Investigation of the internal dumping technology impact on open-pit boundary with the formation of temporary internal dumps when steep deposits mining

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Abstract
The method of boundaries and open pit total depth determination is suggested in the paper. The internal dumping technology impact on open-pit boundary when steep deposits mining were investigated on the basis of this method. It is proved that the use of internal dumping technology with the formation of temporary internal dumps allows increasing of the open pit total depth by 4.1-24.7%.
Key words: OPEN MINING TECHNOLOGY, INTERNAL DUMPING, OPEN-PIT BOUNDARY, TEMPORARY INTERNAL DUMP

Relevance of the work

When final pit boundary designing, the total depth, wherein the most economic benefits are obtained and mineral mining depth is ensured, must be accepted.

The advanced technology of temporary internal dumping with the formation of internal dumps allows starting of the internal dumping before open pit reaching of total depth and has an impact on it. Thus, there is the task of developing of boundaries and open pit total depth determination method with the formation of temporary internal dumps, and also its impact on open-pit boundaries and total depth.

Analysis of research and publications

A large number of scientists were involved in development of determination methods of open-pits boundaries, where the steep deposits mining is carried out. All this methods are based on design comparison principles of economic stripping ratio (n_{ec}) with such stripping ratios as incremental (n_{in}), average, operating and current stripping ratio (n_t).

In accordance with “Standards of technological design of mining companies with mineral deposits open mining technology” [1], the ultimate pit, where the steep deposits mining is carried out, is determined by incremental stripping ratio (n_{in}), which must be equal to economic stripping ratio (n_{ec}), i.e. according to design principles:

$n_{in} \leq n_{ec}$

V.V. Rzhevskiy [2] showed that current stripping ratios differ significantly from incremental ones and do not reach the maximum permitted value (economic stripping ratio). Hence, it follows that open-pit boundary can be expended through increasing of current stripping ratios to economic stripping ratio. In papers [2, 3], the open-pits boundaries determination methods are given according to design principle:

$n_t \leq n_{ec}$

In accordance with this design principle, the open pit mining is carried out with maximum inter-ramp angles of highwalls to the moment when current stripping ratio will be equal to economic one. After that mining activity on top benches is stopped, and the open pit development is carried out in depth without open-cut mining of upper levels. At that, the pit work with economic stripping ratio will be performed only at the moment of the highwall upper benches reaching the ultimate pit. In other periods of open pit operation, the current stripping ratios will be less than economic stripping ratio.

A.I. Arsent'yev [4] suggested the general of open-pits boundaries determination design principle:

$n + n_0 \leq n_{ec}$

where n – the highest period-averaged operating stripping ratio of open pit operating; n_0 – initial stripping ratio.

In the paper [5], V.G. Bliznyukov showed that the boundaries, open pit efficiency and mining mode are immediately interconnected and interplay.

Considering that regardless the large number of proposed design principles for open-pit boundary determining, none of them considered the internal dumping technology mode, which use allows extending of boundaries and increasing of open pit total depth, with the formation of temporary internal dumps, in the paper [6] the new design principle for open-pit boundary determination is suggested:

$n_{ex} + n_{in} + n_{reex} + n_0 \leq n_{ec}$

where n_{ex} - external stripping ratio (stripping supplied to an external dump); n_{in} - current internal stripping ratio reduced by cost to n_{ex} (stripping supplied to an internal dump); n_{reex} - reexcavated stripping ratio reduced by cost to n_{ex} (stripping subject to reexcavation); n_0 – initial stripping ratio reduced by cost to n_{ex}.

Research objective statement

The objective of this paper is developing of boundaries and open pit total depth determination method and research based on this method of the internal dumping technology impact on open-pit boundary with the formation of temporary internal dumps when steep deposits mining.

The material presentation

On the basis of design principle, which considers internal dumping mode with the formation of temporary internal dumps when steep deposits mining [6], the method of final pit boundaries and open pit total depth determination has been developed. This method based on Common Method Variance provides the following graphic analytic operating algorithm fulfillment.

