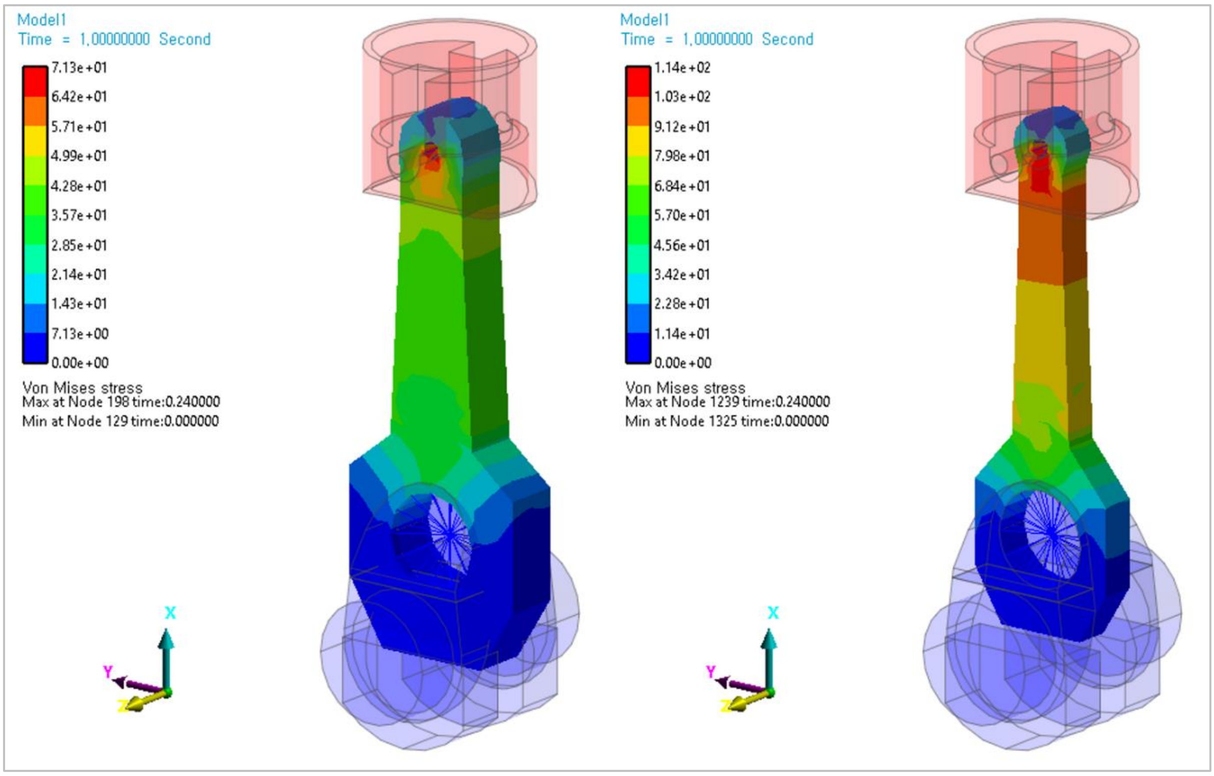
Connecting Rod Shape Optimization Tutorial (AutoDesign)



FunctionBay

Edition Note

This document describes the release information of **RecurDyn V9R4**.

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Sample
G

Connecting Rod Shape Optimization

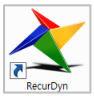
This tutorial deals with the shape optimization design problem. Design target is a connecting rod in engine. Connecting rod function is a transferred reciprocating movement of the piston to crankshaft rotational movement. Therefore, design goal is a minimize mass for energy efficiency and reduce inertial force. Also, a design constraint is strength to withstand compressive forces of piston. Design variable select the shape on connecting rod.

Open files related in Sample-G	
Sample	<Install Dir> \Help\Tutorial\AutoDesign\ConnectingRodShape\Examples\Sample_G.rdyn
Solution	<Install Dir> \Help\Tutorial\AutoDesign\ConnectingRodShape\Solutions\Sample_G.rdyn

Note: If you change the file path at discretion, it can be located in any folder that you specify.

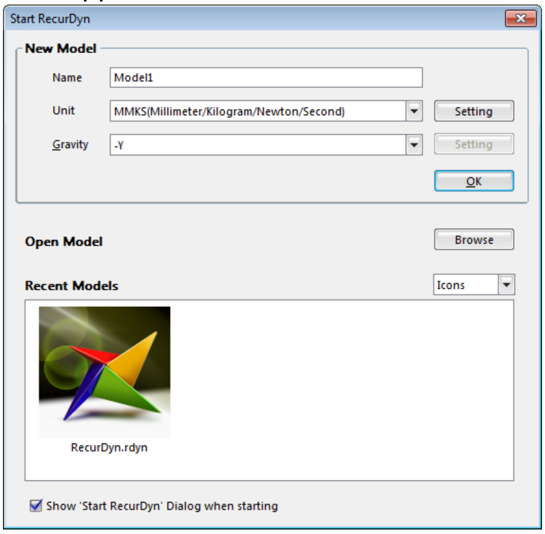
Chapter 1

Loading and simulation the model



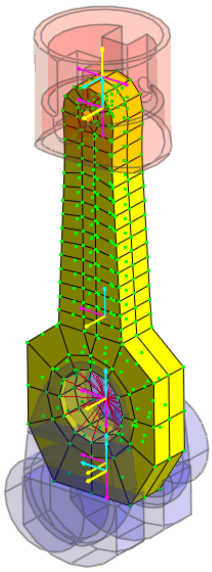
1. On your Desktop, double-click the **RecurDyn** icon.

   RecurDyn starts and the Start RecurDyn dialog box appears.



