ABOUT OPTIMIZATION VARIANTS IN SOLIDWORKS SIMULATIONEXPRESS VS. SIMULATION MODULE

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ABSTRACT:*In this paper are presented the steps to be taken in SolidWorks SimulationExpress module for performing an optimization study of a designed part. There are presented, by an example, the module features and the settings that have to be done for such analysis and the results shown after analysis.*

KEYWORDS: SolidWorks, SimulationExpress, optimization, design variables.

1. INTRODUCTION

As presented in [1], SolidWorks SimulationExpress Module "offers an easy-to-use first pass stress analysis tool for SolidWorks users. SimulationXpress can help you reduce cost and time-to-market by testing your designs on the computer instead of expensive and time-consuming field tests".

As described in [2], when is used a simulation tool, the best part design can be achieved only by CAD and simulation product development cycles, thus saving expensive and time-consuming tests. In a classical manufacturing cycle are taken following steps: modeling the item in SolidWorks CAD system, prototype the design model, test the prototype in the laboratory, evaluate the results of the field tests and if it's necessary, modify the design based on the field test results. This process can be done more than once until a good solution is reached. On the other hand, in a CIM-like environment, by using a Simulation module, cost can be reduced by testing the model using the computer, 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.

In [2] is also presented that two modules are available in SolidWorks: *SolidWorks SimulationXpress* that works on part documents (only solid bodies), included in the core software, and *SolidWorks Simulation* that works on parts and assemblies too, which is available as a separate product, including configuration support and expanded options.

For extended study, if it's available, it must be used *SolidWorks Simulation* which provides options like:

- Can perform optimization analysis on an assembly;
- Can specify up to 20 dimensions as design variables;
- Can specify up to 60 criteria for the model to satisfy;
- Can maximize or minimize any quantity that can be defined as a sensor.

To use *SimulationExpres*s module, one must to model a part and than click SimulationExpress icon (Tools toolbar or Evaluate Command Manager tab), as seen in figure 1, or text menu Tools >SimulationExpress.

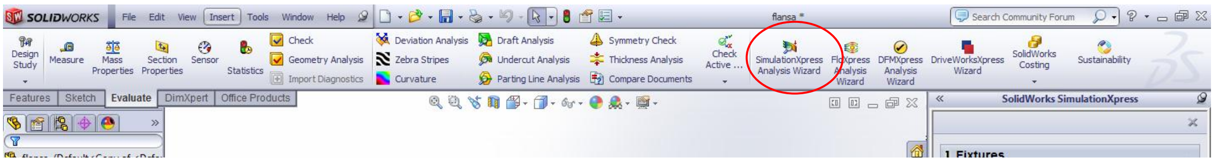


Figure 1. *Evaluate* tab - *SimulationExpress* icon

The interface of *SimulationXpress*, that appears on right side, guide user through a step-by-step process to specify fixtures, loads, material, run the simulation, view the results, and as a last step, perform optimization.

2. SIMULATIONEXPRESS STEPS

After launching *SimulationExpres*s module, with a part open, the SimulationExpress Task Pane from the right side of working board, let one begin the step-by-step process of analysis. The part subject to this study is a support plate.

2.1. Fixtures and Loads

First it's applied fixtures to faces or edges of the part, as environment connection, as shown in figure 2.

The loads of designed part can be applied forces, pressures, or both to faces or edges of the part, figure 2.

