Optimum Design Course
Fall 2016

Ansys Tutorial 3
Link – Design of Experiments

Overview

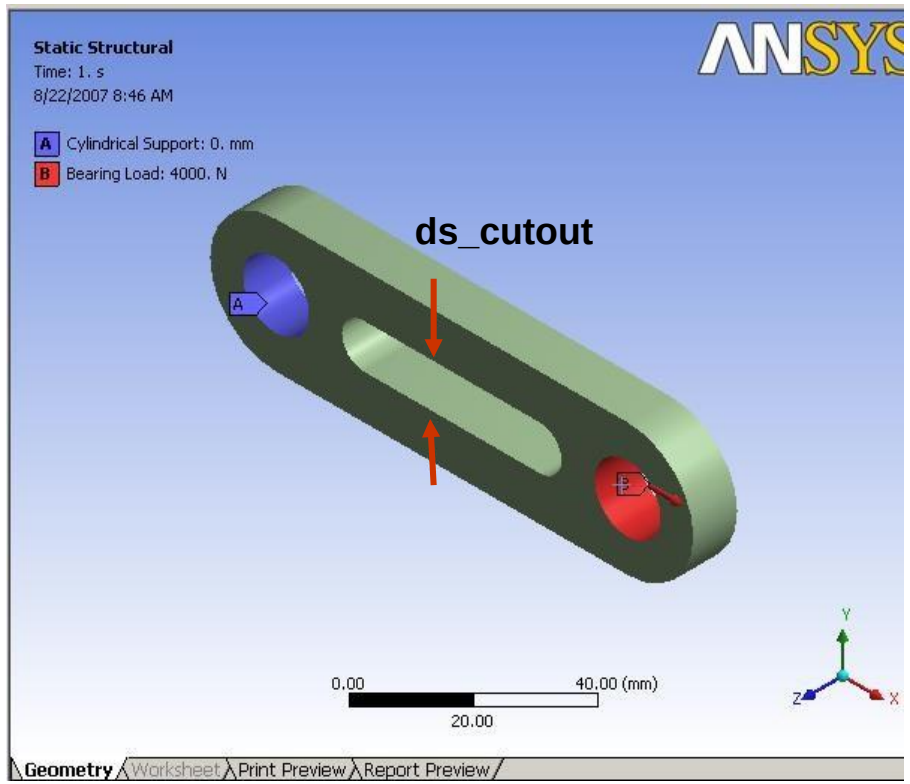
- **Goal**
  - Showing Design Exploration DOE scenario, and creating response charts
- **Model Description**
  - The boundary conditions have been applied as shown here

Input parameters

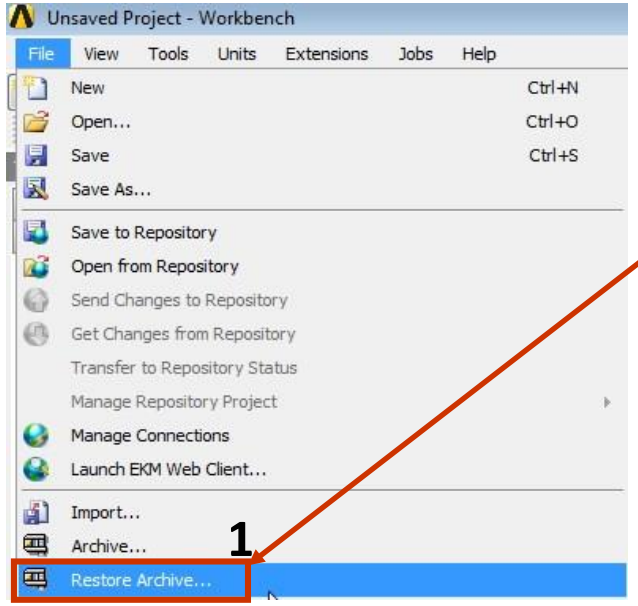
- ds_cutout – geometry parameter
- Bearing load

