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PROPERTIES AND WEAR CHARACTERISTICS OF MATERIALS FUSED ONTO COMPONENT SURFACES

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Annotatsiya: Ushbu maqola ishlanayotgan ishlab chiqarishda ishlagan detallar mustahkamligini oshirish maqsadida ularni eritib qoplash uchun qo‘llab-quvvatlangan metallarning xossalari va ularni yeyilish mexanizmiga bog‘langan.

Kalit so‘zlar: ishchi yuzalar, qattiq qotishmalar, yeyilish, qoplash usuli, fabraziv zarrachalar, material tarkibi, uglerod mahsulotlari, metall qoplama.

Аннотация:Статья посвящена свойствам металлов, используемых для плавки и покрытия их поверхностей с целью повышения прочности деталей, работающих в условиях трения, и механизму их изгиба.

Ключевые слова: рабочие поверхности, твердые сплавы, истирание, способ нанесения покрытия, абразивные частицы, состав материала, содержание углерода, металлическое покрытие.

Annotation: This article is devoted to the properties of metals used for fusion coating on the surfaces of components operating under friction conditions, with the aim of increasing their durability, as well as to the mechanisms of their wear.

Keywords: working surfaces, hard alloys, wear, coating method, abrasive particles, material composition, carbon content, metal coating.

Introduction.

In our country, comprehensive measures are being implemented to increase the volume of excavation, loading, and transportation of materials in road construction, general construction, and mining sectors; to reduce material and energy costs in production; and to ensure the efficient use of widely applied technical equipment. In this context, enhancing the strength, impact resistance, and wear resistance of the working parts of excavator components used in these processes is one of the most pressing issues today.

In this regard, the working surfaces of key excavator components are typically coated with hard alloys of various compositions and structures to increase resistance to abrasive wear. Such coatings are often applied using manual and mechanized arc welding methods, plasma-arc welding, and, in rare cases, gas-

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plasma techniques. Hard-alloy coatings are generally composed of high-carbon alloys based on iron, and in terms of their composition and structure, they are similar to tool steels and cast irons. Materials with low carbon content (0.4–0.7%) are used less frequently.

In recent years, to enhance wear resistance, surface strengthening using plasma and gas-plasma spraying, as well as plasma-arc fusion coating methods with nickel-based materials, has been increasingly applied. Below, the most commonly used iron-based alloys are reviewed. The conditions under which the abrasive environment affects the metal and the degradation of the metal surface determine in advance the required composition, microstructure, phase state, and properties of the fused coating material.

