SDSU
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PROJECT GRIDLOCK

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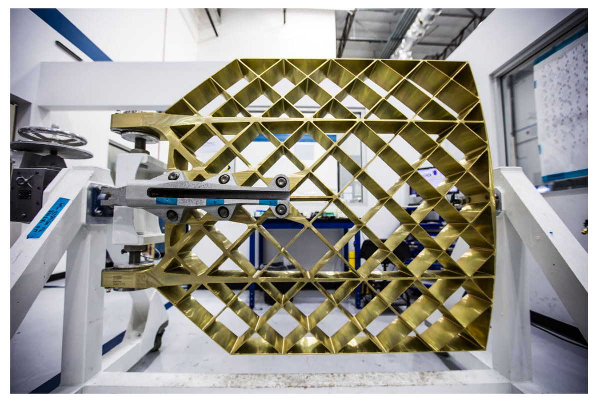
GRID FIN APPLICATIONS

Grid fins are unconventional control surfaces used in missiles and rockets, and they
- Improve lifting abilities at high angles of attack
- Have a smaller hinge moment than traditional planar wings
- Allow for reusability of rockets and fins for other missions
- Control the roll, pitch, and yaw



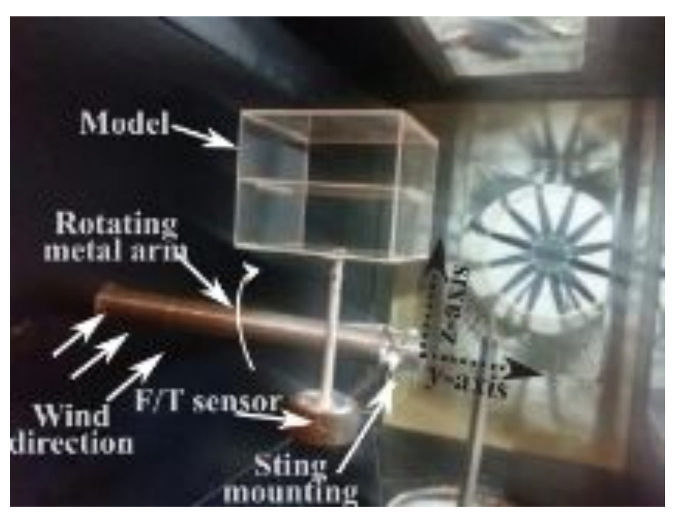

RESEARCH QUESTION AND HYPOTHESIS

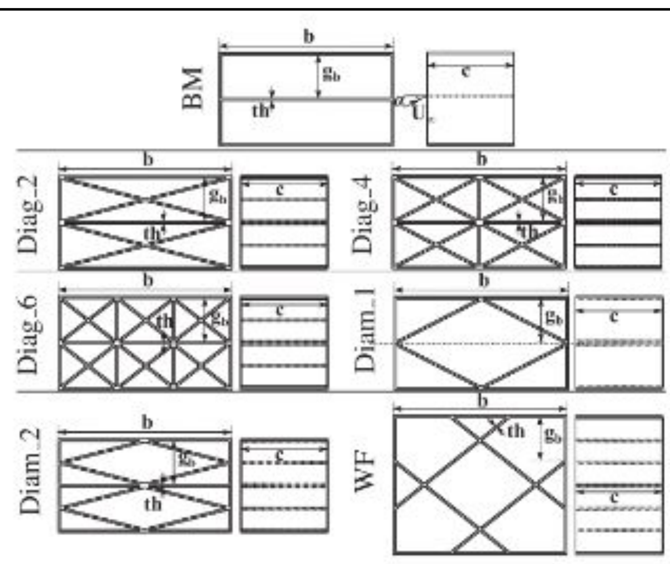
How do geometric parameters of a grid fin design, such as the open area percentage, number of junctions, number of leading edges and incident angles **affect the aerodynamic performance of a grid fin**?

Each of these components will have different effects on the aerodynamic performance of a grid fin. Increasing open area percentage will lead to increased lift, stall delay, and increased aerodynamic efficiency. The more junctions and leading edges a model has, will increase drag.

