STUDY OF THE LOADS ON BUCKETS AND CUTTING ELEMENTS OF QUARRY EXCAVATORS DURING DIGGING AND CUTTING

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ABSTRACT

This article examines the research and their analysis of the loads formed in the sink and cutting elements of career excavators. In addition, on the basis of analytical expressions, research and analysis were conducted on the possibility of changing the constructive properties of the sink and its elements in order to achieve reasonable consistency characteristics, maintaining technical requirements and working equipment indicators.

Keywords: excavator, hopper, cutting element, loading, digging, working equipment, resistance, thrust forces, Mountain Sex, edge.

INTRODUCTION

In the excavation – loading work, the theoretical study of the loading and impact of career excavators on the digging and cutting of mountain rocks using the cutting elements of the Sink plays an important role in their work, which forms them with the rocks of the mountain.

When separating the parts from the massif of the mountain sex with the excavator sink, the following resistance occurs.

The force acting on the train of the main movement of the working member in the direction along the attempt

$$P_{01} = P_P + P_T + P_П \quad (1)$$

here, the P_R, P_t and P_p are the founders of the resistance force of the attempt;

P_r-the strength of the resistance at the entrance of the front edge of the working member to the rocks, which depends on the width and thickness of the piece, the geometry of the working instrument and the category of rocks; P_r is the coefficient of resistance of rocks to the cross section of the $k_f^{\ p}$, and F is the coefficient of

$$P_{01} = K_F^p = K_F^p tb \quad (2)$$

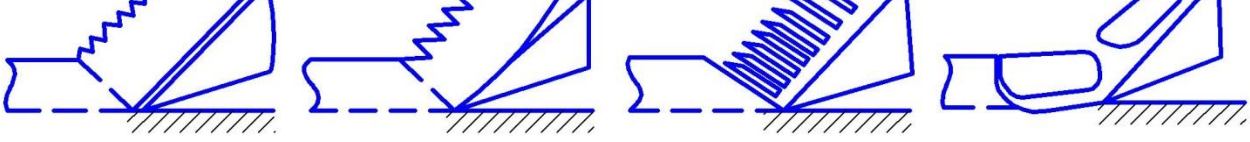
here, t and b-respectively the thickness and width of the piece;

Pt-the resistance force of the friction of the working member to the sex increases with the increase in the transfer force, which is necessary for the deepening of the working member to the sex (especially impassable;

P_p-the resistance force generated by the rock of the working member from the longitudinal or transverse Silge of the edge of the working member or from the prism Silge (stretch) of the rock in front of the working member, as well as the resistance force exerted by the rock of the working member.

LITERATURE ANALYSIS AND METHODOLOGY

Depending on the type and condition of the rocks, as well as the cutting angle, which is separated by the wedge part of the cutting member, the piece will be of different shape. In plastic jeans, the sharp edges separate the spilled pieces that enter the sink in the form of an undissolved stream at the entrance (Figure 1A). With an increase in the hardness of the rocks as well as the passing of the cutting corners and edges,the degree of grinding of the edges increases (Figure 1 b,v, g), the permeability of the latter at the entrance to the sink worsens. And finally, when cutting low-tying rocks, a stretch Prism is formed (Figure 2 a) before the working member (Figure 2 A), either part of the eaten piece (not so large in the connecting rocks) or the whole piece (in the low-tying rocks), its amount decreases at the end with an increase in the slope angle and depends on the traction (Figure 2 b).