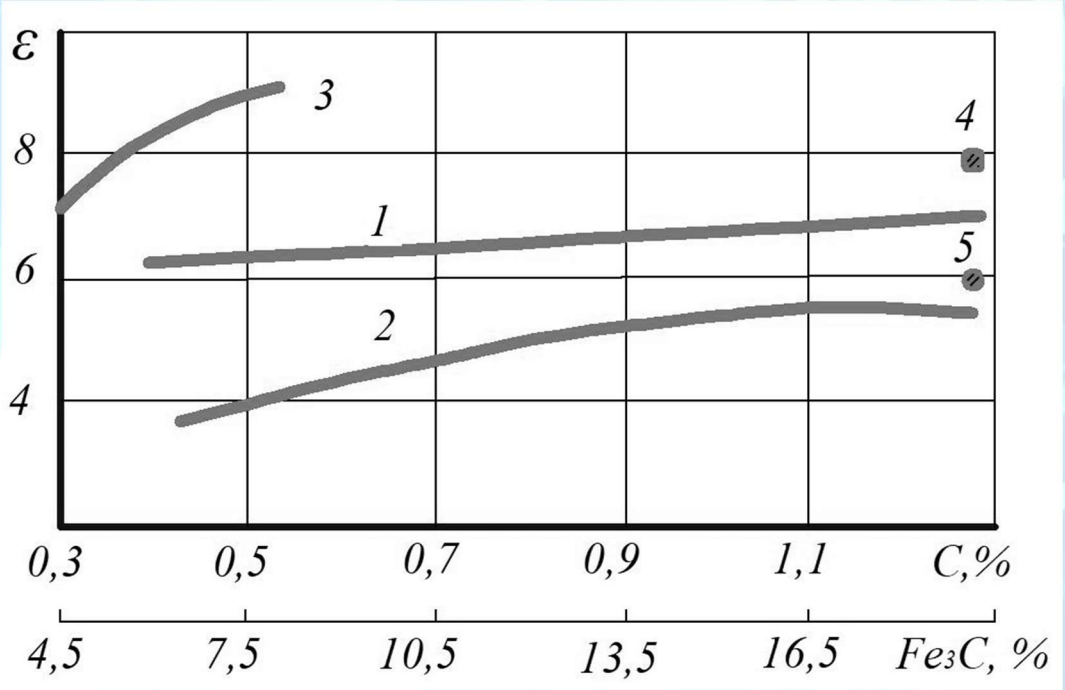
Materials and Methods. Depending on the size and characteristics of abrasive particles, as well as the nature of their interaction with the metal surface (such as friction with monolithic abrasives, friction with dispersed abrasives, impact-abrasive wear, etc.), the degradation of the metal may be associated with the embedding of the abrasive into the surface, followed by micro-cutting processes or the deformation, fragmentation, and deterioration of the coated metal. In impact-abrasive wear, the surface layer of the metal may undergo brittle fracture. Repeated impact of abrasives on the metal surface can lead to fatigue-induced failure. However, in all of the above-mentioned cases, the primary factor contributing to wear is the penetration of the abrasive into the metal surface.

To resist the effects of such an abrasive environment, the metal must possess a hard structural phase. This structural constituent may include carbides, borides, carboborides, carbonitrides, or intermetallic compounds. In some cases, martensite can partially fulfill this function. Naturally, for the effective use of hard particles such as carbides and other compounds, they must be firmly held within the matrix that forms the base of the alloy. However, the alloy matrix must not only retain these hard particles effectively, but also itself contribute to abrasion resistance and enhance overall wear resistance. One such matrix that contributes to improved wear resistance is martensite. The properties of the martensitic matrix largely depend on its carbon content.

Low-carbon martensite exhibits low wear resistance; however, due to its higher toughness compared to high-carbon martensite, it retains hard wear-resistant particles more effectively and enhances resistance to impact loads typical of impact-abrasive wear. As the carbon content in martensite increases, wear resistance under abrasive friction conditions increases continuously (see figure). In impact-abrasive wear, the improvement in wear resistance occurs only up to a certain carbon content in martensite, after which it begins to decrease. In unalloyed

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steels containing up to approximately 1.2% carbon, martensite is almost absent after quenching and limited carbide formation, and changes in the carbon content of the steel directly affect the carbon content in martensite. This, in turn, allows for evaluating the wear resistance of the martensitic matrix.



1 – Unalloyed steel quenched and tempered at 200°C;
2 – Alloyed steel, quenched and tempered at 600°C;
3 – Steel containing 1.6% alloying elements, quenched and tempered at 200°C;
4 and 5 – Steel containing 12% alloying elements, quenched and tempered at 200°C and 600°C, respectively

Effect of carbon content and alloying degree on the wear Resistance of steels

After high-temperature tempering, the structural state of quenched steels is characterized by a carbide-ferrite matrix. In this case, an increase in carbon content in the steel corresponds to a rise in the amount of the carbide phase. The wear resistance of the ferritic matrix is significantly lower than that of the martensitic matrix, which is particularly evident in impact-abrasive wear conditions, where the material's resistance to the penetration of abrasive particles into the metal surface is critical. An increase in the amount of carbides has a more effective impact on wear resistance under abrasive friction conditions, but is less effective under impact-abrasive wear.

