



# ANSYS DesignXplorer参数优化 分析技术

2018年9月13日

# 目 录

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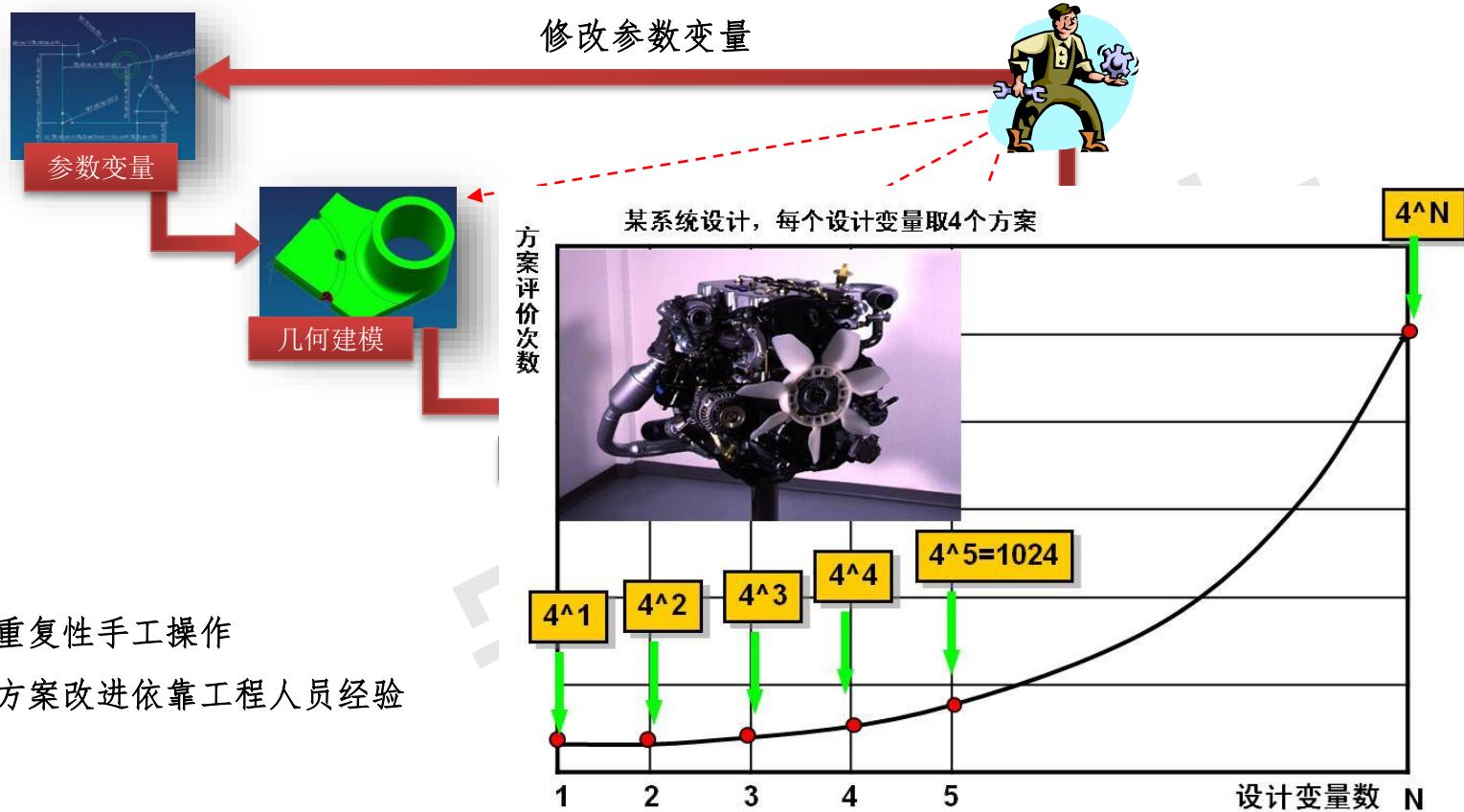
优化概述

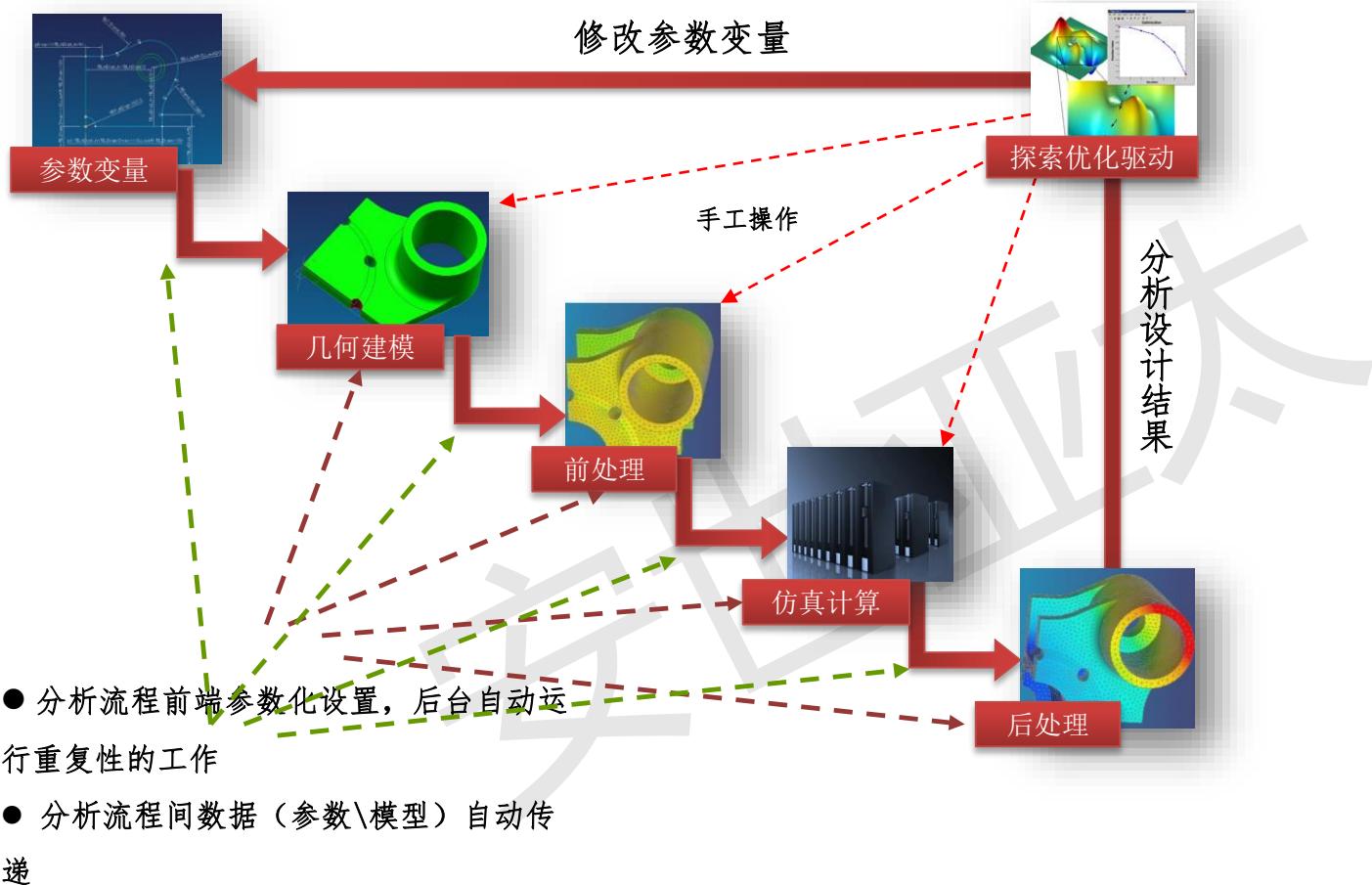
ANSYS参数来源与提取

ANSYS DesinXplorer介绍

案例演示

- 优化-通过算法得到要求问题的更优解。
- 一个典型的工程需要不断进行“设计 - 评估 - 改进”的循环。
  - ✓ CAD/CAE的引入提高了这一过程的效率。CAD加快了造型、装配、出图的设计过程，而CAE则减少了大量的试验，提供了有效的分析和评估工具。
  - ✓ 而优化，属于设计改进阶段。





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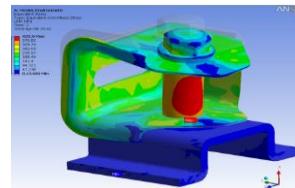
案例演示

## CAD



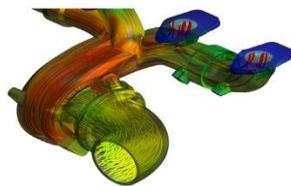
DesignModeler  
SpaceClaim  
Catia V5  
UG NX  
SolidWorks  
Creo Parametric  
Solid Edge  
Autodesk Inventor  
...

## Structural



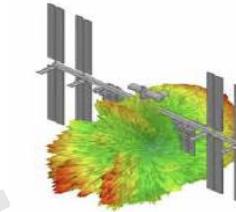
Engineering data  
Meshing  
Mechanical  
Mechanical APDL  
ExplicitSTR  
Vista TF, CCD...  
Icepak  
nCode  
...

## CFD



CFX  
Fluent  
CFD Post  
Polyflow  
AQWA  
ICEM CFD

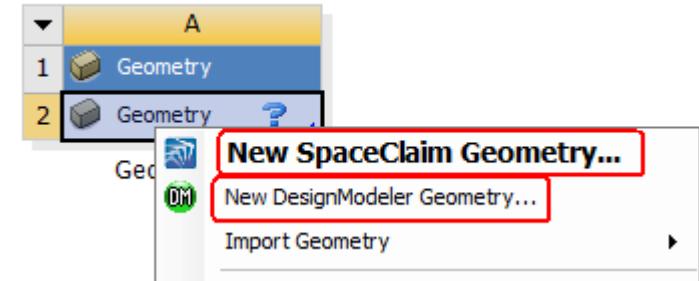
## Electromagnetics



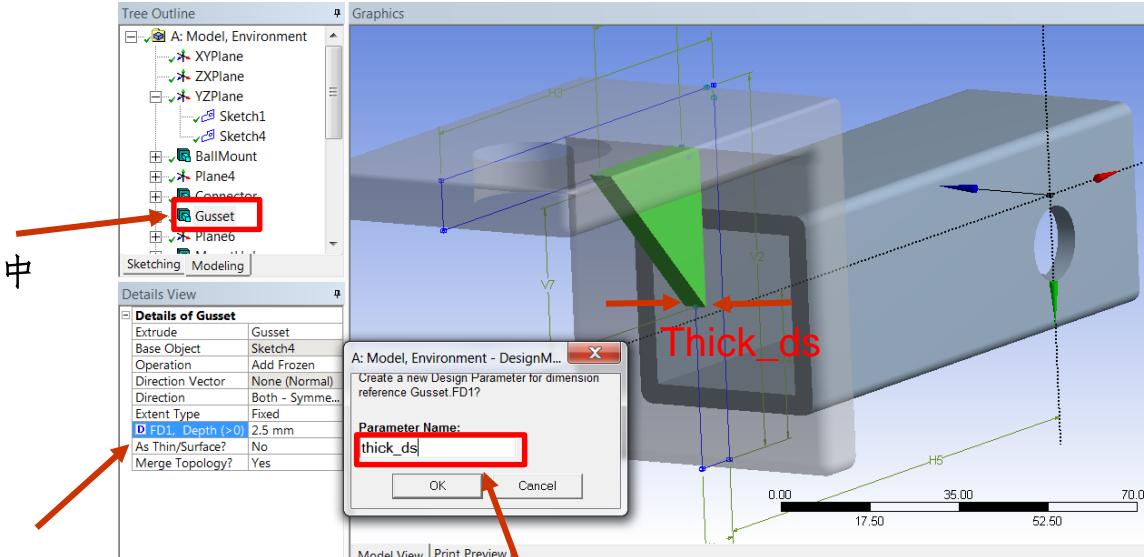
Ansoft Products:  
Designer  
HFSS  
Maxwell  
Q3D Extractor  
Simplorer

以及其它一些自定义使用:  
Excel, External Connection

- CAD参数可以以前缀或后缀进行筛选
- 筛选名称默认为DS（可以修改或者删除）
- 将筛选名称删除就代表着允许所有的CAD参数传递到Workbench.



