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Improving the technology of working the benches of overburden rocks on the non- transport development scheme

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Abstract
The technological scheme of working the overburden benches was developed; a relationship between the depth of advanced trench and additional height of the overburden bench was established; the cost of minerals production with the use of existing and proposed technology of benches development was determined.
Keywords: ADVANCED TRENCH, DUMP CAPACITY INCREASE, REHANDLING FACTOR, ADDITIONAL HEIGHT OF THE OVERBURDEN BENCH, DUMPS FLATTENING, SPOIL BANK CRESTS

Relevance of the problem

The current state of open pit mining operation when exploitation of the horizontal deposits, in particular, in the quarries of Ordzhonikidze OMDP indicates the presence of nature-oriented problems associated with significant changes in landscapes due to development of manganese deposit. The quarries disturb the significant areas of natural lands by outside dumps, working and permanent trenches. These drawbacks are amplified by impossibility of working out the overburden rocks benches using high-performance and low-cost technologies for the non-transport system development.

The analysis of existing researches

Well known scientific and practical solutions ensure the development of deposit with significant power of overburden solid by non-transport way based on multiple rehandling by moving rocks in the inner dump. For example, in a process scheme [1] high benches are divided into top and lower parts and form intermediate work platform of the excavator at a height that does not exceed the height of its excavating. In [2] an increase in the height of the benches is achieved by advanced dass of overburden rocks separate face, moreover the rocks are moved into the working area enabling the parameters of the face that are possible if it is developed by accepted excavator. Development of high benches in [3] is carried out by reducing their height with the help of a bulldozer with a lag by an amount which allows mining the bench by the excavator of specific model. From the results of research presented in [4] it follows that the non-transport technology of mining of the overburden solid considerably complicates works on planning the dump surface for mine technical reclamation. In addition, stripping costs are significantly increased, because the top bench is developed with the help of the transport equipment, and the lower one by rehandling of large amount of overburden rocks.

Analysis of the above mentioned works indicates the presence of significant shortcomings in them such as a significant rocks rehandling factor, a large amount of works on the surface planning of inside dumps, moreover these works are carried out with a delay of front advancing of the overburden operations, which reduces the effectiveness of the disturbed lands restoration by volume and quality and increases the cost of the process [5]. On the basis of studies [6], a considerable amount of money is spent on mining and technical reclamation, which is up to 80% of the total cost of land restoration, in particular, the removal and storage of fertile soil, as well as reducing the dumps to the parameters defined by their subsequent use.

Formulation of the problem

Taking into account these shortcomings of the mentioned high benches development methods at sheet ground exploitation the technology of mining should be developed, which will be based on the principles of continuity and parallelism of the overburden, dump and reclamation works providing favorable conditions for mining and technical reclamation and return the lands to the national economy, but also make it possible to reduce the cost of overburden operations. The general purpose of the article is to provide a technological approach to develop the high benches of overburden rocks and justify the technological scheme main parameters of the direct rocks casting in the inside dump, as well as determining the economic effect of the introduction of this technology.

The basic material of researches

The main direction of development of the opencast mining horizontal deposit systems with significant thickness of overburden massif is the implementation of high-performance low-cost non-transport system based on the technology of overburden rocks direct casting into the inside dump. However, the area of application of this system is limited by receiving capacity of the dump, which is associated with a maximum height of rocks loading by earth mover and permissible angle of dump slope. In order to increase the dumping site capacity for non-transport technology that ensures high benches development without rehandling of overburden rocks the establishment of advanced trench capacity as a working at the waste-pile toe has been proposed. This technique is implemented as follows.

The overburden bench covering the ore bed is divided by intermediate platform by the height on top and bottom accesses. It is developed with the help of two dragline excavators, one of which is located on the surface of the inside dump and by the lower digging it forms advanced trench working at the waste-pile toe of this dump. The second excavator located at the intermediate platform develops top and bottom accesses by upward and downward digging piling the overburden rocks in the inside dump and advanced trench (Fig. 1).

Stripping shovel unloads the overburden rocks from the trench working in the dump trucks, which deliver this rock to the place of unloading in the gap between the backs of the previous and filled dumped dasses. The surface of the dump at the place of dump trucks unloading is leveled by bulldozer.

