Altair MotionView 2019 Tutorials
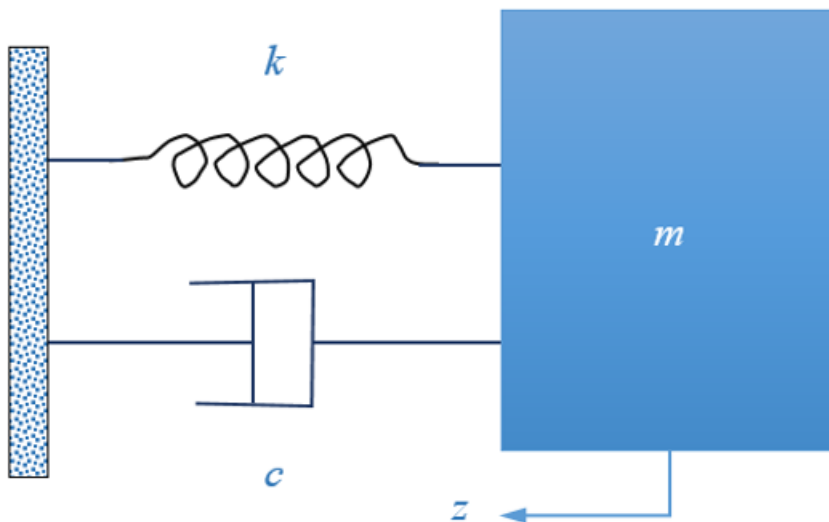
MV-3021: Optimization of an Impact Absorber

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In this tutorial you will learn how to setup an optimization problem using MotionView's Optimization Wizard for an impact absorber. You will learn about:

- Defining stiffness and damping of SpringDamper element as design variables

- Defining responses of type MaxVal

- Using the responses as objectives

- Running the optimization and post-processing the results

Introduction

An impact absorber is modeled as a single degree of freedom system with a mass m, a linear stiffness k and a linear damping coefficient c. The velocity of the mass is 1 m/s; Mass m = 1 kg and a transient analysis end time of 12 seconds is used.


Impact Absorber Model

The objective of the optimization is to minimize the maximum acceleration of the mass in the time interval 0 to 12s subject to the condition that the maximum displacement is less than 1m. In order to achieve this, stiffness k and damping ratio c are modeled as design variables. MotionSolve's FD (Finite Differencing) capability is used to calculate sensitivities.

Model Setup

Copy the file `mv_3021_initial_impact_absorber.mdl` located in the `mbd_modeling\motionsolve\optimization\MV-3021` into your `<working directory>`.

Step 1: Adding Design Variables.

