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APPLICATION OF INNOVATIVE TECHNOLOGIES WHEN RESEARCHING THE PERFORMANCE OF ROAD TRANSPORT

***Annotation**. Considered the physical processes that characterize the stressed-deformed state of the cardan flange. For this in SolidWorks provides a general methodology for building a solid model of a flange and in SolidWorks Simulation selects its material, fasteners, applied loads, creates a mesh of finite elements,*

determines Mises stresses, resulting displacement, equivalent deformations, and margin of safety.

Key words: *innovative technologies, SolidWorks, automobile, cardan transmission, flange.*

Анотація. *Розглянуто фізичні процеси, які характеризують напружено-деформований стан фланця карданної передачі. Для цього у SolidWorks наведена загальна методологія побудови твердотільної моделі фланця, а у SolidWorks Simulation вибраний її матеріал, кріплення, прикладені навантаження, створено сітку скінченних елементів, визначені напруження по Мізесу, результуюче переміщення, еквівалентні деформації, запас міцності.*

Ключові слова*: інноваційні технології, SolidWorks, автомобіль, карданна передача, фланець.*

Introduction. Focus on innovative technologies in the field of education, modern material and technical base, highly professional teaching staff - everything is aimed at producing competent specialists, qualitatively prepared to create high-tech developments, thinking progressively and creatively solving assigned problems [1].

The main educational value of innovative technologies is that they make it possible to create a more vibrant interactive learning environment with unlimited possibilities at the disposal of both teachers and students.

The advantages of innovative and computer technologies compared to traditional ones are manifold. In addition to the possibility of a more illustrative, visual presentation of the material, effective testing of knowledge and everything else, these include the variety of organizational forms in the work of students, methodological techniques in the work of the teacher.

Unlike conventional technical teaching aids, innovative technologies make it possible not only to saturate the student with a large amount of knowledge, but also to develop intellectual and creative abilities, their ability to independently acquire new knowledge, and work with various sources of information [2].

One of the most important problems facing the automotive industry is increasing the operational reliability of cars. The solution to this problem is provided by the release of more reliable car models. Therefore, we considered the physical processes that characterize the stress-deformed state of the flange of the cardan transmission of the MAZ-5336 car.
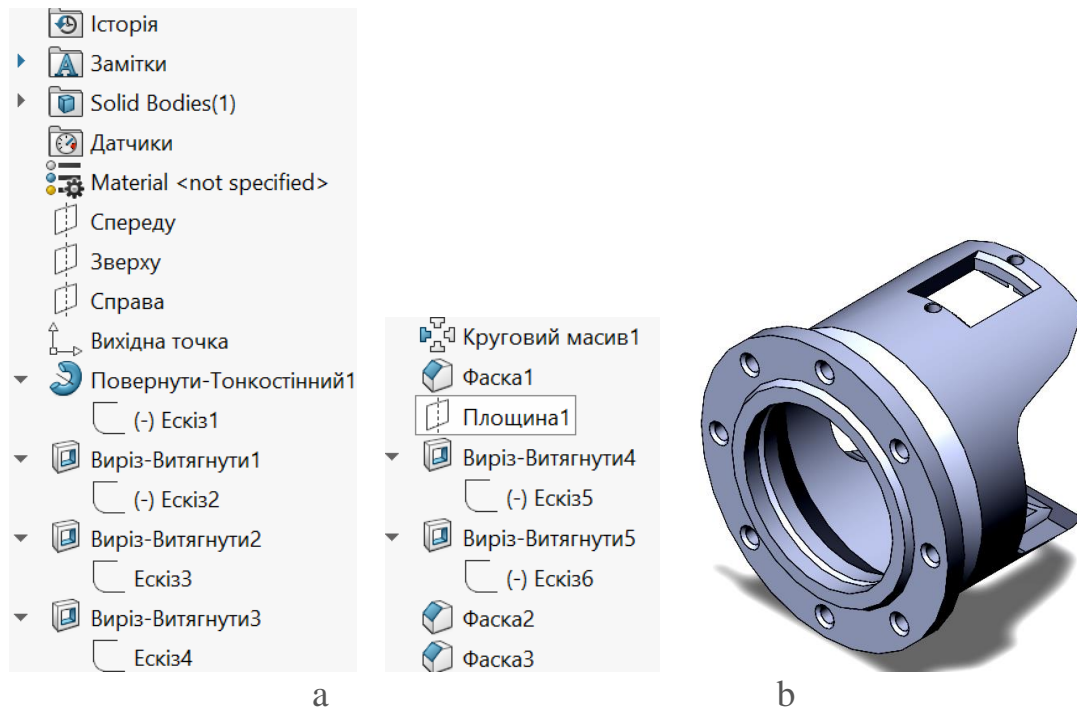
In the cardan flange, the holes for the bearings wear out and cracks and chips appear on their surface. As a result, it is subject to fatigue, oxidation, abrasive wear, seizing, fretting corrosion, and spalling. Therefore, a reasonable calculation of its strength is necessary, which was carried out with the help of the SolidWorks computer engineering analysis application program [3], intended for automated strength analysis of the project structure.

