Variable-Height Fairing for Low-Speed Wind Tunnel Mount

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Introduction

When conducting wind tunnel testing, models are mounted on struts that suspend them in the wind tunnel. These struts are connected to a force balance that measures the forces and moments acting on the body exposed in the air flow. A fairing is used to cover such strut so that air flow would not create additional aerodynamic forces and moments on the mounting struts, affecting a measurement. However, different models come in different sizes and configurations with different mounting requirements. A universal fairing of a fixed height cannot satisfy all test requirements. Additionally, an over-sized fairing would cause interference to the flow around the test articles, resulting in a systematic error in the results. The purpose of this project is to design and manufacture (in-house) a stackable fairing system that allows for adjustment in height. A flow numerical simulation will be utilized to show the potential interference of the fairing to the flow field around a representative test article, namely a sphere. Doing this should minimize the effort to measure and remove the aerodynamic tare for a low-speed wind tunnel test.

Design

- Modular design consist of a series of blocks that can be stacked, pinned together for alignment and fastened
- Each fairing block has a height of one inch so the fairing may be used at height increments of one inch. The fairing block with other height increment is also possible.
- Fairing cross-section is NACA 0025 airfoil with a chord length of 12 inches (25% thickness)
- The circular hole is for force balance main strut (Figure 2) and additional large hole for pneumatic hoses, electronic wires, or other components needed for a wind tunnel test.
- Parts printed in-house using 3-D printer and PLA filament

