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THE INFLUENCE OF EXTERNAL FACTORS ON THE MECHANICAL PROPERTIES OF THE MATERIAL

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Abstract

This article considers the influence of external factors on the mechanical properties of the material. The influence of various factors on the mechanical properties of materials. Experiments have established that with an increase in the loading rate and strain rate, the yield strength and tensile strength increase. With increasing temperature, creep is especially noticeable. At high temperatures, viscous (plastic) properties become more pronounced, while at lower temperatures, embrittlement is observed. The influence on the mechanical properties of metals of the chemical composition is significant. For example, small alloying additives (chromium, nickel, molybdenum, etc.) change the mechanical properties of steels and make it possible to create materials with high strengths.

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One of the main reasons for the intensive wear of the abrasive tool and the poor quality of the treated surface during metal grinding is the flow of a complex complex of physicochemical processes in the cutting zone. The most important factor in ensuring the desired quality of the treated surface in the manufacture of the part and maintaining it at a given level during operation is the external environment, which has special physical and chemical properties. Under extreme conditions of contact interaction, the external environment interacts with the contacted surfaces, changing their initial state.

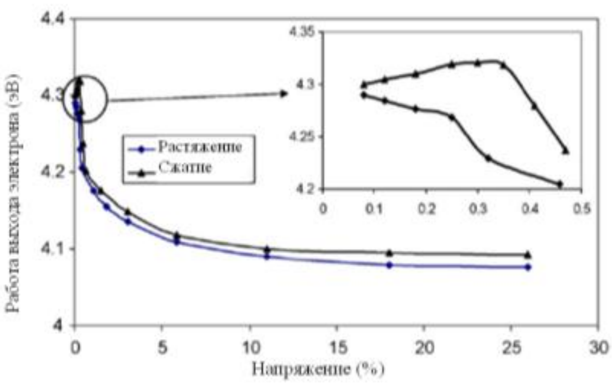
To describe the characteristics of processing and the formation of surfaces, the control of geometric parameters is insufficient. The most informative method for assessing the chemical state of the surface layer is elemental analysis, which is implemented using various special devices such as Auger spectrometer, secondary ion mass spectrometer, etc. Also, as an additional quality parameter of the surface layer of the product, many domestic scientists Karimov A.V., Usmonov T.B., Ayupov Sh.A., Kary-Niyazov T.N. and foreign scientists Muhurov N. I., Panteleev K. V., Svistun A. I., Zharin A. L., Kalmykov V. V., Y. Zhou, J. Q. Lu, W. G. Qin, D. Shaw, Hao Lu and other contemporaries proposed to use such a parameter as surface energy. For the most meaningful description of the surface energy index, the electron work function is used as the most sensitive parameter of the energy state of the surface layer.

Knowing the actual value of the work function of an electron makes it possible to determine with great accuracy the surface energy of solid metals and, thus, to follow the change in the state of their surface layers, and, therefore, to reveal the nucleation and development of defects in it. For example, fatigue cracks are formed mainly on the surface of metal parts, regardless of whether the method of loading them is associated with high surface stresses (for example, in bending and torsion) or not. The possible influence of the energy of the surface of metals on the adhesion and the value of the friction coefficient is also known [1].

In the works of A. M. Dalsky, A. G. Suslov, A. Yu. Albagachiev, E. V. Ryzhov, V. P. Fedorov, it was shown that during the machining of parts, part of the energy is absorbed by the metal. Approximately 75% of the total energy spent on the formation of the surface is associated with heat, and it can be conditionally considered that this amount of heat does not affect the physical essence of the layer. The remaining about 25% of the total energy spent on the formation of the surface by technological action, after processing, passes into the state of surface energy. It, in turn, is spent on the distortion of the crystal lattice, the formation of dislocations, the movement of vacancies, the functioning of Bernard cells, etc. The mutual influence of the data that make up the part during operation represents the accumulated surface energy and affects the physical and mechanical characteristics [2].

