UDC 622.271

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THE IMPACT OF THE GRANULOMETRIC COMPOSITION OF GRAVEL-SAND MASS OF FLUVIOGLACIAL DEPOSITS ON THE OPERATIONAL CHARACTERISTICS OF THE RIPPER

Abstract: *The results of scientific research to establish the influence of the granulometric composition of fluvioglacial sediments on the productivity of bulldozer loosener for the conditions of the quarry are presented.*

It is noted that it is impossible to take into account the granulometric composition of rocks in the natural state when calculating the loosening productivity.

It is offered, at definition of productivity of ripping equipment, to take into account granulometric composition of sand-gravel mass in its natural state through certain components of already existing formulas.

For the existing natural and technological conditions of fluvioglacial deposits development at Sosnovsky quarry and characteristics of the applied working equipment the productivity of ripping for different values of the average weighted size of a piece of rock was determined. It is established that at changing the piece size from 5 to 400 mm the productivity of bulldozer loosener decreases from 583,33 to 308,54 m^3/h, i.e. 1,9 times.

Key words: *mechanical loosening of rocks, bulldozer loosener, gravel-sand mass, fluvioglacial deposits.*

Introduction. At the Sosnivske granite deposit quarry, fluvioglacial deposits are located on the overburden bench, and the rock mass in certain areas of the overburden contains 40-80% gravel and boulders [1, 2]. The excavation and loading equipment of the quarry is technically unable to handle the development of the sand-gravel-boulder mass. During preparation for extraction using drilling and blasting methods, the drill rods become jammed in the rock mass, making it impossible to drill blast holes. Based on the analysis of the current state of mining operations, the technical characteristics of the existing equipment, and the existing technological schemes for developing gravel-sand deposits, a technology for developing fluvioglacial deposits using a bulldozer-excavator-truck equipment complex with preliminary mechanical loosening of the rock by a bulldozer-ripper has been proposed [3]. Therefore, determining the productivity of loosening fluvioglacial deposits depending on their granulometric composition is a relevant scientific and technical task. Solving this task will allow for identifying the effective application area of the proposed equipment complex.

Purpose and objectives. The purpose of the research is to study the influence of the granulometric composition of fluvioglacial deposits on the productivity of the bulldozer-excavator.

The task of the research is to establish the regularities of change in the productivity of the bulldozer-excavator from the granulometric composition of sand and gravel mass at the open-pit mine.

Material and results of the research. The advantages of mechanical loosening include: high cost-effectiveness; safety in execution of works; absence of seismic impact on the rock mass and structures; the ability to adjust the fragmentation of the rock mass; high maneuverability and mobility of the loosening equipment in restricted working conditions.

Among the disadvantages of their use, it should be noted the impossibility and/or inefficiency of their application for preparing weakly fractured and massive rocky formations for extraction.

The analysis of existing formulas for determining the productivity of a ripper shows that, in most cases, they are identical and take into account the main parameters of the loosening process. However, when loosening such a rock mass as fluvioglacial deposits, it is also necessary to consider their granulometric composition, which can significantly affect the productivity of the ripper.

The most comprehensive consideration of the rock mass condition is reflected in the following formula:

$$Q_{\text{p}} = \frac{3600 C_{\text{o}} h_{\text{e}} k_{\text{в}}}{\frac{1}{v_p} + \frac{\tau}{L}}, \text{ m}^3/\text{hr}, \quad (1)$$

where C_{o} – optimal distance between adjacent ripper passes, m; h_{e} – depth of effective, m; $k_{\text{в}}$ – ripper using coefficient ($k_{\text{в}}$=0,7…0,8); v_{p} – technical speed of the ripper (v_{p}=0,9…1,5), m/s; τ – time for the ripper to move to the next furrow (for turn-based operation τ = 30-60), s; L – length of the parallel loosening run, m.

According to the recommendations of prof. Korobiyshchuk V.V. et al. [4], the optimal distance between adjacent ripper passes can be determined by the formula:

$$C_{\text{o}} = \frac{k_1 h_{\text{z}}}{\text{tg}\alpha} + \frac{b}{2}, \text{ m}, \quad (2)$$

where k_1 – coefficient that considers the shape of the cross-section of the furrow (k_1= $h_{\text{ch}}/h_{\text{z}}$, де h_{ch} – height of the formed fissure, m); h_{z} – maximum depth of the ripper tooth penetration, m; α – angle of inclination of the lateral walls of the cut, in degs; b – width of the cut base, m.

Effective loosening depth at optimum distance between bulldozer loosener passes

$$h_e = \frac{C_{\text{o}} \text{tg}\alpha}{2k_2}, \text{ m}, \quad (3)$$

where k_2 – coefficient that considers the condition of the rock formation regarding the size of the undisturbed ridges during parallel passes.

Considering the scientific and practical experience in studying and developing fluvioglacial deposits, as well as the recommendations of renowned scientists, it is proposed to take into account the granulometric composition of the gravel-sand mass through numerical values of k_2. In this case, the numerical values of k_2 will not depend on the values of the coefficient k_1, as it was before, but will characterize the average weighted size of the fractions of the fluvioglacial deposit massif. The table provides the proposed values of k_2 and the width of the cut base b, depending on the predominant fraction and the average weighted size of the rock fragment.

