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Altair HyperStudy 2019 Tutorials

HS-4405: Reliability-Based Optimization Study on an Impact Simulation Using RADIOSS

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HS-4405: Reliability-Based Optimization Study on an Impact Simulation Using RADIOSS

This tutorial demonstrates how to perform a reliability-based optimization on a finite element model defined for RADIOSS.

Before running this tutorial, you must complete tutorial HS-4220: Size Optimization Study on an Impact Simulation using RADIOSS or you can import the archive file `HS-4220.hstx`, available in `<hst.zip>/HS-4405/`.

In the initial optimization problem, as stated in tutorial HS-4220, the objective is to minimize the mass of the beam under the following two constraints: the internal energy must be more than 450, and the resulting reaction force must be less than 75. The input variables are the thicknesses of the four components defined in the input deck `boxbeam1_0000.rad` via the /PROP/SHELL entries. They are combined into two input variables. The thickness should be between 0.5 and 2.0; the initial thickness is 1.0.

The reliability is added in this study through the definition of uncertainties on the input variables and probability targets for the constraints.

The thicknesses follow a normal distribution, with mean 1.0 and coefficient of variation 0.10.

The constraints are expressed as follows:

Prob(internal energy > 450) > 0.98

Prob(reaction force < 75) > 0.98

This means: *Taking into account possible variations created by the random parameters; we want the 98th percentile of the reaction force distribution to be less than 75.*

The ARSM-SORA optimization engine is used in this tutorial. SORA (Sequential Optimization and Reliability Assessment) is an algorithm that makes it possible to manage random variables and set reliability targets on constraints. ARSM-SORA takes advantage of the response surface based approach to reduce the computational effort needed in such problems

Step 1: Start from Tutorial HS-4220

1. Start HyperStudy.
2. Perform all steps in tutorial HS-4220.

Step 2: Run a Reliability-Based Optimization Study

1. In the **Explorer**, right-click on ***Optimization 1*** and select ***Copy Approach*** from the context menu.
2. In the **Copy - HyperStudy** dialog, click ***OK***. A copy of Optimization 1 opens in the **Explorer**.
3. Go to the **Select Input Variables** step.
4. Review and edit the probabilistic properties by right-clicking in the **Select Input Variables** table and selecting ***Columns*** > ***Show All*** from the context menu. All of the columns available appear in the work area.

5. In the **Distribution Role** column of both input variables, select ***Design with Random***.
6. Go to the **Select Output Responses** step.
7. Edit constraints.
   a. Click the ***Constraints*** tab.
   b. Define both constraints.
      - Set **Type** to ***Random***.
      - For **CDF Limit**, enter `98.00`.

	Active	Label	Varname	Type	Apply On	Bound Type	Bound Value	CDF Limit
1	☑	Constraint 1	c_1	Random	Energy (m_1_r_1)	>=	450.00000	98.000000
2	☑	Constraint 2	c_2	Random	Force (m_1_r_2)	<=	75.000000	98.000000

8. Click ***Apply***.
9. Go to the **Specifications** step.
10. In the work area, set the **Mode** to ***ARSM based SORA (SORA_ARSM)***.

    Note: Only the methods that are valid for the problem formulation are enabled.
11. Click ***Apply***.
12. Go to the **Evaluate** step.
13. Click ***Evaluate Tasks*** to launch the Optimization.

Step 3: View the Iteration History of the Optimization Study

When using the SORA or ARSM-SORA engines, additional information is displayed for each of the Random type constraints. These are the percentile values (labeled _PV) and they are related to the CDF Limits.

For a constraint of the form Prob(g > b) > R , the constraint is satisfied in the probabilistic way if the Rth-Percentile value of g is greater than b. R stands for the target probability, and b stands for the bound value.

For a constraint of the form Prob(g < b) > R, the constraint is satisfied in the probabilistic way if the Rth-Percentile value of g is smaller than b.

When using SORA or ARSM-SORA, the history table displays, as the first iteration, the result of the deterministic optimization (i.e. without taking the random parameters into account). The following iterations are successive iterations made to satisfy the probabilistic constraints.

1. Click the ***Iteration History*** tab to review the SORA_ARSM history. Iteration 1 is the outcome of the deterministic optimization. Iterations 2 to 6 summarize the probabilistic steps. The two constraints match the probabilistic target: constraint_2_PV = 75.08. This indicates that the 98th percentile value of constraint 2 (reaction force) satisfies the 75.0 upper bound you defined.

	Upper part	Lower part	Energy	Force	Mass	Objective 1	Constraint 1	Constraint 2	Constraint 1_PV	Constraint 2_PV	Iteration	StepIndex	StepMajor	Violation Coc
1	1.0249392	1.0915549	450.62128	75.025169	25.473381	25.473381	450.62128	75.025169	383.67096	99.382683	1	6	1	2
2	1.2203334	1.1269614	801.21423	59.132378	25.522619	25.522619	801.21423	59.132378	734.26392	75.715157	2	58	2	2
3	1.2760347	1.0269614	639.21100	60.437492	25.510513	25.510513	639.21100	60.437492	572.26068	75.559212	3	79	3	2
4	1.3822058	0.9045306	521.15656	54.124447	25.503628	25.503628	521.15656	54.124447	521.15656	92.662315	4	293	4	2
5	1.3359273	0.9113338	451.72736	57.925980	25.495571	25.495571	451.72736	57.925980	451.72736	75.652977	5	509	5	2
6	1.3436887	0.9049184	450.53638	57.411449	25.495672	25.495672	450.53638	57.411449	450.53638	75.074890	6	656	6	1