Progress Report 2: Tapering and Reinforcing

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I. Chord variation along 'x'

TO satisfy the metrics for tip deflection and max stress, the chord length was tapered along the x-axis based on the given swept geometry of the wing. The height and width of the cross section were set as functions of the chord. The thickness was set as 10 percent of the height of the cross section. This allowed for a larger cross section at the root of the wing, increasing the moments of inertia and reducing stress. The location of the engine was re-evaluated according to the most constrained case - deflection in case 1 - and therefore was set to 20 ft from the root. It should be noted that in Figure 1, the max stress and tip deflections do in fact change by very small amounts.

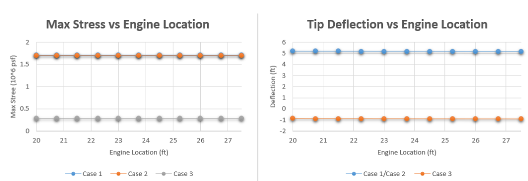


Fig. 1. Stress and Deflection Trends Based on Varying Engine Location

II. Material Change/Addition of Stringers

Iteration 2 incorporated the addition of stringers and a material change. Based on research of common aircraft materials, as well as optimized Young's modulus and density, Silicon Carbide was chosen to replace aluminum. Stringers were placed at each corner of the rectangular cross section. Thickness was held constant throughout the beam for ease of manufacturing. Stringer radius and cross section thickness factor were chosen based on which combination led to the max stress being closest to yield stress without exceeding it, i.e. 0.1 ft and .033, respectively, as expressed in Figure 2.

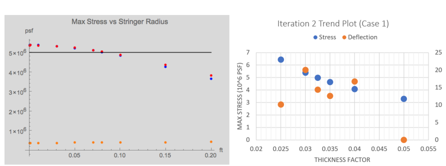


Fig. 2. Stress and Deflection Trends Based on Thickness Factor

III. Tapering the Thickness

In Iteration 2, the cross section was unnecessarily thick closer to the end, thus it was decided to taper the thickness as a function of the height, similar to Iteration 1. Several values for the thickness factor were sampled to obtain the trend plot shown in Figure 3. The optimum thickness factor was decided by selecting the thickness corresponding with the max stress that was closest to the yield stress, i.e. 0.085 times the height, as expressed in Figure 3.

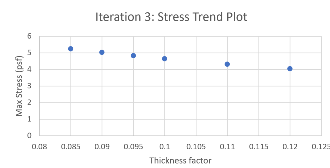
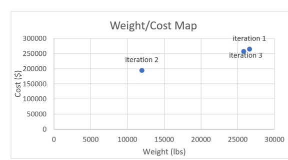


Fig. 3. Various thickness factors as a function of cross section height

IV. Decision Matrix and Weight/Cost Map

The decision matrix below was used to compare each design iteration in terms of key metrics. Each iteration corresponds with each section of this report. For each metric, every iteration was rated between 1 and 3, 3 being the best. Based on the scores, Iteration 3 was determined to be the best design thus far.



Decision Matrix for Progress Report 2

Iteration	Safety	Low Cost	Low Weight	Easy to Fabricate	Total
Weight	0.4	0.3	0.2	0.1	
1: Solid Tapered with Sweep	3	1	1	2	1.9
2: Constant thickness, Stringers	3	2	2	3	2.5
3. Thickness varies with Taper	3	3	3	1	2.8

V. Moving Forward

A new cross section with the shape of the maximum design space is being considered. It is solid, and the area tapers as a function of the chord. Previous analysis shows the cost and weight benefits of a hollow spar, thus this new cross section will likely be hollowed out into a multi-celled cross section. The addition of ribs and stringers will also be explored.

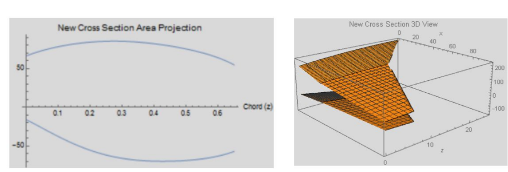


Fig. 4. New Cross Section Starting Area, Derived from Airfoil Data Points