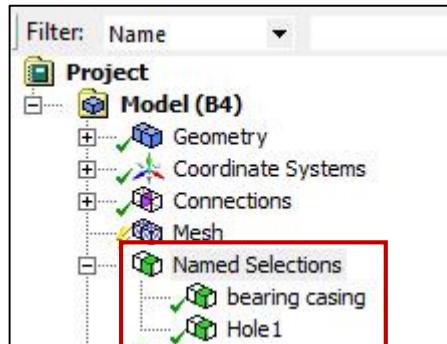
1. 点击提纲树中的“Gusset”



2. 点击D1旁边的参数框

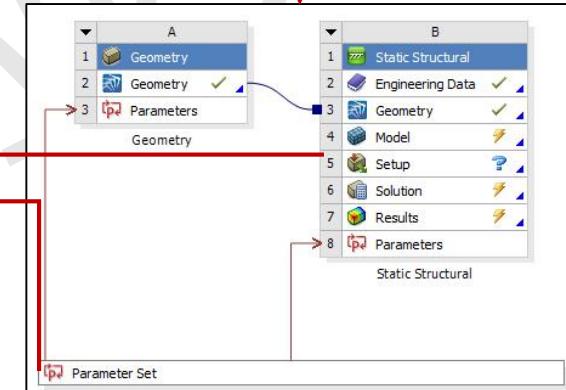
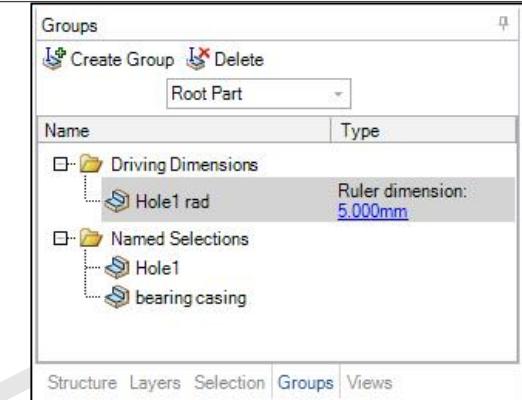
3. 参数重新命名

- Parameters and Named Selections can be transferred to Workbench by **creating Groups** in SpaceClaim
- Driving Dimensions can also be created
  - Need to use the Pull or Move menu
  - Make dimension appearing on the display window.
- Parameters can also be edited and modified within Workbench which will modify the geometry in SpaceClaim



Outline of All Parameters

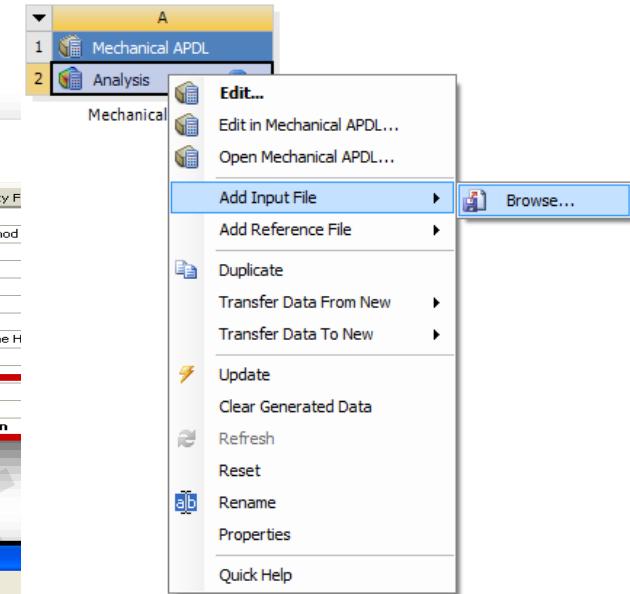
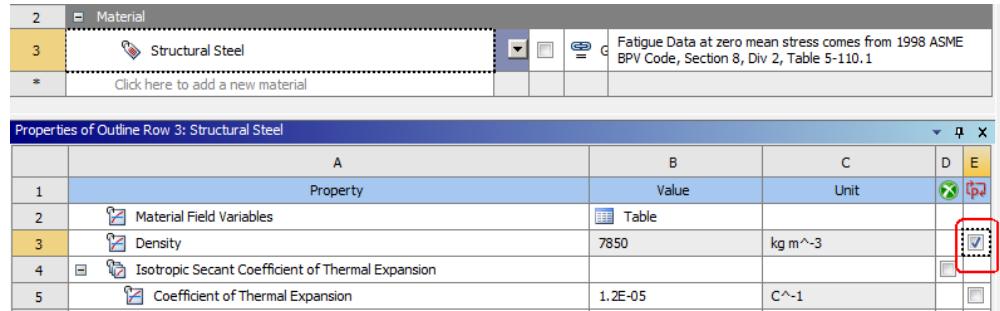
	A	B	C	D
1	ID	Parameter Name	Value	Unit
2	Input Parameters			
3	Geometry (A1)			
4	P1	Hole1rad	5	
*	New input parameter	New name	New expression	
6	Output Parameters			
*	New output parameter		New expression	
8	Charts			



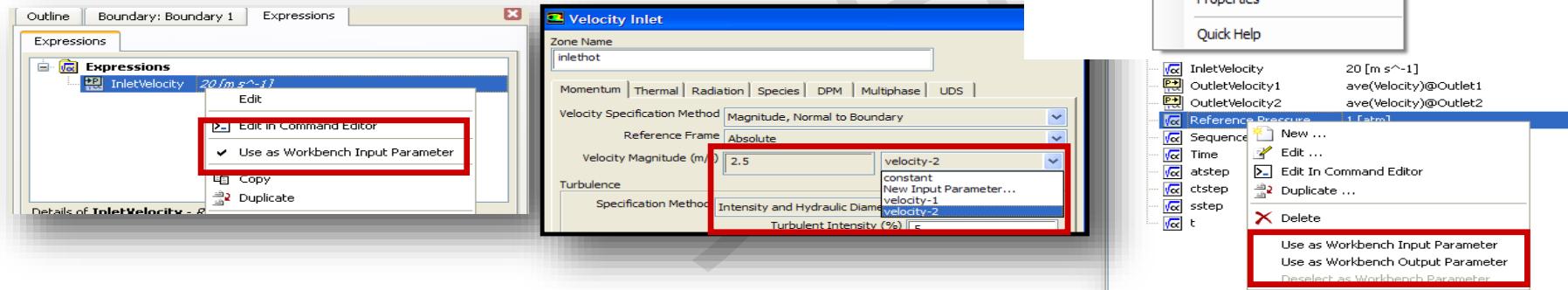
# 参数：WB中的材料、边界条件等参数化

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## 在Mechanical 中创建参数



## 在CFX、Fluent和CFD后处理中设置参数



- 派生参数:

  - 派生参数由提取出来的输入和输出参数通过数学表达式实现.
  - 派生参数可以通过不同的数学、三角以及统计函数来定义.
  - 案例包括 (但不限于):
    - 成本函数(i.e., 产品单位质量的成本)
    - 标准化应力(i.e., 应力响应除以施加的应力)
    - 网格尺寸(设置网格参数为几何尺寸的函数)

Outline of All Parameters				
	A	B	C	D
1	ID	Parameter Name	Value	Unit
<b>2</b> Input Parameters				
3	Static Structural (ANSYS) (A1)			
4	P3	Force Y Component	100	N
5	P4	width	8.6151	
6	P5	height	8.1833	
7	P8	length	30	
*	New input parameter	New name	New expression	
<b>9</b> Output Parameters				
10	Static Structural (ANSYS) (A1)			
11	P2	Total Deformation Maximum	0.012105	mm
12	P6	Geometry Mass	0.016603	kg
13	P7	Equivalent Stress Maximum	36.668	MPa
*	New output parameter		0.02*P4*P5*P6	
<b>15</b> Charts				

9	Output Parameters			
10	Static Structural (ANSYS) (A1)			
11	P2	Total Deformation Maximum	0.012105	mm
12	P6	Geometry Mass	0.016603	kg
13	P7	Equivalent Stress Maximum	36.668	MPa
*	New output parameter		0.02*P4*P5*P6	
15	Charts			

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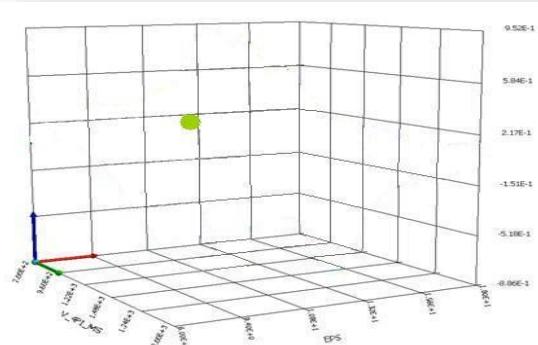
ANSYS DesinXplorer介绍

案例演示

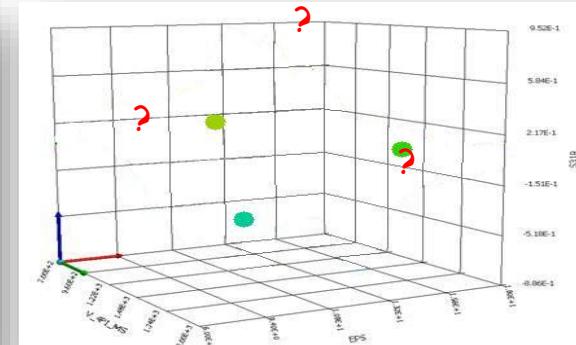
# 什么是DesignXplorer?

