European Journal of Interdisciplinary Research and Development
Volume- 46 December- 2025
Website: www.ejird.journalspark.org ISSN (E): 2720-5746

OPTIMIZATION OF TECHNOLOGICAL PARAMETERS FOR THE FORMATION AND TRANSPORTATION OF MATERIAL FLOWS IN DEEP OPEN-PIT MINES

Norova Khurshida Yunusovna
Doctor of Philosophy in Technical Sciences (PhD),
Acting Associate Professor of the Department of Mining Engineering,
Tashkent State Technical University (TSTU).

Mukhiddinov Khusniddin Oybek ugli
Master's Degree student, Department of Mining Engineering,
Tashkent State Technical University (TSTU).

Abstract

The article examines issues related to the management of technological parameters of material flows in the development of ore deposits by deep open-pit mining. It is shown that as the depth of mining operations increases, the share of costs for the transportation of rock mass reaches 80% or more, which leads to a reduction in the rate of pit deepening.

The aim of the study is to improve the efficiency of open-pit haulage flows by enhancing methods of operational control and ore quality blending. The obtained results make it possible to justify rational technological parameters of transport schemes and can be used in the design and operation of automated mining management systems in deep open pits.

Keywords: deposit, open pit, haulage flow, parameter, ore, quality, reserves, resource, mining operations, rock mass, reserves, technogenic formation, sampling, mining system.

Introduction

The development of ore deposits by deep open-pit mining is currently accompanied by a steady increase in the volumes of overburden removal and extraction operations, as well as by longer transportation distances and greater lifting heights of rock mass. As open pits deepen, the complexity of organizational and technological transportation schemes increases, the productivity of open-pit transport decreases, and the rate of mining deepening slows down. Under these conditions, the efficiency of mining enterprises is largely determined by the rational organization of material flows, which ensures coordinated operation of mining and transport processes.

Material flows of rock mass in deep open pits represent a complex multifactor system, the formation and parameters of which depend on mining and geological conditions, the adopted mining technology, the structure and composition of transport equipment, as well as requirements for the quality of extracted minerals. Disruption of coordination between the elements of this system leads to idle times, increased specific transportation costs, and deterioration of ore quality blending indicators.

In this regard, the task of managing technological parameters of material flows in deep open pits through operational regulation of mining and transport operations becomes particularly relevant. The improvement of material flow management methods is aimed at increasing the efficiency of open-pit transport utilization, reducing the costs of rock mass transportation, and ensuring sustainable rates of mining deepening.

An analysis of mining enterprises has revealed a number of shortcomings in the organization of material flows when serving multiple consumers. One of the main factors that significantly affect the quality characteristics of mineral material flows delivered to consumers is the high variability of mineral quality within the deposit, as well as capacity limitations at transfer points [1–7].

An analysis of the conducted studies has established [6–10] that one of the key approaches to managing material flows in deep open pits is ore quality management. This includes the selection of optimal ore cut-off grades, the determination of optimal levels of ore losses and dilution, the choice of mining development directions that ensure the extraction of ore with a specified quality level, and the determination of the main technological parameters of a deep open pit.

Complex-structure gold ore deposits are characterized by significant volumes of rocks and ores with different properties within the boundaries of the pit field under low average grades of the valuable component; heterogeneity of the physico-mechanical properties of rocks and varying degrees of rock mass blockiness; and complex geometries of ore bodies, with a wide range of variations in their sizes, the absence of regular patterns, and their uneven distribution within the rock mass.

The Muruntau and Kalmakyr deep open pits are unique, large-scale natural accumulations of gold ore mineralization. The initial basis for developing models to simulate various scenarios of mining development is provided by deposit sampling results. To verify the adequacy of the mathematical models with respect to actual deposits, data from operational exploration of mined-out sections were used [10, 11]. Owing to its volume, this information is unique and is actively used for both practical and scientific-methodological purposes.

Considering that sampling is the basis of quality management for complex-structured deposits, and that cut-off grades and quality requirements for minerals in situ and mining conditions serve as criteria ensuring optimal technical and economic performance of extraction and processing, the selection of sampling methods and grids, as well as the justification of operational cut-off grades, constitute the most important elements of raw material quality management [11, 12].

Negative trends in the development of the mining complex include a reduction in the volume of exposed reserves and a decrease in the growth rate of prepared reserves as pit depth increases. These factors should be taken into account when studying the technological parameters of deep open pits during the formation and analysis of ore flows.

