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АВТОМАТИЗИРОВАННОЕ ПРОЕКТИРОВАНИЕ КОМПОНОВОК МЕХАТРОННОГО СТАНОЧНОГО ОБОРУДОВАНИЯ С ПОМОЩЬЮ ПРОГРАММНОГО КОМПЛЕКСА «SOLIDWORKS»

COMPUTER-AIDED DESIGN OF MECHATRONIC MACHINE EQUIPMENT LAYOUTS USING THE SOLIDWORKS SOFTWARE PACKAGE

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Аннотация
В статье предложена методика проведения эскизного проектирования мехатронного станочного оборудования с использованием системы автоматизированного проектирования SolidWorks. Данная система проектирования является наиболее востребованной в машиностроительной области и включает в себя различные дополнения для проведения эскизного проектирования.

Ключевые слова: система автоматизированного проектирования, компоновка, мехатронное станочное оборудование, эскизное проектирование, технологическое оборудование

Abstract
The article proposes a technique for carrying out preliminary design of mechatronic machine tools using the SolidWorks computer-aided design system. This design system is the most popular in the engineering field and includes various add-ons for preliminary design.

Key words: computer-aided design system, layout, mechatronic machine equipment, preliminary design, technological equipment

Introduction

Modern machine-building production must comply with the trends that set the following tasks: increasing productivity, increasing the accuracy of processing, as well as expanding the functionality of process equipment through the introduction of new technological solutions.

Currently, there is a large range of software products [1,2] and complexes [4,7] that allow information support at different design stages [3,5].

The initial stage in the course of introducing new technological equipment is the development of a technical proposal (preliminary design).

For the preliminary design of new technological equipment, both separate software products and modern computer-aided design systems can be used. One of the most common systems is SolidWorks [6].

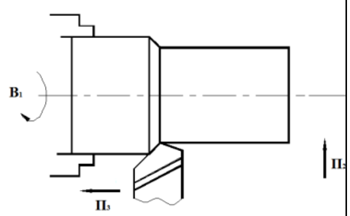
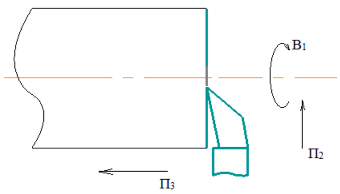
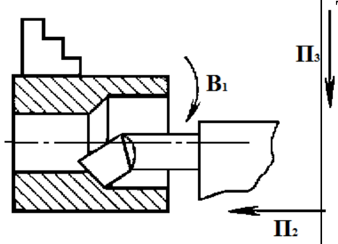
SolidWorks computer-aided design system allows modeling parts and assemblies of any complexity in three-dimensional space with further various engineering calculations and execution of design documentation with various types of requirements (ESKD, ISO) [9].

The main functions of the SolidWorks computer-aided design system:
- designing 2 D and 3 D parts;
- creation of assembly units;
- carrying out various types of engineering calculations;
- modeling of part processing on machine tools;
- registration of design documentation according to standards;
- analysis of manufacturability of part manufacturing processes
- converting received files into various formats.

Stages of preliminary design.

The initial stage in the course of the preliminary design of machine equipment is the definition of executive movements (table 1) performed on the equipment during the processing of the part.

Table 1 - Information about the applied processing schemes

Processing transition name	Processing scheme	Surface shaping method	Composition of Executive Movements
Longitudinal turning		Trace and trace method	Фv (B1) Фs (П2) H1 (L2) H2 (W3)
Cross turning		Touch method	Фv (B1) Фs (П2) H1 (L2) H2 (W3)
Boring		Trace and trace method	Фv (B1) Фs (П2) H1 (L2) H2 (W3)

In this regard, for processing the part, it is necessary to choose such a layout of the machine so that it can provide all these movements.

The next step is the development of the layout of the designed machine using the theory of Yu.D. Vragov [6]. The layout code is a letter code that describes the composition of the movable and fixed blocks and their location relative to each other.

