

24-650 Applied Finite Element Analysis

Assignment 3

submitted by

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Objective

The goal of this assignment is to explore the location and value of the peak equivalent stress in the valve body, as shown in Fig. 1. The valve material is structural steel, and the primary load is internal cyclic internal pressure.

Assumptions and Conditions

- 1) The frictionless support is on the bottom surface.
- 2) All internal surfaces are subject to an internal pressure of 50 MPa.
- 3) The end effect of pipe ends is ignored.
- 4) The stress risers on and near the frictionless support are ignored.
- 5) Analysis is performed on $\frac{1}{4}$ -symmetry model.

Model and Geometry

The valve is made of structural steel, with internal surface subjected to 50MPa of pressure. Figure 1-4 below shows the full model, with and without connections, and $\frac{1}{4}$ model used to perform finite element analysis.

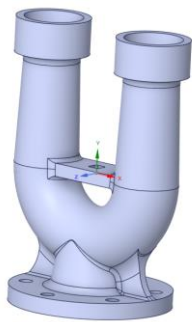


Figure 1. The Default

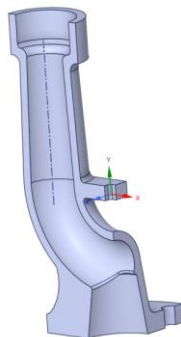


Figure 2. 1/4 Default

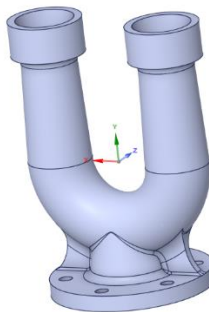


Figure 3. No connection

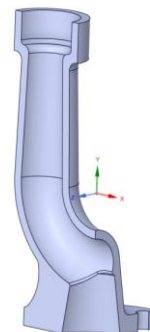
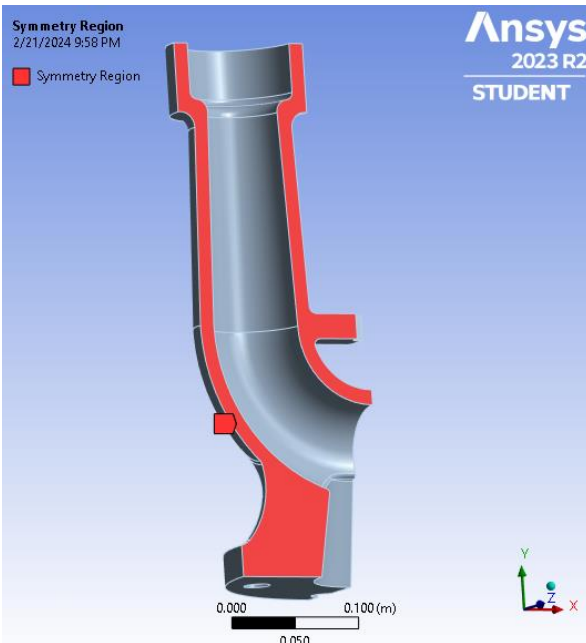


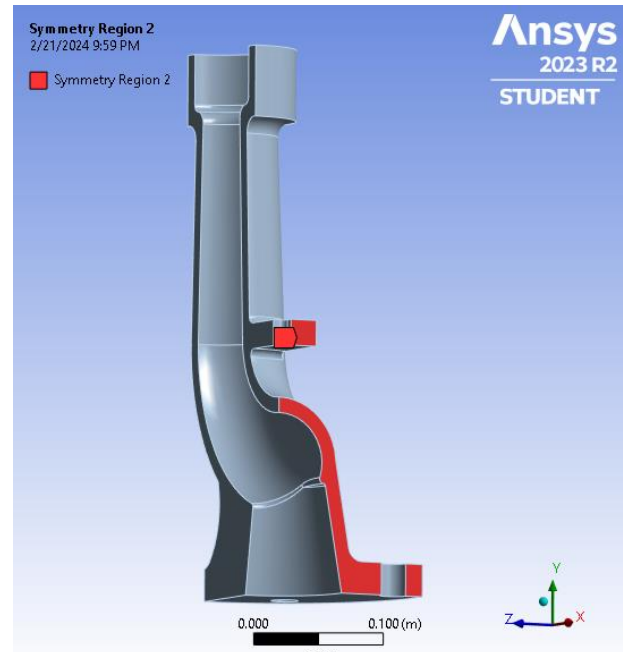
Figure 4. 1/4 No connection

Boundary Conditions (Part A)

