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USING SOLIDWORKS IN MODERN EDUCATION

Annotation: *The article considers the solid-state design and subsequent verification of the static strength of the swivel fork of a carburetor assembly-disassembly device: determining the maximum force that can be applied to it at an allowable safety factor $[n] = 3$ using the SOLIDWORKS solid-state graphics software product and its built-in module for strength calculations – SOLIDWORKS Simulation.*

Key words: *SOLIDWORKS, carburetor, stand, swivel fork, maximum force.*

Анотація: *У статті розглядається твердотільне проектування та наступна перевірка статичної міцності поворотної вилки пристосування для складання-розбирання карбюратора: визначення максимальної сили, яку можна*

прикласти до неї при допустимому коефіцієнті запасу міцності $[n] = 3$ з використанням програмного продукту для створення твердотільної графіки *SOLIDWORKS* і вбудованого в нього модуля для міцнісних розрахунків – *SOLIDWORKS Simulation*.

Ключові слова: *SOLIDWORKS*, карбюратор, стенд, поворотна вилка, максимальна сила

Introduction. The use of *SOLIDWORKS* CAD in modern education is a key element of training engineering and technical personnel, allowing to combine theoretical knowledge with practical skills of 3D modeling, engineering analysis and design. The software package is actively implemented in the educational process of technical universities and colleges to form digital competencies [1; 2].

The main areas of use of *SOLIDWORKS* in education:

1. 3D modeling and design: creation of parametric models of technical parts and assembly units, which develops spatial thinking and engineering graphics skills.
2. Engineering analysis (CAE): prediction of material strength and analysis of the behavior of structures under load.
3. Production preparation: development of molds (die and punch) for stamping, as well as automatic creation of design documentation.
4. International certification: educational institutions (for example, Khmelnytskyi National University) actively involve students in obtaining international SolidWorks certificates (CSWA, CSWP), which confirms compliance of knowledge with world standards.
5. Integration with other systems: use within projects such as FabLab (digital manufacturing laboratories) for the implementation of innovative startups.

Advantages of implementation: using *SOLIDWORKS* allows teachers to improve the level of training of specialists, providing them with up-to-date tools that are in demand in modern production. This contributes to a better understanding of physical processes and optimization of resources during design. The main aspects and advantages of using the SolidWorks application – the SolidWorks Simulation system

in education (this software helps future engineers understand how designed parts function in real conditions, even before the physical creation of a prototype [3; 4]):

1. Visualization and understanding of physical processes: students can analyze stresses, strains, safety factors, and natural frequencies, which makes complex theories of material resistance more understandable.

2. Integration of CAD and CAE: SOLIDWORKS Simulation is part of CAE systems, which allows you to move directly from the 3D modeling environment to engineering calculations, which significantly speeds up the learning process [5].

3. Practical orientation: using the program in courses in mechanics, mechanical engineering, and technical engineering helps prepare specialists who are able to solve problems of optimizing structures, reducing material consumption and production costs.

4. Optimization and Analysis: Simulation Professional and Premium, including Flow Simulation, allow you to study not only strength, but also hydro-gas dynamic processes, which is critically important for modern engineers.

5. Preparation for industry: Mastering SOLIDWORKS Simulation at higher education institutions, such as KhNU, ensures that students' knowledge meets the requirements of modern enterprises implementing CAMWorks and other advanced technologies.

The implementation of SOLIDWORKS Simulation allows you to intensify the learning process and increase the level of engineering training, making training more visual and practical. For effective assembly, disassembly and maintenance of an automobile carburetor, a set of special tools and devices is used that allow you to perform the work carefully, without damaging the jets and gaskets. Violation of the tightness in the “needle valve-valve seat” coupling and damage to the float cause gasoline to overflow through the carburetor sprayer, which leads to enrichment of the working mixture, and incomplete combustion leads to coking of piston rings, contamination of the lubricant in the engine pan.

Contamination of the jets, air suction through the common gaps between the throttle axis and the bosses lead to the appearance of a lean mixture, as a result of

which flares occur in the crankcase, the engine overheats and its power drops sharply. Therefore, the faulty carburetor is disassembled, the parts are thoroughly washed with acetone.

After assembly, the carburetor is tested on a stand. The absence of leaks, the fuel level in the float chamber, the performance of the accelerator pump and the moment of switching on the economizer are checked. If necessary, the fuel level is set by bending the float tongue or placing a gasket under the socket to the shut-off needle. When replacing or repairing a carburetor, all its systems must be adjusted, and the actuators for controlling its throttle and air dampers must work without jamming.

