

**ФАН ВА ТЕХНОЛОГИЯЛАР
ТАРАҚҚИЁТИ**
**РАЗВИТИЕ НАУКИ И
ТЕХНОЛОГИЙ**



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ТАРАҚҚИЁТИ

ИЛМИЙ – ТЕХНИКАВИЙ ЖУРНАЛ

РАЗВИТИЕ НАУКИ И

ТЕХНОЛОГИЙ

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OPTIMAL ANGLE OF INSTALLATION OF THE EKG EXCAVATOR BOOM

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Annotation. The optimization of metal structures of steel wire rope excavators with booms is discussed. The stages of optimization of the excavator boom are considered. The intermediate results of the optimization are shown in the form of a graph of the distribution of equivalent stresses, showing the dependence of the angle of attachment of the lower part of the boom on the angle of attachment.

Keywords: quarry steel wire rope excavator; metal structure optimization; finite element method; articulated axle; optimal mounting angle.

ОПТИМАЛЬНЫЙ УГОЛ УСТАНОВКИ СТРЕЛЫ ЭКСКАВАТОРА ЭКГ.

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Аннотация. Обсуждены вопросы оптимизации металлоконструкций канатных экскаваторов стрела. Рассмотрены этапы оптимизации стрелы экскаватора. Промежуточные результаты оптимизации представлены в виде графика распределения эквивалентных напряжений в зависимости от угла установки нижней части стрелы.

Ключевые слова: карьерный стальной канатный экскаватор, оптимизация металлоконструкций, метод конечного элемента, шарнирно-сочлененная ось, оптимальный угол установки.

EKG EKSKAUTORI STRELASINI OPTIMAL O'RNATISH BURCHAGI

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Annotatsiya. Maqolada strela bilan po'lat sim arqonli ekskavatorlarining metall konstruksiyalarini optimallashtirish masalalari muhokama qilingan. Ekskavator strelasini optimallashtirish bosqichlari ko'rib chiqilgan. Optimallashtirishning oraliq natijalari ekvivalent kuchlanishlarni taqsimlash, strelaning pastki qismini o'rnatish burchagiga bog'liqligi grafik shaklida taqdim etiladi.

Kalit so'zlar: karyer po'lat sim arqonli ekskavator; metall konstruksiyani optimallashtirish; yakunlovchi element usuli; bo'g'inli o'q; optimal o'rnatish burchagi.

Introduction. Sooner or later, construction and road machinery designs have to be optimized. The reasons are problems with machine reliability, increased ergonomic requirements, the desire to increase productivity without resource losses, and much more. Such issues are especially acute when designing and operating heavy and super-heavy machines, since the slightest gain in a separate optimization direction gives a significant long-term effect.

Separately considering the class of excavators for stripping operations and mining, we can highlight excavators with a straight shovel with rope control. These machines are well known and quite common. Although recently they have been replaced by excavators with hydraulic drive of working equipment, nevertheless, in the conditions of a harsh northern or very hot tropical climate, rope excavators have a number of advantages. This is a lower sensitivity of electromechanical drives to temperature and humidity changes compared to hydraulic drives. There are practically no problems with starting mechanisms at significant negative temperatures, long overhaul cycles and equipment service life. In addition, our country has a significant fleet of rope excavators and a well-established infrastructure for the repair and maintenance of these machines. In light of the above, the relevance of improving rope excavators is obvious [1, 2, 4].

A patent search for solutions and designs related to this topic made it possible to identify the direction of application of efforts. Analysis of the search results revealed the vagueness of the recommendations for selecting the geometric parameters of articulated two-section booms of rope excavators. A number of patents for articulated boom designs belong to OOO IZ-KARTEKS, a domestic manufacturer of rope excavators, part of OAO Izhorskiye Zavody. Thus, the application for an invention proposes to install the lower section of the boom of a rope excavator at an angle to the horizon of at least 45°, and the upper section relative to the lower section at an angle different from 0°.

Therefore, the working bodies of rope excavators were considered in order to formulate recommendations for the assignment of optimal geometric parameters using the example of an articulated two-section boom of the EKG-10 excavator (Fig. 1, a). Optimization of the main geometric parameters of the articulated boom should be carried out in stages. First, the optimal installation angles from the horizontal of the upper and lower sections of the boom are determined, then the optimal ratios of the lengths of these sections are determined between themselves, and at the final stage, the cross-sections of the metal structures are optimized. The optimization criterion is the minimization of equivalent stresses in the sections of the structural elements, as well as an increase in the productivity of the machine as a whole [5,6,9].

