

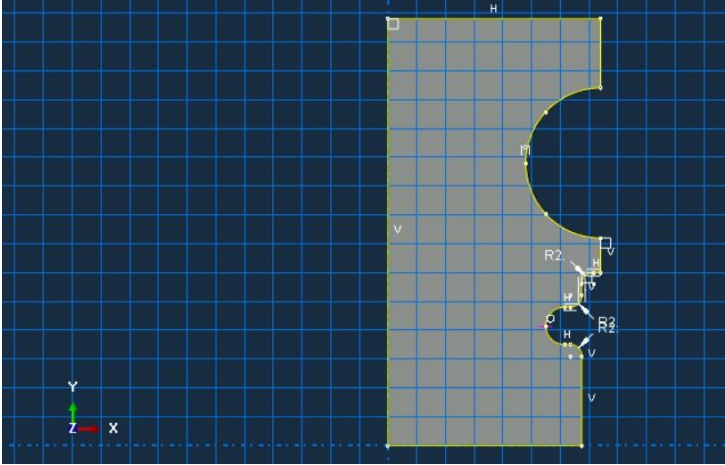
FEM model description:

- a) Boundary conditions:
1. x-symmetry ($U1 = UR2 = UR3 = 0$)
 2. Encastre ($U1 = U2 = U3 = UR1 = UR2 = UR3 = 0$)
 3. Traction load is applied on the top half of the semicircle (No pressure load as bolt is encastred, resultant load is 66 MPa (the applied traction load)).
- b) Plane stress
- c) Element type: Quadratic
- d) Symmetry: Symmetrical over y-axis

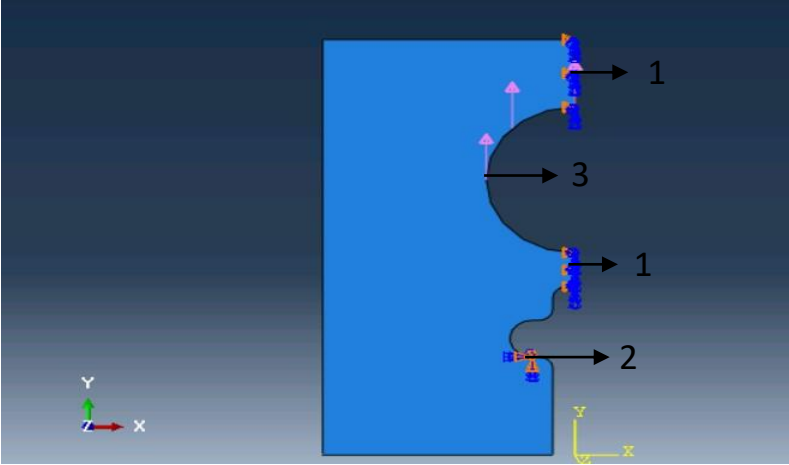
Breaking load: 188.605 N
Maximum principal stress: 623.3 MPa

Mesh refinement study:

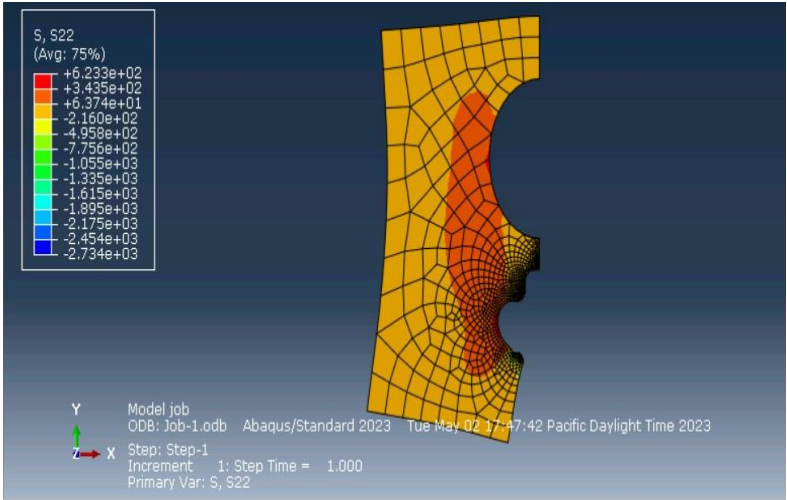
Mesh	Number of elements	Maximum principal stress (MPa)
Coarse	252	592.8
Medium	526	618.2
Fine	955	623.3



