Issue   **Article**

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VERIFICATION CALCULATION OF HOOK BLOCK OF CRANE

Abstract: The results of the verification calculation of the hook block of the crane under various static loads are presented in the article. Contact stresses in the parts of the hook block of the crane were determined. The values of safety factors of the parts of the hook block of the crane were obtained.
Key words: the hook block, load, contact pressure, the safety factor.
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Introduction

A crane is a cyclical machine designed to lift and move in space a load suspended with a hook or held by another lifting device in accordance with GOST 33709.1-2015 [1]. The durability of the crane as a whole depends on the operating modes of the parts included in the design of the machine [2-3]. The design should be carried out on the basis of the

strength calculation of the parts included in the design of the crane [4].

One of the load-handling device of the crane is the hook block [5]. The configuration of the mechanism must ensure the lifting of loads of a certain mass (load capacity). The main part of the mechanism is the hook made of steel by forging or cutting elements from a metal sheet [6]. The hook configuration (single or double) is selected depending on the load capacity of the crane [7]. All parts of the mechanism must have the certain properties sufficient to operate the crane in the various modes [8].

Strength of materials of the mechanism parts is determined by means of the verification calculation performed after the design calculation. Carrying out the verification calculation using the finite element modeling method makes it possible to determine deformations and ultimate strength of the mechanism parts in a three-dimensional representation.

Materials and methods

The deformation analysis of the hook block of the crane was performed using Autodesk Inventor Professional 2022 (Build 260153000, 153). The three-dimensional solid models of the parts included in the assembly were built for the calculation. Next, the parts models were assembled into the mechanism. All models of the parts were given the properties of steels in accordance with IS 24.191.08-81. The total mass of the mechanism was 57.7984 kg, the volume was 7415310 mm^3. The general view of the model of the hook block of the crane, applied loads (5, 10, 15 and 20 kN), selected supports (hinge), partitioning into the finite elements and the materials properties of the parts models are presented in the Table 1.

Table 1. The initial conditions for simulation.

| Front view | Top view | 3D view | Partitioning into the finite elements, load application and hinge definition |
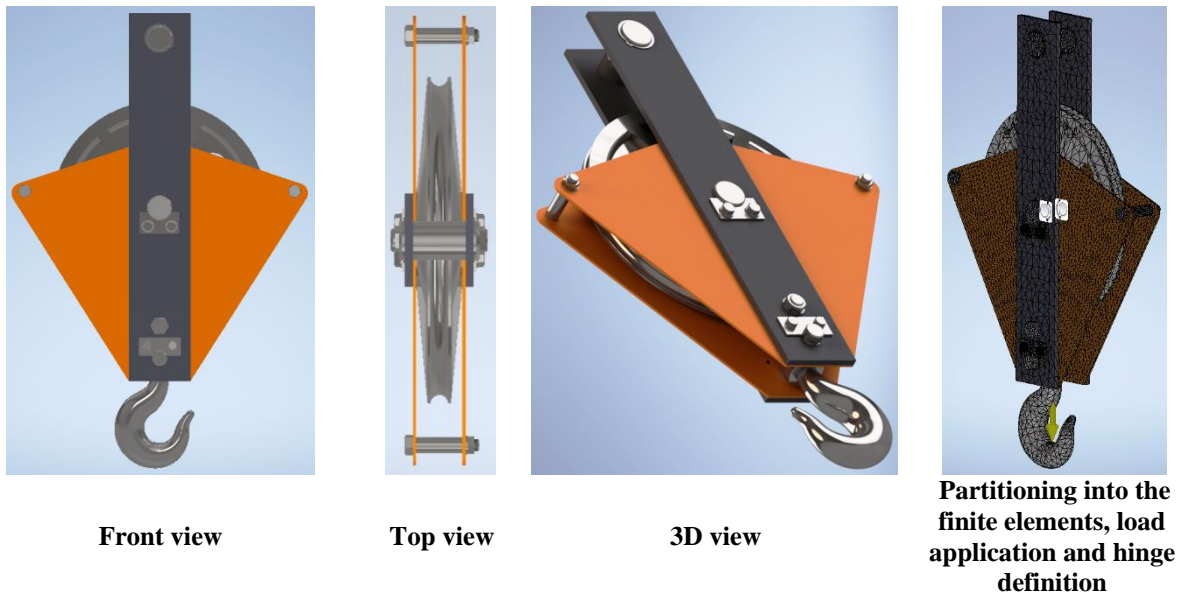
Part name	Parameter	Value
Casing spacer, rib, shaft, hook retainer, casing, upper stop, pulley shaft retainer, rod	Mass density	7.73 g/cm^3
	Yield strength	250 MPa
	Ultimate tensile strength	400 MPa
	Young's modulus	205 GPa
	Poisson's ratio	0.3
	Shear modulus	78.8462 GPa
Pulley, fastener, hook	Mass density	7.85 g/cm^3
	Yield strength	275.8 MPa
	Ultimate tensile strength	448 MPa
	Young's modulus	200 GPa
	Poisson's ratio	0.287
	Shear modulus	77.7001 GPa
M12-6g×16(S18) bolt, M16 nut, washer, M16-6g×85(S24) bolt, 42000 series bearing, 16 L washer, M22 nut, 8000h series bearing, 22 L washer, A 50 ring, M22-6g×105	Mass density	7.85 g/cm^3
	Yield strength	207 MPa
	Ultimate tensile strength	345 MPa
	Young's modulus	220 GPa
	Poisson's ratio	0.275