1. Open `mv_3021_initial_impact_absorber.mdl` in MotionView.

2. Right-click on *Model* in the browser and launch the **Optimization Wizard**.

3. Under the **Design Variables** page, click on the *Springs* tab.

4. Make the **k** and **c** of **SpringDamper 0** as design variables. Select *k* and *c* data-members from the model tree under the spring damper and click *Add*.
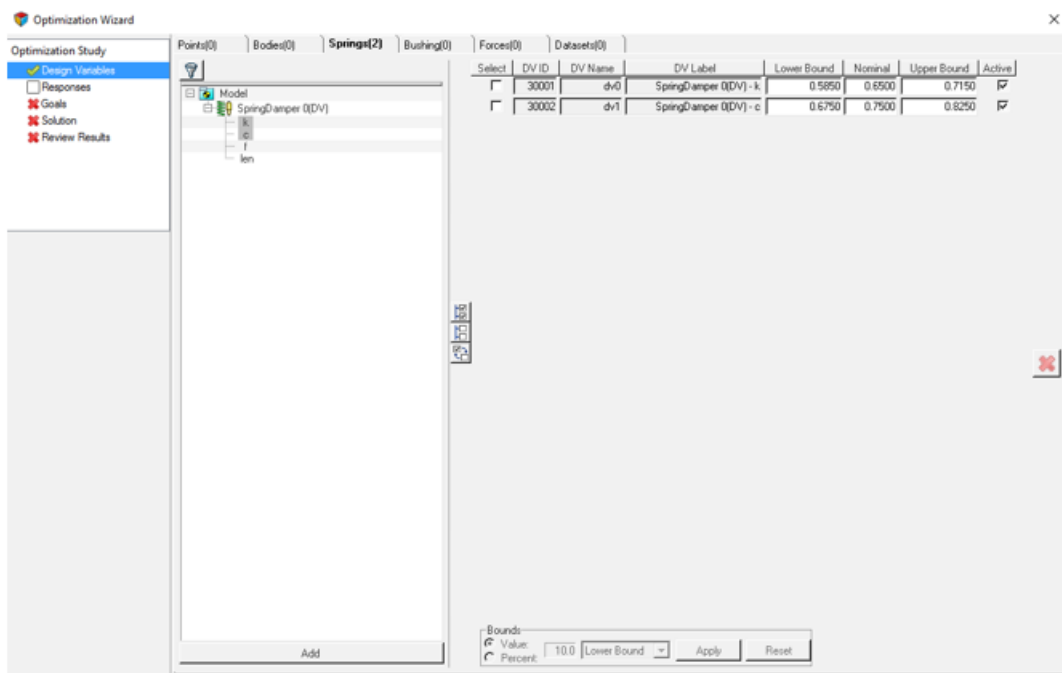
Making k and c as design variables

5. Modify the upper and lower bounds of the design variables using the table below.

DV	Lower Bound	Upper Bound
sd_0.k	0.2	1.0
sd_0.c	0.2	1.0

Step 2: Adding Response Variables.

The objective of the optimization is to minimize the maximum acceleration while keeping the displacement of mass to be less than 1.0. To achieve this, two responses are created:

   a. Maximum z direction acceleration of mass

   b. Maximum z direction displacement of mass

The maximum z-direction acceleration response is used to define an objective; the maximum z-direction displacement is used to define a constraint. Both responses are created using 'MaxVal' response. This response can be used to capture the maximum value of an expression throughout the simulation. The details of 'MaxVal' response can be obtained from the 'Multibody Optimization User's Guide' and the 'MotionView User's Guide'.

1. Go to the ***Responses*** page.

2. Click on the ➕ button to add a ResponseVariable.

    The Label and Variable Names can be retained as default in the the dialog.

3. Click ***OK*** to create a Response Variable.

4. Once the response variable is created, under **Response Type**, choose ***MaxVal***.

    This response needs 1 input from the user: Response Expression.

    For ***Response Expression***, enter in the expression for the absolute value of ACCZ of CM of mass: `ABS(ACCZ({b_0.cm.id},{m_0.id}))`

This completes the creation of the first response. The Response Variable should look as below:
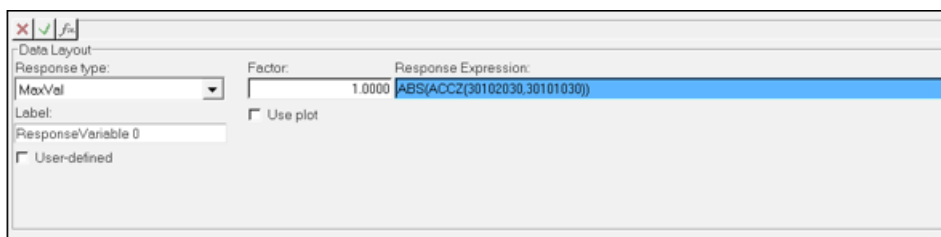
Response Variable of type 'MaxVal'

5. Follow the same procedure to add another 'MaxVal' response, and use:
    `` `ABS(DZ({b_0.cm.id},{m_0.id}))` `` for the **Response Expression**.

