

PAPER • OPEN ACCESS

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To cite this article: E Apsosimova and N Tarasov 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **272** 032066

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On the Issue of Application of Mining Machines in the Arctic Conditions

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Abstract. The question is the experience of studying the wear resistance of mining machines in arctic conditions. Nikolay Tarasov investigated the wear during the penetration of excavations in rocks with negative temperatures. The importance and prospects of similar studies are discussed, taking into account the plans for the exploration of outer space. According to the corporation "ROSCOSMOS" not frozen rocks on the planets of the solar system are found only in the equatorial zone. An analysis is made of the wear characteristics of working tools of mining machines in the development of rocks with temperatures ranging from -9 to -110 °C. Made suggestions: to reduce the abrasive wear of the working tool, new approaches to the solution of the problems of wear resistance must be applied; to make an analysis of the possibility of using nonmaterial to increase the wear resistance of working tools of mining machines; taking into account the prospects of cosmonautics, to use the permafrost rocks of the Arctic zone as a testing ground for studying the wear resistance of rolling machines.

1. Introduction

In Yakutia, there is an experience in the use of mining machines (MM) in the Arctic zones, in rocks with a constant negative temperature. This fact is important for the future use of MM. It is known that not frozen rocks on the planets of the solar system are more common in the Equatorial zone. In this regard, the accumulated experience and research of miners can be widely used in the development of the planets of the solar system. The strategic plan for the development of cosmonautics of the Russian Federation, involves the development of the planets Moon and Mars. The absence of favorable climatic conditions on the planets will require, among other things, the development of underground infrastructure and the use of MM. In this regard, it is necessary to apply new approaches to solving the problems of wear resistance of working tools. The wear resistance of working tools of MM is a factor that affects not only the efficiency of rock destruction, but also determines the feasibility of using machines. The prospect of mining machines and the modern development of science require an integrated approach to solving problems of wear resistance.

2. Primary partition

Under the leadership of associate Professor Tarasov Nikolai, research was conducted on the use of mining combines of the shaft-sinking and tunneling type for the sinking of inclined shafts in the Arctic zone, at the mines of the KULARZOLOTO combine. Comprehensive studies have been determined



the degree of wear of the incisors, allowing to identify patterns of wear of the incisors in the cryolithozone.

The studies were considered:

- Characteristics and properties of rocks;
- Characteristics and properties of the cutting tool;
- Wear mode parameters and environmental conditions.

Quantitative assessment of the degree of wear was made on the following indicators:

- Wear characterizing the wear on the back face of the cutter;
- Wear, characterized by wear of the front face area and profile of the tool;
- Wear, which characterizes the weight wear.

For testing were selected 3 party tools I-90MB, I-79, I90V, in each of selected group were 200 cutters. Each cutter was numbered and certified, the observations were recorded in the log.

As a result of researches it was established that the wear pattern of the incisors in the destruction of perennial frozen rocks in terms of penetration of shafts "not typical" and very different from the pattern observed during the destruction of the coal and rocks of coal deposits at positive temperatures.

Table 1 shows the data on the wear of cutters in different rocks of the cryolithozone. In the presented table, in addition to the wear value, the characteristic breakdowns of the working tool when working in certain types of rocks are indicated, characterizing the degree of wear.

Previously, it was assumed that it is possible to track a clear relationship of wear and breakage of the working tool. The analysis of the data presented in the table gives a different picture. It is obvious that the increased abrasiveness of rocks causes wear of the cutter body, with a relatively high resistance of the hard alloy (figure 1).

Table 1. The parameters of wear of the cutters in rocks of permafrost zone.

The temperature of rocks $-9 \div -110$ °C.