| bolt, M10-6g×10(S16) bolt, M10×1.5×16 heavy hex head screw with collar, M12-6g×14(S18) bolt | Shear modulus | 86.2745 GPa |

The value of the mesh element made it possible to obtain the required accuracy of the calculation results. The average element size of 0.5 and the heterogeneity factor of 1.5 were adopted for this calculation. Detection and elimination of the rigid body modes and separation of shear stresses of the contact surfaces was provided in the static analysis.

Results and discussion

The stress and strain state of the mechanism parts is represented by the color contours of contact pressure (the Fig. 1). The scale to the left of the mechanism model determines the intensity of contact pressure when loading the hook. It is noted that at a load of 5 kN, contact pressure is distributed on the surfaces of the parts that provide the hinge joint and the hook fixation. The maximum value of contact pressure (15.76 MPa) was determined in the hook retainer. The surfaces of the parts of the hinge joint are subjected to pressure to a lesser extent. The calculated maximum values of contact pressure at a load of 10, 15 and 20 kN were 31.52, 47.28 and 63.04 MPa, respectively. Thus, it can be assumed that at a load of 1 kN on the hook, contact pressure in the retainer will be 3.15 MPa.
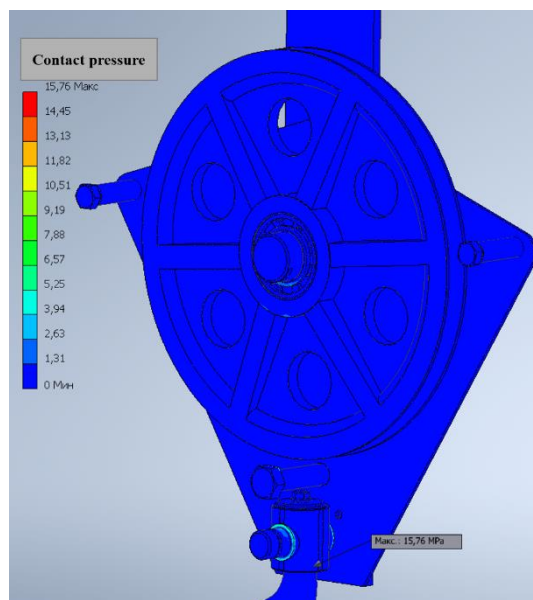

Figure 1. Contact pressure on the mating parts of the hook block of the crane.

The other calculated values of the parameters of the stress and strain state of the mechanism parts are presented in the Table 2. The authors would like to note that the static analysis assumes a linear dependence of the change in the stresses and strains values under conditions of increasing load. The von Mises stress is 2/3 of yield strength of material of the fasteners at maximum load [9]. In accordance with the calculated values of the safety factor [10] in the loads range of 5-15 kN, strength of materials of the mechanism parts is excessive, and at a load of 20 kN, strength of materials is sufficient.

Table 2. The calculated values of the safety factor, von Mises stress and displacement.

Load, kN	Safety factor (min)	von Mises stress, MPa	Displacement, mm
5	9.08	30.36	0.04714
10	4.54	60.73	0.09428
15	3.03	91.09	0.1414
20	2.27	121.5	0.1886

Conclusion

The performed computer calculation provides a qualitative check of strength and determination of the load norms of the mechanism according to the proposed dimensions, geometric shapes and materials of the parts. In particular, the maximum loaded zone was determined, located on the mating surfaces of the threaded part of the hook and the retainer. The safety

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margin of materials of the mechanism parts is sufficient when lifting the loads weighing up to two tons. In the range from 500 kg to one ton, the minimum value of the safety factor decreases by half, and in the range of 1.5-2 tons, the value of the coefficient decreases by 1.33 times.

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