Output parameters

- Mass
- Equivalent stress
- Total deformation

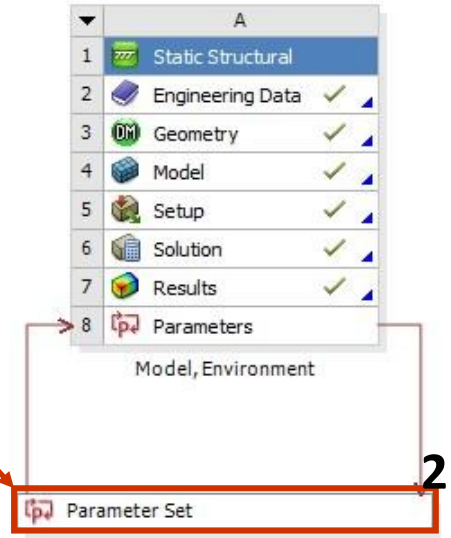


Project Startup



1. File>Restore Archive>Tut_3_Input_File

2. Verify all your input and output parameters by double clicking on Parameter Set



Input parameters

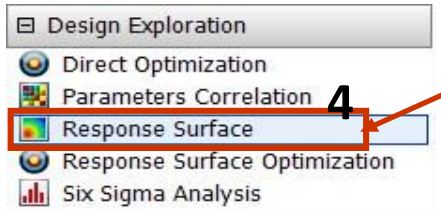
Output parameters

Outline of All Parameters

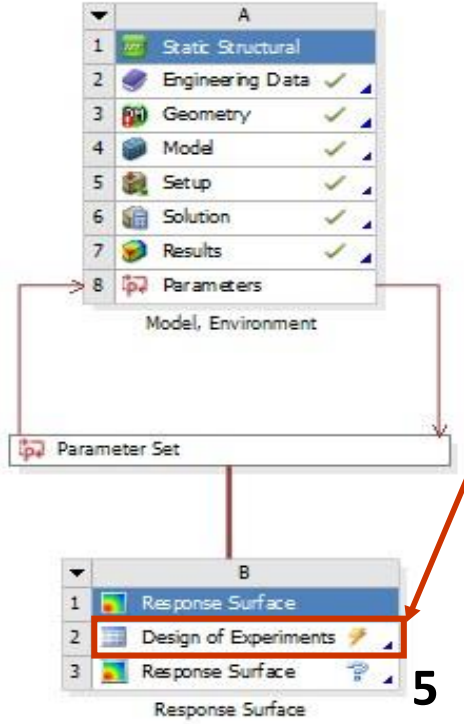
	A	B	C	D
1	ID	Parameter Name	Value	Unit
2	Input Parameters			
3	Static Structural (A1)			
4	P1	ds_cutout	5	
5	P3	Bearing Load X Component	4000	N
*	New input parameter	New name	New expression	
7	Output Parameters			
8	Static Structural (A1)			
9	P2	Solid Mass	0.17858	kg
10	P4	Equivalent Stress Maximum	109.44	MPa
11	P5	Total Deformation Maximum	0.013564	mm
12	P6	Equivalent Stress 2 Maximum	36.88	MPa
*	New output parameter		New expression	
14	Charts			

3. Switch to Project

Design Of Experiments study



4. Double click on “Response Surface” to start DOE study



5. Double click on DOE

Outline of DOE shows input and output parameters

Outline of Schematic B2: Design of Experiments

	A	B
1		Enabled
2	Design of Experiments	
3	Input Parameters	
4	Static Structural (A1)	
5	P1 - ds_cutout	☑
6	P3 - Bearing Load X Component	☑
7	Output Parameters	
8	Static Structural (A1)	
9	P2 - Solid Mass	
10	P4 - Equivalent Stress Maximum	
11	P5 - Total Deformation Maximum	
12	P6 - Equivalent Stress 2 Maximum	
13	Charts	

Design Of Experiments study

Outline of Schematic B2: Design of Experiments

	A	B
1		Enabled
2	Design of Experiments	
3	Input Parameters	
4	Static Structural (A1)	
5	P1 - ds_cutout	☑
6	P3 - Bearing Load X Component	☑
7	Output Parameters	
8	Static Structural (A1)	
9	P2 - Solid Mass	
10	P4 - Equivalent Stress Maximum	
11	P5 - Total Deformation Maximum	
12	P6 - Equivalent Stress 2 Maximum	
13	Charts	