This completes the process of adding Response Variables; the completed 'Response Variable' page should appear as shown below.
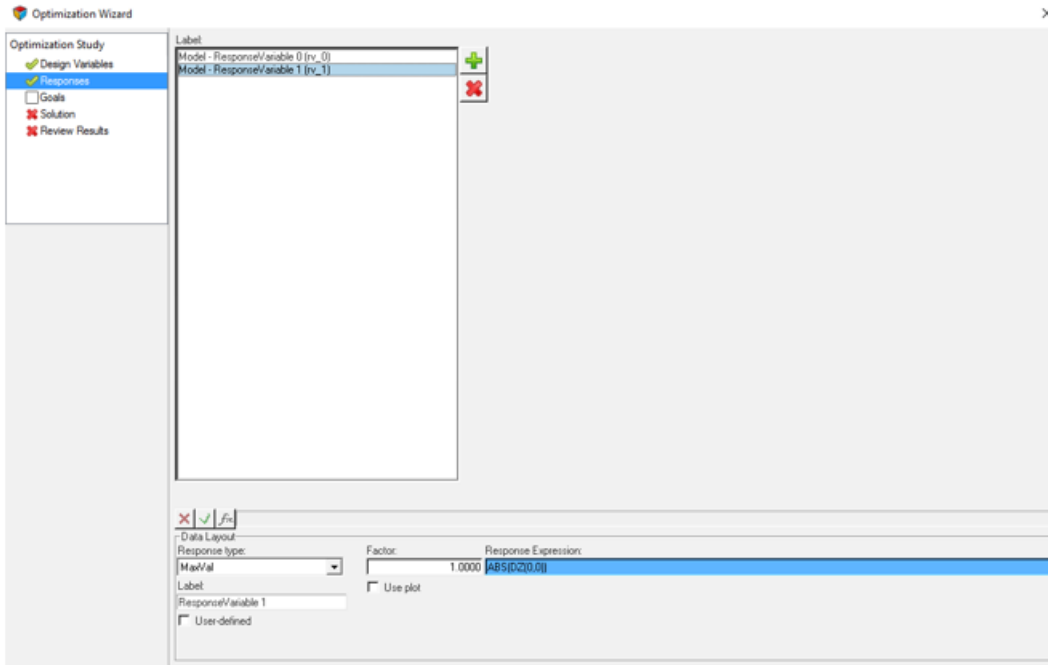

Completed 'Response Variables' page

Step 3: Adding Objectives and Constraints.

We can use responses that were created in the previous section as objectives and constraint.

1. Go to the **Goals** page, click on the ✚ button under **Objectives**.

    An objective is added with response *rv_0*.

2. Choose the **weight** as *1.0* and retain the **Type** as *min* since we want to minimize this response.

3. Click on the ✚ button under **Constraints**.

    A constraint is added with the response as 'rv_0'.

    – Change this to *rv_1*.