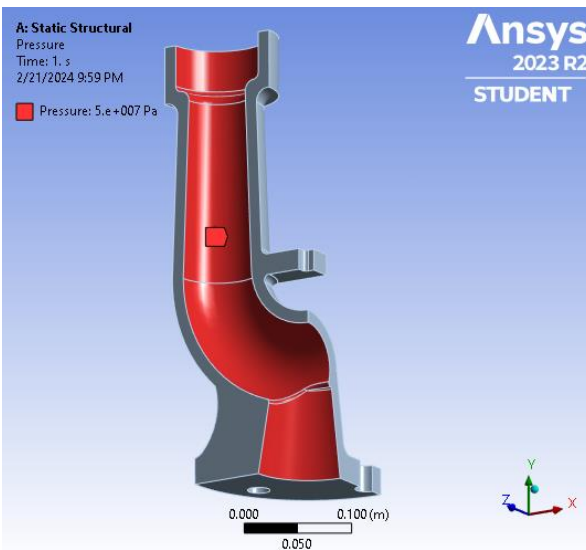
The boundary conditions of symmetry, pressure, and frictionless support is indicated below:



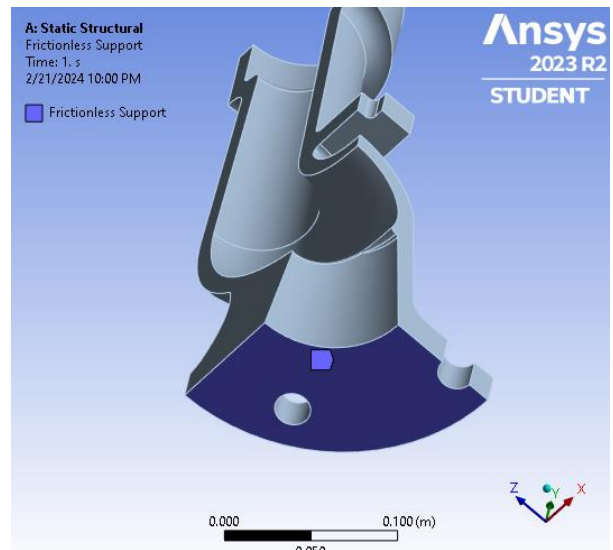
Symmetry 1, Z-Axis Normal



Symmetry 2, X-Axis Normal

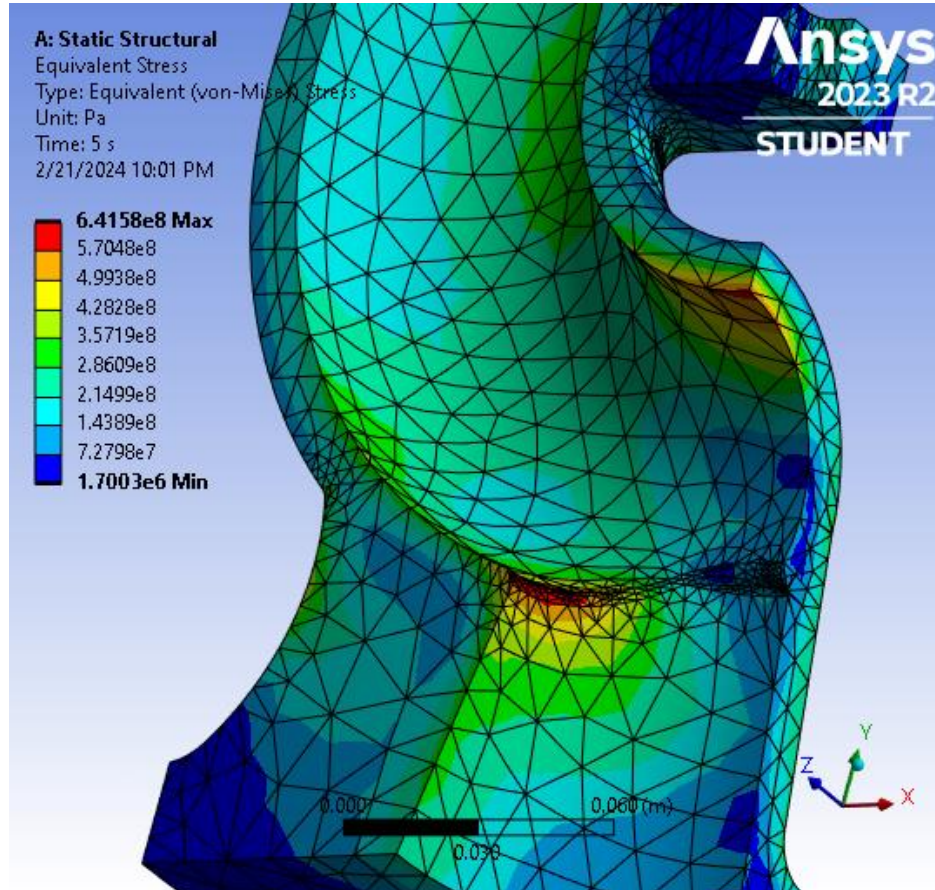


Internal Pressure



Frictionless Support

Results (Part A)



From figure above, the peak equivalent stress happens at the inner edge and top of the lower U-pipe of the valve, as indicated in the red area above. Refinement is added for areas that have higher equivalent stress (above than average, which is the yellow, orange, and red area on the result figure).

