

**APPLICATION OF COMPUTER SIMULATION
FOR STRENGTH CALCULATIONS**

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Abstract: the use of the SolidWorks application - SolidWorks Simulation for calculations of the static strength of the internal rear lever of the automotive diagnostics stand is considered - the possibility of replacing steel X40Cr14 for its manufacture with steel 45. The results of calculations of stresses, displacements, deformation and margin of strength depending on static loads are given.

Keywords: SolidWorks Simulation, diagnostic stand, lever, material replacement.

For more effective assimilation of the material of specific disciplines, modern computer modeling and analysis tools are increasingly being used in higher educational institutions [1-3]. One of the directions on this path can be three-dimensional geometric modeling to solve the problems of determining the strength characteristics of various parts.

To accomplish the task, the authors [4-9] used a modern system of automated design (CAD – SolidWorks) and engineering analysis (CAE – SolidWorks Simulation), which has a simple interface and the ability to:

- determine the distance between the characteristic points of the object, its area, volume and mass;
- change the dimensions and shapes of the projected geometric body;
- create three-dimensional (3D) parametric solid models, etc.

SolidWorks is based on a parametric object-oriented methodology, which allows you to get a 3D model from a 2D sketch using simple and effective tools. With

the help of SolidWorks, they support the life cycle of the product according to the concept of CALS technology, including two-way data exchange with other Windows applications and creation of interactive documentation.

SolidWorks Simulation is an application to SolidWorks designed for solving problems of the mechanics of a deformed solid body by the method of numerical simulation. The program uses the geometric model of the part or assembly in SolidWorks to generate the calculation model. Integration with SolidWorks minimizes operations associated with specific features of finite-element approximation.

After creating a geometric model in SolidWorks, the parts from its library select the material from which it is made. To conduct a static analysis, the SolidWorks Simulation software module is applied to its solid-state model: the place of attachment of the part is selected and external loads are applied to it.

Then the part model is divided into elements connected at nodes: the finite element analysis program considers the model as a mesh.

Thus, the authors [10] used this technology to design a two-post lifter with an electro-hydraulic drive and performed calculations of its most heavily loaded part - the bracket to which levers with legs are attached. The maximum weight of the car is set, which will not lead to safety violations.

The authors of [11] checked the operability of the following part of the lifter - the internal rear lever, made of high-quality alloyed martensitic steel X40Cr14. The analysis of the simulation results established that the minimum margin of safety of the lever is $n = 3,954$, which is more than the permissible $[n] = 2,5$ [12]. Therefore, the purpose of this work was to determine the possibility of replacing this material with another, more accessible in repair shops and cheaper – structural carbon steel 45 (fig. 1).

Имя:	1.2083 (X40Cr14)	Имя:	Сталь 45 ГОСТ 535-88
Тип модели:	Линейный Упругий Изотропный	Тип модели:	Линейный Упругий Изотропный
Критерий прочности по умолчанию:	Максимальное напряжение von Mises	Критерий прочности по умолчанию:	Максимальное напряжение von Mises
Предел текучести:	1,2e+09 N/m ²	Предел текучести:	8,3e+08 N/m ²
Предел прочности при растяжении:	1,5e+09 N/m ²	Предел прочности при растяжении:	9,8e+08 N/m ²
Модуль упругости:	2,1e+11 N/m ²	Модуль упругости:	2,04e+11 N/m ²
Коэффициент Пуассона:	0,28	Коэффициент Пуассона:	0,3
Массовая плотность:	7 740 kg/m ³	Массовая плотность:	7 826 kg/m ³
Модуль сдвига:	7,9e+10 N/m ²	Модуль сдвига:	7,8e+10 N/m ²
Коэффициент теплового расширения:	1,1e-05 /Kelvin	Коэффициент теплового расширения:	1,19e-05 /Kelvin

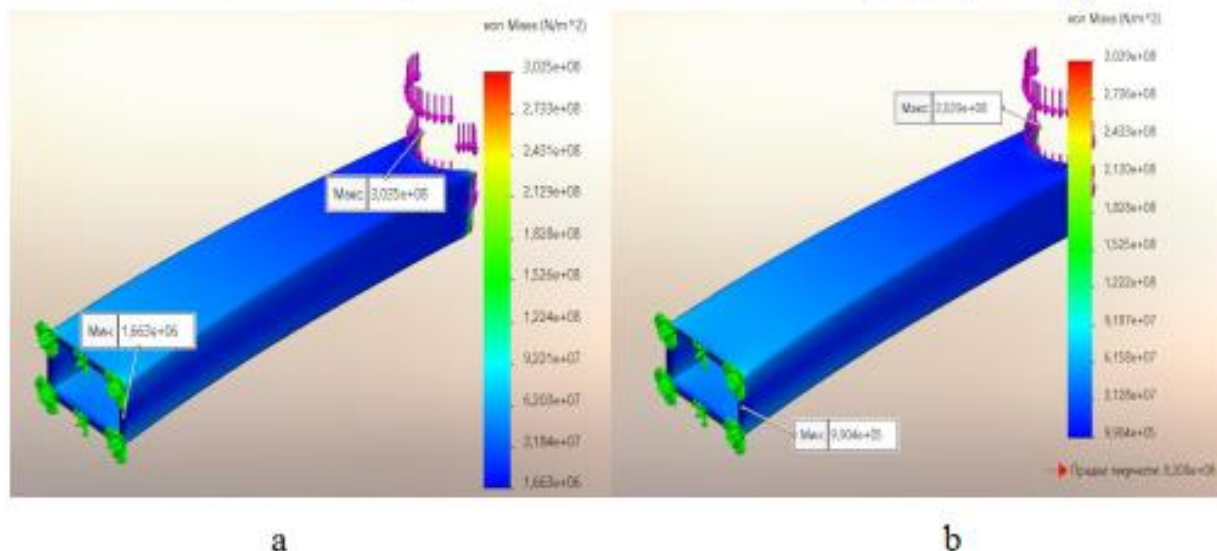
a

b

Fig. 1. Properties of steels X40Cr14 (a) i 45 (b)

By repeated calculations in SolidWorks Simulation:

- constructed a stiffness matrix;
- carried out the synthesis of the finite-element model, taking into account the conditions of its fixation at nodal points;
- solved the resulting system of algebraic equations;
- determined the components of the stress-strain state (fig. 2, table 1).



a

b

Рис. 2. Епюри сумарних напружень von Mises важеля, виготовленого зі сталі X40Cr14 (a) і сталі 45 (б)

Table 1**The results of the study of the shaft**

Steel	Tension (maximum), σ, MPa (node 161)	Moving (maximum), h, mm (node 35)	Deformation (maximum), δ, mm (element 2834)	Margin of safety (minimum), n (node 161)
X40Cr14	303,5	1,576	0,0005484	3,954
45	303,9	1,623	0,0005738	2,731

Since the minimum margin of safety factor for a lever made of steel 45 is $n = 2.731$, in the case of replacing steel X40Cr14 with steel 45 for its manufacture, the margin of safety is sufficient.

Thus, with the help of the SolidWorks CAD system and its application – the SolidWorks Simulation CAE system, the operability of another part of the investigated two-post lifter with an electro-hydraulic drive – the lever – was proven.

In the process of solving this problem, the following advantages of using computer modeling for strength calculations were revealed:

- visibility;
- the ability to evaluate the benefits of calculations using SolidWorks Simulation;
- ease of execution of analytical constructions;
- the convenience of comparing the results of solving problems obtained by CAD-CAE methods and the resistance of materials (machine parts).

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