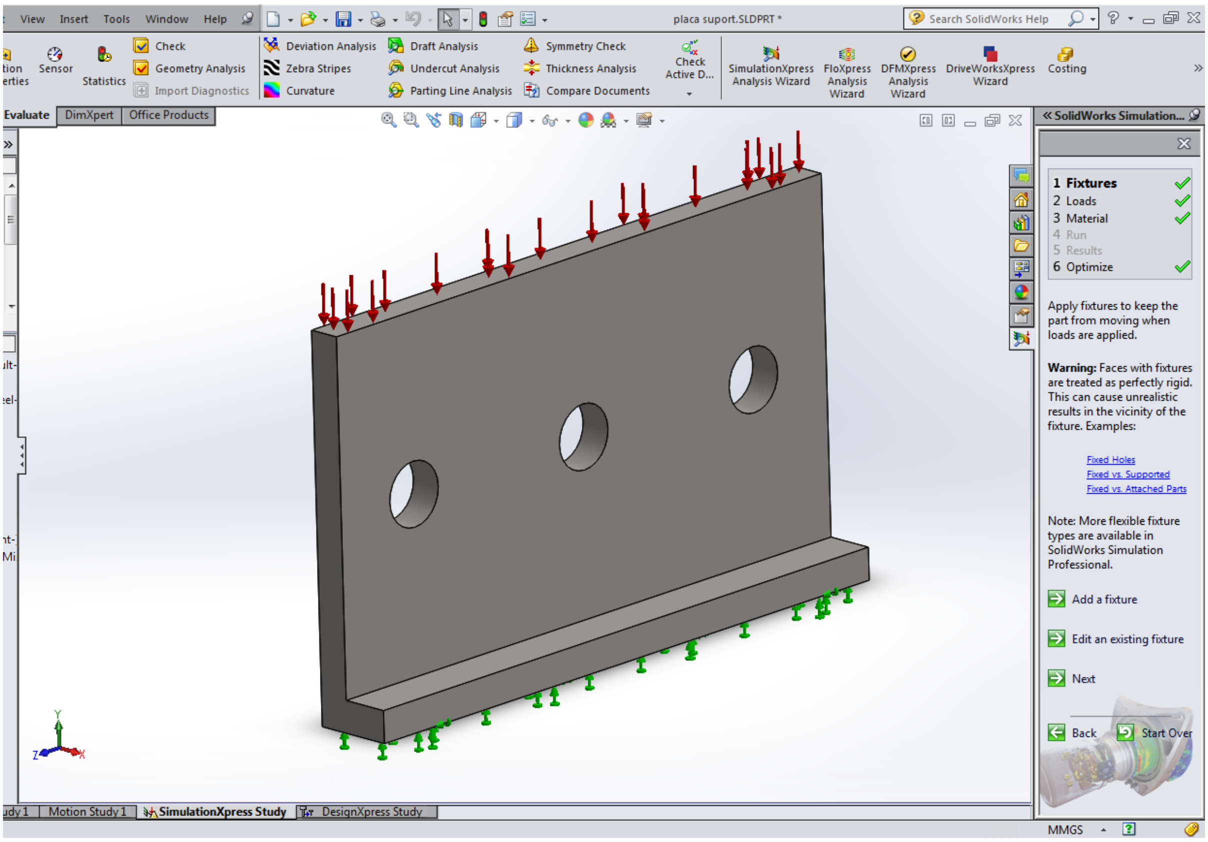


Figure 2. Fixtures applied to part and pressure to a face of the part

2.2. Material

At this stage it is assigned material properties to the part, by choosing one material from library or by defining/modifying individual properties. The material is Plain Carbon Steel, the logical choice for such an item, like a support plate.

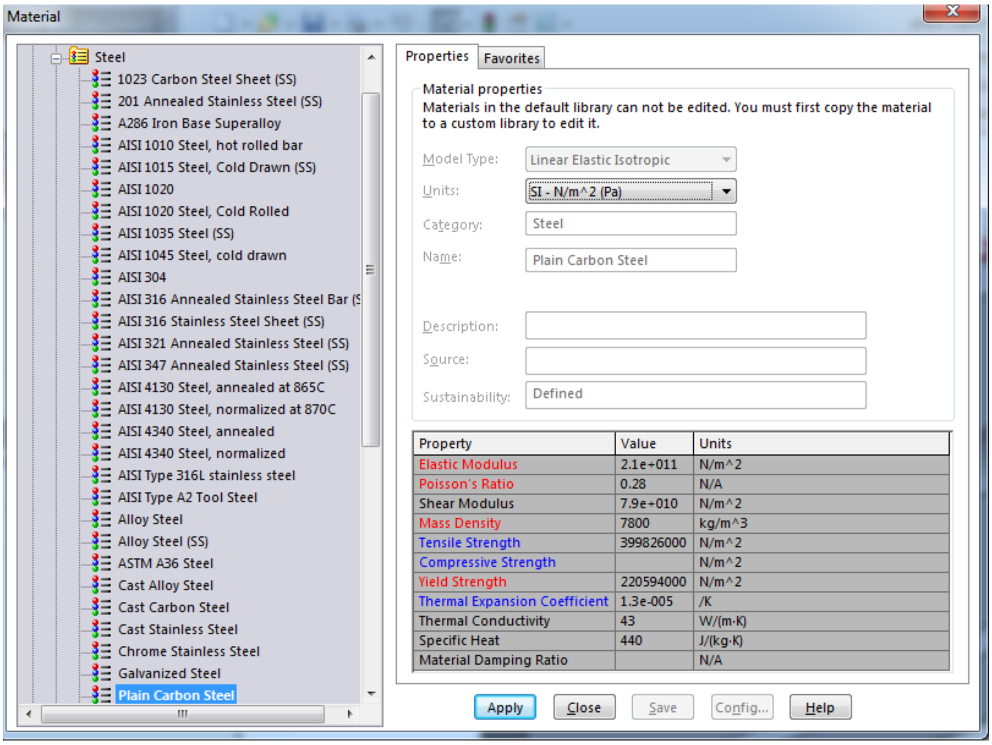


Figure 3. Assigning material for the part

2.3. Run analysis

At this stage it's done a static analysis by FEM of studied part, with default settings for the type of finite element and mesh density. For these elements can be used the default settings or changed settings, as described in [4]. These settings will be used for the simulation and analysis.

