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STUDYING THE STRESS-STRAIN STATE OF A MORE LOADED NODE OF A SPECIAL DEVICE FOR TURN-MILLING

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This article presents the results of studying the stress-strain state of the intermediate shaft part, which is subjected to high dynamic loads during the operation of a special device for turn-milling. The values and the nature of the stress distribution in the body of the intermediate shaft are determined using a special software package ANSYS Workbench. The scheme of forces acting on the intermediate shaft has been revealed. The calculation is based on the method of determining the von Mises yield criterion. It has been established that the maximum value of the voltage and the most critical point occurs at the transition of the steps from the diameter of 25 mm to 30 mm. However, the value of these stresses does not exceed the maximum permissible ones and it can be concluded that the parametric dimensions of the intermediate shaft fully meet the requirements to ensure the quality of the device.

Keywords: turn-milling, shaft, stress, strain, software

INTRODUCTION

Nowadays, the lack of necessary machine equipment and the lack of knowledge of this technology prevent the widespread introduction of the high-performance method of parts such as bodies of rotation by turn-milling. In the conditions of machine-building enterprises of the Republic of Kazakhstan, where universal machine-tool equipment is mainly used, this problem is even worse.

In this regard, within the framework of the studies which are funded by the Science Committee of the Ministry of Education and Science of the Republic of Kazakhstan (Grant No. AP08956387 “Creating a prototype universal device based on a lathe for the implementation of turn-milling technology”), the design of a special device for implementation of the turn-milling technology has been developed.

A patent of the Republic of Kazakhstan was obtained for the design of the turn-milling device [1].

The device for a lathe (Figure 1) consists of intermediate shaft 1, which is mounted in bracket 2 with bearings, half-coupling 3, which are fixed at the other end of the intermediate shaft 1 and connected to second half-coupling 6, fixed to motor shaft 7 using three rubber elastic elements 4, which are attached to half-couplings with screws 5.

Since the device operates in the metalworking process at very high speeds and in complex cutting conditions, its critical components and parts are the intermediate shaft, elastic rubber elements, and bolted connections connecting the elastic elements to the coupling halves.

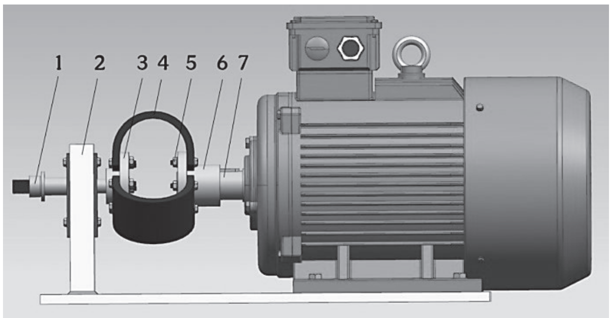

Figure 1 Special device for implementation of the turn-milling technology

Bolted connections are a common type of split connection and affect significantly the device reliability and operation. A significant part of the threaded connections is used to ensure the immobility of parts loaded with shear forces acting in the joint plane. Studies of testing the structures with bolted connections are given quite a lot of attention. This is due to the fact that there are a lot of works, varieties and technological solutions the implementation the bolted connections [2-4]. For example, analytical strength calculations of metal bolted joints for various connection schemes of structural elements are given in articles [5,6].

However, there is no work for studying the stress-strain state of the intermediate shaft part, which is subjected to high dynamic loads during the operation of the special device. This can be explained by the fact that there is no prototype of the special device for implementing the turn-milling technology.