As usual in the non-transport development schemes of overburden benches slope angle of the inside dump β_d is taken from the condition of its sustainability. In order to the overburden bench when the dass width of A_{ov} was placed in dumped dass with width of A_d and in the advanced trench without rehandling the condition of squares equation should be satisfied: $S_d + S_{tr} = S_{ov}$, m^2 , where S_{st} , S_d , S_{tr} are crossing squares of stripping, damped cuts and advanced trench relatively, m^2. In turn, the rocks from the trench were placed in the gap square of S_g between previous and filled dasses the following condition should be satisfied $S_g = S_{tr}$. Advanced trench depth development is determined by the formula:

$$H_{tr} = \frac{A_{ov} - \sqrt{A_{ov}^2 \left(1 - \frac{ctg\beta_{tr} tg\beta_d}{K_f}\right)}}{2ctg\beta_{tr}}, \text{ m} \quad (1)$$

where β_{tr} – the slope angle of trench capacity wall, degrees; K_f - fragmentation index of overburden rock.

Possible depth of advance trench determines the additional height $H_{a.h.}$ of overburden bench with total height of H_b that can be developed by non-transport scheme. It is defined by the formula:

$$H_{a.h.} = (A_{ov} - H_{tr}\, ctg\beta_{tr})\frac{H_{tr}}{A_{ov}}, \text{ m.} \quad (2)$$

Total height of overburden bench H'_b will be equal to sum $H'_b = H_b + H_{a.h.}$. According to formula (2) the additional bench height $H_{a.h.}$ has been determined depending on the depth of the trench H_{tr} for the conditions of manganese ore quarries (Fig. 2). When developing the bench and trenching by draglines ESH-15/90 depending on the depth of the trench for the width of stripping cut 35 and 50 m the additional height of the bench can be 3 ... 7 m.

The proposed technology of high benches development does not require leveling of the dump surface for reclamation works, as it is carried out simultaneously with filling the spoil bank crests by the dump tracks providing uniform rocks contraction.

