COMPUTER PROJECT #3

ME/AE 6212 Advanced Finite Element Analysis

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Statement of the problem:

Consider a pressure vessel as shown in the figure. The cylinder has a longitudinal axis of rotational symmetry and is also symmetric with respect to a plane passing through it at mid-height. Due to symmetry, use a quarter of the solid model as shown in the figure for the analysis. Use 8-node 3D element in ABAQUS.

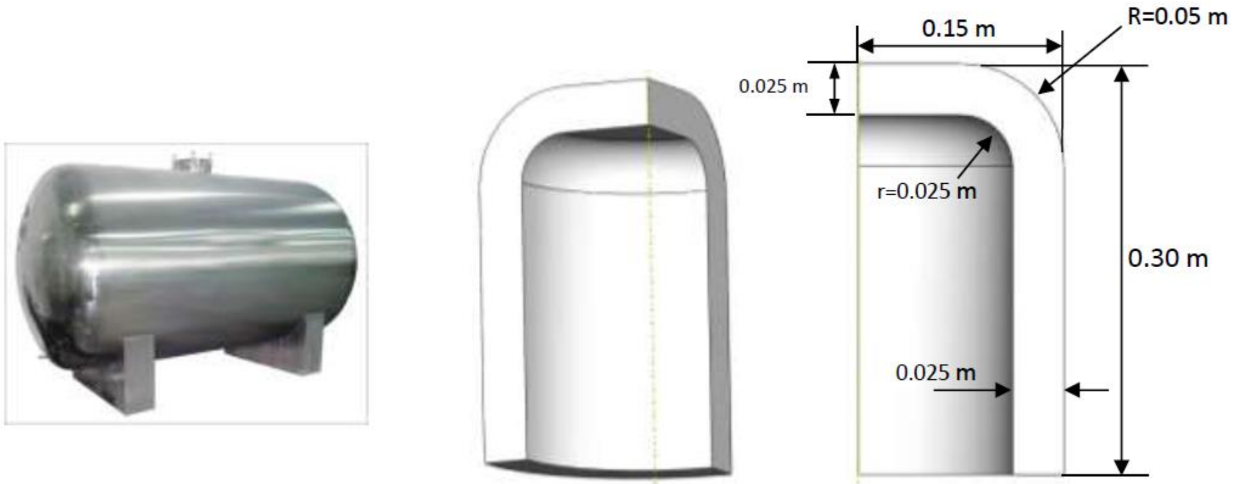


Figure 1. Pressure vessel

Take E = 207 GPa, v =0.3, ρ =7.8x10^3 kg/m3; Coefficient of thermal expansion = 1.2×10^{-5} K^{-1}; Thermal conductivity = 60 W/m/K.

1. The cylinder is subjected to an internal pressure of 34 MPa. Use fine mesh at the fillet and perform the convergence study. Plot the stress and strain distribution, and find the maximum von-Mises stress and its location.

2. The inner surface of the cylinder is kept at 373.15 K, and the heat is lost on the exterior by convection to the ambient. The convection coefficient is 179 W/m2/K and the sink temperature is 293.15 K. Plot the temperature distribution, von-Mises stress and strain distributions.

3. Consider both mechanical and thermal loadings (cases 1 and 2). Plot the von-Mises stress and strain distributions, and find out the maximum von-Mises stress and location.

Procedures:

FE Model and boundary conditions:

Consider a pressure vessel as shown in the above figure. The cylinder has a longitudinal axis of rotational symmetry and is also symmetric with respect to a plane passing through it at mid-height. Due to symmetry, a 1/8 of the full model as shown in the following figure for the analysis was developed. Use “Coupled temp-displacement (Steady-state)” in Step module. Use Interaction->surface film condition module to add convection boundary condition. Use C3D8RT element in ABAQUS.

The boundary conditions of the three cases are listed as follows.