4. Retain the sign as '<=' and type in `1.0` for value, since we want to keep the value of 'rv_1' to be less than 1.0.

The objective and constraint are now defined, and the model is ready to be solved.
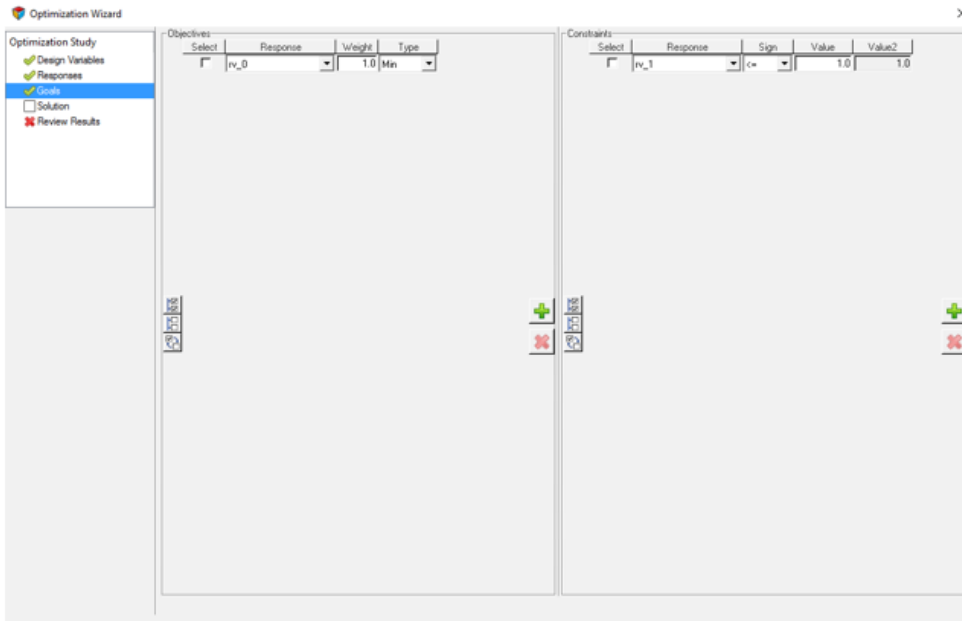
Defining objective and constraint

Step 4: Running the Optimization.

1. Go to the **Solution** page to specify optimization settings and run the analysis. To change the optimization setting, left click on *Optimization Settings*.

2. Change the **DSA type** to *FD*.

    AUTO can also be selected. When AUTO is chosen, MotionSolve will detect the simulation type and choose the best approach to compute sensitivity. The simulation type is dynamic, so FD will be chosen.
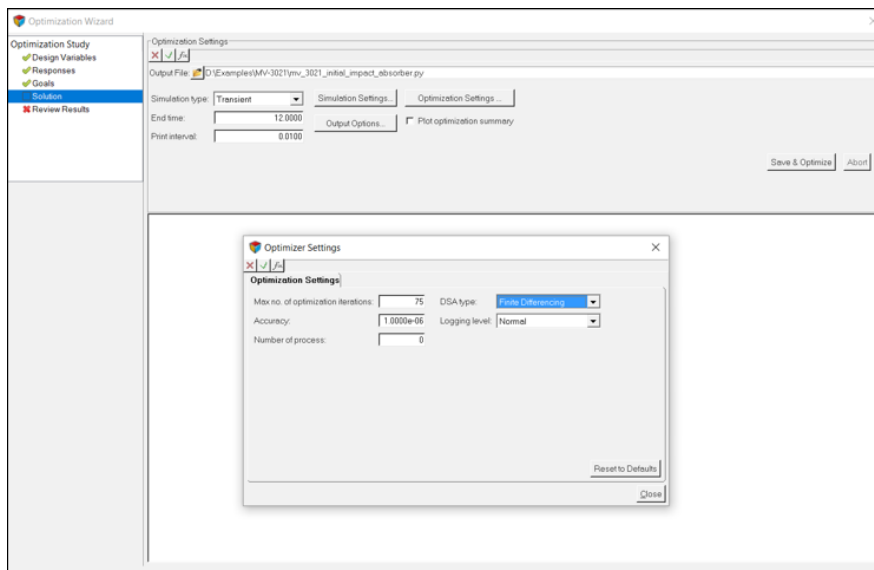

Solution settings

3. Click on *Save & Optimize* to start the optimization.

    While the optimization is running, a plot of total weighted cost vs. iteration number and constraint value is displayed in a separate window.