2.4. Results

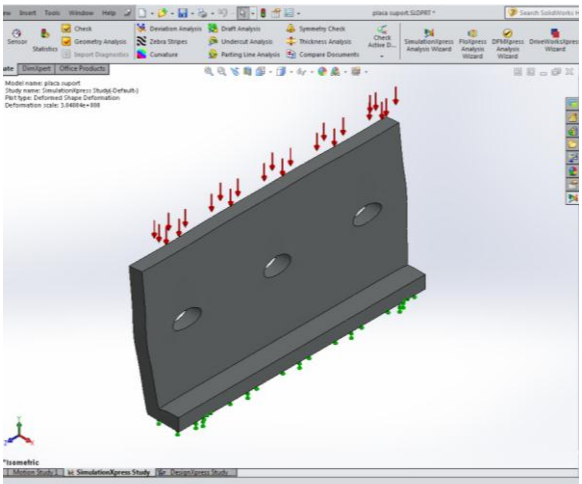
After the running analysis various simulation results it can be displayed:

- part animation, as it stretches under the load; At this moment, if the model doesn't deform as expected, the analysis can be start over with the first step of simulation, applying various modification.

Other simulation results that can be displayed and verified are:

- deformed shape of the model (figure 4);
- VonMises stress distribution in the model, with or without annotation for the maximum and minimum stress values (figure 5);
- resultant displacement distribution in the model, with or without annotation for the maximum and minimum displacement values (figure 6);
- critical areas where the safety factor is less than a specified value (figure 7).

If any of the results are not in the range expected, the analysis may be start over with the first step of simulation, applying modification on geometry, material, and so on.



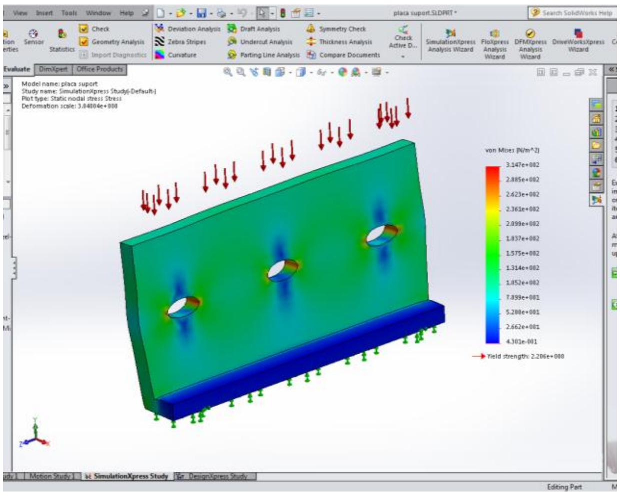
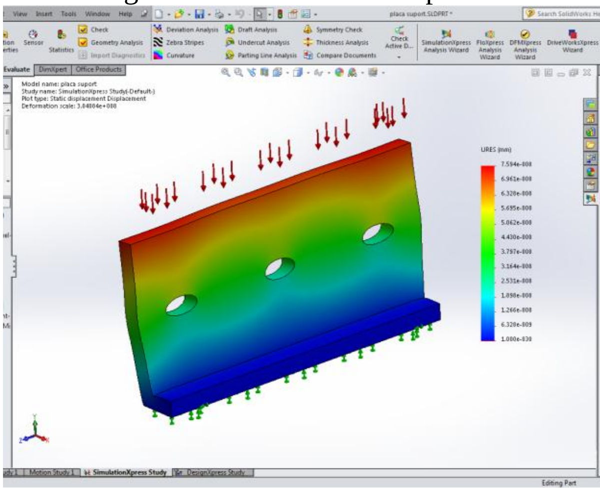


