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Effect of Lift on Wind Turbine Blade Design Parameter

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ABSTRACT

Blade is one of the most important parts for a wind turbine system. Power obtained from the wind can only be extracted when a better design of the blade. Power and the coefficient of lift is calculated easily which is important factor for wind blade design.

INTRODUCTION

Wind turbine blades are shaped to generate the maximum power from the wind at the minimum cost. Primarily the design [1] is driven by the aerodynamic requirements, but economics mean that the blade shape is a compromise to keep the cost of construction reasonable. In particular, the blade tends to be thicker than the aerodynamic optimum close to the root, where the stresses due to bending are greatest.

As well as varying day-to-day, the wind varies every second due to turbulence caused by land features, thermals and weather. It also blows more strongly higher above the ground than closer to it, due to surface friction. All these effects lead to varying loads on the blades of a turbine as they rotate, and mean that the aerodynamic and structural design needs to cope with conditions that are rarely optimal.

The blades of a wind turbine are usually made from composite materials. Composite materials are often preferred because of the possibility of achieving high strength and stiffness-to weight ratio (Manwell et al. 2002)[2]. They are also corrosion resistant and good electrical insulators. These properties are advantageous in an offshore environment where corrosion is a critical factor to be considered.

There are two major forces acting on wind turbine blades as they rotate: Lift and Drag as shown in fig.1. Lift and drag are in constant competition, acting to cancel each other out. When optimizing wind turbine blades, the goal is to maximize the lift force while minimizing the drag force.

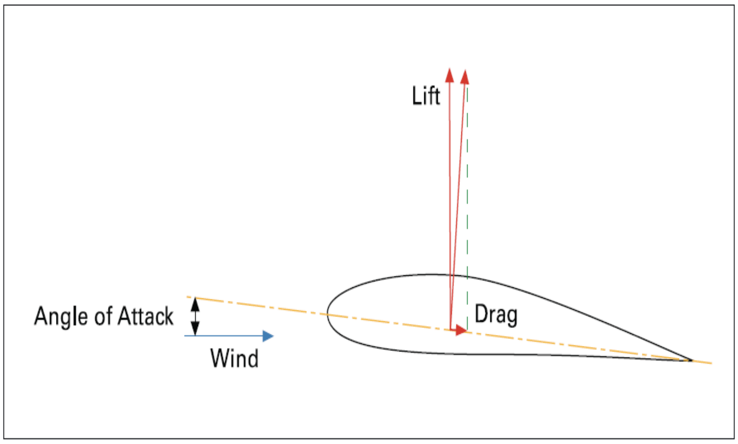

Fig.1 Lift and Drag [3]

DEVELOPMENT OF LIFT ON AN AIRFOIL

The airfoil is characterised by its chord length C, angle of attack and span length L of the airfoil. The lift on the airfoil is due to negative pressure created on the upper part of the airfoil. The drag force on the airfoil is always small due to design of shape of the body, which is streamed lined. From the theoretical analysis the circulation developed on the airfoil so that the stream line at the trailing edge of the airfoil is tangential to the airfoil is given as

$$\Gamma = \pi \, CU \, \mathrm{Sin}\alpha \qquad (1)$$

Where C = chord length

U= Free stream velocity of the airfoil

$\propto$= Angle of attack

Lift force F_L is given by the equation as

$$F_L = \rho \, UL \, \Gamma = \rho \, UL \times \pi \, CU \, \mathrm{Sin}\propto$$

$$= \rho \, \pi \, CU^2 \, L \, \mathrm{Sin}\propto \qquad (2)$$

The Lift Force is given by equation as,

$$F_L = C_L \times A \times \frac{\rho U^2}{2}$$

$$F_L = C_L \times A \times \frac{\rho U^2}{2}$$

Where C_L = Co-efficient of Lift

A = Projected Area = C × L for airfoil

$$F_L = C_L \times C \times L \times \frac{\rho U^2}{2} \qquad (3)$$

Equating the two values of lift force given by the equations (1) and (3.18), as

$$\rho \, \pi \, CU^2 \, L \, \mathrm{Sin}\propto = C_L \times C \times L \times \frac{\rho U^2}{2}$$

$$C_L = \frac{2\pi\rho \, C \, U^2 \, L \, \mathrm{Sin}\alpha}{C \times L \times \rho \, U^2} = 2 \, \pi \, \mathrm{Sin} \, \alpha \qquad (4)$$

Thus it is clear from the above equation (4) that co-efficient of Lift depends upon the angle of attack.

RESULT

From the equation (4) the lift can be calculated easily. In designing wind turbine blade lift force is important. The lift force increases as the blade is turned to present itself at a greater angle to the wind. This is called the angle of attack. At very large angles of attack the blade “stalls” and the lift decreases again. So there is an optimum angle of attack to generate the maximum lift. Fig.4 shows the positions of different angle of attack.

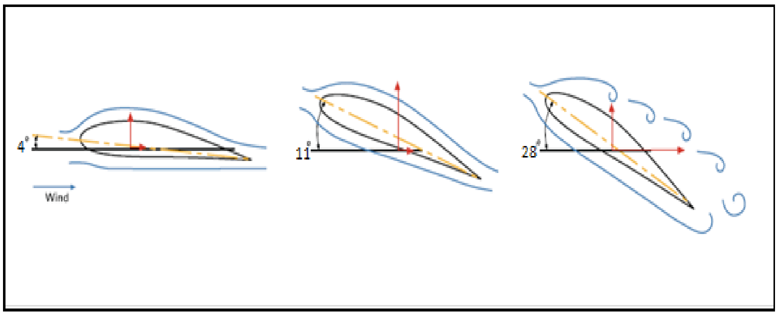

Fig. 2 Blade at Low, Medium and High Angle of Attack

There is, unfortunately, also a retarding force on the blade: the drag. This is the force parallel to the wind flow, and also increases with angle of attack. If the aerofoil shape is good, the lift force is much bigger than the drag, but at very high angles of attack, especially when the blade stalls, the drag increases dramatically. So at an angle slightly less than the maximum lift angle, the blade reaches its maximum lift/drag ratio. The best operating point will be between these two angles.

CONCLUSION

The blades have an aerodynamic profile in cross section to create lift and rotate the turbine. So angle of attack is 4 degree that will create enough force to rotate the turbine easily. This is optimum parameter.

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