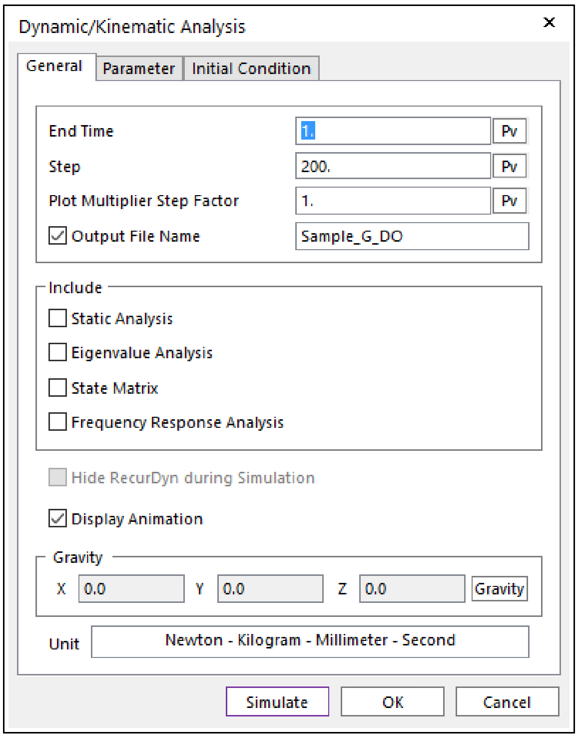
2. Close **Start RecurDyn** dialog box. You will use an existing model.
3. In the Quick Access toolbar, click the **Open** tool and select '**Sample_G.rdyn**' from the same directory where this tutorial is located.

   The system appears on the screen.



4. Click the **Dynamic/Kinematic** button.

5. Click the **Simulate** button.



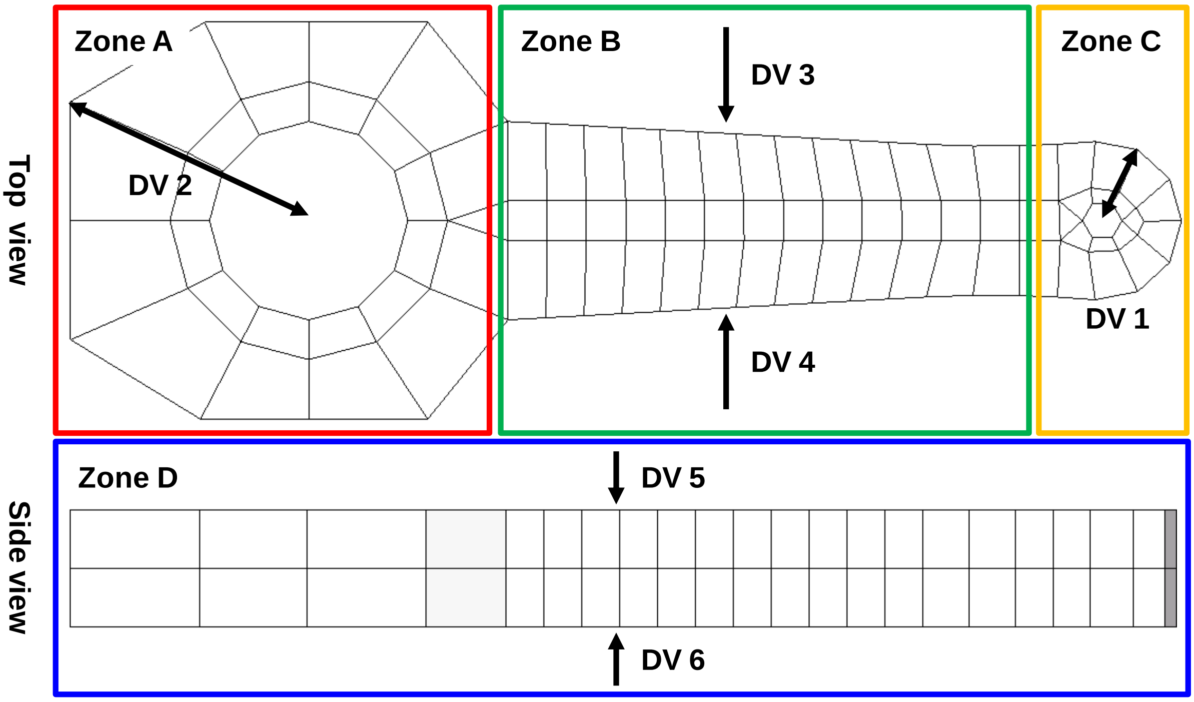
6. In order to view result, click the **play** button

Chapter

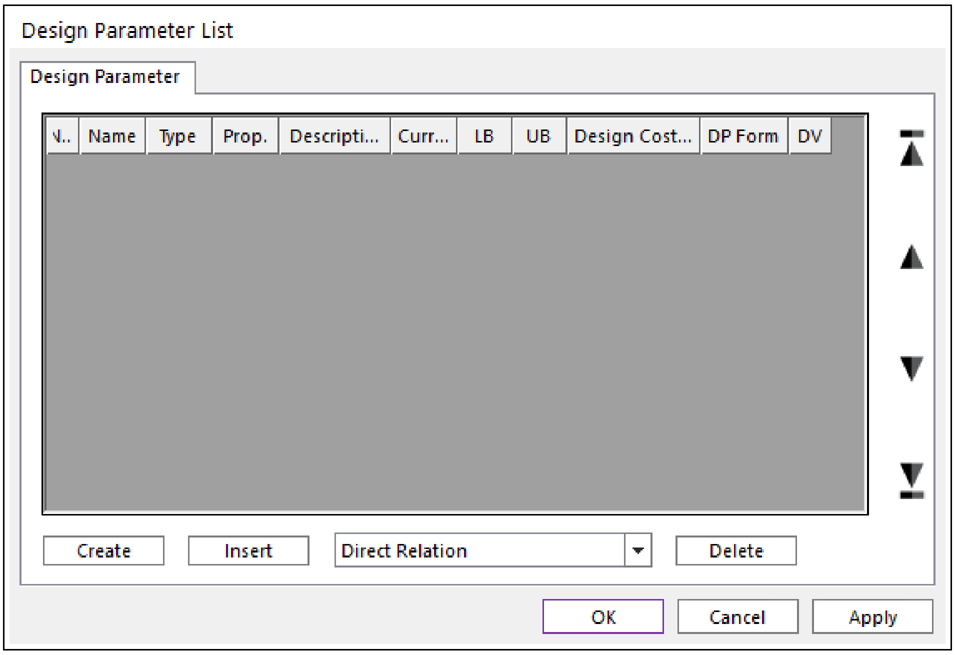
2

Defining the design variables and setting

In the figure, design variable selects connecting road shape. Design variables divide into 4 design variable zones. And, DV1 is a radius in zone C and DV2 is radius in zone A. DV3 and 4 is a width in zone B. DV 5 and 6 is a height in zone D.

