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Cooper-graphite composite material for application to sliding electrical contacts

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Various requirements are laid on the sliding electrical contacts carrying electrical current between the stationary and rotating parts of e.g. electromotors, generators, seam welding machines. Special requirements are laid on the properties of these contacts, particularly on their electrical and thermal conductivity, wear resistance, etc. For high voltage and low current densities it is possible, e.g. in electromotors, to employ all-carbon or all-graphite sliding contacts which exhibit the sufficient electrical conductivity and superior sliding properties. In the case of low voltage and high current densities, typical for eg. seam welding machines, it is reasonable to employ materials with high specific electrical conductivity, satisfactory thermal conductivity and low friction coefficient. Such conditions are best fulfilled by composite material composed of matrix showing high electrical conductivity, while graphite in the form of particles, fibres and the like creates the secondary phase in the matrix, which ensures high sliding properties. Generally the materials referred to as metal graphites in the field of electrical engineering are concerned. The nominal chemical composition of metal graphites covers typically the following ranges: graphite-5 to 70%, Sn-0 to 10%, Pb-0 to 12%, balance-Cu. To obtain the materials falling in this group is possible only by powder metallurgy because certain components of the given composites are mutually insoluble. The classical procedure of such material fabrication includes preparation of a powder mixture followed by cold pressing and sintering of the mixture. Tin, zinc and lead additions enable sintering at presence of the liquid phase thus providing the possibility to achieve high compacting of these materials by free sintering. On the other hand, activating sintering additions markedly decrease the electrical conductivity of the examined material.

In the order to reduce the unfavourable effect of the additions on the electrical conductivity we have prepared by hot isostatic pressing the cooper-graphite based material which was free of activating sintering additions. For experimental works, electrolytical cooper with particles smaller than 70 μm and graphite with particles smaller than 3 μm and of 99.9% purity were employed. The content of graphite in the composite system was graded from 3 up to 40 vol.%. The mentioned composite materials were subjected to complete examinations with focus on their structural and physical properties.

