kind of tail shapes in their assembly [2]. The sufficient information about tails shapes and their effect on yawing performance of wind turbine is not available. This paper presents an investigation on the effect of different tail shapes on yawing performance of a micro wind turbine. Also, different pressure response and forces acting on the front side of different tail shape at different angle is observed and evaluated. In order to investigate this effect, three different tailshapes; rectangular, trapezoidal and triangular are considered and yawing performance for these shapes is recorded computationally.

2. Yawing in Wind Turbine

In small wind turbine, alignment of rotor surface area facing the wind direction is nothing but the yawing. In other words, rotation of the rotor axis about a vertical axis (for horizontal axis wind turbine only) is called yawing [7]. Horizontal-axis wind turbine yaw system is mainly divided into two types: passive yaw and active yaw. Mostly the active yaw system is used in large wind turbines; while the passive yaw system is adopted by small wind turbines. The active yaw systems are equipped with some of torque producing device able to rotate the nacelle of the wind turbine against the stationary tower based on automatic signals from wind direction sensors or mutual actuation. The passive yaw systems utilize the wind force in order to adjust the orientation of the wind turbine rotor into the wind. In their simplest form these systems comprise a simple roller bearing connections between the tower and the nacelle and tail fin mounted on the nacelle and designed in such way that it turns the wind turbine rotor into the wind by exerting a corrective torque to the nacelle. Therefore, the power of the wind is responsible for the rotor rotation and the nacelle orientation. Alternatively in case of downwind turbines the tail fin is not necessary since the rotor itself is able to yaw the nacelle into the wind. Yaw system used in downwind turbines sometime called as semiactive yaw system [8]. Types of yaw system used in wind turbine are shown in Figure 1.

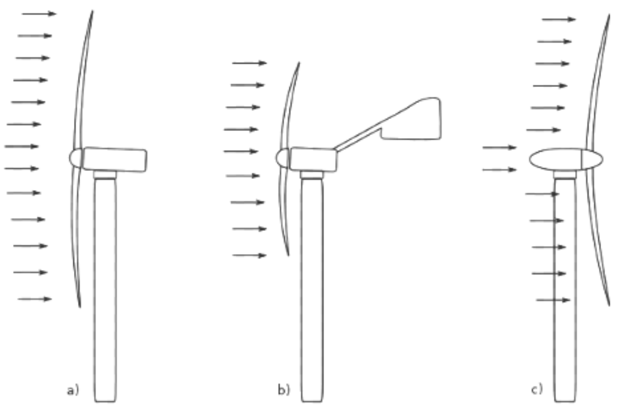

Figure 1. *a) active yaw system in large WT; b) passive yaw system used in upwind turbine; c) semiactive yaw system in upwind turbine.*

3. Computational Analysis

In order to know yawing performance of a micro wind turbine, it is necessary to determine the pressure distribution and forces acting on the surface of tail shape. The pressure and forces acting on the vane area were determined using Computational Fluid Dynamics. During this analysis, wind having 7m/s velocity and rotor with 350 rpm was considered. Pressure plots for 0,10,20,30 degree angle of inclination were obtained. This section presents various pressure plots of trapezoidal, rectangular, triangular tail shapes at different inclinations. The computational results of these tail shapes are presented in Figure. 2 to Figure 13.