Rocks	Average specific gravity of the causes of failure of cutters, %			
	Wear	The separation of the reinforcement	Breakage of the cutting part on the cutter body	Losses
Ice, icy silt	32,5	0,5	65,0	2,0
Silt-sand-clay deposits	22,0	4,0	72,0	2,0
Desva, lignites	30,0	2,5	64,0	3,5
Viscous clay with silt and sand	29,5	3,5	63,0	4,0
Fine, medium, coarse sand with forces	15,3	12,0	68,7	4,0
Silt-clay deposits with the inclusion of Gali, crushed stone, quartz (up to 10%)	10,0	17,0	68,0	5,0
The silty-clay sediments with inclusion of quartz (up to 20%)	7,0	25,0	48,0	10,0
Silt-clay deposits with the inclusion of Gali, crushed stone, fine quartz (up to 30%)	5,0	50,5	31,5	13,0
Fine-medium-grained sand with quartz inclusions of size more than 20 mm, silt-clay deposits with quartz inclusion of size up to 100 mm (more than 30%)	5,0	75,5	4,0	20,0

Figure 1 shows the characteristic qualitative pattern of wear of cutters in the destruction of permafrost silt-clay rocks.

Increased wear of the cutter body, the hardness of which is lower than the carbide, caused a change in the cross-section profile, contributed to the wear of the hard alloy, weakened the cutter, reduced the cross-section to 45-50% (critical wear) and led to premature failure.

Analysis of the study data shows that the main causes of failure of working tools are wear, tear plates reinforcement and breakage. Breakdown is predominant. Experimental records of Tarasov group show that the cutting edge breakage occurred due to wear of the cutter body.

The practical importance of identifying the causes of breakdowns-critical wear, was associated with the need to extend the performance and increase the productivity of mining machines by timely replacement of cutters or increase the service life of working tools.

According to the results of research to solve the problem of "critical wear" Tarasov N. proposed: in order to reduce wear of the cutter body and increase wear resistance to increase the length of the reinforcement.

The experimental batch of I-90MB cutters was reinforced to a height of 46 mm with a carbide of the form G-1107 made of WC-15 alloy. As a result, the wear resistance of the working tool increased 5-6 times [1].

Analysis of the literature showed that the existing solutions to the problem of wear resistance of the working tool are not much different from the proposals of Tarasov.



Figure 1. Characteristic wear of cutters.

As the solution closest in time, let us cite the work of PhD student Krestovozdvizhensky [2]. In the work devoted to the performance of the destructive tool (RS 32-70/16), it is said: "Due to the use of a smaller diameter of carbide-tipped rates (W12 mm instead of W16 mm), the radial size of the end face of the head body of the tool was reduced, which, with abrasive wear of the housing, led to breakage insertion and outage of the tool. " The author notes that the main causes of the failure of working tools are the destruction of the hard alloy and the abrasive wear of the tool body around the hard alloy, followed by the breaking of the latter. To solve the problem, it is proposed to use as an insertion element an insert made of wear-resistant steel, X12MF. The length of the landing (sealed) surface of the cutting element (insert), as in N. Tarasov, is increased. In the work it is said that it is also proposed to replace the costly reinforcement of the hard alloy with wear-resistant steel.

In the works of Tarasov N. and Krestovozdvizhensky P. a single idea is being monitored. However, the use of nanotechnology can offer new approaches for solving the problem of increasing wear resistance (the body of the cutter).

In 2008, sites devoted to nanotechnology published information on the application of the so-called "gene spray" metal to metal. We can assume that this is an idea proposed by Sobolevsky P.G. (for powder metallurgy), but the article deals with "sputtering", acting at the molecular level [3].

In 2014, the Russian professor Golberg Dmitri get into the prestigious "Thomson Reuters" rating [4]. In the materials on nanotechnology there is information that in the laboratory "Non-metallic nanomaterials" under the guidance of Golberg D. on the basis of aluminum, a material that is equally light but with a strength exceeding almost 25 times has been developed. It is noted that this was made possible by the unique technology of hardening materials using nanotubes of boron nitride (Fig. 2) [5].

When solving the problem of wear resistance, in the first case, a new technology can be used in the "gene spraying" of a part (fragment) or body of a working tool to increase the resistance to abrasive wear. And in the second - the application of nanotechnology can provide an increase in the strength of the entire working tool.

Known experience in the use of nanotechnology for the production of new alloys [6].