Once the optimization process is complete, the text window in the **Solution** page displays the optimized design variables values, final value of the responses and optimized cost function.
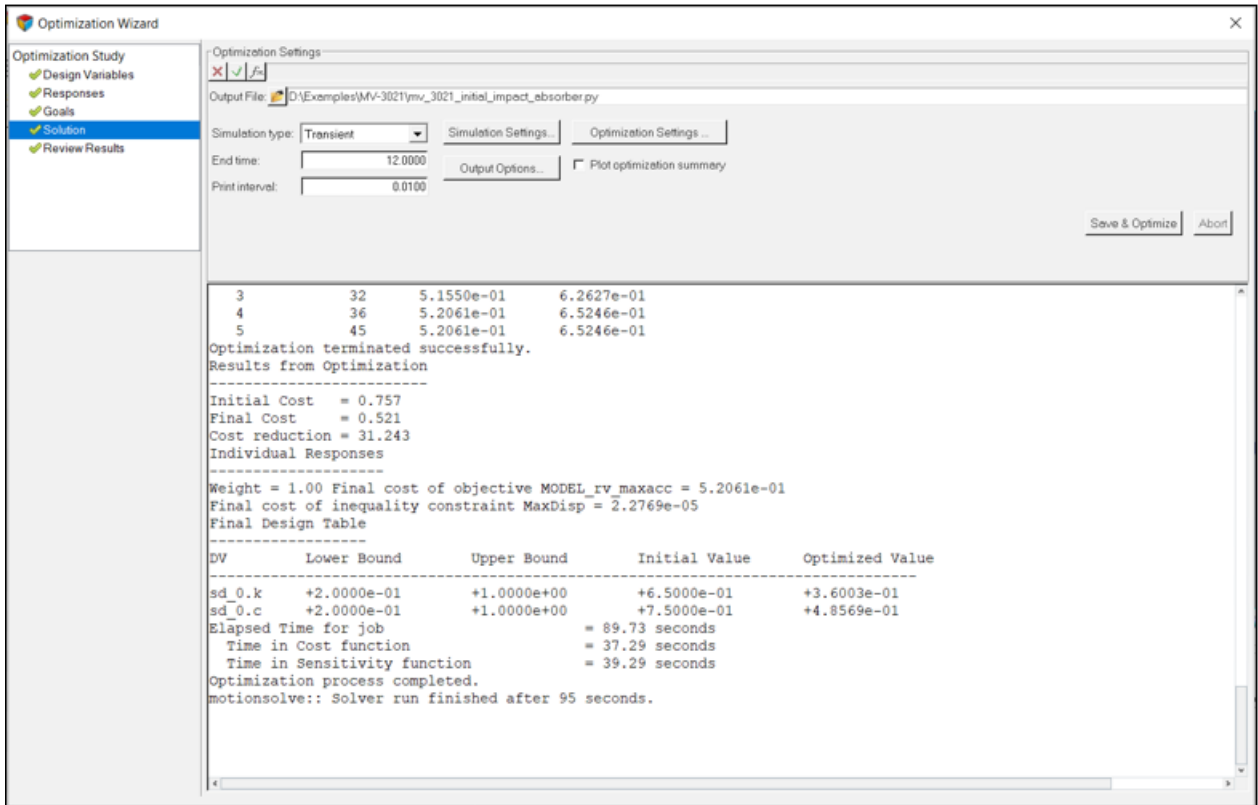

Optimization text window after the optimization is complete

The expected values of design variables are given below:

| RV/DV	Expected	From Optimizer
rv_0	0.5206	0.5206
sd_0.k	0.3606	0.36003
sd_0.c	0.4851	0.48569