Figure 4. Part deformed shape

Figure 5. VonMises stress distribution



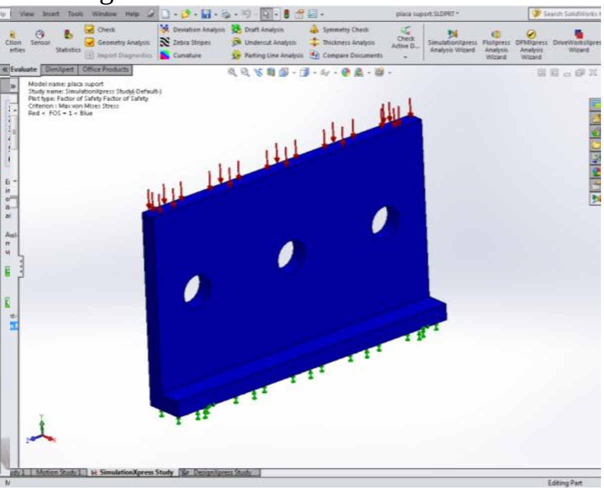


Figure 6. Displacement distribution

Figure 7. Safety factor distribution

3. OPTIMIZATION OF PART

Next will be performed an optimization of modeled part, based on a specified *criterion* and *constraint*. The software module is performing a *dimensional optimization* not a shape one, using as objective function *minimization of mass* [4], [5].

So after completing a stress analysis, the *optimization analysis* is used to find the optimal value for *model dimensions*, while satisfying a specified criterion. For example, it can be find the optimal holes diameter such that the stresses do not exceed a specified value.

To perform optimization analysis must click *Optimize* in the SimulationXpress wizard.

The *DesignXpress* study appears below the graphics area. DesignXpress is an introductory version of the optimization tools available in SolidWorks Simulation, meaning one can analyze just one variable at the time.

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 8. In the *DesignXpress study*, under *Variables*, enter the Min value, and the Max value, which is the minimum/maximum allowable value for the dimension. These values must not contradict other relations specified in the model. Under *Constraints* select the criterion from the list: Factor of Safety, Max

Displacement, and Max Stress. It can be specified the minimum value for Factor of Safety or the maximum value for Max Displacement or Max Stress.

The results appear in Results View (figure 9) after a necessary number of iterations, and the model updates to reflect the optimal value.

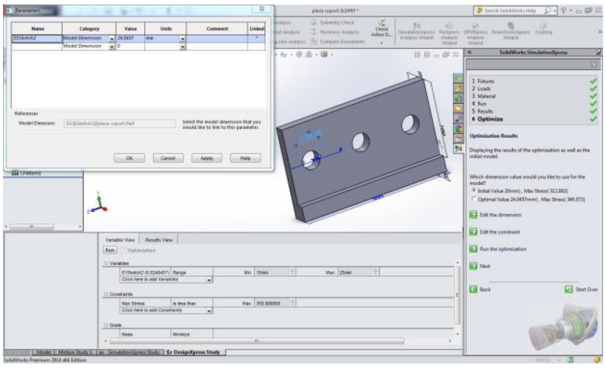


Figure 8. Defining optimization variable

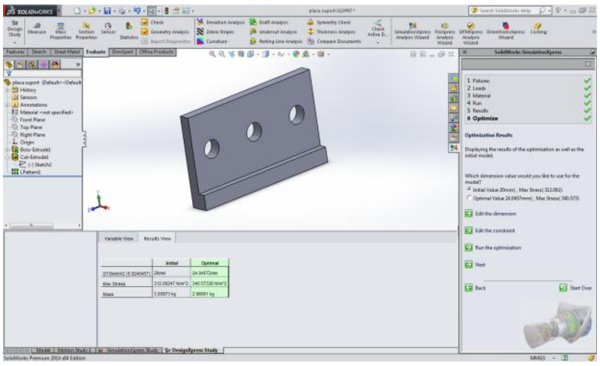


Figure 9. Results of optimization (SimulationXpress)