In order to theoretically confirm the conclusions of operational tests, the SolidWorks application – SolidWorks Simulation was used: with the help of a system of linear algebraic equations, the values of elastic stresses and deformations were calculated at each node of the finite element grid. Values of these characteristics at any point of the selected area were constructed by the approximation method.

Analysis of the latest research. In paper [4] considered the physical processes that characterize the stress-deformed state of the crosshead of the cardan transmission of the MAZ-5336 car. The authors of [5, 6] developed a technique that uses SolidWorks as a means of teaching technical disciplines of the automotive profile: solid-state 3D-design and modelling of components and parts of automotive equipment and devices in the first courses of study (SolidWorks); strength, stability, fatigue and other engineering calculations of these nodes and parts - on the following (SolidWorks applications).

The aim of the article. But the performance of the cardan transmission also depends on the strength characteristics of its other parts. Therefore, it is necessary to conduct appropriate studies, for example, for its flange.
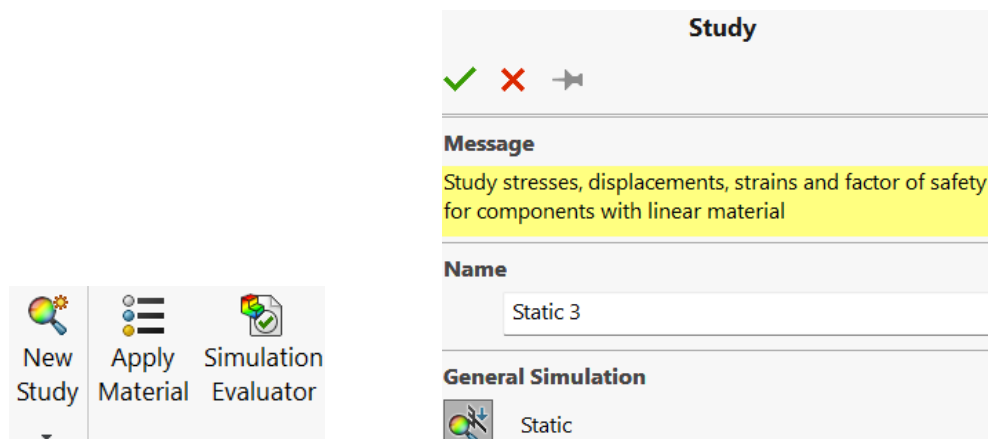
Research Methodology. The general methodology for building a solid-state model of the gimbal flange in SolidWorks is shown in fig. 1.

