SNS COLLEGE OF ENGINEERING

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

19EE711 SOLAR AND WIND ENERGY

UNIT II-WIND GENERATOR TOPOLOGIES

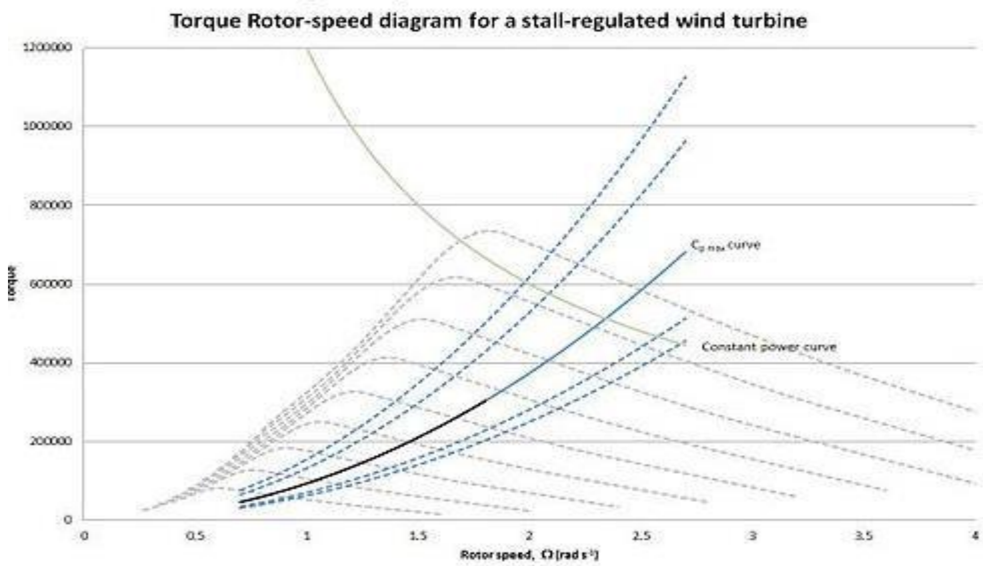
Operating strategies for variable speed

Stall regulated

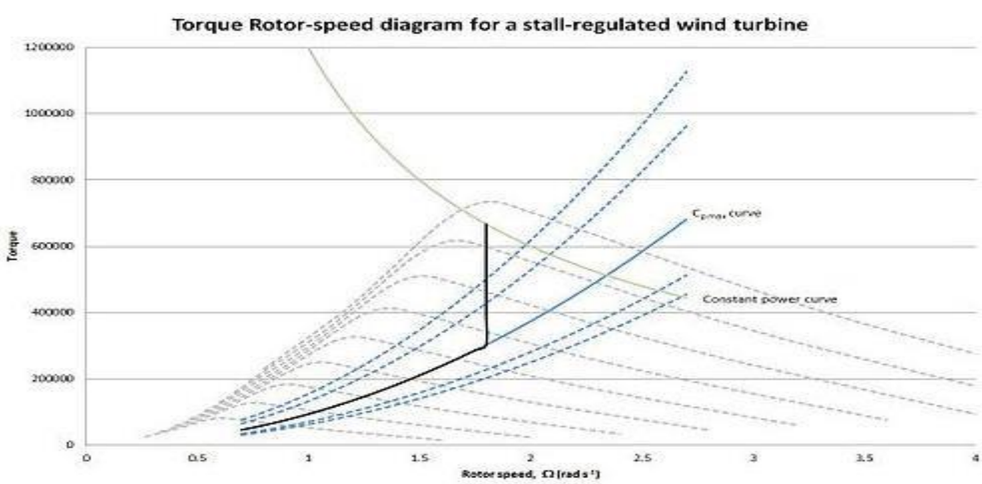
As discussed earlier, a wind turbine would ideally operate at its maximum efficiency for below rated power. Once rated power has been hit, the power is limited. This is for two reasons: ratings on the drivetrain equipment, such as the generator; and second to reduce the loads on the blades. An operating strategy for a wind turbine can thus be divided into a sub-rated-power component, and a rated-power component**.**

Below rated power

Below rated power, the wind turbine will ideally operate in such a way that Cp=C pmax. On a Torque-rotor speed diagram, this looks as follows:



where the black line represents the initial section of the operating strategy for a variable speed stall- regulated wind turbine. Ideally, we would want to stay on the maximum efficiency curve until ratedpower is hit. However, as the rotor speed increases, the noise levels increase. To counter this, the rotor speed is not allowed to increase above a certain value. This is illustrated in the figure below:

