

**COMPUTER SIMULATION OF THE STRESSED AND DEFORMED STATE OF MOTOR  
VEHICLE PARTS**

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*Mathematical and computer modeling of complex processes has advantages over other traditional calculation methods. Therefore, in this study, the SolidWorks program and its SolidWorks Simulation application were used to replace the material of the primary shaft of the gearbox of the GAZ-24 car (alloy steel) with structural steel (after chemical and thermal treatment), which is cheaper and more accessible in repair shops.*

In order to increase efficiency, prevent breakdowns, extend the service life and properly analyze the operation of structures under deformations of any magnitude with very high accuracy, it is suggested to use mathematical modeling of individual units and parts of motor vehicles in the SolidWorks program and its SolidWorks Simulation application [1-5].

The method of numerical modeling of car parts has the following advantages over other traditional methods [6]:

- allows to model and study the phenomena predicted by any theories;
- is environmentally friendly and does not pose a danger to nature and humans;
- makes it possible to simulate effects, the study of which in real conditions is impossible or very difficult for technological reasons;
- provides clarity and is accessible to use.

As an example [6], the primary shaft of the gearbox of the GAZ-24 car, the material of which is steel 12X18H10T, was studied using SolidWorks Simulation. An analogue of this material was selected from the SolidWorks library - steel DIN 1.4541. As a result of the calculations, it was established that the minimum safety factor of FOS is  $n = 2.1957$ , which is more than the permissible  $[n] = 1.5$ . Therefore, the aim of the work was to study the possibility of replacing this material [7] with a cheaper and more accessible one in repair shops – steel 15 after chemical-thermal treatment (cementation, an analogue of this material – steel 1.0401 – fig. 1).

Имя:	1.4541 (X6CrNiTi18-10)	Имя:	1.0401 (C15)
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:	4e+08 N/m <sup>2</sup>	Предел текучести:	3,8e+08 N/m <sup>2</sup>
Предел прочности при растяжении:	6e+08 N/m <sup>2</sup>	Предел прочности при растяжении:	5e+08 N/m <sup>2</sup>
Модуль упругости:	2e+11 N/m <sup>2</sup>	Модуль упругости:	2,1e+11 N/m <sup>2</sup>
Коэффициент Пуассона:	0,28	Коэффициент Пуассона:	0,28
Массовая плотность:	7 900 kg/m <sup>3</sup>	Массовая плотность:	7 850 kg/m <sup>3</sup>
Модуль сдвига:	7,9e+10 N/m <sup>2</sup>	Модуль сдвига:	7,9e+10 N/m <sup>2</sup>

Figure 1 – Properties of steels 12X18H10T (a) and 15 (b)

After repeated calculations in SolidWorks Simulation (separation of the primary shaft model into finite elements, construction of the stiffness matrix; synthesis of the finite-element model taking into account the conditions of its fixation at nodal points; solving the resulting system of algebraic equations), the components of the stress-strain state are determined (fig. 2).

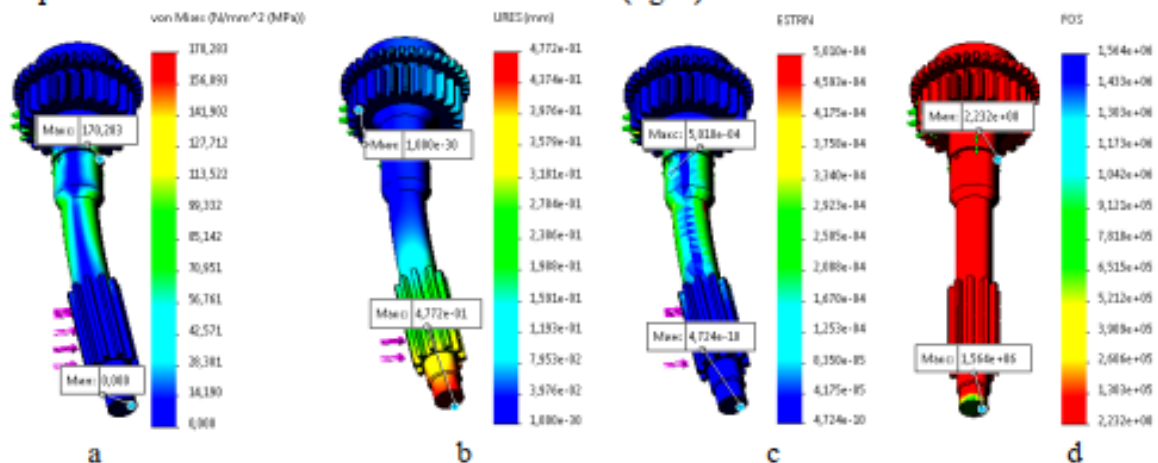


Figure 2 – Plots of total von Mises stresses (a), displacements URES (b), equivalent strains ESTRN (c), margin of safety FOS (d) of the primary shaft

Since the minimum margin of safety factor for the primary shaft made of steel 15 is  $n = 2.232$ , which is more than permissible, the margin of safety is sufficient.

## REFERENCES

1. Rudyk O. Application of SolidWorks for the training of highly qualified specialists [Електронний ресурс] / O. Rudyk, P. Kaplun, V. Gonchar. – URL: <https://jml.nau.edu.ua/index.php/APSE/issue/view/879>
2. Rudyk O. Yu. Using SolidWorks in modern education and science [Electronic resource] / O. Yu. Rudyk, I. I. Baranov, M. M. Gereta, V. O. Dytynyuk, S. I. Fedoryshyn. – URL: <https://elar.khmnu.edu.ua/handle/123456789/14676>
3. Rudyk O. Yu. Application of SolidWorks in the educational process [Electronic resource] / O. Yu. Rudyk, N. S. Mariin, S. I. Yaroshchuk. – URL: <http://acup.poltava.ua/wp-content/uploads/2020/02/36ірник-2020-0203.pdf>

4. Rudyk O. Yu. The use of computers in scientific research [Electronic resource] / O. Yu. Rudyk, Yu. Yu. Vasyura. – URL: <http://elar.khnu.km.ua/jspui/handle/123456789/8773>
5. Rudyk O. Yu. SolidWorks – CAD/CAE system of technical universities [Electronic resource] / O. Yu. Rudyk, P. V. Kaplun. – URL: <http://sci-conf.com.ua/ii-mezhdunarodnaya-nauchno-prakticheskaya-konferenciya-science-society-education-topical-issues-and-development-prospects-20-21-yanvarya-2020-goda-harkov-ukraina-arhiv/>
6. Rudyk O. Yu. Teaching technical disciplines in military educational institutions using CAE/CAD systems [Electronic resource] / O. Yu. Rudyk, I V. Yankovsky. – URL: [http://acup.poltava.ua/?page\\_id=1173](http://acup.poltava.ua/?page_id=1173)
7. Rudyk O. Yu. Study of the possibility of replacing the material of a car part using SolidWorks Simulation [Electronic resource] / O. Yu. Rudyk, A. A. Tarashevskiy. – URL: <http://acup.poltava.ua/wp-content/uploads/2020/02/36ірник-2020-0203.pdf>