Table 2 - Layout Matrix

~~cOXZ~~	cZOX	~~cXOZ~~
cOZX	~~cXZO~~	~~cZXO~~

The constructive implementation of machine layouts crossed out in the matrix will be very complex and irrational. Therefore, for the next stage of the preliminary design, the cZOX and cOZX machine layouts are selected.

The study of layouts for accuracy and static stiffness is carried out using the Solidworks CAD system and the Solidworks CAE system simulation [2].

For the study, 3D models of machine layouts were developed, and specific connections of nodes were calculated using the finite element method in the Simulation system integrated into the SolidWorks CAD system. The analysis is carried out at the 5 most loaded points of the working field of the machine being designed [8].

Consider point 1 of the cOZX layout (Figure 1), because at this point, when the cutting force is applied, the largest resulting displacements occur.

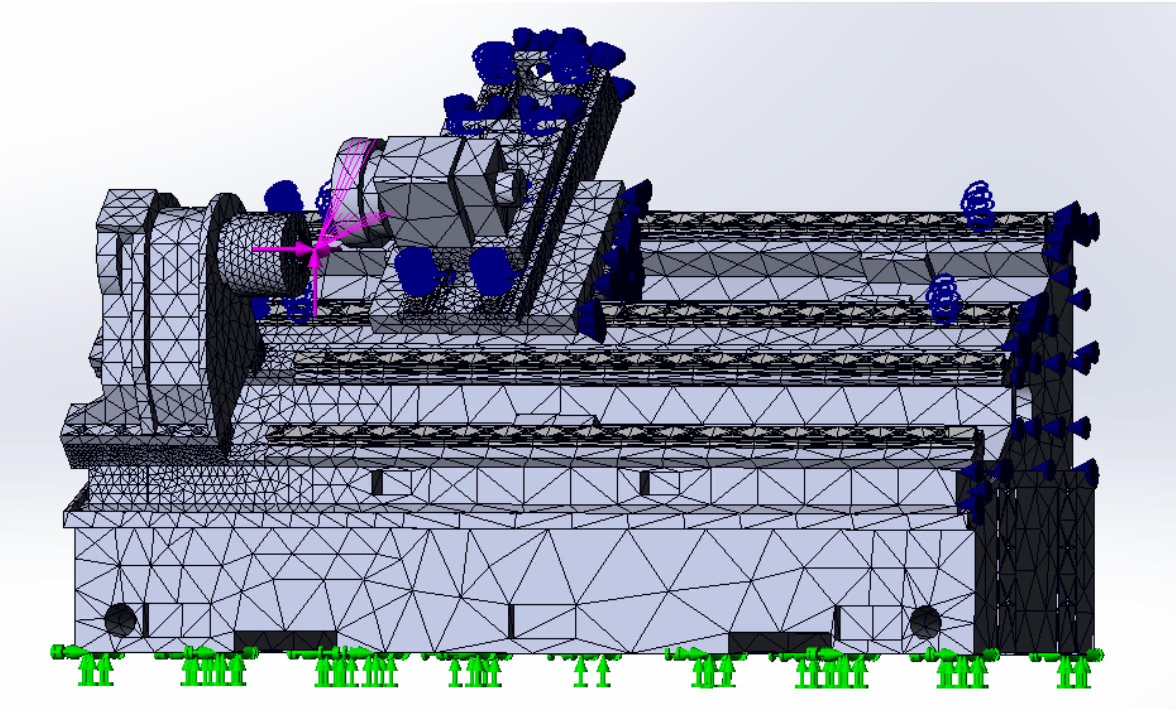


Figure 1 - Finite element model of the cOZX machine

The results of the study for 1 point of the working field are presented in table 3.

Table 3 - Results of the study for 1 point of the cOZX machine layout

Characteristic	Minimum value	Maximum value
Voltage 1 Von Mises (N / m ^2)	2.025 *10^ -2	7.382 *10^7
Move 1 Ures (mm)	1*10^-30	2.086 *10^-1
Safety margin 1 FOS	4.005	8.511 *10^ 9

Figures 2 - 4 show diagrams of equivalent stresses, resulting displacements and safety factor of the cOZX machine layout.