The stress value is presented below:

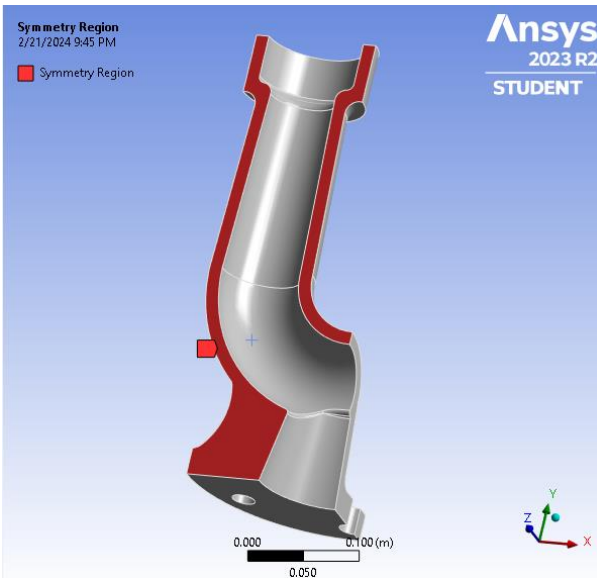
Mesh convergence study table:

Mesh Settings	Element Size: 0.025m Refinement Level: 0	Element Size: 0.025m Refinement Level: 1	Element Size: 0.01m Refinement Level: 2	Element Size: 0.007m Refinement Level: 2
Result (stress, MPa)	641.65	638.76	637.72	637.16

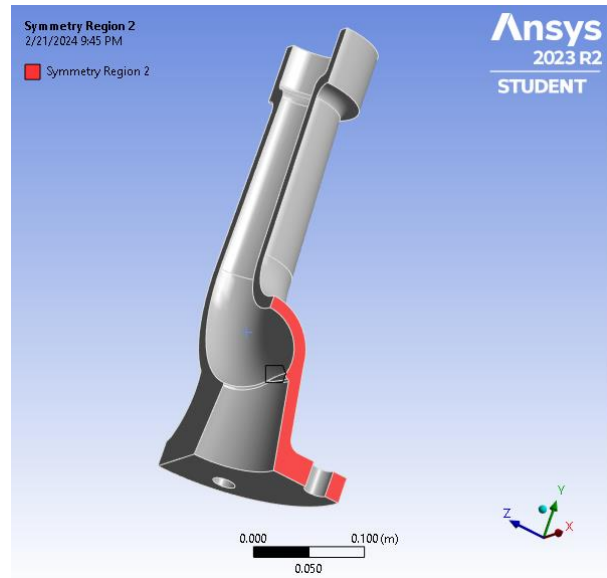
From the table above, one can see that as the mesh element increases from 0.01m to 0.007m, the peak equivalent stress increased 0.56MPa, which is below the +/- 1MPa requirement. As a result, the peak equivalent stress is around **637 MPa**.

Boundary Conditions (Part B)

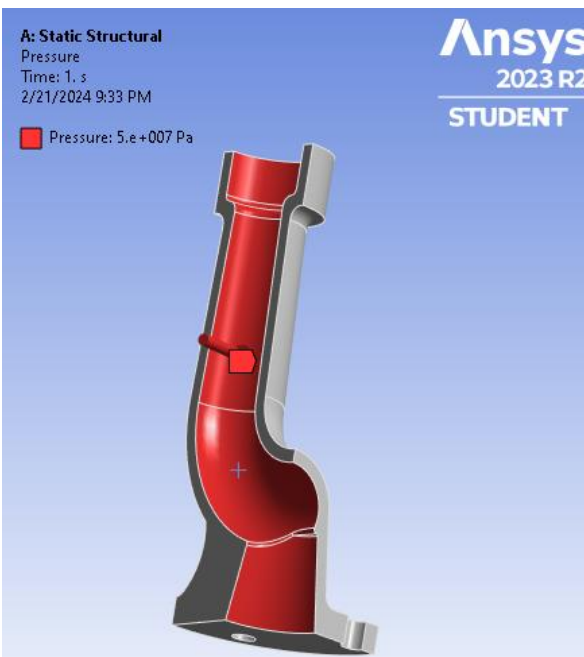
The boundary conditions of symmetry, pressure, and frictionless support is indicated below:



