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АНАЛІЗ МОЖЛИВОСТІ ПОЛЕГШЕННЯ ВАЛ-СЕПАРАТОРА ЗІ ЗБЕРЕЖЕННЯМ ЗАПАСУ МІЦНОСТІ

В роботі проведено аналіз можливості модернізації вал-сепаратора шляхом зменшення металомісткості конструкції без значної втрати міцності.

Ключові слова: *допустиме напруження, запас міцності, прикладене навантаження, система CAD/CAE, передача з проміжними тілами кочення.*

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ANALYSIS OF THE POSSIBILITY OF LIGHTENING THE SHAFT SEPARATOR WITH PRESERVING THE STRENGTH MARGIN

The paper analyzes the possibility of upgrading the separator shaft by reducing the metal content of the structure without significant loss of strength.

Keywords: *allowable stress, safety margin, applied load, CAD/CAE system, transmission with intermediate rolling elements.*

Introduction. Gears have found wide application in various branches of the national economy, they are used in drives of low-power devices and powerful drives of equipment, as well as in mechanisms and devices for various purposes. However, developments in this direction continue to this day in the field of improving transmission parameters. One of the relatively new types of gearboxes is a gearbox with intermediate rolling elements. The advantages of the gearbox include, first of all, a large gear ratio in one stage, with a small mass and dimensions of the device.

Analysis of literary sources. The advantages of this type of gearbox and the prospects for their improvement have led to the interest of researchers in this type of gearbox in many branches of technology[1-3]. But as the analysis of literary sources in scientific publications has shown, the studies mainly concern the possibility of alternative replacement with this type of gearbox[1], structural analysis for the design of new types[2], or the effects of design parameters on its operating characteristics[3]. However, studies on the possibility of modernization by reducing the metal content of the design of existing models are practically absent.

Task statement. Investigation of the stress state on the shaft-separator of a gearbox with intermediate rolling elements using CAD.

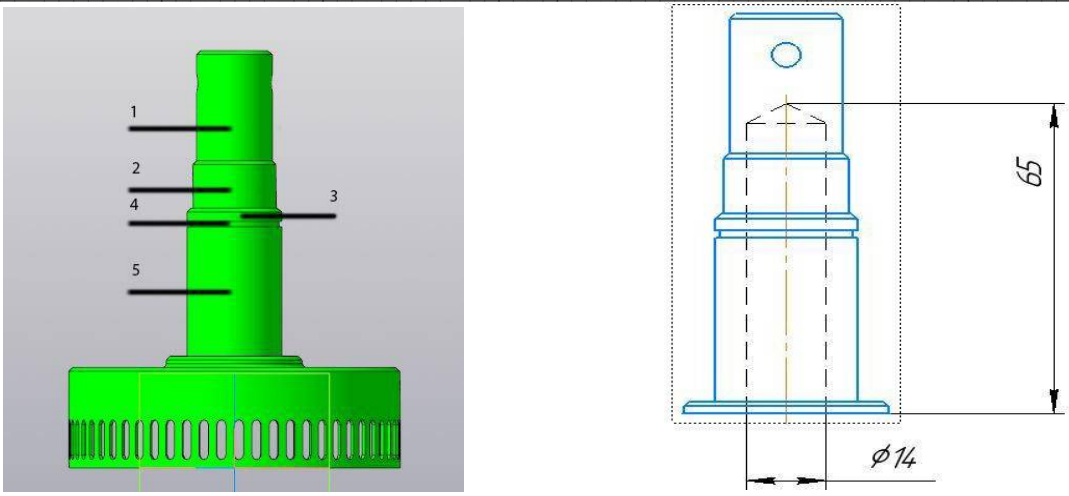
Presentation of the main material. Modeling and analysis in many industries help to avoid expensive and long development cycles of the “design - production - test” type. Currently, CAE systems are used to calculate stresses in elements and complex assemblies, which allows calculating and analyzing the characteristics of individual elements and the structure as a whole at the design stage. Usually, these modules are directly integrated with CAD systems, such as SolidWorks [4], or, conversely, they have a CAD module in their system, for example, CAE ANSYS [5].

To calculate the stresses of the gearbox part in CAD, we designed a 3D model of the basic and modified shaft separator. To calculate the stresses on the shaft separator, we created a simulation using a multiplier - fixing the separator zone and applying torque to the pin hole zone. For the purpose of the study, we divide the simulated shaft separator into 5 conditional parts according to the change in size in diameter (Fig. 1a). The Static Structural module was used to create the calculation.

Let us consider the possibility of lightening the separator shaft by deep drilling Ø 14mm to a depth of 65mm according to Fig. 1b.

The settings for the research parameters were as follows: in the " Engineering" section data » the parameters of the separator shaft material were specified – Steel 40X Tensile strength – 395.0 MPa, yield strength – 345.0 MPa, density 7820.0 kg m3. The turning torque on the hole is 35 N mm² along the coordinate of the X axis, which is the axis of the shaft, and the shaft is mounted on a surface with separate windows for intermediate rolling elements.

As a result of drilling a shaft-separator weighing 0.7067 kg, the calculated lightening of the part was 9.03% - 0.0780 kg.



a **b**

Figure 1. **Shaft separator: a – diagram of shaft division into 5 zones, b – diagram of shaft modernization**

The results of stress calculations of the modernized model of the shaft-separator in CAE ANSYS are presented in Fig. 2, and Table 1 presents the generalized calculation values of both shafts.