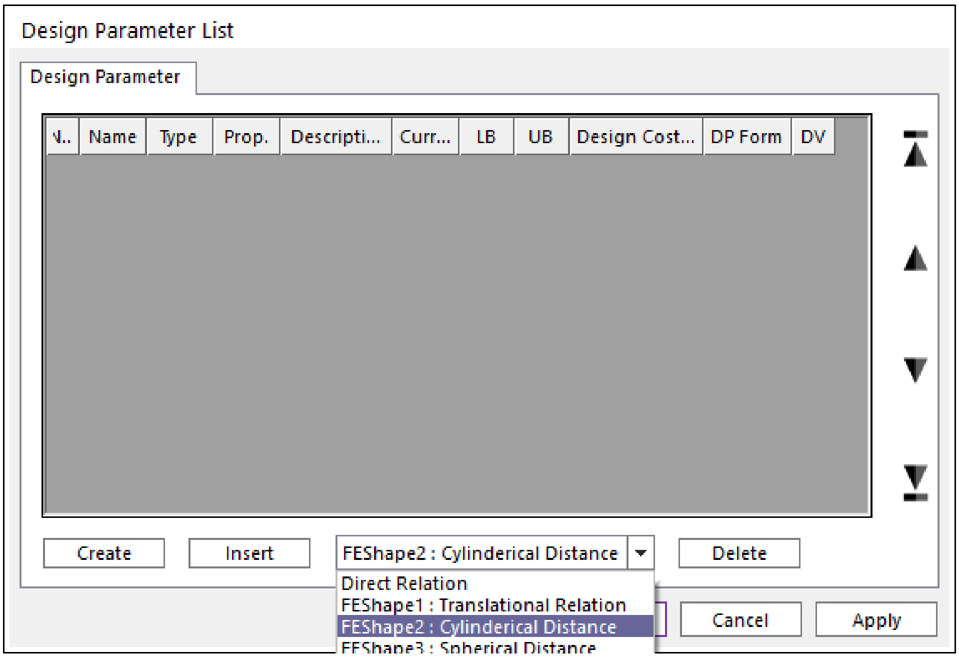


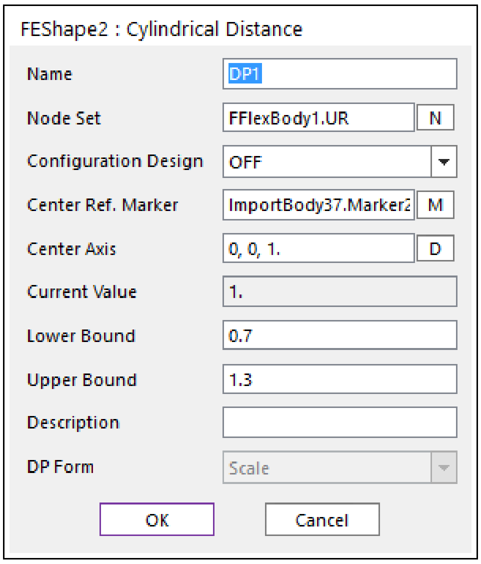
1. From the **Auto Design** menu, click **Design Parameter**. This will bring up the design parameter list dialog as shown below.



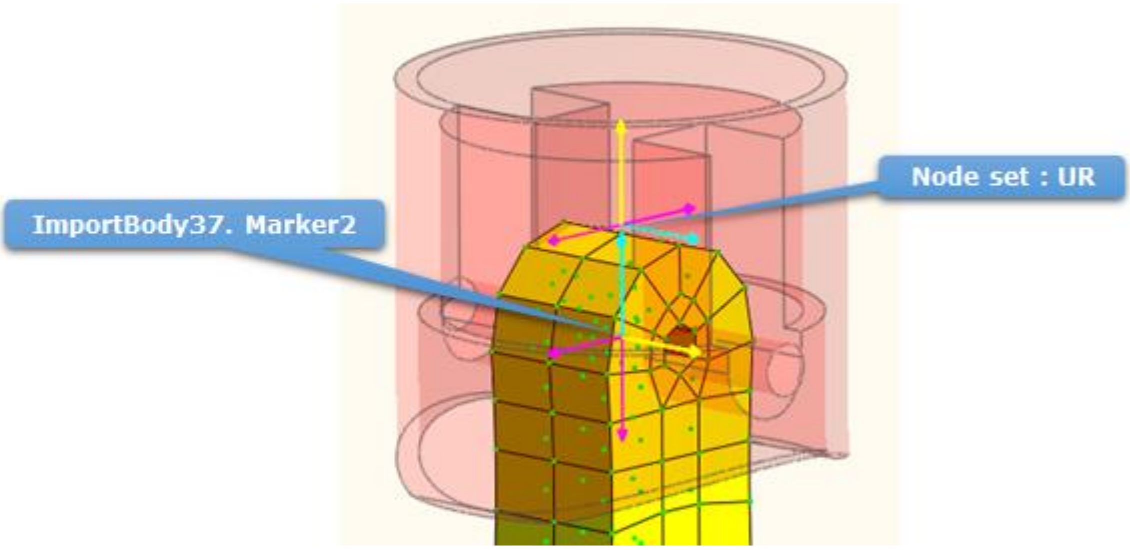
2. **To set design variable 1**

   a. Select design parameter type as **FEShape2 : Cylindrical distance**. And, click **Create** button to add design parameter. This will bring up the **FEShape 2: Cylindrical distance** window shown below.