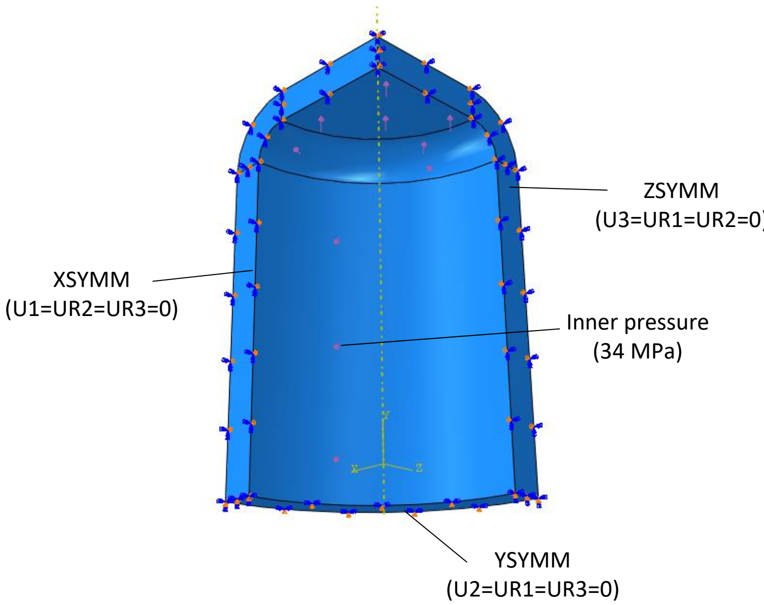


Figure 2. Boundary conditions of case 1

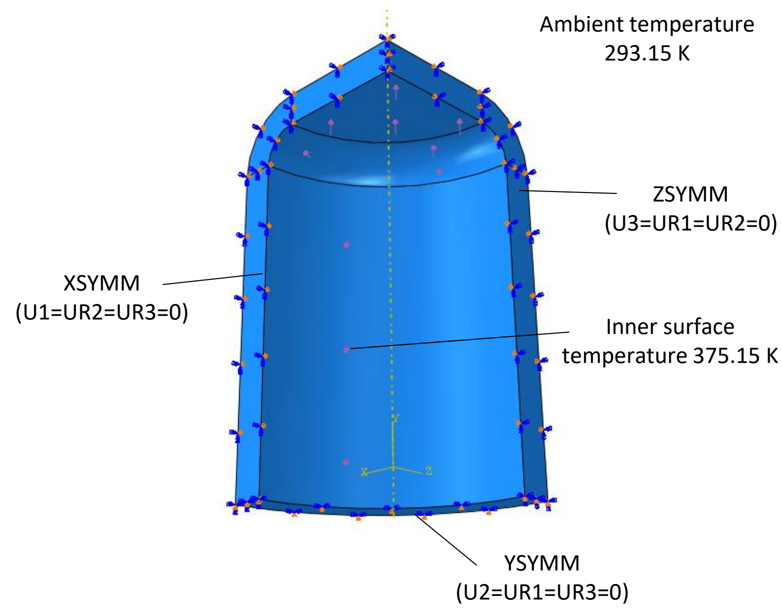


Figure 3. Boundary conditions of case 2

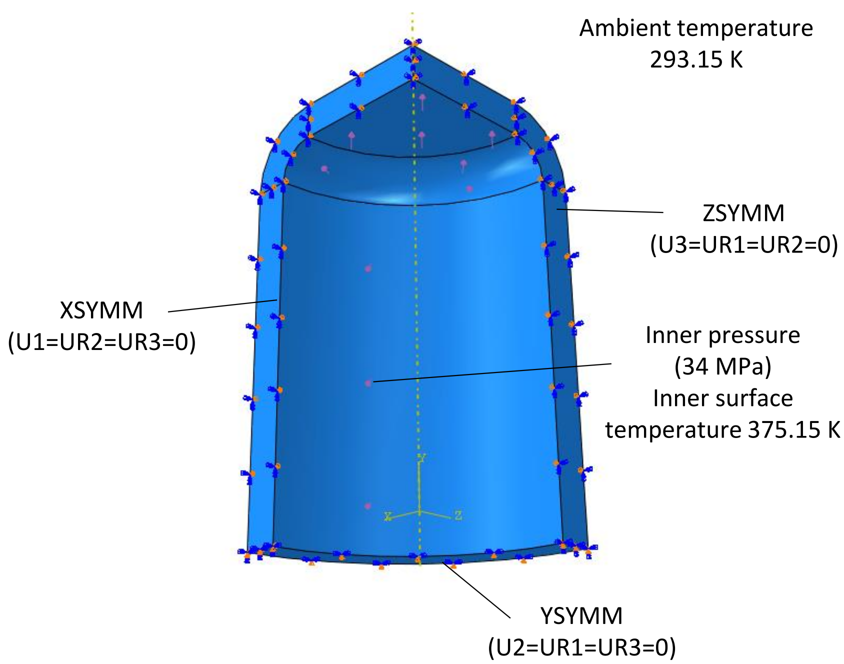
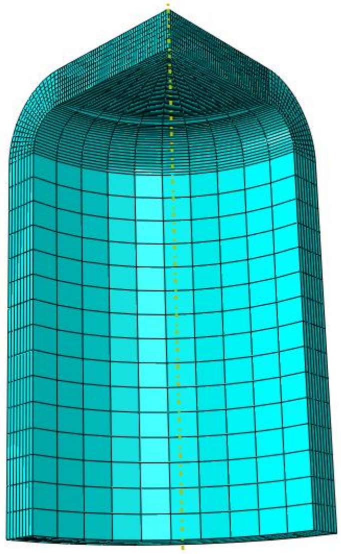


Figure 4. Boundary conditions of case 3

Convergence study: In order to acquire enough accuracy and acceptable computing time, different meshing size were implemented, as listed below. And the corresponding FEA results are listed in the table as follows.