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Properties of Outline A5: P1 - ds_cutout

	A	B
1	Property	Value
2	General	
3	Component ID	Design of Experiment
4	Directory Name	RSR
5	Units	
6	Type	Design Variable
7	Classification	Continuous
8	Notes	
9	Notes	
10	Values	
11	Lower Bound	4.5
12	Upper Bound	5.5
13	Use Manufacturable Values	☐

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6. Highlight parameter 1, ds_cutout in Outline of Design of Experiments

7. In Properties of Outline set the classification of the parameter and define the lower and upper bounds

Ds_cutout:

4.5-5.5

8. Bearing Load X Component: 3600-4400

6	P3 - Bearing Load X Component ☑

Properties of Outline A6: P3 - Bearing Load X Component

	A	B
1	Property	Value
2	General	
3	Component ID	Design of Experiment
4	Directory Name	RSR
5	Units	N
6	Type	Design Variable
7	Classification	Continuous
8	Notes	
9	Notes	
10	Values	
11	Lower Bound	3600
12	Upper Bound	4400
13	Use Manufacturable Values	☐

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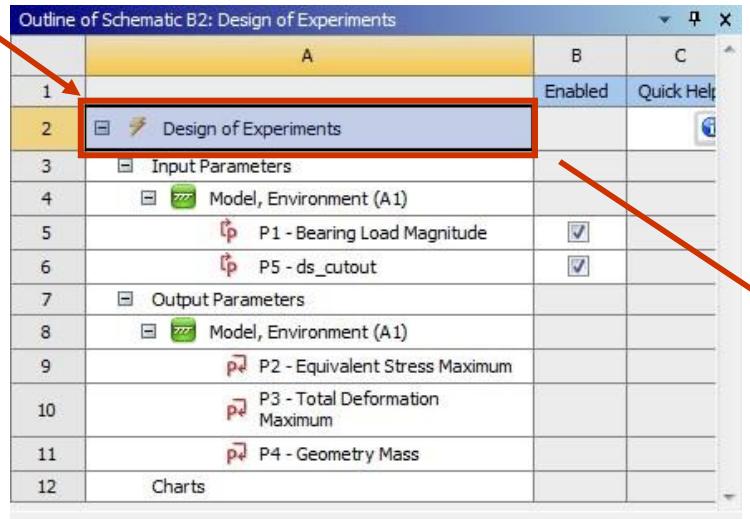
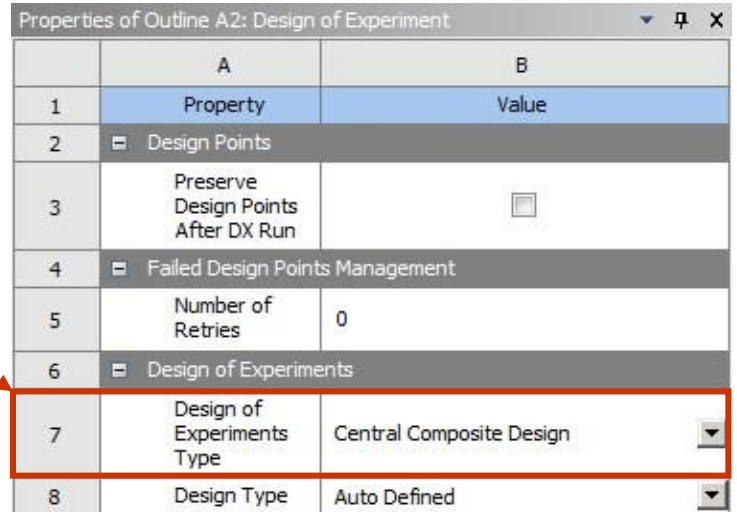
Design Of Experiments study

9. Select Design of Experiments and make sure that the DOE Type is set to Central Composite Design





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10. Click Preview to check the planned DOE to see how many design points are required. Then once you are ready to run the solver, hit Update

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11. Click on Show Progress to expand Status bar

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Design Of Experiments Results