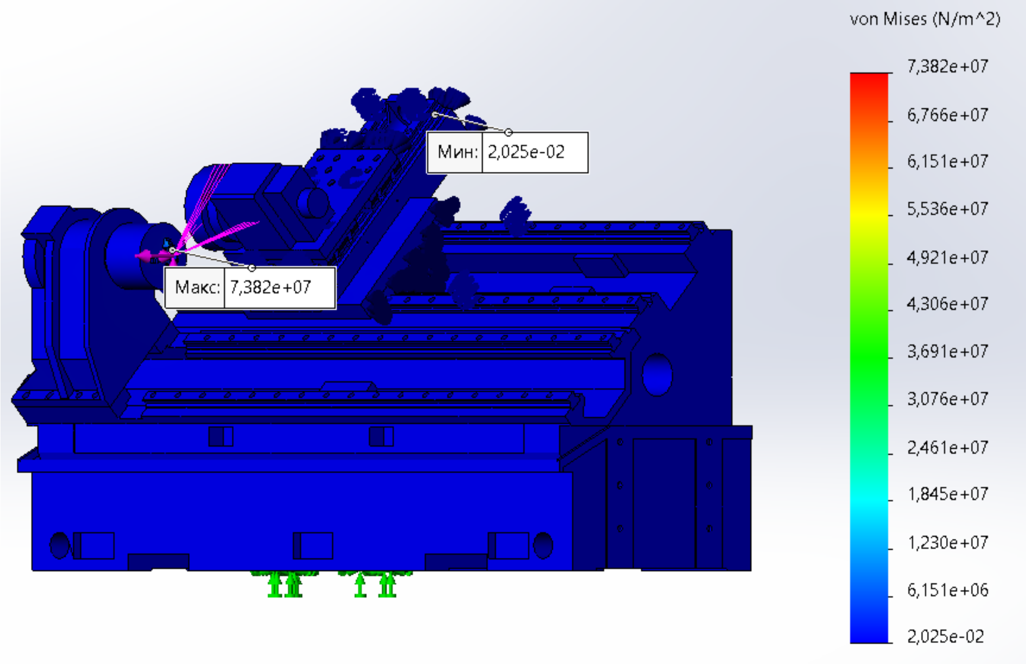


Figure 2 - Diagram of equivalent stresses for 1 point of the cOZX machine layout

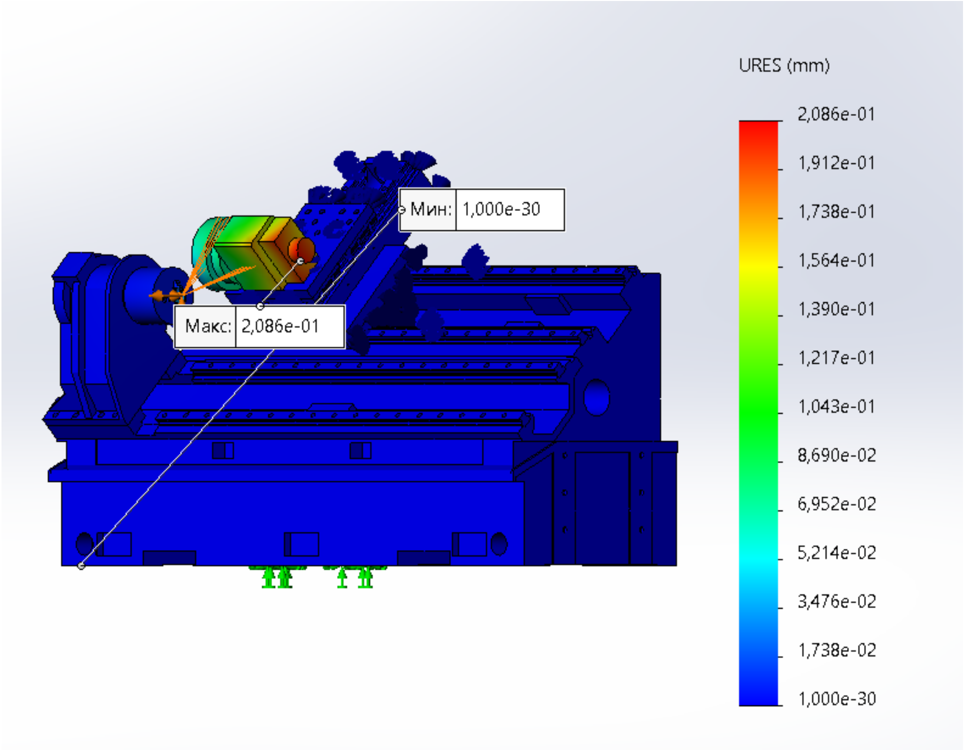


Figure 3 - Diagram of the resulting displacements for 1 point of the cOZX machine layout