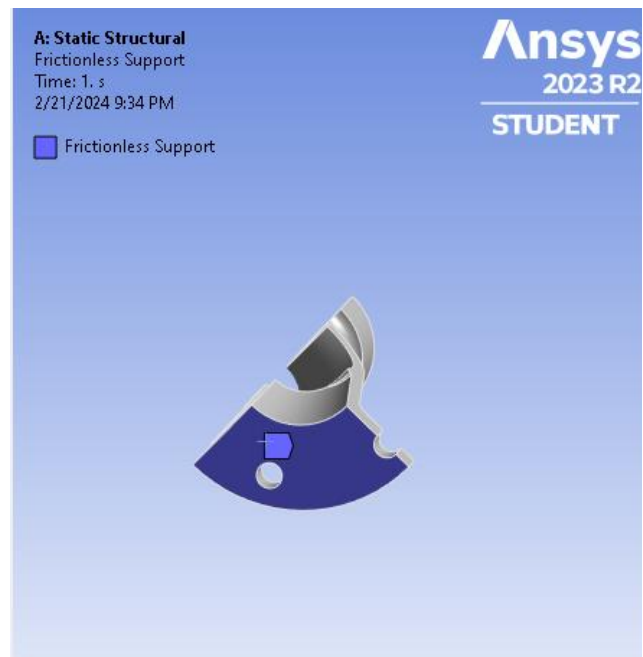
Symmetry 1, Z-Axis Normal



Symmetry 2, X-Axis Normal

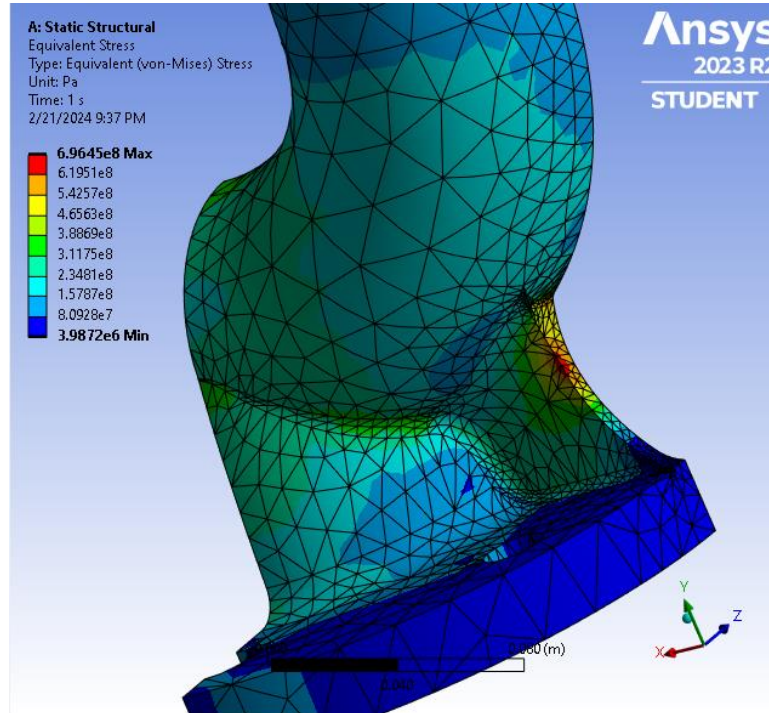


Internal Pressure



Frictionless Support

Results (Part B)



From figure above, the peak equivalent stress happens at the outer support of the valve, as indicated in the red area above. Refinement is added for areas that has higher equivalent stress (above than average, which is the yellow, orange, and red area on the result figure).

The stress value is presented below:

Mesh convergence study table:

Mesh Settings	Element Size: 0.025m Refinement Level: 0	Element Size: 0.025m Refinement Level: 1	Element Size: 0.01m Refinement Level: 2	Element Size: 0.007m Refinement Level: 2
Result (stress, MPa)	658.76	660.01	694.54	696.07

From the table above, one can see that as the mesh element increases from 0.01m to 0.007m, the peak equivalent stress increased 1.53MPa, which is below the +/- 5MPa requirement. As a result, the peak equivalent stress is around **696 MPa**.

Conclusion

Based on the finite element analysis conducted above, one conclusion is that with the brace support, the maximum stress happens at the inner surface of the valve, whereas for the situation of without the brace support, the peak stress is at the outer support of the U-shape pipe. Also, the peak equivalent stress is higher than with the brace support, which increases the risk of material fatigue and failure.