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SOLIDWORKS AS A TRAINING TOOL FOR TRAINING HIGHLY QUALIFIED SPECIALISTS

Annotation. *SOLIDWORKS is one of the world leaders in innovative technologies. The use of this software product contributes to improving the level of professional training of future specialists. In the work, using SOLIDWORKS Simulation, the performance of the rear axle gearbox shaft-gear was determined.*

Key words: *SOLIDWORKS Simulation, shaft-gear, static analysis.*

Анотація. *SOLIDWORKS – один із світових лідерів інноваційних технологій. Застосування цього програмного продукту сприяє підвищенню рівня професійної підготовки майбутніх фахівців. У роботі за допомогою SOLIDWORKS Simulation визначили працездатність вал-шестерні редуктора заднього моста.*

Ключові слова: *SOLIDWORKS Simulation, вал-шестерня, статичний аналіз.*

Introduction. In today's rapidly developing innovative technologies and digitalization of production, it is difficult to imagine effective engineering activities without the use of specialized design software. One of the undisputed world leaders in this field is SOLIDWORKS, which is an important tool in the training of highly qualified engineering personnel. This software environment provides extensive capabilities of solid-state parametric modeling, and also supports complex processes of automated design, analysis and production preparation (CAD/CAE/CAM).

Using SOLIDWORKS in the educational process gives students access to modern engineering approaches, allows them to create three-dimensional models of parts, assembly units and a full set of working design documentation. In the process of work, a systematic understanding of the principles of design is formed, practical skills in working with digital tools and the ability to perform engineering analysis are developed. In addition, the use of this software product contributes to increasing the level of professional training of future specialists, as they master current standards and methods that are widely used in modern industry.

Thus, the integration of SOLIDWORKS into the educational process significantly improves the quality of engineering education and the level of training of specialists. The main advantages of using SOLIDWORKS in education are as follows:

- formation of practical skills (students learn to work independently in the system, create sketches and complex 3D parts);
- innovative approach (the program allows you to integrate theoretical knowledge of engineering graphics with practical modeling, especially in the automotive industry);
- engineering training: (SOLIDWORKS simplifies the design process by converting 3D assemblies into technical drawings, which is critical for highly skilled professionals);

- parametric modeling (learning is based on changing parameters, which allows you to quickly adapt designs).
- using SOLIDWORKS provides a deep understanding of engineering processes and prepares students to work in a modern industrial environment.

Analysis of the latest research. The introduction of modern information and communication technologies into the educational process allows us to move from traditional methods of teaching design to modeling using CAD systems with the subsequent use of CAD/CAE automated complexes [1], one of which is a 3D hybrid automated design, engineering analysis and production preparation system for products of any complexity and purpose SOLIDWORKS [2 - 4]. It is the core of an integrated enterprise automation complex, which supports the product life cycle in accordance with the CALS technology concept, including bidirectional data exchange with other Windows applications and the creation of interactive documentation. The application of this program - SOLIDWORKS Simulation uses the geometric model of the SolidWorks part to form a calculation model [5 - 9].

The aim of the article. The purpose of the study is to use SOLIDWORKS Simulation to determine the performance of the shaft-gear of the rear axle reducer of the IFA W50 vehicle.

Research Methodology. The static analysis methodology in Simulation is based on the finite element method (FEM) and involves seven main steps: creating a 3D model, assigning material, defining restraints (boundary conditions), applying loads, building a mesh, running the calculation, and analyzing the results (stresses, displacements, safety factor).