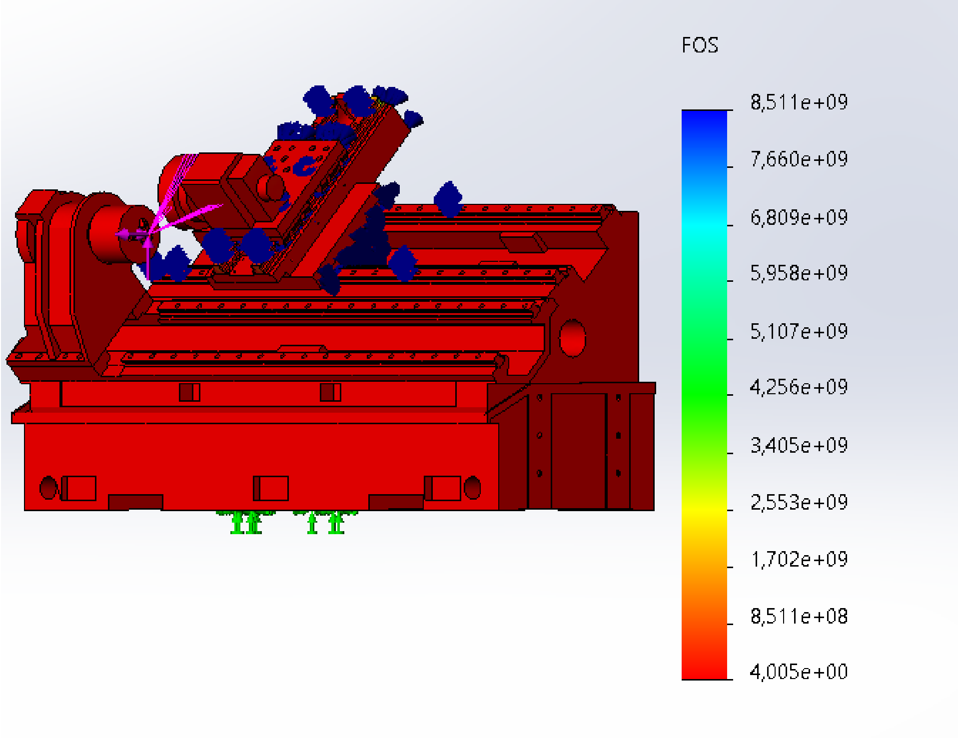


Figure 4 - Diagram of the safety factor for 1 point of the cOZX machine layout

Consider point 3 of the cZOX layout (Figure 5), since at this point, when the cutting force is applied, the largest resulting displacements occur.