a   b

Fig. 1. The general methodology for building a solid-state model of a cardan flange in SolidWorks (a) and the model itself (b)
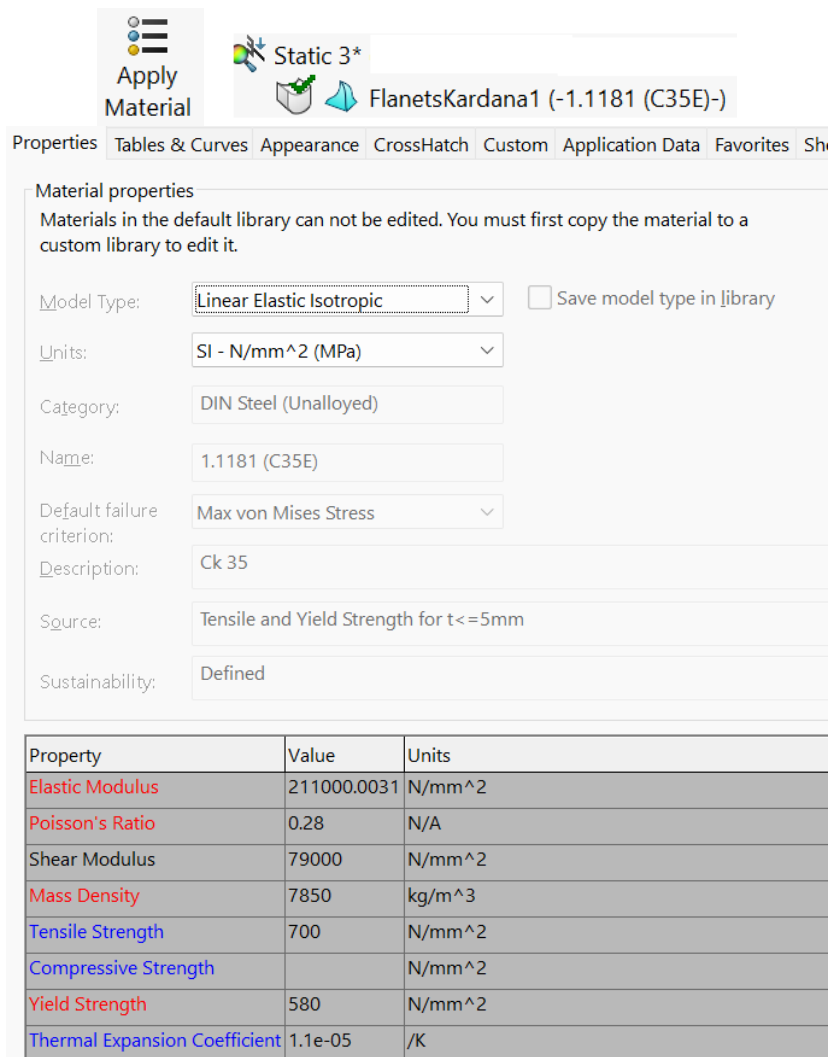
The solid-state model of the gimbal flange is ready for strength analysis.

Research results. Let's define the main parameters of the model. In the same file, we will create an analysis project – «New study». Let's assign the type of analysis – «Static» (fig. 2).

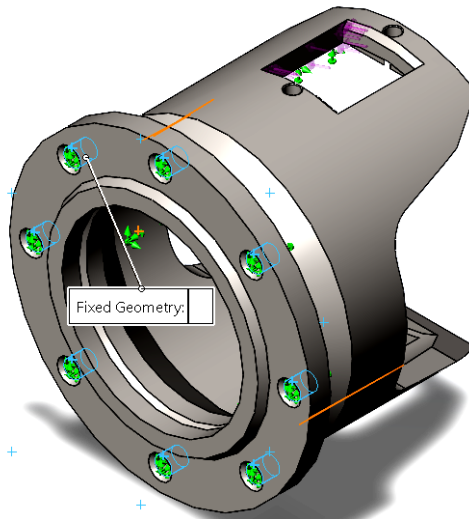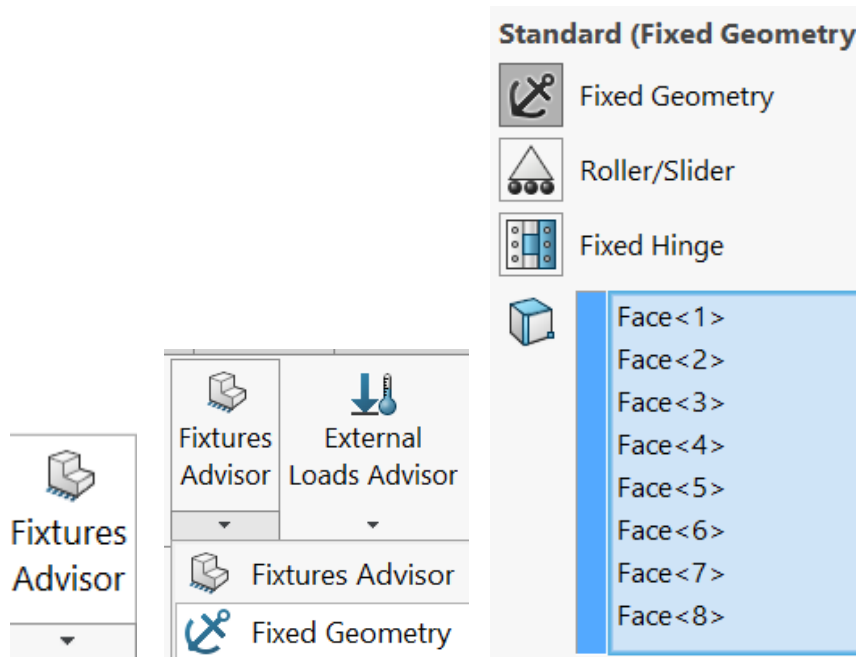**Fig. 2. Creating an analysis project**

