Preliminary FEA of major components

March 23, 2020

The determination of the FOS for yielding for a polycarbonate top plate

Context

Some plastics *can* have yielding before ultimate failure. (see here: https://www.engineeringclicks.com/yield-strength-of-plastics/, https://www.acplasticsinc.com/informationcenter/r/tensile-strength-of-polycarbonate). There are limits to this assumption and the FEA simulation should be exercised prudently when considering material properties.

Objective

I want to measure the stresses for the top plate with the hinge to find the factor of safety in yielding. I will assume it is a brittle material so I will plot (1) maximum normal stress, the (2) total deformation, (3) the normal elastic strain and (4) briefly comment on the accuracy limitation of the simulation.

Procedure

Determination of mass

First, I assigned all of our parts to be made out of polycarbonate since it is a fairly strong plastic.

I evaluated the mass properties in SolidWorks to get the total weight to get a total of 1.48 pounds-force for the model assumed to be all polycarbonate (except bearings, bolts, screws).

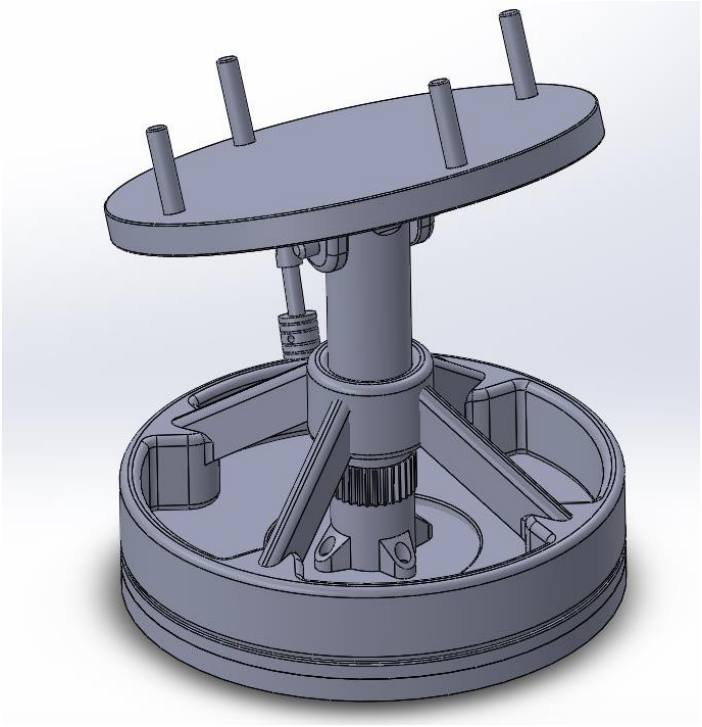

Figure 1. model measured for weight.

Since I didn't have any motors selected and added in the model, I ***liberally*** assumed each motor would add an average of 0.75 pounds. We could stand to challenge this in the future but I'm keeping it low for now to see if the plate is strong enough for this smaller load. This totals for 2.98 pounds or basically 3 lbs.

Static Analysis

With that assumption, I calculated the moments and torques acting on the plate. Idealized as a cantilever beam.

