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Opinion

Application of Breaking and Sliding Electrical Contacts Based on Copper-Molybdenum Pseudo Alloys for Use in the Mining Industry

Grechanyuk NI and Grechanyuk VG*

Doctor of Chemical Sciences, National University of Building and Architecture of Managing Department of Chemistry, Ukraine

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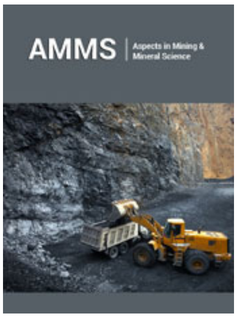

***Corresponding author:** Grechanyuk VG, Doctor of Chemical Sciences, National University of Building and Architecture of Managing Department of Chemistry, Ukraine

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Opinion

In [1] the structure, properties and operational characteristics of pseudo alloys (Cu-Zr-Y-Nb) -Mo (МДК), which are widely used for the manufacture of electrical contacts and electrodes, were studied in detail. МДК materials [2-5] have a relatively low corrosion resistance, so the task of increasing the corrosion resistance of these materials is urgent. The authors [6] proposed a composite material consisting of a metal matrix - low-alloy copper-based alloy with the following content of components, % wt.: yttrium-0,01-1,0; zirconium 0.01-1.0; niobium-0.01-0.5; the rest is copper, which is strengthened by dispersed particles of molybdenum, copper oxide and molybdenum oxide. The ratio of components in the specified composite material was,% wt .: molybdenum-1,5-15; copper oxide-0.1-5; molybdenum oxide-0.1-5; alloy Cu-Zr-Y-Nb residue. To increase the corrosion resistance of the material, the matrix (Cu-Zr-Y-Nb) was additionally doped with chromium at its content in the alloy of 0.2-0.41% wt. The technology of obtaining composite materials (Cu-Cr-Zr-Y-Nb)-Mo-CuO-MoO_3 includes simultaneous evaporation from two independent crucibles of ingots of Cu-(0.2-0.41) alloy. Cr through a bath mediator (Cu-Zr-Y-Nb) and molybdenum. Additional chromium doping increases the corrosion resistance of composites by 1.5-2 times compared to pseudo alloys (Cu-Zr-Y-Nb)-Mo, which are widely used in industry [3,4]. Breaking contacts made of the material (Cu-Cr-Zr-Y-Nb)-Mo-CuO-MoO_3 with increased corrosion resistance are used in switching devices of Smolinskaya and Ingulskaya mines for uranium mining, in the atmosphere of which there is an increased content of CO_2 and SO_2 at a humidity of about 80%. Another important area of further use of high-speed evaporation-condensation technology to obtain electrical contact materials is the development of compositions for sliding contacts. In a sliding electric pair, one of the elements removes the electric current by moving on the other. Contacts of this type differ in the values of current and voltage for which they are designed, the speed of movement, the shape of the contact surface, environmental conditions and the type of materials used. All sliding contacts are a tribosystem through which an electric current passes. This means that the contact interaction is due to the force of friction, which causes wear of the contact surfaces, their heating and the course of chemical reactions in the contact zone.

Direct current to a greater extent than alternating current affects the processes occurring in contact. This is mainly due to a certain direction of electron motion [7,8]. The presence of moisture in the contact zone can promote mass transfer between contacts due to electrolysis [7]. Positive metal ions in the process of micro-discharges are transferred to the negatively charged contact [9]. Thus, on the surface of the copper contact, which works in pair with carbon, carbon deposition occurs, which leads to the formation of a layer that conducts electricity poorly and, as a consequence, to a significant release of thermal energy. Simultaneous mechanical and electrical effects in the sliding contact system leads to an effect qualitatively different from the simple sum of the effects caused by each of them. According to [7], significant wear of contacts is given as the sum of separate types of wear: mechanical, electric and wear caused by mechanical influence on the surface damaged by electric discharges. Until recently, graphite was used as a material for the pantograph. After three months of operation, the pantograph is almost completely worn out. Therefore, despite systematic research and technical development, the question of creating new materials for sliding contacts of pantographs with the use of the latest environmentally friendly technologies is acute. In this paper, the task of developing materials based on composites (Cu-Zr-Y-Nb) -Mo-CuO-MoO_3 with high tribotechnical characteristics in comparison with known pseudo alloys was set [3,4]. The problem is solved in such a way that in the composite material (Cu-Zr-Y-Nb) -Mo-CuO-MoO_3, which was obtained by simultaneous electron beam evaporation of copper containing yttrium, zirconium and niobium, and molybdenum with the formation of copper oxide II and molybdenum trioxide at controlled oxygen supply, for doping the alloy (Cu-Zr-Y-Nb) in its vapor cloud was carried out dosed acetylene supply with its gradual decomposition and the formation of carbon in the amount of 0.07-3.5% of the mass. Based on the results of laboratory tests, it was found that the introduction into the matrix (Cu-C-Zr-Y-Nb) of carbon in the range up to 1.5 wt%. (3.5 vol.) Leads to a significant reduction (3-4 times) of the reduced wear and almost halves the reduction of the coefficient of friction [10] (Table 1).