We will determine the material of the part, for which we will select steel C35E from the «SolidWorksMaterials» library – an analogue of the material of the cardan flange – steel 40 (fig. 3).
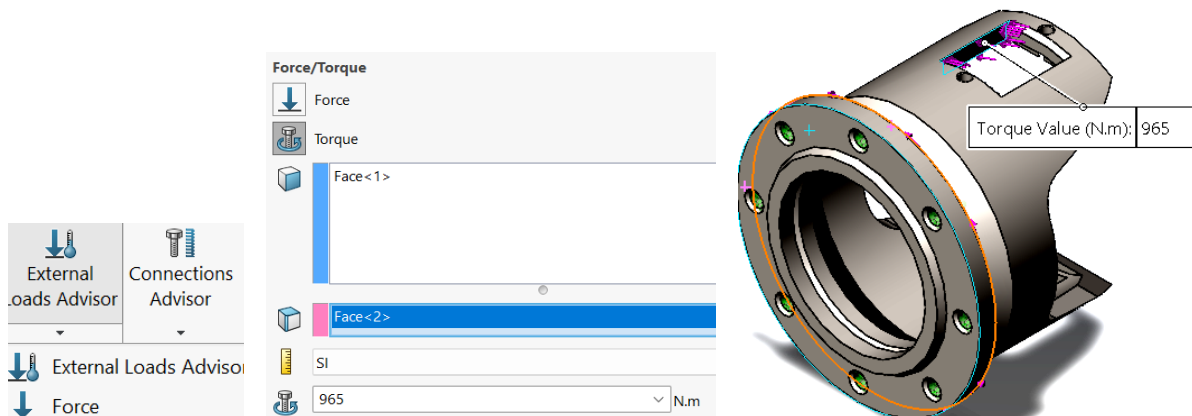
Fig. 3. Purpose of the material of the cardan flange

According to the calculation scheme, we add restrictions (fastenings) to the model. Movement restrictions will be applied in all directions. To do this, select the type of fastening «Fixed geometry» (fig. 4).

Let's apply a load to the flange - a torque of 965 Nm acting on it. To do this, select the «Torque» command, applying it to the cut-out in the flange, thereby determining the direction (fig. 5).

Standard (Fixed Geometry)

Fixed Geometry

Roller/Slider

Fixed Hinge

Face<1>
Face<2>
Face<3>
Face<4>
Face<5>
Face<6>
Face<7>
Face<8>

Fixtures Advisor

Fixtures Advisor   External Loads Advisor

Fixtures Advisor

Fixed Geometry

Fixed Geometry:

Fig. 4. Restrictions on flange movements

Force/Torque

Force

Torque

Face<1>

Face<2>

SI

965   N.m

External Loads Advisor   Connections Advisor

External Loads Advisor

Force

Torque Value (N.m): 965
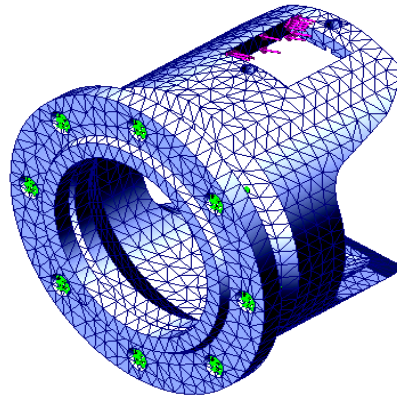
Fig. 5. Application of torque to the cardan flange

The formation of the model grids flange model is activated by the «Create mesh» command. We leave all the parameters of this command at their defaults (fig. 6).