1-picture. Types of Edge: a-spill; b-splinter;v-broken; g-interrupted

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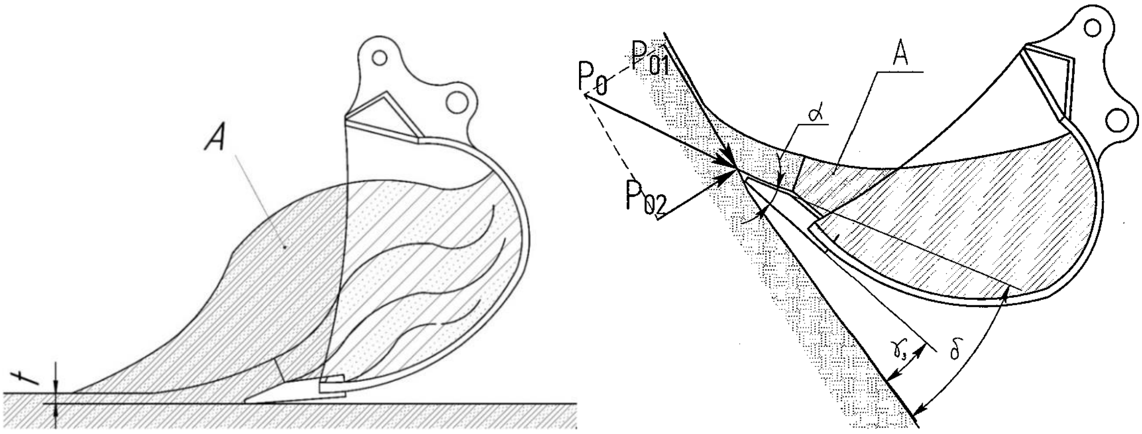
At the current slope of the train (more than 45º), the prism slides from the sink, forming a "hat" when the working member breaks away from the excavation site. In the horizontal train of low – bound dry and blown rocks, the size of the stretch prism can reach 0,5 E (e-working member capacity), and in the connecting solid rocks (0,15÷0,2)E. For these conditions, when it reaches the limit dimensions of the prism, the excess of the latter sex goes to the valices formed on the side of the working member. Work on the stretch Prism, which is spent on the Silge of the rocks, is usually lost, because when lifting the sink, the stretch prism remains in the digging place.



2-picture. The prism of stretching in the squat train: a-horizontal; b-inclined

The amount of power P_{01} and the relative amount of its three constituents depend on the hardness of the rock and the structure of the sink. With an increase in the hardness of the rock, the absolute amount of strength increases, which leads to a decrease in their relative amount. The right shovel with the most favorable conditions for the operation of the excavator sink (the high slope of its trarektori to the horizon at the peak of the sink) contributes to a significant reduction in the amount of P_p power compared to its importance in working with draglayn.

Prof. N.G. Dombrovsky [1] recommended to determine the thrust force according to the following formula

$$P_{01} = K_F^p = K_F tb \tag{3}$$

here, K_F is a coefficient of resistance of the Mining Rock, which is experimentally determined and takes into account all types of resistance that occurs in the sink (shear, friction and resistance to deposition of the sink.

In the normative direction to the train, P_{02} is formed resistance force to the entrance of the working member edge to the working member side or the sex directed to the massive side (equivalent to the transmission voltage).

Depending on the type of machine (the structure of its working member, the size of the impingement of its click, traction and other factors), the normative reaction from the sex side of P_{02} is determined by the following expression:

$$P_{02} = K_1 P_{01} \quad (4)$$

bu yerda, K_1=0,1÷0,95 — proportsionallik koeffitsienti (o'tmas kesuvchi element va juda qattiq tog' jinslari uchun katta ahamiyatga ega).

P_0 the full strength of the resistance to digging in the sink (see Figure 2B) consists of attempts to traektoriya, which form the rocks of the mountain to grind P_{01} and its normative organizer R_{02}. The endgisi is in the direction from the mass, equal to the normative organizer of the pressure-giving voltage. P_{02} force in the direction to the sides of the massif of its rocks helps to deepen the working member. Deepening of the Crucible is observed in the separation of relatively thin cuttings, which do not pass through the teeth (with cutting edges), as well as in more than 60º corners of the cut, when the deepening is observed in the separation of thick cuttings, which are cut with sharp edges at non-large corners of the cut.

The value of P_{02} (0,1÷0,15)in the optimal form of the cutting edge and in the same plastic rocks does not exceed P_{01}. P_{02} resistance strength can be increased in 1,5-2 times and more than P_{01} when working in well unexploded digging areas and impassioned cutting edges.

The impingement and ingestion of the cutting tool has an independent effect on the resistance of the rocks to decay. Even the normally permissible ingestion of the cutting tool can increase the resistance of forces to digging by 1,5-2 times. The strength of the resistance of the eaten instrument to sex increases slowly with the increase in the thickness of the cut, and at its almost zero thickness is not equal to zero. Relying on the core strength of The Tig input, the additional power will bring about a significant increase in the P_{01} digging resistance power, and the P_{02} norm is a serious change in the organizer.

The impact of cutting edge geometry and the dimensions of the excavating process on the magnitude of the digging resistance force is determined by experiment. The dimensions of the process include the following: the speed of movement of the working member, the size of the part and the nature of the static or dynamic influence of the working member on the rocks on its location relative to its predecessor.

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The effect of the cutting angles δ, the sharpness α of the teeth (cutting edge) and the back yz sharpness 2 B - is described in the picture.

The cutting element differs according to its static and kinematic geometrical dimensions and is shown in Figure 3.