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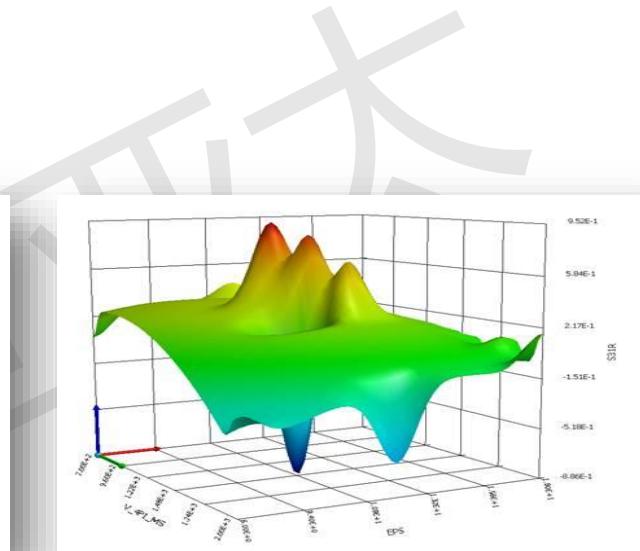
- DesignXplorer 是一种用来探索、认识以及优化您的工程设计方案的强大工具。
  - 确定影响设计的主要参数
  - 探索和认识其它设计条件下的响应
  - 寻找最优设计
  - 探索设计的稳健性



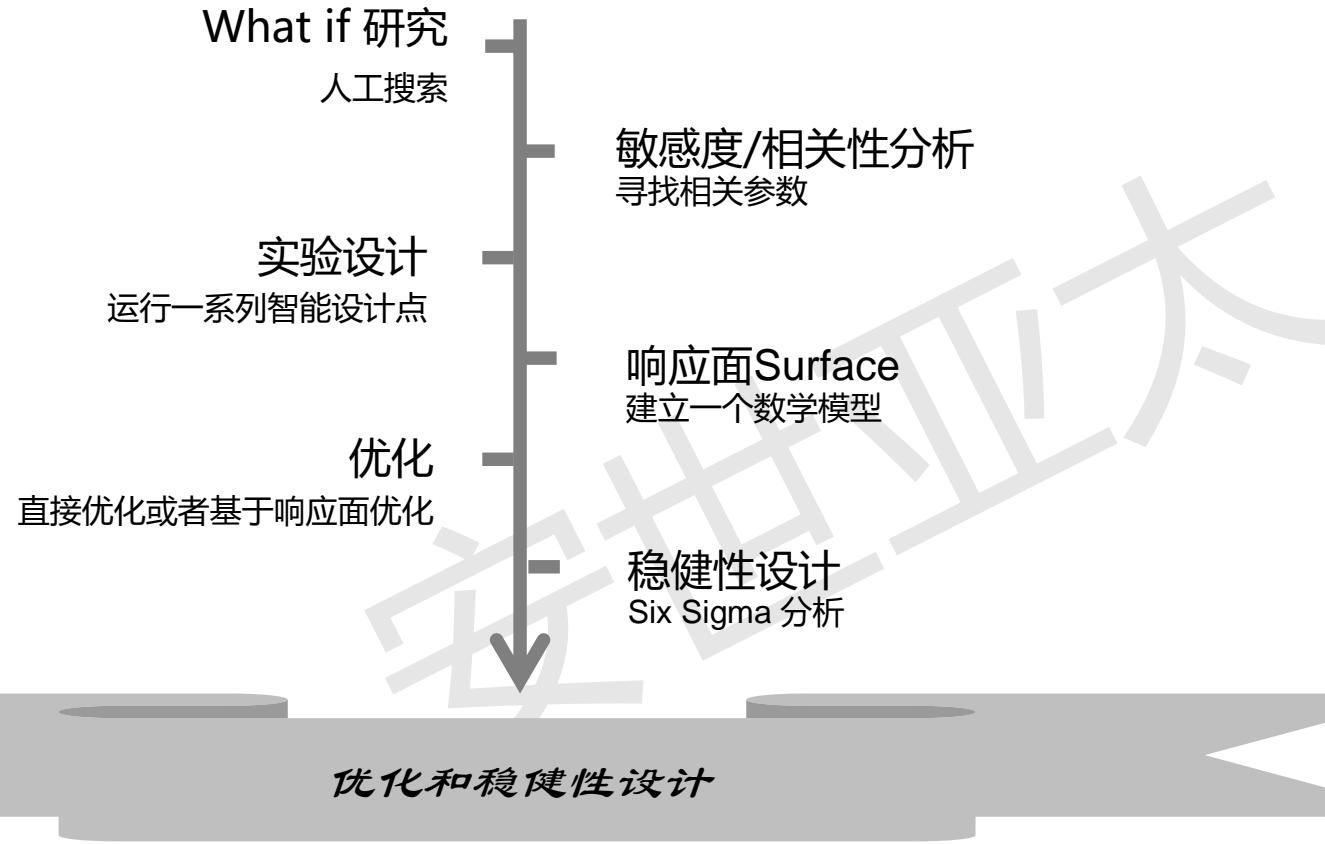
Single Point



What If?



Response Surface



## 自动运行一系列人为指定的设计点

The screenshot shows a software interface for managing design points. On the left, a 'Table of Design Points' is displayed with columns A through G. Row 6 is currently selected, showing values for various parameters. A context menu is open over row 6, listing options such as Copy, Paste, Set Update Order by Row, Show Update Order, Optimize Update Order, Delete Design Point, Copy inputs to Current, Duplicate Design Point, Update Selected Design Points, and Export Data (Beta). To the right of the table, a 'Parameter Set' panel lists several items, with 'Parameter Set' highlighted with a red border.

	A	B	C	D	E	F	G
1	Name	P1 - velocity-1	P2 - Face Sizing Element Size	P4 - PipeLength	P3 - Solid Volume	P5 - PressureDrop	<input type="checkbox"/> Exported
2		m s <sup>-1</sup>	m		m <sup>3</sup>	Pa	
3	Current	1	0.001	1	3.0844	1.1146E+05	
4	DP 1	2	0.001	1			
5	DP 2	1	0.002	2			
6	DP 3	2	0.002	2			

Context menu (over row 6):

- Copy
- Paste
- Set Update Order by Row
- Show Update Order
- Optimize Update Order
- Delete Design Point
- Copy inputs to Current
- Duplicate Design Point
- Update Selected Design Points
- Export Data (Beta)

Parameter Set panel:

- 1 Static Structural
- 2 Engineering Data
- 3 Geometry
- 4 Model
- 5 Setup
- 6 Solution
- 7 Results
- 8 Parameters

Parameter Set (highlighted):

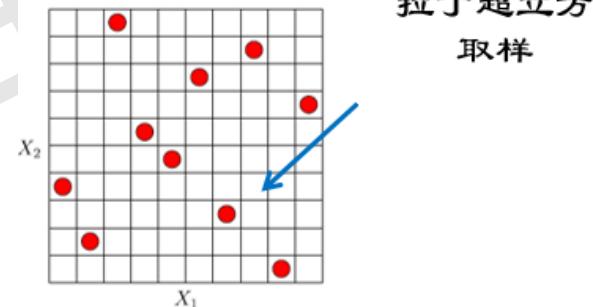
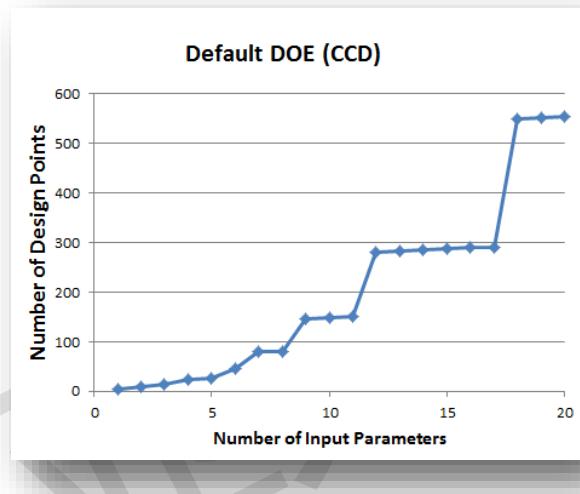
- Parameter Set

## 目的：

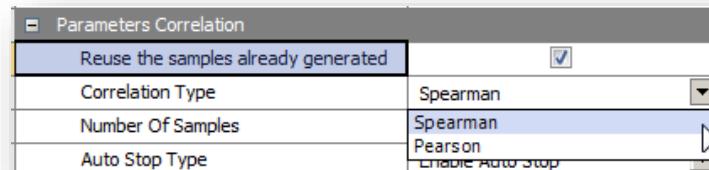
- 在DOE计算过程当中，设计点数量会随着输入参数的增加快速增加，从而使得计算过程的效率降低。
- 建议从DOE样本中剔除不重要的参数以减少不必要的样本点。

## 方法

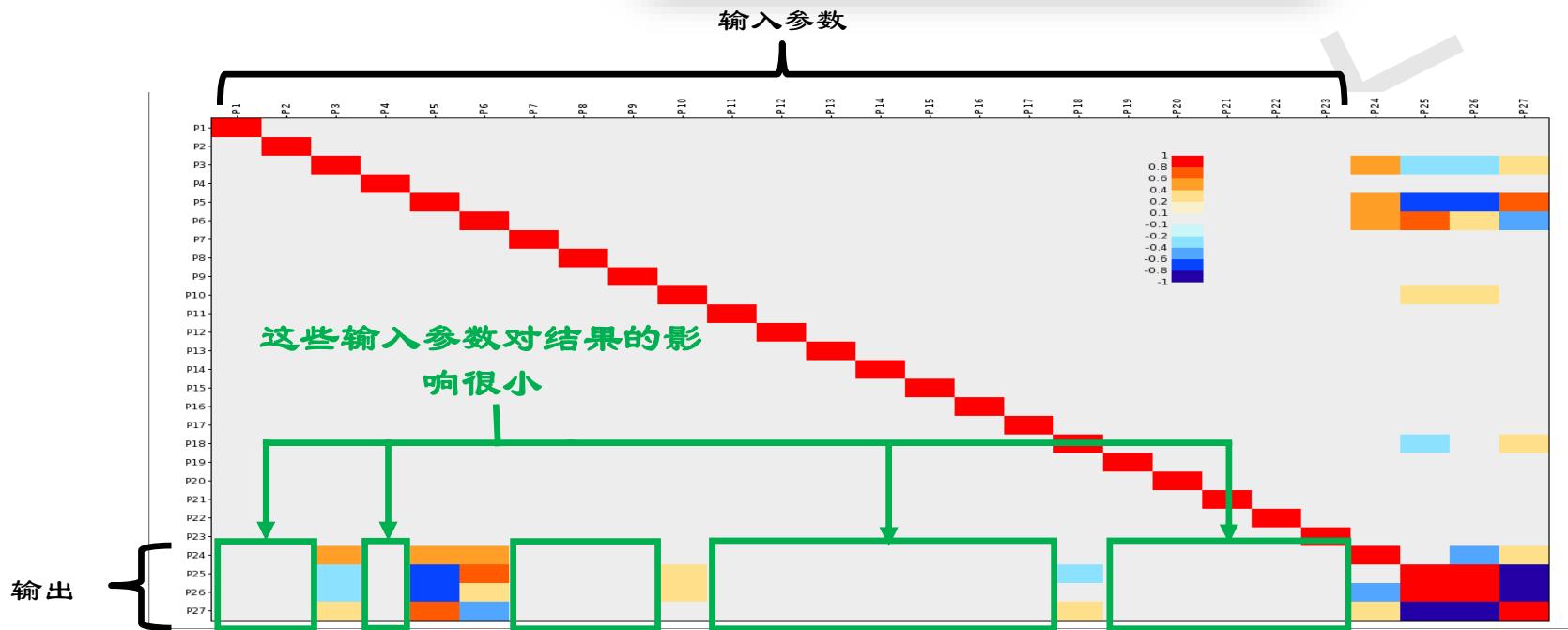
- 参数相关性方法将根据设计空间的随机抽样进行模拟（使用拉丁超立方样本）以便正确认识所有参数之间的相关性
- 拉丁超立方一样本点是随机放置的，但会确保没有任何两个点共享相同的输入参数，样本数量由用户指定。