The main technological parameters of deep open pits include bench height, length of the working front, and working berm width. All these parameters determine the slope angle of the working pit wall and the current stripping ratio, which naturally affects the efficiency of mining operations. The length of the excavator block during the development of the overburden working front influences the rate of bench development and, consequently, the resulting inclination angle of the working pit walls. The rational value of the excavator block length is determined based on the required height of the pit wall section, the type of transport used, and

European Journal of Interdisciplinary Research and Development
Volume- 46 December- 2025
Website: www.ejird.journalspark.org ISSN (E): 2720-5746

the bench mining scheme. During periods of active control of the mining operation regime, its value varies within the range of 300–800 m for truck haulage and 600–2000 m for rail transport. When developing mining plans, the width of working berms averaged over the length of the active working front (or a specific section thereof) is calculated and regulated. Under systematic mining operations, this width must include the minimum working berm width required by technological conditions. In order to determine the technology for overburden excavation in deep open pits (with depths exceeding 500 m), it is proposed to classify open pits according to the length of the excavator block operating in overburden, for which a statistical analysis of pit parameters has been performed.

One of the important conditions for applying efficient technologies for the development of hard and semi-hard rock using single-bucket excavators is ensuring the quality of rock mass preparation by blasting. For the effective implementation of all subsequent technological processes, the preparation of working faces for single-bucket excavators must meet the following basic requirements:

– ensuring a specified degree of fragmentation and rational loosening characteristics of the rock mass corresponding to the technical capabilities of excavation and haulage equipment;

– compliance of muck pile parameters with the rational elements of the mining system;

– ensuring a sufficient volume of prepared rock mass for uninterrupted and high-performance operation of mining and transport equipment;

– ensuring safety and high economic efficiency of mining operations.

When substantiating the working berm width for hard rock excavation at the lower levels of a deep open pit, it is necessary to determine the width of the drilling-and-blasting cut, the required muck pile width that ensures efficient excavator operation with due consideration of the selected face configuration, as well as the haul truck travel and positioning scheme for loading, which ensures the minimum permissible working berm width during hard rock mining.

Since the working berm width affects the slope angle of the working pit wall and, consequently, the current stripping ratio, the width of the cut in solid rock also depends on its value. For this purpose, the relationship between the current stripping ratio and the slope angle of the working pit wall is determined. The obtained values of working berm width indicate a direct dependence of the working berm width on bench height, the number of benches, and the pit wall slope angle. These data make it possible to control the mining operation regime and all technological parameters of a deep open pit.

Thus, the developed rational parameters of the sampling network used in reserve preparation, together with the technological parameters of deep open pits, make it possible to manage material flow parameters. At the same time, differences in the complexity of ore contours across various sections of a deposit require the application of different technological mining schemes to ensure the rational extraction of reserves from the subsurface.

References

1. Yakovlev, V.L., Kornilkov, S.V. (2015). Geotechnological problems and features of mining operations in deep open pits. GIAB, No. 7. Moscow: Gornaya Kniga, pp. 54–65.

2. Kornilkov, S.V. (2012). Technological aspects of deep open-pit mining. In: Deep Open Pits: Proceedings of the All-Russian Scientific and Technical Conference with International Participation, June 18–22, 2012. Apatity–St. Petersburg: Mining Institute, KSC RAS, pp. 38–52.
3. World Nuclear Association. (2009). The Global Nuclear Fuel Market: Supply and Demand 2009–2030.
4. Shemetov, P.A., Glotov, G.N. (2010). Theoretical fundamentals of automated systems for uranium in-situ leaching geotechnology. In: Proceedings of the VI International Scientific and Practical Conference "Current Problems of the Uranium Industry", September 14–16, 2010, pp. 67–73.
5. Aristov, I.I., Rubtsov, S.K., Snitka, N.P. (2006). Experience in the step-by-step improvement of methods for standardization and accounting of ore losses and dilution at the open pits of the Navoi Mining and Metallurgical Combine. Mining Bulletin of Uzbekistan, No. 4, pp. 38–45.
6. Anistratov, Yu.I., Anistratov, K.Yu. (2003). Open Pit Design. Moscow.
7. Anistratov, Yu.I. (1970). Investigation of technological material flows in open pits with hard rock. Doctoral dissertation abstract. Moscow, 42 p.
8. Anistratov, Yu.I. (1955). Technological processes of open-pit mining. Moscow: Nedra, 351 p.
9. Kaplunov, D.R., Chaplygin, N.N., Rylnikova, M.V. (2003). Principles of designing combined technologies for the development of large solid mineral deposits. Mining Journal, No. 12, pp. 21–25.
10. Shemetov, P.A., Sytenkov, V.N., Fedyanin, S.N., Naimova, R.Sh. (2009). Justification of threshold gold grades for ore classification at the Muruntau deposit. Mining Bulletin of Uzbekistan, No. 4, pp. 8
11. Snitka, N.P., Strygin, I.V. (2005). Optimization of loss and dilution levels during mining operations. In: Resource-Reproducing, Low-Waste and Environmental Technologies for Subsoil Development: Proceedings of the IV International Conference, September 18–25, 2005. Moscow–Navoi, pp. 109–110.
12. Snitka, N.P. (2008). Quality management of ore flows in open-pit mining of deposits with conditional ore body boundaries. Mining Journal, No. 8, pp. 40–43.