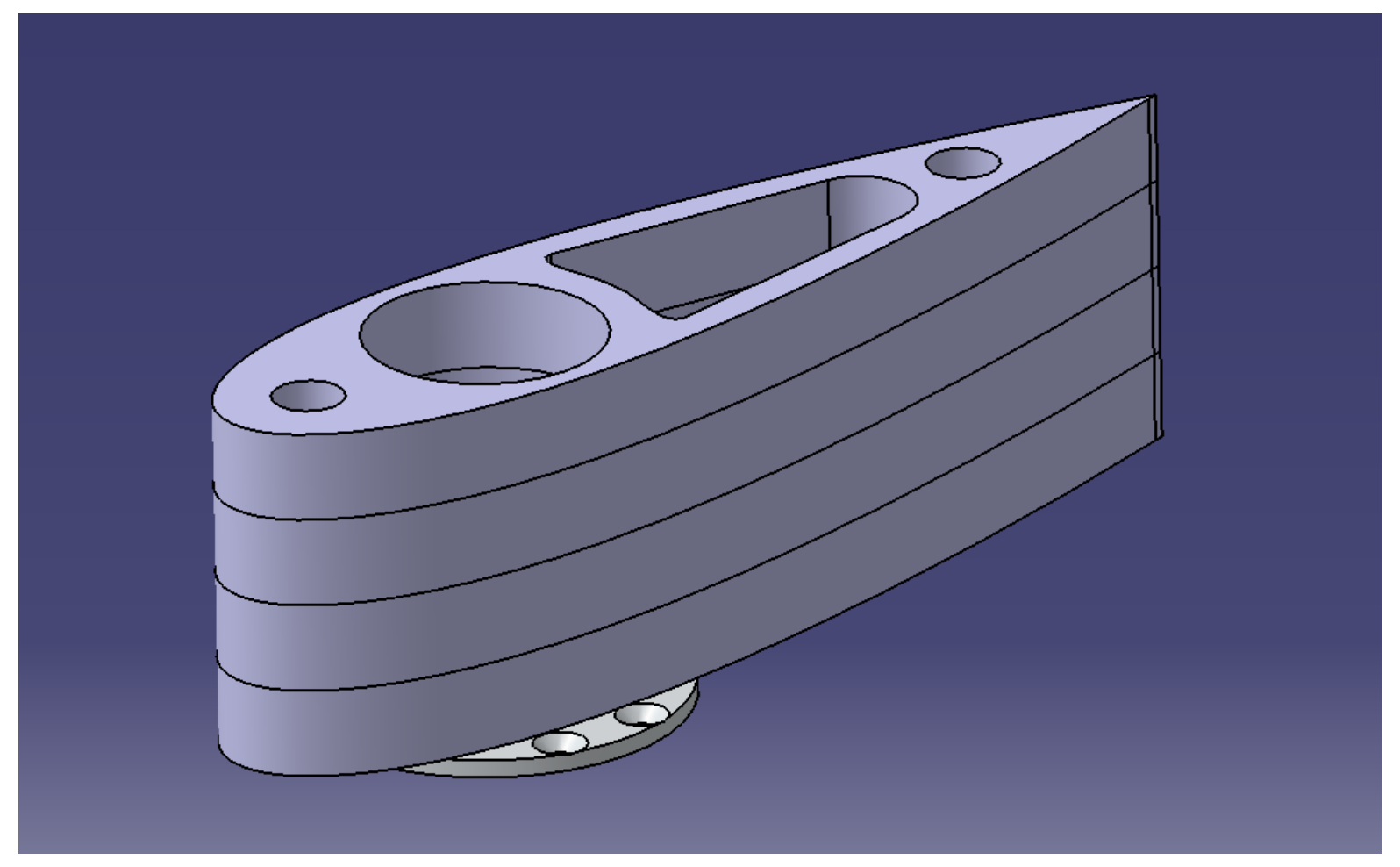

Figure 1: Fairing Assembly CAD Model