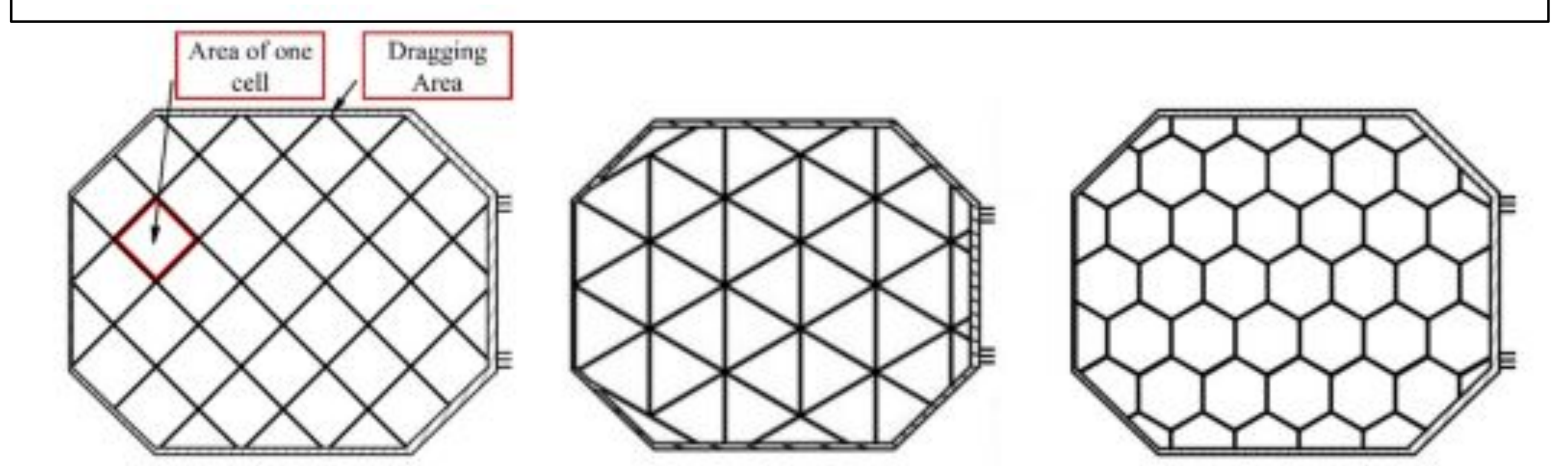
PAST STUDIES

Tripathi1 et al. (2019) performed an experimental analysis of cell pattern on grid fin aerodynamics in subsonic flow.
Evaluated and compared the aerodynamic performance of various grid fin cell patterns, particularly under subsonic flow conditions, with a focus on:
- Seven fin patterns (baseline model, diagonal, diamond, and webbed types) were tested at three gap sizes (40mm, 50mm, 60mm).
- Effects on lift, drag, stall angle, and aerodynamic efficiency



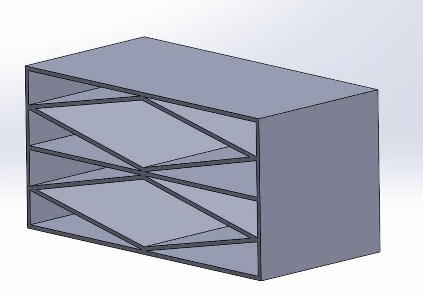
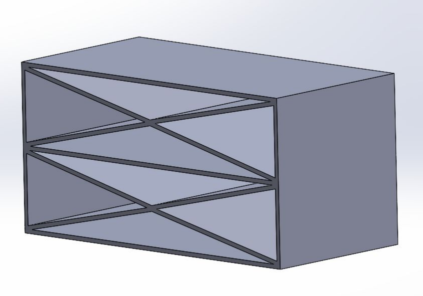
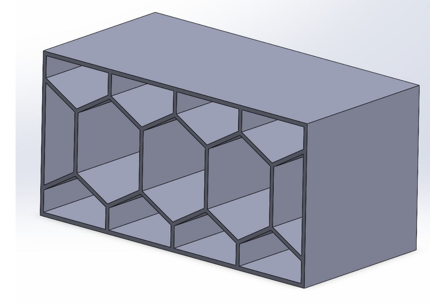