Static dimensions determine the shape of the working part of the instrument. Static dimensions in wedge-shaped teeth and at the cutting edges are as follows: sharp angle α — ∠AOC, rear angle yz — ∠COD, cutting angle δ = α + yz, the angle of inclination on the side of the tooth ψ— ∠RON.

The kinematic dimensions of the tooth determine the mutual location of its working limits and the surface of the digging site in the process of cutting in the space siljas of the tooth with some speed.

In the general case, under the influence of vr on the cutting speed during the processing of teeth, the transmission can be silenced in three mutually perpendicular directions under the influence of V_n and side silencing V_b.

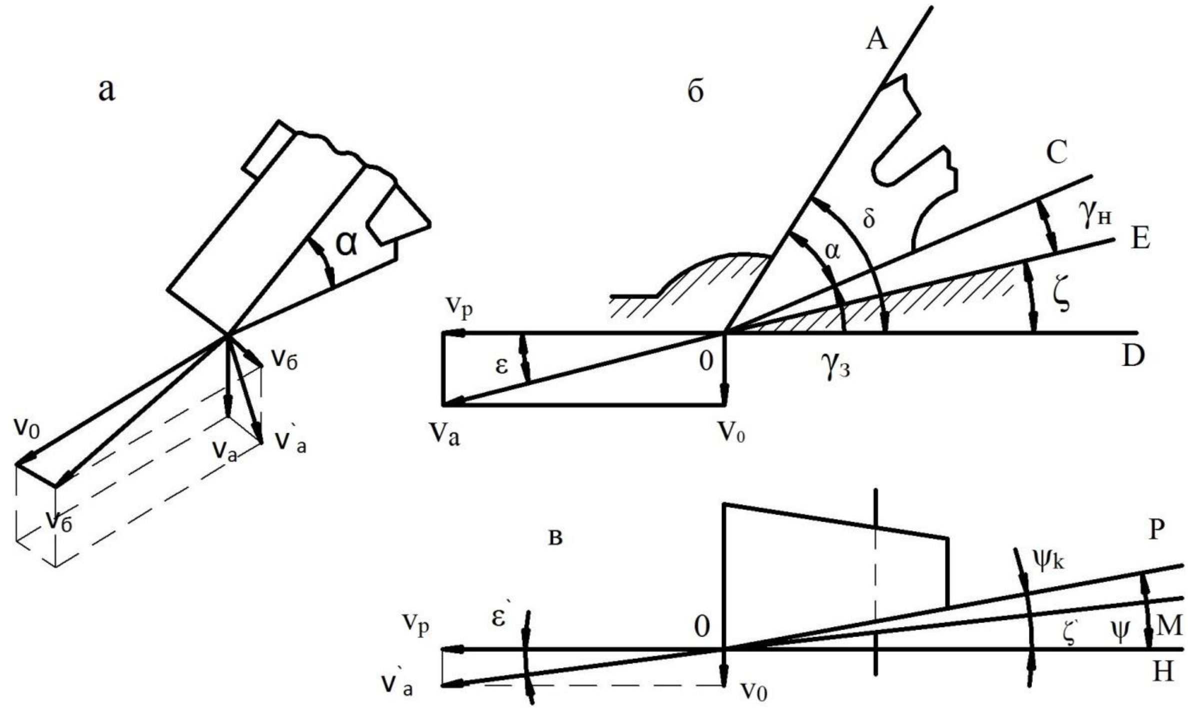
The quantities of the deviation angles of the working member movement train ζ, ξo, y_z and ψ_k are determined from the following expressions:

$$\xi = arctg \quad v_n / v_p ;$$
$$\gamma_к = \gamma_з - \xi;$$
$$\xi^{'} = arctg \quad v_б / v_p ; \tag{4}$$
$$\psi_к = \psi - \xi.$$

In the operation of mining machines, V_n and vb speeds are much less than V_r speeds, and ζ and ξo angles are not large, but it is worth taking into account, because in small values of the magnitude of yz and ψ angles, their kinematic values can be zero yk and ψ_k, or even negative. In the last case, it is important that the edges of the back and sides of the tooth (sink) to the sex friction.

