Development of Mining Assets in the Mining Industry

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Abstract. In practice, the industry and the business sector have felt the impact of the coronavirus that has spread around the world. Today it is not known when the system will recover, but it is already quite clear that the post-covid reality will require radically new approaches to the organization of mining operations. Usually, the conservative mining industry in Russia has felt the influence of new trends set by the pandemic, such as, for example, the transition of employees to remote work, which has spurred an accelerated transition to automated work; a change in the distribution chain, are inseparable from the closure of borders, the acquisition of new skills from staff, and others. This article focuses on the development of mining assets in the mining industry. The article concretizes the essence of geometry. Appropriate solutions for end-to-end optimization of the "mine-factory" system are outlined due to a deep understanding of the characteristics of the ore and the introduction of digital tools. The most popular innovations necessary for implementation into the modern mining process have been identified, ranked according to the categories "Production materials, technologies and equipment", "Automation and digitalization", "Field development", "Technologies of deep processing of raw materials: green chemistry", "Technologies of deep processing "processing of raw materials: green metallurgy". The production assets of the Polar Division are analyzed using the example of PJSC Mining and Metallurgical Company Norilsk Nickel. As a project initiative to improve the efficiency of ore mining within the mine field, the reconstruction of a skip ventilation shaft from a cage to a skip-cage is being created. A variant of solving the geomechanical problems of the company is being considered.

1. Introduction

The mining industry is an important industry representing a wide segment of the economies of countries around the world. It has its own specifics and individual features. The long-term aspect of mining operations distinguishes it from most other business areas as it is some mining regions or survey sites have remained active for centuries.

2. Formatting the title, authors and affiliations

The research methodology includes a combination of general scientific methods and techniques. The works of V. I. Golik, V. I. Komashchenko, D. N. Shkuratsky, K. Drebenstedt [2; 5], V. G. Lukyanov, V. A. Shmurygin [7], E. D. Vorobyov, D. A. Volkov [6], etc. During the study, the works
of foreign scientists were studied: [14-17; nine; twenty]; materials from Internet sources [3; ten; eighteen].

Purpose of the article: scientific and practical substantiation of the need for the development of mining assets in the mining industry.

The novelty of the research lies in the fact that the article is an independent scientific study of promising options for the development of mining assets in the mining industry.

3. Discussion and results
Traditionally, the processes of most mining enterprises are primarily focused on maximizing production, and much less attention is paid to processing. While it is produced at the processing facilities using an efficient method, it can increase productivity and recovery. However, in many cases, it is the concentrator that becomes the mill's bottleneck, both in terms of limited flexibility to increase capacity and in terms of opportunities to increase average hourly productivity, optimize quality, or recover parameters.

This situation can be changed by introducing such a direction as geometallurgy in production. Geometallurgy is a process based on a deep understanding of the characteristics of the ore and their impact on the productivity of the plant and involves aligning the operation of a mining and processing plant from the optimal characteristics of the charge required for the plant, taking into account the limitations existing during the extraction [8].

At the same time, the appropriate digital solutions must be applied at each stage of control from the processing plant (Fig. 1).

![Figure 1](image-url)

**Figure 1.** End-to-end optimization of the mine-mill system through deep understanding of ore characteristics and the introduction of digital tools.

In addition, the most demanded innovations required for introduction into the mining process will be:
- in the category "Manufacturing materials, technologies and equipment": reagents; introduction of energy saving and water use systems, control; energy efficient raw materials processing technologies;
- in the category "Automation and digitalization": the introduction of unmanned mining equipment; automation and dispatching of all production processes; Big Data for field development; the use of digital twins of equipment, technological processes; computer vision and machine learning algorithms; the use of artificial intelligence in logistics; robotization of processes in extreme climatic conditions;
- in the category "Development of deposits": development of rocks of complex occurrence; development for the extraction of rare earth metals; design of digital fields.
- in the category "Technologies for deep processing of raw materials: green chemistry": obtaining polymers and paraffins from coal (for example, the development of such industries in China with the production of 10 million tons per year and plans to 25-30 million tons of products per year [3]);
- in the category "Technologies for deep processing of raw materials: green metallurgy": obtaining highly demanded and profitable ferroalloys from dump and low-calorie coals.

The Public Joint Stock Company Mining and Metallurgical Company Norilsk Nickel is the leader among the enterprises of the mining industry in Russia and occupies one of the leading positions in the world's largest producer of metals. The main function of the enterprise is to meet the growing needs of the Russian and world economy in raw materials and materials necessary to create vital products in order to improve the quality of life of the population. The company carries out the extraction and enrichment of mineral resources, the production and sale of metals such as nickel, copper, platinum, palladium, rhodium, cobalt, gold. The company's products are widely demanded in the energy and electronics industries, mechanical engineering and construction; they are an intermediate product in the production of consumer goods, food and chemical industries, medicine and other industries.