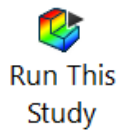The finite-element mesh is presented in fig. 7.

We launch the calculation program. To do this, select the «Start this study» command (fig. 8).

Mesh

Definition | Mesh Quality

Mesh Density

Coarse   Fine

Reset

☐ Issue warning for distorted elements

☑ **Mesh Parameters**
- ○ Blended curvature-based mesh
- ○ Curvature-based mesh
- ● Standard mesh

mm

8.47420783mm

0.42371039mm

Mesh Advisor...

Simplify Model for Meshing

Create Mesh...

Mesh Details	
Study name	SimulationXpress_Study*
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	8,47421 mm
Tolerance	0,42371 mm
Mesh quality	High
Total nodes	20946
Total elements	11718
Maximum Aspect Ratio	10,328
Percentage of elements with Aspect Ratio < 3	90,2
Percentage of elements with Aspect Ratio > 10	0,00853
Percentage of distorted elements	0
Number of distorted elements	0
Time to complete mesh(hh:mm:ss)	00:00:01

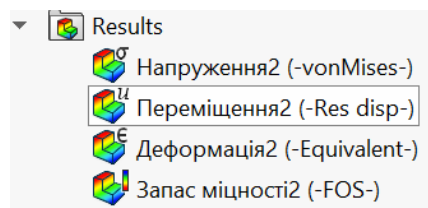**Fig. 6. Grid parameters of the gimbal flange model**

Fig. 7. Finite element mesh of the gimbal flange model

Run This
Study
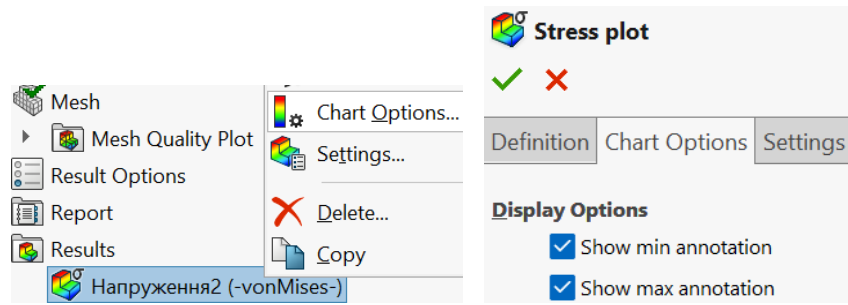
Fig. 8. Launching the calculation program

By default, 4 types of analysis results are available in the «Results» folder of the research tree (fig. 9): mises stress; resulting displacement; equivalent deformations; margin of safety.

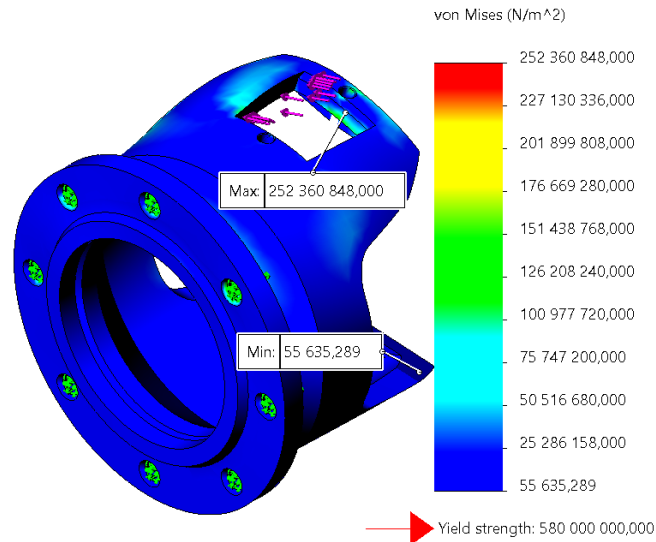**Fig. 9. «Results» folder of the research tree**

For greater informativeness and ease of analysis of the results, it is necessary to configure the charts displayed using the «Chart Options» command. In the «Stress plot» settings, select MPa as the units of measurement according to the requirements. In the settings of the «Display parameters» command, activate the options: «Automatic determination of the maximum value», «Automatic determination of the minimum value», «Display the minimum note», «Display the maximum note» (fig. 10).