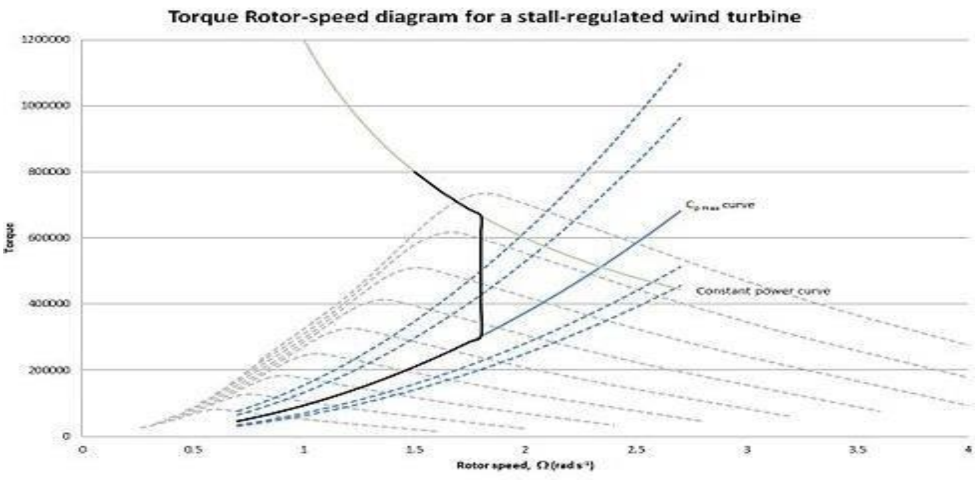


Rated power and above

Once the wind speed has reached a certain level, called rated wind speed, the turbine should not be able to produce any greater levels of power for higher wind speeds. A stall-regulated variable speed wind turbine has no pitching mechanism. However, the rotor speed is variable. The rotor speed can either be increased or decreased by an appropriately designed controller. In reference to the figure illustrated in the blade forces section, it is evident that the angle between the apparent wind speed and the plane of rotation is dependent upon the rotor speed. This angle is termed the angle of attack.

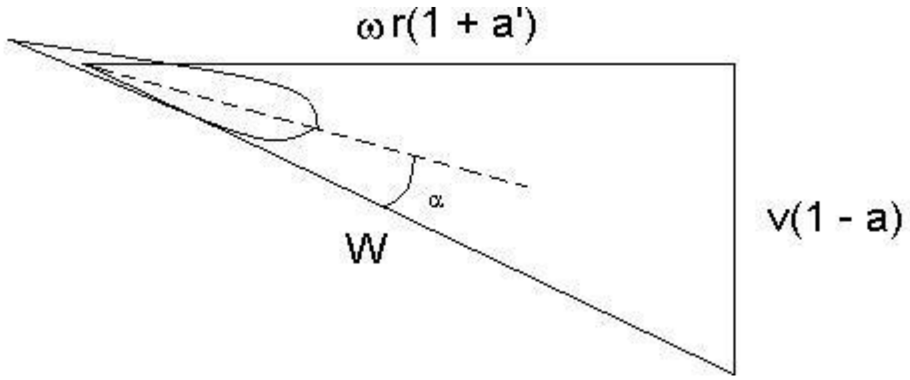
The lift and drag co-efficients for an airfoil are related to the angle of attack. Specifically, for high angles of attack, an airfoil stalls. That is, the drag substantially increases. The lift and drag forces influence the power production of a wind turbine. This can be seen from an analysis of the forces acting on a blade as air interacts with the blade (see the following link). Thus, forcing the airfoil to stall can result in power limiting.

So it can be established that if the angle of attack needs to be increased to limit the power production of the wind turbine, the rotor speed must be reduced. Again, this can be seen from the figure in the blade forces section. It can also be seen from considering the torque-rotor speed diagram. In reference to the above torque-rotor speed diagram, by reducing the rotor speed at high wind speeds, the turbine enters the stall region, thus bringing some limiting to the power output.



Blade forces

Consider the following figure:



This is the depiction of the apparent wind speed, as seen by a blade (left of figure). The apparent wind speed is influenced by both the free-stream velocity of the air, and the rotor speed. From this figure, we can see that both the angle theta and the apparent wind speed W are functions of the rotor speed, omega . By extension, the lift and drag forces will also be functions of omega . This means that the axial and tangential forces that act on the blade vary with rotor speed. The force in the axial direction is given by the following formula: