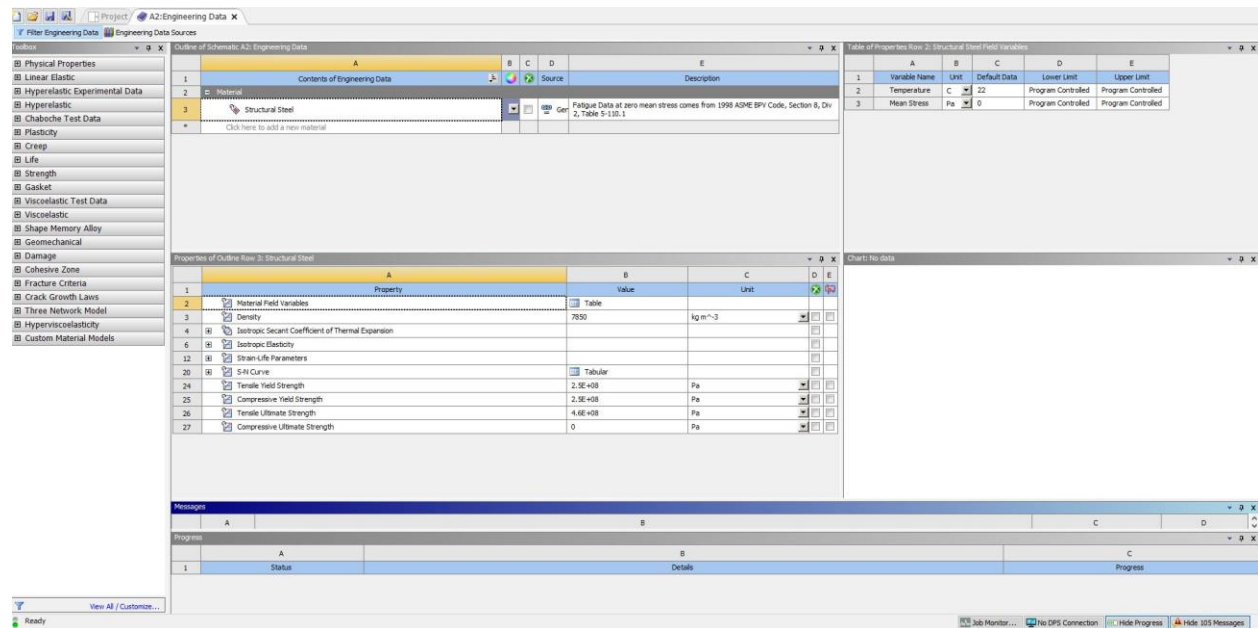


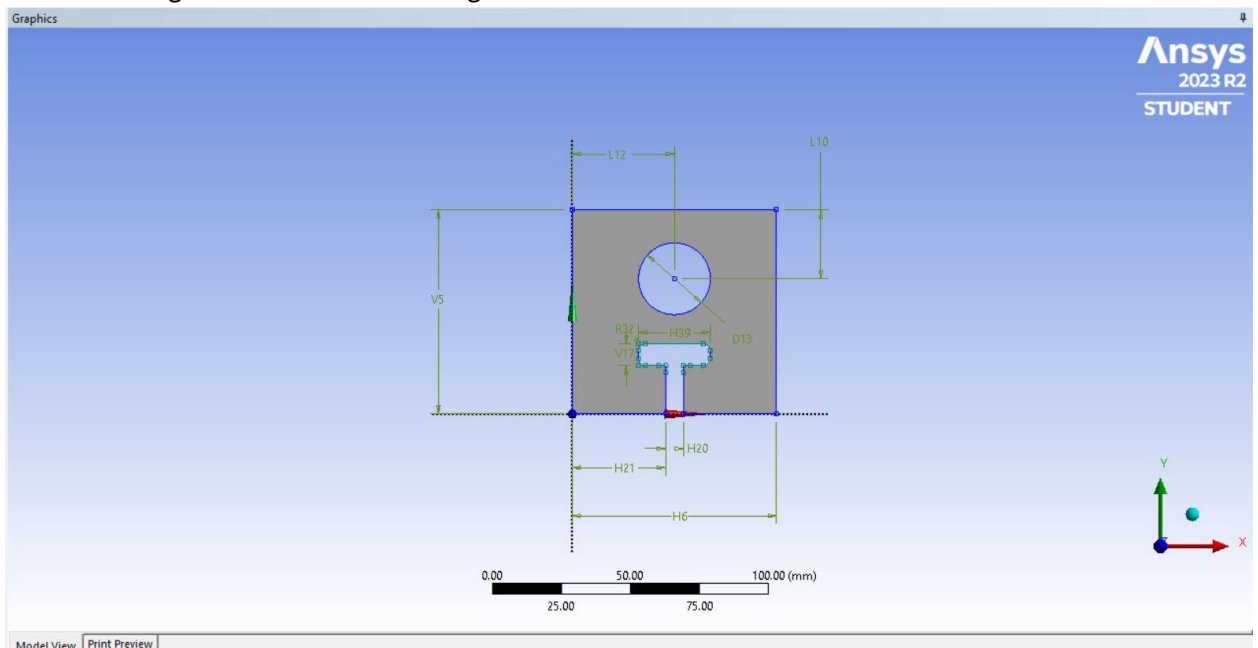
Ansys Design

I created a structural analysis project in Ansys and designed a plate which will be constrained on one side and will have a load acting on one of the surfaces in the downward direction. The load will be acting on a slot in my part.