1. The pit boundaries for the external dumping conditions (total depth H_{tot}) and open pit highwalls boundaries (depth H_t) corresponding to total depth H_{tot} in accordance with design principle of open pit boundaries determination $n_t \leq n_{ec}$ are built up on a typical geological cross-section of deposit (Fig. 1).

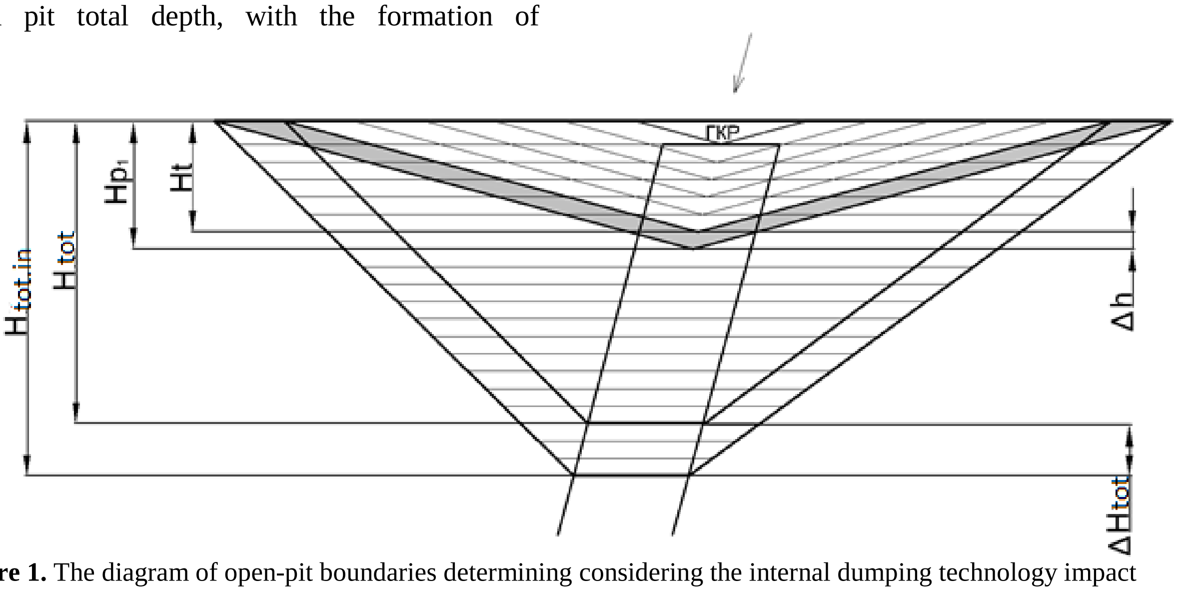

Figure 1. The diagram of open-pit boundaries determining considering the internal dumping technology impact

2. The stripping soils reexcavation maximum volume is determined [7]:

$$V_{reex}^{max} = \frac{(P_c \cdot \gamma_c - a - a_c) \cdot \Delta P - \Delta V \cdot b_{in}}{b_{reex}}$$

where P_c - the wholesale price of concentrate H_t, UAH/t; γ_c – merchantable ore yield, unit fraction; a – prime cost of ore extraction excluding the stripping operations prime cost, UAH/t; a_c - prime cost of ore processing into concentrate, UAH/t; ΔV, ΔP – stripping soils and ore growth under maximum current stripping ratio n_t; b_{in} - the developing prime cost of stripping 1 m^3 when internal dumping excluding the internal dump reexcavated solids prime cost, UAH/m^3; b_{reex} – prime cost of reexcavation of temporary internal dump 1 m^3 solid.

3. The number of temporary internal dump reexcavations is determined if it is formed at a depth:

$$N_{reex} = \frac{(H_c - H_t)}{H_{st}}$$

where H_{st} – stage depth, which is determined considering extraction-and-loading equipment for temporary internal dump reexcavation, m.