Mesh 1	Mesh 2	Mesh 3
		
Mesh 4	Mesh 5	Mesh 6
		

Cooresponding results:

	Maximum von-Mises stress (Pa)		
	Case 1	**Case 2**	**Case 3**
Mesh 1	4.795e8	1.024e7	4.873e8
Mesh 2	5.055e8	1.152e7	5.141e8
Mesh 3	5.152e8	1.211e7	5.240e8
Mesh 4	5.158e8	1.213e7	5.247e8
Mesh 5	5.289e8	1.297e7	5.381e8
Mesh 6	5.444e8	1.344e7	5.462e8

From the above values it could be noticed that Mesh-6 was accurate enough and the computational time was acceptable. Therefore, the Mesh-6 was utilized for the further presentation of the results within the report.

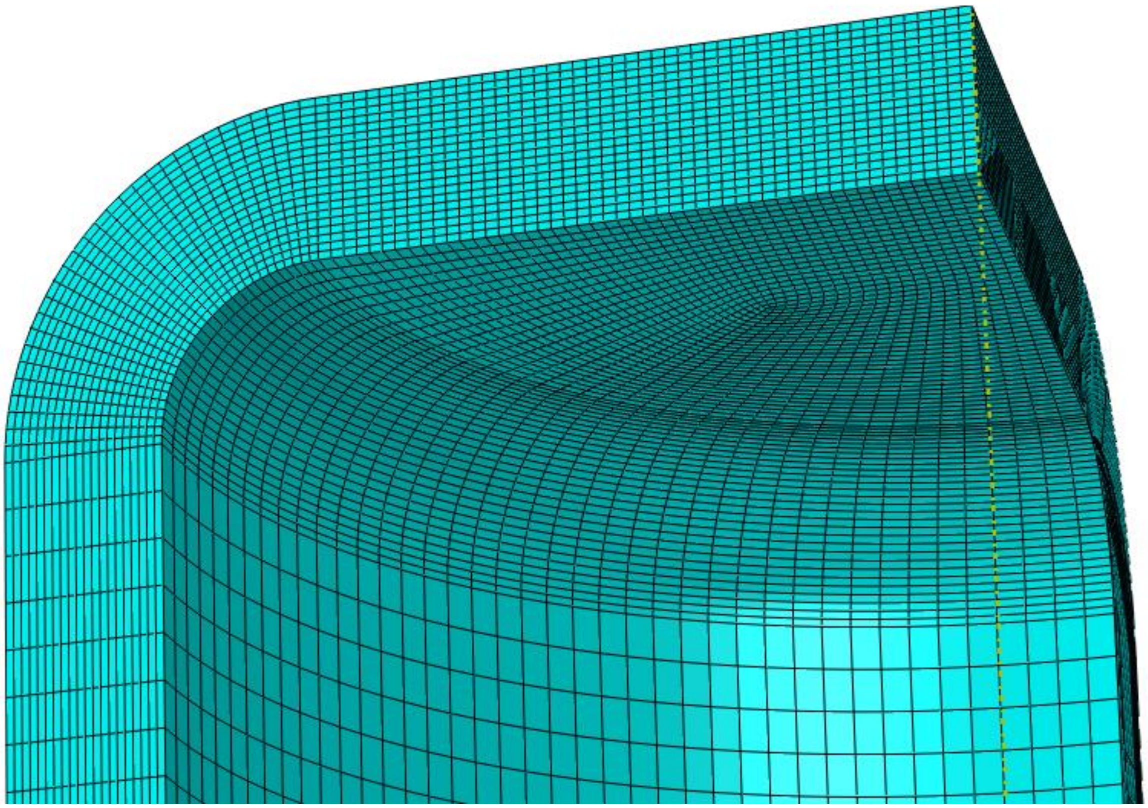


Figure 5. Mesh-6 used in this project

Results:

Case 1, mechanical loading

The cylinder is subjected to an internal pressure of 34 MPa. Use fine mesh at the fillet and perform the convergence study. Plot the stress and strain distribution, and find the maximum von-Mises stress and its location.

The stress and strain distributions are shown below in fig.6 and 7. The maximum von-Mises stress was 5.444e8 Pa, as indicated in fig.6.

