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Effects of Vortex Generator Placement on a Horizontal Axis Wind Turbine Blade

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Problem Statement

- Vortex generators are used to delay flow separation and increase the lift of a wing or wind turbine blade
- There are lots of different shapes and sizes of vortex generators, in this study triangle vortex generators were used
- Four cases of vortex generators were studied:0°, 15°, 20°, and a clean airfoil
- All cases had 6 vortex generators evenly spaced and placed at 20% chord length
- Purpose of the study was to determine the optimal placement of vortex generators

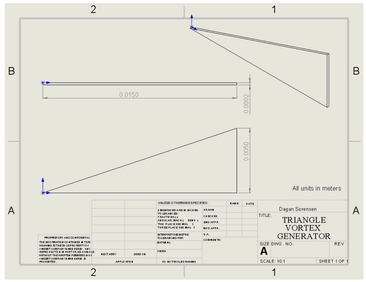

Figure 1: Vortex generator dimensions

Geometry and Meshing

- The geometry was created using SolidWorks 3D modeling
- A small cross section of a wind turbine blade was modeled using an NREL S809 airfoil
- The flow field mesh was created using Pointwise mesh generation software
- The vortex generators and the airfoil were modeled as a solid wall with slip condition
- The two sides of flow field were modeled as solid wall with no slip
- The inlet velocity was set to 17.2m/s or 0.05 Mach

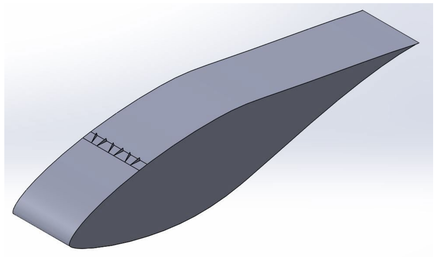

Figure 2: SolidWorks model of the 15° case

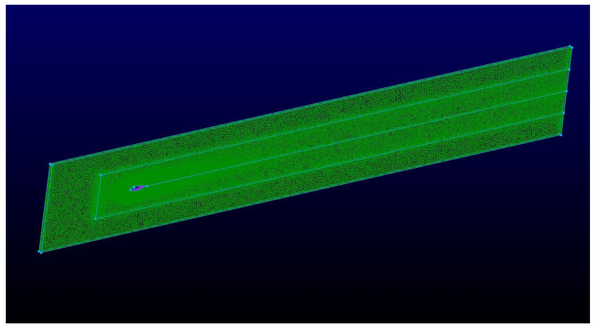

Figure 3: Picture showing the entire flow field mesh that was generated.

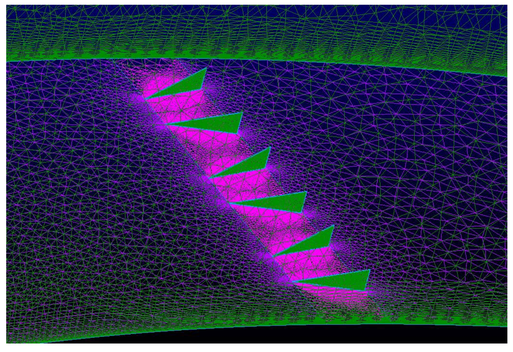

Figure 4: Close up of the mesh around the vortex generators, showing t-rex cells generated that surrounded the edge of the airfoil

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Results

- The figures to the right demonstrate the flow separation control of the vortex generators
- In the cases with the vortex generators at and angle, the bottom two pictures, it is evident that the flow separation occurs much later along the chord than in the other cases
- The torque, thrust, and power produced by the wind turbine were calculated using the blade element method, which can be seen in Table 1
- The wind turbine blades were modeled as straight blades with a uniform chord length

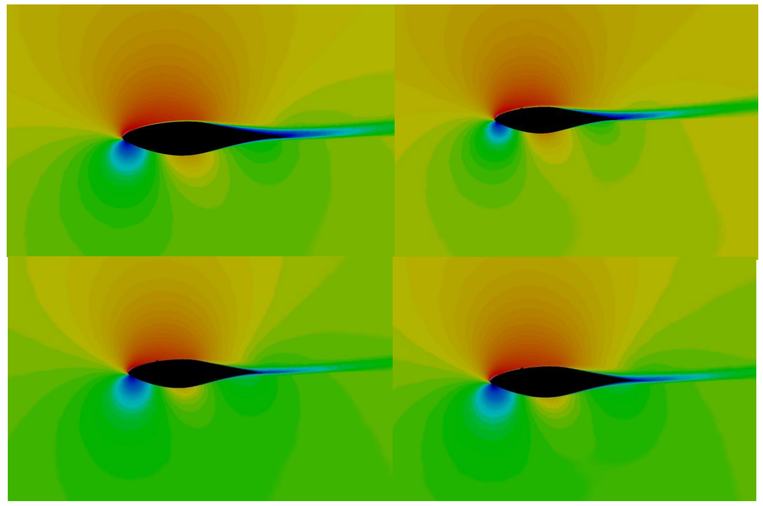

Figure 5: Velocity magnitudes for each of the clean airfoil(top left), the 0° case(top right), the 15° case(bottom left), and the 20° case(bottom right)

Table 1: Calculated torque and thrust for a single blade for each of the four cases run

	Clean	0°	15°	20°
Torque (N-m)	1647	1520	1808	1780
Thrust (N)	2831	2681	3037	3023

Table 2: Numerical results of the coefficients of lift and drag obtained from the CFD solution

	Clean	0°	15°	20°
C_l	0.065971	0.062352	0.070692	0.070351
C_d	0.0027184	0.0027658	0.0027307	0.0028060

Conclusions and Recommendations

- From the calculated thrust and torque on the wind turbine blade, the angular placement of 15° is the most optimal, as it provided the most amount of torque
- The airfoil vortex generators placed at 15° also had the highest lift to drag ratio
- The 20° case had similar lift to that of the 15° case, however the increase in drag made this angle less desirable
- If this study were to be conducted again, it would be advised to run additional cases in order to better understand the effects of vortex generator placement.