At present, methods based on recording the distribution of the work function of an electron, for example, by contact potential difference, are widely used for research and non-destructive testing of surface parameters and processes occurring in the surface and near-surface layers of solids. The value of the work function of an electron is directly related to the physicochemical and mathematical-mechanical properties of a substance in a condensed state. A change in the physicochemical and mechanical parameters of the surface of a solid should cause a corresponding change in the work function of the electron. As practice shows, during the processing and formation of supersmooth surfaces of non-ferrous metals and alloys, free electrons formed during the technological impact of the cutter lead to surface oxidation processes and changes in physicochemical parameters. In this case, the thickness of the resulting oxide film can be comparable to or greater than the maximum roughness height [3].

In the works of Y. Zhou, J. Q. Lu, W. G. Qin, D. Shaw, Hao Lu, the influence of deformation on the work function of an electron was experimentally proved: elastic deformation causes an increase in the work function of an electron, and in the region of plastic deformation, the work function decreases (Fig. 1). Moreover, the decrease in the work function of the electron output corresponds to the degree of plastic



deformation, and the value of the increment in the work function of the electron by the moment of destruction is different for different metals.

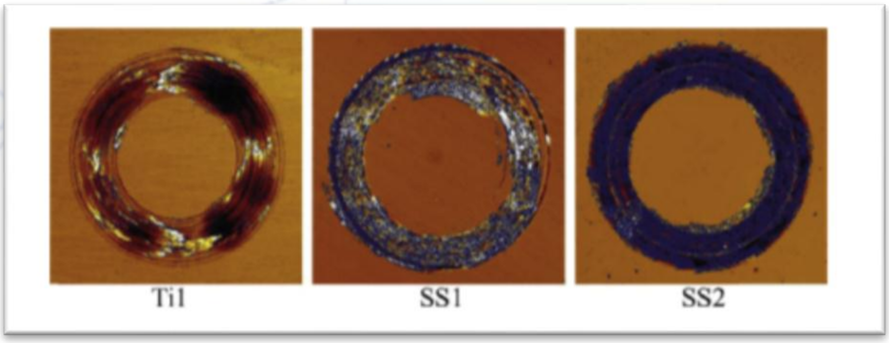
Fig. 1. Electron work function (EWF) of Al under bending deformation.

Levitin V. V. in co-authorship experimentally studied the change in the work function of the electron Al, Ti, Fe and Ni alloys in relation to tensile strain and calculated the EWF using the density functional method for elastically stressed single crystals. Experimental and theoretical results have shown that the electron work function decreases with tensile deformation. Another theoretical calculation, using the method of self-consistent electron-deformation interaction, also showed that the work function of an electron decreases if the crystal lattice is deformed under tension. However, studies by S. V. Loskutov and M. I. Pravda, based on a self-consistent calculation of the surface energy, showed that the work function of an aluminum electron increases during deformation by the processes of a relaxation phenomenon [4].

The above studies demonstrate that the effect of deformation, in particular, under complex regimes, remains unexplored so far; even some experimental observations of various researchers are contradictory. This indicates that the physical mechanism responsible for this effect has not been fully understood [4]. Thus, there is a need to establish a clear theoretical correlation between the work function of an electron and various deformations. To this end, it is necessary to clarify theoretically the influence of displacements on the work function of an electron, since plastic deformation is associated with their formation.

It was also noted in [4] that the strain rate can play the same role on the change in the work function of an electron as strain. The electron work function decreases in proportion to the increase in tensile strain. In [5], the electron work function and the behavior of the friction force of three inert alloys were studied under various grinding conditions. The electron work functions were determined using a scanning Kelvin probe and the hardness of the samples using a hardness tester, the coefficients of friction under conditions with and without cutting fluids, were measured using a tribemate needle.

The coefficient of friction depends on two factors, surface adhesion and mechanical deformation. Stronger adhesion is observed with greater friction force, lower hardness leads to an increase in the contact area, which increases the overall adhesion force. In order to understand the trend of the coefficient of friction in dry and coolant conditions, needle marks were also observed on specimens treated under various conditions. Fig. 2 and 3 illustrate the tracks along which the needle slid.