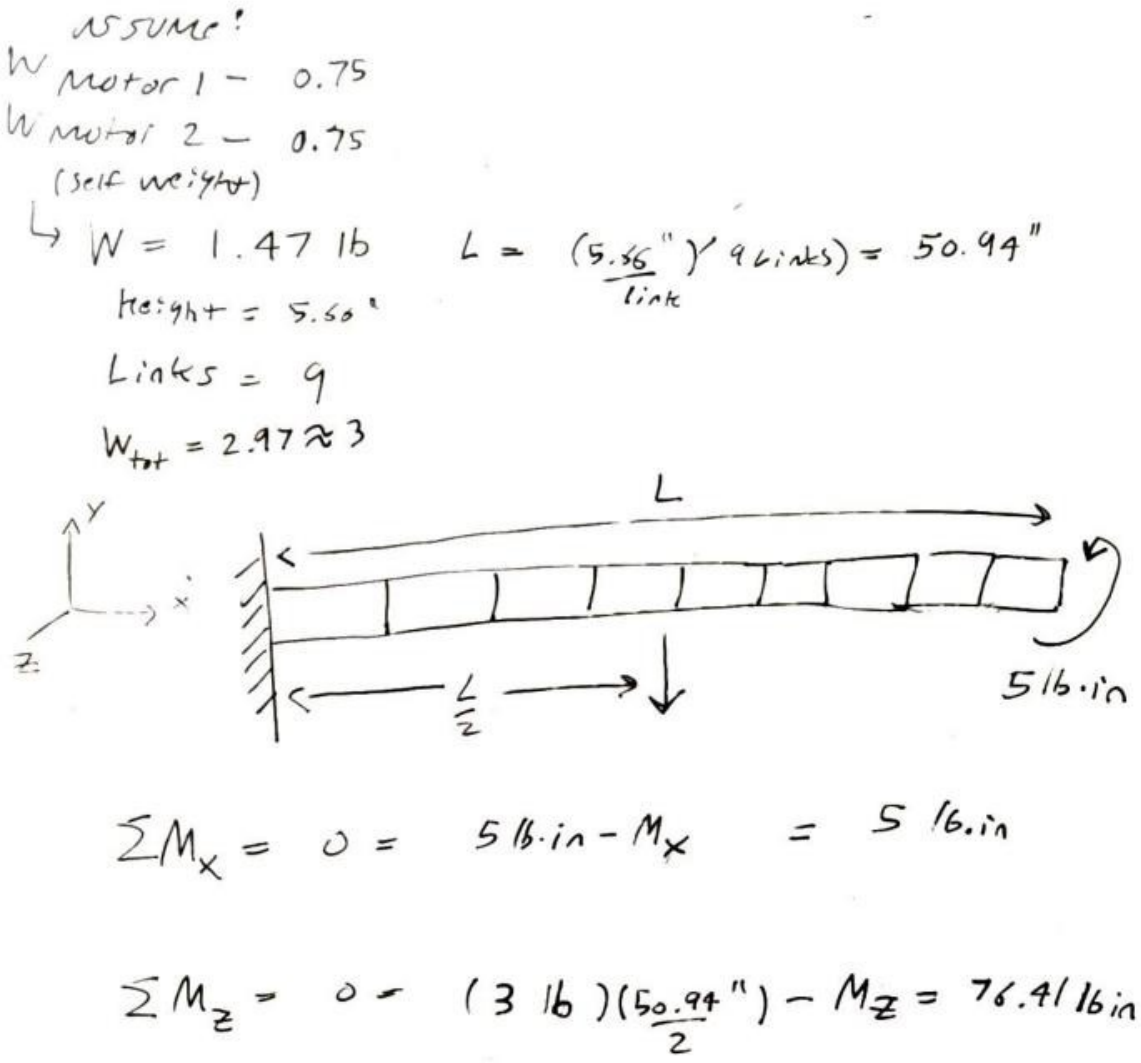

Figure 2. each block is an arm segment. The arm is fully extended and turning a valve resulting in the maximum load case.

(Those should be arrows, not equal signs). The reactions are given on the right.

