Spacecraft Assembly - Verification & Validation

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Verification & Validation

We do not have experimental data to validate our results. So we'll be carrying out only verification here.

Comparison with Hand Calculations

We'll check the following using hand calculations:

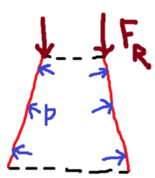
- Reaction in axial (z) direction where mid nozzle is attached to top nozzle (not modeled)
- Thermal strain
- Hoop stress
- Bolt preload

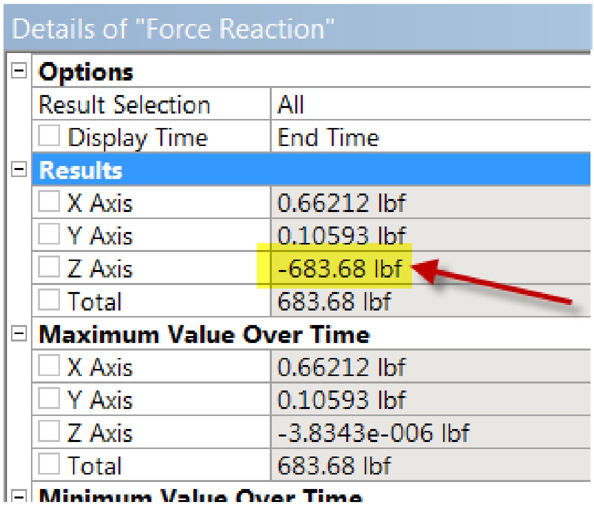
Reaction in Axial Direction

The reaction reported by ANSYS is within 10% of the hand calculation as per the images below.

Hand Calculations: Reaction in Axial (*z*) Direction

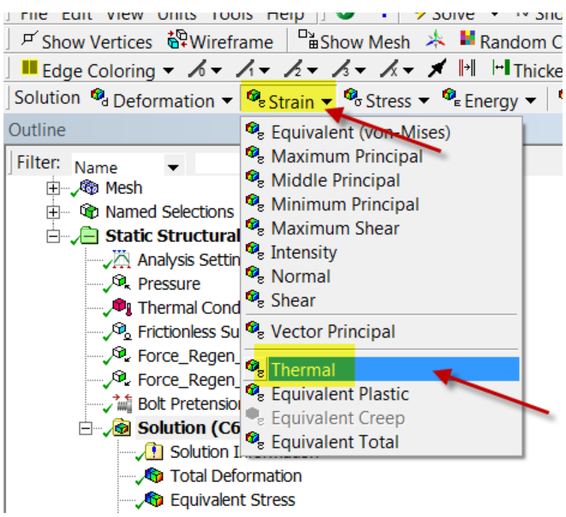
- Average gas pressure:
  - $\frac{12.17+47.72}{2} \approx 30\ psi$
- Top radius = 41.75 inches
  Bottom radius = 69.50 inches
- Projected area in *z* direction = $\pi(69.50^2 - 41.75^2) = 9699\ in^2$
- Net pressure force in *z* direction = $30 * 9699$
- Net reaction force in -*z* direction on 1/400th model = $\frac{30*9699}{400} \approx 720\ lbf$





Thermal Strain

Select *Solution* > *Strain* > *Thermal*

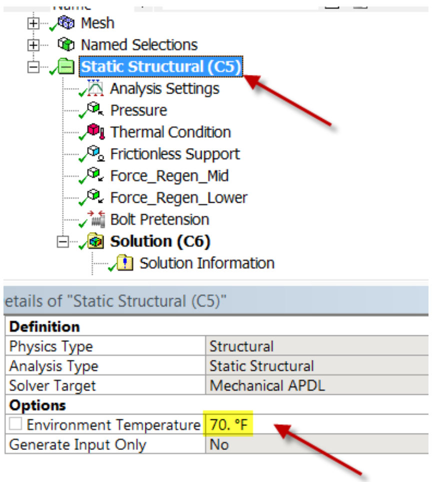


Check that the thermal strain reported by ANSYS for all parts compares well with the expected value from *alpha*(dT)*.

dT is calculated as T2-T1

T2 is the temperature specified in the *Thermal Condition* under *Static Structural.* Note that *alpha* is calculated at this temperature.

T1 is the *Environment Temperature.* Make sure it is set to 70F as per below.

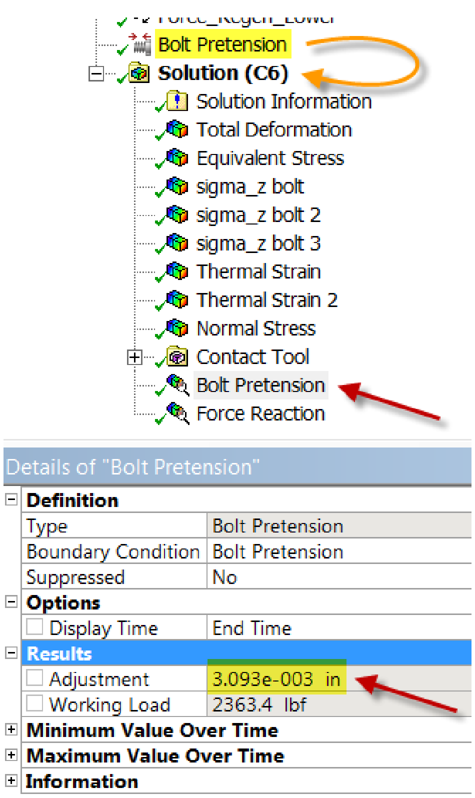


Hoop Stress

The hoop stress can be estimated using *pr/t*. Check this against the corresponding ANSYS result which can be determined by looking at the stress in a direction normal to the symmetry planes. You can spot check at a couple of locations in the model.

