The following temperature points can be distinguished on the resistivity curve of the alloy $\rho = f(T)$: $M_s = 305°K$; $M_f = 255°K$; $A_s = 255°K$; $A_f = 355°K$, which correspond to the temperature intervals of the martensitic transition in cooling (M_s and M_f — forward transition) and in heating (A_s and A_f — reverse transition). These temperature intervals of the forward and reverse transitions in the investigated alloy are close to the intervals of the transition in titanium mononickelide (51 at. % Ni) [1].

Figure 2 shows the measured thermal conductivity of the investigated alloy in the temperature interval 90-300°K. It can be seen that the thermal conductivity of the alloy increases with temperature, although above 220-230°K it decreases noticeably, and with increasing temperature a shallow minimum is observed on the plot of $\lambda = f(T)$ at 265°K.

Our results on the thermal conductivity of NiTi are in good agreement with Goff's data [8] (within the limits of experimental error) at temperatures below 230°K. The results diverge at higher temperatures. Thus, according to the data of [8], the thermal conductivity λ of NiTi above 230°K is somewhat greater than the thermal conductivity of the alloy investigated by us and monotonically increases with increasing temperature in the range 3-300°K.

The discrepancy between our results and the results of [8] lies outside the limits of experimental error and is probably connected with the effect of the structural changes that the lattice of the investigated alloy undergoes as a result of the martensitic transition in the temperature range 230-350°K; Goff, on the other hand, studied an NiTi intermetallide of stoichiometric composition, the transition in which is observed at higher temperatures (around 350-400°K) [3].

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MASS TRANSFER IN THE INTERACTION OF A SINTERED COMPOSITE WITH A LIQUID METAL

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An equation is derived to describe the migration of a liquid in a sintered composite consisting of a refractory skeleton and a bonding metal; an approximate solution is given.

Sintered composites are used in various branches of engineering, particularly ones consisting of refractory particles cemented by metal; it has been found [1, 2] that such a material absorbs molten metal rapidly if the temperature is such as to allow a liquid phase to exist. This process is used in the manufacture of components with a variety of physicomechanical properties [3]. Various technological problems involve a knowledge of the distribution of the bonding metal in the material together with the migration kinetics of the liquid. The liquid-metal uptake may be represented as a directional flow along channels formed by the

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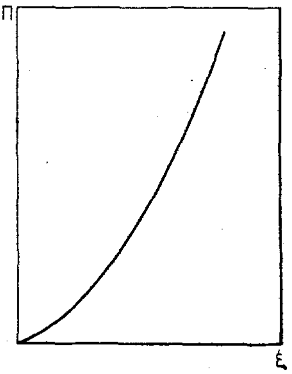

Fig. 1

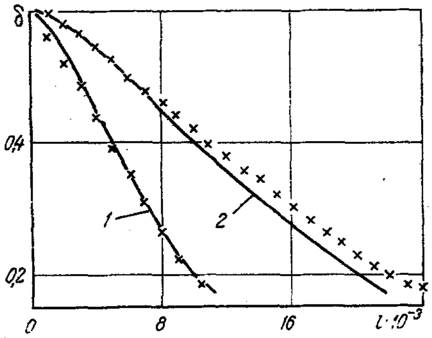

Fig. 2

Fig. 1. Migration pressure Π as a function of the variable ξ.

Fig. 2. Distribution of the liquid-phase content along VK8 alloy specimens: 1, 2) after 180 and 720 sec, respectively; the curves are from theory and the points are from experiment.

refractory particles. Measurements [4] show that such flow is laminar and obeys Darcy's law. The driving force is the migration pressure Π, which may be interpreted as an effective negative pressure.