ANSYS stress simulation

Boundary conditions:

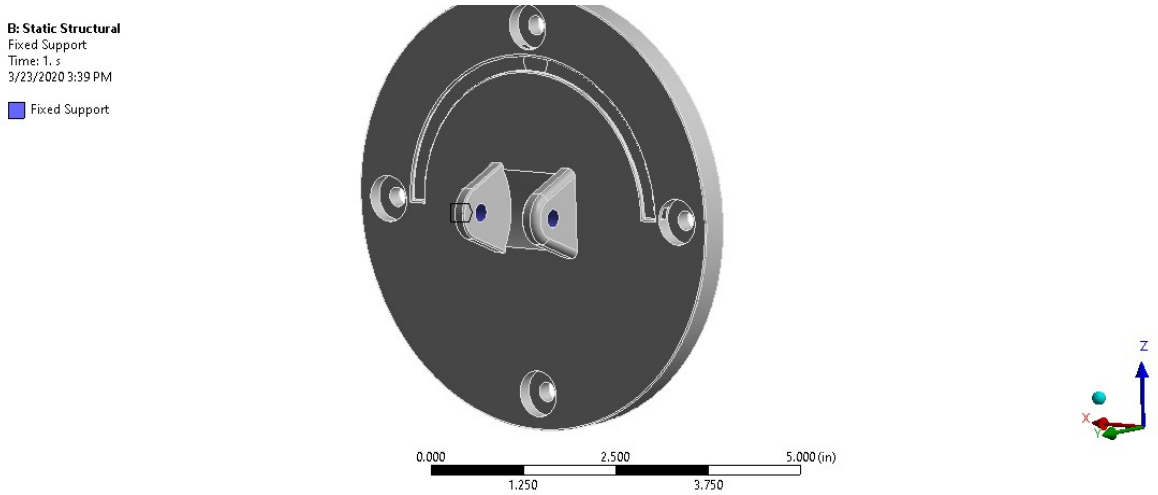

Figure 3. fixed just at hinged.

Load conditions:

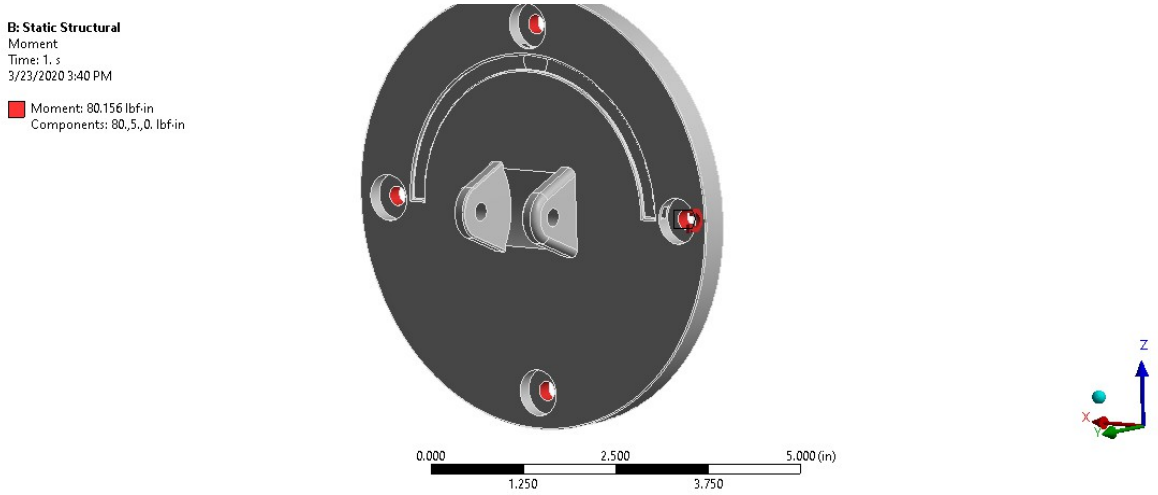

Figure 4. Reaction moments along arm (80 lb-in) and turning valve (5 lb-in).

