Justification of the Technology of Construction of Mine Shafts for the Conditions of the Maly Kuibas Deposit

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Abstract. The technology of construction of mine shafts for the conditions of the Maly Kuibas deposit is presented. The dimensions of the cross-section of the mine shafts are selected. The parameters of drilling and blasting operations have been calculated. Selected equipment for drilling holes in the borehole and loading the blasted rock mass. The lifting parameters were determined, the ropes were selected, and the lifting machines were selected. The technological schemes and methods of construction of shafts are considered. Designs of mine headframes are proposed.

1. Introduction

The Maly Kuibas iron ore deposit is located in the Verkhneuralsky district of the Chelyabinsk region, 18 km north-east of Magnitogorsk. At the Maly Kuibas deposit, iron ore and associated construction stone are mined.

The field is being developed on the basis of decisions made in the "Technical design for the development of an open pit at the Maly Kuibas field"

At the first stage, the following works are supposed to be performed:
- analysis of mining and geological and hydrogeological data of the Maly Kuibas deposit;
- determination of field reserves. Justification of the production capacity of the mine during the completion of reserves by the underground method and the procedure for the development of the deposit;
- development of options for technological schemes for the construction of mine shafts at the Maly Kuibas deposit.

2. Relevance, scientific significance of the issue with a brief overview of references

Analysis of the current state of mining in the open pit shows that at the present time the southern part of the open pit has been completed to the limiting contour and backfilling of the mined-out area with overburden from the development of the northern part of the open pit is being carried out. The height of the dump is about 60 m. There is also a formed internal dump in the north of the northern part of the quarry, which was formed at the worked-out sites. Mineral extraction and overburden excavation is carried out only in the northern part of the open pit.

The Maly Kuibas open pit is currently close to the completion stage. Depending on the actually achievable productivity of the open pit for ore, open pit mining will be extinguished in the period 2023-2026, therefore, the substantiation of the technology for the construction of mine shafts for the
conditions of the Maly Kuibas deposit is a very urgent task.

Modern mine construction requires an ever-increasing volume of construction of new shafts and reconstruction of existing mines and mines. Therefore, increasing the intensity of labor, improving the quality and reducing the time of underground construction, primarily due to the improvement of the organization of production and the introduction of new equipment and technology of work, are very important.

The works conducted during the construction of shafts are characterized by great complexity and labor intensity, which is due to some peculiarities: constrained conditions for performing technological processes, the presence of water inflows into the shaft and other factors.

For these reasons, the construction of the shaft sometimes accounts for up to 20% of the total cost of building an enterprise as a whole. In this regard, the generalization of advanced experience and the introduction of advanced technology and work technology in the construction of shafts is of immense importance.

In accordance with safety rules, each mine and mine must have at least two exits to the surface, i.e. usually at least two barrels. One serves for lifting minerals and rocks, and the second for supplying fresh air, lowering, and lifting people, materials and equipment.

The size, cross-sectional shape and depth of the shafts are determined by many factors: the conditions of opening the deposit, the production capacity of a mine or mine, the physical, mechanical, and hydrogeological properties of the rocks being crossed, the ventilation mode of underground operations, the life of the shaft, etc.

When determining the number of main opening workings, the main factors were their ability to ensure the delivery of the required volume of minerals to the surface, the descent and ascent of people, equipment, various auxiliary materials, etc., the normative ventilation of the extensive network of mine workings, as well as safe working conditions, both in normal and emergency situations.

3. Problem statement
The following types of trunks are distinguished as objects:
1. Shaft "Ventilation", depth 1110 m (first stage - 790 m);
2. Kletevoy trunk, 1110m deep (first stage - 790m);
3. Skipova trunk, 1190m deep (first stage - 860m).

Considering the physical and mechanical properties of the rocks being crossed, the service life of the shafts, the properties of the lining materials, a round shape of the section of the mine shafts is adopted.

According to the declared production capacity of the mine - 2.6 million tons / year. the dimensions of the cross-section of mine shafts are determined, equipped with a skip hoist for lifting the ore mass (Skipovoy shaft) and a cage hoist for lowering / lifting people, cargo, materials, as well as for lifting rock in trolleys of the VG-2.5 type (shafts Ventilation "and" Kletevoy ").

4. Theory
A mine shaft is a vertical mine opening that has a direct exit to the surface.

The trunk is divided along the length into the following sections:
• mouth - the upper section that goes directly to the surface;
• the main part - from the mouth to the lower horizon of the near-stem yard;
• sump - the lower section of the barrel for collecting water.
• According to their purpose, the shafts are divided into exploration, construction and production.

In most cases, vertical shafts have a circular cross-section.

Shaft construction includes several stages:
• preparatory period - a set of works on:
  - providing the construction site with energy, transport, water, machines and mechanisms;
  - installation of buildings and structures;
  - construction of the wellhead and process waste;
• construction of the main part of the shaft and sump;
• carrying out workings, conjugated with the shaft;
• shaft reinforcement (sometimes, in order to shorten the construction period of the shaft, its reinforcement is performed simultaneously with the construction);
• re-equipment of equipment in the shaft for horizontal and inclined workings.