- 鉴别不重要的参数

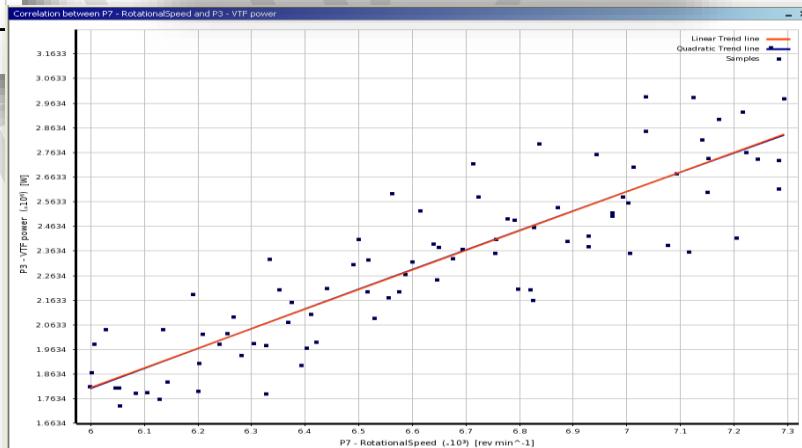
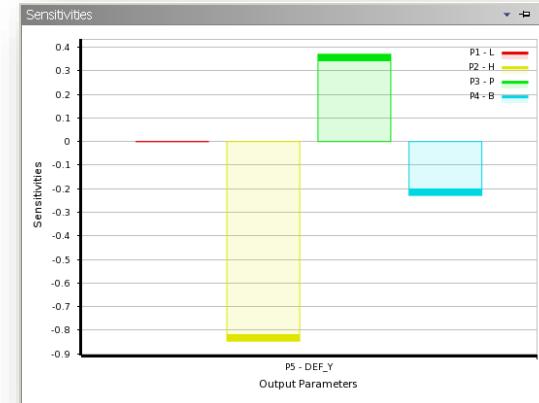
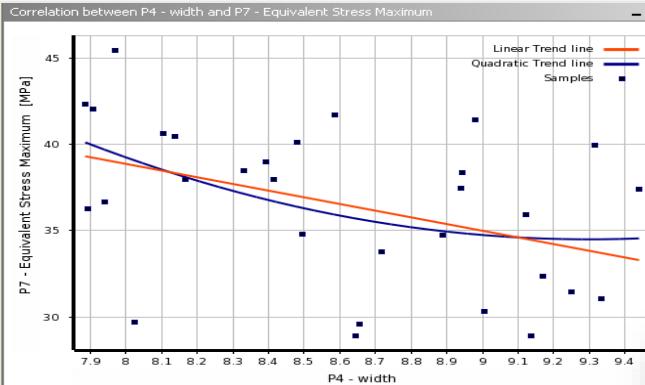


$$r = \frac{\sum ((X - \bar{X})(Y - \bar{Y}))}{\sqrt{\sum (X - \bar{X})^2} \sqrt{\sum (Y - \bar{Y})^2}}$$



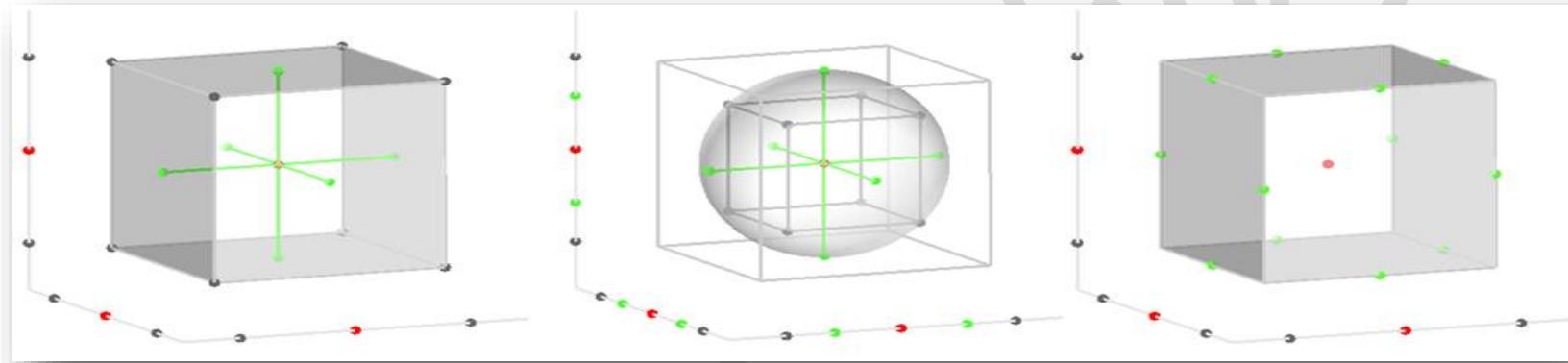
- 确定参数的相关程度：线性还是二次

A	B	C
Property	Value	Enabled
1		
2	Axes	
3	X axis	P4 - width
4	Y axis	P7 - Equ...
5	Trend Lines	
6	Linear	R <sup>2</sup> = 0.17728
7	Quadratic	R <sup>2</sup> = 0.19282



- 相关散点图允许为样本点绘制直线的和二次的曲线并提取线性的和二次的决定系数
- 样本越接近曲线，决定系数越接近1
- 如果参数之间的关系更为复杂并且不能用一个线性的或二次的相关曲线来解释，这将更难以建立一个标准响应面（全二阶多项式），在这种情况下，建议使用其它的响应面类型（克里格法、非参数回归法等.....）

- 目的：收集有代表性的一组数据来生成响应面，按照统计规律设计采样策略。
- 指定DOE类型（算法）
- 定义每一个参数的范围和类型（连续、离散、可制造值）
- 自动选择设计点来有效探索参数空间

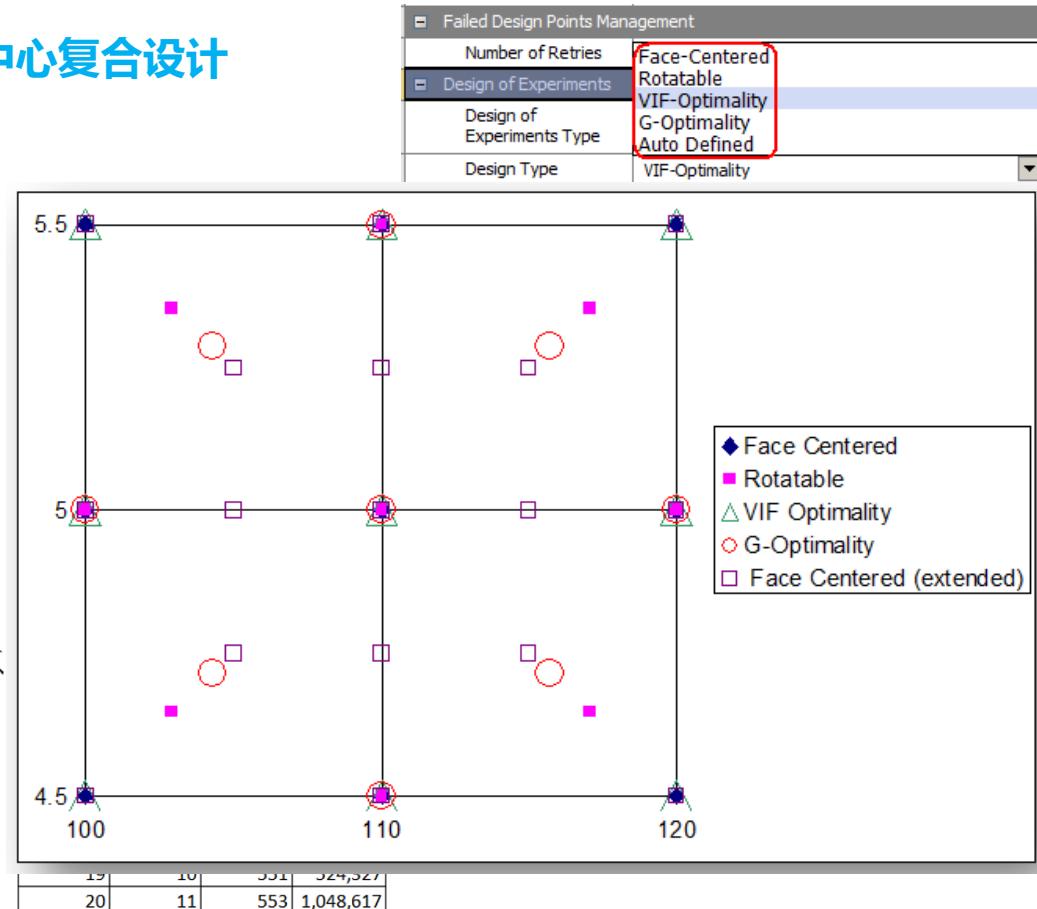
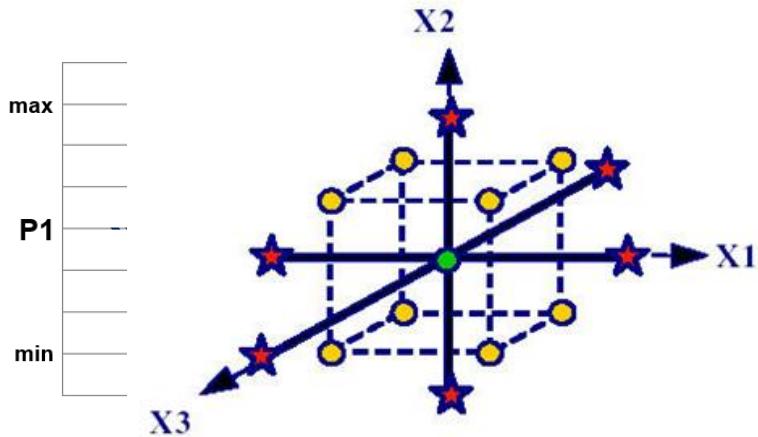


## DOE类型（算法）

- Central Composite Design
- Optimal Space-Filling Design
- Box-Behnken Design
- Sparse Grid Initialization
- Custom
- Custom + Sampling
- Latin Hypercube Sampling Design
- External sampling methods as defined by the DOE extensions loaded to the project.

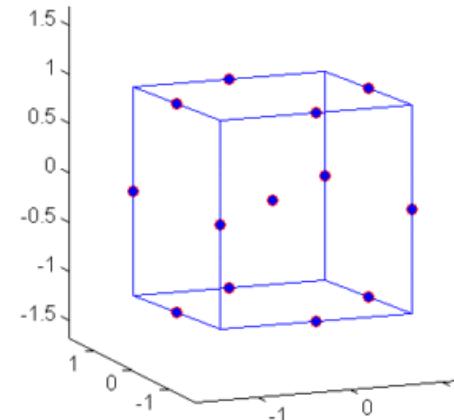
## Central Composite Design (CCD) 中心复合设计

