of the material of the specimens was probably higher than that of steel 15 and less than that of Armco.

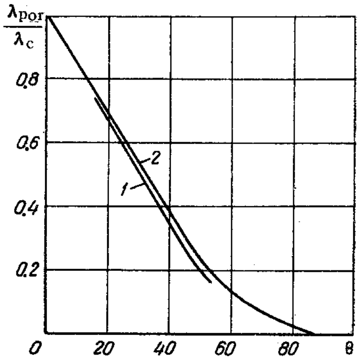

Fig. 4. $\lambda_{por}/\lambda_c = f(\theta)$: from author's data; 2) [2].

For investigation we took three powder fractions: +160 μ, −120/+80 μ, and −40 μ. The specimens were pressed at different specific pressures. The sintering conditions were as follows: sintering temperature 1473° K, isothermal holding time 7200 sec, atmosphere of purified and dried dissociated ammonia. Some of the sintered specimens were pressed a second time to provide specimens with lower porosity.

From the results of the experimental investigations, we plotted the relationships shown in Figs. 1–4.

Figure 1 shows the thermal conductivity λ as a function of the porosity θ for the three powder fractions. The mean temperature of the specimens was 323° K. Since the error of the measurements was 3–5%, the spread of the results for the different powder fractions lay within the region of error. As Fig. 1 indicates, the thermal conductivity was practically independent of the particle size of the powder.

The relationship shown in Fig. 1 is a straight line. Extrapolation of this line until it intersects the y-axis, thus giving the thermal conductivity λ_c of the compact (zero-porosity) metal, and calculation of the ratio λ_{por}/λ_c for each porosity clearly show that our relationship agrees with Skorokhod's postulated relationship [2] (see Fig. 4).

Figures 2 and 3 show the thermal conductivity as a function of the temperature for different porosities and as a function of the porosity at temperatures of 323, 573, and 773° K. These relationships are also linear.

Figure 2 shows that the straight lines have different angles of inclination. With reduction in porosity, the angle of inclination increases.

A calculation of the ratio $\lambda_{por}/\lambda_c = f(\theta)$ for each porosity, taking the values of λ_c and λ_{por} at 323°, 573°, and 773° K (Fig. 3), shows that these ratios are practically independent of the temperature.

Figure 4 shows the relationship $\lambda_{por}/\lambda_c = f(\theta)$ according to our experimental data and those of Skorokhod [2].

Thus, the thermal conductivity of sintered iron is practically independent of the particle size of the powder.

The effect of porosity on the thermal conductivity can be taken into account by Skorokhod's formula [2].

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NONISOTHERMAL FILTRATION IN A CAPILLARY-POROUS BODY

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This paper gives a solution, obtained by the small-parameter method, for the equation of nonisothermal filtration of moist air through a capillary-porous body. It is shown that the shift of the temperature field caused by a change in the viscosity of the air differs by 15% from that calculated without consideration of the viscosity.

The differential equation of nonisothermal filtration when

$$k = k_0(1 + \beta t)$$

has the form

$$\frac{d^2t}{dx^2} - M\frac{dt}{dx} - M\beta t\frac{dt}{dx} = 0, \tag{1}$$

where

$$M = \frac{\Delta p k_0 c_p}{\lambda\delta}.$$

The boundary conditions are

$$\text{when } x=0 \quad -\lambda\frac{dt}{dx}=-\alpha_1(t-t_c), \tag{2}$$

$$\text{when } x=\delta \quad \lambda\frac{dt}{dx}=-\alpha_2(t-t_h). \tag{3}$$

To solve the nonlinear equation (1), we use the small parameter method [2].

We seek the solution in the form of a power series in β:

$$t=\sum_{i=0}^{\infty}\beta^i t_i.$$

To determine t_0, we obtain the equations

$$\text{when } i=0 \quad \frac{d^2t_0}{dx^2}-M\frac{dt_0}{dx}=0, \tag{4}$$

$$\text{when } x=0 \quad -\lambda\frac{dt_0}{dx}=-\alpha_1(t_0-t_c), \tag{5}$$

$$\text{when } x=\delta \quad \lambda\frac{dt_0}{dx}=-\alpha_2(t_0-t_h). \tag{6}$$