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Step 5: Post-processing

1. Go to the **Review Results** page. The **Summary** tab is displayed with lists of values for design variables, responses and objective being tabulated iteration-wise. For this tutorial, the optimized design variables are from the last iteration 5.
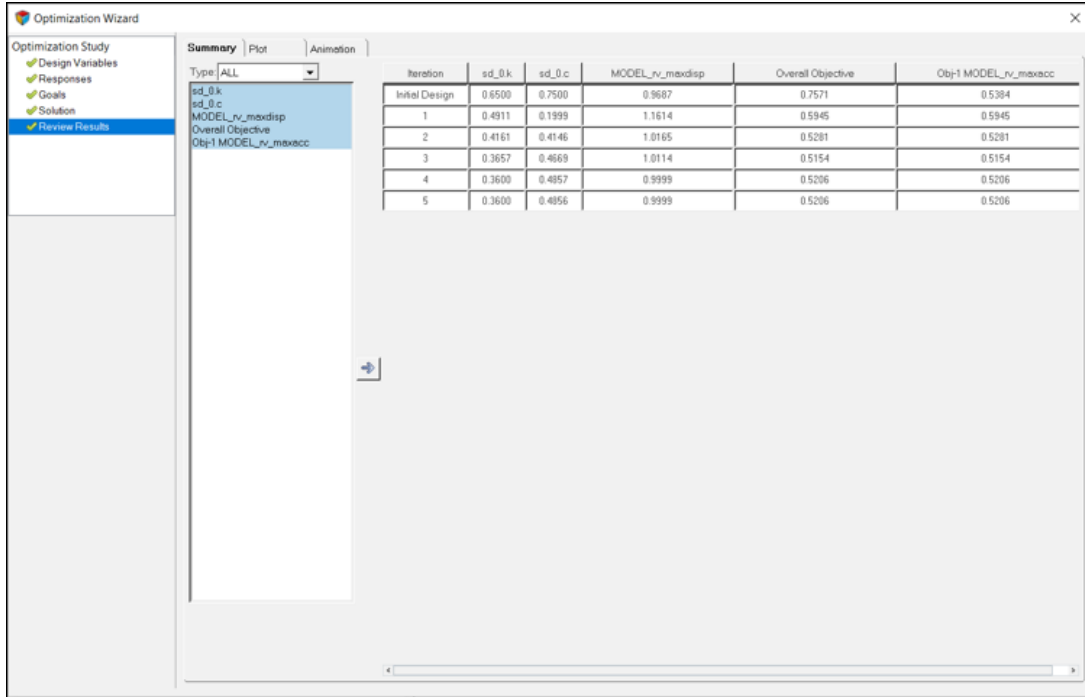

Summary tab listing design variables, responses and cost function iteration-wise

2. Select the **Plot** tab to visualize variation of design variables, response variables and cost function using graphs.
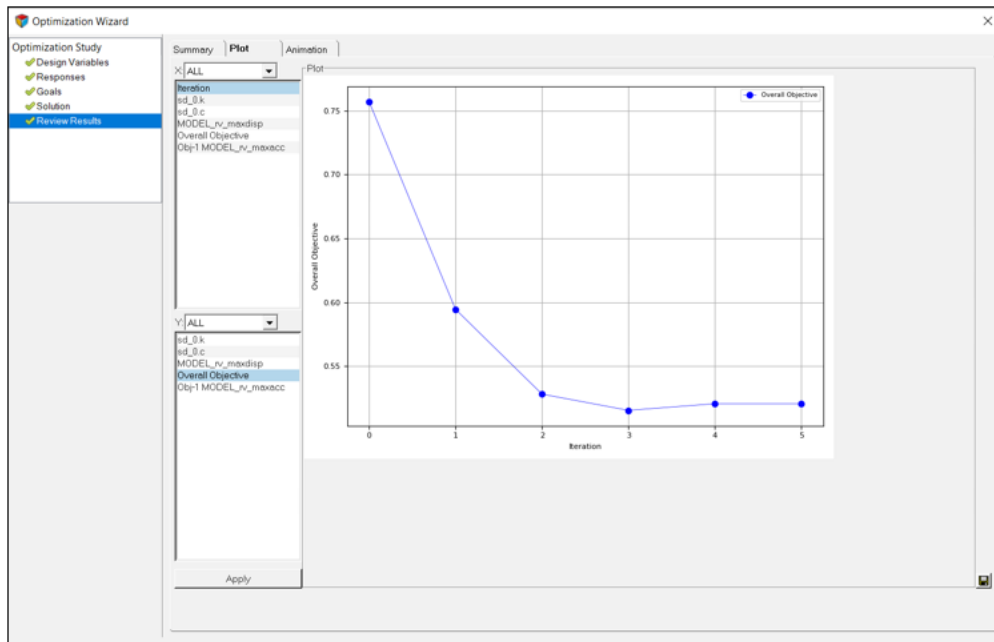
Plot of overall objective vs. iteration number. The 💾 button on the page helps you to save the plots in PNG format.