Mesh:

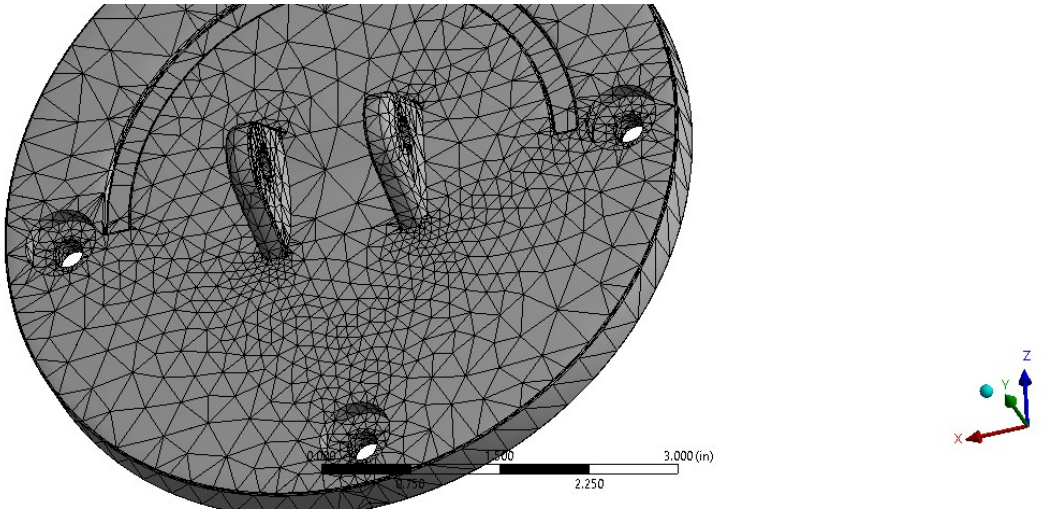

Figure 6. For once, the default mesh does not violate my product license and is good quality!