- 适合于校准二阶交互作用模型。包含
  - 1个中心点
  - $2^N$ 个轴向点
  - $2^{(N-f)}$ 因子点



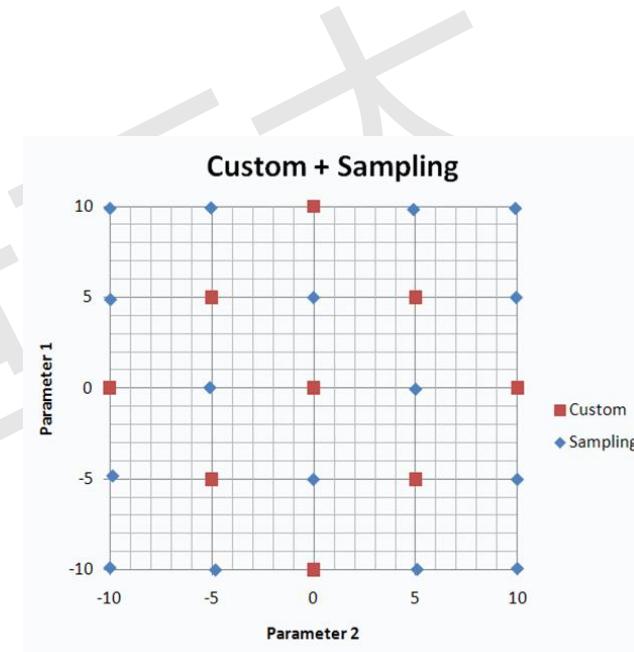
## Box-Behnken 设计

- 3水平设计，输入参数限制个数12
- 由中间点与中心点组成
- 比CCD需要的设计点少
- 避免了设计区域极端点



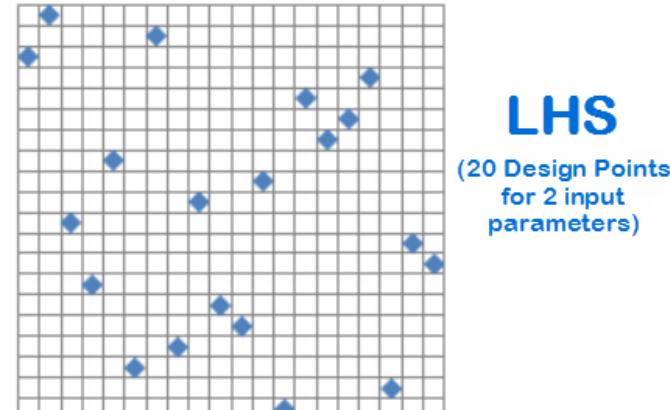
## Custom / Custom + Sampling

- 自定义输入参数取代了默认的DOE设计
- 可导入外部的CSV文件定义设计点
- 在上一次DOE方法基础上进行修改
- 可添加采样点，自动填充设计空间



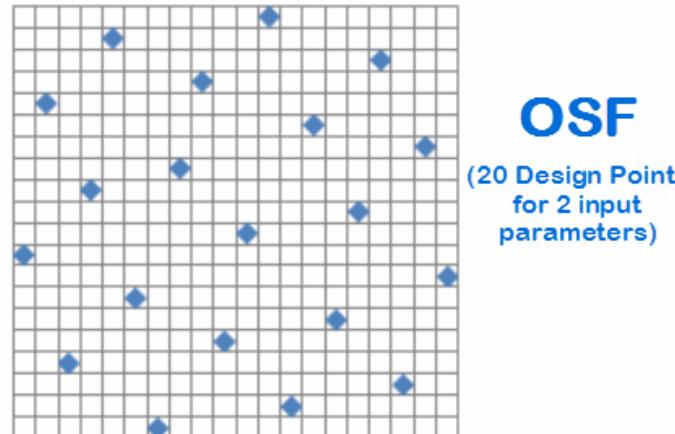
## Latin Hypercube Sampling (LHS)

- 设计空间内均匀抽样
- 每个因子的水平数相同
- 每行、每列均只出现一个试验点



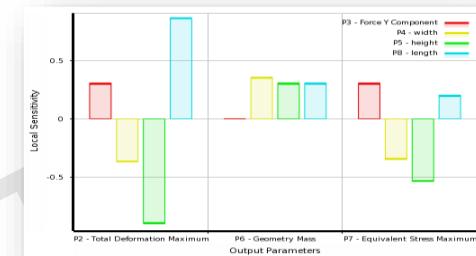
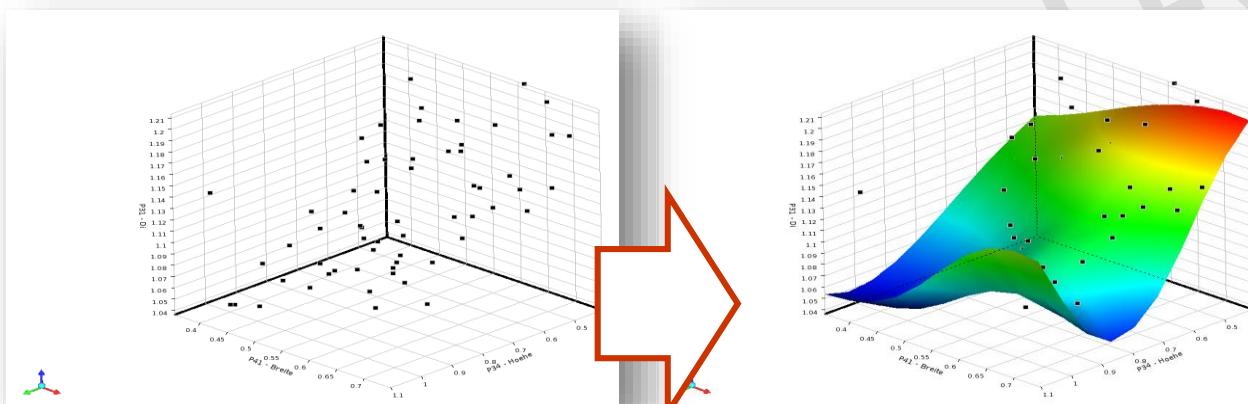
## Optimal Space Filling

- 通过设计空间均匀地分配设计参数
- 当计算次数受限时，该方法依然有用
- 角或者中心点不一定包括
- 起始点的选择会影响随机性



OSF本质上就是一个LHS，都是避免创建重复的点来优化资源；OSF可最大化点之间的距离，在整个设计空间实现更均匀的分析，全面覆盖设计空间

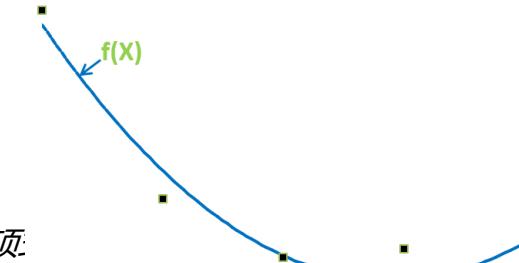
- 生成一个替代模型，
  - ✓ 由输入变量的函数模型构造的代表预期输出变量的响应曲面
  - ✓ 在设计区域的每个点，不需要全部计算，响应面提供输出参数的预估值
- 最大/最小值搜索
  - ✓ 每个输出参数都会自动运行极值优化
- 2D/3D图展示
- 局部敏感度
- RS 质量评估



## 响应面类型（算法）

### 二阶多项式法

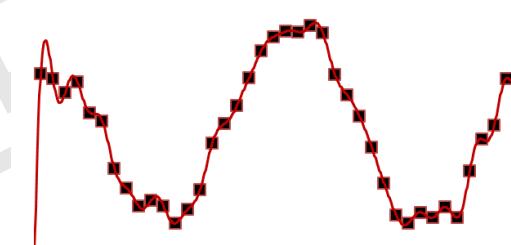
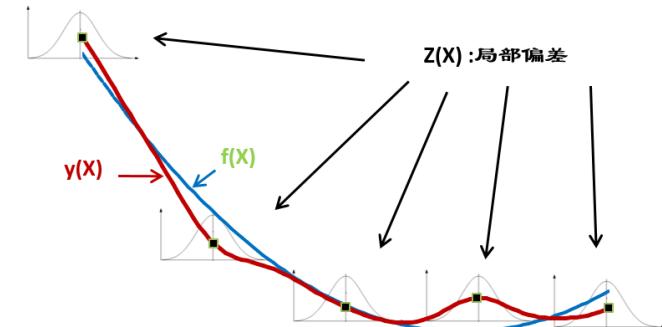
- 以修正的多项式公式为基础
- 输出= $f$  (输入)       $f$ 是二阶多项式



### Kriging法

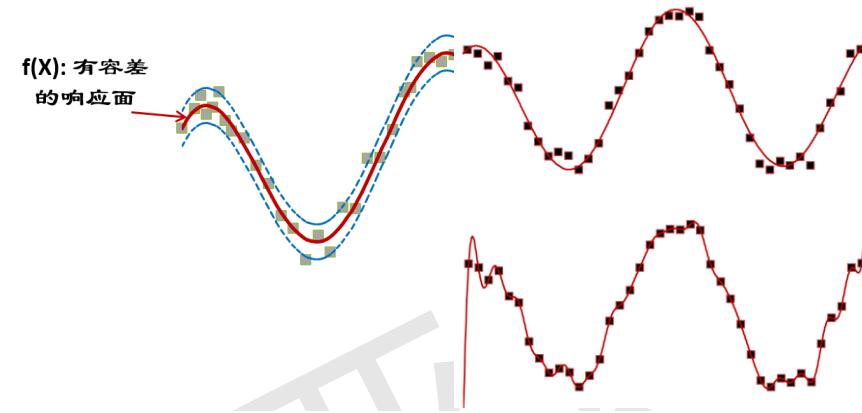
- 多项式模型，加上局部偏差
- 输出= $f$  (输入) + $Z$  (输入)     $f$ 是二阶多项式 (描述模型总的行为)， $Z$ 是 修正项 (描述模型局部的行为)
- 可手动或者自动插入设计点进行细化

当输出参数变化较大或者非线性的时候，Kriging法比标准响应面法更好；但是结果跳跃时候不建议采用

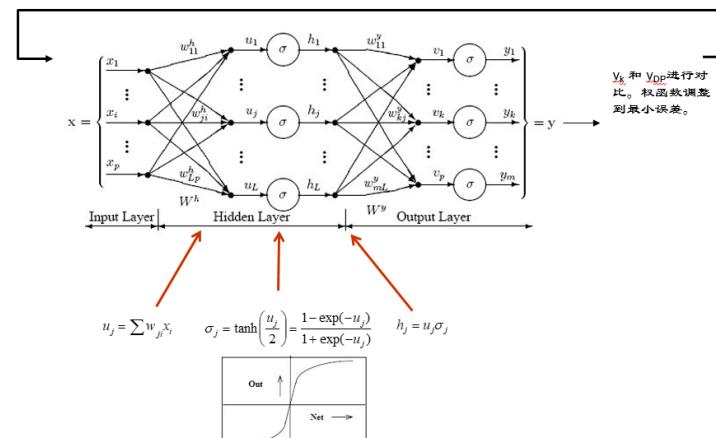


## 非参数回归法

- 在实际的输出面建立一个狭窄容差边界层，所有或大多数样本点都落在边界层内。
- 当二阶响应面拟合度不好时候建议采用
- 通过设计点容差进行拟合，不易出现震荡

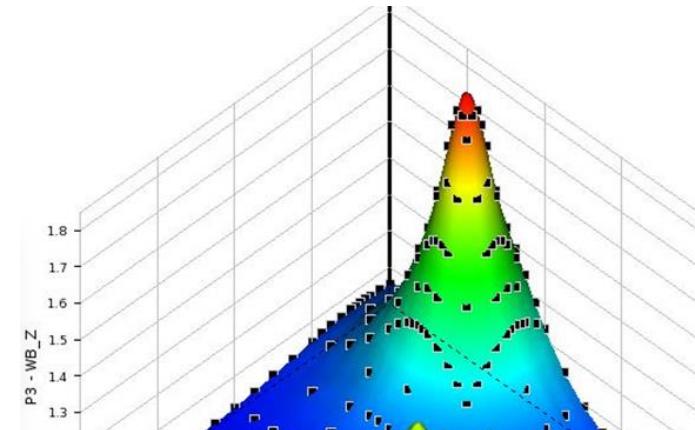


“一个包含权重，非线性传递函数附加值的网络”