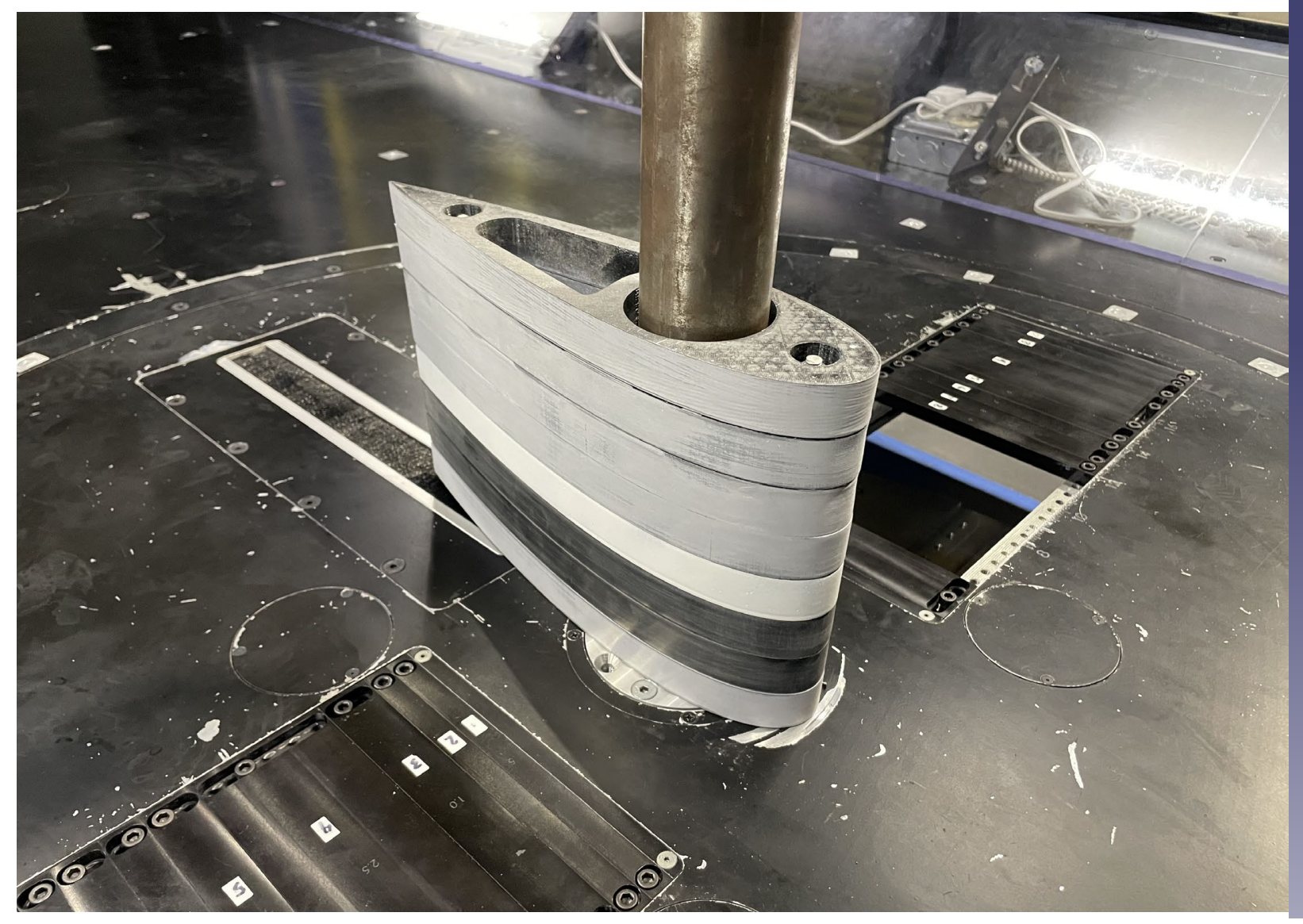

Figure 2: Fairing in Test Section (Front)