Bolt Preload

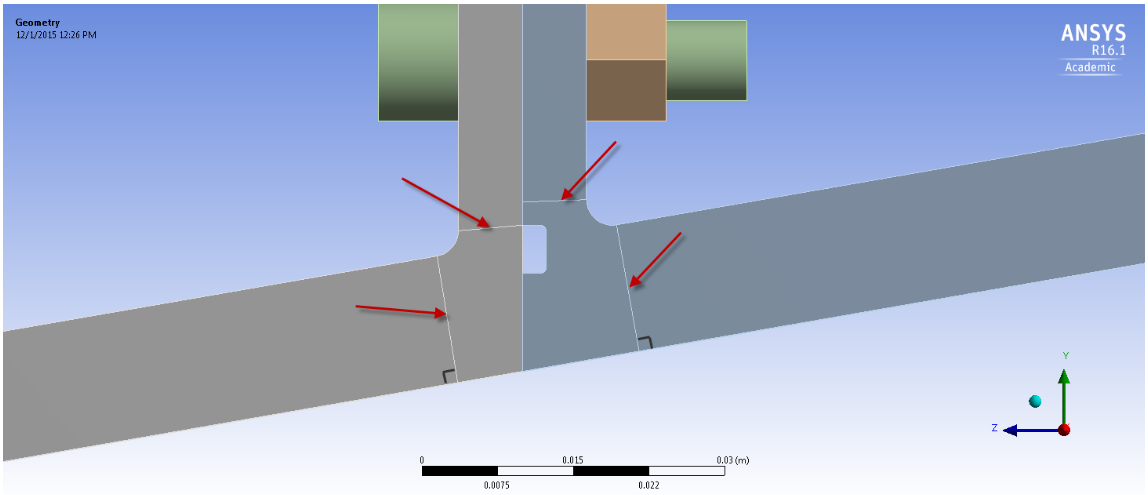
Dragging the *Bolt Pretension* object under *Static Structural to Solution* and evaluating results gives the amount by which the bolt has to be shrunk in order to generate the specified preload. See below. The value reported by ANSYS (3.093e-3 in) can be checked using 1D elasticity approximation: *dL = (F L)/(E A)*



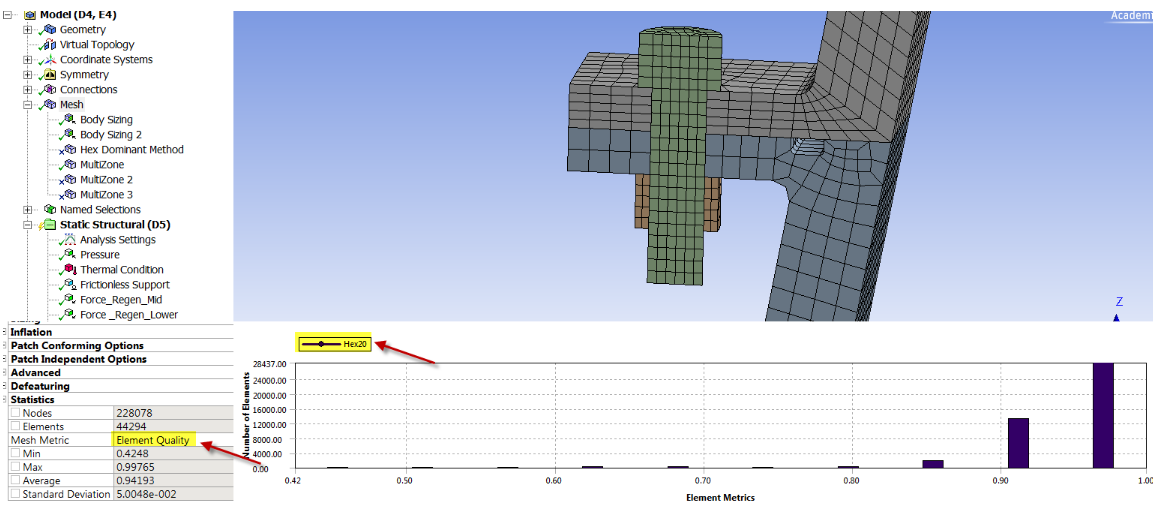
Hex Mesh

The disadvantage of the Hex Dominant meshing technique is that it generates poor elements in transition regions between hex and tet elements. A pure hex mesh can be generated by splitting up the model and using the Multizone meshing technique as per the video below. Heads-up: The solution on the new mesh might take over 5 minutes.

The video considers hex meshing for one part only. It turns out you need to divide the parts as per the image below to get a pure hex mesh for *all* parts. Note that the mesh quality improves if you make two of the splits perpendicular to certain faces as indicated in the image.



Check that you have a pure hex mesh by turning on element quality. The *Hex20* label refers to hex elements with 20 nodes per element including midside nodes.



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Go to all ANSYS Learning Modules