

PAPER • OPEN ACCESS

Technology for fixing mine workings with friction anchors of the SZA type with a new type of anticorrosive coating

To cite this article: P V Volkov *et al* 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* **966** 012017

View the [article online](#) for updates and enhancements.

You may also like

- [Modeling the propagation of air blast waves in mine workings](#)
E E Mazepa, P I Kusainov, A Yu Krainov et al.
- [Modeling of mine workings intersections in KOMPAS 3D program](#)
A E Sudarikov, E Kh Muratbakeev and I E Zvonarev
- [The concept of risk-based technical solutions for the protection of coal mine workings](#)
Serhii Skipochka, Tetiana Palamarchuk and Liliya Prokhorets

ECS
The
Electrochemical
Society
Advancing solid state &
electrochemical science & technology

DISCOVER
how sustainability
intersects with
electrochemistry & solid
state science research

Technology for fixing mine workings with friction anchors of the SZA type with a new type of anticorrosive coating

P V Volkov^{1,2}, R V Kulsaitov¹ and A M Magitov¹

¹ Department of Mineral Deposits, Nosov Magnitogorsk State Technical University, 39, Lenina av., Magnitogorsk, 455000, Russia

E-mail: ²wolf1709@rambler.ru

Abstract. The issues of ensuring the stability of mine workings in weak rocks due to the use of combined roof support based on anchors with a new type of anti-corrosion coating on the example of mining enterprises of the Russian Federation are considered. As a result of the work, the quality indicators of man-made mine waters of mining enterprises of the Russian Federation were determined, the conditions of the mine atmosphere that contribute to the intensification of metal corrosion were identified, an experiment was conducted in the research laboratory to determine the corrosion resistance of self-fixing anchors, the most suitable anchor coatings for their use in aggressive mine environments were identified, The technology of fixing with anchors with a new type of anti-corrosion coating is proposed. Also shown are the conditions for the use of galvanized, paint and varnish coatings, as well as various protective materials, the scope of their application, the advantages, and disadvantages of these coatings in mine environments are indicated. The prospects for the use of new types of coating are shown and directions for further research in this direction are indicated.

1. Introduction

At present, in the underground mines of the Russian Federation, opening vertical as well as horizontal mining and rifling workings are carried out on unstable rocks and ores. Tunneling in such conditions is associated with the presence of metasomatic sites, ore masses with sulfur occurrences, and waters of high mineralization, which negatively affect the durability and reliability of metal structures and rapidly reduce their service life. In such areas, it is recommended to use anchor supports only with a corrosion-resistant coating.

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

Self-fastening anchor support (SZA) is a widespread use when fixing mine workings in underground mines – this is a type of shaft support fixed in holes and boreholes due to frictional interaction. SZA is intended for fastening the roof and sides of underground mine workings of ore and non-metallic deposits, including those developed by the open-pit method, for fastening the sides and slopes of open pit mines. SZA is allowed to be used both independently and as part of a reinforced combined lining.

The use of combined fastening methods based on anchors in conjunction with shotcrete in rocks of low stability in domestic and foreign mines is becoming more and more popular.

In this regard, the results of studies conducted at the mining enterprises of Australia and Canada [7–9], which have experience in attaching workings using fiber-shotcrete, as well as studies [10] by scientists of the Russian Federation, are of great interest[3].



The main functions of the combined lining based on anchors and shotcrete are to form bonds between the lining and the rock, which creates a bearing rock beam, as well as holding pieces of rock between the anchors, while ensuring increased resistance of the massif to destruction and weakening from the effects of the mine atmosphere. The choice of parameters and construction of the lining is based on the analysis of several factors: cost, bearing capacity, operational readiness, expediency and laboriousness of the installation, load (static or dynamic), etc. [1–6].

Of the currently known achievements in the field of applying anti-corrosion coatings for objects operating in high humidity conditions, is the use of surface-active substances (surfactants), as well as inhibited coatings.

For anticorrosive protection of metal surfaces of objects operating in a humid environment, coatings with a gum composition, in particular, based on nairite NT, have spread.

The experience of the Ukrtsvetmetremont trust in protecting the metal and reinforced concrete structures with the gumming composition showed that their durability (under conditions of air humidity more than 75% and exposure to chlorine, sulfuric anhydride) increased by 3–5 times.

The experience of VO Soyuzkhimremoborudna on the protection against corrosion of metal structures using epoxy-coal compositions with high chemical resistance is interesting. The disadvantage of this method is that the start of operation of the structure can be made 7–10 days after coating.