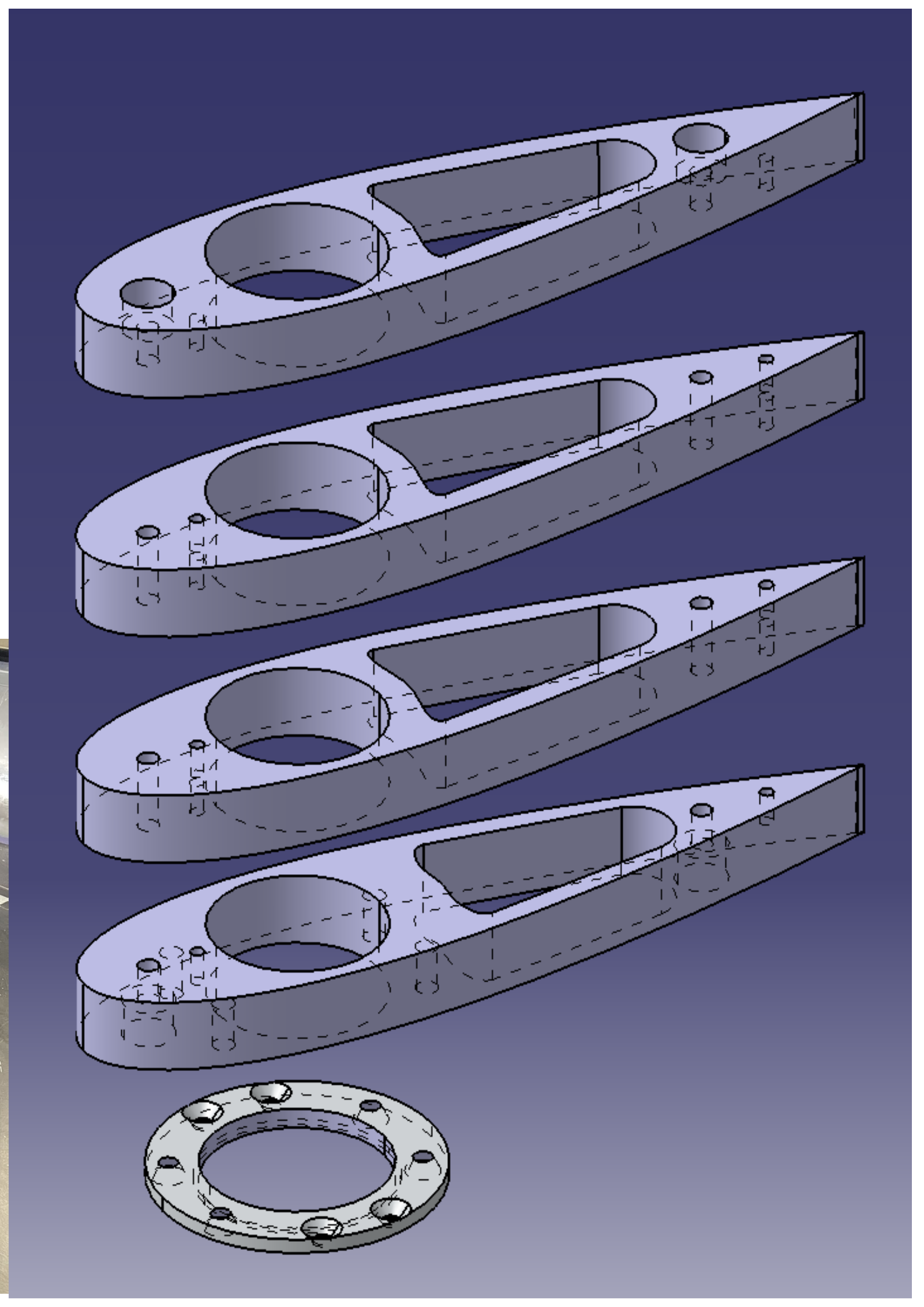

Figure 3: Fairing Assembly Exploded View

Numerical Simulation

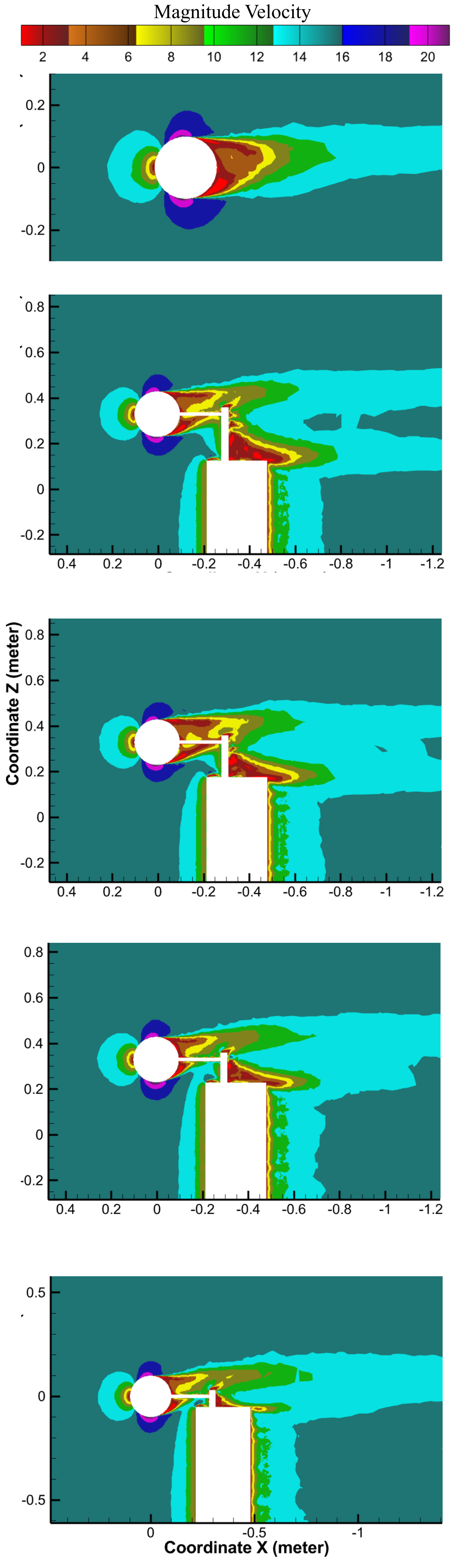

Figure 5: Velocity Profile

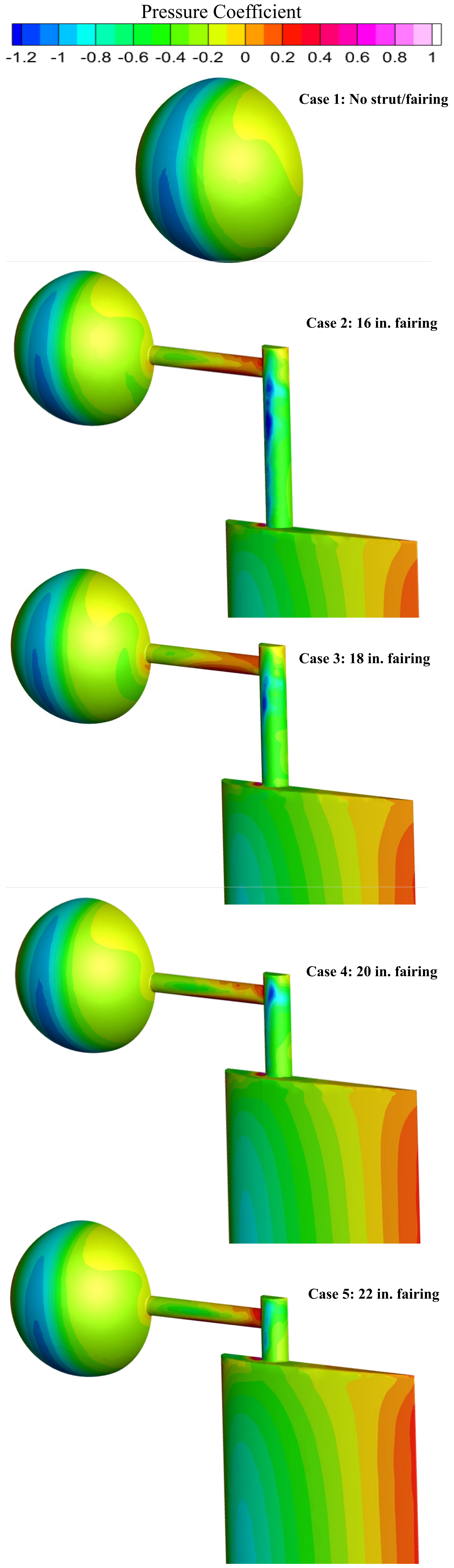

Figure 6: Surface Pressure Distribution

Discussion

A flow simulation on a sphere is conducted in a commercial computation fluid dynamics (CFD) software to study how the height of faring affects the flow field around the test model. The velocity and pressure field for a sphere without using strut/fairing (Case 1) is present as a baseline and the results of the sphere mounted with the modular fairing system (Case 2 – 5) are also shown. The fairing is built up in two-inch increments from 16 in. to 22 in. (with sphere mounted at 24 in. above the test section floor). In the velocity profiles (left), the air flow velocity is mapped on a 2-D plane through the center of the 3-D models. The exposed strut appears to cause additional drag to the force balance. However, a high fairing (20 or 22 in.) may cause flow field interference. The case with 18-in. fairing would be optimal for such test. Furthermore, it may be seen in the surface pressure distribution at the leeward side of the sphere has been slightly modified due to using a horizontal post and the vertical fairing. However, the error is still need to be quantified in future.