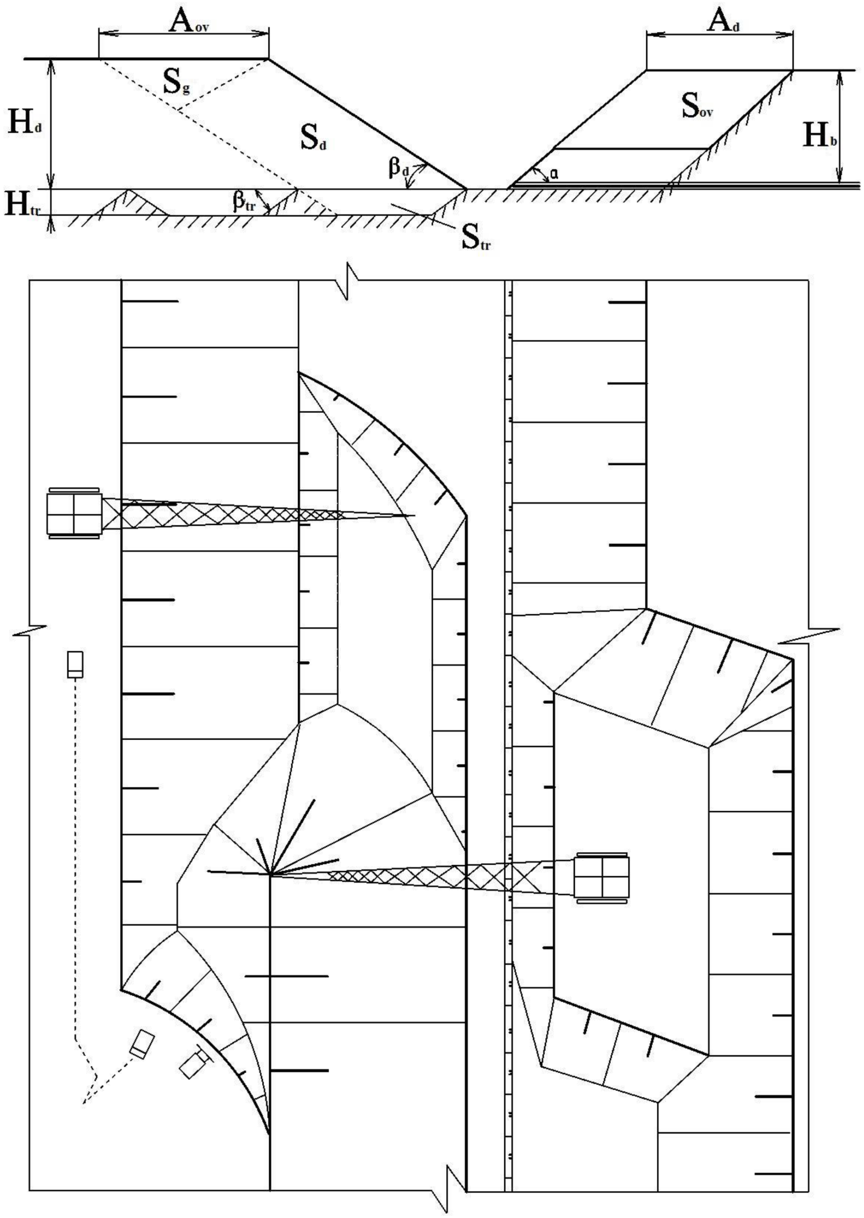

Figure 1. The suggested technological scheme of development of overburden rocks high benches

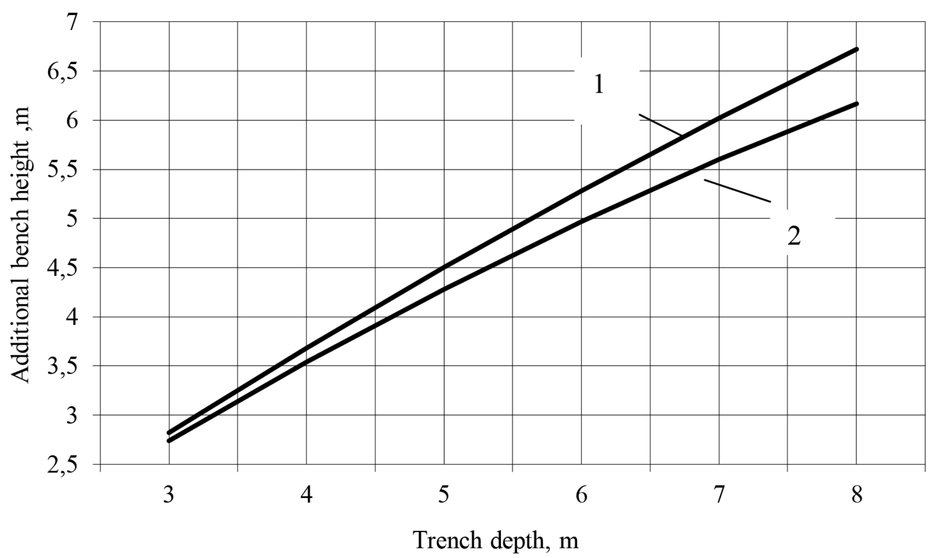

Figure 2. Dependence of the additional height of stripping cut from the depth of the advanced trench: 1, 2 - respectively, when the width of stripping cut is 50 and 35 m.

This technology creates favorable conditions for the dragline work with high performance when a small number of vehicles required for stripping works at the advanced bench: transport distance is reduced from 2000 ... 2500 m (in the traditional scheme) to 200 ... 300 m. Taking into account above mentioned effects prime cost of ore raw materials production P_t can be calculated by the formula:

$$P_t = P_o + \frac{P_c\,(H_b + H_{a.h.})}{m_o} + \frac{P_{c.tr.}\,S_{tr}}{m_o A_{ov}} + P_{1m\cdot km} L_{m.n.} \gamma_d \frac{S_{tr}}{m_o A_{ov}},\ \text{UAH/ m}^3, \quad (3)$$

where P_o – the prime cost of the ore bed mine production, UAH/m^3; P_c, $P_{c.tr}$ - prime cost of development by draglines the overburden bench and trench working respectively, UAH/m^3; $L_{m.n.}$, $P_{1t\cdot km}$ - the distance, km and prime cost respectively, UAH/1t.km, transportation of the overburden rocks by dump tracks in the gap between the dump backs; m_o - thickness of ore bed, m; γ_d - density of the overburden rocks, t/m^3.