In the zeroth approximation, the obtained formula is identical to that given by Luikov [1]:

$$t_0=\frac{\left[\exp\left(K_f\frac{x}{\delta}\right)-1+\frac{K_f}{\mathrm{Bi}_1}\right](t_h-t_c)}{\left(1+\frac{K_f}{\mathrm{Bi}_2}\right)\exp(K_f)-1+\frac{K_f}{\mathrm{Bi}_1}}+t_c. \tag{7}$$

The equation for the determination of t_1 when i = 1 is

$$\frac{d^2t_1}{dx^2}-M\frac{dt_1}{dx}-Mt_0\frac{dt_0}{dx}=0, \tag{8}$$

and the boundary conditions are

$$x=0 \quad -\lambda\frac{dt_1}{dx}=-\alpha_1 t_1, \tag{9}$$

$$x=\delta \quad \lambda\frac{dt_1}{dx}=-\alpha_2 t_1. \tag{10}$$

The solution of Eq. (8) has the form

$$t_1=C_3\exp(Mx)+C_4+C_1C_2Mx\exp(Mx)+$$
$$+0.5C_1^2\exp(2Mx). \tag{11}$$

Confining ourselves to two terms of the expansion in view of the smallness of the term β of the series, we finally obtain

$$t=t_0+t_1\beta$$

or

$$t=C_1\exp(Mx)+C_2+[C_3\exp(Mx)+C_4+$$
$$+C_1C_2Mx\exp(Mx)+0.5C_1^2\exp(2Mx)]\,\beta, \tag{12}$$

where

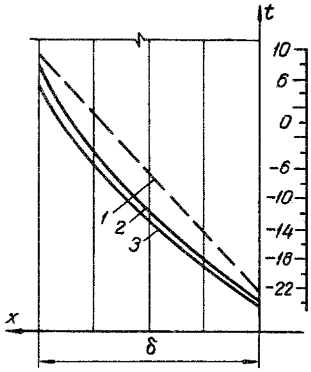
$$C_1=\frac{t_h-t_c}{\exp(M\delta)\left(\frac{\lambda M}{\alpha_2}+1\right)+\frac{\lambda M}{\alpha_1}-1}, \tag{13}$$

$$C_2=t_c-C_1\frac{(\alpha_1-\lambda M)}{\alpha_1}; \tag{14}$$

$$C_3=\frac{C_1(C_2\lambda M+C_1\lambda M-\alpha_1\cdot 0.5C_1)-\alpha_1C_4}{\alpha_1-\lambda M}, \tag{15}$$

$$C_4=\{C_1(C_2\lambda M+C_1\lambda M-0.5\alpha_1C_1)\times$$
$$\times\exp(M\delta)(\lambda M+\alpha_2)+$$
$$+\lambda MC_1\exp(M\delta)[C_2M\delta+C_2+$$
$$+C_1\exp(M\delta)](\alpha_1-\lambda M)\}\times$$
$$\times\{\alpha_1\exp(M\delta)(\lambda M+\alpha_2)-\alpha_1(\alpha_1-\lambda M)\}^{-1}. \tag{16}$$

The figure shows the temperature distribution curves in the case of isothermal and nonisothermal



Temperature distribution over the thickness of the barrier: 1) filtration of air neglected; 2) isothermal filtration; 3) nonisothermal.

filtration for values of the filtration number $K_f = M\delta = 0.802$ through a porous plate with $\delta = 0.125$ m, $\lambda = 0.154$ W/m·deg, $\alpha_1 = 23$ W/m^2·deg, and $\alpha_2 = 10.5$ W/m^2·deg. The value which takes into account the change in the air permeability coefficient when the temperature changes by one degree, according to the author's experimental data, for materials with $k_0 = 0.113\cdot10^{-4}$ kg/m·sec·N/m^2 is $\beta = 0.005$ 1/deg.

NOTATION

λ is the thermal conductivity of material; t is the temperature; j_f is the filtration flow of air; c_p is the specific heat of air at constant pressure; ΔP is the pressure drop on each side of the plate; k is the air permeability coefficient; δ is the plate thickness; k_0 is the experimentally determined air permeability coefficient; K_f is the filtration number; Bi is the Biot number; t_h is the temperature of hot air; t_c is the temperature of cold air; α_1 and α_2 are the heat-transfer coefficients of the plate surfaces.

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