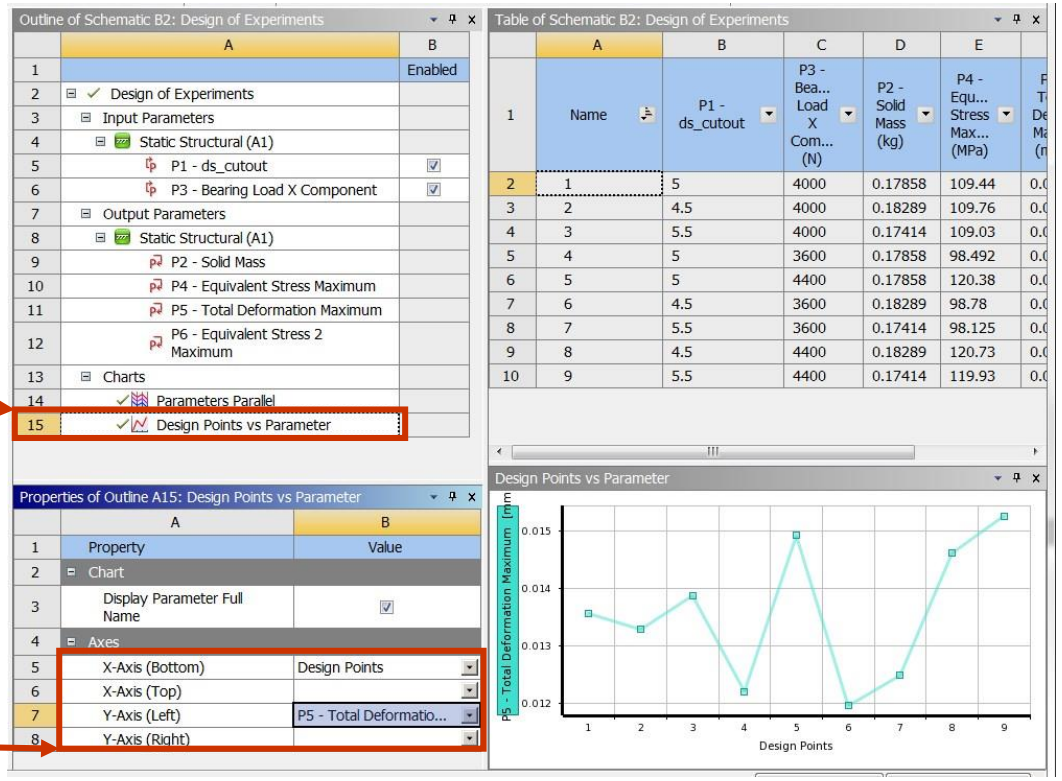
Table of DOE shows 9 completed design points

Table of Schematic B2: Design of Experiments (Central Composite Design : Auto Defined)

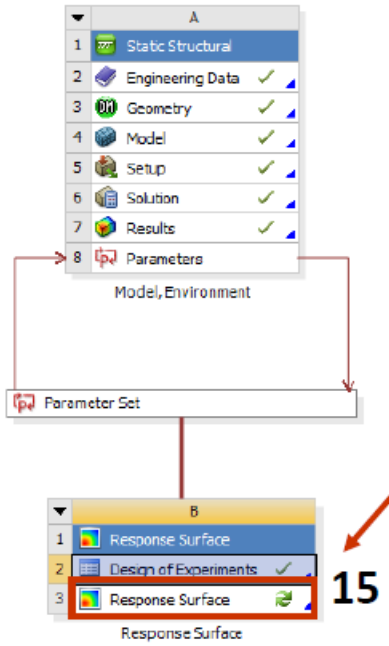
	A	B	C	D	E	F	G
1	Name	P1 - ds_cutout	P3 - Bearing Load X Component (N)	P2 - Solid Mass (kg)	P4 - Equivalent Stress Maximum (MPa)	P5 - Total Deformation Maximum (mm)	P6 - Equivalent Stress 2 Maximum (MPa)
2	1 DP 0	5	4000	0.17858	109.44	0.013564	36.88
3	2	4.5	4000	0.18289	109.76	0.013287	35.44
4	3	5.5	4000	0.17414	109.03	0.013876	38.315
5	4	5	3600	0.17858	98.492	0.012208	33.192
6	5	5	4400	0.17858	120.38	0.014921	40.568
7	6	4.5	3600	0.18289	98.78	0.011959	31.896
8	7	5.5	3600	0.17414	98.125	0.012489	34.483
9	8	4.5	4400	0.18289	120.73	0.014616	38.984
10	9	5.5	4400	0.17414	119.93	0.015264	42.146

