THE UNIVERSITY OF ALABAMA IN HUNTSVILLE | COLLEGE OF SCIENCE

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Qualification of the Aerodynamic Performance Degradation of an Iced Wind Turbine Model

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Overview/Introduction

- In recent years, wind energy has emerged as a highly promising renewable energy source.
- A significant challenge is ice accretion on wind turbines during winter, which increases surface roughness and diminishes aerodynamic efficiency.
- This project aims to enhance the fundamental understanding of how icing affects aerodynamic performance by utilizing force sensors to measure performance degradation.

Explanation/Conceptual Framework

- We examined the DU91-W2-250 model, which features the airfoil used at the midspan of a wind turbine.
- Our study focused on glaze ice, which forms from supercooled precipitation and is difficult to remove. Both designs used PLA (Polylactic Acid) 3D printing.
- An aluminum beam was inserted through the airfoil at 25% of the chord (c/4) to allow for adjustments of the angle of attack (AOA).
- Using a 6-axis load cell, we measured the lift and drag on the airfoil model.

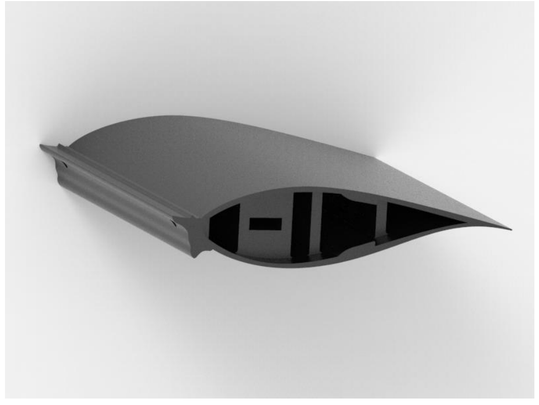

Figure 1: CAD model of airfoil with ice

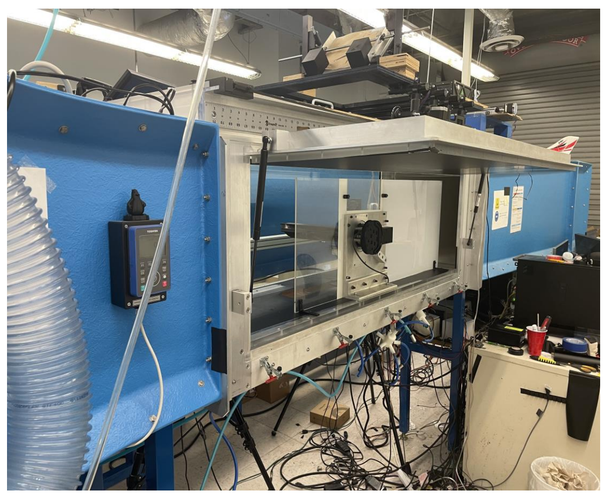

Figure 2: Equipment in the Wind Tunnel

Key Findings/Results

- The CL vs AOA and CD vs AOA plots show that the lift decreased and the drag increased with the ice model. Specifically, CL is reduced by as much as 1/3 to 1/2 by Ice.
- In the CL vs AOA plot, it is evident that with ice, the airfoil experiences stall at a lower angle of attack (AOA) compared to the airfoil without ice. This phenomenon occurs because the ice causes earlier flow separation and accelerates the transition from laminar to turbulent flow around the airfoil.
- The CL vs CD plot reveals a significantly higher lift-to-drag ratio without ice, emphasizing the diminished efficiency of the airfoil when ice is present.

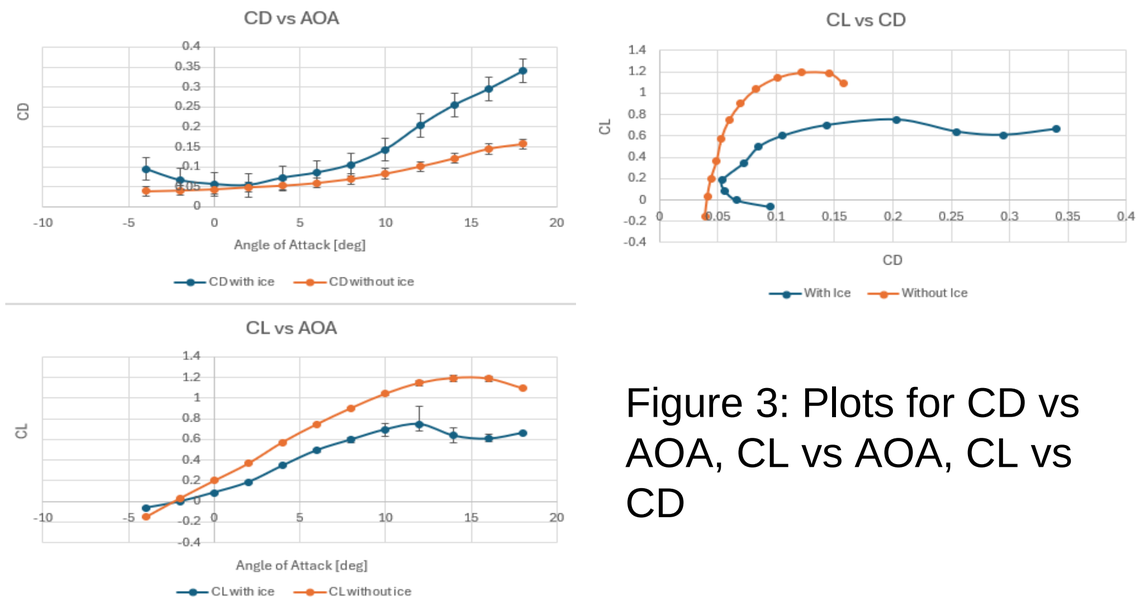

Figure 3: Plots for CD vs AOA, CL vs AOA, CL vs CD

Impact/Conclusions

- Force measurements indicate that ice accretion on airfoils during winter adversely affects both lift and drag generation.
- Due to time constraints, PIV measurements were not conducted during this study. Future work will focus on analyzing flow separation and wake characteristics influenced by ice accumulation using PIV measurement.

References

1. Broeren, A. P., Addy, H. E., Bragg, M. B., Busch, G. T., & Montreuil, E. (2011). *Aerodynamic Simulation of Ice Accretion on Airfoils*

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