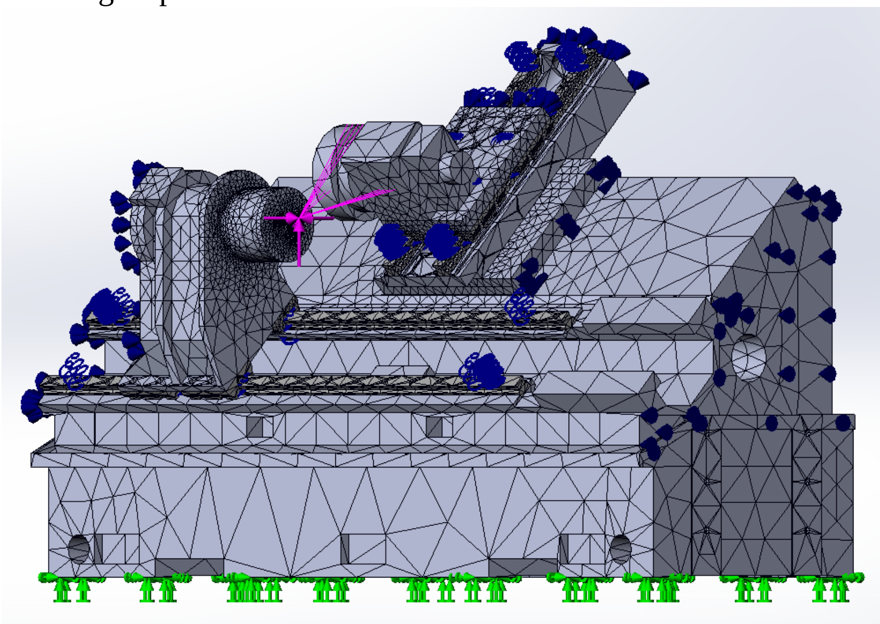


Figure 5 - Finite element model of the cZOX machine

The results of the study for 3 points of the working field are presented in table 4.

Table 4 - Results of the study for the 3-point cZOX layout

Characteristic	Minimum value	Maximum value
Voltage 3 Von Mises (N / m ^2)	6.886	5.573 *10^7
Move 3 Ures (mm)	1*10^-30	4.127 *10^ -2
Safety margin 3 FOS	3.209	4.268 *10^ 7

Figures 6 - 8 show diagrams of equivalent stresses, resulting displacements and safety factor.