1. For the engineering data I choose the default structural steel properties.

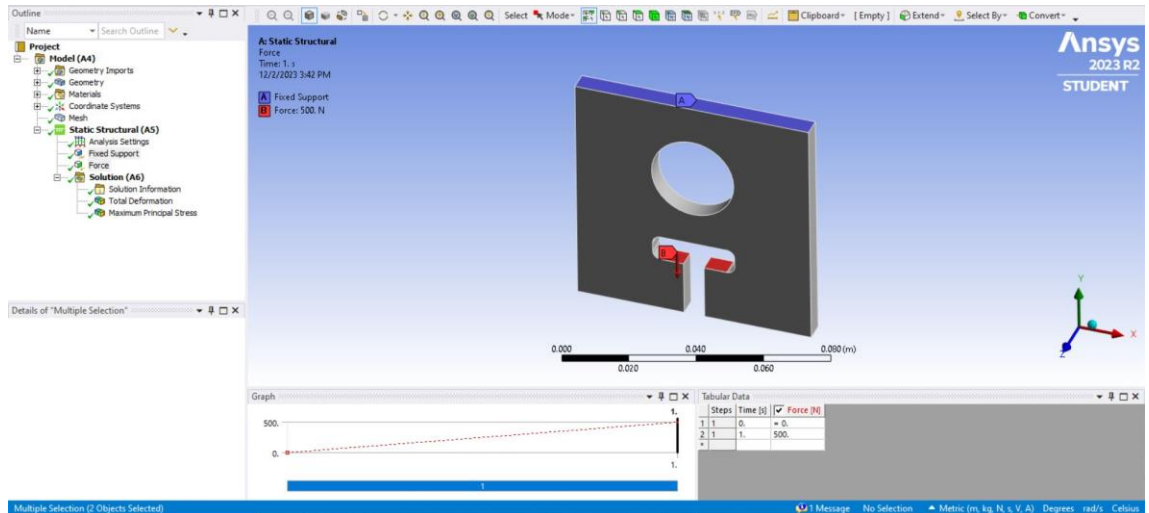


2. I then modeled my part in design modeler and create a rectangular part with fastener slot in between along which load will be acting.