b. Node set: UR in zone C

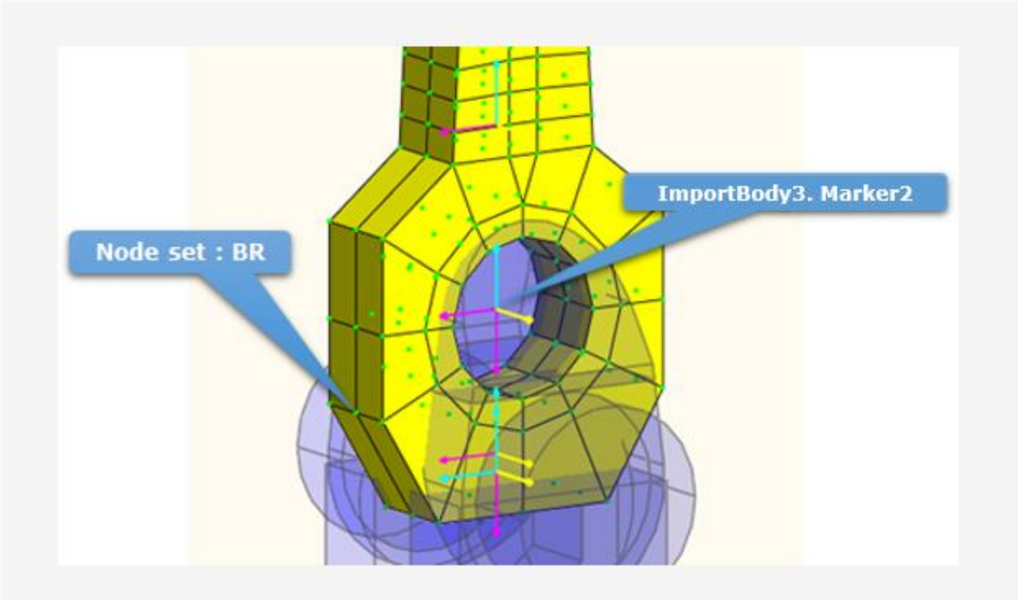


c. Configuration design: off
d. Center Reference marker: importbody37.Marker2
e. Center Axis: 0,0,1
f. Lower & upper bound: 0.7,1.3
g. OK

3. **To set design variable 2**

   a. Select design parameter type as **FEShape 2: Cylindrical distance**. And, click **Create** button to add design parameter.

   b. Node set: BR in zone A



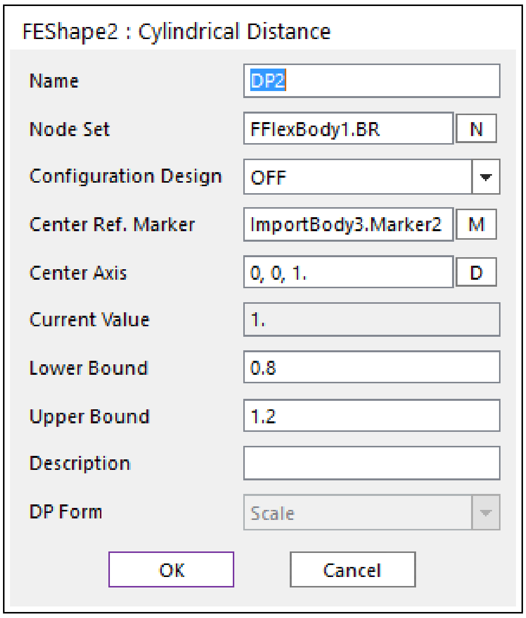
   c. Configuration design: off

   d. Center Reference marker: importbody3.Marker2

   e. Center Axis: 0,0,1

   f. Lower & upper bound: 0.8,1.2

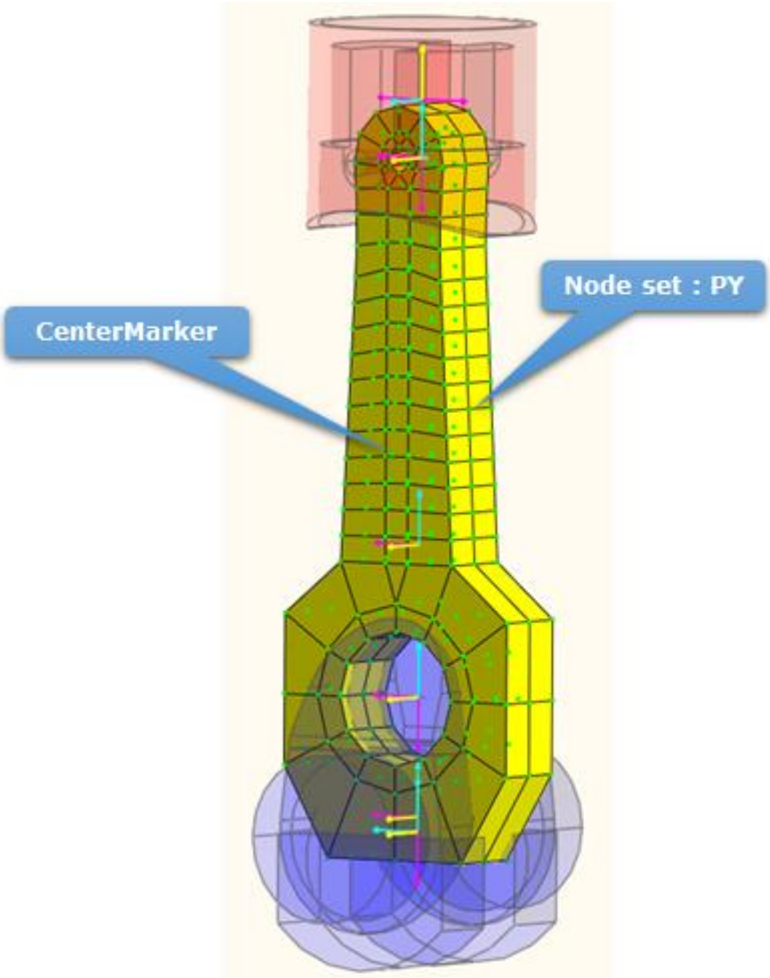
   g. OK



4. **To set Design variable 3, 4**

   a. Select design parameter type as **FEShape 1: Translational relation**. And, click **Create** button to add design parameter. This will bring up the **FEShape 1: Translational relation** window shown below.