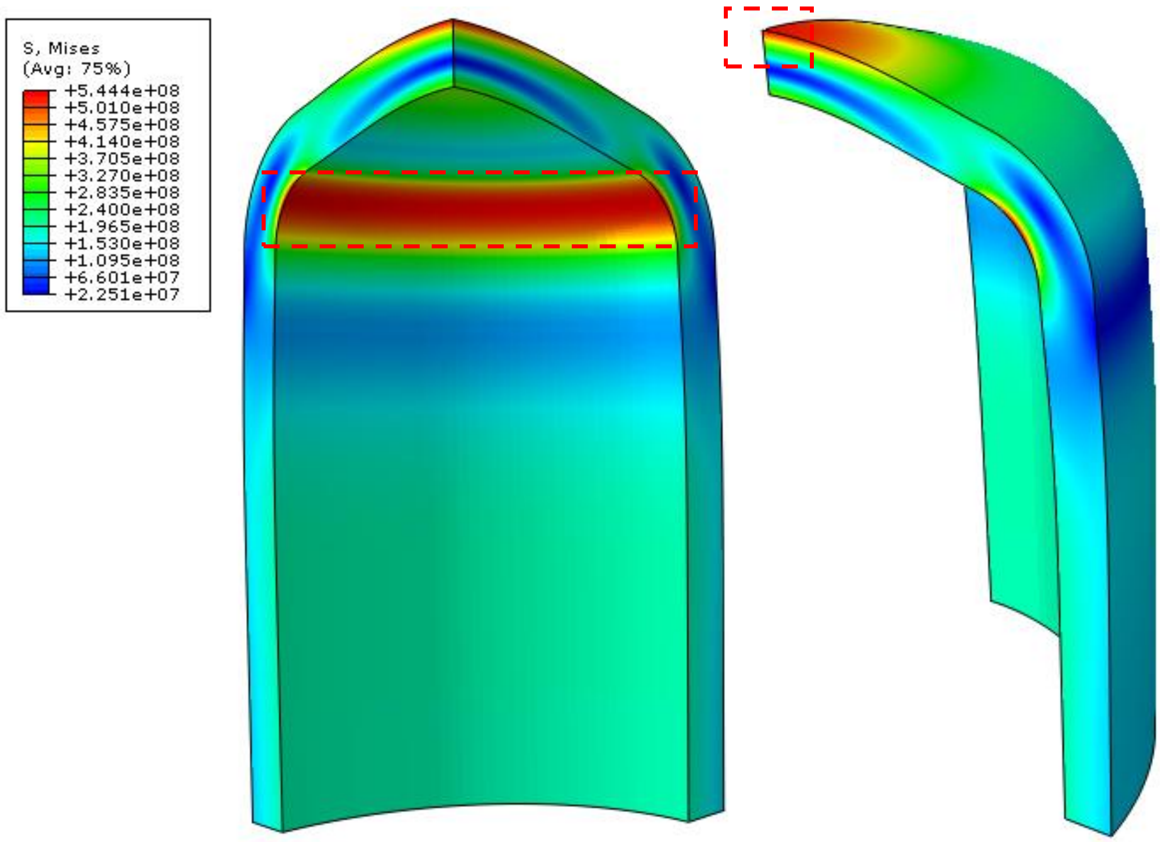


Figure 6. von-Mises stress distribution of case 1

The strain distribution of case 1 is shown below in fig. 7. The maximum strain is located at the inner fillet region.

