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THE IMPORTANCE OF FINE FRACTIONS IN THE TRANSPORTATION OF CEMENTED BACKFILL INTO MINED-OUT VOID SPACES

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Abstract. The article examines the issues of proper selection of pipeline diameter used for transporting backfill mixtures during the filling of mined-out spaces in ore bodies developed under complex mining and technical conditions. The study also considers methods for increasing the density of the transporting medium by increasing the proportion of coarse-grained material and by increasing the content of the –0.15 mm fraction in the composition of the backfill mixture.

Keywords: cemented backfill, pipeline, rigid mixtures, fine fraction, density of the solid phase, mixture transportation.

Аннотация. В статье рассматриваются вопросы правильного выбора диаметра трубопроводов, используемых для транспортирования закладочных смесей при заполнении выработанного пространства в рудных телах, разрабатываемых в сложных горно-технических условиях. Также рассмотрены методы повышения плотности транспортирующей среды за счёт увеличения доли крупнозернистого материала и повышения содержания фракции –0,15 мм в составе закладочной смеси.

Ключевые слова: твердеющая закладка, трубопровод, жёсткие смеси, мелкая фракция, плотность твёрдой фазы, транспортирование смеси.

Annotatsiya. Maqolada murakkab kon-texnik sharoitlarda qazib olinayotgan ruda tanalaridagi bo‘shliqni to‘ldirishda qo‘llaniladigan to‘lg‘azma aralashmalarini transport qilish uchun quvurlar diametrini to‘g‘ri tanlash masalalari ko‘rib chiqilgan. Shuningdek, to‘lg‘azma aralashmasi tarkibida yirik donali material ulushini oshirish va –0,15 mm fraksiyaning miqdorini ko‘paytirish orqali tashuvchi muhit zichligini oshirish usullari tahlil qilingan.

Kalit so‘zlar: qotuvchi to‘lg‘azma, quvur, qattiq aralashmalar, mayda fraksiya, qattiq faza zichligi, aralashmani transport qilish.

INTRODUCTION.

Due to the progressive deepening of mining operations and the increasing complexity of mining and geological conditions, the method of mining with the

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filling of mined-out voids using cemented backfill has been widely applied in recent years.

The proper selection of the composition of cemented backfill ensures the formation of a strong (monolithic) artificial massif in the mine. The selection of an optimal backfill composition requires careful consideration of both technological and economic factors.

The selection of the backfill composition should be carried out by taking into account the suitability of locally available materials near the mine, their reserves, the usable quantities, their future supply or extraction, as well as possible methods of transporting them to the site of extraction and placement (filling) operations. At the second stage, it is necessary to study the physical and mechanical properties of the aggregates and the activity of the binders. The rational composition of cemented backfill is determined experimentally by producing samples of various compositions and testing their transportability (delivery to the stope). The composition of cemented backfill should be selected based on the required strength and hardness of the formed artificial massif, the adopted method of mixture delivery, the technology of backfill placement, the intensity of bonding and compaction, as well as the economic indicators of the filling operations. In recent years, due to the increasing depth of mining operations and the complication of geological conditions, the method of mining with the filling of mined-out voids using cemented backfill has been widely applied. Under such conditions, the proper selection of the backfill mixture composition determines not only the strength of the artificial massif but also its transportability characteristics.

Practical experience shows that the stable movement of cemented backfill mixtures through pipelines largely depends on their granulometric composition, particularly on the proportion of fine fractions. While traditional approaches emphasized the role of coarse materials, modern studies highlight the decisive importance of fine fractions in the transportation process.

MATERIALS AND METHODS. Fine fractions (–0.15 mm) form the carrier medium within the mixture, filling the voids between particles and ensuring a homogeneous structure. As a result, internal friction decreases, particle segregation is prevented, and a stable flow regime is achieved within pipelines.

One of the main problems in transporting backfill mixtures is segregation and blockage formation inside pipelines. This phenomenon becomes especially pronounced when the content of fine fractions is insufficient. In such cases, coarse particles settle, leading to flow instability and disruption of the transportation process.

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One of the key indicators used to evaluate the transportability of the mixture is the transport concentration coefficient:

$$K_t = \frac{V_{v.p}}{V_{t.v}}$$

where:

$V_{v.p}$—volume of particles larger than 0.15 mm, m³;

$V_{t.v}$— total volume of the mixture, m³.

It can also be expressed as:

$$K_t = \frac{V_v}{V_v + (V_{c.m} + V_w)} = \frac{V_v}{V_v + V_{c.m}}$$

where:

V_v—volume of fine fraction;

V_w— volume of water;

$V_{c.m}$— volume of the carrier medium.

Studies indicate that optimal transport concentration values (K_t=0,26÷0,37) are achieved by maintaining a proper balance between coarse and fine fractions.

The composition of the transporting medium is selected taking into account the availability of fine-dispersed materials at the site where the backfill mixture is prepared.

In this regard, the following requirements are imposed on backfill mixtures:

— the amount of water required for the hydration of the binder in 1 m³ of the mixture must be minimal;

— the particle size distribution of the materials must comply with the specified proportions.

Thus, it can be concluded that the considered mixture composition is not optimal in terms of transportation and placement and requires additional adjustment of the ratio of +0.15 mm and –0.15 mm fractions.

To keep coarse particles in a suspended state within a moving flow, the transporting medium must possess certain rheological properties. The criterion for these properties is the yield shear stress of the transporting medium, which must satisfy the following condition:

$$\tau_o \geq \frac{d_{\max}(\gamma_s + \gamma_{t.m})q}{6K}$$

where:

$\gamma_s, \gamma_{t.m}$— density of the solid phase and density of the transporting medium, respectively, kg/m³; $d_{\max}$— maximum size of filler particles; K — empirical coefficient (for rock materials, it is taken as 0.6); q — acceleration due to gravity.

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Under the considered conditions, the rheological constants do not meet the requirements for optimal transportation. While at a transportation distance of 600–700 m the mixture still satisfies transportability conditions, an increase in distance necessitates an increase in the content of the –0.15 mm fraction.

Laboratory studies show that the yield shear stress of the transporting medium is insufficient to form a stable, non-segregating mixture structure. This leads to the need to increase the critical transportation velocity.

RESULTS AND DISCUSSION. Fine fractions play a crucial role in determining the rheological properties of the mixture. One of their main functions is to increase the density of the carrier medium. A denser carrier medium enables the suspension of coarse particles, ensuring stable flow through pipelines.

If the fine fraction content is insufficient, coarse particles settle, leading to blockages and unstable flow conditions. Both laboratory and field experiments confirm that increasing the proportion of fine fractions (–0.15 mm) significantly improves the transportability of the mixture.

This effect is particularly important when transporting mixtures over long distances (600–700 m or more), where maintaining a stable flow regime becomes more challenging.

Additionally, an increase in fine fraction content enhances the plasticity of the mixture, which:

-facilitates flow through pipelines,
-reduces critical velocity requirements,
-improves overall transportation efficiency.

CONCLUSION. Based on the conducted studies, it can be concluded that the transportability of cemented backfill mixtures primarily depends on their granulometric composition. Fine fractions (–0.15 mm) serve as the main component forming the carrier medium.

An adequate amount of fine fractions:

-prevents segregation,
-stabilizes flow,
-increases transportation efficiency.

For long-distance pipeline transport, the optimal proportion of fine fractions becomes a critical factor. Therefore, in modern mining practice, special attention must be paid to the fine-dispersed components when designing backfill mixtures.

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