OpenAeroStruct Wing Optimization Report

April 15, 2025

1 Problem Definition

The objective of this optimization was to minimize the drag coefficient (C_D) of a wing while maintaining a lift coefficient (C_L) of 2.0. The geometric constraints included a fixed wing area ($S = 100$ m^2) and span ($b = 10$ m). The design variables allowed to vary were the taper ratio, twist distribution, and sweep angle of the wing. The optimization was performed using the SLSQP optimizer. The baseline wing mesh was set to 'rect', and the desired output included a plot of the elliptical lift distribution.

2 Optimization Results

The optimization process concluded with a 'FAIL' status, indicating that it did not converge within the allotted 200 iterations. Only 18 driver iterations were executed. The final drag coefficient achieved was $C_D = 0.11836269$. The taper ratio converged to its lower bound of 0.2. The twist distribution had values of -10 and 10 degrees at different locations, which is not physically realistic. The sweep angle was 14.5 degrees. The plot shows that the final lift distribution is not elliptical.

3 Analysis and Recommendations

The optimization process encountered convergence issues, leading to a non-optimal and potentially unrealistic design. Several recommendations can be made to improve the optimization:

1. **Re-run the Optimization:** The optimization should be executed again with adjustments to ensure convergence. The illogical twist distribution and non-elliptical lift distribution suggest that the optimization exited prematurely.
2. **Adjust Taper Ratio Bounds:** The taper ratio hit its lower bound, indicating that the optimal value might be higher. The bounds for the taper ratio should be adjusted to allow higher values.
3. **Employ a More Robust Optimizer:** Consider using optimization algorithms from the pyoptsparse driver, such as SNOPT or IPOPT, as they are better suited for constrained problems and may provide improved convergence compared to SLSQP.
4. **Relax the Lift Coefficient Constraint:** The optimizer may be struggling to simultaneously meet the C_L constraint and minimize drag. Relaxing the C_L constraint slightly might aid convergence.

4 Figure: Optimized Wing

Figure 1 shows the optimized visualization of the wing. The lift distribution is not elliptical, and twist distribution also does not make physical sense. This is likely due to the optimization exiting prematurely.

5 Additional Considerations

The report indicates that values are in unscaled, physical units. Consistency and correctness of units throughout the model should be verified. Additionally, the angle of attack (α) influences C_L but was not specified as a design variable. It should be verified whether α should be included as a design variable. Manufacturing difficulties associated with very low taper ratios should also be considered.

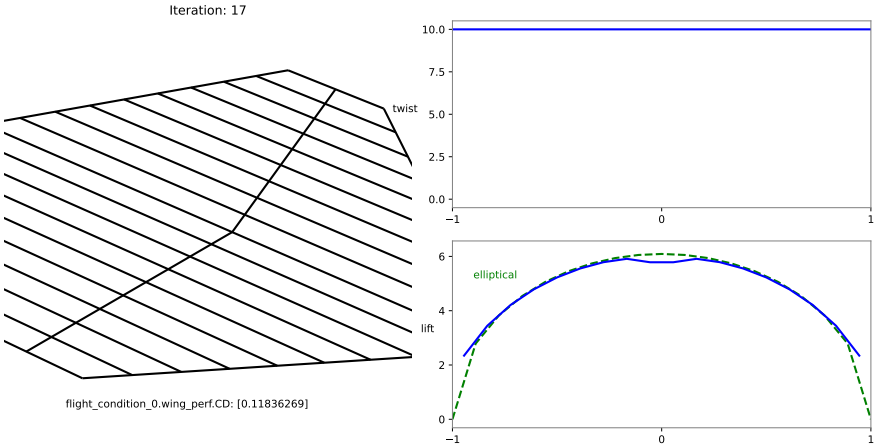

Figure 1: Optimized Wing Visualization