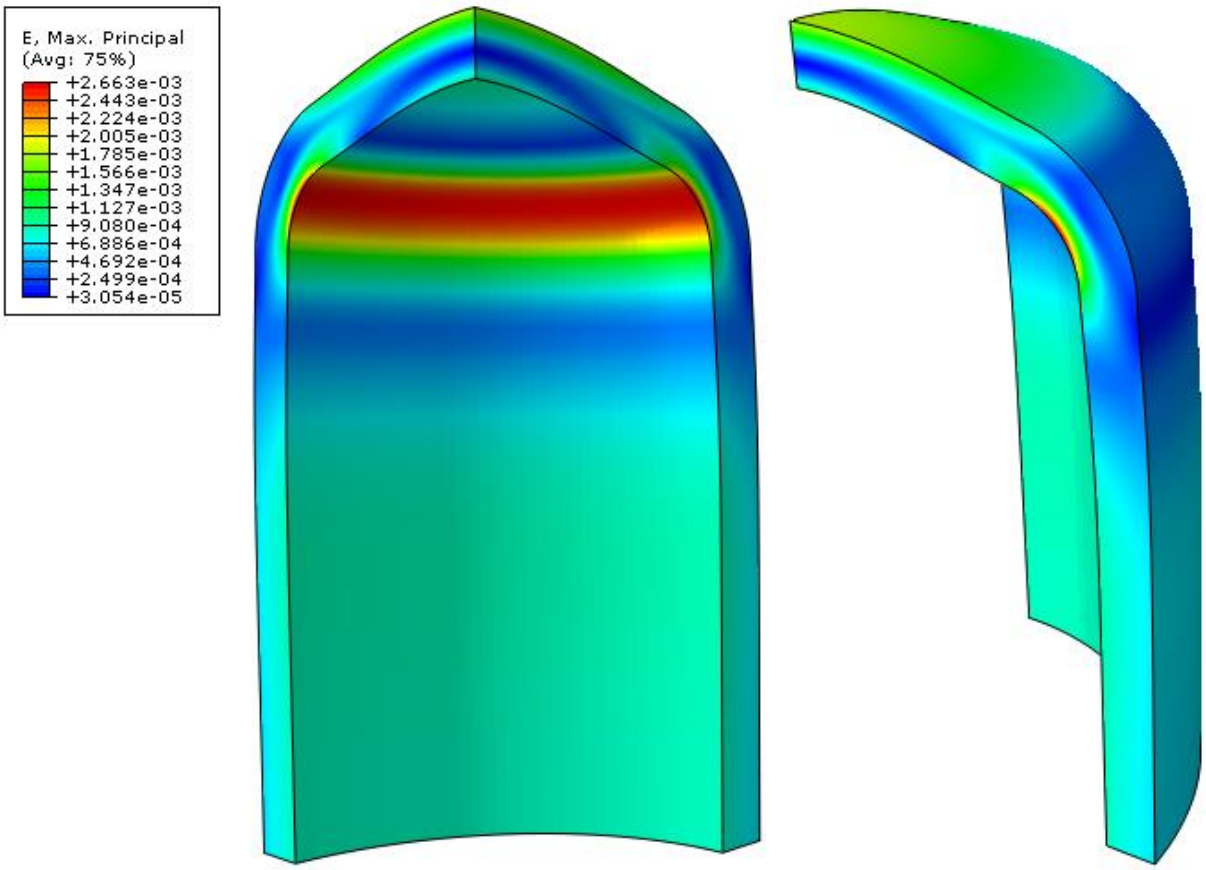


Figure 7. Strain distribution of case 1

Case 2, thermal loading

The inner surface of the cylinder is kept at 373.15 K, and the heat is lost on the exterior by convection to the ambient. The convection coefficient is 179 W/m2/K and the sink temperature is 293.15 K. Plot the temperature distribution, von-Mises stress and strain distributions.

The temperature distribution is shown in fig.8. The temperature of the inner surface is constant at 373.15 K and decreases from the inner surface to the outer surface. The minimum temperature is 365.5 K in the outer fillet region.