Since it is necessary to ensure the preservation of the functional qualities of metal structures over the estimated life cycle, especially when used in a mine atmosphere, this is an urgent issue; during operation, the metal lining is in conditions most favorable for the occurrence and development of corrosion; annually up to 100 thousand tons of rolled metal is used for fastening mine workings; as a result of the influence of physical and chemical factors, about 10% of the metal is lost per year, as a result of which the metal lining loses its bearing capacity; self-fixing anchor support (SZA) has a core thickness of up to 3–4 mm, in connection with this, the issue of anticorrosion protection during their operation in mine conditions is especially acute [10–14]. Therefore, the development of technology for fixing mine workings with friction anchors of the SZA type with a new type of anti-corrosion coating is an urgent task.

3. Problem statement

As mining operations develop, along with the deterioration of mining and geological conditions, we see the problem of stability of mining operations during the design life at minimal cost.

The experience gained during the use of self-fixing anchor supports in the mines of the Russian Federation indicates the need for protection the supports from the influence of aggressive environments of the mine atmosphere and the main factor – corrosive groundwater.

The purpose of this work is to find ways to corrosion protection of self-fixing anchor lining.

At a visual examination:

- 1) the location of the lining was analyzed relative to the factors of an aggressive environment - casing and washing of the lining structure with aggressive mine waters;
- 2) an overview of the design of anchors;
- 3) studied and analyzed design materials for the use of lining - passports for fixing mine workings with self-fixing anchor lining.

During visual examinations, the strength of the supporting structures and their water permeability are assessed by a thorough inspection with fixing in the log of observations, delaminations, cracks, caverns, traces of filtration and corrosion damage.

Measurement of metal corrosion is carried out by electrical methods, by weighing a corrosion film taken from a unit area of a metal, or by weighing a metal purified from corrosion. Also, to determine the corrosion of the metal supports in places, a device is used to measure the thickness of the metal, cleaned of the corrosion layer, which is produced using a dial indicator with an accuracy of 0.01 mm.

The main problems of using metal anchor support in mine conditions:

- 90–100% humidity;

- constant temperature 10–15°C;
- the presence in the soil and in mine water of lithoautotrophic– iron-oxidizing bacteria;
- wandering currents;
- low pH;
- mineralization of the liquid phase.

4. Theory

The hydrogeological conditions of the Ural deposits are characterized by the presence of groundwater of alluvial-deluvial deposits, weathering crust and rock zone. The water of the weathering crust and rock is hydraulically interconnected to form a single aquifer. The depth of active groundwater circulation is 80–150 m in tectonic zones, along contacts with dikes – up to 250 m. The water cut of the field is characterized by significant unevenness. Hydrogeological conditions for the development of deposits are classified as medium complexity. Pore-fractured (to depths of 6–70 m), fractured (to depths of 100–120 m), fractured-vein waters of tectonic fault zones (at depths below 120 m, up to 350–400 m) are developed in the deposits. The rate of filtration of fractured waters is 0.14–0.58 m/day.

According to the code of rules SP.28.13330.2012, insulation coatings for structures in soils must meet the requirements of Russian State Standard GOST 9.602 for medium-aggressive and highly aggressive environments, the following anti-corrosion coatings should be used:

- thermal diffusion zinc coatings with a thickness of 45–60 microns with overlapping with paint coatings of groups 2 and 3;
- hot zinc coatings, 60–100 microns thick with overlappings with paint and varnish coatings of groups 2 and 3;
- gas-thermal zinc or aluminum coatings, 120–160 microns thick, with overlappings by paint and varnish coatings of 2,3,4 groups;
- chemically resistant paint coatings of 2,3,4 groups;
- gas-thermal zinc coatings, 250–300 microns thick;
- insulation coatings in conjunction with electrical protection;
- electrochemical protection in liquid media and bottom soils.

In the research laboratory, the experiment was carried out in two stages:

Stage I included surface preparation before applying an anti-corrosion coating.

At the second stage of research, the corrosion resistance of self-fixing anchors, with different types of protection, when exposed to aggressive environments was determined.

5. Practical significance, offers and introduction results

Laboratory studies have shown that an innovative polymer coating applied using the new technology can provide reliable protection of the anchor fastener against corrosion for more than 10 years, which reduces the cost of maintaining the workings in a stable state.

Today, large-scale pilot-industrial tests of the first samples of polymer-coated anchor fasteners have been carried out at the enterprises of Apatit JSC, UGMK-Holding LLC, and PF MMC Norilsk Nickel, positive results have been obtained that allow us to carry out work on amendments to the regulatory – technical documentation.

6. Conclusions

As a result of the data obtained, it can be concluded that for acid mine waters, where the pH is below 4.5–5, a galvanized surface cannot be used, there is a strong etching of iron and the loss of metal mass during the month is 4.04%. This is because zinc in this case intensifies the process of iron etching due to the electrochemical action of the Zn-Fe galvanic pair.