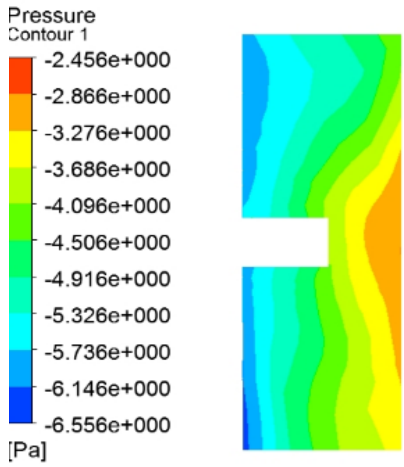

Figure 2. *Pressure Plot for rectangular tail at 0 degree.*

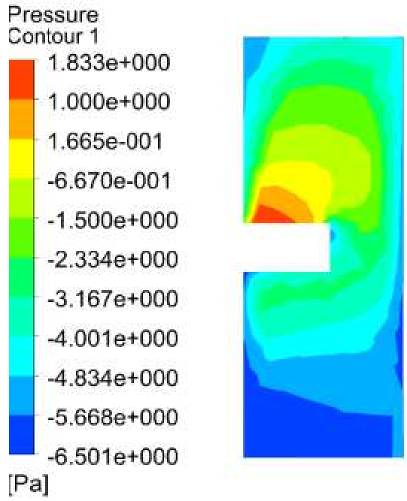

Figure 3. *Pressure Plot for rectangular tail at 10 degree.*

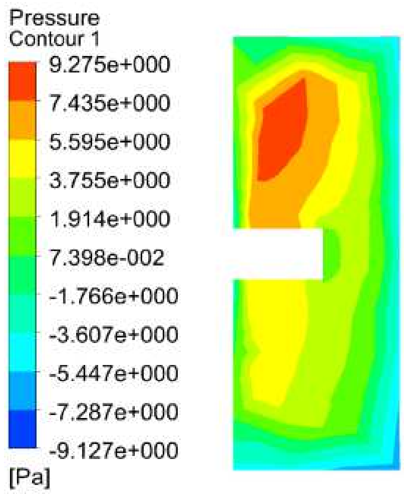

Figure 4. *Pressure Plot for rectangular tail at 20 degree.*

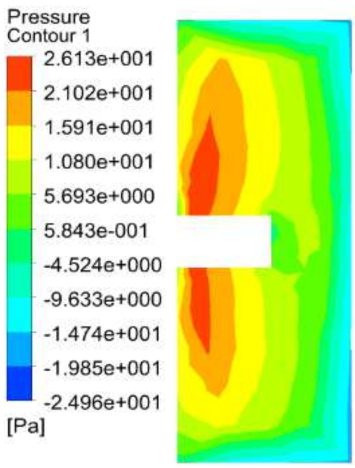

Figure 5. *Pressure Plot for rectangular tail at 30 degree.*

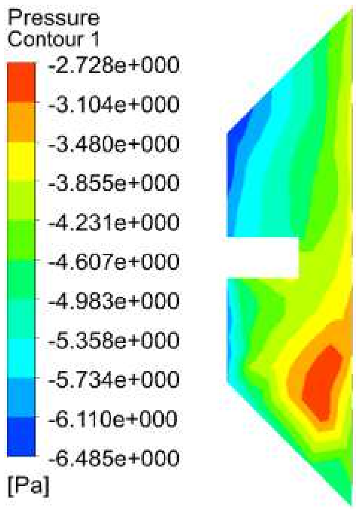

Figure 6. *Pressure Plot for trapezoidal tail at 0 degree.*

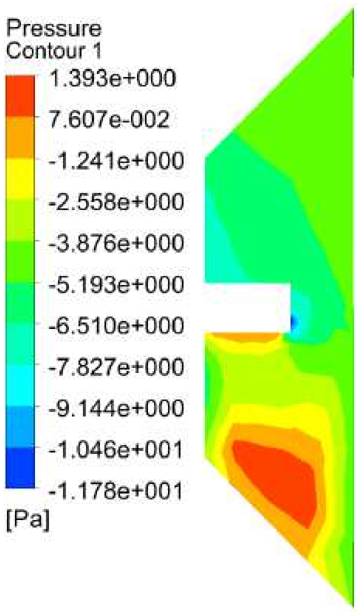

Figure 7. *Pressure Plot for trapezoidal tail at 10 degree.*

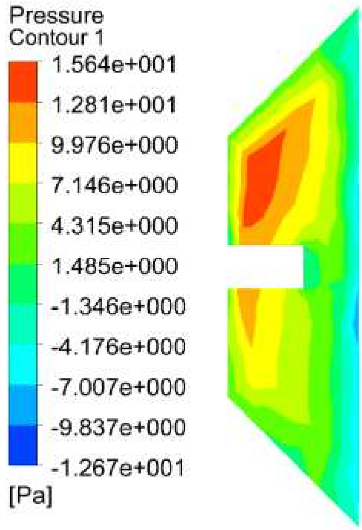

Figure 8. *Pressure Plot for trapezoidal tail at 20 degree.*

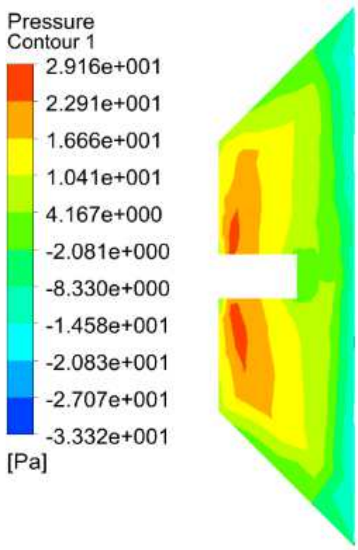

Figure 9. *Pressure Plot for trapezoidal tail at 30 degree.*

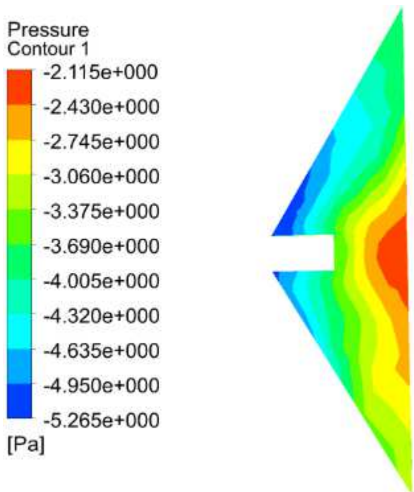

Figure 10. *Pressure Plot for triangular tail at 0 degree.*

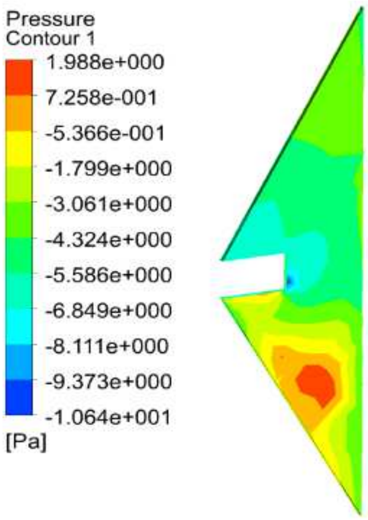

Figure 11. *Pressure Plot for triangular tail at 10 degree.*

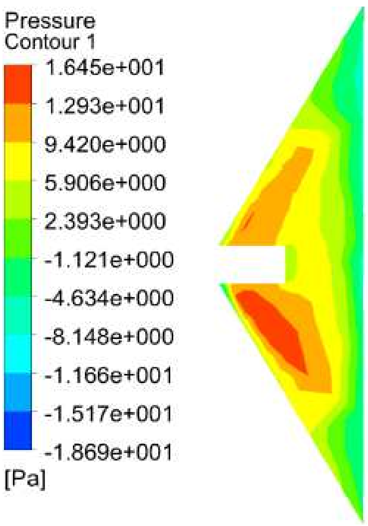

Figure 12. *Pressure Plot for triangular tail at 20 degree.*

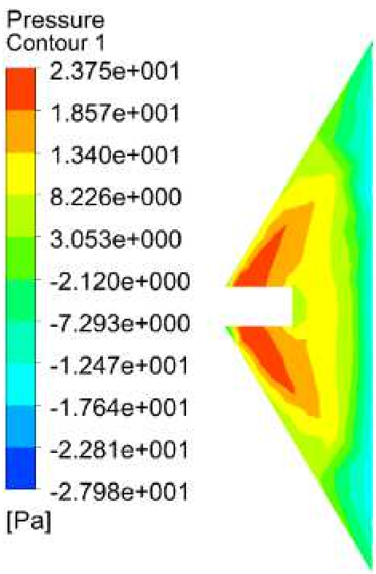

Figure 13. *Pressure Plot for triangular tail at 30 degree.*

4. Results and Discussion

The results obtained through computational analysis were significant. Table.1 shows the forces acting on trapezoidal, rectangular, triangular tail shapes at different angle of inclination. These results show that the pressure and forces induced on triangular tail shape are slightly higher than that of trapezoidal and rectangular tail.

Table 1. *Force Acting on Different Tail Shapes.*

Angle of Inclination (degree)	Forces(N) acting on		
	Rectangular Tail	Trapezoidal Tail	Triangular Tail
0	0.00106	0.00113	0.00196
10	0.00557	0.00574	0.00660
20	0.02797	0.04420	0.05280
30	0.07152	0.07551	0.07759

5. Conclusion

Three uniform micro wind turbines having different tail shapes of same area are modeled and analyzed successfully using CFD software. The results obtained from computational analysis are favorable for triangular shape. From which it is clear that yawing performance of triangular shape is better followed by trapezoidal and then rectangular shape. These results show that use of triangular tail shape will slightly improves performance of wind turbine compared to other two tail shape. It is also observed that as angle of inclination increases forces on tail shapes are also increases.

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