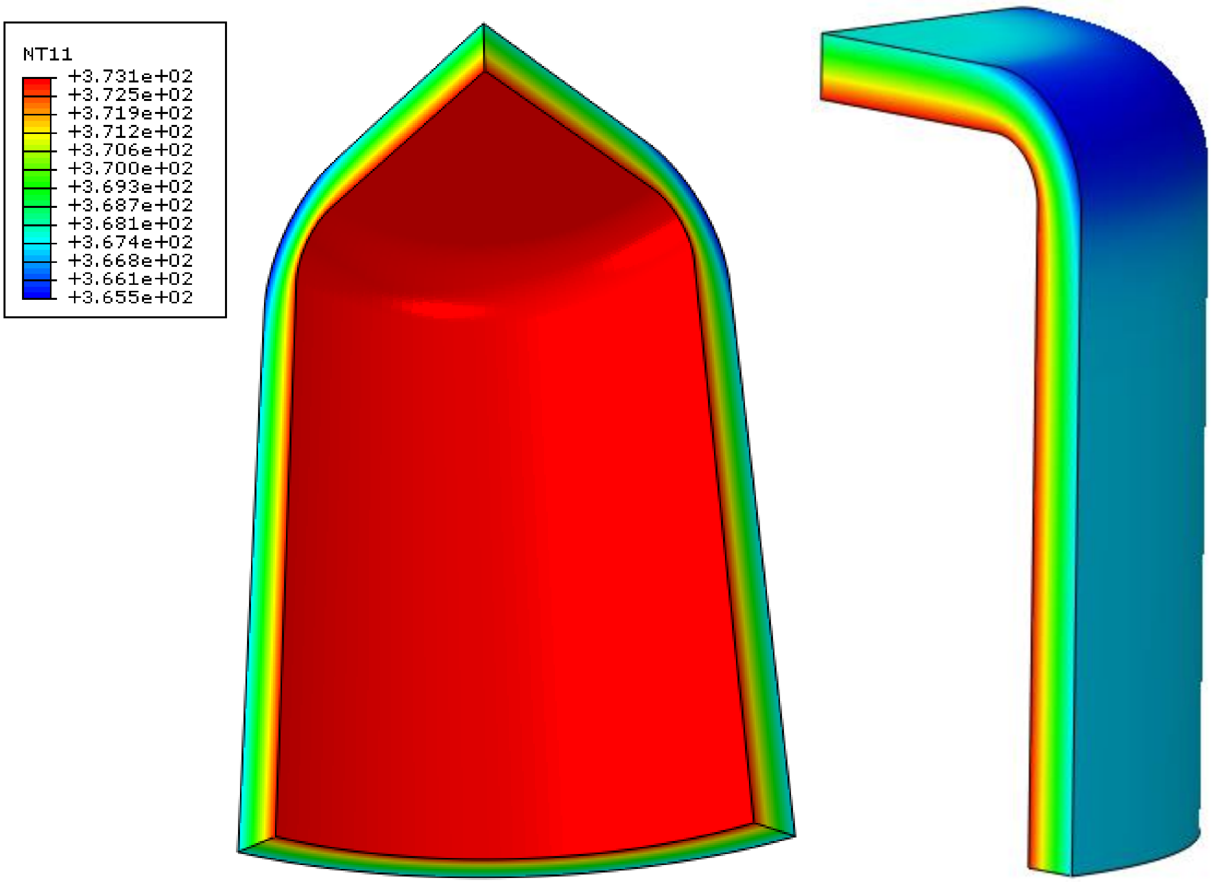


Figure 8. Temperature distribution of case 2

The stress distribution of case 2 is shown below in fig. 9. The maximum stress is located in the inner fillet region. And the strain distribution of case 2 is shown in fig.10.