Also, SNiP 2.03.11–85 stipulates that for medium and highly aggressive environments a galvanized coating.

Positive results were shown in coatings: epoxy and epoxypolyester. They withstand acidic

basement and mine water, the loss of metal mass in two months of the experiment is 1.07%–1.37 % and 0.03 % for mine water when exposed to basement water, as well as coatings based on low-pressure polyethylene.

The cost of fixing 1 meter was made for the following types of supports: arch metal lining from the special profile of SVP; reinforced composite lining of reinforced concrete anchors and spray concrete reinforced with a metal mesh; reinforced combination support using self-fixing anchors with a new type of corrosion protection.

In the calculations, the use of the following equipment was taken into account: drilling holes – Boomer 282 drilling rig; UKK grid hinge and installation of SVP – PDM Toro – 301; spraying concrete – Aliva.

Calculations have shown that, compared with the technology used for fastening arch metal supports from the SVP special profile (cost 64.212 rubles/m²) and reinforced combined support from reinforced concrete anchors and spray concrete reinforced with metal mesh (cost 36.630 rubles/m²) reinforced combination lining with the use of self-anchoring anchors (cost 32622 rub/lm) will reduce the cost of fixing 1 lm output by 47% and 12%, respectively. The results obtained show the possibility of reducing the cost of securing workings in rocks below the average stability category. Reinforced combined lining with the use of self-fixing anchors is technologically and economically feasible in rocks of medium and lower stability category, and also allows you to effectively use this type of lining in order to reduce water manifestations in underground mine workings, as well as in case of hardening of unstable rocks.

References

- [1] *Guidelines for the design of underground mine workings and the calculation of lining* 1983 (Moscow: Stroytekhnizdat)
- [2] Karetnikov V N, Kleimenov V B and Nordihin A G 1989 *Fastening capital and preparatory workings, reference* (Moscow: Nedra)
- [3] Neugomonov S S, Volkov P V and Zhirnov A A 2018 Mounting Low Stability Rocks with Reinforced Combined Support on the Basis of Friction SZA Anchors *Gorny Zhurnal (Mining Journal)* **2** pp 31–4
- [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 and 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 and Latkin V V 2016 Enhancing Structure and Technology of Mounting Supports with Friction Fastening *Gorny Zhurnal (Mining Journal)* **5** pp 50–3
- [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** pp 70–6
- [8] Zubkov A A, Latkin V V, Neugomonov S S and Volkov P V 2014 Advanced Methods of Mine Working Mounting at Underground Mines *Mining Information&Analytical Bulletin. Certain Articles (Special Issue)* **10** pp 106–17
- [9] Kalmykov V N, Volkov P V and 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** pp 27–35
- [10] TamilSelvi M, Thandavamoorthy T. S. 2015 Energy Absorption Characteristics of Steel, Polypropylene and Hybrid Fiber Reinforced Concrete Prisms *Int. J. of Earth Sci. and Eng.* **8** 2 372-376
- [11] Kalmykov V N, Meshcheryakov E Yu and Volkov P V 2011 Analysis and Justification of Parameters of Wellfield Module ‘Cleaning Activities’ at Development of Resources in

- Border Areas of Quarries *Bulletin of Magnitogorsk Nosov State Technical University* **4** pp 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 Technical University* **1** pp 17–22
- [13] Yermenko V A, Razumov Ye A, Zayatdinov D F 2012 Modern Technologies of Anchorage *Mining Information&Analytical Bulletin* **12** pp 38–45
- [14] Kalmykov V N, Gibadullin Z P, Zubkov A A, Neugomonov S S, Volkov P V and 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** pp 64–70
- [15] Lushnikov V N, Yermenko V A et al 2014 Mounting Mine Workings Under Deformed and Bump Hazardous Rock Masses *Gorny Zhurnal (Mining Journal)* **4** pp 37–44
- [16] Gibadullin Z R and 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** pp 11–3
- [17] Nguyen Viet Dinh 2014 Defining Stability of Mine Workings with Combined Support on the Basis of Numerical Simulation *Mining Information&Analytical Bulletin* **1** pp 325–9
- [18] Kalmykov V N, Volkov P V and 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* pp 31–3
- [19] Kalmykov V N, Neugomonov S S and 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 and Volkov P V 2015 Technological Peculiarities of Building Up Reinforced Combined Support at Underground Mines *Mining Information&Analytical Bulletin* **4** (Special Issue **15**) pp 63–9
- [21] Kalmykov V N, Kotik M V and 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