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CORROSION OF THE WORKING PART OF MINING EXCAVATORS

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Abstract

This article analyzes the corrosion processes occurring in the working parts of mining excavators and their causes. Mechanical wear, abrasive wear and corrosion processes are studied on the example of excavator tracks, coatings and cutting tools. The study investigated the influence of steel composition, alloying elements, operating conditions and maintenance parameters on corrosion. The results provide recommendations for extending the service life of working parts and increasing technical efficiency. The article is of current importance for the fields of mining equipment, metallurgy and mechanical engineering.

Keywords

mining excavator, working part, wear, steel, alloying, abrasive wear, mechanical wear, corrosion, hardness, heat treatment, service life, cutting tool, coating, metallurgy, maintenance, materials, technology, operation, efficiency, steel composition

Introduction

Mining excavators are one of the most important technical tools of the modern mining industry, which perform the function of lifting and transporting heavy loads in mines, as well as extracting hard rocks. The working parts of this equipment - shovels, covers, cutting tools and drive mechanisms - are in constant contact with stone, gravel, sand and other abrasive materials. As a result, processes such as mechanical wear, abrasive wear, corrosion and thermal stress occur.[1]. The wear of working parts not only leads to technical failures and shortening of service life, but also reduces the efficiency of mining operations and increases operating costs. Therefore, the development of effective methods for analyzing and preventing the wear of excavator working parts is of urgent importance in the fields of metallurgy and mechanical engineering.[2].

The wear process of excavator working parts is complex and depends on many factors. Steel composition, alloying elements, heat treatment and hardness parameters determine the wear resistance of the material. For example, optimal amounts of carbon, manganese, chromium and molybdenum form martensite and bainite phases, which ensure that the steel is resistant to abrasive wear and mechanical stress. Coatings and heat treatments also significantly increase the service life of working parts. Operating conditions, i.e. contact of working parts with hard rocks, temperature changes and humidity levels, also directly affect the wear process. Therefore, in order to extend the service life of mining equipment and increase technical efficiency, it is necessary to perfectly control the mechanical, metallurgical and operational parameters of working parts[3].

In addition, the use of recycled metal resources in modern mining equipment is an environmentally and economically efficient approach. Steel production through the processing

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of secondary raw materials and waste reduces energy consumption, reduces waste and optimizes production costs. At the same time, optimizing the wear mechanisms and steel composition of working parts increases the stability of mining operations, reduces technical failures and ensures operator safety. Thus, a scientific study of the wear of working parts of mining excavators, analysis of mechanical wear, abrasive wear and corrosion processes, as well as optimization of materials and maintenance parameters are important and urgent issues for the metallurgical, mining and mechanical engineering industries.[4].

This article is devoted to a systematic study of the wear processes occurring in the working parts of mining excavators. In the study, the influence of steel composition, alloying elements, heat treatment and coating on mechanical wear and abrasive wear was evaluated using laboratory and industrial tests. The results provide recommendations for extending the service life of working parts and increasing technical efficiency. At the same time, the article is of scientific and practical importance for the mining machinery, metallurgy and mechanical engineering industries, and identifies promising directions for increasing the wear resistance of working parts[5].

Research and method

Experimental studies were conducted in laboratory and industrial conditions to determine the corrosion processes in the working parts of mining excavators. The main objective of the study was to determine how the steel composition, alloying elements, heat treatment and coating work affect the resistance of the working parts to abrasive and mechanical wear. The excavator bucket, cutting tools and coated elements were selected as the working parts. In laboratory conditions, the steel composition was determined using spectrometric analysis, and the content of carbon, manganese, chromium, molybdenum, nickel and silicon elements was determined. At the same time, the presence of coatings on the surface of the working parts and their thickness were assessed using microscopic analysis[6].

To study the wear process, the hardness of the steel was measured using the Rockwell and Vickers methods. Abrasive wear tests were carried out using tribological devices. The working parts were brought into contact with stone, gravel and sand in accordance with their operating conditions. To analyze the combination of mechanical wear and corrosion, steel samples prepared by coating and heat treatment were tested in special tanks under the influence of moisture and chemical agents. The results were analyzed based on the microstructure and hardness indicators of the working parts. It also showed how the steel composition and alloying elements change in contact with soft and hard abrasive materials[7].

The following parameters were systematically measured during the study:

Po‘late composition (C, Mn, Cr, Si, Ni, Mo),

Hardness HRC and HV,

Abrasive wear rate (%),

Mechanical wear rate (mm^3/min),

Coating thickness (µm),

Operating conditions (temperature, humidity).

The results are presented in the table below. These parameters allowed to predict the service life and wear resistance of the working parts of the excavator. During the analysis,

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microscopic cracks on the surface of the test samples, coating wear and changes in the microstructure of the steel were studied in detail.[8].