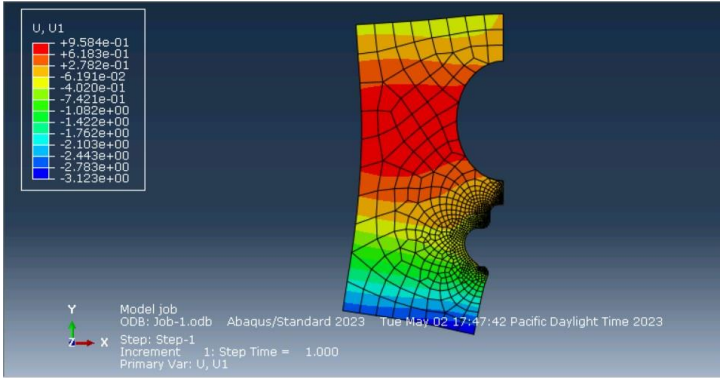
Part drawing



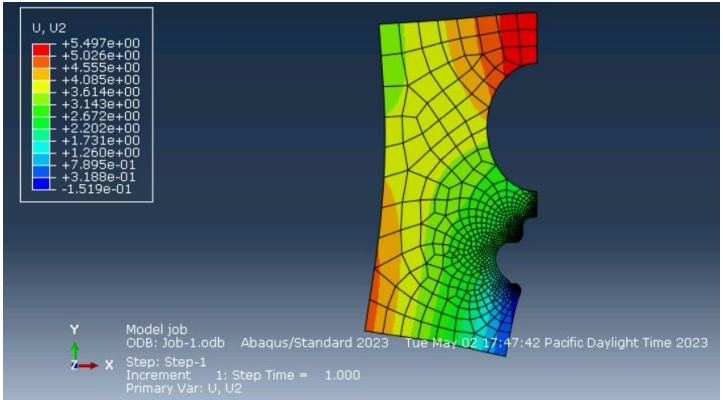
Part boundary conditions



Stress contour plot



Displacement contour plot (x component (above) and y component (below))



Improvements/Corrections in the FEM modeling:

- The 'cross' part of the design has been chamfered to a radius of about 2 mm for each edge.
- The stress values from the original design compared to the modified design:
 - a) S22: Original design: 708.5 MPa
 - b) S22: Modified design: 623.3 MPa
 - c) U: Original design: 3.848 mm
 - d) U: Modified design: 5.497 mm

The provided values do make sense. As the design of the mesh is changed to reduce the maximum principal stress, there is an increase in distance as the change in the surface area means the displacement of the design (in mm) also increases due to the lower stresses. Since the load is distributed at the top half of the hole, the design is bent in such a way that the top half is bent in a manner like that of a pulling force, while since the bolt side is encastred, there is no change in the displacement but because it is encastred, the bottom side also experiences a slight bend like that of a pulling force. This suggests that at a stress of 623.3 MPa, the design can experience a maximum displacement of 5.497 mm before it breaks.

Summary:

Calculating the breaking loads for each of the cases, we get:

- a) Original design: 165.924 N
- b) Coarse mesh: 198.308 N
- c) Medium mesh: 190.161 N
- d) Fine mesh: 188.605 N

Thus there is no substantial change ($>20\%$) in the loads provided. The percentage change in load is shown to range from about 1.13% to 1.19% (from fine to coarse).