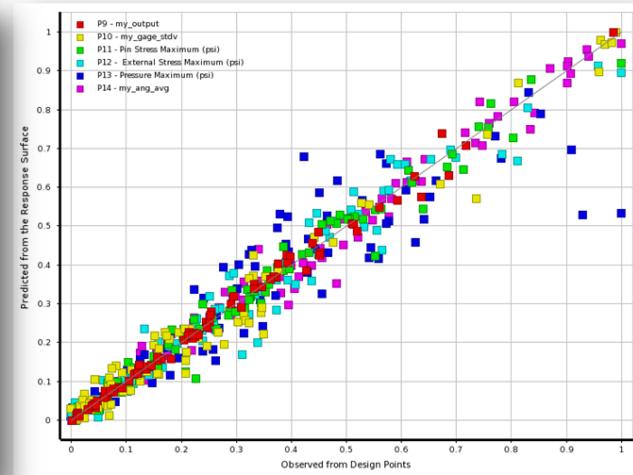
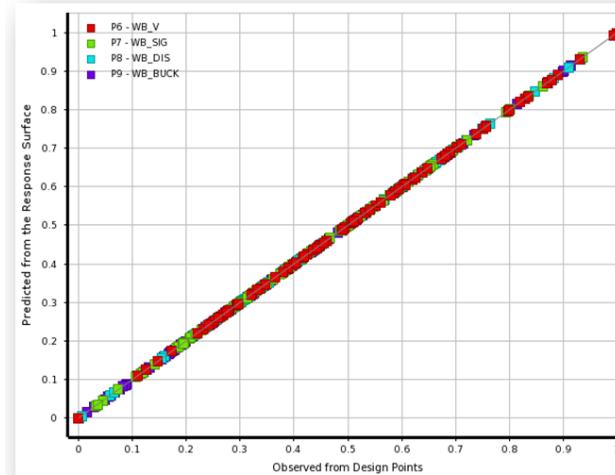
## 稀疏网格法

- 自定义自适应响应面
- 需要更多计算
- 只在需要改善的方向上进行细化（增加设计点，直到满足最大相对误差或者分层插补水平的最大数目）

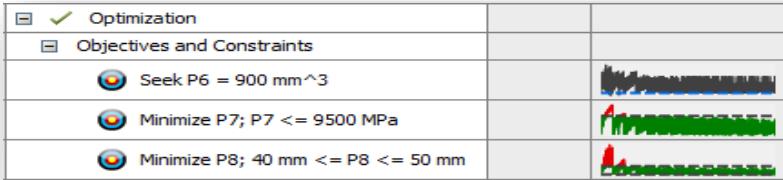


## Goodness of fit拟合度

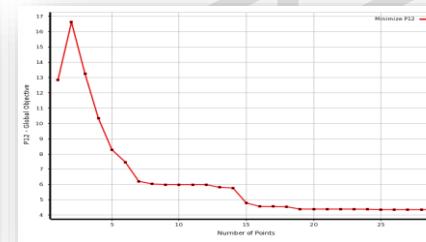
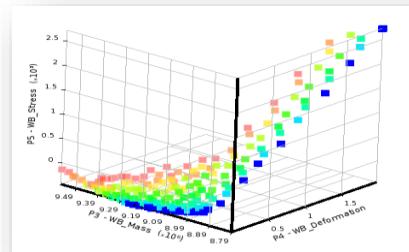
- 均方根误差
- 相对均方根误差
- 相对最大绝对值误差
- 相对平均值误差



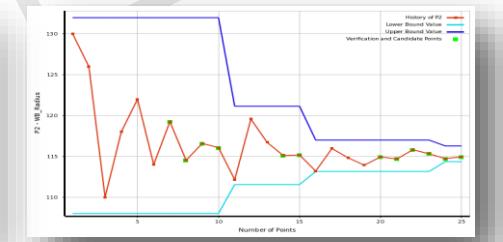
- 定义目标、约束以及设计参数
- 基于响应面优化
  - 在几秒时间内探索数千个设计方案



- 直接优化
  - 遵循算法收敛性



Reference	Name	P8 - WB_DIS (mm)	
		Parameter Value	Variation from Reference
Initial Design	79.999	0.00 %	
Initial Design (verified) (DP 0)	80	0.00 %	
Candidate Point 1	41.449	-48.19 %	
Candidate Point 1 (verified)	41.632	-47.96 %	
With Rounded Values	41.186	-48.52 %	
With Rounded Values (verified)	41.373	-48.28 %	
New Custom Candidate Point			

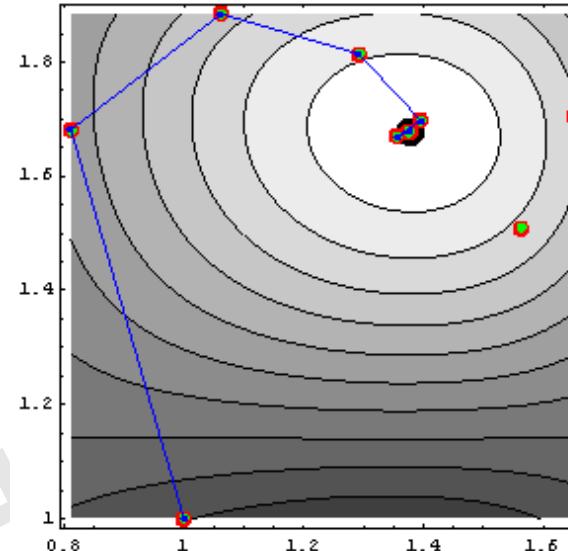


## 优化算法

- 筛选 (Screening) [默认]
  - ✓ 非迭代的直接采样方法
  - ✓ 基于Hammersley算法随机生成器
  - ✓ 为设计提供全局视角，适用于连续和不连续参数，局部/全局优化
  - ✓ 精确度基于样本点个数
- MOGA (多目标遗传算法)
  - ✓ 通过多次迭代计算保留样本 “精华”；
  - ✓ 通过每次迭代，允许样本从遗传学角度进化直到发现最优解集合；
  - ✓ 适用于全局/局部优化；
  - ✓ 可处理多个目标。

## 优化算法

- NLPQL (二次拉格朗日非线性规划)
  - ✓ 梯度优化
  - ✓ 适用于局部优化
  - ✓ 计算快，精度高
  - ✓ 只适用于连续参数
  - ✓ 单目标优化
- MISQP (混合整数连续二次规划)
  - ✓ 局部优化算法
  - ✓ 计算快，精度高
  - ✓ 适用于连续参数和离散参数
  - ✓ 单目标优化



## 优化算法

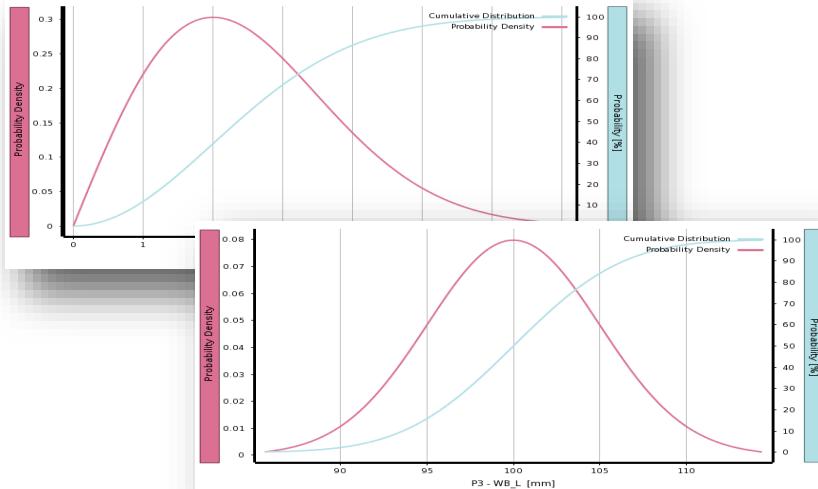
- **Adaptive Single-Objective**自适应单目标(只适用于直接优化)

- 是一种组合了LHS设计经验、Kriging响应面和NLPQL优化方法的迭代算法；
- 提供了一种智能筛选方法可以得到全局化的最优值；
- 容错能力强
- 单目标优化
- 只处理连续参数

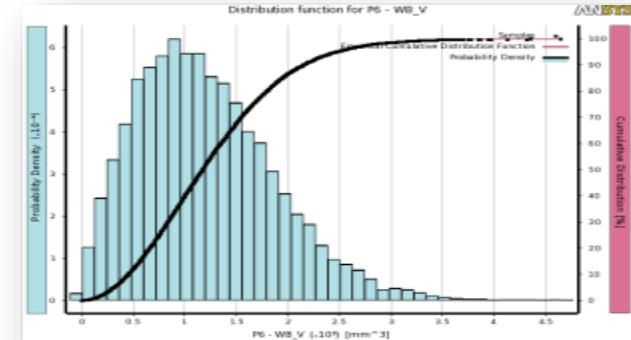
- **Adaptive Multiple-Objective**自适应多目标(只适用于直接优化)

- 是一种组合了MOGA算法和Kriging响应面算法的迭代计算方法
- 适用于局部/全局优化
- 多目标优化
- 仅处理连续参数

输入参数是变化的!



输出参数



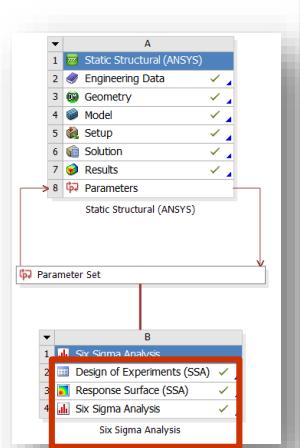
- 获悉结果是如何随着设计点界限而变化的 (概率性分析)
- 确定哪些部分可能失效
- 获悉哪些参数需要最严格控制

## 案例:

- 如果你在进行热分析，并且想求得相关热应力，计算公式如下：
- $$\sigma_{\text{therm}} = E \alpha \Delta T$$
- 由公式可以看出热应力与杨氏模量以及材料热膨胀系数成正比。
- 下表列出了一些热应力由于输入变量不确定性而导致计算出的热应力高于预期值的概率值。

Uncertainty variables taken into account	Probability that the thermal stresses are more than 5% higher than expected	Probability that the thermal stresses are more than 10% higher than expected
Young's modulus (Gaussian Distribution with 5% standard deviation)	~16%	~2.3%
Young's modulus and thermal expansion coefficient (each with Gaussian distribution with 5% standard deviation)	~22%	~8%

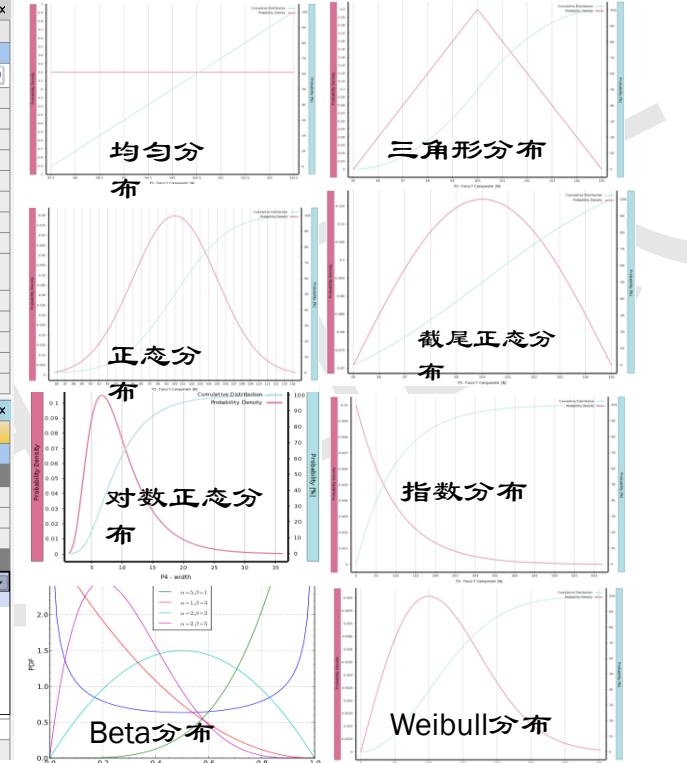
## 输入参数分布



Outline of Schematic B2: Design of Experiments (SSA)		
	A	B
1		Enabled
2	Design of Experiments (SSA)	Quick Help
3	Input Parameters	
4	Static Structural (ANSYS) (A1)	
5	P3 - Force Y Component	
6	P4 - width	
7	P5 - height	
8	P6 - length	
9	Output Parameters	
10	Static Structural (ANSYS) (A1)	
11	P2 - Total Deformation Maximum	
12	P6 - Geometry Mass	
13	P7 - Equivalent Stress Maximum	
14	Charts	
15	Parameters Parallel	
16	Design Points vs Parameter	

