ABOUT OPTIMIZATION DESIGN STUDY ON SOLIDWORKS

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Abstract: In this paper are presented the steps to be taken in SolidWorks for conducting an optimization design study of parts designed. There are presented the Design Study module features and the settings that have to be done for such analysis and the results and their interpretations.

Keywords: SolidWorks, Design Study, optimization.

1. INTRODUCTION

As stated in [1], along with other modules of SolidWorks, like SimulationExpress or Simulation, Design Study, an extended version of a feature of SimulationExpress, one can “help you reduce cost and time-to-market by testing your designs on the computer instead of expensive and time-consuming field tests”.

Without using an optimization study, the best part design can be achieved only by expensive and time-consuming product development cycles. So typically must first build the model in SolidWorks CAD system, prototype the design, test the prototype in the field, evaluate the results of the field tests and modify the design based on the field test results. This process can continue until a satisfactory solution is reached. On the other hand by using SolidWorks modules for preliminary studies (SolidWorks SimulationExpress/Simulation/Design Study) it can be accomplished tasks like testing the model using the computer rather than field tests, thus reducing cost, reducing time to market by reducing the number of product development cycles and optimize the designs by simulating concepts and scenarios before making final decisions [2].

Design Study is one feature of SolidWorks that can be used for achieving mentioned goals above.

There are two main modes for running a Design Study:

- Evaluation, when it’s specified discrete values for each variable and use sensors as constraints. The software runs the study using various combinations of the values and reports the output for each combination.

- Optimization, when it’s used values for each variable, either as discrete values or as a range. Sensors can be used as constraints and as goals. The software runs iterations of the values and reports the optimum combination of values to meet a specified goal (minimum mass for example).

To begin a Design Study do one of the following: Click Design Study (Tools toolbar) or Insert menu> Design Study > Add.

A new design study can be done by right-click an existing Design Study tab and click Create New Design Study. A Design Study tab appears at the bottom of the graphics area (figure 1).
2. DESIGN STUDY TASK PANE

The wizard interface of Design Study guide through a step-by-step process to specify Variables, Constraints and Goals, run the study, and view the results (figure 2).

Fig. 1. Starting a design study

Fig. 2. Design study task pane
For Evaluation studies only, clear Optimization and for Optimization studies, select Optimization.

This option allows optimization of a model dimension based on a specified criterion and constraint. Practically it’s done a dimensional optimization rather than a shape one, using as goal (objective function) for example minimization of mass [3].

As constraint for example, it can be find the optimal dimensions of a part such that the Von Mises stresses do not exceed a specified value.

To perform optimization analysis must be taken the steps:
- In the graphics area, select a model dimension (design variable) to optimize.
- The model dimension appears in the Add Parameters dialog box. It can be defined several parameters to be used as design variables, as shown in figure 3.
- Click OK.
- In the Design study pane, under Variables, enter the Min value, which is the minimum allowable value for the dimension, and the Max value, which is the maximum allowable value for the dimension. When specifying these values, they must not contradict other relations specified in the model.

![Fig. 3. Defining parameters for optimization](image)

- Under Constraints: select the criterion from the list:
  - Factor of Safety
  - Max Displacement
  - Max Stress
As a constraint was chosen the Max Stress and was set a 10 time less than the yield limit, meaning $2 \times 10^7 \text{ N/m}^2$.

- Under Goals: select from a list. As goals can be selected sensors as:
  - Mass Properties - properties such as Mass, Volume, Surface Area, and Center of Mass.
  - Dimension - monitors selected dimensions.
  - Simulation Data – can be selected simulation results such as stress, strain, and displacement.

As goal was selected the minimization of mass, as shown in figure 4. It can be seen that for chosen variables and the increasing steps, there are possible 210 active scenarios.

![Figure 4. Variables, constraint and goals for optimization study](image)

Since there are a large number of possible scenarios, the software warns about time consuming analysis and suggests changing option to Fast, and after a preliminary analysis can be done a more detailed study only for selected scenarios (figure 5).
3. RUNNING STUDY AND RESULTS

3.1 Run

After clicking Run there are performed a minimum number of iterations. The results appear in Results View (figure 6), and the model updates to reflect the optimal value.

Fig.5. Options for Design Study quality
As a design variable was defined:
- the diameter of the three holes, which is 25 mm, and Min value was set to 20 mm and the Max value was set to 30 mm, with a step of 2 mm.
- the upper width of the part, which is 15 mm, and Min value was set to 10 mm and the Max value was set to 18 mm, with a step of 2 mm.
- the high of milled part, which is 100 mm, and Min value was set to 80 mm and the Max value was set to 110 mm, with a step of 5 mm.

As a constraint was defined the VonMises stress and the value was set a 10 time less than the yield limit for material (plain carbon steel) meaning $2.10^7 \text{ N/m}^2$.

As specified before as goal (objective function) was selected the minimization of mass.

After specifying option Fast for design study where done only 15 steps from the initial possible 210 active scenarios.

3.2 Results

The maximum VonMises stress in the designed part is, at final proposed dimensions, according to analysis results, is $2.046.10^5 \text{ N/m}^2$.

After running the optimize step of the analysis, the results are as follows (figure 6):
- the diameter of the hole:
  - before: 25 mm
  - after: 30 mm
- the upper width of the part:
  - before: 15 mm
  - after: 10 mm
- the high of milled part:
  - before: 100 mm
  - after: 110 mm
-the maximum VonMises stress:
  - before: $2.046 \times 10^5$ N/m$^2$
  - after: $2.089 \times 10^5$ N/m$^2$
- the mass of designed part:
  - before: 2.734 kg
  - after: 1.939 kg

4. CONCLUSIONS

So at this stage of the design study can be achieved a mass reduction of approx. 29%. The analysis can be continued by adding another dimension of the model to the study, until it can be obtained a significant mass reduction, with respect to specified constraints.

The study can be extended by using several options. Some of these options are:
- Perform optimization analysis on an assembly (for optimization background and options can be checked [4]).
- Specify up to 20 dimensions as design variables.
- Specify up to 60 criteria for the model to satisfy.
- Maximize or minimize any quantity that can be defined as a sensor.

In conclusion, as presented in [5], by following the steps and the settings described in this paper, one can perform a Design Study that can lead to:
- reducing time to market by reducing the number of product development cycles;
- optimize the design;
- reducing costs by testing the model on the computer, rather than field tests.

By using the Design Study feature of SolidWorks one can save time and money, and create better products.

REFERENCES