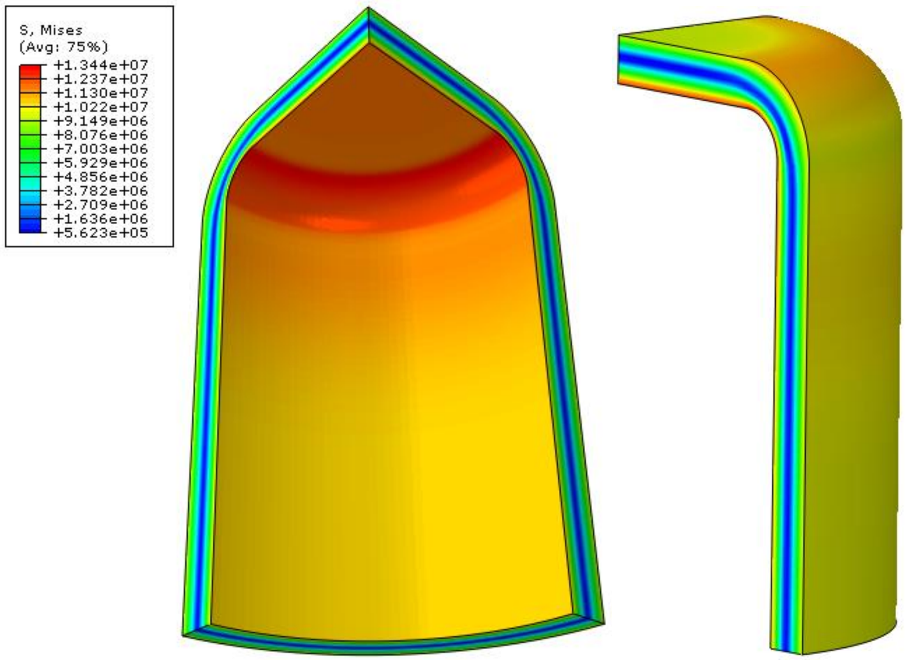


Figure 9. von-Mises stress distribution of case 2

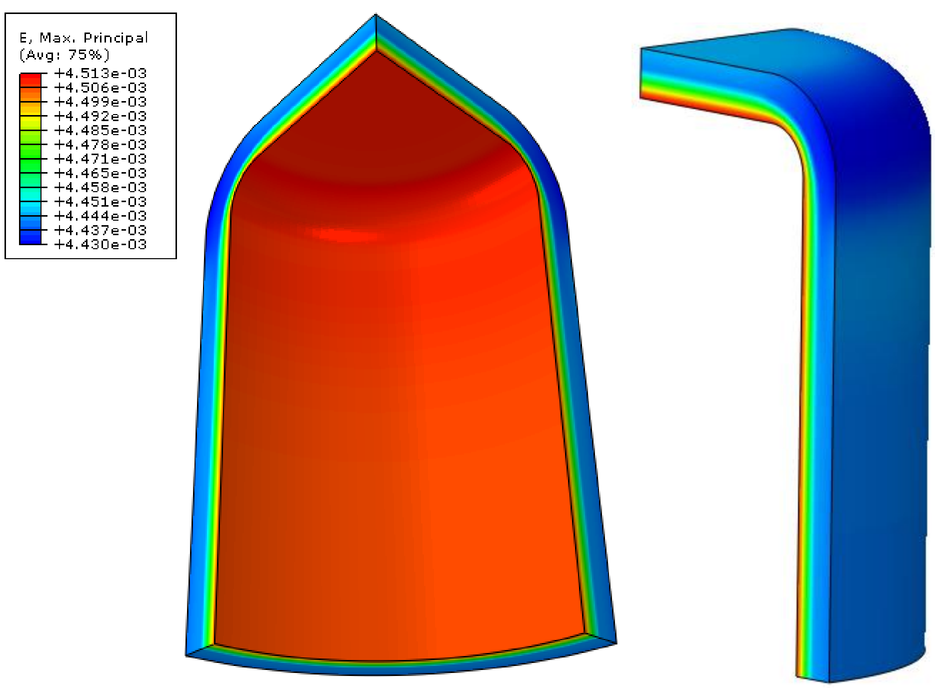


Figure 10. Strain distribution of case 2

Case 3, mechanical and thermal loading

Consider both mechanical and thermal loadings (cases 1 and 2). Plot the von-Mises stress and strain distributions, and find out the maximum von-Mises stress and location.

The von-Mises stress distribution is shown below in fig.11. The maximum von-Mises is 5.462e8 Pa which is located in the regions indicated in fig.11.

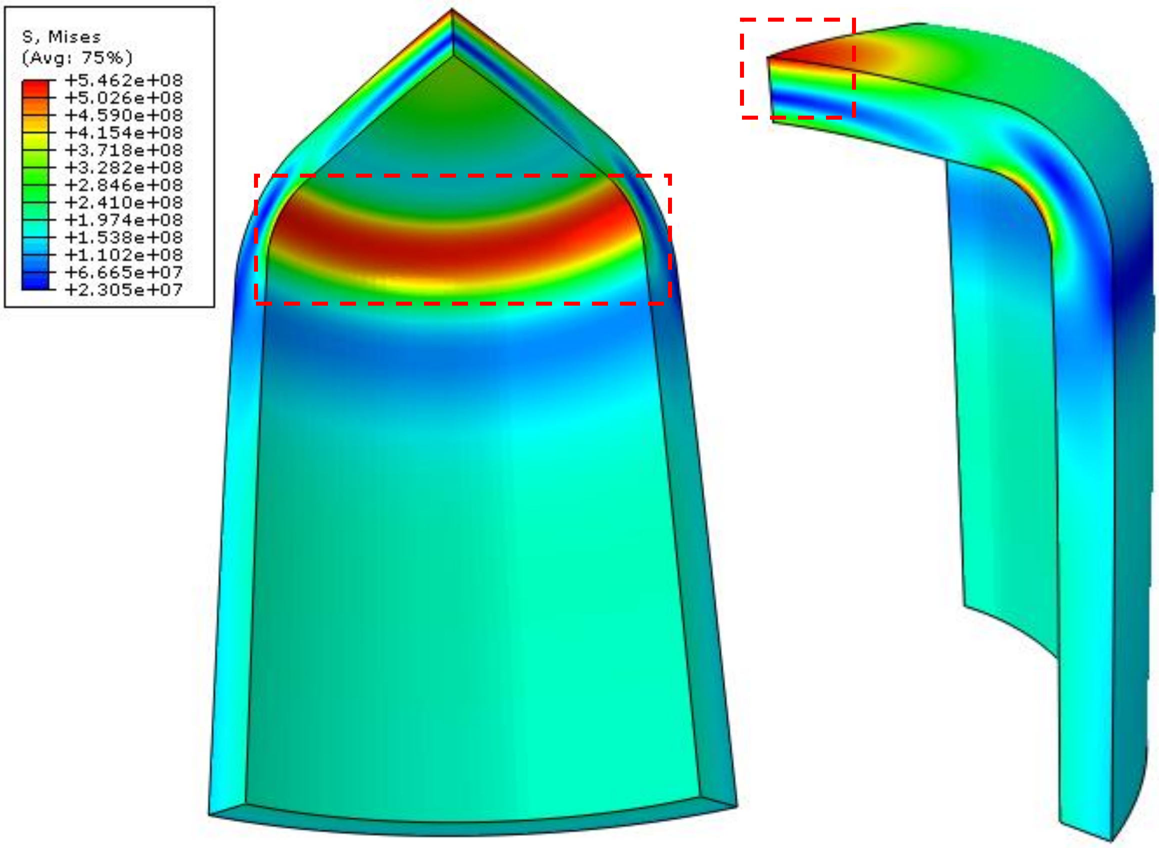


Figure 11. von-Mises stress distribution of case 3

The strain distribution of case 3 is shown below in fig. 12. The maximum strain is located in the inner fillet region, which is larger that both case 1 and case 2.

