Thus, the results of this investigation indicate that in principle electric-discharge sintering can be employed as a method of producing carbon-aluminum composite materials. The properties of these materials can be improved by using fibers of higher strength, coating the fibers with materials facilitating infiltration, and optimizing the EDS process conditions.

**LITERATURE CITED**


**DETERMINATION OF THE POROSITY OF SPRAY-DEPOSITED COATINGS BY HYDROSTATIC WEIGHING**

V. M. Rogozhin, L. V. Akimova, and Yu. V. Smirnov

Study of the properties of coatings applied by the detonation, plasma, and other spraying methods, with allowance for their conditions of deposition, is essential for the development of suitable deposition techniques, and enables data to be obtained determining quite precisely areas of effective employment of various methods in industry and directions in which further improvements can be made.

It is only rarely, because of the complexity, high cost, and slowness of large-scale operational tests, that such direct tests are employed for determining the service properties of coatings in the course of technological investigations. Usually, the quality of coatings is assessed by means of indirect indicators of properties such as strength, hardness, porosity, density, structure, and phase composition. Specific features of individual methods of application of coatings are allowed for by modifying methods of determination of parameters. Instead of ultimate strength and yield stress, for coatings determinations are made of adhesional strength; Brinell and Rockwell hardnesses, whose values are difficult to find for thin and brittle coatings, have been replaced by microhardness. Special techniques for the determination of parameters are also used which are applicable perhaps to only one or two methods of spray deposition. In plasma and gasothermic deposition practice, e.g., a parameter indirectly characterizing deposition efficiency — coefficient of deposition — is used. This is defined as the ratio of the mass of powder which has settled on a special specimen to the mass of powder supplied to the spraying unit in a given period of time.

An analysis of methods for determining various properties of spray-deposited coatings, taking into account their effectiveness and the extent to which they permit a strict quantitative assessment of measured values, has revealed that modifications of techniques without exception fail to make provision for estimating the accuracy of results, which creates serious difficulties both in the evaluation of data and in determining ways of improving existing technological processes.
This article is concerned with the effect of the specific features of the hydrostatic weighing technique on the accuracy of results; it gives suitable formulas for calculation and a description of an apparatus for the determination of parameters under plant conditions and in scientific-research laboratories. The results obtained can be employed also for determining the porosity of coatings deposited by the detonation, gas-flame, gaseous-phase, and other methods.

The hydrostatic weighing method of determining the density of materials, which has been described in many works, e.g., [1, 2], consists in finding the mass of a specimen by weighing it in air and then finding its volume by reweighing it in a liquid whose density is known.

The parameter sought is obtained from the expression

\[ \rho = \frac{m_1}{V} = \frac{m_1 - m_2}{m_1 - m_2} \rho_l, \]

where \( m_1 \) is the mass of the specimen weighed in air; \( V \), volume of the specimen; \( m_2 \), mass of the specimen weighed, after being coated with varnish, in water (the masses of the varnish and the suspending thread are small and can be neglected); and \( \rho_l \), density of the liquid.

If the material being investigated is porous, the density determined in this manner is referred to as apparent density or bulk weight and denoted by \( \rho_a \). With a porous material of known phase composition, its total porosity can be determined from the expression

\[ \Pi = 1 - \frac{\rho_3}{\rho_1}, \]

where \( \rho_3 \) is the density of the material in the nonporous condition.

Let \( m_3 \) be the mass of the uncoated and liquid-impregnated specimen in air and \( m_4 \) the mass of the liquid-impregnated specimen in the liquid. Then, using the expression

\[ \frac{m_3 - m_1}{m_3 - m_4} = \Pi_{op} \]

we can determine the relative magnitude of the open porosity \( \Pi_{op} \) of the specimen. It should be noted that the weighing of impregnated specimens in air yields, because of evaporation of the liquid, a series of values of \( m_3 \) described by a decreasing linear function of time. The true value of \( m_3 \) must therefore be determined at \( t = 0 \), the ordinate of the point of intersection of the straight line \( m_3 = -at + b \) with the axis of ordinates (\( a \) and \( b \) are empirical coefficients).

The differences \( m_1 - m_2 \) and \( m_3 - m_4 \) in Eqs. (1) and (3) enable us to find the minimum acceptable sizes of test specimens at a given class of accuracy of the balance used. For example, in the determination of the porosity of a coating of thickness \( \delta = 200 \mu m \) applied to a 20-mm-diameter disk the difference \( m_3 - m_1 \) with distilled water as the impregnating liquid will be from 3 to 6 when the open porosity of the coating changes from 5 to 10%. The ADV-200 balance can be used, for which \( \Delta = \pm 0.1 \text{ mg} \). In a general case, the type of balance for such investigations is chosen by comparing the maximum permissible basic error \( \Delta = \pm a \) with the quantity \( m_3 - m_4 \) (\( a \) is a constant for balances of a given class of accuracy).

As can be seen from Eq. (3), the open porosity is a function of the quantities \( m_1, m_3, \) and \( m_4 \), which are determined by direct measurements. The error in the determination of \( \Pi_{op} \) with Eq. (3) is found from the expression

\[ \Delta \Pi_{op} = \Pi_{op} \sqrt{\frac{(\Delta m_3)^2 + (\Delta m_1)^2}{(m_3 - m_4)^2} + \frac{(\Delta m_3)^2 + (\Delta m_1)^2}{(m_3 - m_4)^2}} \]

or, after making the substitution \( \Pi_{op} = (m_3 - m_4)/(m_3 - m_2) \),

\[ \Delta \Pi_{op} = \sqrt{\frac{(m_3 - m_4)[(\Delta m_3)^2 + (\Delta m_1)^2] - (m_3 - m_1)[(\Delta m_3)^2 + (\Delta m_1)^2]}{(m_3 - m_4)^2}} \]

where \( \overline{m}_1, \overline{m}_3, \) and \( \overline{m}_4 \) are the mean values of the masses \( m_1, m_3, \) and \( m_4 \), respectively; \( \overline{m}_1 = \frac{1}{n} \sum_{i=1}^{n} m_i \); and \( \Delta m_1, \Delta m_3, \) and \( \Delta m_4 \) are the rms deviations of the corresponding values.