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SOME REGULARITIES GOVERNING THE CHANGE IN THE PROPERTIES OF CONTACT MATERIALS MANUFACTURED BY POWDER METALLURGY TECHNIQUES

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Amid the array of equipment at the disposal of modern engineering is a large group of special materials used to make parts for sliding electric contacts. These "contact" materials are employed to make the working elements of devices passing current between parts of electric machines, instruments, and pieces of apparatus while in mutual motion. On account of the great variety of conditions under which the contact elements have to operate, the materials used to make them have to possess a number of specific properties that can vary within very wide limits. For this reason they are manufactured from multicomponent compositions that are members of the system "copper-carbonaceous material-alloying additive", and "graphite-coke-soot" which are, in turn, made by powder metallurgy and carbon ceramic techniques [1, 2]. By varying the ratio of ingredients, industry can put out a wide selection of contact materials of a variety of bonds (EG74, EG3, EG71, EG20, EG4, etc.).

By studying the properties of different brands of such materials the author established at an earlier stage that the numerical values of their technical characteristics were distributed according to laws very close to normal, and that to describe the distributions discovered we have to apply the statistical parameters of arrangement X and dispersion σ [1, 2, 3]. The results obtained made it possible to move on from an investigation of the properties of individual brands of contact materials to a study of the multicomponent systems of which they are a part. To do this the industrially produced brands were placed on the planes of corresponding composition triangles [1], and it was the cross sections of the latter that made it possible to trace the change in properties as a function of the place occupied by a particular brand on the composition diagram. The figure shows typical forms of the regularities derived thereby governing the change in some of the characteristics of the materials in question. Two cross sections through the composition triangles are combined along the x-axis: the one on the left is from the triangle "copper-carbonaceous material-alloying additive" (brands MG1, MG2, MG4, M1, M3 M11M), and on the right there is one from the triangle for the system "graphite-coke-soot" (brands EG4, EG20, EG71, EG8, and EG74). Along the y-axis are the values of parameters showing location and distribution of numerical quantities describing the investigated properties of the contact materials.

These parameters are the most probable values of the characteristics in question and are essentially their nominal values. On consideration of the figure, one interesting fact comes to light: at the joint between cross sections belonging to different systems there is a smooth transition between the analyzed properties of the contact materials. The regularities governing the change in the characteristics inherent in materials from one system show up as a continuation of lines formed by materials from another one. This fact explains why there is need to manufacture contact materials of both systems in order to meet ever growing demands. One complements the other, as it were, and both of them together provide the essential range of variation in specific properties of the compositions.

Further study of the graphs shown suggests other conclusions on the properties of the contact materials. For example, the observed arrangement of lines E, γρ, 2ΔU, Δh and N is conditioned by variation in their composition, and can easily be explained by the corresponding change in properties of the components. The horizontal position of line f shows that to impart friction properties in materials from the metal-containing group it is only necessary to add a small quantity of graphite. A further increase in the amount might cause changes in the friction properties. It might be to the point to mention that this conclusion is valid for contacts through which there is a current flowing during operation. The possibility of extending the conclusion to cover contacts operating without current is not dealt with in this paper.

Variation in properties of contact materials as a function of their composition. E) Modulus of elasticity of the first kind; γ) specific gravity; ρ) specific electroresistance; 2ΔU) transient voltage drop on two contact elements of different polarity; f) friction coefficient; Δh) wear and tear over fifty hours of testing; N) commutating power.

It is of still greater interest to consider the dependence between the different characteristics of the contact materials. Comparing the position of lines f and Δh, it can be concluded that the increase in wear and tear is not connected with the increase in f. This is because when using contact parts made from MG1, MG2, and MG4 as elements of electric sliding contacts, the main factor determining their rate of wear is an electrical one and not a mechanical one. Comparison of the lines Δh and 2ΔU shows that over a considerable area of the systems under consideration there is no relationship between wear and transient voltage drop. The exception is the left-hand segment of the metal-containing system where, at very small values of 2ΔU, the quantity Δh increases.