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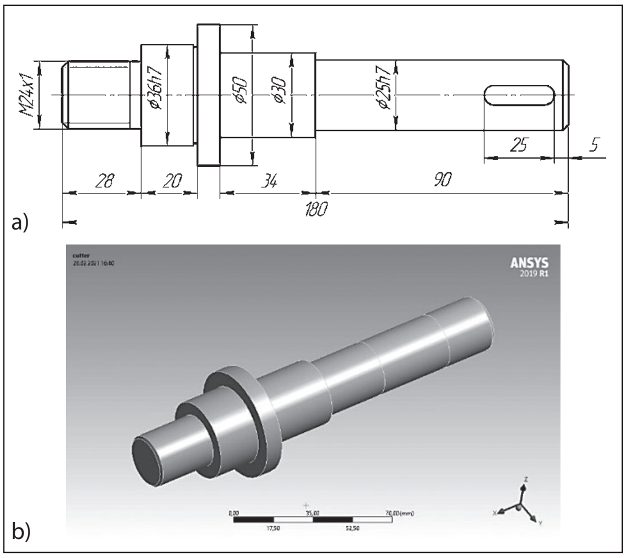

Figure 2 The main geometric parameters of the intermediate shaft (a) and the three-dimensional model of the object (b)

Therefore, studying the stress-strain state of the intermediate shaft that is experiencing large dynamic loads is an urgent task.

The purpose of this work is to select the material and the main dimensions of the intermediate shaft by determining the values of the internal forces acting during machining and comparing the obtained values of the maximum stresses with the calculated resistances of the shaft material of the special device.

STUDIES AND DISCUSSING THE RESULTS

To solve the problems of determining the values and nature of the stress distribution in the body of the intermediate shaft, we will use a special software package ANSYS Workbench.

Figure 2 shows the main geometric parameters of the intermediate shaft and the three-dimensional model of the object.

When constructing a three-dimensional model of the part, we will use a simplified configuration, which significantly reduces the calculation time.

Using the ANSYS software package to perform the calculation of the stress-strain state allows obtaining the results in the form of three values of the main stresses σ.

Figure 3 shows the diagram of the forces acting on the device node under consideration.

The calculation is based on the method of determining the von Mises yield criterion (Mises stresses or equivalent stresses). Equivalent tensile stress or equivalent Mises stresses can be used to predict malleability of the shaft material since it assumes a complex multi-axis loading condition using the theory of maximum energy of shape change [7-9].

$$\sigma_{vonMises} = \sqrt{\frac{1}{2}\left[\left(\sigma_1 - \sigma_2\right)^2 + \left(\sigma_2 - \sigma_3\right)^2 + \left(\sigma_3 - \sigma_1\right)^2\right]}$$

where σ_1, σ_2, σ_3 – stress axes.

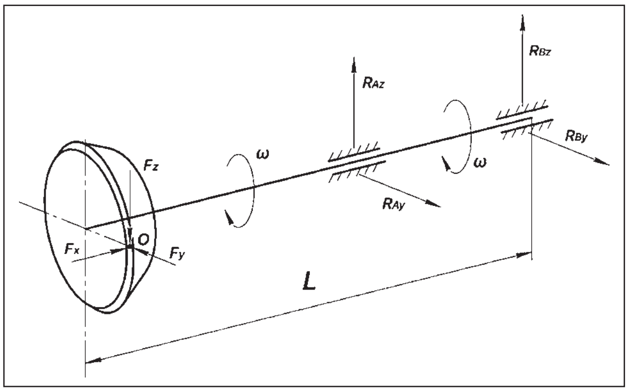

Figure 3 Diagram of the forces acting on the shaft

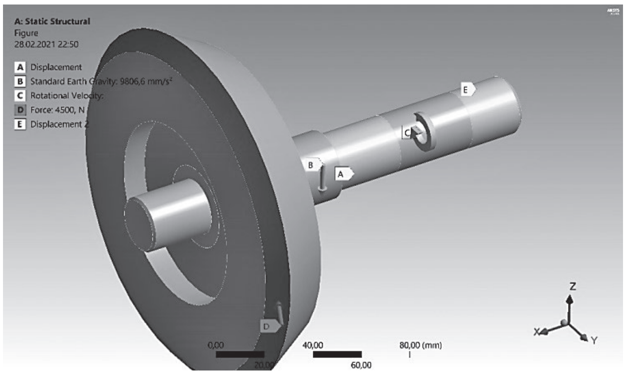

Figure 4 The calculation scheme of the intermediate shaft model

Table 1 **Initial data for calculations**

Parameter	Value	Unit
The material of the shaft	Steel 45/Structural steel	-
Total length	180	mm
Material density	7 850	kg/m^3
Young’s modulus	2E+05	MPa
Poisson’s ratio	0,3	-
Tensile yield strength	250	MPa
Tensile strength	460	MPa