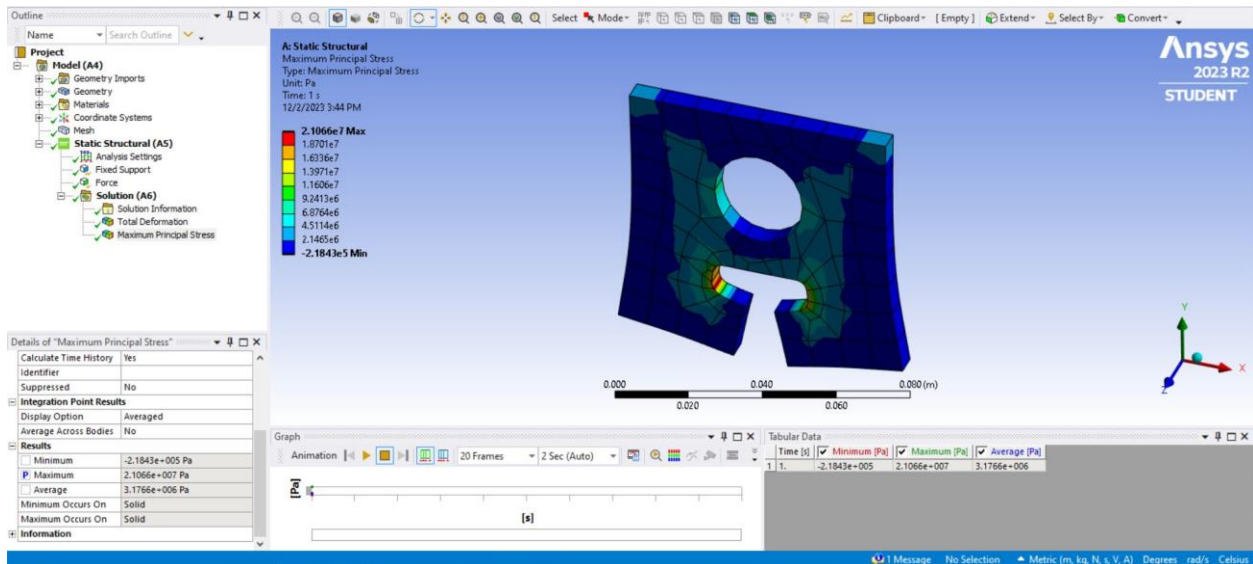
In this design, the radius of the corner, the height and width of the slot were set as modifiable parameters. These will get tuned by the DOE to get the best possible combination.

3. After creating the CAD model, I needed to constrain my geometry and also mesh the part and run my results.



From the image it can be seen that I add a load of 500 N in the downward direction of my slot and I constrain the top surface of my part as a fixed support.

I choose the maximum principal stress as my output parameter. Which can be seen below.



4. Following are the list of the parameters chosen

Outline of Schematic A8: Parameters				
	A	B	C	D
1	ID	Parameter Name	Value	Unit
2	Input Parameters			
3	Static Structural (A1)			
4	P10	XYPlane.R32	2.5	mm
5	P11	XYPlane.H39	26	mm
6	P12	XYPlane.V17	8	mm
*	New input parameter	New name	New expression	
8	Output Parameters			
9	Static Structural (A1)			
10	P9	Maximum Principal Stress Maximum	2.1066E+07	Pa
*	New output parameter		New expression	
12	Charts			

5. We now run the DOE analysis: We use Latin Hyper cube sampling design and select the user defined number of samples where I choose 8 samples.

Outline of Schematic A2: Design of Experiments				
1	Design of Experiments	enabled		
2	Input Parameters			
3	Static Structural (A1)			
4	P10 - XYPlane.R32	<input checked="" type="checkbox"/>		
5	P11 - XYPlane.H39	<input checked="" type="checkbox"/>		
6	P12 - XYPlane.V17	<input checked="" type="checkbox"/>		
7	Output Parameters			
8	Static Structural (A1)			
9	P9 - Maximum Principal Stress Maximum			
10	Charts			
11	Parameters Parallel	<input checked="" type="checkbox"/>		
12	Design Points vs Parameter	<input checked="" type="checkbox"/>		

Table of Outline A2: Design Points of Design of Experiments				
	A	B	C	D
1	Name	P10 - XYPlane.R32 (mm)	P11 - XYPlane.H39 (mm)	P12 - XYPlane.V17 (mm)
2	1	2.175	25.025	8.5
3	2	2.625	24.375	8.1
4	3	1.875	26.325	7.7
5	4	2.475	23.725	7.3
6	5	2.025	27.625	7.9
7	6	2.925	26.975	8.3
8	7	2.325	25.675	8.7
9	8	2.775	28.275	7.5