Table 1: Tribotechnical characteristics of condensed composites (Cu-C-Zr-Y-Nb)-Mo-CuO-MoO_3 with different carbon content.

No	Carbon Content		Parallel to Stratification		Perpendicular to Stratification	
	% Wt.	% Vol	Reduced Wear	Coefficient of Friction	Reduced Wear	Coefficient of Friction
1	0.05	0.17	0.2-0.22	0.32±0.05	0.25-0.38	0.4±0.05
2	0.5	1.7	0.08-0.1	0.24±0.03	0.12-0.14	0.27±0.03
3	1.5	3.5	0.05-0.07	0.18±0.02	0.05-0.08	0.2±0.02
4	3.0	10.2	0.3-0.35	0.15±0.02	0.18-0.22	0.15±0.02
5	2.8	13	0.5-1.0	0.1±0.02	0.7-1.0	0.1±0.02

A further increase in carbon content to 3.0 wt% (10.2% vol.) Dramatically increases the reduced wear with a further decrease in the coefficient of friction. Therefore, to achieve optimal tribotechnical properties, it is necessary that the carbon content in low-alloy copper-based alloys was in the amount of 0.5-1.5% of the mass. It should also be noted that when the concentration of carbon in low-alloy copper-based alloys is more than 3% of the mass. there is a sharp embrittlement of the copper matrix, which leads to the impossibility of forming friction joints from composites (Cu-C-Zr-Y-Nb) -Mo-CuO-MoO_3. Based on the results of laboratory tests, industrial batches of sliding contacts were made of composites (Cu-C-Zr-Y-Nb) -Mo-CuO-MoO_3 and tested at a copper ore mining company (Lublin, Poland). Industrial tests of new sliding contacts have been conducted for more than three years. Test conditions: direct current up to 250A at a voltage of 250V, humidity up to 80%, in the atmosphere of a mine with a high content of CO_2 and SO_2. During the tests it was found that the average temperature on the surface of the graphite contact fluctuates in the range of 58-88 °C, while on the working contact surface of the compositions based on copper and molybdenum with carbon additive temperature fluctuations are in the range of 26.5-29.1 °C . The electrical resistance at the interface of the sliding contact was approximately 4 times lower compared to the pair of graphite contact wire. Important is the fact that despite the significantly higher values of hardness of composites based on copper and molybdenum compared to graphite, no noticeable wear of the contact wire. Studies of the contact surface of sliding contacts of composites (Cu-C-Zr-Y-Nb)-Mo-CuO-MoO_3 showed that when sliding on their surface, in addition to carbon, there is molybdenum disulfide and a small amount of MoO_3. These compounds are secondary structures and contribute to the antifriction of the contact system and provide protection of the contact wire from wear during reliable electrical contact. A feature of such solid lubrication, which is formed due to the interaction of the material with the atmosphere of the mine, is its ability to self-clean when reaching a certain critical thickness (10-20μm). The industrial batch of sliding contacts is still in operation. It is established that the service life of sliding contacts made of composites (Cu-C-Zr-Y-Nb) -Mo-CuO-MoO_3 exceeded 10 times the service life of carbon-based contacts, which is not more than 4 months. Despite the fact that the cost of sliding contacts made of composites (Cu-C-Zr-Y-Nb) -Mo-CuO-MoO_3 is approximately 20% higher compared to the cost of graphite contacts, the high durability of these composites based on copper and molybdenum fully compensates for their higher cost.

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