This theory assumes that the material of the part begins to be damaged in places where the Mises stress becomes equal to the limit stress. In most cases, the yield limit is used as the stress limit (σ).

$$\sigma_{vonMises} \le (\sigma).$$

The calculation scheme of the intermediate shaft model is shown in Figure 4.

Since the total cutting force (D) applied to≤ the shaft is transmitted by the cutting tool, i.e. the cutter, it is also necessary to model the tool in the calculation. Thus, the calculation takes into account the anchors on the supports (A and E), the standard gravity (B), and the total cutting force (B) (Figure 4).

Table 1 shows the initial data for calculating the stress-strain state of the intermediate shaft.

The results of the calculation are shown in the form of graphical images of the stress distribution fields in the body of the intermediate shaft in Figure 5.

The most stressed zone occurred in the cantilever section in the area of the coupling with the bearing as-

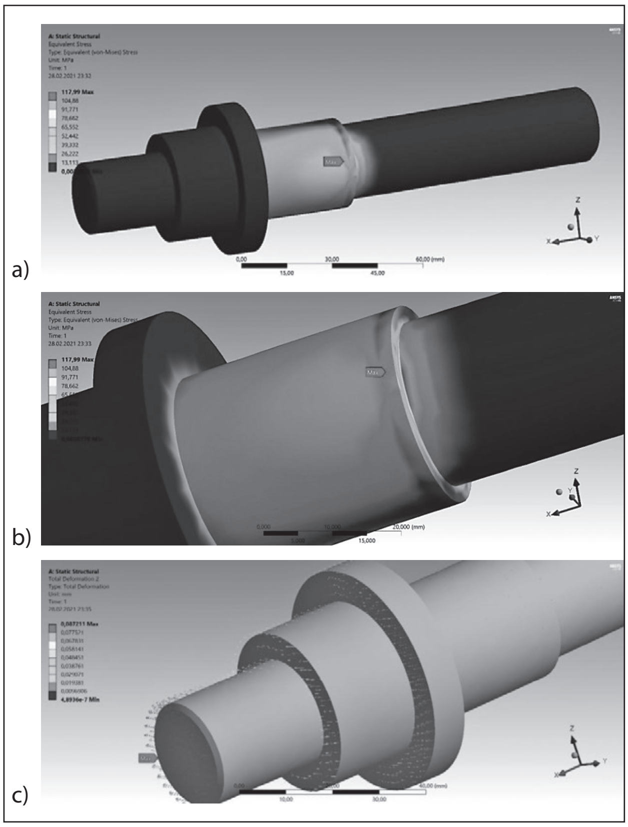

Figure 5 Graphic images of the stress distribution fields in the body of the intermediate shaft, a) distribution of equivalent stresses in the shaft body, b) critical zone, c) values and directions of deformation of the intermediate shaft

sembly, and the maximum stress value and the most critical point occur at the transition of the steps from the diameter of 25 mm to 30 mm.

CONCLUSION

- Studies of the design and operation of a special device for turn-milling have shown that the most important node is the intermediate shaft, which is constantly subjected to high dynamic loads.

- As a result of studying the stress-strain state of the intermediate shaft, it has been found that the maximum value of the stress and the most critical point occur at the transition of the stages from the diameter of 25 mm to 30 mm. However, the values of these stresses do not exceed the maximum permissible ones and it can be concluded that the parametric dimensions of the intermediate shaft (Figure 2a) fully meet the necessary requirements for the high-quality operation of a special turn-milling device.

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