Table of Outline A2: Design Points of Design of Experiments				
	A	B	C	D
1	Name	P9 - Maximum Principal Stress Maximum (Pa)		
2	1	2.211E+07		
3	2	2.2178E+07		
4	3	2.6642E+07		
5	4	2.102E+07		
6	5	2.1632E+07		
7	6	1.9382E+07		
8	7	2.0011E+07		
9	8	2.4483E+07		

Properties of Outline A2: Design of Experiments				
1	Property	Value		
2	Design of Experiments	enabled		
3	Preserve Design Points After OK Run	<input type="checkbox"/>		
4	Failed Design Points Management			
5	Number of Runs	0		
6	Design of Experiments			
7	Type	Latin Hypercube Sampling Design		
8	Sample Type	User Defined Samples		
9	Random Generator Seed	0		
10	Number of Samples	8		
11	Design Point Support			
12	Report Design	None		

6. We next run the response surface analysis and we select the genetic aggregation from the response surface type. We also generate 2 verification points

Project: B2:Design of Experiments x B3:Response Surface x

Update Clear Generated Data Refresh Export Response Surface

Outline of Schematic B3: Response Surface

A	B
1	Enabled
5	P10 - XYPlane.R32
6	P11 - XYPlane.H39
7	P12 - XYPlane.V17
8	Output Parameters
11	Min-Max Search
12	Refinement
13	Tolerances
14	Refinement Points
15	Quality
16	Goodness Of Fit
17	Verification Points
18	Response Points

Properties of Outline A2: Response Surface

A	B
1	Property Value
2	Design Points
3	Preserve Design Points After DX Run
4	Preserve Design Points Management
5	Number of Retries
6	Model Root
7	Response Surface Type
8	Generate Verification Points
9	Number of Verification Points
10	Design Point Report
11	Report Image
12	None

Table of Schematic B3: Response Surface: Tolerances

A	B	C	D	E	F	
1	Name	Calculated Minimum	Calculated Maximum	Maximum Predicted Error	Refinement	Tolerance
2	P9 - Maximum Principal Stress Maximum (Pa)	1.7651E+07	2.6924E+07	5.9203E+06		

Chart: No data

7. We check the verification points that are shown in the response surface analysis and we can see the verification points prediction are close to the model.

Project: B2:Design of Experiments x B3:Response Surface x

Update Clear Generated Data Refresh Export Response Surface

Outline of Schematic B3: Response Surface

A	B
1	Enabled
8	Output Parameters
11	Min-Max Search
12	Refinement
13	Tolerances
14	Refinement Points
15	Quality
16	Goodness Of Fit
17	Verification Points
18	Response Points
19	Response
20	Local Sensitivity
21	