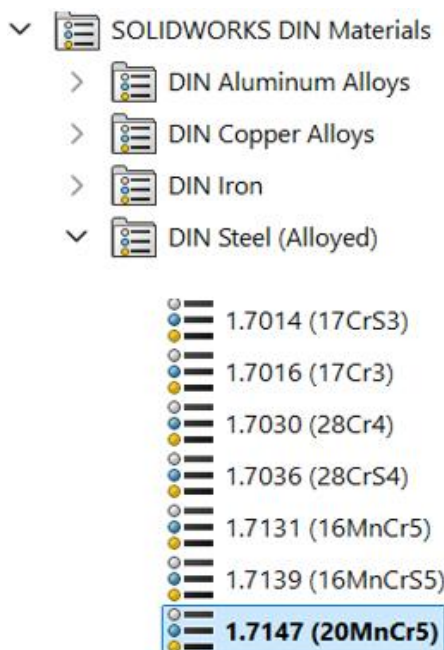
The main stages of static analysis:

- creation of a geometric model (development of a part in the SOLIDWORKS environment or import of a ready-made model);
- launch Simulation and select the type of study (open the Simulation module, create a new study and select static analysis – Static);

- assignment of the material (selection of a material from the SOLIDWORKS library that provides the program with the necessary mechanical characteristics – Young's modulus, Poisson's ratio, yield strength);
- defining Fixtures: (setting boundary conditions that limit the movement of the model – fixing faces, edges or vertices);
- applying Loads (indicating forces, pressures, moments or gravity acting on the part);
- creating a Meshing grid (dividing the part into finite elements – a mesh – for numerical calculation; the smaller the mesh, the higher the accuracy, but the longer the calculation time);
- launch the calculation and analyze the results (launch the calculations and view the plots – von Mises stresses, displacements, deformations; check whether the stresses do not exceed the yield strength to ensure strength).

This approach allows you to check the performance of the part before its physical manufacture, reducing prototyping costs.

Research results. After creating a geometric model of the shaft-gear in Simulation, static analysis was selected as the type of study of its stress-strain state. Then, from the SOLIDWORKS library, DIN 1,6523 steel was selected, which corresponds to the gear shaft material (20XGR) (Fig. 1).



✓ SOLIDWORKS DIN Materials

- > DIN Aluminum Alloys
- > DIN Copper Alloys
- > DIN Iron
- ✓ DIN Steel (Alloyed)
 - 1.7014 (17CrS3)
 - 1.7016 (17Cr3)
 - 1.7030 (28Cr4)
 - 1.7036 (28CrS4)
 - 1.7131 (16MnCr5)
 - 1.7139 (16MnCrS5)
 - 1.7147 (20MnCr5)**

Properties	
Name:	1.7147 (20MnCr5)
Model type:	Linear Elastic Isotropic
Default failure criterion:	Max von Mises Stress
Yield strength:	108 778 psi
Tensile strength:	159 661 psi
Elastic modulus:	3,04579e+07 psi
Poisson's ratio:	0,28
Mass density:	0,281793 lb/in ³
Shear modulus:	1,1458e+07 psi
Thermal expansion coefficient:	6,11111e-06 /Fahrenheit

Fig. 1. Selection of shaft-gear material

To perform static analysis, a shaft-gear was defined and a load was applied to it (Fig. 2).