   b. Node set: PY in Zone B



   c. Configuration design: off

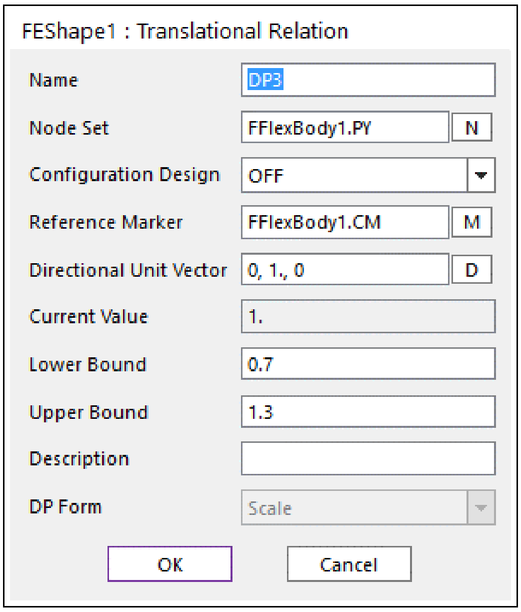
   d. Reference marker: Flexbody1.CM

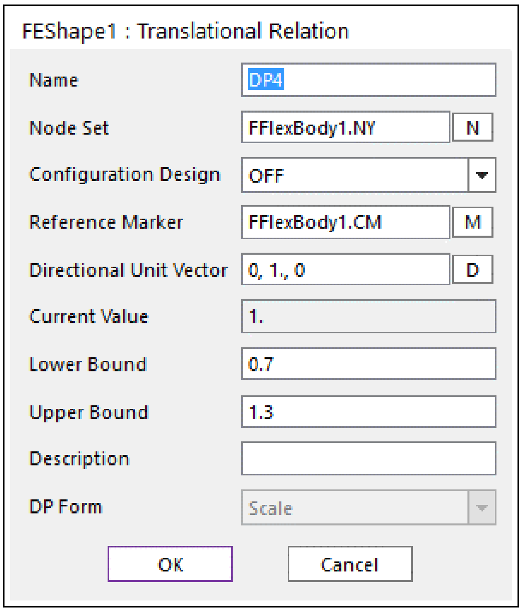
   e. Directional unit vector: 0,1,0

   f. Lower & upper bound: 0.7,1.3

   g. OK

   h. In like manner, To generate DV4 about node set:NY

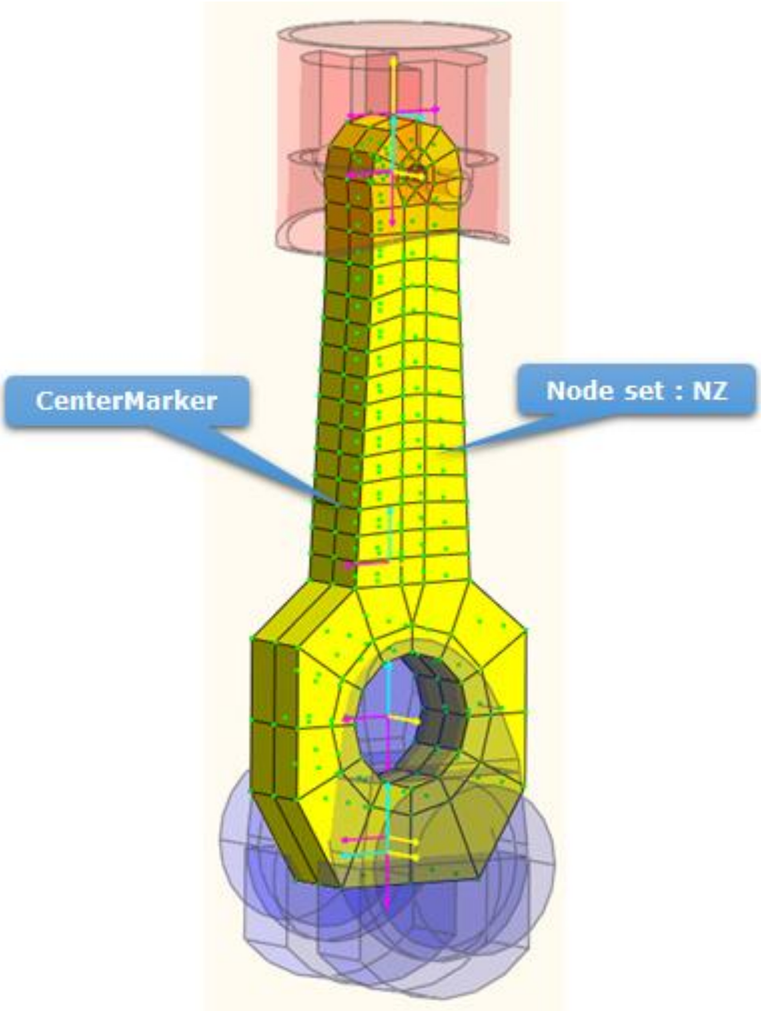




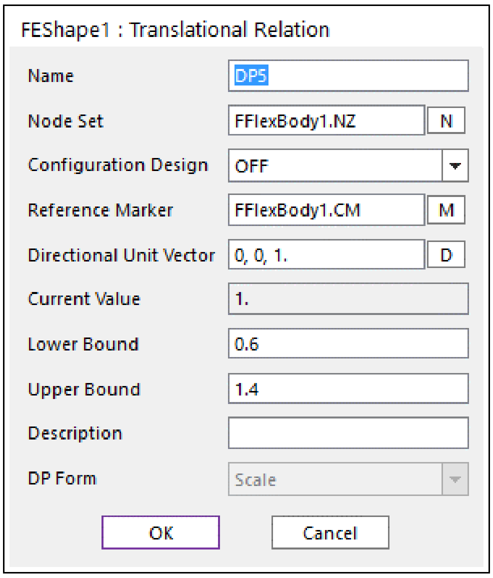
5. **To set Design variable 5, 6**

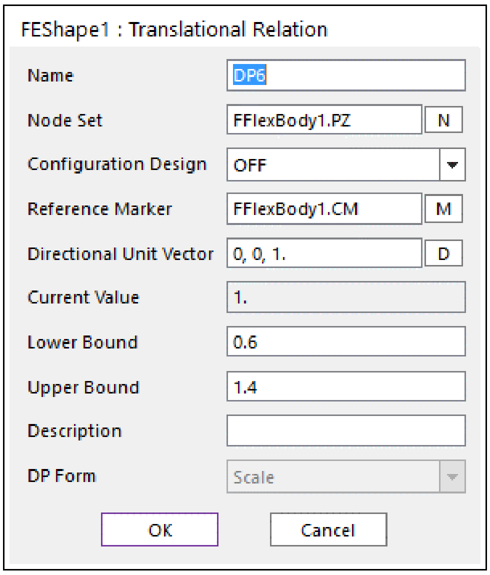
   a. Select design parameter type as **FEShape 1: Translational relation**. And, click **Create** button to add design parameter.

   b. Node set: NZ in zone D



c. Configuration design: off
d. Reference marker: Flexbody.CM
e. Directional unit vector: 0,0,1
f. Lower & upper bound: 0.6,1.4
g. OK
h. In like manner, To generate DV6 about node set: PZ

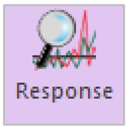

FEShape1 : Translational Relation
Name
DP5
Node Set
FFlexBody1.NZ
N
Configuration Design
OFF
Reference Marker
FFlexBody1.CM
M
Directional Unit Vector
0, 0, 1.
D
Current Value
1.
Lower Bound
0.6
Upper Bound
1.4
Description
DP Form
Scale
OK
Cancel


FEShape1 : Translational Relation
Name
DP6
Node Set
FFlexBody1.PZ
N
Configuration Design
OFF
Reference Marker
FFlexBody1.CM
M
Directional Unit Vector
0, 0, 1.
D
Current Value
1.
Lower Bound
0.6
Upper Bound
1.4
Description
DP Form
Scale
OK
Cancel

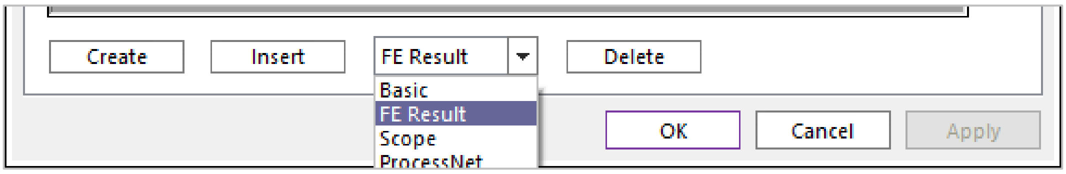
Chapter 3

Defining the analysis responses

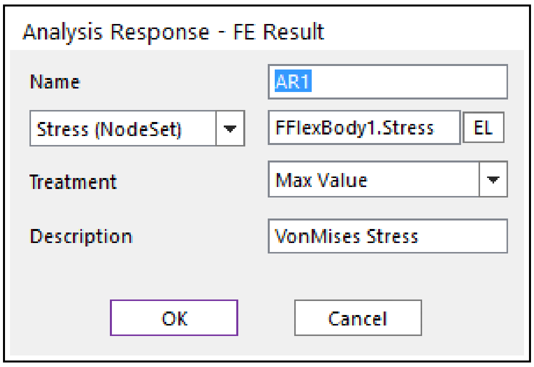
