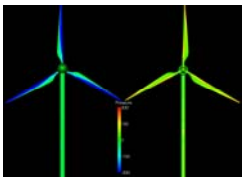
CFD Model of rotating Horizontal Axis Wind Turbine



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Wind Turbine Model

Introduction | Background | Model & Mesh | Results | Conclusions

This project aims to model wind turbine operation using CFD.

Objectives:
- to implement in Fluent a 3D model for turbine blades rotation.
- to evaluate the lift and drag coefficients of the model and validate
- to study the wake behind the turbine compared with rotational velocity
- to visualize the pressure distribution on the wind turbine

The focus of this model was on Three-Blade Horizontal Axis Wind Turbine (HAWT) (As seen to the right)

The Three-Bladed HAWT is the most common wind turbine because of its combination of efficiency and dynamic stability

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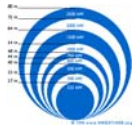
Theory:
- A wind turbine produces energy by transforming the kinetic energy from the wind into mechanical work
- From actuator-disc theory the maximum theoretical efficiency of a wind turbine is 59%; known as Betz Law
- Currently the average HAWT is 35% efficient

Power & Size:
- Power in the wind $P = \frac{1}{2}(\pi r^2)V^3$
- Scales with the square of the turbine radius
- Scales with the CUBE of the velocity



Spacing & Wake effect:
- Turbines are most effective in areas of strong & steady wind
- Placed High off ground
- Placed outside of the wake of one another
- The wake effect increases land space needed and cost

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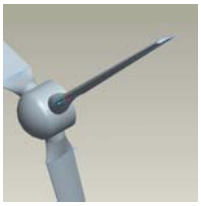
Model:
- Modeled in Pro/E and imported into gambit
- 30 meter blade length
- Airfoil angle of attack 6 degrees
- Realistic blade variation from hub to tip



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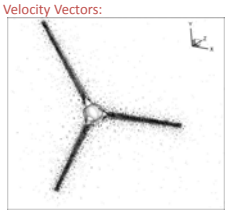
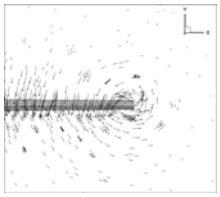
Velocity Vectors:





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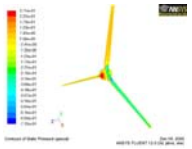
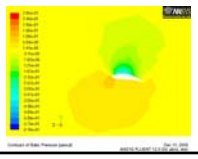
Pressure & Axial Velocity Contours:





Notes:
- Stagnation Point
- Low pressure on blade top
- High pressure on blade bottom
- Axial Velocity Distribution Similarity