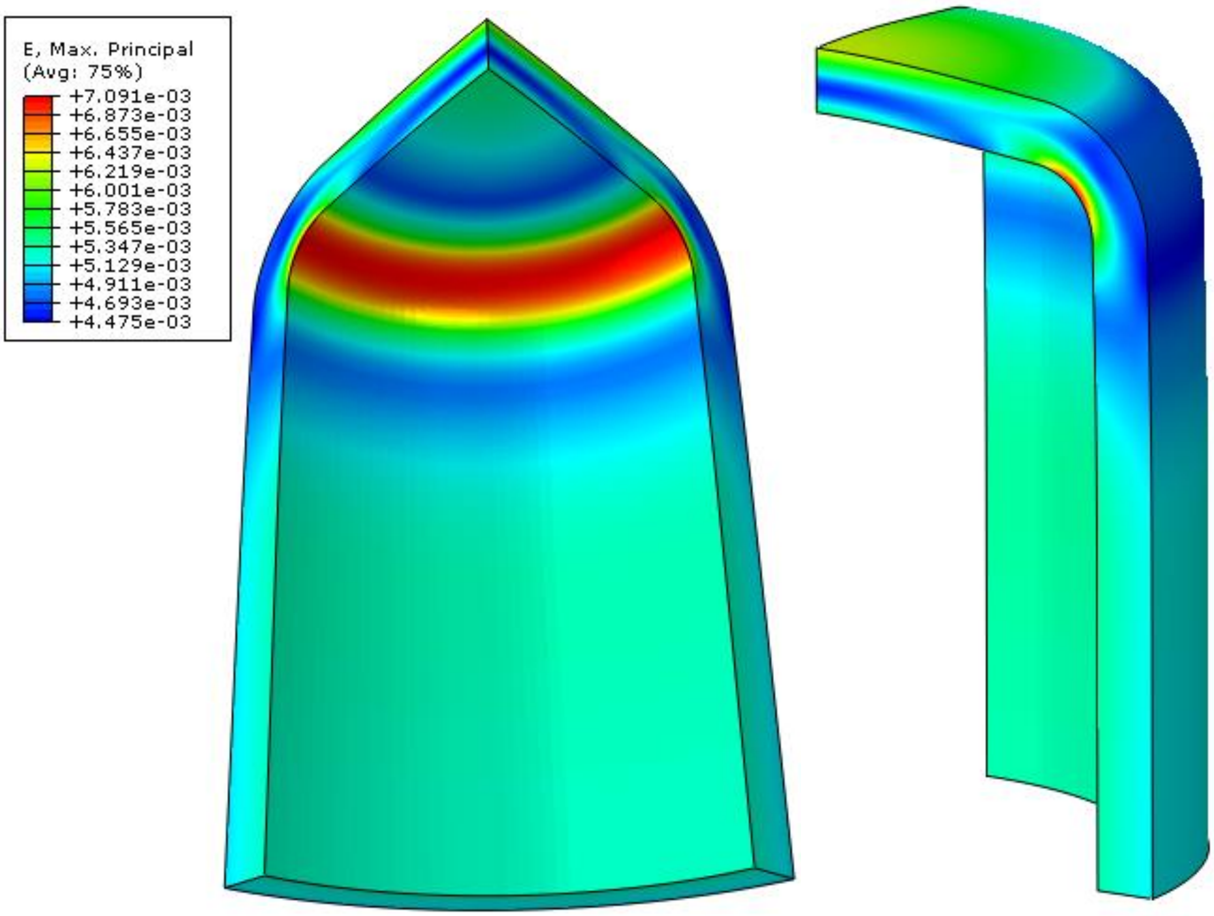


Figure 12. Strain distribution of case 3

The comparison of the maximum von-Mises stresses and the maximum strain for case 1, 2 and 3 are summarized in the following table.

	Maximum von-Mises stress (MPa)	**Maximum strain**
Case 1	544.4	2.663e-3
Case 2	13.44	4.513e-3
Case 3	546.2	7.091e-3