SPECIAL FEATURES OF THE WEAR OF TUNGSTEN–COPPER
ELECTRIC CONTACTS IN AIR AND IN OIL

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In the Soviet Union and in other countries [1] it is common practice to use tungsten (molybdenum)–copper electric contacts made by the method of powder metallurgy to equip air, oil, and low oil switchgear. The prospects of improving the reliability of contacts, other conditions being equal, are connected with the refinement and development of the notions concerning their electric erosion in the switching process under different conditions and with reducing the level of erosion (also with the aid of metallurgical methods at the stage of synthesis of the materials and of making contacts from them).

Earlier on some authors [1-6] discovered the effect of the medium on the wear of contacts made of the pseudoalloys W–Cu in the switching of heavy currents (>1000 A). The results obtained by these authors show that, regardless of the variety of experimental conditions on stands and in actual gear, there is a tendency to reduced wear of contacts made of pseudoalloys when current is switched in air. It was noted in [2, 5] that this tendency has to do with a certain range of switched currents: independently of the number of switchings, with currents up to 3 kA electroerosive wear of W–Cu contacts in air is lower than in oil. When the current intensity is increased, wear in air becomes equal to or even somewhat greater than in oil [2]. The difference in the dependence of wear of contacts on the amount of tungsten in the composite W–Cu in switching current in air and in oil, distinct when the content of the high melting component is less than 40% (Fig. 1), vanishes when it is subsequently increased [2, 4, 7]. The smallest wear of contacts corresponds to a tungsten content of the composition of 50–70 weight %. When the amount of tungsten is further increased, electric erosion of the contacts increases in oil as well as in air. Such a nature of wear of the contacts is connected with the processes occurring in their working layer [5, 8, 9] and in the contact gap.

The object of the present work is to select and investigate possible model chemical reactions of interaction of the components of the working layer of tungsten–copper contacts (also in the gaseous phase) with the medium, to determine the thermodynamically most probable ones among them, and to analyze from this point of view the special features of electroerosion wear of W–Cu contacts by switching of current in air and in oil.

Under the effect of the arc discharge in the contact gap the transformer oil is decomposed, the heavy molecules are fragmented into simpler ones: CH₄, CH₂, CH, C, H, etc., [10]. At high temperatures it is also possible that gaseous molecules C₂, C₃ form, that the components of the electrodes and the decomposition products of organic substances interact with atmospheric oxygen [10]. In the present work we therefore investigate the thermodynamic probability of reactions proceeding in the system W–Cu–C–O–H. In the model adopted by us we

![Graph showing the effect of the content of tungsten on the erosion of W–Cu contacts in oil and in air.](image-url)
Therefore deal solely with equilibrium reactions and do not take into account the peculiarities of processes in the electrode gap and near the electrodes which are due to the effect of an electric and other fields (e.g., the formation of excited atoms, ionization, polarization of mass transfer, etc.) and may lead to increased chemical activity and differentiation of chemical reactions, and also influence the kinetics of the processes. Although the equilibrium model chosen by us does not fully express the physical properties of the investigated system, it has the advantage of providing the possibility to carry out fairly simple calculations with acceptable accuracy [11].

We carried out a thermodynamic analysis of about 60 possible reactions of evaporation, oxidation, carbide formation, etc. The most characteristic reactions of the same type and their standard enthalpies are presented in Table 1, and the temperature dependences of the change of Gibbs free energy of these reactions $\Delta G^0_T$ in Fig. 2. The values of $\Delta G^0_T$ were calculated for the range 298-3000 K and extrapolated to 5000 K. This range corresponds to the notion on the temperatures developing in the base $(2-4) \cdot 10^3$ K and in the core $(5-15) \cdot 10^3$ K of the arc [12]. The thermodynamic data required for the calculations were taken from the handbooks [13-16].

An analysis of the presented dependences shows that out of all the reactions in the system W-Cu-C-O-H, the most probable one in the presence of oxygen is oxidation in the solid and gaseous phases, in the presence of carbon and of fragments of CH₄, CH₂, and CH, it is carbide formation, although the presence of atmospheric oxygen may promote the development of various exchange processes, inhibit carbide formation, cause oxidation of carbon as well as of the carbide itself. According to the data of the calculation, the reaction of vapor formation, of evaporation of copper under these conditions is less likely, especially in the temperature range below 2000 K (Fig. 2).