Properties of Outline A15: Goodness Of Fit

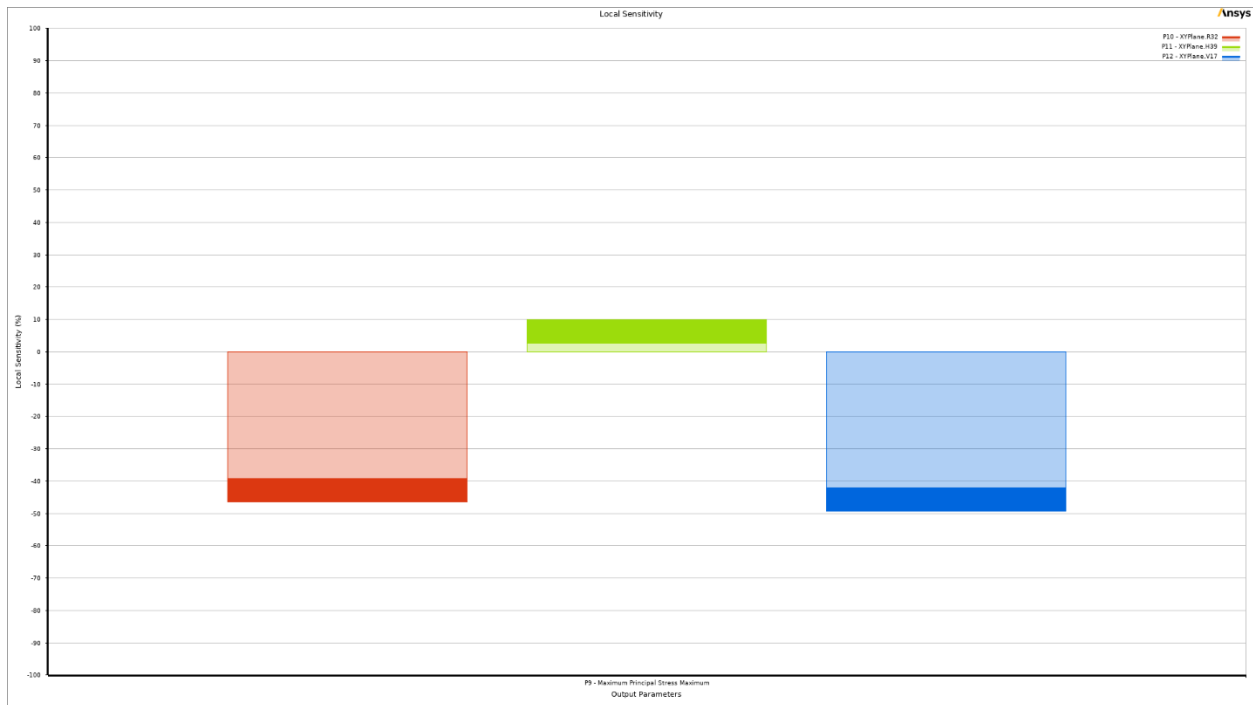
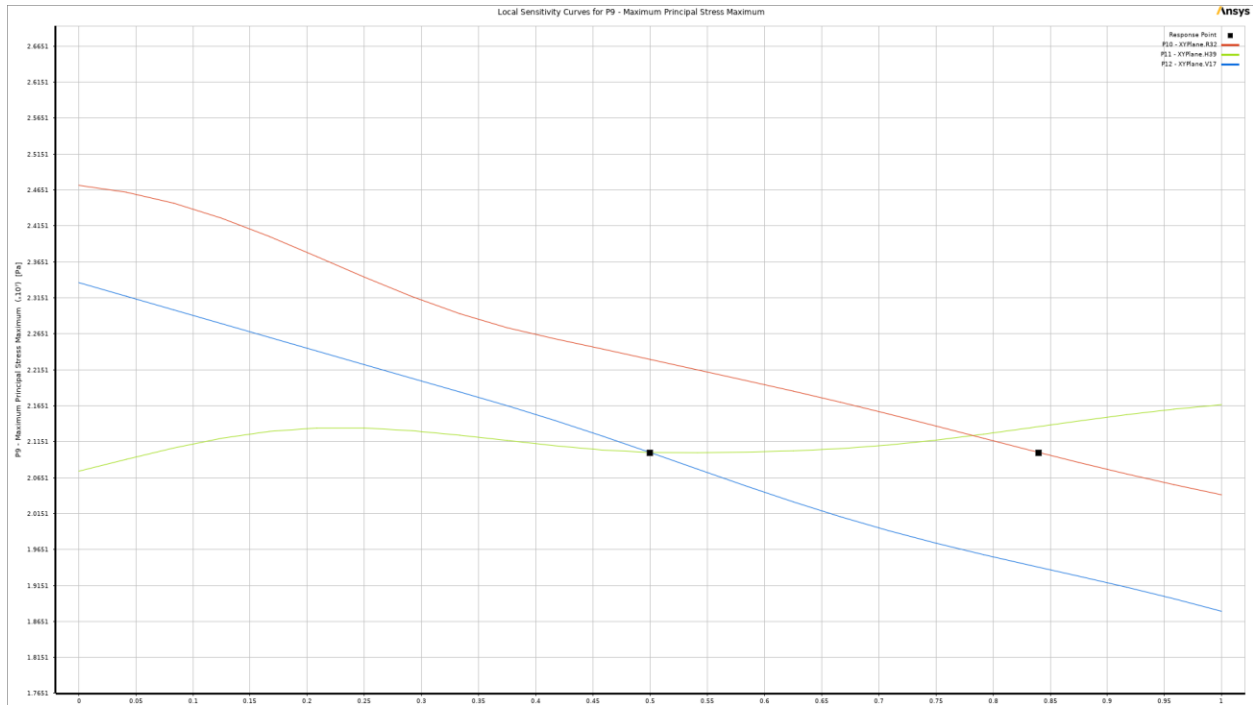
A	B	C	D
1	Property	Value	Predicted Value
2	Chart		Enabled
3	Display Parameter Full Name		
4	Show Verification Points		
5	Show Learning Points		
6	Input Parameters		
7	P10 - XYPlane.R32	2.325	
8	P11 - XYPlane.H39	25.675	
9	P12 - XYPlane.V17	8.7	
10	Output Parameters		
11	P9 - Maximum Principal Stress Maximum	2.0011E+07	2.0011E+07