The thermodynamics of such migration in a system with comparatively large particles [5] provide a relationship between Π, the particle size, and the amount of liquid phase in the system:

$$\Pi = -\frac{E}{r}\left[\left(\frac{1-\delta}{\delta}\right)^{1/3} - A\delta^{m}\right]. \tag{1}$$

From (1) we get a differential equation for the migration:

$$\frac{\partial \Pi}{\partial \tau} = \frac{k_m}{F(\Pi)}\,\frac{\partial^2 \Pi}{\partial x^2} \tag{2}$$

Here $F(\Pi)$ is the derivative of the function $\delta = \Phi(\Pi)$ inverse to (1); the latter is almost a linear function when $\ln\delta$ is plotted against Π, where $\delta = \Psi(\Pi)$ can be approximated as

$$\Phi(\Pi) = a\exp(-C\Pi). \tag{3}$$

We represent Π as a function of the new variable $\Pi = f(\xi)$, where $\xi = x/\tau^{1/2}$, which gives the equation $\xi f'_{\xi} = [-2k_m/F(\xi)]f''_{\xi\xi}$, which becomes the system

$$\begin{aligned} f'_{\xi} &= w, \\ w'_{\xi} &= \frac{\xi w}{G\exp[Cf(\xi)]}, \end{aligned} \tag{4}$$

where $G = 2k_m/aC$.

The coefficients a and k_m reflect the physical features of the sintered material; a is numerically equal to the proportion of the liquid phase at which the refractory particles become completely separated. In the case of WC–Co composites, this state corresponds to a volume proportion of the liquid metal of 0.6. The migration coefficient k_m includes the viscosity ϑ of the liquid and the permeability coefficient k_p ($k_m = k_p/\vartheta$), so k_m incorporates the fluidity of the liquid and infiltration features of the refractory skeleton.

System (4) has been solved by the Runge–Kutta method with a Nairi computer subject to the boundary conditions $f(\xi_1) = f_0$, $w(\xi_1) = w_0$; the solution is fitted satisfactorily by the power law $\Pi = D\xi^b$ (Fig. 1). This expression is substituted into (3) to give an approximate equation for the content of liquid phase as function of time and position:

$$\delta = a\exp[-CDx^{b}/\tau^{b/2}]. \tag{5}$$

We tested (5) in measurements on the penetration of molten cobalt into WC–Co hard alloys.

The measurements on the interaction between molten cobalt and VK8 alloy specimens (7.6 wt. % Co 92.4 wt. % WC) were made by the method described in [2]; the times of contact between the VK8 specimens and the molten cobalt saturated with tungsten and carbon were 180, 300, 480, 720, 1080, and 1380 sec. The cobalt distribution was examined by x-ray spectral microanalysis; the following results were obtained for VK8 alloy: $a = 0.6$; $C = 2.5 \cdot 10^{-6}$ m^2/N; $D = 1.86 \cdot 10^7$ N $\cdot$ sec$^{b/2}$/m^{2+b}; $b = 1.44$. The measurements agree well with the calculations (Fig. 2).

Therefore, (5) can be used in quantitative determination of the amount of bonding metal in a sintered material and in analyzing the kinetic characteristics.

Also, (5) can be used in research on other processes described by differential equations of parabolic type, e.g., thermal conduction, diffusion, gas infiltration, and motion of ions in an electric field. However, (5) can be used only if a negative-exponential relationship applies for the extensive quantities (heat, mass, and volume) in terms of the intensive quantities that provide the driving force (temperature, chemical potential, and pressure), i.e., if the conditions represented by (3) are met.

NOTATION

Π, migration pressure; r, particle size; δ, amount of liquid phase as a volume fraction; k_m, migration coefficient; k_p, permeability coefficient; ϑ, viscosity; x, coordinate; τ, time; A, a, E, G, C, D, coefficients; b, m exponents.

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X-RAY STUDY OF DRYING IN A CAPILLARY POROUS BODY

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Nonisothermal transport of moisture in a capillary porous body was studied by an x-ray method. Radiometry of the radiation and precision temperature control of the drying sample are discussed.

Absorption measurements of radiation passing through a sample should be recognized as a most effective method for studying the motion of moisture in a capillary porous body during drying. Gamma radiation from radioactive isotopes is being used successfully for this purpose [1, 7, 8]. Because of the high energy of the radiation quanta, however, the mass absorption coefficient μ is extremely small and the beam path in a sample is large (tens of centimeters); this creates experimental difficulties connected with temperature control and equalization of air flow above the drying surface in a constant-temperature device. Therefore, bremsstrahlung x-rays were used in the present work [2]. The presence of absorbing walls of the sample holder, of sample material, of the covering of the radiation detector, and of the beryllium window of the x-ray tube makes it

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