In order to design connecting rod, analysis response is a mass and stress



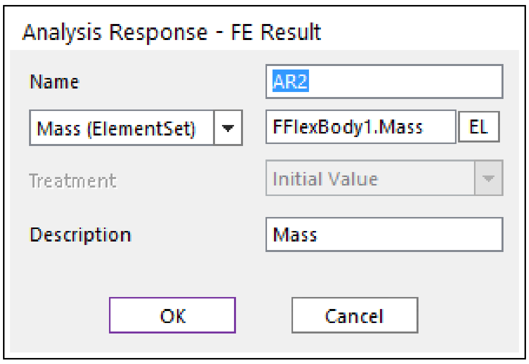
1. Click the **Analysis Responses** menu. Then, you can change the response type (FE-Result) as follow figure:



2. Click the **Create** button. Then you can see the analysis responses-**FE result** window as following figure.
3. To set the analysis response of **stress** is defined as
   a. Name: AR1
   b. Result type: Stress(NodeSet)
   c. Select Node Set: FFlexBody1.Stress
   d. Response treatment: Max value
   e. Description: VonMises Stress
   f. OK.



4. Click the **Create** button. Then you can see the analysis responses-**FE Result** window as following figure.
5. To set the analysis response of **mass** is defined as
   a. Name: AR2
   b. Result type: Mass(ElementSet)
   c. Select Element Set: FFlexBody1.Mass
   d. Description: Mass
   e. OK.



Chapter 4

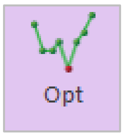
Running a design optimization

The optimization problem is defined as:

Minimize the mass of the connecting rod

Subject to

- The stress =< Limit value



1. Click the **Design Optimization** menu. Then, you can see the design variable list as following figure:

Design Optimization

Design Variable | Performance Index | Optimization Control | Result Sheet | Summary Sheet

DV	DP	Description	Current	LB	UB	Type	Value
1	DP1		1.	0.7	1.3	Variable	0.
2	DP2		1.	0.8	1.2	Variable	0.
3	DP3		1.	0.7	1.3	Variable	0.
4	DP4		1.	0.7	1.3	Variable	0.
5	DP5		1.	0.6	1.4	Variable	0.
6	DP6		1.	0.6	1.4	Variable	0.