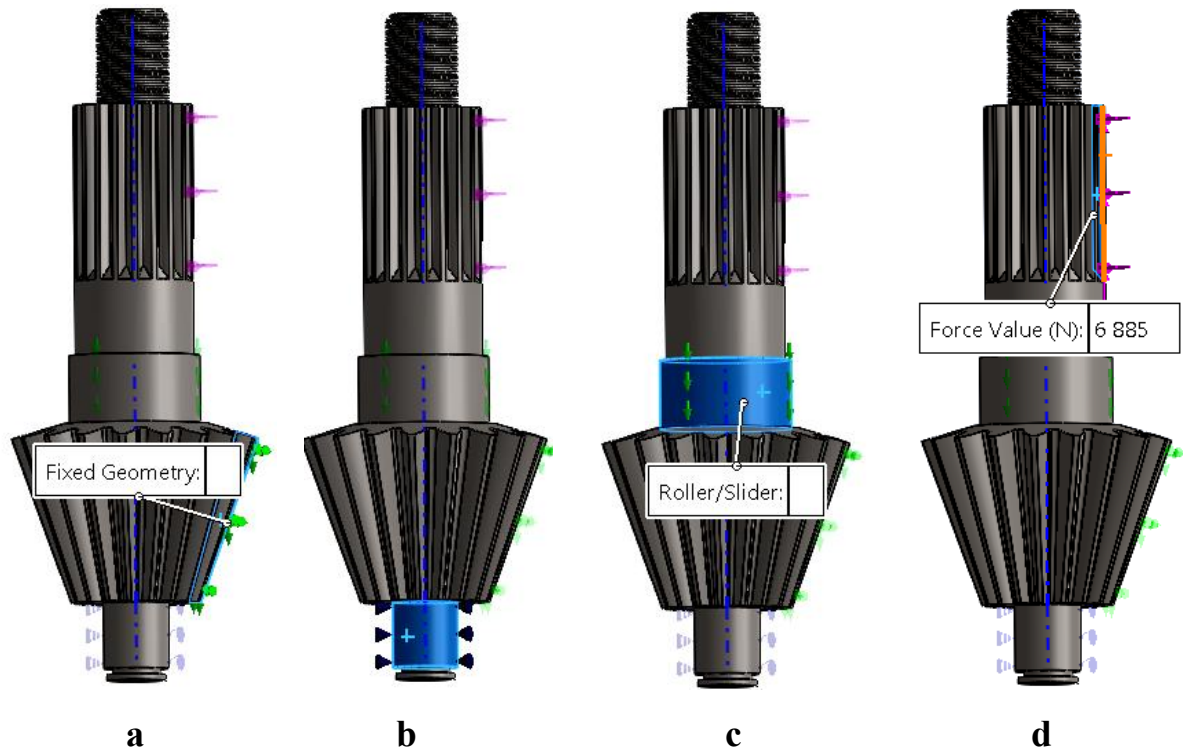


Fig. 2. Definition of the shaft-gear supports (a – bevel gear tooth, b – bearing support, c – Roller/Slider) and application of load to it (d)

A stiffness matrix was constructed and a finite element model was synthesized from its individual elements (the conditions for fixing the shaft-gear at the nodal points were taken into account) (Fig. 3).

DetailsMesh type	Solid Mesh
Mesher Used	Standard mesh
Automatic Transition	Off
Include Mesh Auto Loops	Off
Jacobian points for High quality mesh	4 points
Element size	6,80668 mm
Tolerance	0,340334 mm
Mesh quality	High
Total nodes	33539
Total elements	20719
Maximum Aspect Ratio	1 299
Percentage of elements with Aspect Ratio < 3	72,6
Percentage of elements with Aspect Ratio > 10	0,56
Percentage of distorted elements	0
Number of distorted elements	0
Time to complete mesh(hh:mm:ss)	00:00:07

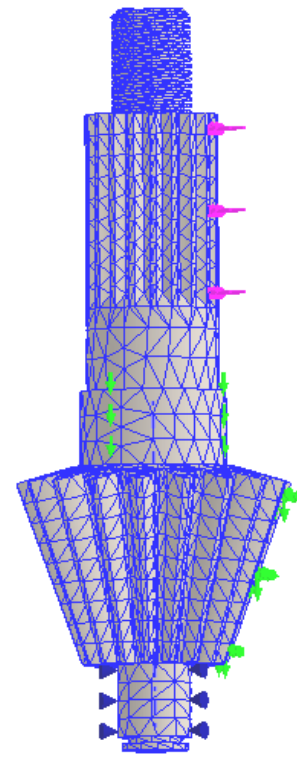


Fig. 3. Mesh parameters (a) and its mapping onto the shaft-gear solid (b)

In Simulation, the resulting system of algebraic equations was solved and the components of the stress-strain state of the shaft-gear were determined (Fig. 4).

