THE UNIVERSITY OF UTAH
MECHANICAL ENGINEERING

WIND TUNNEL LIFT/DRAG BALANCE

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OBJECTIVE

The thermal, fluid, and energy systems (TFES) lab is a fundamental course required by all upper-level mechanical engineering students. A particular lab in the course involves finding the lift and drag forces present on a symmetric airfoil, which refers to the cross-sectional shape of an airplane wing. The existing apparatus for this lab presents key issues our team will be addressing:

- Inaccurate and tedious changes of the angle of attack of the airfoil (students must change the angle of attack with a long Allen key while referencing a protractor)
- Large fluctuations in lift/drag force data obtained in the lab due to force sensor selection and excessive vibration of the airfoil

DESIGN SOLUTIONS

MOTORIZED ANGLE CONTROL

Our team's solution to inaccurate and tedious angle changes was to implement a servo motor (Figure 1) on the top side of the wind tunnel. The servo motor allows for accurate changes of the angle of attack as well as sufficient holding torque to prevent large vibrations.

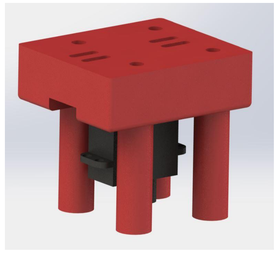

Figure 1. Servo motor with mounting sleeve.

LIFT/DRAG FORCE SENSOR

Our team's solution to large fluctuation in lift/drag force data was to build a force sensor using strain gauges (Figure 2), which are predicted to decrease the data fluctuation due to their ability to detect smaller displacements.

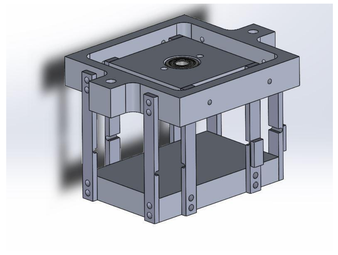

Figure 2. Strain Gauge Lift/Drag Sensor.

MATLAB GUI

Our design aims to improve the students' interactions with the lab through use of a MATLAB GUI (Figure 3) that controls changes of the angle of attack and displays real-time lift/drag force data.

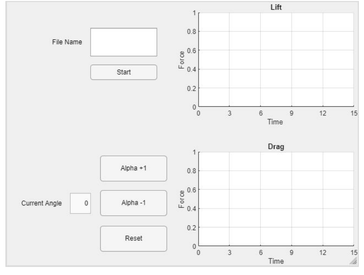

Figure 3. MATLAB GUI.

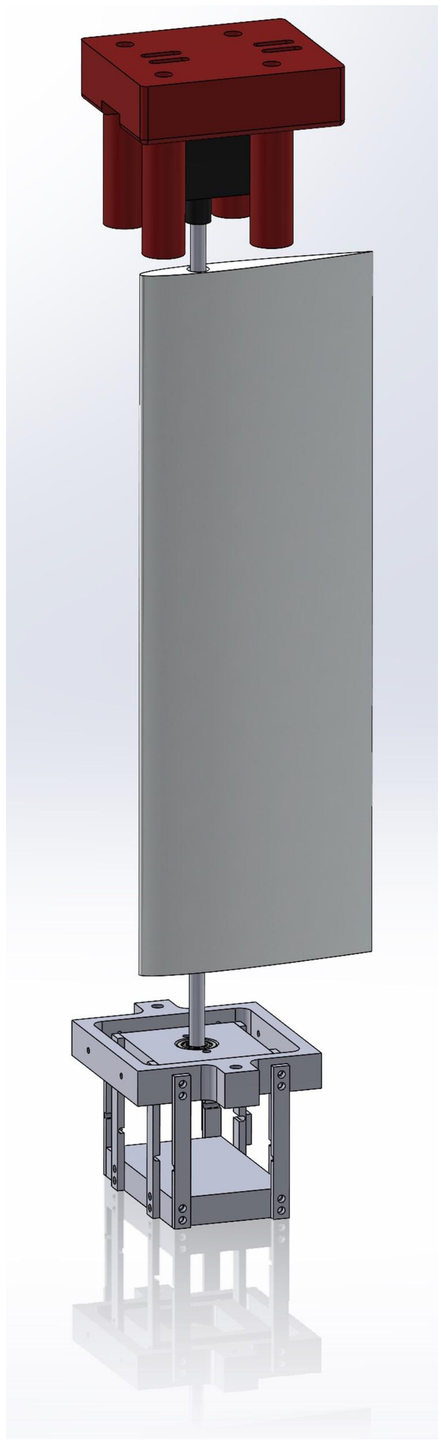

Figure 4. Full assembly of airfoil experiment. The windtunnel is not shown in this assembly to more clearly see the components.

SPECIFICATIONS

Goal	Metric	Achieved
Motorized angle change	Accuracy within 0.5 degrees of desired angle	Average error of 0.156 degrees
Vibration reduction	Fluctuations of data within 2% of mean value	Fluctuations of 1.24%
GUI	Interaction with only one program to complete lab	Using only GUI allows students to complete entire lab

RESULTS

The fluctuations of the data from the mean value has been reduced to 1.524%. This is compared to data collected using the old force sensor and airfoil which had fluctuations of 18.144%. A sample of the data can be seen below in Figure 5.

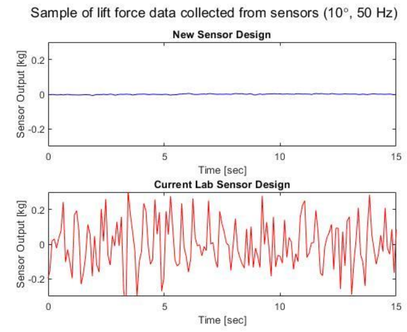

Figure 5. Sensor output vs. time for new sensor (top) and current sensor (bottom).

The data that were collected during testing was then used to complete the lab exercise from the TFES lab. From Figure 6 below, it can be seen that our data currently do not match published data. We are continuing to work on a more accurate method of calibrating our sensor so that our data will more closely match published data.

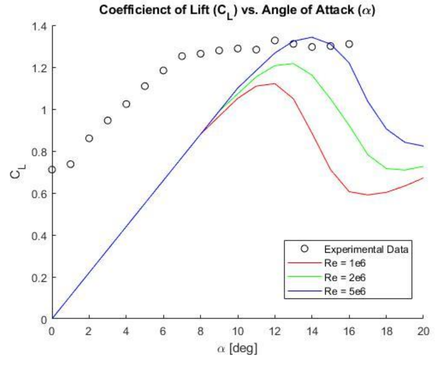

Figure 6. Our experimental data compared to published data.