Properties of Outline A5: P3	
A	B
Property	Value
General	
Units	N
Type	Uncertainty Variable
Classification	Continuous
Distribution	Uniform
Mean	Uniform
Standard Deviation	Triangular
Skewness	Normal
Kurtosis	Truncated Normal
Values	Lognormal
Lower Bound	Exponential
Upper Bound	Beta
Initial Value	Weibull



## 观察输出参数分布

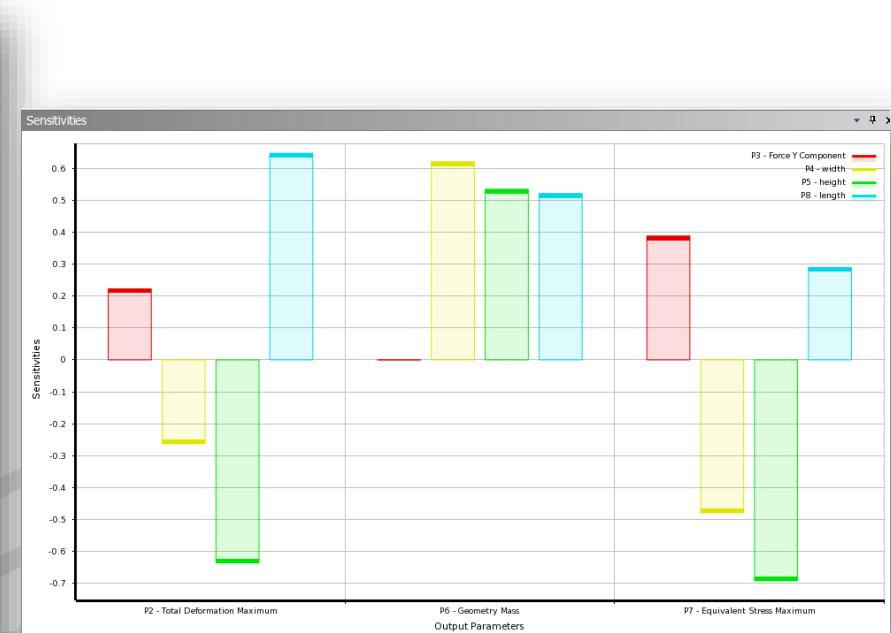
**Outline of Schematic B4: Six Sigma Analysis**

	A	B
1		Enabled
2	<input checked="" type="checkbox"/> Six Sigma Analysis	
3	<input type="checkbox"/> Input Parameters	
4	<input checked="" type="checkbox"/> Static Structural (ANSYS) (A1)	
5	<input checked="" type="checkbox"/> P3 - Force Y Component	<input checked="" type="checkbox"/>
6	<input checked="" type="checkbox"/> P4 - width	<input checked="" type="checkbox"/>
7	<input checked="" type="checkbox"/> P5 - height	<input checked="" type="checkbox"/>
8	<input checked="" type="checkbox"/> P6 - length	<input checked="" type="checkbox"/>
9	<input type="checkbox"/> Output Parameters	
10	<input checked="" type="checkbox"/> Static Structural (ANSYS) (A1)	
11	<input checked="" type="checkbox"/> P2 - Total Deformation Maximum	<input checked="" type="checkbox"/>
12	<input checked="" type="checkbox"/> P6 - Geometry Mass	<input checked="" type="checkbox"/>
13	<input checked="" type="checkbox"/> P7 - Equivalent Stress Maximum	<input checked="" type="checkbox"/>
14	<input type="checkbox"/> Charts	
15	<input checked="" type="checkbox"/> Sensitivities	

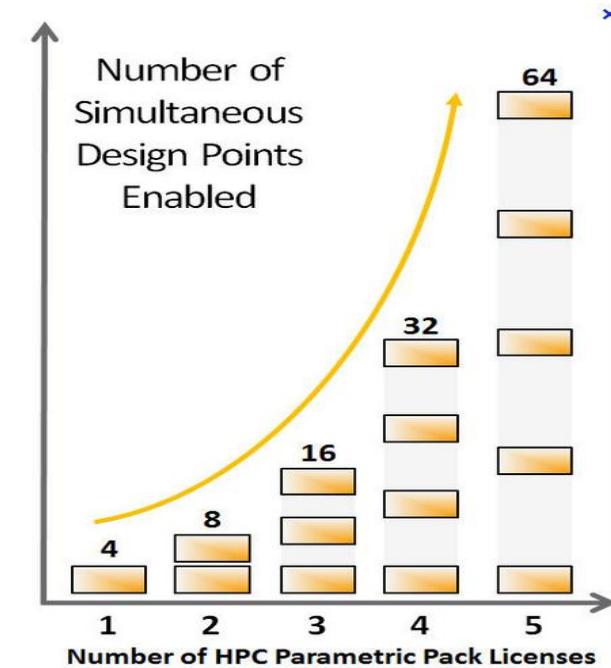
  

**Properties of Outline A11: P2**

	A	B
1	Property	Value
3	Units	mm
4	Values	
5	Calculated Minimum	0.0035...
6	Calculated Maximum	0.0409...
7	Statistics	
8	Probability Table	Quan...
9	Mean	0.0124...
10	Standard Deviation	0.0026...
11	Skewness	0.47765
12	Kurtosis	0.0232...
13	Shannon Entropy (Complexity)	-4.5511
14	Signal-Noise Ratio (Smaller is Better)	37.926
15	Signal-Noise Ratio (Nominal is Best)	13.341
16	Signal-Noise Ratio (Larger is Better)	-38.728
17	Sigma Minimum	-3.1976
18	Sigma Maximum	3.1976
19	Chart	
20	Display Parameter Full Name	<input checked="" type="checkbox"/>



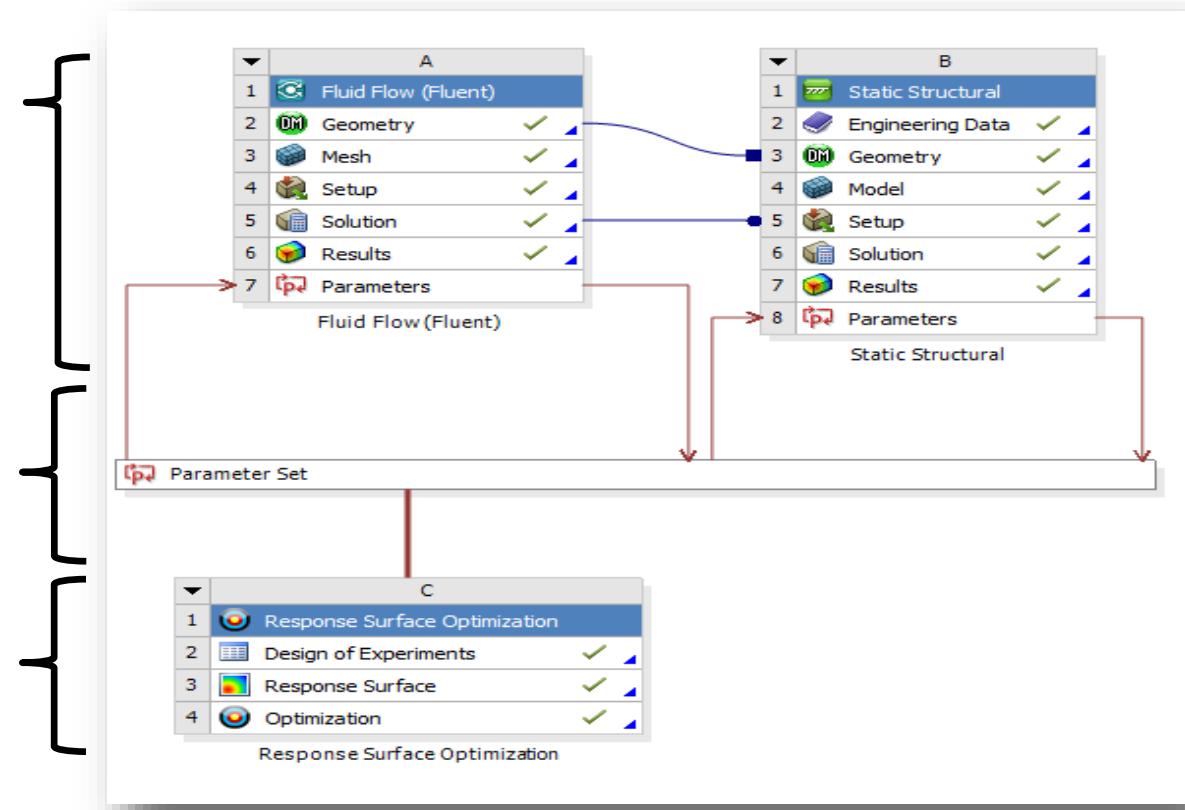
- Workbench的输入和输出参数是DX分析所需要
- 可同时运行多个设计点Run Design Points simultan
  - 集群运行
  - 办公机器
- 可充分利用HPC参数包许可证
  - 增加许可证个数同时运行多个设计点
- 能够保留许可来运行设计点



**CFD-Structural 分析**  
在流体和结构分析系统中定义输入  
和输出参数

**Parameter Set**  
列出所有参数设计点表格(What If)

**DX 系统**  
**3-step 流程**



# Parameter Set: 设计点表格 (“what-if” 研究)

39

The screenshot shows a software interface for parameter management and design point optimization. On the left, a 'Parameter Set' dialog is open, listing four items under 'Goal Driven Optimization': Goal Driven Optimization, Design of Experiments, Response Surface, and Optimization. The 'Design of Experiments' item is checked. A red box highlights the 'Parameter Set' dialog.

In the center, a 'Table of Design Points' window is displayed. The table has columns labeled A through G. Row 1 contains parameter names: Name, P1 - velocity-1, P2 - Face Sizing Element Size, P4 - PipeLength, P3 - Solid Volume, P5 - PressureDrop, and Exported. Rows 2 and 3 show values: m s^-1 and m respectively. Rows 4 and 5 show DP 1 and DP 2 with values 2 and 1 respectively. Row 6 is highlighted with a yellow background and contains 'DP 3' with a 'Copy' icon. A red box highlights the entire row 6. A red arrow points from the 'Parameter values currently loaded in applications' text to the row 6 cell 'DP 3'. Another red arrow points from the 'Update All Design Points' button to the same cell.