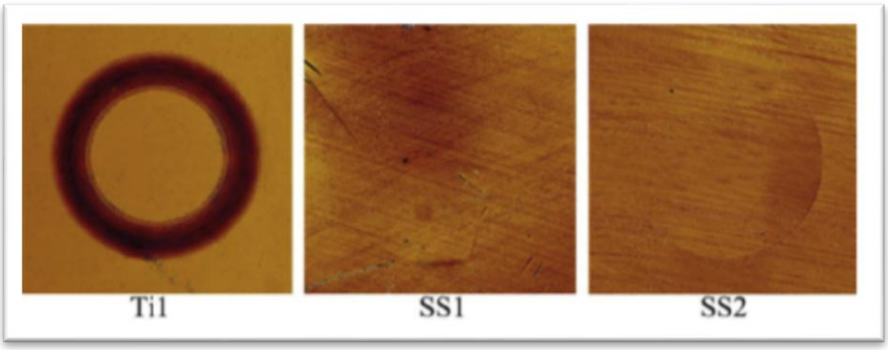


Fig. 2. Traces of friction in dry conditions

Fig. 3. Traces of friction with the use of cutting fluids

During dry friction, the surface of the samples together with inert films were damaged, the needle was in direct contact with the bulk of the alloy or with broken active atomic bonds. In this case, a material with a higher work function of an electron should have a greater adhesive force, and a large atomic bond leads to an increase in surface energy (for surfaces with the same density of broken bonds) [5].

Surfaces of specimens with higher work function during dry grinding have higher coefficients of friction. While with the use of cutting fluids, this trend disappears. Surfaces and inert films were damaged during dry sanding. When using cutting fluids, the surfaces and inert films of the stainless steels showed good integrity, and the surface and films of the Ti alloy were damaged. The observed trends in the change in the coefficient of friction with respect to inert alloys during dry grinding and with the use of cutting fluids are based on the point of view of the activity of atomic activity and the role of various films in blocking the interaction between electrons and the environment [5].

Conclusions. Because the Kelvin probe method is a powerful non-destructive method, it has been used to measure the work function of an electron from a metal, and has provided invaluable insights into surface physics and chemistry, which is critical to the development of advanced materials. For example, the work function of an electron is dominated by the oriented mobility of positive and negative charges, which is an important function of a heterogeneous compound in microelectronics, photo-catalysis, sensor technology, solar cells, etc. However, to date, little attention has been paid to the application of the Kelvin probe method to study mechanical properties of materials. It is known that most of the mechanical, tribological and electrochemical properties of materials are fundamentally determined by their electronic properties. These properties in some sense can characterize the work function of an electron. However, the main limitation that hinders the use of this method in the study of the mechanical behavior of materials is the lack of established patterns of the relationship between mechanical properties and the electron work function. Thus, the creation of a theoretical relationship between mechanical properties and the electron work function is a prerequisite for using the Kelvin probe in the study of mechanical properties, as well as for studying the potential of materials design.

The analysis of scientific works on this topic allowed us to draw several fundamental conclusions. Since plastic deformation can increase the density of displacements, the electron work function of deformed specimens must always decrease no matter what kind of deformation. In addition, elastic deformation does not involve displacements, in other words, the elastic deformation mechanism is a deformation of the crystal lattice or a shift in the potentials of atoms, corresponding to an increase / decrease in the work function of an electron with tension or compression, caused by an increase / decrease in the electron density of metal surfaces.

In addition, the influence of the strain rate is similar, i.e., the displacement density increases. Accordingly, with an increase in the strain rate, the electron work function should decrease. It should also be noted that surfaces with a higher work function are more reactive to interact with the environment and form surface films. Thus, the largest electron work function should correspond to a strong barrier against the penetration of electrons from the metal through inert films / tribochemicals / cutting fluids and contribute to the adhesive interaction.

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