12. Click on the Design Points vs Parameter chart

13. Plot Total deformation Maximum vs Design Points



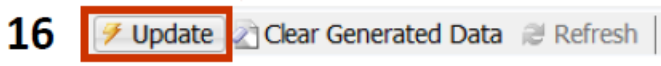
Response Surface



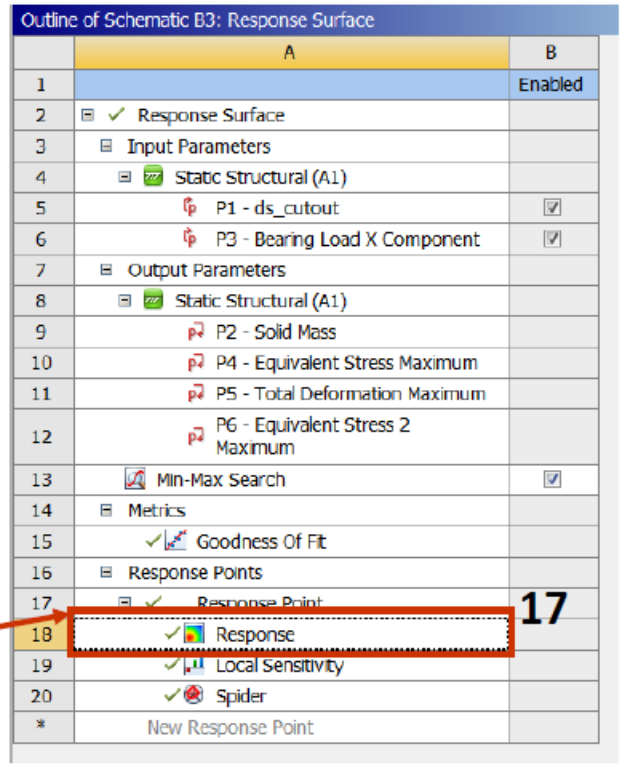
14. Return to Project Page

15. Double click on Response Surface. Click the Response Surface object in the Outline of schematic. Set the Response Surface type to Standard Response Surface

16. Update Response Surface



17. Click on Response



Results

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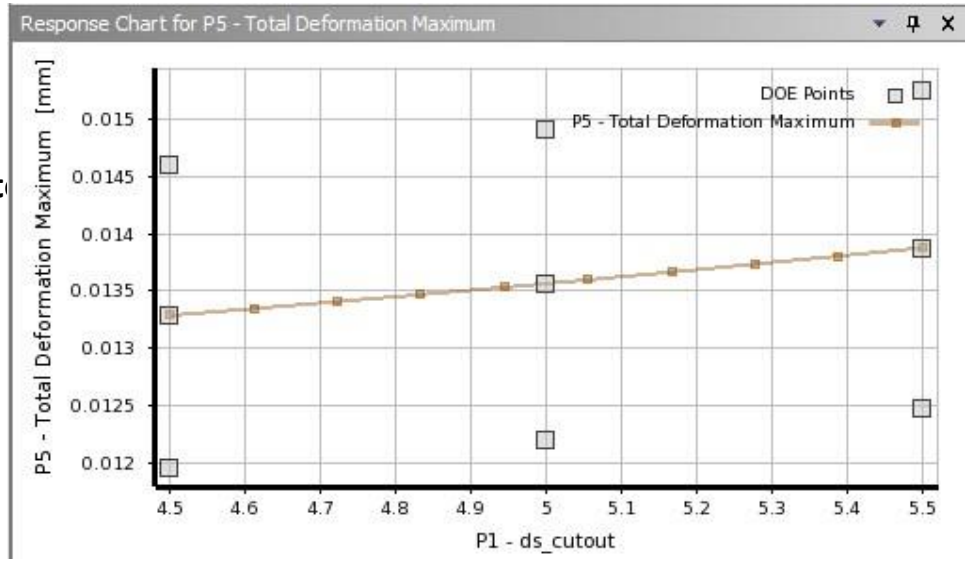
Properties of Outline A18: Response