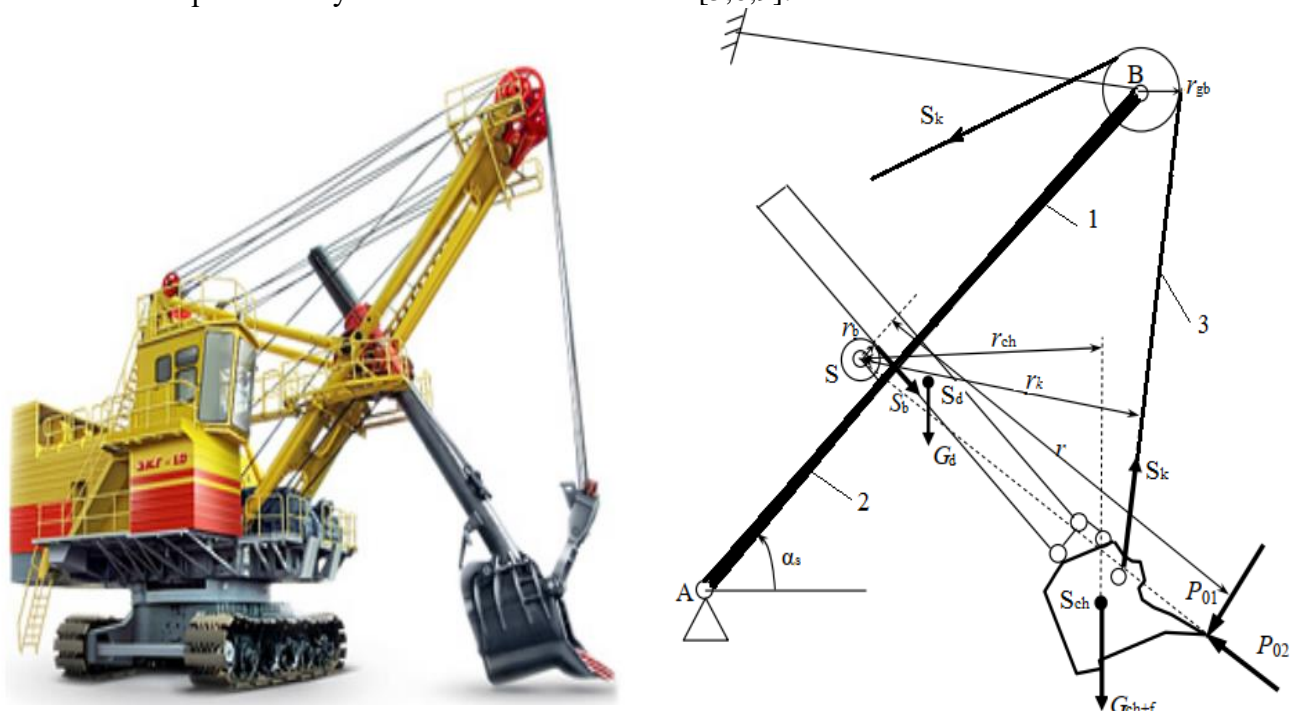


Fig. 1. Quarry single-bucket excavator with rope control EKG-10

We are currently in the first stage of design optimization. The intermediate result of this work is recommendations for selecting the optimal installation angle for the lower section of the EKG-10 excavator boom (Fig. 1, b). The angle range from 40 to 60° for installing the lower section of the boom 2 (Fig. 1, b) from the horizontal was considered with an unchanged position of the upper section of the boom at an angle of 35° from the horizontal 1 (Fig. 1, b). The maximum traction force of the lifting winch of 1300 kN and the gravity force of the soil in the bucket of 400 kN were taken as the design load. These loads and all mass characteristics are taken from the manufacturer's data. This module of the CAD system uses the finite element method, i.e., the entire structure is represented by a set of finite elements (node, rod, and plate). The necessary nodes were fixed in space to create structure supports by imposing restrictions on the degrees of freedom. All active forces and mass characteristics acting from the pressure mechanism and the handle with the bucket were replaced by reactive forces on the boom head and the pressure shaft in the joint of the upper and lower sections of the excavator boom (Fig. 2, a).

Four calculated positions of the handle with the bucket relative to the boom were considered:

- 1) start of digging - the handle is vertical, the bucket teeth are at the level of the excavator parking;
- 2) the handle is at maximum reach, axis 3 (Fig. 1, b) of the bucket hoisting rope is vertical;
- 3) the cutting edge of the bucket teeth is raised to the height of the pressure shaft axis, while the bucket hoisting rope is vertical;
- 4) the cutting edge of the bucket teeth is raised to the height of the pressure shaft, the handle is extended as much as possible.