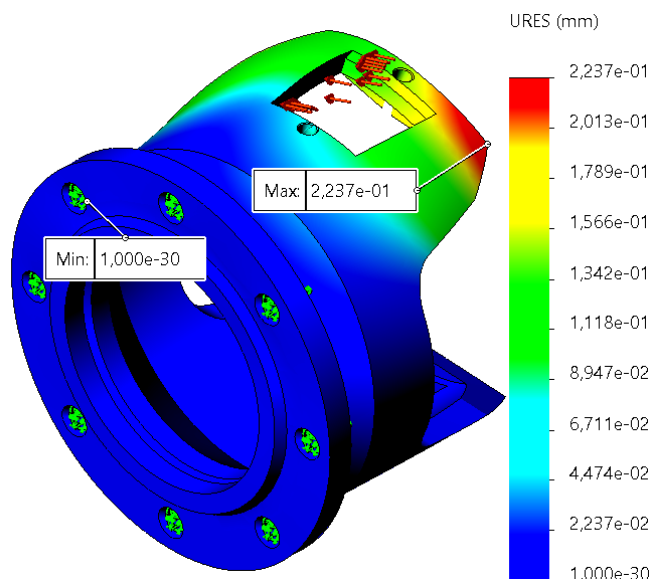**Fig. 10. Configuring the Display Options command**

The Mises stress diagram is presented in fig. 11.

Fig. 11. The von Mises stress diagram of the cardan flange model

Analyzing the diagram, we notice that the maximum stress value is 252,360 MPa, which does not exceed the yield point of the material.
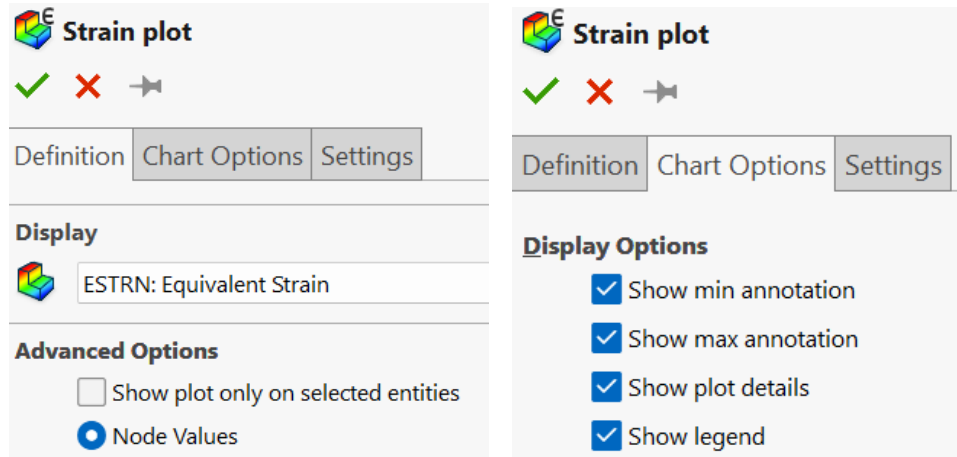
The diagram of total displacements is presented in fig. 12.

Fig. 12. URES total displacement diagram of the cardan flange model
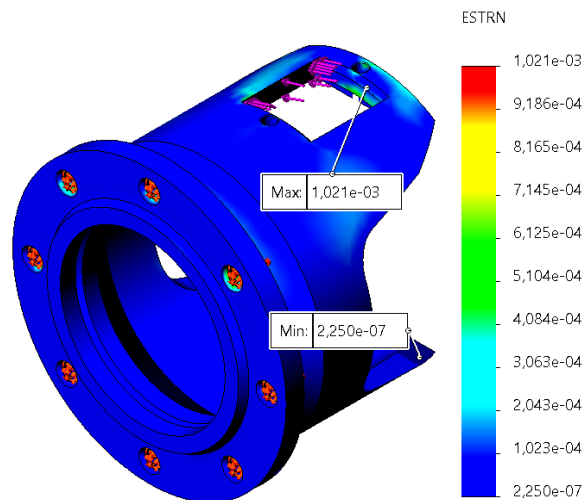
The maximum resulting movement is 0,2237 mm.