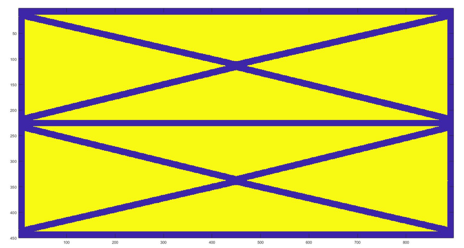
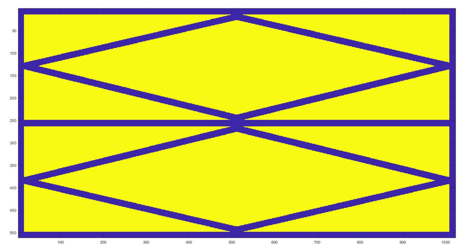
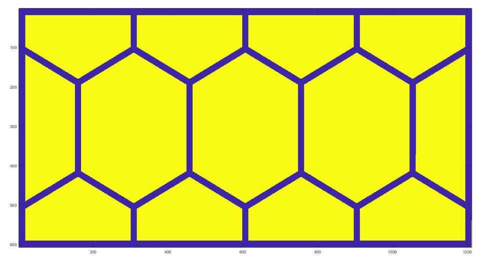
Dinh et al. (2023) numerically studied aerodynamic characteristics of the grid fins with different grid patterns.
- Investigated how different grid cell patterns affect the aerodynamic performance of grid fins using 3D computational fluid dynamics (CFD) simulations
- Square, triangle, and hexagonal patterns
- Mach 0.7, 1.2, and 2.5 flow regimes.
- Hexagonal pattern consistently delivered higher lift, lower drag, lower hinge moments and greater stability



(a) (b) (c)

GRID FIN DESIGNS

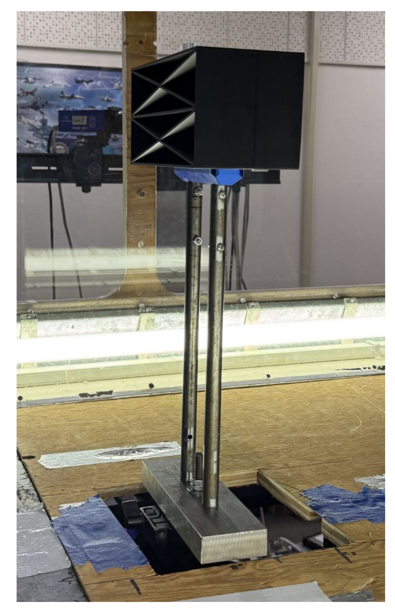
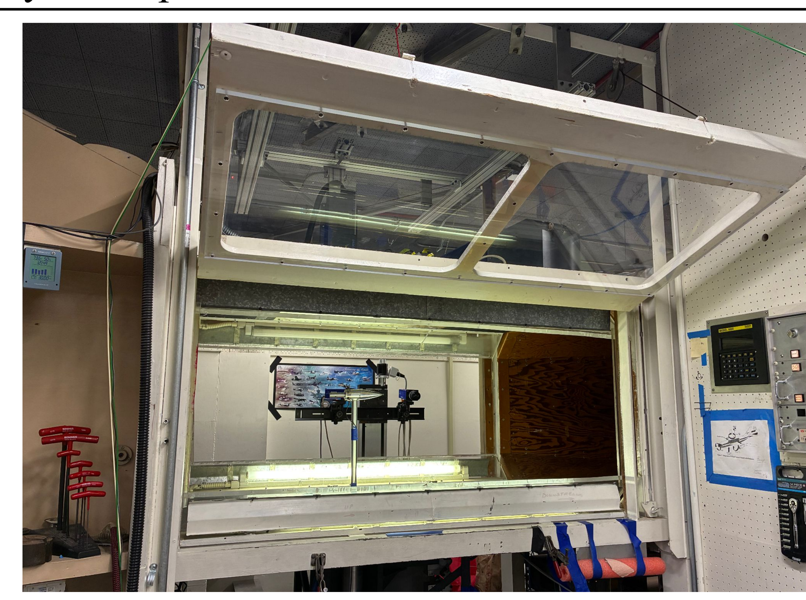
DIAM_2	DIAG_2	HEXA
		
Open Area Percentage: 77.77% Number of Lifting Members: 7	Open Area Percentage: 78.20% Number of Lifting Members: 7	Open Area Percentage: 82.79% Number of Lifting Members: 4

Each grid fin will have the following dimensions
- Chord (c) = 0.1 m
- Thickness (th) = 2.5 mm
- Span (b) = 0.2 m
- Gap = ~0.0525 m

Shapes included
- Pentagon
- Hexagon
- Trapezoid

EXPERIMENT SETUP

- Testing angles of attack -1° to 51° in increments of 6
  - -1,0,5,11,17,23,29,35,41,47,53
- Tested at Reynold's number of 233,319, which is close to reference study at Re = 2.09 x 10^5 (Tripathi, 2019)
- Force balance system
- Used a manual angle of attack changing mechanism
- Smoke test
- Dynamic pressure of 2.97 in. H2O