Table 1

Influence on steel composition and corrosion parameters

Sample	Composition (C, Mn, Cr, Si, Ni, Mo)	ardness HRC	Abrasive yeyilish (%)	Mechanical wear (mm³/min)	Coating thickness (µm)	Note
N1	0.38, 1.0, 1.8, 0.45, 0.5, 0.3	2	100	0.35	150	Optimal combination
N2	0.42, 1.2, 2.0, 0.5, 0.5, 0.3	4	105	0.32	180	Abrasive wear resistant
N3	0.35, 0.9, 1.5, 0.4, 0.4, 0.2	0	95	0.40	120	Mechanically stable
N4	0.40, 1.1, 1.7, 0.45, 0.5, 0.25	3	102	0.33	160	With optimal coverage

In the process of analyzing the research results, the mechanisms of wear of working parts were studied in detail. Excavator buckets and cutting tools showed significant resistance to abrasive wear, provided that the steel composition and coating work were optimal. The combination of mechanical wear and corrosion was identified as the most damaging factor. At the same time, alloying elements and heat treatment increase the microstructure and hardness of the steel, which significantly extends the service life of working parts. The research results allow us to develop recommendations that can be practically applied in the fields of metallurgy and mining engineering. On this basis, effective strategies were identified to prevent wear processes and increase the service life of working parts[9].

Result and negotiation

The experimental results showed that the working parts of mining excavators - shovels and cutting tools - are significantly corroded depending on the operating conditions. The steel composition and alloying elements are the main factors determining the abrasive wear resistance. In the study, the N2 sample (C 0.42%, Mn 1.2%, Cr 2.0%, Si 0.5%, Ni 0.5%, Mo 0.3%) showed the highest abrasive wear resistance and the mechanical wear rate was 0.32 mm³/min. At the same time, the N3 sample (C 0.35%, Mn 0.9%, Cr 1.5%, Si 0.4%, Ni 0.4%, Mo 0.2%) showed the lowest resistance and the mechanical wear rate was 0.40 mm³/min. These results confirm that the combination of steel composition and coating treatments directly affects the service life of the working parts.[10].

Coatings, particularly nickel and chromium coatings, have been shown to increase the service life of workpieces by 20–30%. Table 1 presents the steel composition, hardness, abrasive and mechanical wear characteristics, and coating thickness. The results show that as

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hardness increases, resistance to abrasive wear increases, but other types of mechanical wear (chipping, impact) cannot be reduced by coating. Therefore, achieving an optimal microstructure with alloying elements and heat treatment, when used in conjunction with coatings, can help maximize the service life of workpieces.

Table 2. Steel composition and corrosion results

Sample	Composition (C, Mn, Cr, Si, Ni, Mo)	Hardness HRC	Abrasive (%)	Mechanical wear (mm^3/min)	Coating thickness (µm)	Note
N1	0.38, 1.0, 1.8, 0.45, 0.5, 0.3	52	100	0.35	150	Optimal combination
N2	0.42, 1.2, 2.0, 0.5, 0.5, 0.3	54	105	0.32	180	Abrasive wear resistant
N3	0.35, 0.9, 1.5, 0.4, 0.4, 0.2	50	95	0.40	120	Mechanically stable
N4	0.40, 1.1, 1.7, 0.45, 0.5, 0.25	53	102	0.33	160	With optimal coverage

The results of the analysis showed that the combination of mechanical wear and abrasive wear is the main wear mechanism of the workpieces. When the microstructure of the workpieces is rich in martensite and bainite phases, the resistance to abrasive wear increases. At the same time, the corrosion effect, i.e. the combination of moisture and chemical agents, reduces the wear resistance of the steel. This shortens the service life of the workpieces and reduces the technical efficiency. The results show that with the optimal combination of composition and coating operations, the negative effects of mechanical and abrasive wear are minimized. On this basis, it is necessary to develop systematic prevention and material optimization strategies to prevent the wear mechanism of the workpieces and increase the service life.

The results of the experimental study allow us to give practical recommendations for the design and selection of materials for the working parts of mining excavators. The optimization of the steel composition and alloying elements, the combination of heat treatment and coating operations significantly extend the service life of the working parts. The results show that the optimal combination of coating operations and alloying increases the resistance of the working parts to abrasive and mechanical wear, reduces the effects of corrosion and maximizes technical efficiency. At the same time, recommendations for preventing corrosion processes and extending the service life of the working parts are of scientific and practical significance, which can be used in the fields of metallurgy, mining equipment and mechanical engineering.

Conclusion

The results of the study of corrosion processes occurring in the working parts of mining excavators showed that the steel composition, alloying elements, coating and heat treatment directly affect the service life of the working parts. During the study, it was found that the optimal combination of carbon, manganese, chromium, molybdenum and nickel elements significantly increases the resistance of the cutters and cutting tools to abrasive and mechanical

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wear. The level of hardness and the presence of martensite and bainite phases in the microstructure slow down the corrosion process of the working parts and prevent technical failures. At the same time, coating increases the resistance of the working parts to abrasive wear and corrosion. The results of the study allow to determine the optimal composition of the working parts, thereby increasing the efficiency of mining operations and reducing technical costs.

The experimental results also confirm the importance of systematic prevention and material optimization strategies to extend the service life of working parts. Recommendations for increasing the mechanical, abrasive and corrosion resistance of working parts can be practically applied in the fields of metallurgy, mining equipment and mechanical engineering. On this basis, the combination of steel made from secondary raw materials and coating works increases the efficiency of working parts, extends the service life and ensures the stability of mining operations. The results obtained during the study are also scientifically significant and create a basis for further research on preventing corrosion processes and increasing the service life of working parts in the future. At the same time, these results will also help to increase the energy efficiency of mining equipment, reduce waste and ensure economic efficiency.

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