In a similar way, we will derive the diagram of equivalent deformations. In the settings, in the additional parameters, select the option «Values in nodes» and display the deformed shape in auto mode, and in the settings of the graph parameters, select the display of minimum and maximum values (fig. 13).

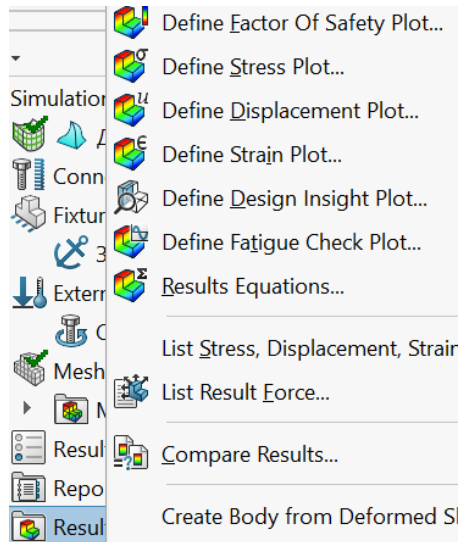**Fig. 13. Setting up the diagram of equivalent deformations**

The diagram of equivalent deformations is presented in fig. 14.

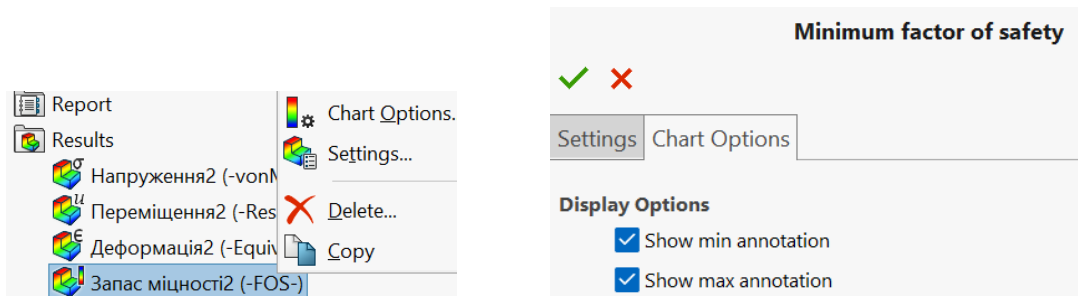**Fig. 14. Diagram of equivalent deformations of the ESTRN model of the gimbal flange**

The maximum amount of deformations is 0.001021.

Now let's build a safety margin diagram. To do this, select the command «Define safety margin check» (fig. 15).
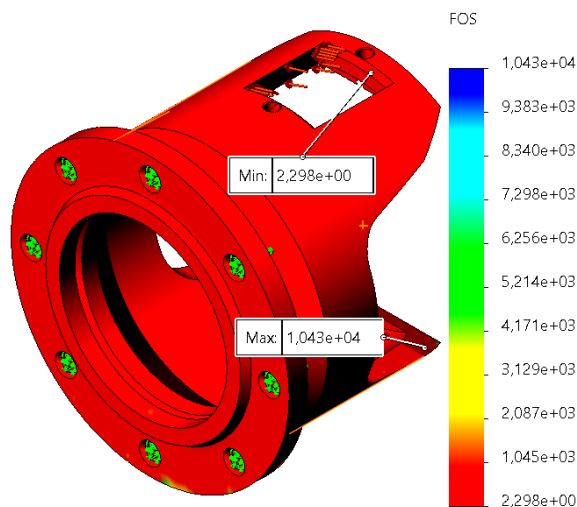
Fig. 15. Task of the command «Define safety margin check»

Select «Safety margin (FOS)», and in the display parameters, configure the display of the minimum and maximum values (fig. 16).

Fig. 16. Setting display parameters

The diagram of the distribution of the safety factor is presented in fig. 17.

Fig. 17. Distribution diagram of the safety factor of the cardan flange model

Conclusions. Thus, nodal maximum Von Mises stresses, displacement URES, deformation ESTRN, as well as the margin of safety FOS of the cardan flange model do not exceed the permissible values (fig. 11-17): the minimum coefficient of margin of strength n = 2,3, which is greater than the permissible [n] = 1,5.

Thus, with the help of SolidWorks and its application – SolidWorks Simulation, the workability of the cardan shaft flange was proven.

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