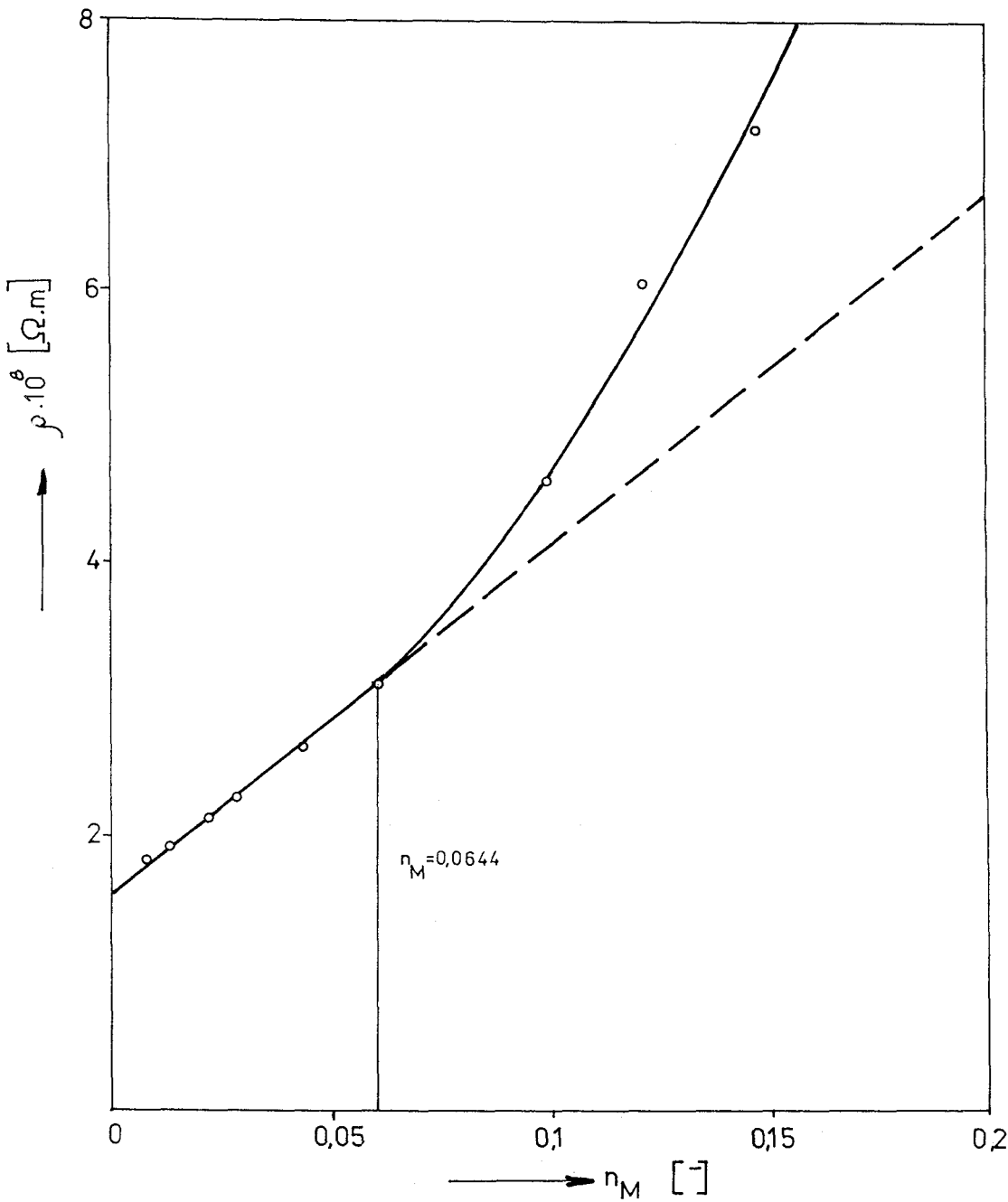
Obtained Results

The presence of graphite and its uniform distribution in the copper matrix is well observable by optical microscopy. After hot isostatic pressing high compacting of composite materials was achieved in the Cu-C composite system for all examined volume fractions of graphite. No residual porosity was observed. The high degree of compacting of the Cu-C composite system was confirmed also by the results obtained from measuring the specific weights.

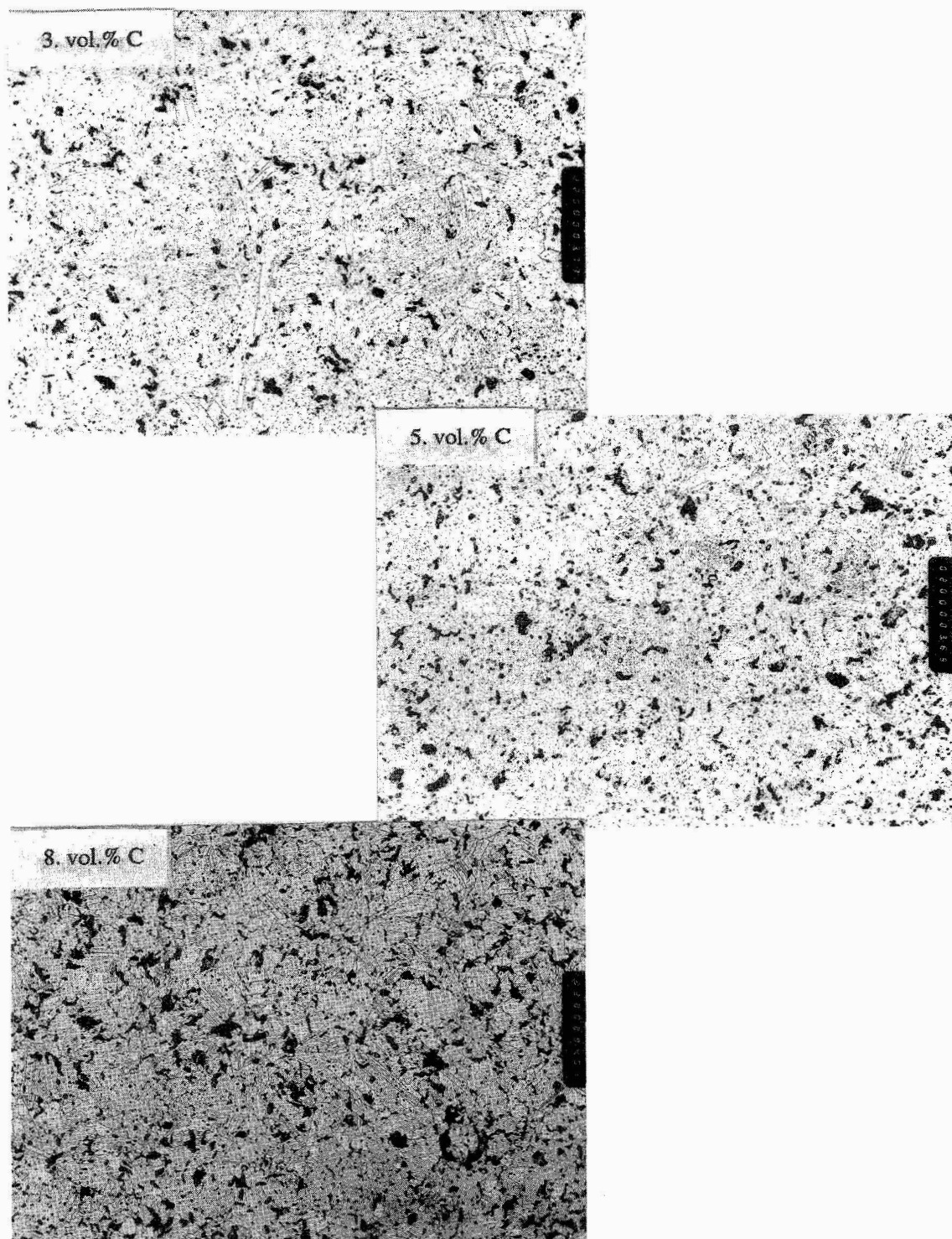
The results of the specific electrical resistance of the Cu-C system are given in the following table