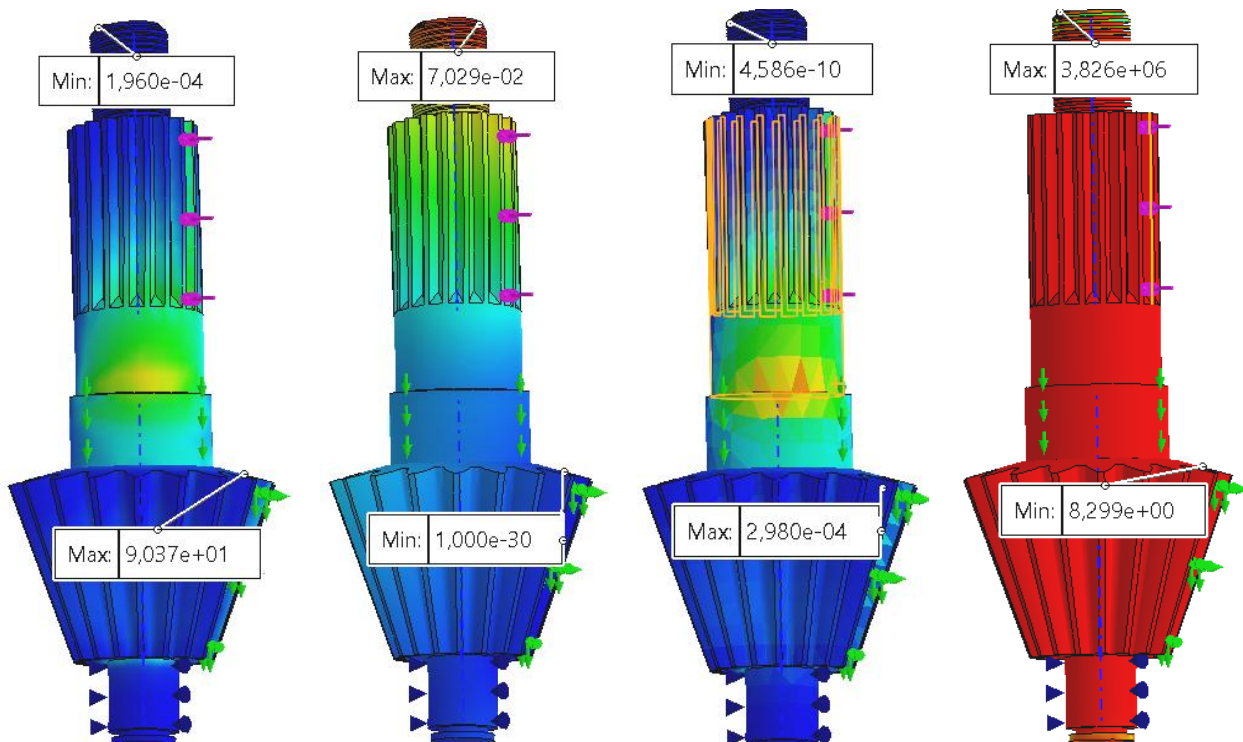


Fig. 4. Calculation results of total von Mises stresses (a), displacements URES (b), deformations ESTRN (c) and margin of safety FOS (d) of the shaft gear

Calculation results: for the shaft-gear, the maximum nodal von Mises stresses, the resulting displacement URES, and the deformation ESTRN do not exceed the permissible ones. At the same time, the minimum safety factor FOS $n = 8,299$, which is greater than the permissible $[n] = 1,5$.

Conclusions. The implementation of the SOLIDWORKS CAD/CAE system and its SOLIDWORKS Simulation application for training highly qualified specialists will contribute to both the development of their creative orientation and a more complete and high-quality mastery of the system of knowledge and skills by students.

References

1. Rudyk O. Yu., Kaplun P. V. SolidWorks – CAD/CAE system of technical universities. *SCIENCE, SOCIETY, EDUCATION: TOPICAL ISSUES AND DEVELOPMENT PROSPECTS: Abstracts of the 2nd International Scientific and Practical Conference*. SPC «Sci-conf.com.ua». Kharkiv, Ukraine, 2020. P. 249-253. URL: <http://sci-conf.com.ua/ii-mezhdunarodnaya-nauchno-prakticheskaya-konferenciya-science-society-education-topical-issues-and-development-prospects-20-21-yanvary-2020-goda-harkov-ukraina-arhiv/> (last accessed: 2026/01/12).
2. Rudyk O. Yu. Application of SolidWorks in the educational process *Proceedings of the IV All-Ukrainian Scientific and Practical Internet Conference «RESOURCE-ORIENTED LEARNING IN «3D»: ACCESSIBILITY, DIALOGUE, DYNAMICS*. Poltava : KUEP PDAA, 2020. P. 96-100. URL: <http://acup.poltava.ua/wp-content/uploads/2020/02/Збірник-2020-0203.pdf> (last accessed: 2026/01/12).
3. Rudyk , O., Kaplun , P., & Gonchar , V. Application of SolidWorks for the training of highly qualified specialists *Actual Problems in the System of Education: General Secondary Education Institution – Pre-University Training – Higher Education Institution*. 2022. № 2. P. 699 - 706. <https://doi.org/10.18372/2786-5487.1.16657>. URL: <https://jrnل.nau.edu.ua/index.php/APSE/issue/view/879> (last accessed: 2026/01/12).