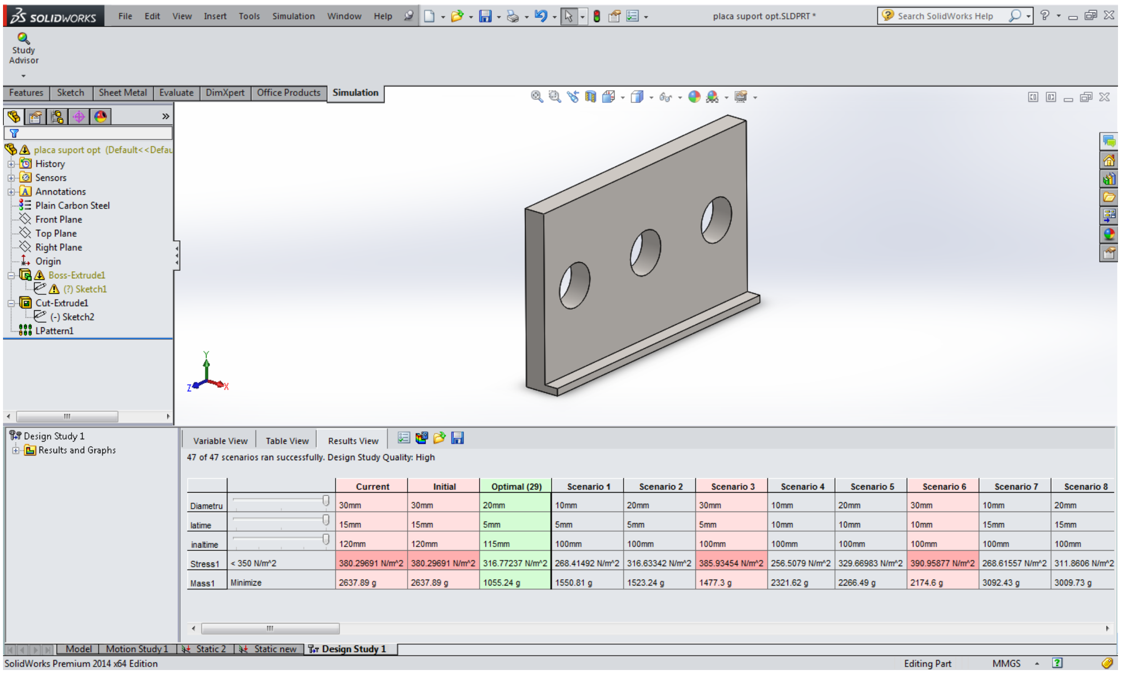


Figure 10. Results view of optimization (*Simulation* module)

4. RESULTS AND CONCLUSIONS

In *DesignXpress study*, as *design variable* was defined the diameter of the holes, which is 20 mm, and Min value was set to 15 mm and the Max value was set to 25 mm.

As a constraint was defined the VonMises stress and the value was set to 350 N/m^2, since the allowed value for material (plain carbon steel) is 370 N/m^2.

The maximum VonMises stress in the designed part is, at these dimensions, according to analysis results is 314.7 N/m^2.

The objective function is *minimization of mass* for the designed part.

After running the optimize step of the analysis, the results are as follows (figure 9):

- The diameter of the hole:

- before 20 mm and after 25 mm

- The maximum VonMises stress:

- before 314.7 N/m^2 and after 343 N/m^2

- The mass of designed part:

- before 2.03 kg and after 1.99 kg

So at this stage can be achieved a mass reduction of approx. 2%. The analysis can be continued for another dimension of the model, until we obtain a significant mass reduction.

Next, by using *Simulation* module can be defined as much as 20 dimensions as design variables. Were defined 3 design variables:

- the hole diameter -20 mm, Min value 15 mm and Max value 25 mm;
- the support width -10 mm, Min value 5 mm and Max value 15 mm;
- the support height – 110 mm, Min value 100 mm and Max value 120 mm.

After running the optimization, the program cycles through 47 possible scenarios, and offers as optimal result the scenario no. 29 (figure 10) for which:

- the hole diameter -20 mm;
- the support width - 5 mm;
- the support height - 115 mm.

- The maximum VonMises stress:

- before 314.7 N/m^2 and after 316.7 N/m^2

- The mass of designed part:

- before 2.03 kg and after 1.05 kg

So, by using optimization feature of *Simulation* module can be achieved a mass reduction of approx. 48%, what means a significant reduction.

As a conclusion, by following the steps and the settings described in this paper, as stated in [6], it can be performed a study using either *SimulationExpress* or *Simulation* module, which makes possible to reduce Time-To-Market by reducing the number of product development cycles. In the same time can be optimized the design and thus reducing cost by testing the model on the computer, rather than laboratory expensive tests.

This approach to design is useful in terms of time and money saving, pointing also to better sustainability of designed products.

REFERENCES

[1]. *SolidWorks user help*, Dassault Systèmes SolidWorks Corporation, Waltham, MA, USA, 2014.

[2]. **Iancu C**., *About SimulationExpress module features*, Fiability & Durability Revue, ISSN 1844-640X, pp.185-190, no.1/2015

[3]. **Iancu C**., *About optimization feature on Solidworks SimulationExpress module*, Fiability & Durability Revue, ISSN 1844-640X, pp.78-84, nr.2 / 2016

[4]. **Iancu, C**., *Contributions to dimensional optimization of mechanical press in dynamic regime*, Ph.D. Thesis, University of Pitesti, Romania, 2002.

[5]. **Iancu, C**., *Dimensional optimization of mechanical press*, Ed. MJM, Craiova, Romania, 2002.

[6]. **Lombard, M**., *Solid Works Bible*, Wiley, USA, 2013