5. Go to the **Animation** tab to animate the configuration generated during any iteration.

6. Choose the *Iteration* 5 and click on *Load Result* to load the H3D file from that iteration. Buttons to start/play, pause and stop the animation are provided at the bottom.
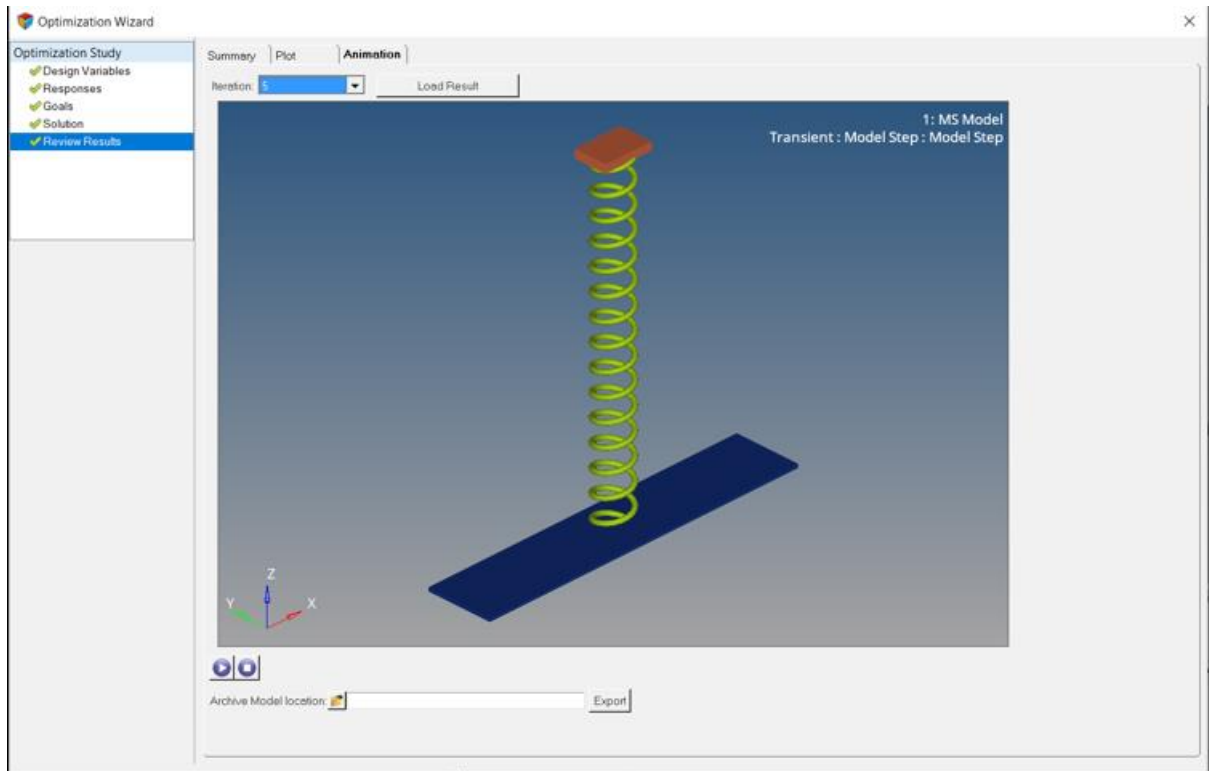
Animation tab in the 'Post Processing' page

An option is available in this tab to export an archive of the model in a state corresponding to any iteration.

7. Specify a file path in **Archive Model location**.

8. Click on the *Export* button. An archive folder is created which contains all files necessary to open/run/optimize the model. The design variable values are set to the values in the iteration number chosen.

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