Table of Schematic B3: Response Surface

A	B
1	P9 - Maximum Principal Stress Maximum
2	Coefficient of Determination (Best Value = 1)
3	Learning Points
4	Cross-Validation on Learning Points
5	Root Mean Square Error (Best Value = 0)
6	Learning Points
7	Verification Points
8	Cross-Validation on Learning Points
9	Relative Maximum Absolute Error (Best Value = 0%)
10	Learning Points
11	Verification Points
12	Cross-Validation on Learning Points
13	Relative Average Absolute Error (Best Value = 0%)
14	Learning Points
15	Verification Points
16	Cross-Validation on Learning Points

Predicted vs Observed

We next check the sensitivity analysis of the design parameters:



We can see that the radius parameter and the vertical height parameter play a larger role in affecting the maximum principal stress.

We can also see the maximum and minimum values that can be achieved by varying the parameters.

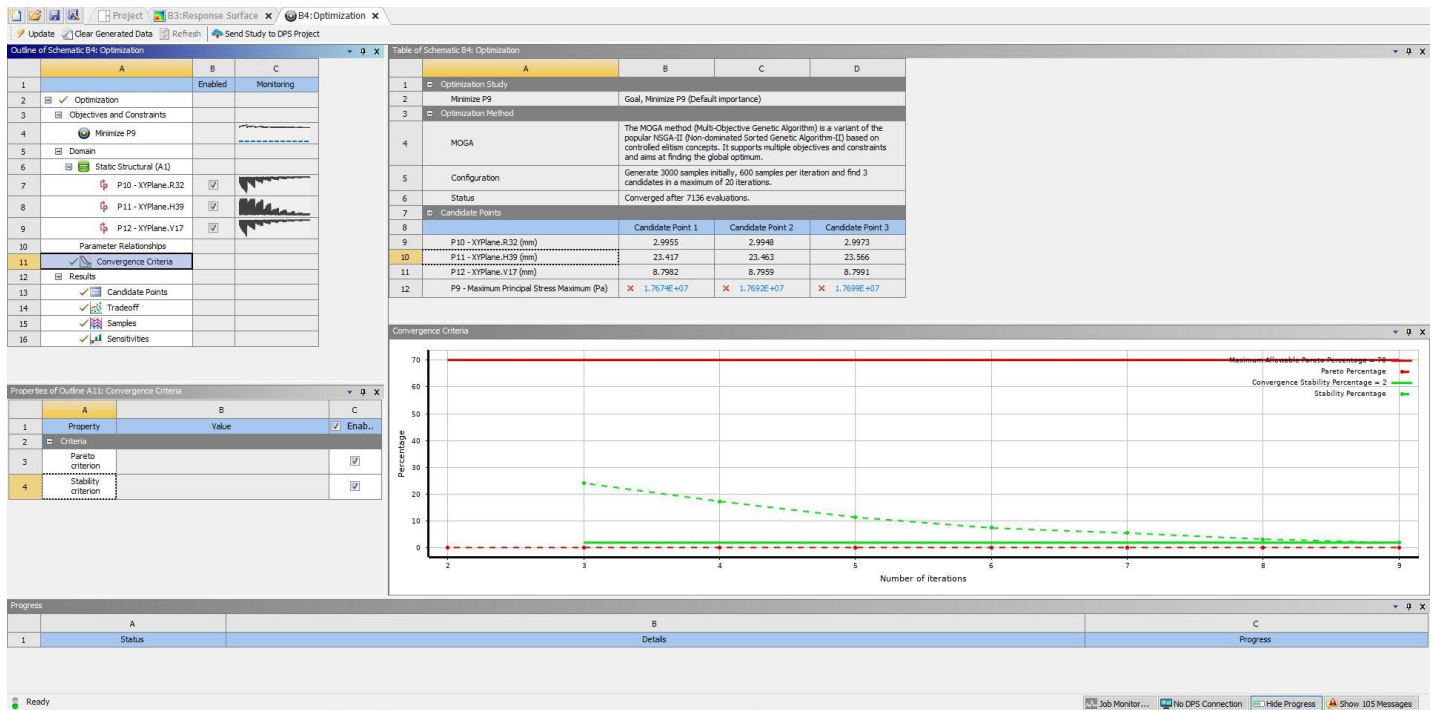
Outline of Schematic B3: Response Surface		
1	A	B
2	✓ Response Surface	Enabled
3	Input Parameters	
4	Static Structural (A1)	
5	P10 - XYPlane.R32	✓
6	P11 - XYPlane.H39	✓
7	P12 - XYPlane.V17	✓
8	Output Parameters	
11	✓ Min-Max Search	✓
12	Refinement	
13	✓ Tolerances	
14	✓ Refinement Points	
15	Quality	