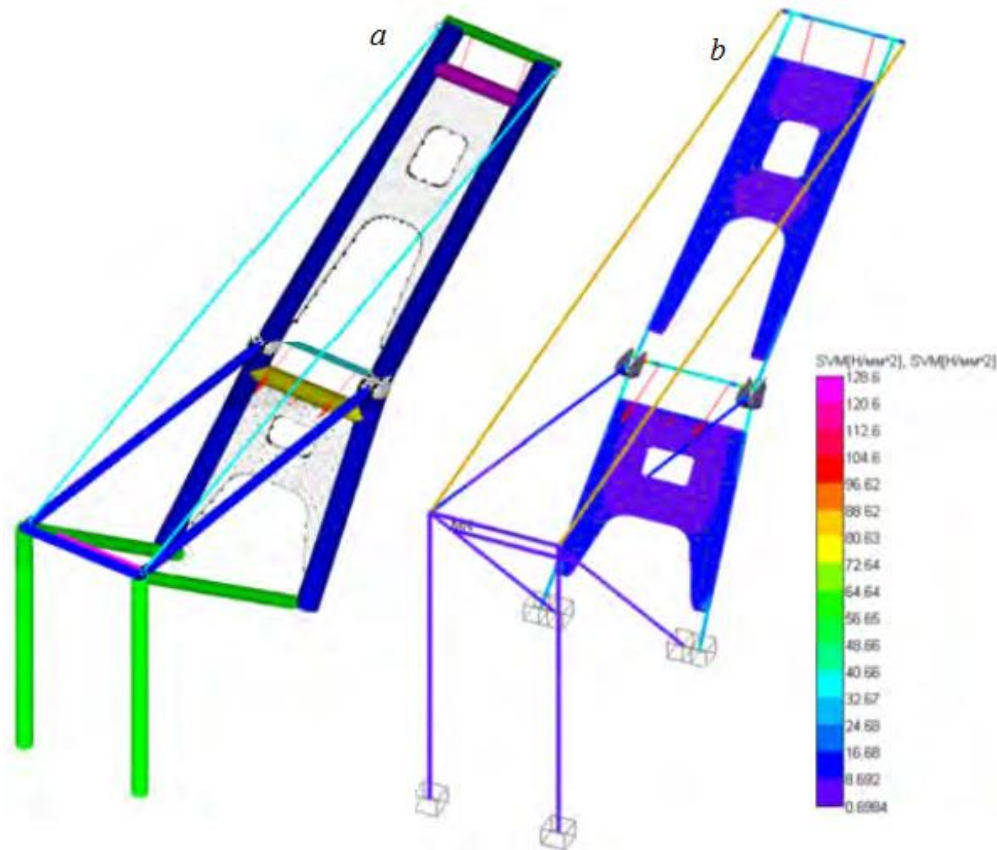


Fig. 2. Calculation scheme of the structure at various stages of calculation: a – 3D model; b – typical distribution of equivalent stresses

The result of strength calculations in the computer-aided design system was the distribution of equivalent stresses in the elements of the excavator working equipment, as well as a map of the distribution of the safety factor. A typical view of the 3D model and the distribution of equivalent stresses is shown in Fig. 2. After processing the calculated data based on the recommendations, graphical dependencies of the maximum equivalent stresses in the elements of the excavator working equipment on the installation angle of the lower section of the boom were obtained. The graphical dependency (Fig. 3) was constructed for each of the four calculated positions presented above.

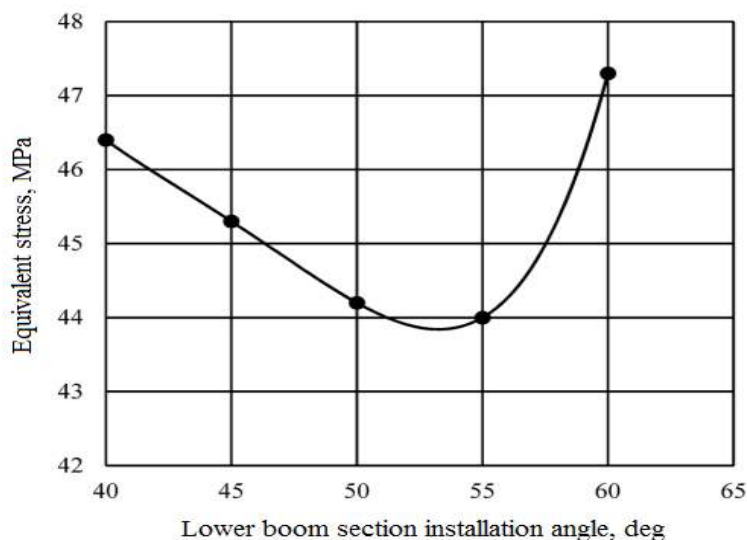


Fig. 3. Graphic dependence of maximum equivalent stresses on the installation angle of the lower boom section for the third calculated position

Conclusion. The analysis of the dependence of the maximum equivalent stresses on the installation angle of the lower boom section for all design positions shows that the dependence graph is extreme in nature with a clearly expressed minimum, which is in the range of the installation angle of the lower boom section of 45–55°. The level of maximum stresses in the metal structure of the lower boom section drops by 8%. The results of the study show the presence of a significant effect and the correctness of the chosen optimization direction.

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