	A	B
1	Property	Value
2	Chart	
3	Display Parameter Full Name	☑
4	Mode	2D
5	Chart Resolution Along X	10
6	Show Design Points	☑
7	Axes	
8	X Axis	P1 - ds_cutout
9	Y Axis	P5 - Total Deformation ...
10	Input Parameters	
11	P1 - ds_cutout	5
12	P3 - Bearing Load X Component	4000
13	Output Parameters	
14	P2 - Solid Mass	0.17858
15	P4 - Equivalent Stress Maximum	109.44
16	P5 - Total Deformation Maximum	0.013564
17	P6 - Equivalent Stress 2 Maximum	36.88

18. Set Mode to 2D and X and Y axis as shown and choose t show Design Points



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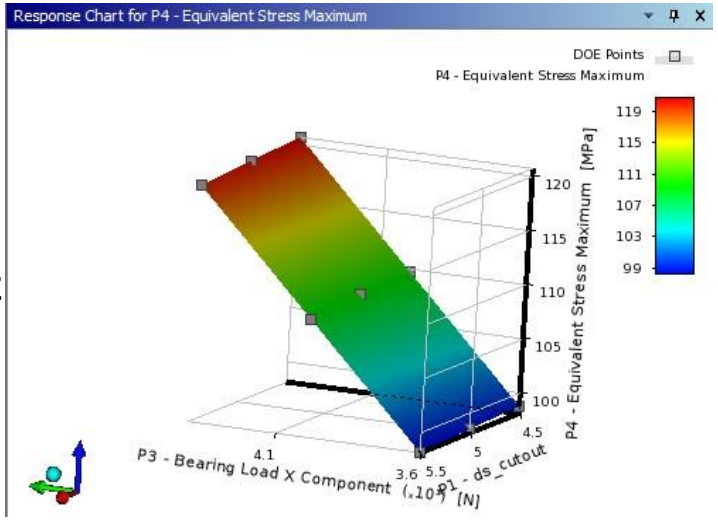
Properties of Outline A18: Response

	A	B
1	Property	Value
2	Chart	
3	Display Parameter Full Name	☑
4	Mode	3D
5	Chart Resolution Along X	10
6	Chart Resolution Along Y	10
7	Show Design Points	☑
8	Axes	
9	X Axis	P1 - ds_cutout
10	Y Axis	P3 - Bearing Load X Component
11	Z Axis	P4 - Equivalent Stress Maximum
12	Input Parameters	
13	P1 - ds_cutout	5
14	P3 - Bearing Load X Component	4000
15	Output Parameters	
16	P2 - Solid Mass	0.17858
17	P4 - Equivalent Stress Maximum	109.44
18	P5 - Total Deformation Maximum	0.013564
19	P6 - Equivalent Stress 2 Maximum	36.88

19. Switch Mode to 3D and Set X, Y, and Z axis as shown



Results

20. Click on spider and local sensitivities to plot charts

Outline of Schematic B3: Response Surface

	A	B
1		Enabled
2	Response Surface	
3	Input Parameters	
4	Static Structural (A1)	
5	P1 - ds_cutout	☑
6	P3 - Bearing Load X Component	☑
7	Output Parameters	
8	Static Structural (A1)	
9	P2 - Solid Mass	
10	P4 - Equivalent Stress Maximum	
11	P5 - Total Deformation Maximum	
12	P6 - Equivalent Stress 2 Maximum	
13	Min-Max Search	☑
14	Metrics	
15	Goodness Of Fit	
16	Response Points	
17	Response Point	
18	Response	
19	Local Sensitivity	
20	Local Sensitivity Curves	
21	Spider	
*	New Response Point	