The company operates an integrated management system that complies with international practices and standards ISO 14001, ISO 9001, ISO 26000, ISO 45001.

The main priority in the field of the company's investment policy is long-term growth of production based on existing assets. The task of ensuring long-term growth of production is solved by a cost-effective increase in the output of marketable products on the resource base of the company's Polar Division.

The polymetallic resource base of the Polar Division is unique. Combined with the low cost of production, this makes this asset a top-notch asset. The production assets of the Polar Division are shown in Figure 2.

![Figure 2. Production assets of the Polar Division of TheNorilsk Nickel.](image)

The assets of the Polar Division include the full cycle of metal production - from the extraction of ore raw materials to the shipment of finished products to the consumer. The presence of significant volumes of mineral resources within the mine field creates the preconditions for increasing the productivity of the mine and improving the efficiency of operating activities.

The main limiting factors for increased productivity are: mining capabilities; ventilation; lifting rock mass to the surface. Mining capabilities are the productivity of the development front of mining operations, which means the possible size of the annual production of a mineral, achieved with a particular technique, technology and organization of field development. The effect of the ventilation shafts is to ensure the supply of sufficient air for the optimal operation of the machinery and workers housed in the mine. The rise of the rock mass to the surface affects the rate of unloading of the spent ore to empty the storage tanks. According to the results of technical analysis, it was established that the mine's productivity in terms of mining potential is 6.0 million tons of ore per year, for ventilation - 6.5 million tons of ore per year, for lifting rock mass to the surface - 4 million tons. ore per year [10].
The limiting factor is the limitation on the ascent of the rock mass to the surface, due to the capabilities of the current skip ascent (skip shaft).

Reconstruction of a skip ventilation shaft from a cage to a skip-cage acts as a project initiative to improve the efficient mining of ores within the mine field. The ventilation shaft of the mine is designed to discharge and supply air used for ventilation of mine workings. The ventilation shaft is also used for lowering and lifting rock and filling material.

Reconstruction of the ventilation shaft consists in the installation of a new skip hoisting unit with an electric motor of greater power for accelerated lifting of the rock, which in turn will make it possible to additionally organize the lifting of 2 million tons of waste rock mass and increase the productivity of the mine, performing the functions of an additional reserve ore lift.

Design and survey work includes the initiation of tender procedures and the selection of a potential contractor, upon completion of which the technical specifications are prepared and the initial data are transferred to the performers. Also, when assessing geomechanical and hydrogeological risks in the development of ore raw materials, it is necessary to conduct surface and underground field surveys for the composition of internal resources.

In the long term, this project will increase the production of disseminated ores, while maintaining the production of nickel and platinum group metals. Based on the results of the successful implementation of the project, it is planned to extract 2 million tons of ore annually, which will reduce the duration of the process of developing disseminated ore reserves within the mine field and will lead to an increase in the productivity of the mine. The mine's capacity will be 6.0 million c.u. ore per year [3].

Numerical modeling allows you to take into account the process of developing reserves, take into account the schedules in order to obtain adequate values of the rock pressure parameters. Based on the results, a block model can be built that includes grade parameters, disturbance parameters and stress state data, as well as other data on processes in the rock mass, which are critical for a particular field - for example, geodynamic, hydrogeological [8]. This is the best approach to solving geomechanical problems (Figure 3).

![Figure 3. Geomechanical problems of The Norilsk Nickel.](image-url)
But for this, each mine must have a separate geomechanics service. Many enterprises in Russia have such services; their conceived tasks are performed by the Service for Forecasting and Prevention of Rock Bursts, the creation of which is regulated by federal rules and regulations. These services also focus on mine support innovations, backfill material selection, and more. Most likely, in every enterprise, especially in a large one, such a service will soon have to work.

4. Conclusions
The Covid-19 pandemic has seriously impacted the global commodity sector. However, despite the shocks associated with the spread of the virus, the pandemic has significantly accelerated the processes associated with the introduction of automation and digitalization. The current transition of the economy to the post-industrial era, the struggle to reduce CO2 emissions into the atmosphere, and the attraction of investments in production also served as an impetus for companies to further increase the level of ESG, that is, to address issues related to social development, internal corporate relations and environmental protection. Companies both in Russia and in the world have begun to adapt to new conditions - the current crisis will contribute to the active introduction of robotics and artificial intelligence into value chains, which, in turn, will reduce the involvement of personnel in the production process, thereby reducing the likelihood of proliferation infections. The set trend for an active transition to the introduction of "green" technologies, which are aimed at reducing harmful emissions into the atmosphere, will lead to an increase in demand for a wide range of minerals and metals, thus new significant opportunities will open for countries rich in mineral resources. Thus, in the new technological cycle, the industry expects significant changes associated primarily with the introduction of the most advanced practices, in compliance with the principles of environmental friendliness, social and corporate governance, with the introduction of advanced technologies for automation and production control.

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