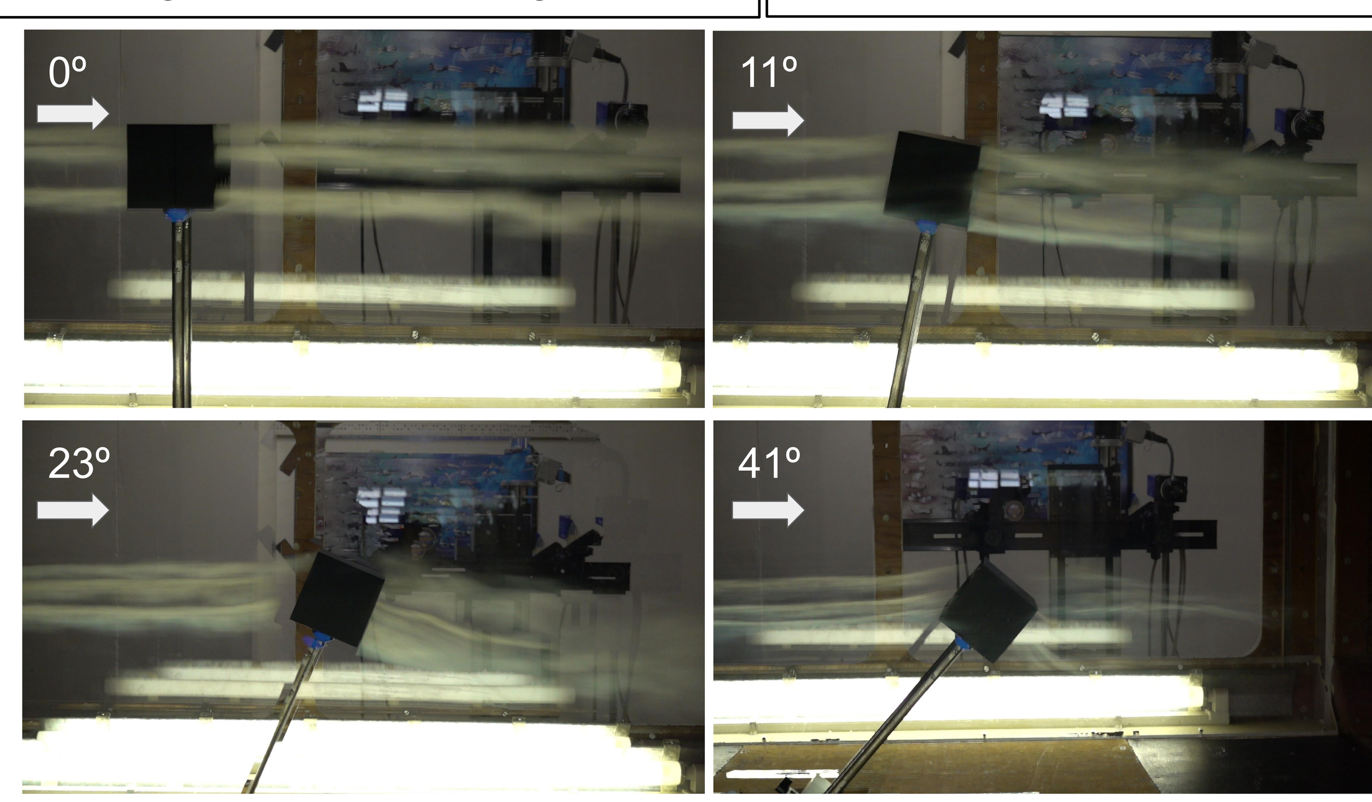



Aerodynamic performance focus:
- Coefficient of drag Cd
- Coefficient of lift Cl
- The angle of attack α
- Pitching moment
- Lift-to-drag ratio (Cl/Cd)