A context menu is open over row 6, listing options: Set Update Order by Row, Show Update Order, Optimize Update Order, Delete Design Point, Copy inputs to Current, Duplicate Design Point, Update Selected Design Points, and Export Data (Beta). A red arrow points from the 'RMB > Update Selected Design Points' text to this menu.

On the right, a large red 'X' is overlaid on the interface. A text box in Chinese says: '选择 “Retain” 来保持该设计点的所有文件并可以在这些之间进行切换' (Select "Retain" to keep all files of this design point and switch between them).

	A	B	C	D	E	F	G
1	Name	P1 - velocity-1	P2 - Face Sizing Element Size	P4 - PipeLength	P3 - Solid Volume	P5 - PressureDrop	Exported
2	m s^-1		m		m^3	Pa	
3	Current	1	0.001	1	3.0844	1.1146E+05	
4	DP 1	2	0.001	1			
5	DP 2	1	0.002	2			
6	DP 3	Copy		2			
*							

# DX 用户界面：响应面优化

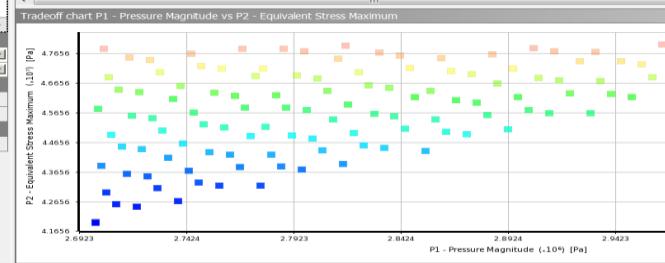
40

The screenshot shows the DX User Interface with several windows open:

- Parameter Set**: A tree view showing various optimization components.
- Outline of Schematic D4: Optimization**: A table with columns A, B, and C. Row 2 (Optimization) is highlighted with a red box. Row 13 (Candidate Points) is also highlighted with a red box.
- Optimization Algorithm**: A section showing the selected algorithm is "Screening". Other options listed are Screening, MOGA, NLPQL, and MISQP.

Table of Schematic D4: Optimization	
1	A
2	Optimization
3	Objectives and Constraints
4	Maximize P1
5	P3
6	Minimize P2
7	Domain
8	Static Structural (A1)
9	P1 - Pressure Magnitude
10	P3 - Extrude1.FD1
11	Results
12	Candidate Points
13	Tradeoff
14	Samples
15	Sensitivities

优化候选点



- DX 系统可生成统一的报告 (html)
- 包括所有的DX 表格和图表信息

The diagram illustrates the process of generating a unified report. On the left, the 'ThinPlate-14 - Workbench' application window is shown. The 'File' menu is open, and the 'Export Report...' option is highlighted with a blue selection bar. To the right, a large grey arrow points from the application window towards a separate browser window. The browser window displays a report titled 'unsaved\_project\_report.htm'. The report contains two main sections: 'Status' and 'Candidates'. The 'Status' section includes a table with five rows: Converged (Yes), Number of Evaluations (1000), Number of Failures (0), Size of Generated Sample Set (1007), and Number of Candidates (3). The 'Candidates' section is titled 'Candidates of the optimization study' and lists five rows: Candidate Point 1 (Thickness: 2.281, Radius: 108.13, Mass: 8.9284E+06, Deformation: 0.029144, Stress: 219.91), Candidate Point 2 (Thickness: 2.457, Radius: 110.57, Mass: 9.141E+06, Deformation: 0.0053034, Stress: 92.731), Candidate Point 3 (Thickness: 2.369, Radius: 113, Mass: 9.3272E+06, Deformation: 0.0019694, Stress: 12.384), Initial Design (Thickness: 2, Radius: 120, Mass: 9.85E+06, Deformation: 0.224, Stress: 179.11).

Property	Value
Converged	Yes
Number of Evaluations	1000
Number of Failures	0
Size of Generated Sample Set	1007
Number of Candidates	3

	P1 - WB_Thickness	P2 - WB_Radius	P3 - WB_Mass	P4 - WB_Deformation	P5 - WB_Stress
Candidate Point 1	2.281	108.13	8.9284E+06	0.029144	219.91
Candidate Point 2	2.457	110.57	9.141E+06	0.0053034	92.731
Candidate Point 3	2.369	113	9.3272E+06	0.0019694	12.384
Initial Design	2	120	9.85E+06	0.224	179.11

## 目 录

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优化概述

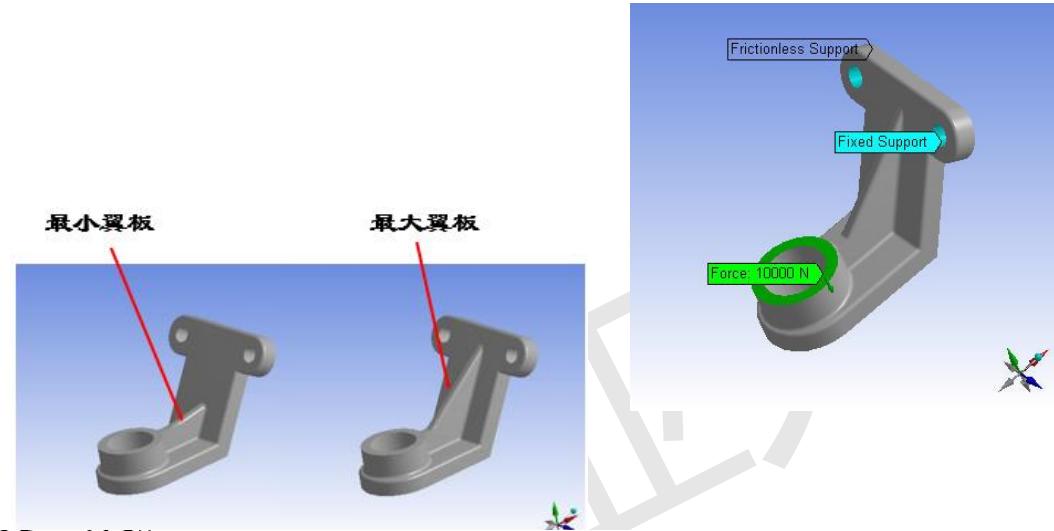
ANSYS参数来源与提取

ANSYS DesinXplorer介绍

案例演示

- 支架多目标优化案例

- 设计参数：几何变量、输入载荷
- 目标：质量最小，变形最小



Details of "Geometry"	Details of "Force"	Details of "Equivalent Stress"	Details of "Total Deformation"	Details of "Safety Factor"
<input type="button" value="Definition"/>	<input type="button" value="Scope"/>	<input type="button" value="Scope"/>	<input type="button" value="Scope"/>	<input type="button" value="Scope"/>
<input type="button" value="Bounding Box"/>	<input type="button" value="Definition"/>	<input type="button" value="Definition"/>	<input type="button" value="Definition"/>	<input type="button" value="Definition"/>
<input type="button" value="Properties"/>	<input type="button" value="Type Force"/>	<input type="button" value="Type Equivalent Stress"/>	<input type="button" value="Type Total Deformation"/>	<input type="button" value="Type Safety Factor"/>
<input type="checkbox" value="Volume"/> 3.3508e-000	<input type="checkbox" value="Force"/>	<input type="checkbox" value="Integration Point Results"/>	<input type="checkbox" value="Results"/>	<input type="checkbox" value="Integration Point Results"/>
<input checked="" type="checkbox" value="Mass"/> 2.6304 kg	<input type="checkbox" value="Component"/>	<input type="checkbox" value="Global Coor"/>	<input type="checkbox" value="Minimum"/>	<input type="checkbox" value="Results"/>
<input type="checkbox" value="Scale Factor Value"/> 1.	<input type="checkbox" value="X Component"/>	<input type="checkbox" value="Y Component"/>	<input checked="" type="checkbox" value="Maximum"/>	<input type="checkbox" value="Information"/>
<input type="checkbox" value="Statistics"/>	<input type="checkbox" value="Y Component"/>	<input type="checkbox" value="Z Component"/>	<input type="checkbox" value="Information"/>	<input type="checkbox" value="Information"/>
<input type="checkbox" value="Preferences"/>	<input type="checkbox" value="Z Component"/>	<input type="checkbox" value="Suppressed"/>	<input type="checkbox" value="No"/>	

- 支架多目标优化案例
  - 基于响应面优化
  - 设计变量范围：翼板尺寸[60,80]；载荷[-11000,-9000]
  - DOE算法：CCD，增强面心
  - 响应面：Kriging
  - 优化算法：扫掠，样本点1000

**Outline of Schematic B4: Optimization**

A	B	C
1 Optimization	Enabled	Monitoring
2 Objectives and Constraints		
3 Minimize P7		
4 Minimize P5		
5 Domain		
6 Static Structural (A1)		
7 P1 - ds_web	<input checked="" type="checkbox"/>	
8 P3 - Force Y Component	<input checked="" type="checkbox"/>	
9 Results		
11 Candidate Points		
12 Tradeoff		
13 Samples		

**Outline of Schematic B3: Response Surface**

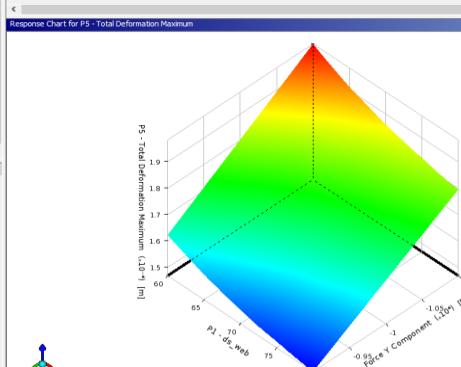
A	B
1 Response Surface	Enabled
2 Input Parameters	
3 Output Parameters	
4 Min-Max Search	<input checked="" type="checkbox"/>
5 Refinement	
6 Refinement Points	
7 Quality	
8 Goodness Of Fit	<input checked="" type="checkbox"/>
9 Verification Points	
10 Response Points	
11 Response Point	
12 Response	<input checked="" type="checkbox"/>
13 Local Sensitivity	
14 Local Sensitivity Curves	
15 Spider	
16 New Response Point	

**Properties of Outline A2: Response**

A	B
1 Property	Value
2 Mode	3D
3 Chart Resolution Along X	25
4 Chart Resolution Along Y	25
5 Show Design Points	
6 Axes	
7 X Axis	P1 - ds_web
8 Y Axis	P3 - Force Y Component
9 Z Axis	P5 - Total Deformation Maximum
10 Input Parameters	
11 P1 - ds_web	70

Outline of Schematic B2: Design of Experiments		
	A	B
1		Enabled
2	Design of Experiments	<input type="checkbox"/>
3	Input Parameters	
4	Static Structural (A1)	
5	P1 - ds_web	<input checked="" type="checkbox"/>
6	P3 - Force Y Component	<input checked="" type="checkbox"/>
7	Output Parameters	
8	Static Structural (A1)	
9	P2 - Solid Mass	
10	P4 - Equivalent Stress Maximum	
11	P5 - Total Deformation Maximum	
12	P6 - Safety Factor Minimum	
13	P7 - Geometry Mass	
14	Charts	
15	Parameters Parallel	<input checked="" type="checkbox"/>
16	Design Points vs Parameter	<input checked="" type="checkbox"/>

Properties of Schematic B2: Design of Experiments	
A	B
1 Property	Value
2 Design Points	
3 Preserve Design Points After DX Run	<input type="checkbox"/>
4 Failed Design Points Management	
5 Number of Retries	0
6 Design of Experiments	
7 Design of Experiments Type	Central Composit...
8 Design Type	Face-Centered
9 Template Type	Enhanced



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# 谢 谢

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