Table of Outline A11: Min-Max Search				
	A	B	C	D
1	Name	P10 - XYPlane.R32 (mm)	P11 - XYPlane.H39 (mm)	P12 - XYPlane.V17 (mm)
2	Output Parameter Minimums			
3	P9 - Maximum Principal Stress Maximum	3	23.4	8.8
4	Output Parameter Maximums			
5	P9 - Maximum Principal Stress Maximum	1.8	28.6	7.2

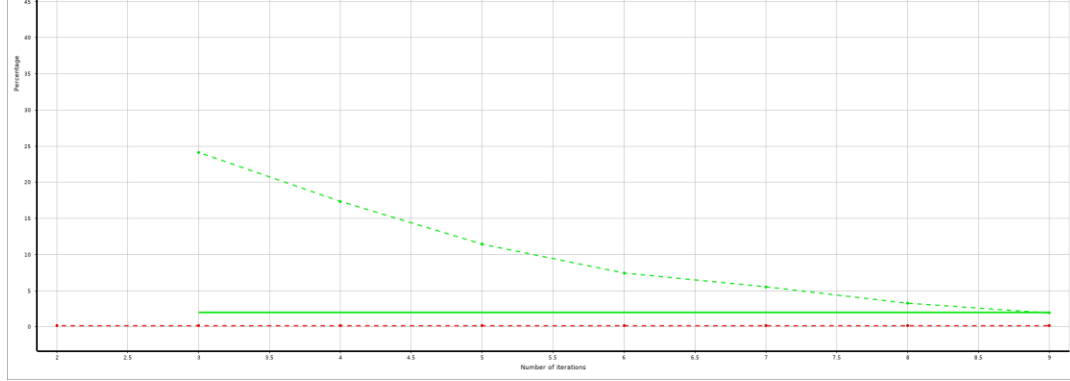
1	Name	P9 - Maximum Principal Stress Maximum (Pa)
2	Value	1.7651E+07
3	Value	2.6924E+07

8. We finally conducted the optimization study: We choose the output parameter of maximum principal stress as the objective function that needs to be minimized.

For the optimization method we use MOGA- which is expanded as the multi-objective genetic algorithm



We validate the optimal solution by looking at the convergence criteria, since we have convergence for this set of parameters



We also have the tradeoff analysis for the radius parameter that is shown.



Conclusion:

1. We see that for the parameters: Radius, Height and Length we have the following values that are optimum
 - a. Radius: **3 mm**
 - b. Height: **8.8 mm**
 - c. Length: **23.4 mm**
2. Having these optimum values we can minimize the maximum principal stress to **1.765×10^7 Pa**