n_M [-]	$10^4 \cdot v_M$ [mg ³ .kg]	T [K]	$10^8 \cdot \rho$ [$\Omega \cdot m$]
0	1.15837	295.75+ .01	2.00597+ .00857
0	1.15274	295.34+ .02	1.98295+ .01419
0	1.16503	296.19+ .11	2.13551+ .00206
0	1.18717	296.39+ .11	2.16840+ .00036
0	1.16664	296.73+ .09	2.18727+ .03813
0	1.11430	295.98+ .05	1.70246+ .00372
0.0079	1.14595	296.08+ .02	1.84501+ .00583
0.0079	1.15335	296.35+ .08	1.86151+ .00105
0.0079	1.15630	296.39+ .11	1.84123+ .00236
0.0079	1.15315	296.50+ .11	1.88201+ .01637
0.0134	1.16083	296.43+ .12	1.89457+ .00211
0.0134	1.17078	296.55+ .11	1.92344+ .00249
0.0214	1.20743	296.73+ .09	2.11886+ .00338
0.0214	1.20735	296.57+ .14	2.11992+ .00133
0.0278	1.23567	296.72+ .15	2.30811+ .00411
0.0278	1.22967	296.75+ .16	2.29209+ .00103
0.0435	1.27332	296.91+ .11	2.67074+ .03616
0.0605	1.31597	297.08+ .13	3.09914+ .03130
0.0994	1.46327	296.99+ .10	4.64434+ .02646
0.1217	1.54272	297.13+ .09	6.06951+ .02382
0.1465	1.63049	297.24+ .11	7.19154+ .01710

In the graphical representation of the obtained results the position n_{Mc} is designated which separates the zone of carbon concentration for which the linear mixture rule is valid from the zone of carbon concentration in which the apparent percolation is observed. The n_{Mc} value represents the experimentally assessed value of the percolating threshold for the Cu-C system

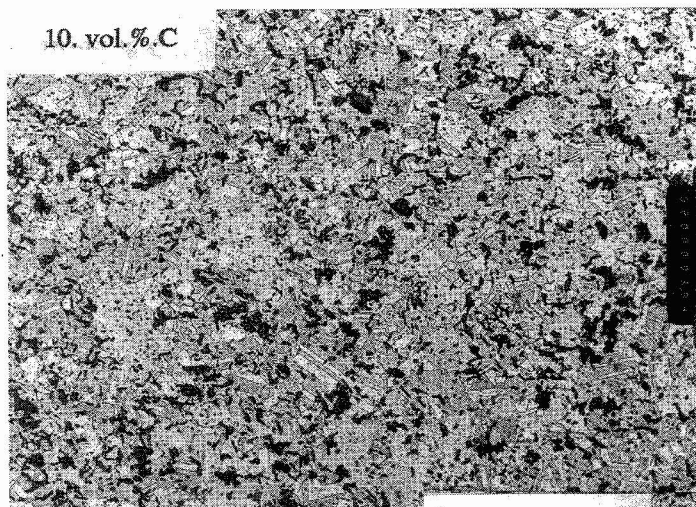


Experimental dependence of specific resistance as a function of the weight fraction n_M for the Cu-C system

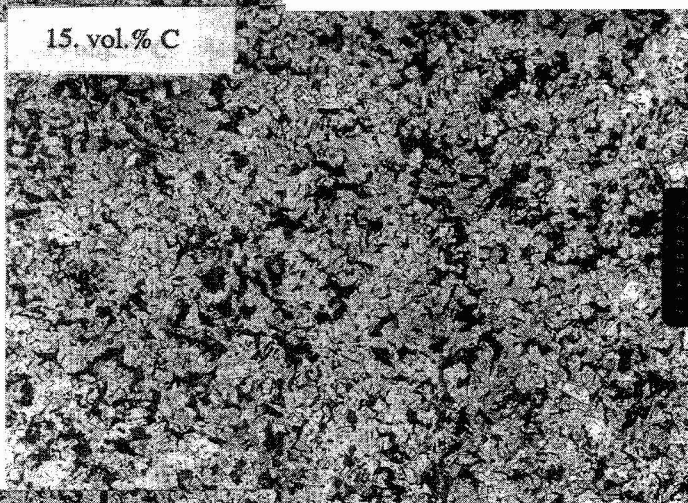


The structures of the copper-graphite composite materials with different volume fraction of graphite

10. vol.% C



15. vol.% C



20. vol.% C