4. Rudyk, O., Barnych, M., Humeniuk, O., & Shchur, V. SolidWorks as an innovative means of researching automotive engineering. *Actual Problems in the System of Education: General Secondary Education Institution – Pre-University Training – Higher Education Institution*. 2023. № 3. P. 130–141. <https://doi.org/10.18372/2786-5487.1.17688>. URL: <https://jrnل.nau.edu.ua/index.php/APSE/article/view/17688/24992> (last accessed: 2026/01/12).

5. Rudyk O. Yu. The impact of the SolidWorks Simulation network quality on the accuracy of the calculations / O. Yu. Rudyk, V. A. Gonchar. *Eurasian scientific congress: Abstracts of the 1st International scientific and practical conference*. Barca Academy Publishing. Barcelona, Spain, 2020. P. 185-188. URL: <http://sci-conf.com.ua/i-mezhdunarodnaya-nauchno-prakticheskaya-konferenciya-eurasian-scientific-congress-27-28-yanvary-2020-goda-barselona-ispaniya-arhiv/> (last accessed: 2026/01/12).

6. Rudyk O. Yu. Computer simulation of the electrohydraulic lift with the help SolidWorks Simulation / O. Yu. Rudyk, O. V. Shepilo. *The world of science and innovation. Proceedings of the 10th International scientific and practical conference*. Cognum Publishing House. London, United Kingdom. 2021. P. 160-167. URL: <https://sci-conf.com.ua/x-mezhdunarodnaya-nauchno-prakticheskaya-konferentsiya-the-world-of-science-and-innovation-5-7-maya-2021-goda-london-velikobritaniya-arhiv/> (last accessed: 2026/01/12).

7. Rudyk O. Yu. Studies of the performance of automobile parts using SolidWorks Simulation/ O. Yu. Rudyk, S. V. Psyol, V. V. Rechytskyi . *Modern trends in the development of engineering, technologies and transport: collection of abstracts of reports of the International Scientific and Practical Conference of Higher Education Applicants and Young Scientists*, October 18-19, 2022. Khmelnytskyi : KhNU, 2022. P. 316 - 320. URL: https://pk.khmnu.edu.ua/wp-content/uploads/zbirnyk_piitt_2025_25.04.25_2.pdf (last accessed: 2026/01/12).

8. Rudyk O. Yu. Use of information technology based on SolidWorks Simulation for calculations of automobile repair equipment / O. Yu. Rudyk ,

S. V. Antoniuk, Yu. A. Korneev. *Modern world trends in the development of science, education and technologies: collection of abstracts of reports of the international scientific and practical conference* (Bila Tserkva, March 20, 2024): in 2 parts. Bila Tserkva : TsFEND, 2024. Part 2. P. 82 - 84. URL: <https://elar.khmnu.edu.ua/handle/123456789/16980> (last accessed: 2026/01/12).

9. Rudyk, O., Poberezhnyi, M., Kaplun, P., & Gonchar, V. Using SolidWorks Simulation as an innovative technology when calculating of performance of details. *Actual Problems in the System of Education: General Secondary Education Institution – Pre-University Training – Higher Education Institution*. 2025. № 5. P, 94–103. <https://doi.org/10.18372/2786-5487.1.20256>. URL: <https://elar.khmnu.edu.ua/workspaceitems/23749/edit> (last accessed: 2026/01/12).