The prime cost of mining operations at the dass width of 50 m on the proposed technology is calculated. In the case of increasing the height of the overburden bench worked by dragline ESH-15/90 for 2 ... 7 m, the prime cost is reduced by 10.9 UAH/m^3.

The economic effect from the proposed benches development method of overburden benches compared with the traditional is calculated as follows:

$$E = (P_{tr} - P_t) \cdot Q_{k.k.}\ \text{UAH/year}, \quad (4)$$

where P_t, $Q_{k.k.}$ are ore mining prime cost, UAH / m^3, and its volume, m^3 / yr respectively, when developing the overburden benches by the traditional method.

According to the formulas (3) and (4) the effect of the high overburden bench developing by the dragline ESH-15/90 on the manganese ore quarry with thickness of 400 thous. t/ yr in conditions of Ordzhonikidze OMDP has been determined. By increasing the bench height from 21.9 m to 5 ... 7 m as a result of using the proposed technology the annual costs of the mining works can be reduced by 5.2 ... 9.2 mln UAH.

Conclusion

1. The maximum possible height of the above-ore bench when its development by excavator according to the high-performance non-transport scheme is limited by receiving capacity of the inside dump, which, in turn, is limited by a radius of excavator unloading and dump slope angle. To increase the dumped capacity the technology providing performance of the trench developing at the waste-pile toe is proposed.

2. The technological parameters of trench working and the overburden bench development by draglines ESH-15/90 were defined. When the depth of the trench is 2 ... 9 m to place the overburden rocks the height of the overburden bench can be increased by 2 ... 7 m (by 20 ... 25% of the bench height when the traditional technology of its mining).

3. Placing the overburden rocks between spoil bank crests create favorable conditions for leveling the surface of the dumps and mining and technical reclamation simultaneously with advancing the front of stripping operations. As a result of switching to non-transport technology of above-ore bench development with height of 23.9-28.9 m instead of the transport, the costs on mining of the ore raw materials in conditions of the manganese ore quarry can be reduced by 5.2 ... 9,2 mln UAH.

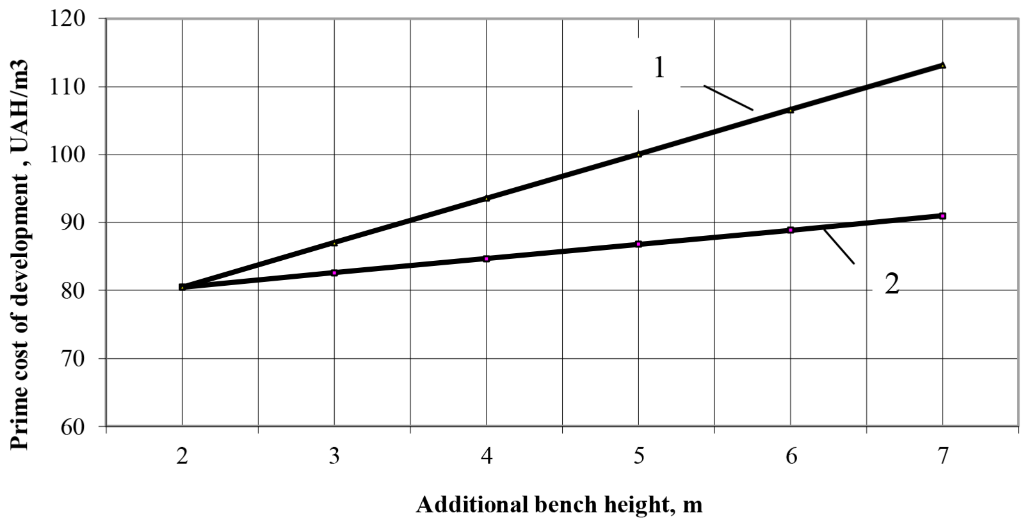

Figure 3. Dependence of the ore raw materials production cost from the additional height of overburden bench: 1, 2 - respectively, when the traditional and the proposed technological schemes of stripping works

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