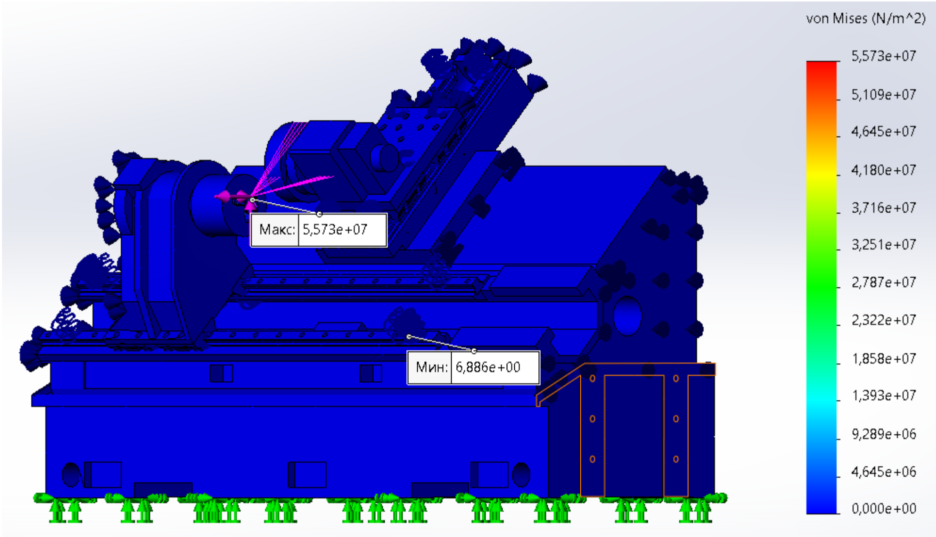


Figure 6 - Diagram of equivalent stresses for 3 cZOX layout points

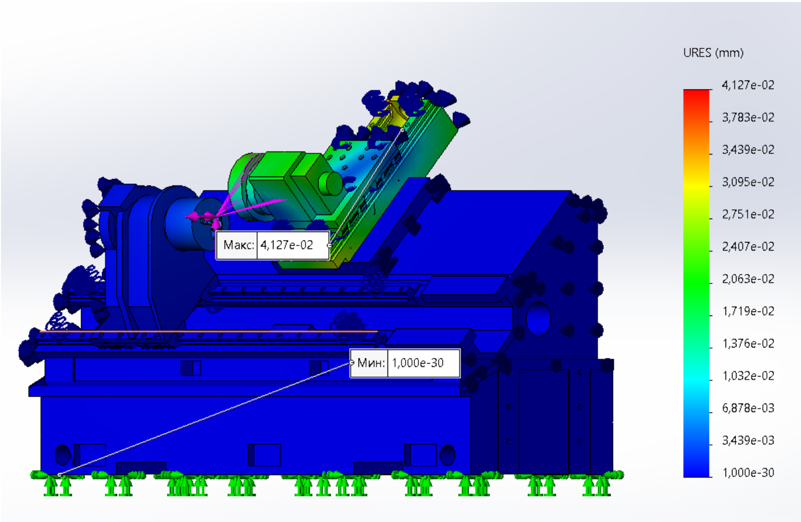


Figure 7 - Diagram of the resulting displacements for 3 cZOX layout points

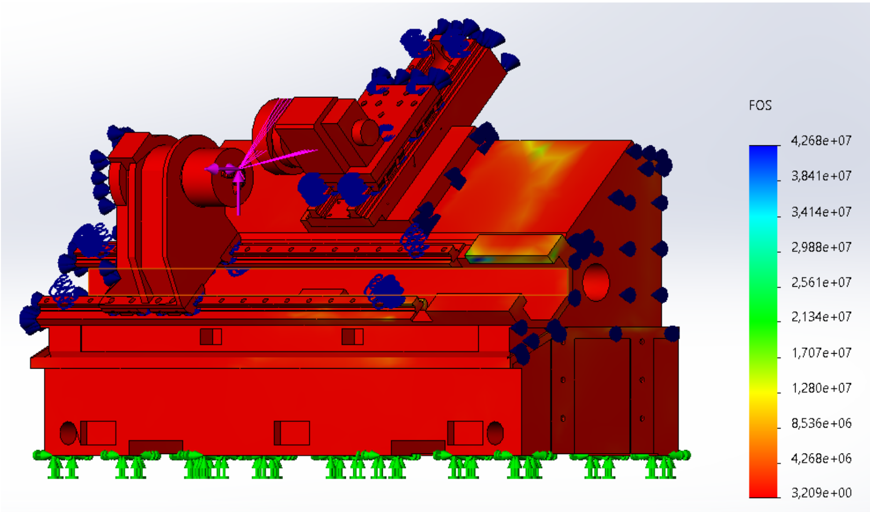


Figure 8 - Plot of safety factor for 3 cZOX layout points

Let's build summary graphs of maximum stress values (Figure 9), displacements (Figure 10) and safety factors (Figure 11) at each point of the working field for each layout.

