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SE - 160A

Spar Analysis Project

Table 1: Preliminary Structural Analysis and Design of an Aluminum Wing Spar

Aluminum Spar	*units*	*Stall*	*Cruise*	*PHAA*	*PLAA*	*NHAA*	*NLAA*
MS - spar (minimum)		1.0132	1.0134	0.0067	0.0067	1.0124	1.0112
Tip vertical displacement	(inch)	69.7977	69.7977	139.5885	139.5885	-69.7977	-69.7977
Tip twist	(degree)	0.2707	0.1044	0.2089	0.4017	-0.6224	-0.9443
Thickness	(inch)	0.0789	-	-	-	-	-
Spar weight	(lb)	-65.4381	-	-	-	-	-
Spar self-weight tip deflection	(inch)	-118.546	-	-	-	-	-

Table 2: Preliminary Structural Analysis and Design of a Carbon/Epoxy Wing Spar

Carbon/Epoxy Spar	*units*	*Stall*	*Cruise*	*PHAA*	*PLAA*	*NHAA*	*NLAA*
MS - spar (minimum)		1.0065	1.0065	0.0033	0.0033	1.0063	1.0061
Tip vertical displacement	(inch)	193.6948	193.6948	387.3815	387.3815	-193.6948	-193.6948
Tip twist	(degree)	0.4685	0.1808	0.3616	0.6952	-1.0773	-1.6344
Thickness	(inch)	0.0285	-	-	-	-	-
Spar weight	(lb)	-13.2369	-	-	-	-	-
Spar self-weight tip deflection	(inch)	-28.2588	-	-	-	-	-

Step 3: Comment on the following:

a) Compare the weight of the aluminum wing spar and the composite wing spar having a (min MS > 0).

b) If the in-flight maximum tip displacement is excessive, recommend ideas for reducing the tip displacement.

c) Compare the self-deflection tip displacement of the aluminum wing spar and the composite wing spar.

d) Perform a 5 to 10 minute Google search, how would you manufacture the aluminum spar and the
carbon/epoxy spar.

a) The weight of the aluminum spar is about 4 times the weight of the composite wing spar. This is backed up by the fact that the aluminum wing spar is almost twice the thickness of the composite wing spar.
b) The maximum tip deflection of the composite spar is quite excessive during PHAA and PLAA. One possible solution would be to attach stringers inside the string itself to reduce the effects of bending due to self weight. Although this was not an option while testing the spar thicknesses, we could also reduce the length of the wing and adjust other parameters accordingly. We could also try filling the wing with a light material such as paper or foam in order to increase the flexural rigidity without significantly increasing the weight. We could also carry an additional load at the tip of the wing to minimize the upward deflection caused by positive angle load factors.
c) The self-deflection tip displacement of the aluminum wing spar is about 4 times that of the composite wing spar.
d) As seen in Valley Engineering's manufacturing video, (https://youtu.be/arfkDMUbp8M?si=wb9V61XdpwNnzuZ-), aluminum tubes are fitted according to the specifications of the design. For this design, the manufacturer uses multiple tube diameters. Each tube is partially slid into the next largest tube and the joints are then bolted down. There is a small "spacer" tube that goes in between each 6 foot tube where the rivets are fastened. In BlueCub's video, (https://youtu.be/Jbsdvhs-Xcs?si=v0Z5YP48zztW89Jh), epoxy resin is first set according to the specifications of the design. After that, carbon fiber strips are placed along the epoxy. The composite is then vacuum sealed and allowed to set. The composite strips are then placed into a foam mold. First, a strip is placed along the span of the mold, followed by a foam spar along the strip, and a second strip is adhered on top of the foam spar. Finally, the composite spar is removed from the mold and has another sheet layer of carbon fiber wrapped around it.