For the normative functioning of the gums and its teeth γ_k and ψ_k the size of the corners is selected from the following fasteners:

$$\gamma_к = \gamma_з - \xi_{max} = \gamma_з - arctg\, v_{p\max} / \quad v_{r\max} ;$$
$$\psi_к = \psi - \xi^{'}_{\max} = \psi - arctg\, v_{b\max} / \quad v_{r\max} . \tag{5}$$



3-picture. Geometrical dimensions of the cutting element and its velocity vectors: a — in Space; b and v-in vertical and horizontal planes

RESULTS AND DISCUSSIONS

The cutting angle δ has a great influence on the cross-section resistance of the rock, and it is usually set at 30-40º limits. Because the increase in the cutting angle from 40º to 60º will double the resistance of the vertical direction of the tooth beam. On the other hand, an extreme decrease in the cutting angle (30º less) can occur with increased resistance, especially when cutting along the folding of rocks. Given the fact that the chewing teeth are eaten, the cutting edges and the angle of sharpness of the teeth α should not be taken less than 20º for plastic grinds and 22-25º for heavy stone rocks. It is recommended to keep the back corner within 5-8º limits.

In order to reduce the overall resistance of the sink to penetration into the rock, it is desirable to exclude the presence of the side walls of the sink when cutting, for this it is necessary to rub them either from the middle part and tilt them back at an angle of 30-40º, or to push away the front cutting edge (tooth).

Teeth increase the comparative load on the gums 2-2,5 times, this will relieve the process of its decay. The teeth should be smaller than the earring, this will ensure their necessary consistency. Sharp teeth on a flat cutting edge in dense rocks, compared with impacted teeth due to ingestion, contribute to a decrease in the overall resistance to digging by 8-15%, a decrease in the resistance to cutting byilikni 16-35%.

To increase the load on the Sexes, the width of the teeth is made as small as possible. The load on the width of the tooth 1 cm should not exceed 7 cm. The distance between the teeth they are obtained is equal to 1,2-1,25 of their width. Reducing this distance leads to an increase in the aggregate width of the teeth, accordingly, the resistance of the rocks to the exudation increases. At the same time, the increase in the distance between the teeth leads to the fact that the chewing gum between them is eaten, because the rock between the rocks does not break down, and the chewing gum does not eat them. The ingestion of teeth occurs along the edge of the back. The permissible level of tooth decay is indicated in the factory instructions for use.

M. S. In a similar study on this topic by Turgunbaev, it was considered that the long-term performance of exkavato's resistance to working weights in the excavation of mountain rocks with decayed chewing teeth leads to the fact that the effects of loading and fatigue do not pass through the teeth of the sink [2]. He determined the expression of an effective analytical calculation between the loading processes in the metal structures of working teeth in the extraction of Mountain Ash with teeth of different impurity, as well as the calculation of the coefficient of account of the effects of tooth decay and the equivalent amplitude loading of Mountain Ash. M. S. In his calculations, Turgunbaev learned that when designing a sink and other working equipment using computer-generated software, only one parameter changes, that is, the rate of Decay changes in percentage or metric form. Therefore, the determination of the effect of other structural parameters of the cutting elements is considered promising from the point of view of conducting scientific research.

Comparing with experimental and theoretical studies [3], the author concluded that the impingement of the teeth to 25-30 mm leads to an increase in the frequency of vibration loading by 30-45% and the value of the amplitude loading indicators. Turgunbaev developed a method of calculating the metal structures of the working equipment for the durability of the excavators, which made it possible to assess the impact of YASA on the wear and tear of the teeth, the loading and durability of the metal structures of the working equipment, to determine the highest loading amounts.

In the process of analysis of the impact of the cutting speed, the cutting speed not exceeding 4-5 m/s is almost unknown at the average resistance to digging. However, the speed at which linear deformation is formed in some rocks with a cutting speed exceeding 5 m/s is the same dimensional as the speed of tool movement, which results in an increase in the resistance of rocks to decay. The effect of the cutting speed is very known in large corners of the cut.

Interaction of the size of the sink and the size of the piece. The increase in dimensions, accordingly, with an increase in capacity, the resistance to digging when working on hard rocks of medium hardness, except for the exploded rock, decreases, depending on the type of rocks, where the constant interaction between the width of the sink and the tear of the piece is maintained, this tension almost does not change.

N.G. According to dombrovsky's Formula [1], the thickness of the edge t and the width of b affect the absolute magnitude of the resistance force and the resistance of the excitation rocks. P_{01} strength in F constant area of the edge must also be constant, but this is not confirmed in the experiment. The resistance of excavated rocks decreases with the increase of K_F shavings Area F, it can be concluded that the expediency of rock mining with large capacity mining machines with large capacity of the bunda sink. Physically, this situation is explained by a low degree of grinding of the volume of the mass of the Rock (less work is spent on grinding the material).

An increase in the thickness of the shavings for a single sink of the same leads to an absolute increase in the coefficient of K_F digging resistance, but to a lesser extent this is for large-capacity sinks. This situation confirms that the mean values of the K_F coefficient, which are given in the calculation of the excavators, can be used. and the category of rocks with an increase in the strength of the excavators indicates a decrease in the impact.