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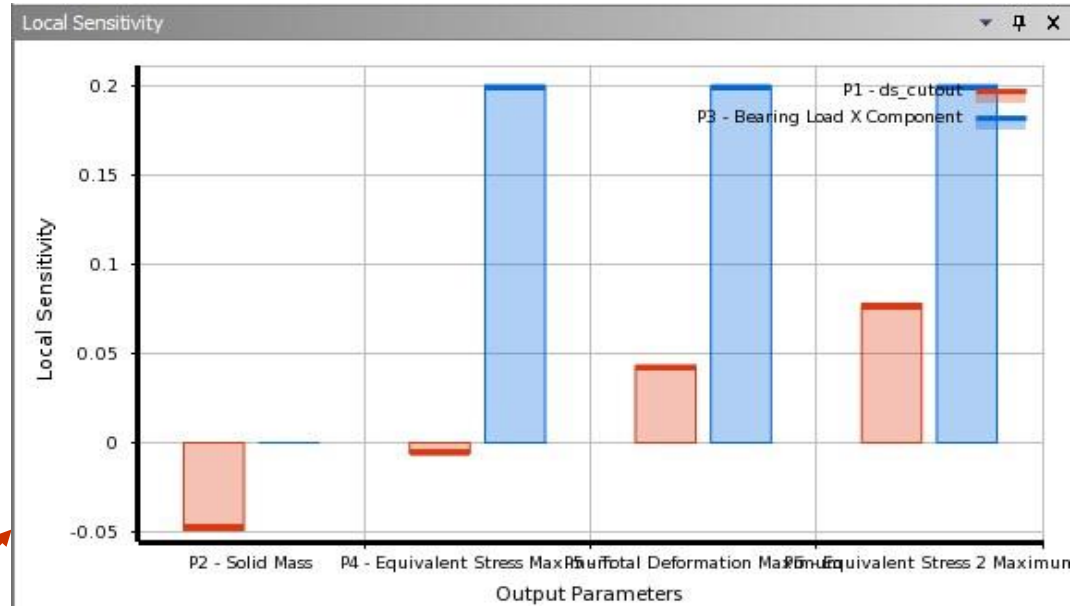
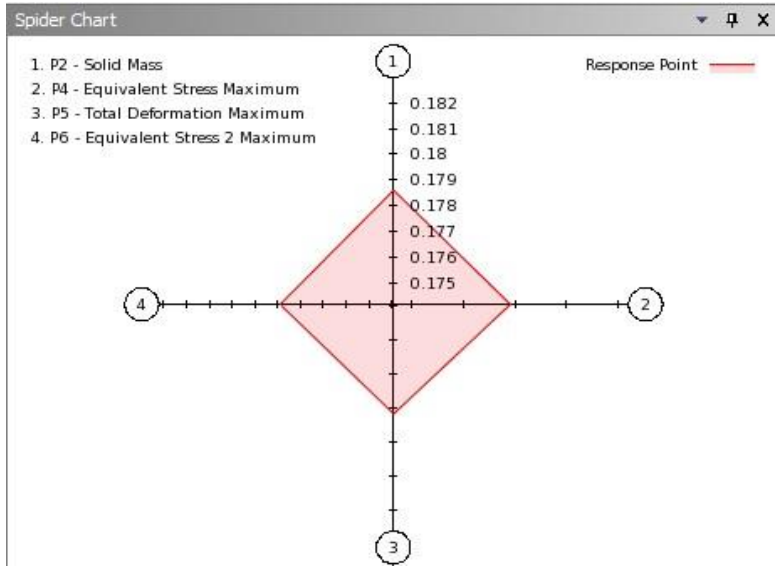
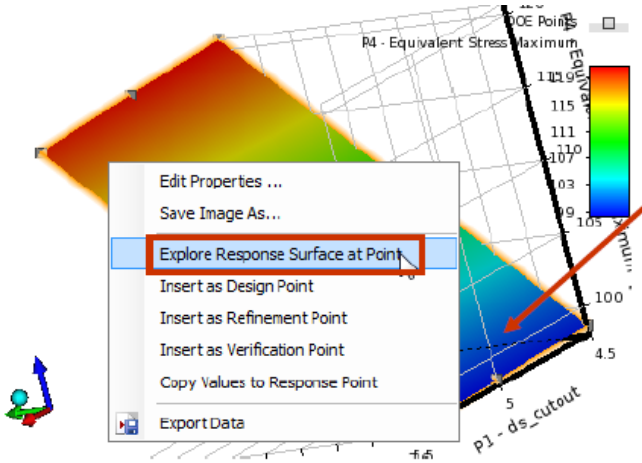