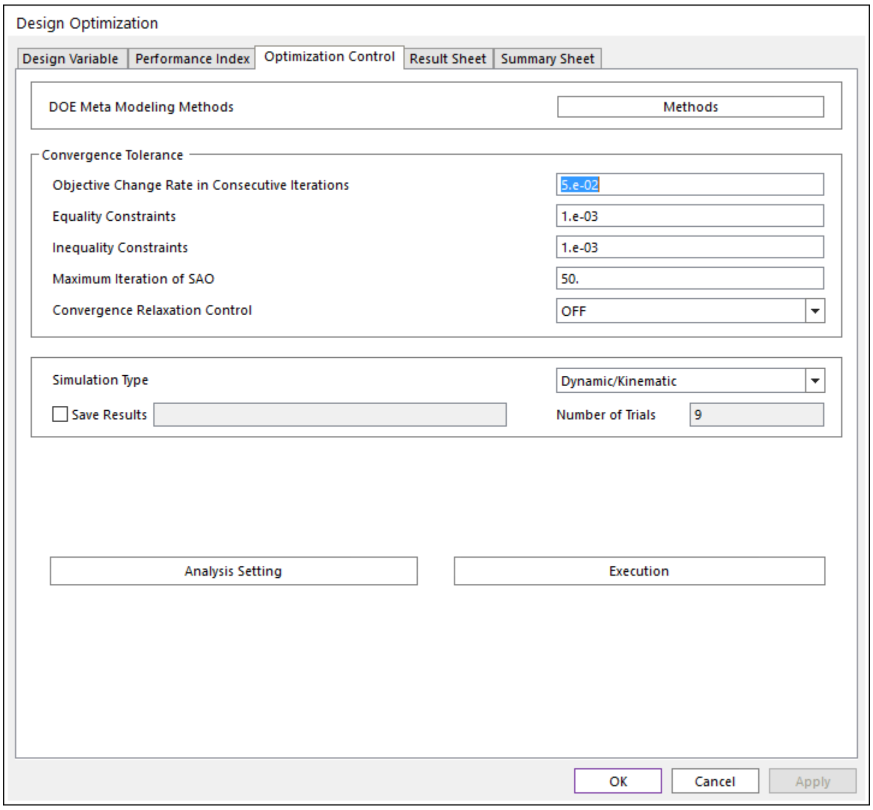
2. Click the **Performance Index** tab. Then, you can see the following list. If this window is empty, then you create the following PIs.

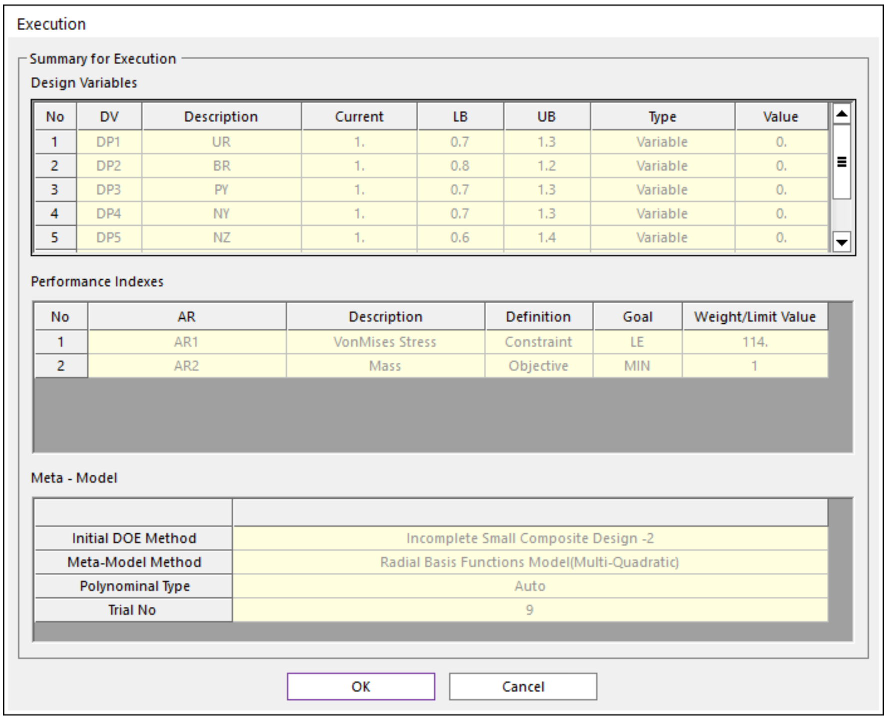
Design Optimization

Design Variable | Performance Index | Optimization Control | Result Sheet | Summary Sheet

PI	Use	AR	Description	Definition	Goal	Weight/Limit Value
1	✔	AR1	VonMises Stress	Constraint	LE	114.
2	✔	AR2	Mass	Objective	MIN	1