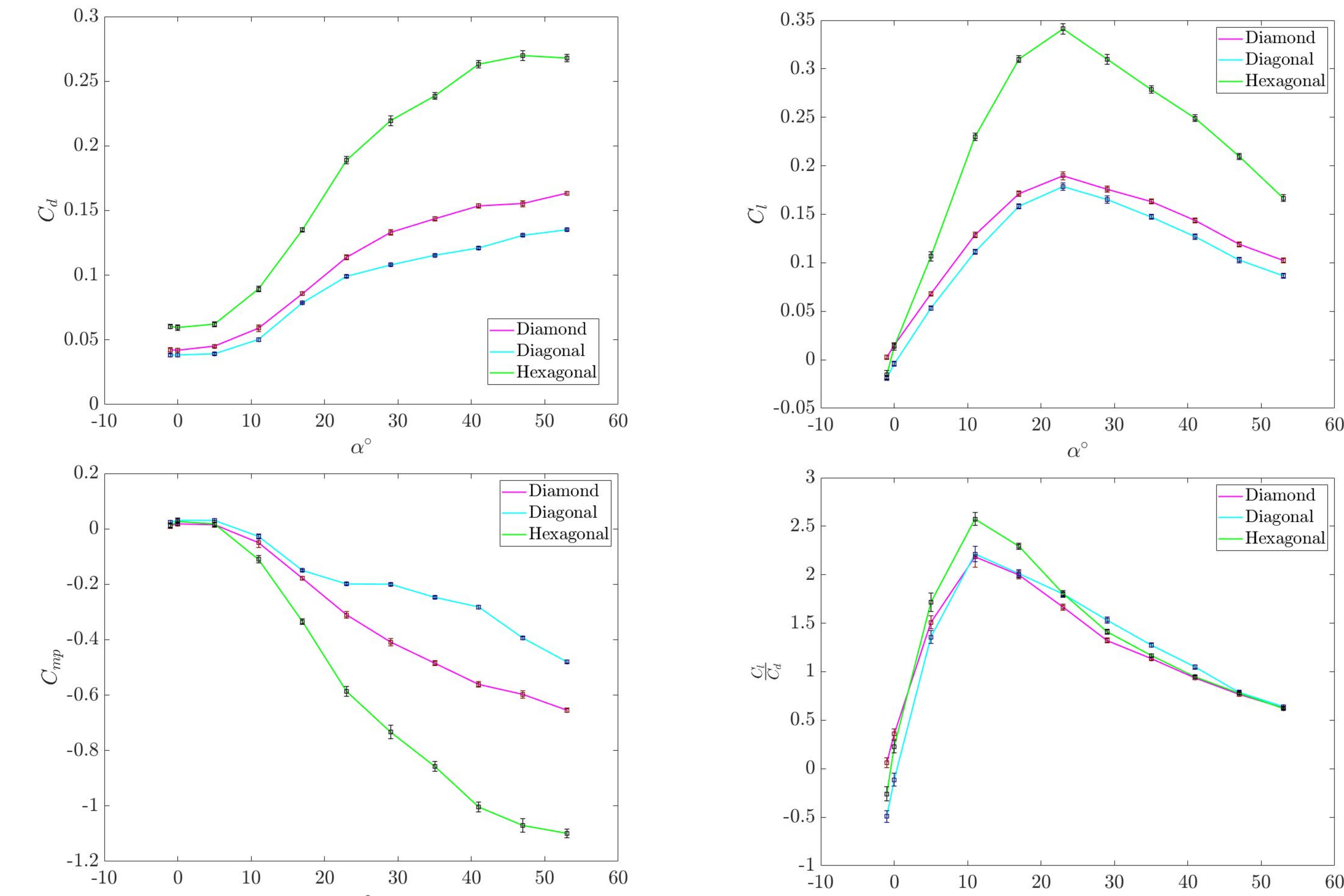
FLOW VISUALIZATION

Selected from 4 AoAs:
- 0 degrees: good baseline/reference
- 11 degrees: max Cl/Cd
- 23 degrees: max Cl
- 41 degrees: end of AoA range reference