Results



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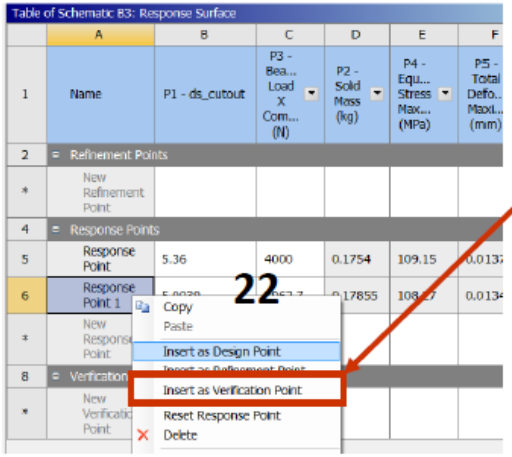
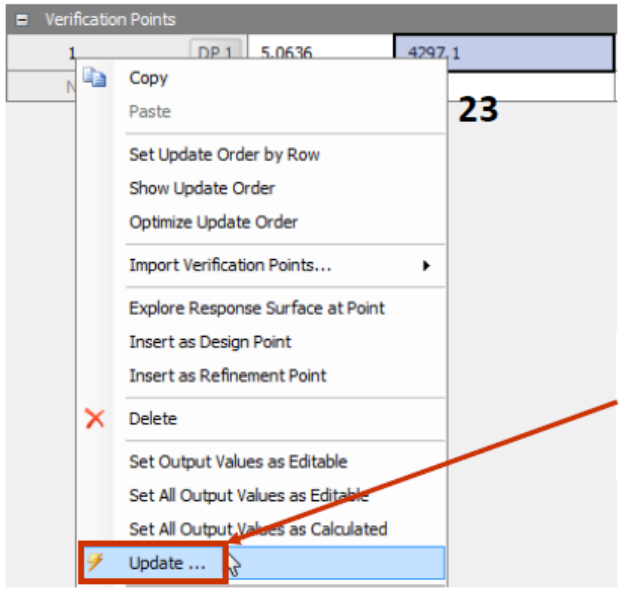
21. RMB on the Response surface and click on 'Explore Response Surface at Point'. In the Table of Schematic you will see the input and output parameter values. [Please note, your Response point will not be the same as one shown here]



22

22. The response point shows the predicted output parameter values based on the response surface. To see whether the prediction was accurate, right-click the response point in the Table of Schematic and select Insert as Verification Point

Results

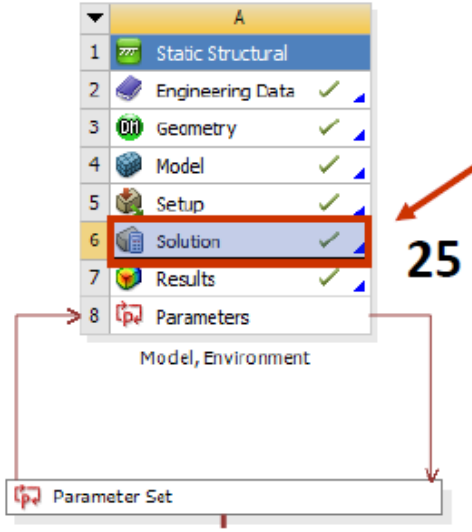


23. Right-click the Verification point in the Table of Schematic and Select Update. This will solve the corresponding scenario

24. Compare the response point values with the verification point values. The response surface very accurately predicted the true behavior

6	Response Point 1	5.0636	4297.1	0.17799	117.51	0.014612	39.816
*	New Response Point						
8	Verification Points						
9	1 DP 1	5.0636	4297.1	0.17802	117.51	0.014612	39.816
*	New Verification Point						

Mechanical Results



25. Double click on Solution

Check the results in Mechanical