There are two groups of shaft sinking methods:
• conventional (without the use of water pressure or strengthening of the enclosing rocks);
• special (drilling, the use of dewatering, freezing, or plugging of rocks, sinking structures, etc.).

The technological scheme of shaft sinking is a set of production processes for rock excavation and erection of permanent support, conducted in a certain sequence in time and space.

The technological process is understood as a part of the production process, which is distinguished by tools and means of labor, for example, drilling holes, loading rock, erecting permanent support.

The main technological processes can be performed:
• in one bottom-hole link or in two adjacent links - bottom-hole and top, adjacent to it.
• sequentially, in parallel (simultaneously) or with partial overlapping.

Shaft sinking technological schemes are classified according to:
• the factor of using temporary lining: with the use of temporary lining, without the use of temporary lining;
• the method of erecting a permanent support: from top to bottom, from bottom to top.
• sequence of works on rock excavation and erection of permanent support: sequential, parallel, combined.

5. Practical significance, offers and introduction results, results of experimental research

For shafts "Ventilation", "Kletevoy," Skipovoy "the round shape of the section of the mine shafts is adopted.

As lifting vessels in the "Ventilation" shaft, a counterweight cage, type 21HB3.1 was adopted; in the Kletevoy shaft - 2 stands - 21HB3.1 (a trolley, type VG2.5 was adopted for lifting the rock); in the Skipova shaft - 2 SNM-15 skips.

The diameters of the shafts "Ventilation", "Kletevoy", "Skipovoy" in the light are 6.0 m., In the rough - 6.5 m. concrete lining 250 mm.

All mine shafts have been drilled in the usual way. The method of destruction of rocks - drilling and blasting. The technological scheme for shaft sinking is sequential.

For blasting operations, a cartridge-type explosive of the Ammonit No. 6 ZhV type is used. The charge design is columnar with reverse initiation of the PB. To initiate charges, a low-energy system of the "ISKRA-SH" type is adopted.

The specific consumption of explosives was 3.2 kg / m³, the advance of the bottomhole per cycle was 3.4 m.

Based on the mining and geological conditions for drilling the bottom of the shafts "Skipovoy", "Ventilation", "Kleteyeva", a drilling rig of the "BUKS-1u5" type was adopted.

For shipment of rock mass from the bottom of the shafts "Skipovoy", "Ventilation", "Kleteyevoy", a trunk loader with a clamshell executive body "KS - 1MA" was adopted.

To lift the blasted rock during shaft sinking, two buckets of the BPS4 type, with a capacity of 4 m³, LK-RO rope 6x36 (1 + 7 + 7/7 + 14) + 7x7 (1 + 6), 26.5 mm in diameter, C - 2.5 x 2.

A multistage drainage scheme was adopted, with the issuance of the stem inflow to the surface. As a downhole pump, 2 pumps of the NPP-1M type with a flow rate of 30.0 m³ / h are used. As an overhead pump - 2 pumps of the "IIIH - 30-250" type with a flow rate of 30.0 m³ / h. As a transfer pump - a pump of the TsNS - 105-441 type with a flow rate of 105.0 m³ / h.

To supply compressed air during shaft sinking, two staves of air ducts with a diameter of 250 mm were adopted. Compressed air will be supplied by a K-250-61-1 / 2/5 piston compressor.

To ventilate the dead-end development, a combined ventilation method was adopted with two local ventilation fans of the "VM - 12A" type, one for pumping, the second for suction.
During shaft sinking, the operating mode is three-shift, 7 hours a day.

For lifting people, equipment, rocks on the "Ventilation" and "Kletevoy" shafts, the following are adopted: rope LK-RO 6x36 (1 + 7 + 7/7 + 14) + 7x7 (1 + 6), 39 mm in diameter, lifting machine C - 3.5 x 2.4.

To lift the ore on the Skipovoy shaft, the following were adopted: rope LK-RO 6x36 (1 + 7 + 7/7 + 14) + 7x7 (1 + 6), diameter 52 mm, hoisting machine TsSh 5 x 4. The number of ropes is 4.

## 6. Conclusions

Estimated rate of penetration of mine shafts - 51 m / month. The design speed of shaft reinforcement is 300m / month. Estimated construction time of shafts: "Ventilation" and "Kletevoy", respectively, 25.7 months; Skipova - 28 months

On the shafts "Ventilation" and "Kletevoy" it is advisable to use a pile driver system with a single-rope lifting unit, on the “Skipova” shaft - a tower reinforced concrete pile driver with a multi-rope lifting unit.