Considering the rock formation conditions and the parameters of the working area of the Sosnivske granite deposit quarry, the DP-22C ripper with the T-180KS tractor as its base has been selected, with the following characteristics: engine power – 132,4 (180) kW (hp); maximum traction force – 164 kN; speed in km/h: forward – 12,0, reverse – 7,5; tooth mounting: hinged; distance between tooth axes – 800 mm; number of teeth – 1-3 (selected 1);

maximum tooth penetration – 550 mm; width of the ripper tip – b_1=0,1 m; ripper utilization coefficient assumed as $k_в$=0,8.

Table 1 – Values of k_2 coefficient depending on the granulometric composition of the gravel-sand mass

Pregominant fractions of fluvioglacial deposits	Average weighted size of rock fragment, mm	k_2	b, м
Cemented fine-, medium-, and coarse-grained sands	0,005…5	0,80	$3b_1$
Крупнозернистий пісок з мілким та середнім гравієм	5…40	0,85	$2,5b_1$
Sands including all fractions of gravel	40…100	0,90	$2b_1$
Gravelly-sandy mass with inclusion of small boulders	100…200	0,95	$1,5b_1$
Gravel-sand mass containing all types of boulders	200…400 and more	1,00	b_1

According to the classification based on the degree of loosening, fluvioglacial deposits belong to easily loosened materials. Therefore, we assume an average angle of inclination of the furrow walls α = 55°, a technical speed of v_p = 1,2 m/s (70-80% of the tractor's speed in first gear), and a possible tooth penetration according to the technical characteristics of the ripper $h_з$ = 0,55 m.

Taking into account the dimensions of the working area of the open-pit overburden bench, we assume a length of the parallel loosening run to be L =140 m. The time for the ripper to move to the next furrow is τ=60 s.

Given that fluvioglacial deposits belong to easily loosened rock formations, they can be tentatively classified as moderately fractured, and the value of k_1, which takes into account the shape of the furrow, is equal to k_1=1

For the above parameters of fluvioglacial deposits at the Sosnivske quarry and the characteristics of the working equipment, the productivity of the ripper has been calculated for various values of the fractional composition of the gravel-sand mass. According to the obtained data, a graphical representation of the change in ripper productivity as a function of the average weighted size of the gravel-sand mass fragment has been constructed (fig. 1).

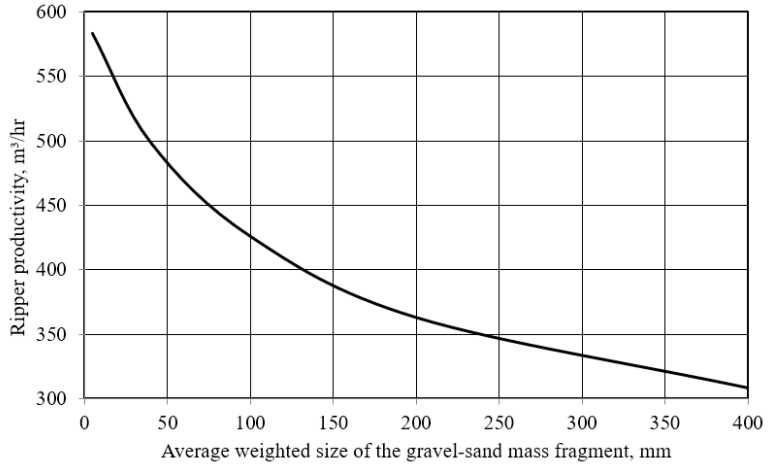

Figure 1 – Dependence of the ripper productivity on the fractional composition of the gravel-sand mass of fluvioglacial deposits

Conclusions. The analysis of the obtained data shows that, with a change in the fragment size from 5 to 400 mm (from cemented fine-, medium-, and coarse-grained sands to boulders), the ripper productivity decreases from 583,33 to 308,54 m³/hr, which is 1,9 times less. For the investigated area of the Sosnivske quarry, where the average weighted size of the gravel-sand-boulder mass fragment is 171 mm, the ripper productivity, according to the figure, will approximately be 370 m^3/hour.

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УДК 622.271

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ВПЛИВ ГРАНУЛОМЕТРИЧНОГО СКЛАДУ ГРАВІЙНО-ПІЩАНОЇ МАСИ ФЛЮВІОГЛЯЦІАЛЬНИХ ВІДКЛАДІВ НА ЕКСПЛУАТАЦІЙНІ ХАРАКТЕРИСТИКИ РОЗПУШУВАЧА

Анотація: *Наведено результати наукових досліджень зі встановлення впливу гранулометричного складу флювіогляціальних відкладів на продуктивність бульдозера-розпушувача для умов кар'єру.*

Відзначено, що при розрахунку продуктивності розпушування неможливо врахувати гранулометричних склад порід в природному стані.

Запропоновано, при визначенні продуктивності розпушувального обладнання, враховувати гранулометричний склад піщано-гравійної маси в її природньому стані через певні складові вже існуючих формул.

Для існуючих природних і технологічних умов розробки флювіогляціальних відкладів на Соснівському кар'єрі та характеристик застосовуваного робочого обладнання визначено продуктивність розпушення для різних значень середньозваженого розміру шматка породи. Встановлено, що при зміні розміру середньозваженого шматка з 5 до 400 мм продуктивність розпушувача зменшується з 583,33 до 308,54 м^3/год, тобто у 1,9 рази.

Ключові слова: *механічне розпушування гірських порід, бульдозер-розпушувач, гравійно-піщана маса, флювіогляціальні відклади.*

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