Results

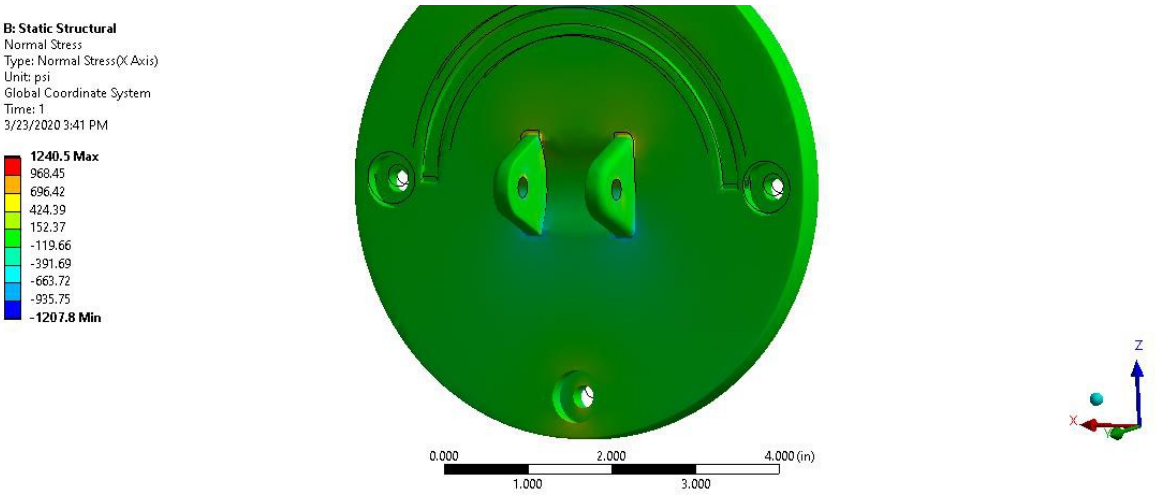

Figure 7. Normal stress plot

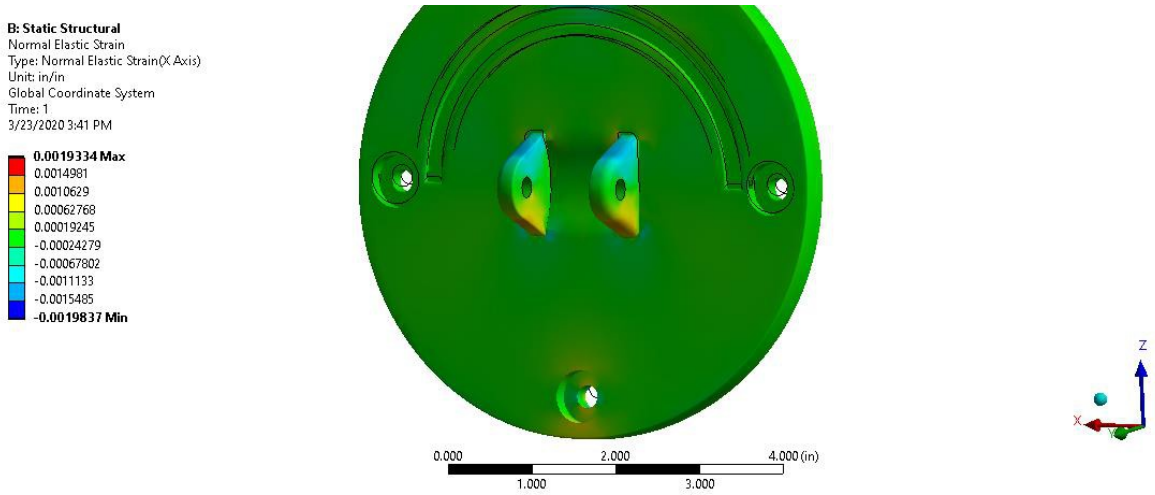

Figure 8. Normal elastic strain

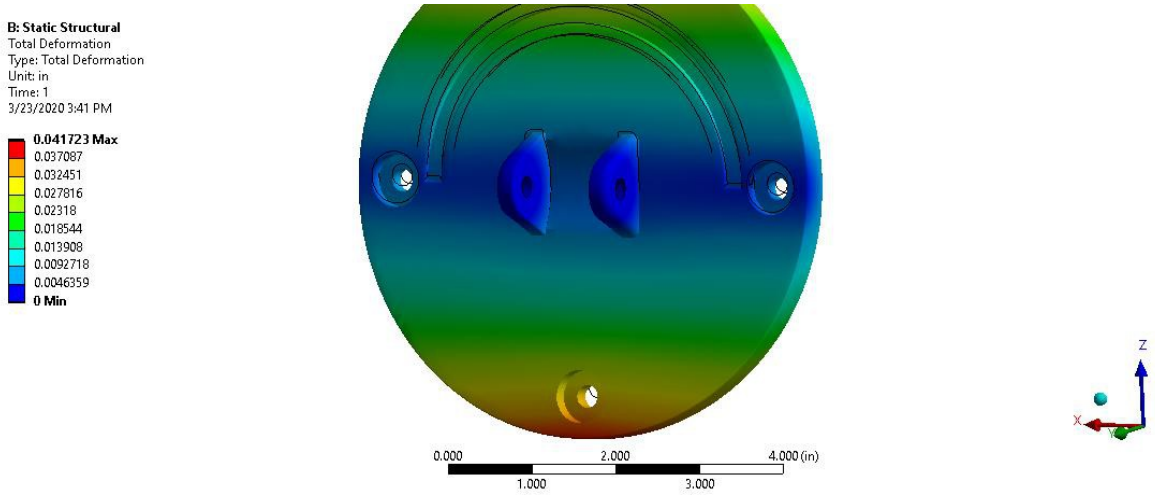

Figure 9. Total deformation

Discussion

There are many things that could level up here. One, the mesh, theoretically could be refined around the likely stress concentrations. Two, the bolts may be pretensioned\friction fit for which there is an option. Three the top pin for the plate is likely not “fixed” and will need to be looked at further. Not sure what it will be. It also depends on how the motors are attached as well.

So, assuming a yield strength of 8,500 psi (see second link), the FOS for yielding is **6.8** so definitely good so far.