## 7. References

[1] 1983 Guidelines for the design of underground mine workings and the calculation of lining (M. Stroytekhizdat)
[2] Karetnikov V N, Kleimenov V B, Nordihin A G 1989 Fastening capital and preparatory workings, reference (Moscow, Nedra)
[3] Neugomonov S S, Volkov P V, Zhirnov A A 2018 Mounting Low Stability Rocks with Reinforced Combined Support on the Basis of Friction SZA Anchors Gorny Zhurnal (Mining Journal) 2 31-34
[4] All-Union Building Standards 126-90 (Ministry of Transport of the USSR) Fastening workings with spray concrete and anchors in the construction of transport tunnels and subways Standards for the design and production of work
[5] Masayev Yu A, Masayev V Yu, Filina L D 2015 Recent Developments in Area of Mounting and Enhancing Stability of Rock Outcrops in Mine Workings Bulletin of KuzGTU 1 41-44
[6] Zubkov A A, Zubkov A V, Kutlubayev I M, Latkin V V 2016 Enhancing Structure and Technology of Mounting Supports with Friction Fastening Gorny Zhurnal (Mining Journal) 5 50-53
[7] Dyomin V F, Dyomina T V et al 2015 Evaluation of Stress-Deformed State of Rock Masses Around Mine Working Mounted with Anchor Support Mining Information&Analytical Bulletin 10 70-76
[8] Zubkov A A, Latkin V V, Neugomonov S S, Volkov P V 2014 Advanced Methods of Mine Working Mounting at Underground Mines Mining Information&Analytical Bulletin. Certain Articles (Special Issue) 10 106-117
[9] Kalmykov V N, Volkov P V, Latkin V V 2016 Analysis and Justification of Parameters of Resin-Grouted Anchor Support at Conduct of Pilot Testing under Conditions of Safyanovsky Underground Mine Relevant Mining Issues 2 27-35
[10] Energy Absorption Characteristics of Steel, Polypropylene and Hybrid Fiber Reinforced Concrete Prisms M. Tamil Selvi, T S Thandavamoorthy ISSN 0974-5904 08 02
[11] Kalmykov V N, Meshcheryakov E Yu, Volkov P V 2011 Analysis and Justification of Parameters of Wellfield Module “Cleaning Activities” at Development of Resources in Border Areas of Quaries Bulletin of Magnitogorsk Nosov State Technical University 4 5-8
[12] Kalmykov V N, Grigoryev V V, Volkov P V 2010 Searching for Options of Deposit Development Systems to Excavate Near Edge Zones at Combined Geotechnology Bulletin of Magnitogorsk Nosov State G.I. Technical University 1 17-22
[13] Yeremenko V A, Razumov Ye A, Zayatdinov D F 2012 Modern Technologies of Anchorage Mining Information&Analytical Bulletin 12 38-45
[14] Kalmykov V N, Gibadullin Z P, Zubkov A A, Neugomonov S S, Volkov P V, Pushkarev Ye I
2013 Development of Technology of Mechanized Mounting of Mine Workings Using “Liquid” Shotcrete at Underground Mines of JSC “Uchalinskiy MPP” Mining Information&Analytical Bulletin 54 64-70

[15] Lushnikov V N, Yeremenko V A et al 2014 Mounting Mine Workings Under Deformed and Bump Hazardous Rock Masses Gorny Zhurnal (Mining Journal) 4 37-44

[16] Gibadullin Z R, Volkov P V 2009 Method of Evaluation of Options for Ore Transportation at Mining of Marginal Resources Bulletin of Magnitogorsk Nosov State Technical University 3 11-13

[17] Nguyen Viet Dinh 2014 Defining Stability of Mine Workings with Combined Support on the Basis of Numerical Simulation Mining Information&Analytical Bulletin 1 325-329

[18] Kalmykov V N, Volkov P V, Meshcheryakov E Yu 2009 Development of Integrated Processing Schemes of Intensive Deposit Development of Near Edge Quarry Areas Combined Geotechnology: Integrated Development and Preservation of Subsoil Riches of Yekaterinburg, June 22-26, 2009 Materials of International Scientific and Technical Conference: Collection of Papers. 2009 Publishing House: MSTU 31-33

[19] Kalmykov V N, Neugomonov S S, Volkov P V 2019 Features of Fastening Very Unstable Rocks with Combined Support on the Basis of SZA and Shotcrete IOP Conf. Series: Earth and Environmental Science 272 022108

[20] Kalmykov V N, Latkin V V, Zubkov A A, Neugomonov S S, Volkov P V 2015 Technological Peculiarities of Building Up Reinforced Combined Support at Underground Mines Mining Information&Analytical Bulletin 4 (Special Issue 15) 63-69

[21] Kalmykov V N, Kotik M V, Volkov P V 2019 Evaluation of the Stressed State of the Rock Massif and the Renovated Shaft Support of the Skipova Shaft of Sibay Branch of Uchalinsky Ore Mining and Processing Enterprise IOP Conf. Series: Earth and Environmental Science 272 032070