Analysis of the latest research. Solid-state design and subsequent verification of the static strength of one of the parts using SOLIDWORKS was considered for: a transmission rack for lifting and moving loads during assembly and disassembly of components and assemblies from cars [6]; a stand for straightening deformed stamped wheel disks of passenger cars [7]; a stand for diagnostics of automotive equipment [8]; a stand for repairing rear axle gearboxes of cars [9].

The aim of the article. The purpose of this work is to determine the maximum force that can be applied to the swivel fork of the carburetor assembly-disassembly device (Fig. 1) with an allowable safety factor $[n] = 3$ using the SOLIDWORKS solid-state graphics software and its built-in module for strength calculations – SOLIDWORKS Simulation [6; 10].

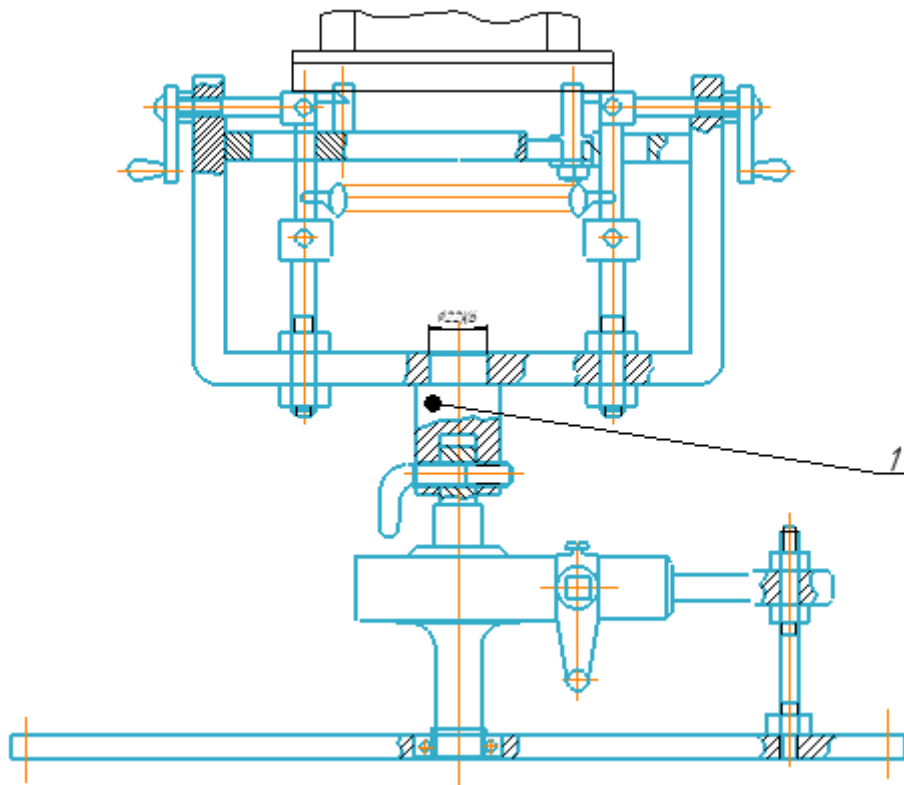


Fig. 1. Drawing of a device for assembling and disassembling a carburetor (1 – swivel fork)

Research Methodology. Initially, a model of the swivel fork was created in SOLIDWORKS [7; 11] (Fig. 2, a) according to the drawing of the swivel fork (Fig. 2, b).