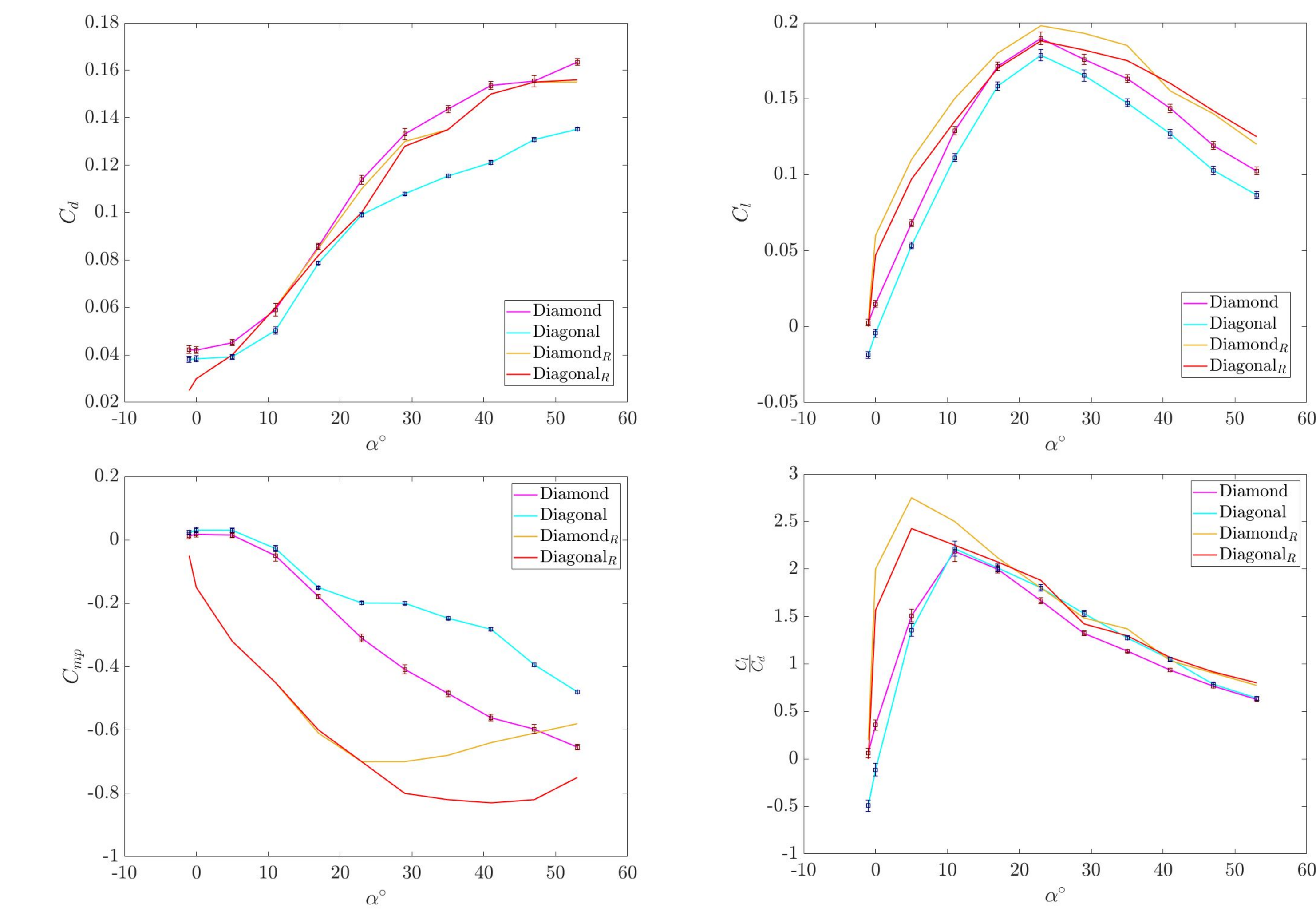
- Cycled from bottom to middle to top of the height (gap) of the grid fin
- Tested at 0.5 in. H20
- Used to show the vortex created at the trailing edge of grid fin



ANALYSIS OF DATA



The diamond and diagonal grid fins we fabricated from (Ref. 1) versus our own original hexagonal design with error bars to acknowledge any variations in data.



Our fabricated diamond and diagonal grid fins tested against the data results found in the study (Ref. 1) along with error bars to acknowledge any variations in data.

FURTHER RESEARCH AND DEVELOPMENT

- Test across a range of Reynold's numbers to see if results differ
- Do not use 3D printing for models to avoid manufacturing inaccuracies
- Use a motorized AoA increment changer to gather more data points
- Test different geometry types for the grid to further explore the effects of open area percentage, number of junctions/lifting members, and inclined members

REFERENCES

[1] Tripathi M, Sucheendran MM, Misra A. Experimental analysis of cell pattern on grid fin aerodynamics in subsonic flow. 2019
[2] Van-Son Dinh, Cong-Truong Dinh, Van-Sang Pham; Numerical study on aerodynamic characteristics of the grid fins with different grid patterns. 2022
[3] Alfonso Acosta, Kendall Miller, Bradley J. Zelenka and Xiaofeng Liu. "The History of the Low-Speed Wind Tunnel at San Diego State University," 2022

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