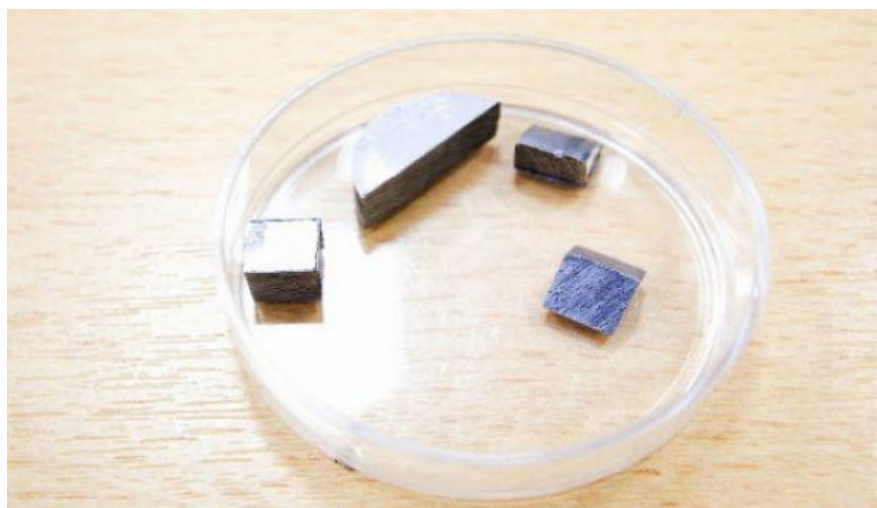


Figure 2. Composite. Aluminum alloy with a nanotube of boron nitride.

However, there are at least two problems that impede the realization of this idea. The first is the lack of a single information and technological space. If we assume that research data on the wear resistance of MM working tools will require the data of the soils of the planets of the solar system, it can be seen that they are scattered like the data on nanomaterials. In 1971, the temperature was measured on the surface of the planet Mars, it was -110°C , it also became known that at a depth of 30-50 cm the soil temperature does not experience diurnal fluctuations [7]. Lunar soil, seized from a depth of 160 cm, was delivered in 1976 [8]. It should also be noted that access to materials is limited.

The second is the need to address the issue of innovative industry development [9]. In the work of Professor Moiseenko Yu. M. said the need for strategic forecasting and planning of scientific and technological development and innovation planning for the practical implementation of new technologies [10]. Such strategic planning is well developed in the military-industrial complex, but not in the mining sector. Although the history of the development of mining equipment was inherently linked, in particular tunneling combines, with the development of missile forces.

Analysis of the literature shows the existence of experience in the formation of a single scientific and technical space in the field of nanotechnology in the creation of space technology and the introduction of elements of artificial intelligence [11, 12]. The presented experience can be used to develop and expand the union of science, production and the state.

Taking into account the practice of using tunneling combines in permafrost rocks, in 2011 it was proposed to establish an international research center (IRC) [13]. This proposal was based on an analysis of the prospects for the exploration of outer space and data on the planet Mars [14, 15]. Five years ago this seemed a distant prospect, however, the speech of Deputy Prime Minister Rogozin on the formation of the strategy for the development of the national space industry and the plans of the state corporation ROSKOSMOS, corrected the time [16, 17, 18].

Professor Robert Winglee [19] in the field of development of space rocket engineering on the basis of theoretical research put forward the hypothesis of a plasma amplifier. According to the professor, an amplifier located in the orbit of the planet can significantly shorten the spacecraft's flight time in interplanetary space [20, 21]. Winglee hypothesis, taking into account the plans of NASA for the development of "Deep Space Gateway" even closer to the time of the beginning of space exploration.

3. Conclusion

Today, no one of the known planets of the solar system has a favorable conditions like on Earth. Sharp temperature changes and high radiation levels suggest that the design of the space base infrastructure can be associated with the use of subterranean excavations. Underground location of bases will require the use of mining machines. The prospect of using tunneling equipment in space conditions dictates the need for using nanomaterials. A preliminary analysis of literature sources shows that in general, the propagation of rocks with negative temperatures is observed on the planets of the solar system. Obviously, the Arctic zone is an optimal place for conducting practical testing of new technological solutions and creating a research ground.

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