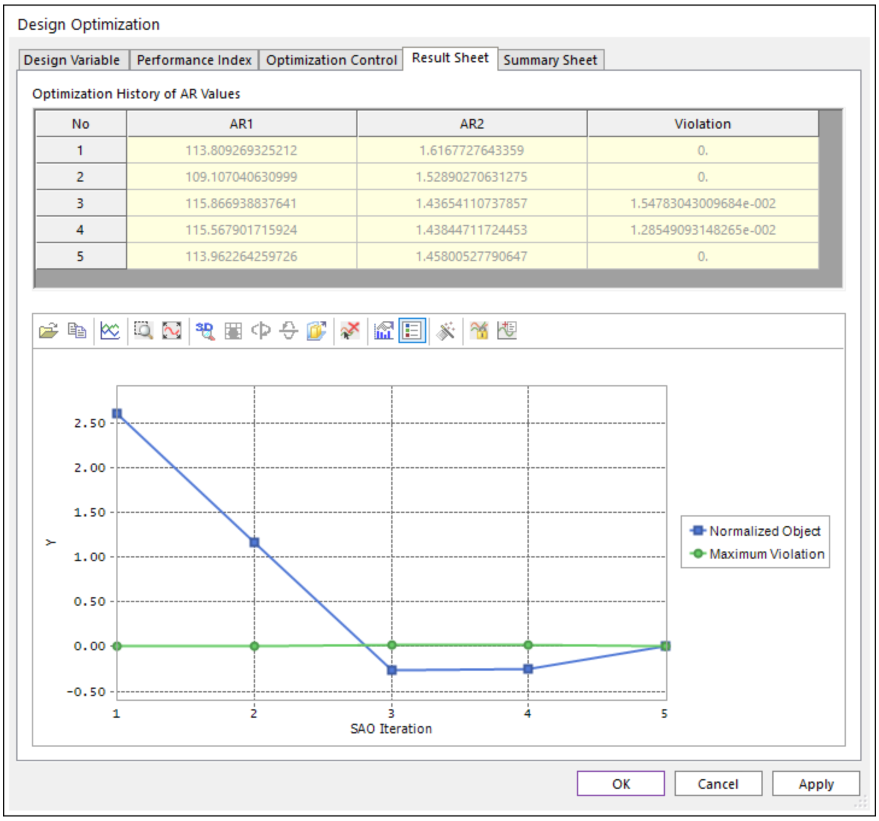
3. Click the **Optimization Control** tab. The default values are directly used. Then, click the **Execution** button. Then, you can see the summary of design formulation. Check design variables, performance index and Meta-Model information. If all information is correct, then click the **OK** button. Then, optimization process is progressed.



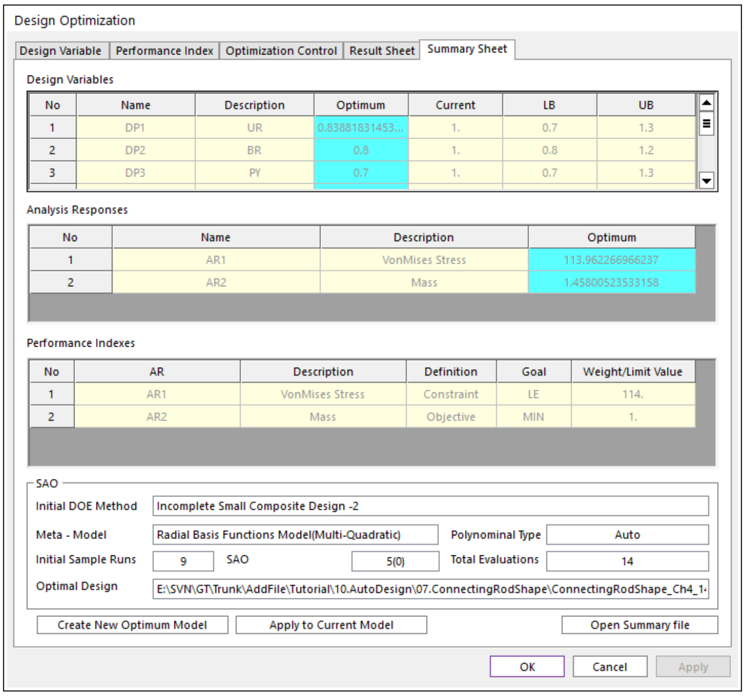


4. When the optimization process is completed, the result sheet tab is automatically shown. The optimization process is converged only in 5 **iterations**. Thus, **AutoDesign** solves the connecting-rod system design having 6 design variables for **14 analyses** that

includes **9 analyses for the initial sampling points**. The final design gives that AR1=113.96 Mpa and AR2=1.458 kg which can minimize the Mass by 58 % and the Stress is satisfied with design constraint (less than 114 Mpa).



5. The optimization results are summarized in the design variables and analysis responses lists. Also, the SAO information is summarized, which shows that SAO 5 requires. The analysis result of optimal design is ‘DO_005’.



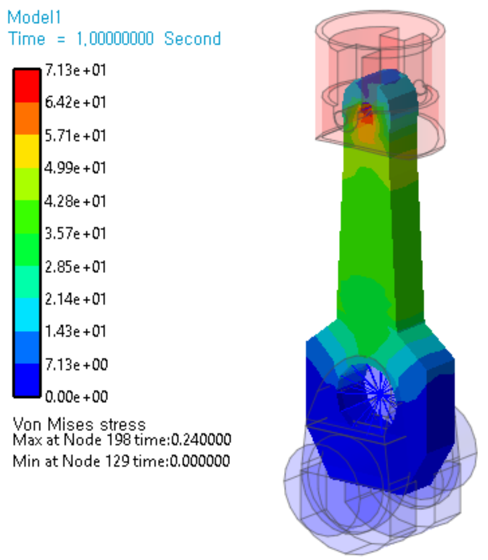
Chapter

5

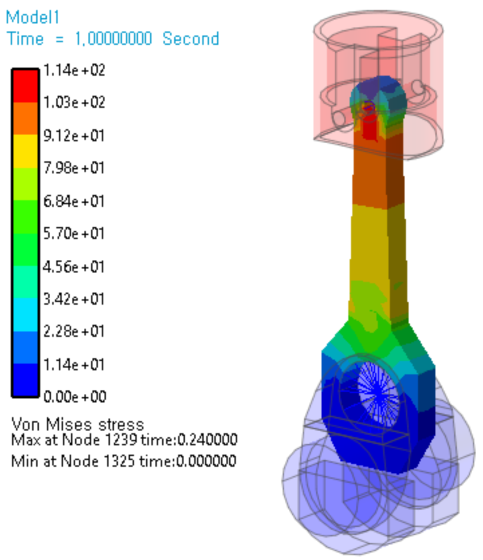
Comparison of analysis results

Finally, let's compare the mass and stress level for the initial design and the optimal design. SAO5 is the optimal design. Also, DOE005 is the initial design. The following figures show those comparisons.

The initial design



The optimal design



	The initial design	The optimal design
Mass (Kg)	3.478	1.458
Stress (Mpa)	71.3	113.96

Thanks for participating in this tutorial!