[4] the work is of great interest from the point of view of determining the theoretical basis for the breakdown and excavation of the rocks depending on the parameters of the structure of the elements cutting the rock, the technology of the work. On the basis of theoretical data and statistical studies it will be possible to calculate and determine the structure and technological parameters of the hopper and cutting working elements of Rotary excavators. On the basis of calculations should be based on the study of technical requirements and the possibility of changing the constructive properties of the sink and its elements in order to achieve reasonable consistency characteristics while maintaining the indicators of the working equipment.

The total resistance that forms in the excavation of the Rock [5] is determined by the formula Dombrovsky-Goryachkin P_{01} as a function of the coordinate of the motion path of the cutting edge of the element that breaks the rock, in which the thickness of the scraper $P_{er.k}$ the effect of variability is taken into account:

$$P_{01} = P_{01}^{*} \cdot (1 - m^{*}) + P_{er.k} \qquad (6)$$

here, P_{01} is the resistance that forms in the excavation of the rock without taking into account the change in the thickness of the edge;

m* - the percentage of free cutting resistance P_{01}* Content (as a result of Y.V.Vetrov's scientific research).

Theoretical studies conducted by S.Kuzmin [6] suggest that depending on the rotation and shear train, loads on the structural elements of the shear elements of the sink change, but do not determine the solution of loads to specific structural elements taqsimlash.

But in the proposed theory work, it can be useful from the point of view of calculating the cutting parameters for flat, one and two surfaces formed in the case of pre-excavation from the schemes studied.

$$P_{er.k} = k_1^l bR(1 + Cos\psi)\frac{Cos\alpha - Cos\alpha_{gr}}{1 + Cos(\psi - \alpha)} \qquad (7)$$

or without size,

$$\eta = \frac{P_{er.k}}{k_1^l bR} - (1 + Cos\psi)\frac{Cos\alpha - Cos\alpha_{gr}}{1 + Cos(\psi - \alpha)} \qquad (8)$$

where, k_1^l – comparative resistance to the intersection of the mountain sex; b – width bucket; R - radiusi rotation of the edges of the teeth of the bucket; α_{gr} – the cutter is half the angle of the guy; $\alpha -$ the angle of rotation of the current bucket; $\psi = \delta + \varphi + \rho$ ($\delta, \varphi, \rho -$ cutting, internal and external friction angles, respectively)

The formula for determining the resistance of a rock to surface shear is obtained by solving the equilibrium equations of forces acting on the front surface of the cutting element and the elastic surface of the rock and in accordance with Coulomb's law. The length l of the cutting surface of the rock and its angle b (Fig. 4) are determined by the minimum impact force condition acting on the front edge of the cutting element along the trajectory of the cutting element.

Analysis of the work on the effect of geometric parameters of rock cutting elements showed that in order to obtain such values, changes in their design properties and technological parameters during the excavation process, as well as the most important components of the bucket and cutting elements and the possibility of detecting the least occurring loads in the rock-cutting elements themselves has not been sufficiently studied.

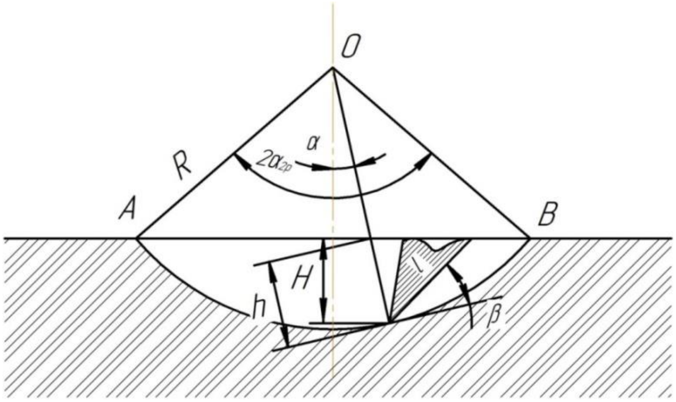


Figure 4 Scheme for calculating the parameters of the cut in the initial plane

CONCLUSION

Solving such a problem requires identifying the key factors that affect the description and size of the loads on the components, increasing their reliability and the probability of trouble-free operation of the entire bucket and its individual elements.

According to the results of the analysis, one of the main tasks is to determine the edge of the excavator bucket, the structural structure of the cutting elements, their location and the amount of loads distributed to them. Thus, on the basis of the development of the design of excavators, it will be possible to develop theoretical calculations and experiments to increase their efficiency.

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