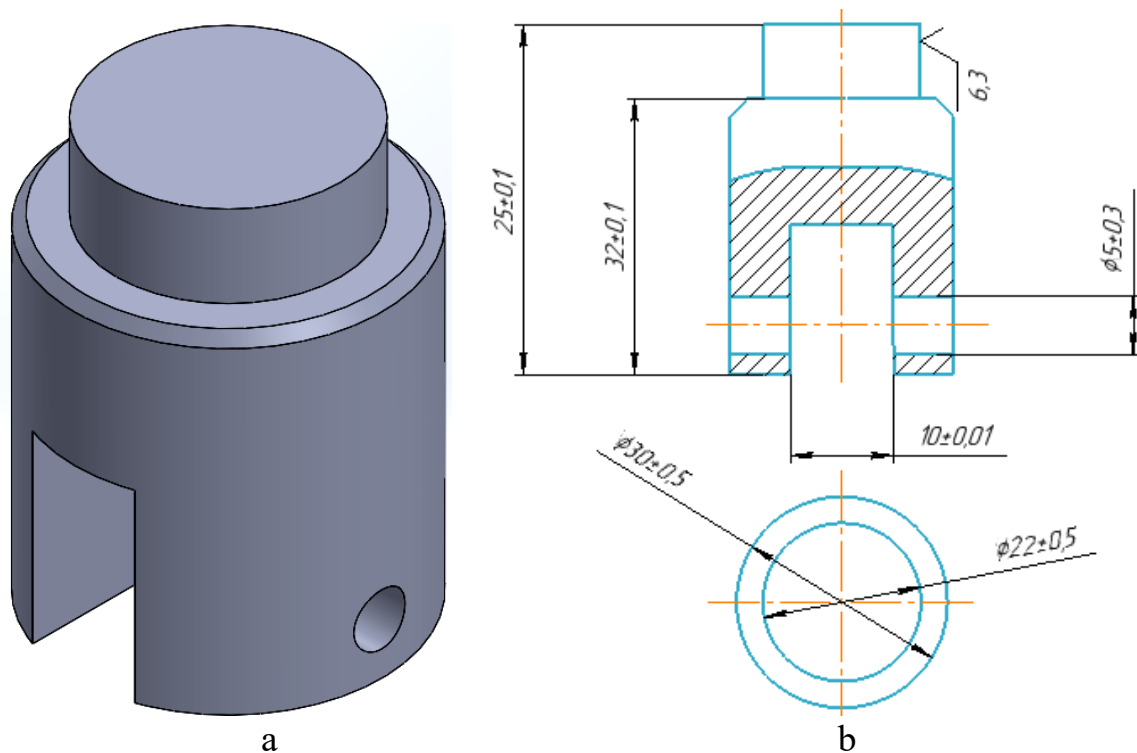


Fig. 2. 3D model (a) of the swivel fork and its design

The SOLIDWORKS Simulation software module [5; 12] was applied to the model of the rotary fork: static analysis was selected as the type of study of its stress-strain state.

Research results. When conducting a static analysis of the swivel fork model: its material was assigned (steel 18Kh2N2M, analogue 1.6587, 18CrNiMo7-6) (Fig. 3).

Property	Value	Units
Elastic Modulus	210000.0031	N/mm ²
Poisson's Ratio	0.28	N/A
Shear Modulus	79000	N/mm ²
Mass Density	7800	kg/m ³
Tensile Strength	1100.825984	N/mm ²
Compressive Strength		N/mm ²
Yield Strength	785.593984	N/mm ²
Thermal Expansion Coefficient	1.1e-05	/K
Thermal Conductivity	14	W/(m·K)
Specific Heat	440	J/(kg·K)

DIN Steel (Alloyed) 1.5714 (16NiCr4) 1.5805 (10NiCr5-4) 1.5810 (18NiCr5-4) 1.5918 (17CrNi6-6) 1.6523 (20NiCrMoS2-2) 1.6566 (17NiCrMo6-4) 1.6569 (17NiCrMoS6-4) 1.6571 (20NiCrMoS6-4) 1.6587 (18CrNiMo7-6)

Fig. 3. Purpose of the swivel fork material

According to the calculation scheme, constraints were added to the swivel fork model (Fig. 4, a) and a load was applied (Fig. 4, b).

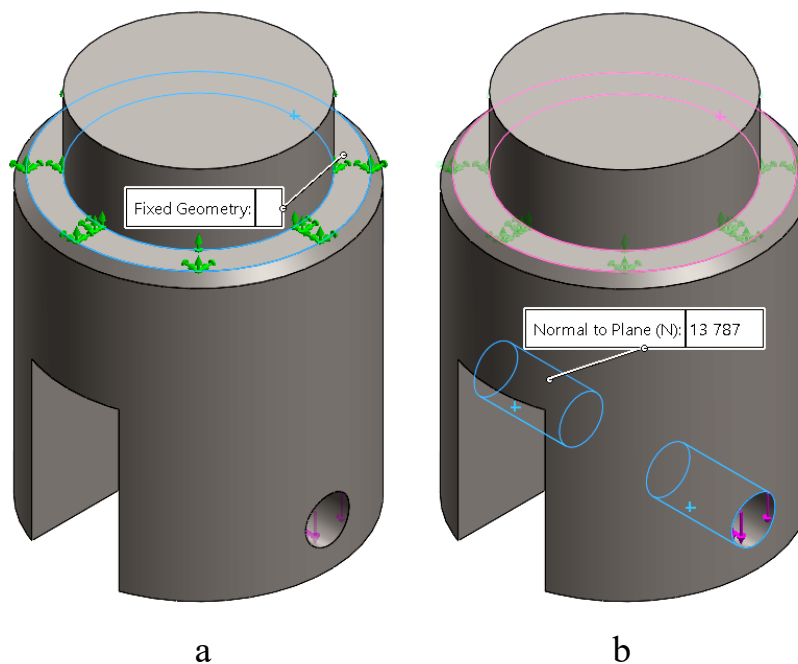
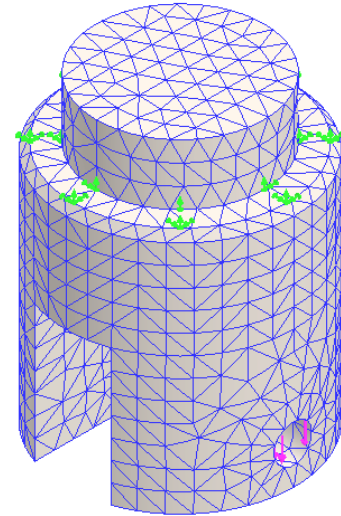