Figure 9 - Stress graphs of layouts with OZX and c ZOX

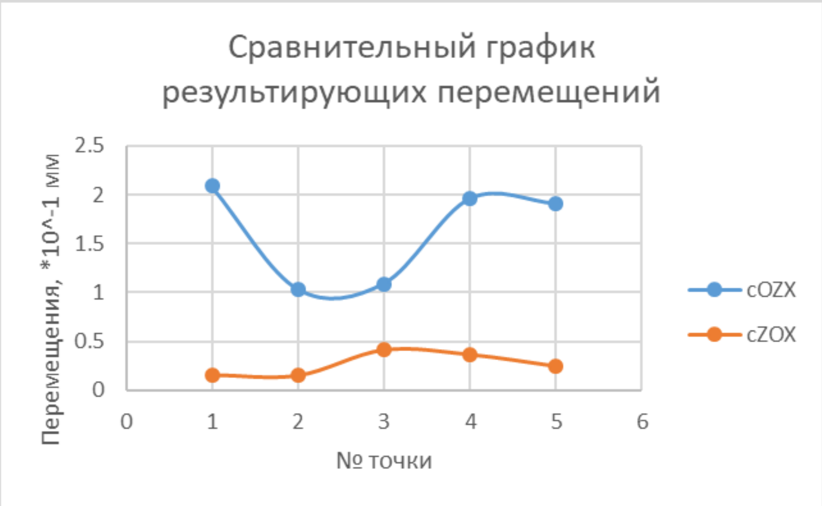


Figure 10 - Graphs of the resulting displacements of the layouts with OZX and with ZOX

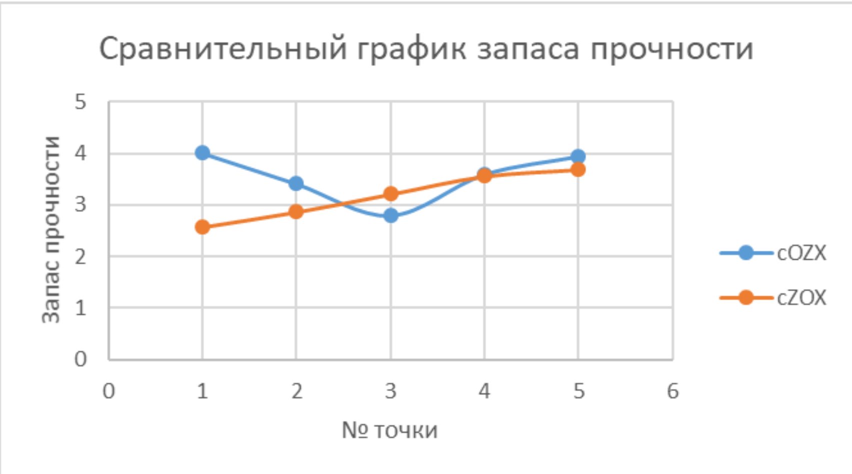


Figure 11 - Graphs of safety factor of layouts with OZX and with ZOX

We choose the first cZOX layout, since it is better in terms of static stiffness criteria and simpler from a constructive point of view.

SolidWorks software product can also implement the design of a design drawing with the requirements of ESKD (Figure 12) [10].

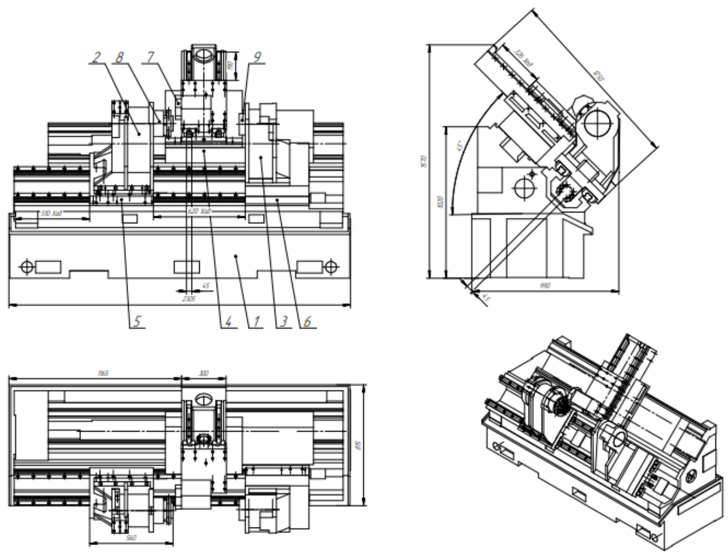


Figure 12 - Sketch of the designed machine

Conclusion

The proposed method of preliminary design of mechatronic machine tools can significantly reduce the time and use of software products using the SolidWorks computer-aided design system, which includes various add-ons that allow you to perform preliminary design.

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