4. The temporary internal dump maximum volume is determined. The dump must be formed at the depth H_t for ensuring of pit operation highwalls extending opportunity:

$$V^{max}_{t.in.d} = \frac{V^{max}_{reex}}{N_{reex}}$$

5. The possible variant of further pit highwalls expansion and deepening on the value Δh (one level) to the depth H_{p1} is outlined relating to the depth H_t:

$$H_{p1} = H_t + \Delta h$$

6. The stripping ΔV_1 and ore ΔP_1 volume growth corresponding to depth H_t is measured and stripping design ratio value n_{p1} is determined for a new designed depth (H_{p1}) of operating highwalls extensions and deepening:

$$n_{p1} = n^t_{ex} + n^t_{in} \cdot \frac{b_{in}}{b_{ex}} + n^t_{reex} \cdot \frac{b_{reex}}{b_{ex}} + n^t_0 \cdot \frac{b_0}{b_{ex}}$$

where n^t_{ex} - current external stripping ratio, m^3/t; n^t_{in} - current internal stripping ratio, m^3/t; n^t_{reex} - current reexcavation stripping ratio, m^3/t; n^t_0 – initial stripping ratio, m^3/t; b_{ex} - the developing prime cost of stripping 1 m^3 when external dumping, UAH/m^3; the developing prime cost of stripping 1 m^3 when capital mining operations, UAH/m^3.

7. Design n_{p1} and economic stripping ratio n_{ec} values are compared. If the design principle conditions are not observed, i.e. when:

$n_{pl} \le n_{ec}$

The further possible variant of pit highwalls expansion and deepening on the value Δh (one level) to the depth H_{p2} is in contemplation:

$$H_{p2} = H_{p1} + \Delta h$$

8. All of the graphic analytical works are repeated until the design principle is observed.

9. The variant of development depth:

$$H_{pi} = H_{pi-1} + \Delta h,$$

where the design principle right and left sides are equal, is accepted as final.

On the basis of suggested method, the dependence of the maximum open pit final depth growth $\Delta H_{f.in}$ (in percentages) from deposit horizontal breadth *m* (Fig. 2) is investigated when using of the internal dumping technology with the formation of temporary internal dumps. For the investigation, the deposit thickness range from 50 m to 150 m is accepted if bottom pit length is from 200 m to 2000 m.

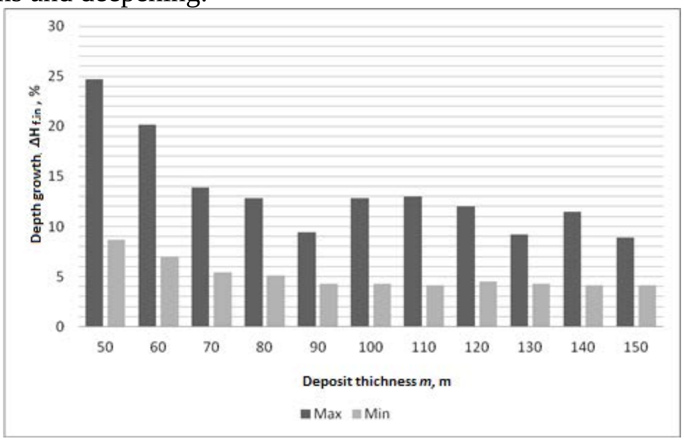

Figure 2. The histogram of maximum open pit final depth growth $\Delta H_{f.in}$ (in percentages) when using of the internal dumping technology with the formation of temporary internal dumps from deposit horizontal breadth m

Conclusions

The use of internal dumping technology with the formation of temporary internal dumps allows increasing of the open pit total depth by 4.1-24.7%, at that, during the entire period of open pit running, the design stripping ratio, which is the sum current internal, external and reexcavation stripping ratios of reduced to external stripping ratio and also reduced initial stripping ratio, should not be higher than the boundary stripping ratio.

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