Fig. 4. Limitations of the swivel fork (a) and application of external loads (b)

We divided the model into elements connected at nodes (the finite element analysis program considered the model as a mesh (Fig. 5);

Mesh 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	2,71203 mm
Tolerance	0,135601 mm
Mesh Quality	High



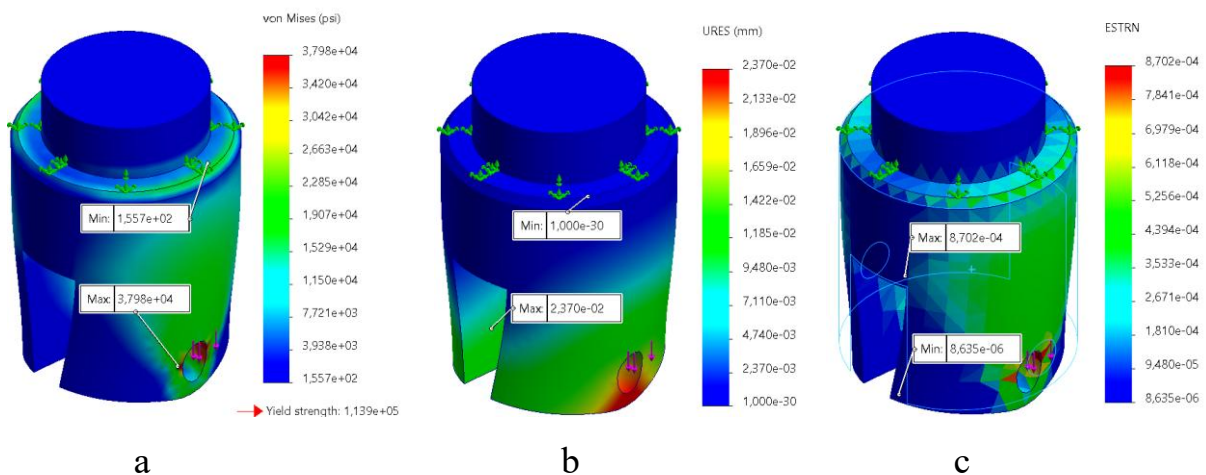
a

b

Fig. 5. Grid parameters (a) and its representation (b) on the rotary fork model

We constructed a stiffness matrix and synthesized a finite element model of the swivel fork from its individual elements (we took into account the conditions for fixing the model at the nodal points).

We solved the resulting system of algebraic equations and determined the components of the stress-strain state of the swivel fork model. We established that with a safety factor of the swivel fork model $n = 3.0$, the maximum Von Mises nodal stresses (37,98 MPa, node 11001– Fig. 6, a), displacement URES (0.02373 mm, node 463 (Fig. 6, b) and equivalent deformation ESTRN (0.0008702 mm, element 2954 – Fig. 6, c) do not exceed the permissible values.



a

b

c

Fig. 5. Diagrams of distribution of nodal Von Mises stresses (a), displacements URES (b), deformations of the torsion fork ESTRN (c) of the torsion fork

Conclusions. It was established that the maximum force that will not lead to violations of the safety requirements of the swivel fork is $F = 13787 \text{ N} = 1405 \text{ kg}$. At the same time, the weight of a truck carburetor is usually from 2,5 to 4 kg. Thus, using the SOLIDWORKS CAD system and its application - the SOLIDWORKS Simulation CAE system, based on the finite element method, the operability of the swivel fork of the carburetor assembly-disassembly device has been proven.

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