Manufacturing

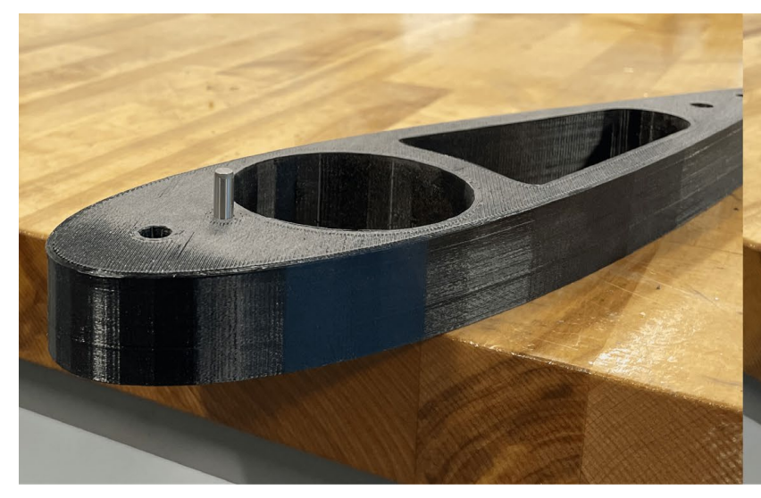

Figure 7a: Before Primer

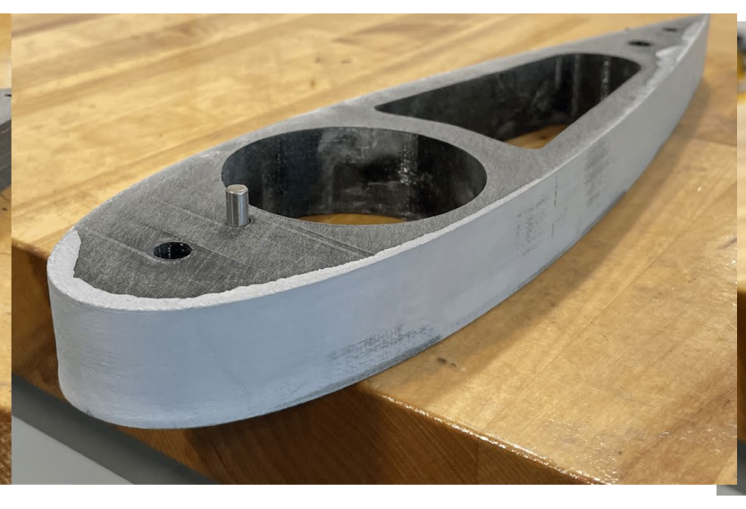

Figure 7b: After Primer

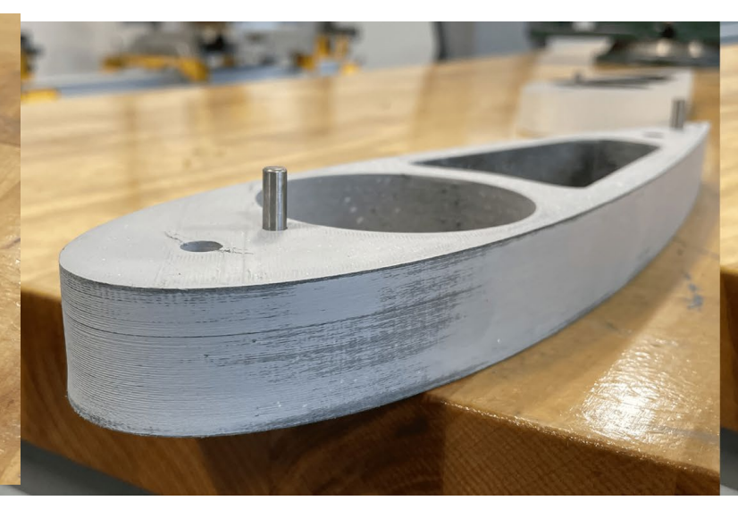

Figure 7c: After Sanding

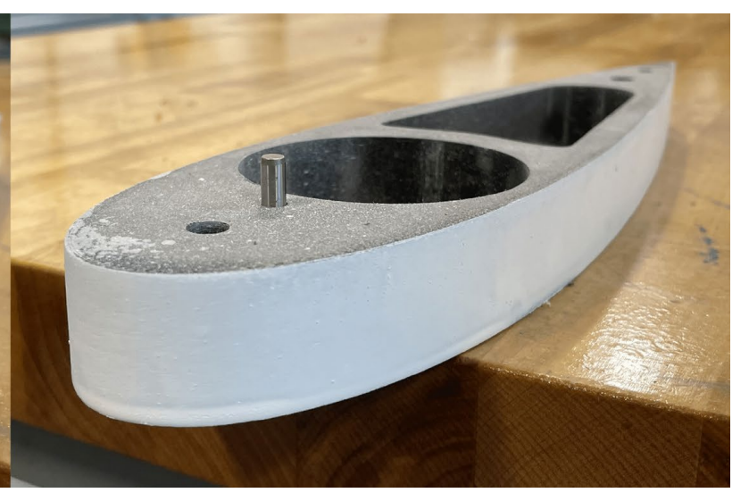

Figure 7d: After Painting

- For a smooth surface, the finishing process consists of the following:
  - Step 1: Application of filler primer (Figure 7b)
  - Step 2: Sanding surface up to 180 grit (Figure 7c)
  - Step 3: White paint coating (Figure 7d)
- Manufacturing challenges included using the correct filament, fixing leaking extruder, resolution, warping, melting of bottom layers onto heat table, inconsistency in hole sizes, and rough surface
- We corrected filament, fixed the printer extruder, and model resolution
- We modified the print temperature and print bed surface to mitigate warping and melting and used iteration to find correct hole sizes
- Additional possible solutions include using a belt sander to smooth uneven surfaces and using a putty product to fill gaps and uneven edges

Project Future

- Conduct wind tunnel testing for quantification of fairing effectiveness
- Find an effective and repeatable surface finishing method
- Manufacture of more blocks and larger blocks (greater height than one inch)
- Implementation at other wind tunnel facilities

Acknowledgments

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