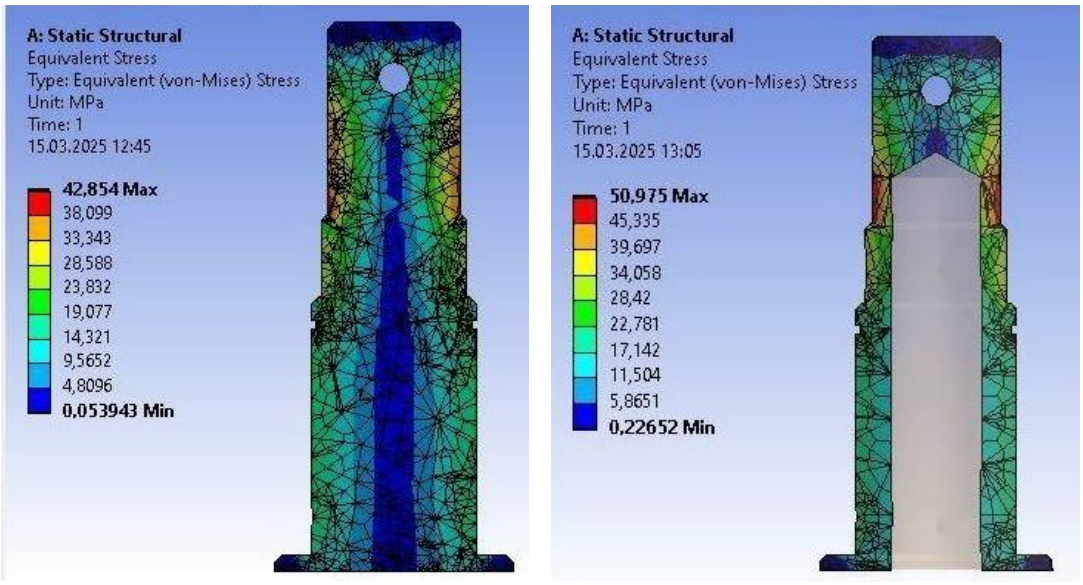


Figure 2. **Calculation of stresses on the modernized shaft.**

Table 1.

Design stress of shafts

Base shaft, MPa	Modified shaft, MPa
22.33	26.52
16.71	20.38
6.08	5.84
14.46	14.99
11.44	12.85

The results of engineering calculations of the tangential stresses of the shaft are given in Table 2.

To verify the calculations, we will simulate real operating conditions by adding a possible load during gearbox operation in a conventional device in the form of a normal to the axis of rotation of the shaft, which is equal to 1000 N.

Table 2.

Results of shaft engineering calculations

MPa	N mm	mm³	mm
22,281	35000	1570,795	20
16,741	35000	2090,728	22
11,408	35000	3067,959	25
13,735	35000	2548,198	23.5

Fig. 3 shows the resulting von Mises stress diagram.

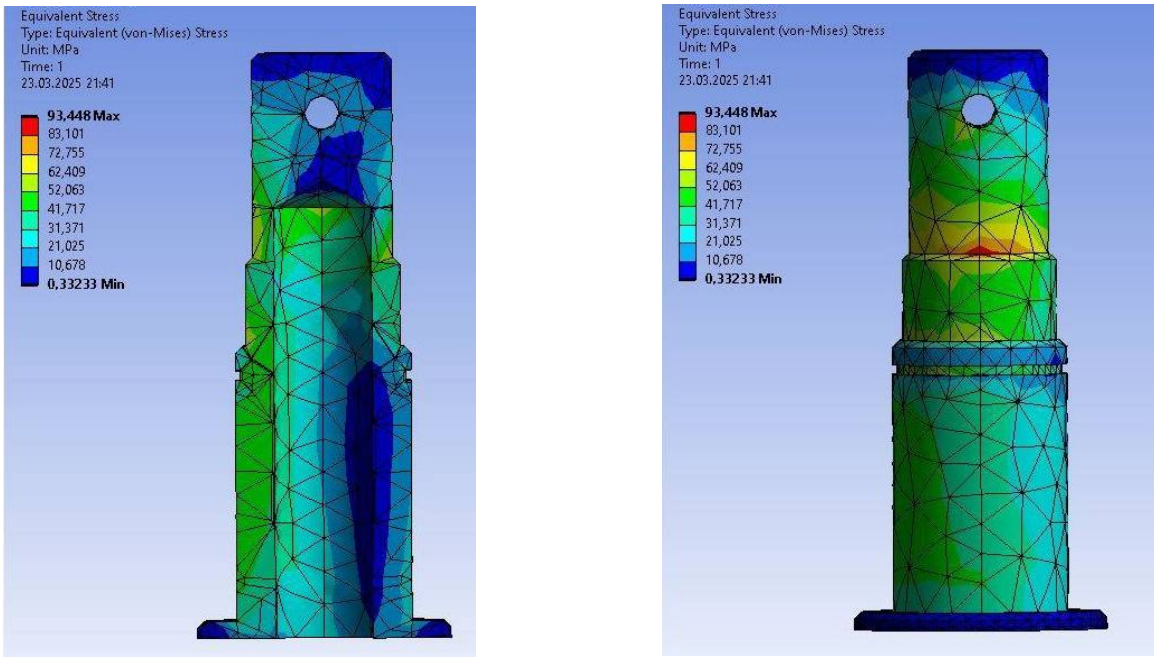


Figure 3. **Stress distribution on a modified shaft with additional load**

Conclusions. The results of the strength factor calculations based on the design stresses were: $N_{base} = 17.59$ for the base shaft, $N_{mody} = 14.79$ for the lightweight shaft. The results of the strength factor calculations based on the von Mises design stresses were: $N_{base} = 9.22$ for the original shaft, and $N_{mody} = 4.24$ for the lightweight shaft, respectively. Based on the results of these studies, it was confirmed that it is possible to unload the part without a significant loss of safety margin.

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