In abrasive and impact-abrasive wear, the influence of carbon content in the fused coating metal is closely related to the nature of surface degradation. In abrasive wear, during sliding friction or friction involving abrasives, the primary factor is the material's resistance to the penetration of abrasive particles into the metal surface and their subsequent movement along the surface while embedded.

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These characteristics are determined by the metal's resistance to elastic and plastic deformation, i.e., its strength properties. In this case, the key property of the component material is its hardness, along with the hardness of its individual phase constituents. However, hardness does not always directly correlate with the abrasive wear resistance of welded coatings. For example, in structures with martensite and martensite–carbide phases, even when the overall hardness is the same, the wear resistance is higher in the latter.

In impact-abrasive wear, the energy-related characteristics of the metal are important—sometimes even decisive—as they reflect the material's resistance to the dynamic action of abrasive particles. In such cases, an increase in mechanical properties, such as hardness, does not necessarily indicate improved wear resistance unless it is accompanied by an increase in the energy capacity of the material to resist destruction. Nevertheless, the influence of hardness or other mechanical parameters cannot be disregarded, as even in impact-abrasive wear, the material's resistance to the penetration of abrasive particles into its surface remains critical. Therefore, a combination of mechanical strength and energy-related properties (strength and toughness) can serve as an indicator of resistance to impact-abrasive wear. For instance, in abrasive sliding wear, steels that have been quenched and low-temperature tempered (which are harder and less tough) tend to show higher wear resistance. In contrast, under impact-abrasive conditions, steels that have been quenched and then tempered at higher temperatures (softer but with greater toughness) demonstrate greater resistance to wear.

In addition to martensite and ferrite, the matrix of wear-resistant fused coatings can also consist of austenite or ledeburite. An austenitic matrix offers several advantages over a ferritic one. Firstly, austenite is characterized by significantly higher toughness and strength compared to ferrite. This, on one hand, improves its ability to retain hard carbide particles and other precipitates, and on the other hand, enhances overall wear resistance, especially under impact-abrasive wear conditions. Moreover, austenite can be either fully or partially unstable, and during plastic deformation accompanying the wear process, it may transform into martensite. This transformation contributes to an additional increase in wear resistance under abrasive friction - particularly under high pressure of abrasive particles - and in impact-abrasive wear conditions.

For wear-resistant fused coatings, the partial retention of austenite in the matrix alongside its partial transformation into martensite (30–50%) is considered optimal. This structure enhances the wear resistance of the alloy while maintaining its toughness.

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Ledeburite can serve as the matrix in high-carbon alloyed fused coatings. It may be conventionally referred to as a matrix, although it contains significant amounts of ferrite, martensite, or austenite. However, due to its uniformity and relative homogeneity, ledeburite can be regarded as the base in which hard phases - typically carbides and borides - are embedded.

Results

Thus, taking into account the aforementioned considerations regarding the hard phases and matrix of wear-resistant fused coatings, their structural-phase composition can be classified as martensitic (M), martensitic–carbide (M+C), ferritic–carbide (F+C), austenitic–carbide (A+C), ledeburitic–carbide (L+C), or with a mixed matrix.

Considering that fused coatings are often used without heat treatment, their structural-phase state and wear resistance are primarily determined by the carbon content and the amount of alloying elements.

The structure of a wear-resistant fused coating is primarily determined by its chemical composition. However, the fusion coating technology - particularly the thermal regime of the process - can also have a significant influence. An increase in linear energy input, a rise in welding current, or a decrease in the travel speed of the electrode wire (the heat source) during fusion coating leads to a longer residence time of the molten metal and a slower cooling rate of the fused coating.

Conclusion

Thus, under existing conditions, the crystallizing phases - namely, primary carbides - tend to increase in size. As a result, it is advisable to take appropriate measures during the fusion coating process to prevent the deterioration of the properties of the fused metal.

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