A direct confirmation of nonequilibrium concentration is the thermal cooling curves of the alloys. On not one of them is recorded a transformation corresponding to a temperature of 1275°C but either immediate crystallization of the supercooled ternary eutectic is observed or, if the alloy is located in the area of overlapping of the nonvariant planes at 1275 and 1235°C, the reaction corresponding to 1235°C preceded crystallization of it, also with supercooling (Fig. 5a). From the polythermal section for 70% Zr (Fig. 4c) it may be seen that nonequilibrium crystallization of the alloys on the $L + \delta + \eta$ surface does not lead to the appearance of nonequilibrium phases, as a result of which homogenization of them is significantly eased [1].

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DETERMINATION OF THE AVERAGE PORE SIZE IN THIN SHEETS OF PERMEABLE FIBER MATERIALS BY AN OPTICAL METHOD

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The majority of known methods of determination of the structural parameters of porous materials are inapplicable for use as nondestructive methods of continuous inspection of the structure of thin sheets of permeable fiber materials during their production and in finished form. In addition the results of measurements of the structural parameters of permeable materials by different methods differ significantly and there is not a strict correlation between them.

Certain geometric parameters of the sheet itself and of the elements (fibers) of which it consists or their projection may serve as structural characteristics of thin sheets of permeable fiber materials not dependent upon the methods of their determination. Since in formation of the structure of felt-type materials the location of each individual particle at some point in space within the limits of the volume of the part is random, the statistical characteristics of the random process describing it may be used as the structural parameters of such materials. In [1] it was shown that the structure of a permeable fiber material may be represented on the basis of a Poisson model from the porosity of a permeable fiber material is determined as the probability of an arbitrary point falling in a space between fibers and its optical transmission factor as the probability of falling in the optically transparent portions of the projection of the permeable fiber material sheet. The use of a single probability-statistical approach to evaluation of porosity and the optical transmission factor of a permeable fiber material made it possible to establish a functional relationship between them. One of the advantages of practical use of it is the possibility of determination of the porosity of thin permeable fiber material sheets from their optical transmission factor.

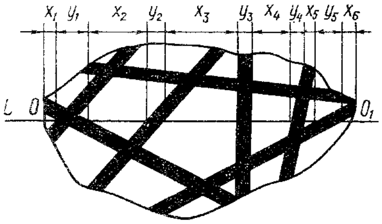

Fig. 1. Projection of a portion of a thin porous fiber material sheet.

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The purpose of this work was selection of one of the geometric parameters of the structure of thin permeable fiber material sheets unambiguously related to their average pore size, establishment on the basis of the Poisson model of a functional relationship of the average pore size to the geometric parameters of thin permeable fiber material sheets, establishment of the basis for the possibility of determination of their average pore size by an optical method, and verification of it.

Figure 1 shows the projection of a portion of a porous fiber material on a plane parallel to it. Through the whole projection is drawn the arbitrary line L. The section OO_1 of the line L bound by the dimensions of the projection of the portion of the sheet is the geometric sum of the sections lying both within the limits of fibers (y) and between them (x). As the average size of the permeable fiber material pores was selected the mean statistical length $\bar{x}$ of the sections included between the projections of the fibers, that is, the mean statistical size of the optically transparent portions of the permeable fiber material sheet. The length $\bar{x}$ is measured on an arbitrary straight line parallel to the sheet. Since the structure of the permeable fiber material is isotropic in any plane parallel to the sheet, the character of distribution of the sections x on the line L does not depend upon its direction. Therefore, the selection made is completely acceptable.

The length of the sections $\bar{x}$, according to [2], may be determined from the expression

$$\bar{x} = \int_0^\infty xW(x)\,dx, \tag{1}$$

where W(x) is the probability density of sections with a length of x.

Since the value of W(x) is related to the integral rule F(x) of distribution of the sections $x\left[W(x) = \frac{d}{dx}F(x)\right]$, first let us establish the function F(x) from the expression [3]

$$F(x) = 1 - P(x), \tag{2}$$

where P(x) is the probability of the fact that a section with a length of x does not intersect the projections of the fibers. The calculation of P(x) was done, according to the data of [2], using the equation

$$P(x) = \exp\left[-\lambda h \int_0^{2\pi} \omega(\varphi) \iint_S \bar{P}(\varphi)\,dS\,d\varphi\right], \tag{3}$$

where $\omega(\varphi)$ is the probability density of distribution of the angles φ of orientation of the fibers (since in the case considered the structure of the material in the plane parallel to the sheet is isotropic $\omega(\varphi) = \frac{1}{2\pi};\ \varphi[0;\ 2\pi]$) and $\bar{P}(\varphi)$ is the probability of intersection by the section x of the projection of the fiber. The integral $\iint_S \bar{P}(\varphi)\,dS$ is numerically equal to the area of the figure formed by the geometric place of the center of a fiber oriented at an angle φ to the section x and intersecting it. Having calculated this area, and having integrated with respect to $d\varphi$, we obtain the expression for P(x):

$$P(x) = \exp\left\{-\lambda h\left[ld + \frac{2}{\pi}(l+d)\,x\right]\right\} \tag{4}$$

and for W(x):

$$W(x) = \frac{d}{dx}[1 - P(x)] = \frac{2dh}{\pi}(l+d)\,e^{-\lambda l d - \frac{2\lambda h}{\pi}(l+d)x}. \tag{5}$$

Here d, l, and λ are the diameter, length, and density of the centers of the fibers and h is the thickness of the sheet.

Having normalized Eq. (4) to the value of $\int_0^\infty W(x)\,dx = e^{-\lambda h l d}$, we obtain

TABLE 1. Average Pore Size of Thin Permeable Fiber Material Sheets Determined by Different Methods

Sheet thickness, mm	Sheet porosity, %	$\bar{d}$, μm	dopt, μm	$\bar{x}$, μm
0,33	93,5	206	201	192
0,36	88,1	90	94	78
0,23	72,6	58	56	51

$$W(x) = \frac{2\lambda h}{\pi}(l+d)\,e^{-\frac{2\lambda h}{\pi}(l+d)x} = \lambda e^{-\bar{\lambda}x}, \tag{6}$$

where $\lambda = (2\lambda h/\pi)(l + d)$ is the mean statistical density of intersection of the line with the fibers on the projection of the sheet.

Now, using Eq. (1), we determine the mean statistical length $\bar{x}$ of the sections, which is equal to the mean statistical size $\bar{d}$ of the permeable fiber pores:

$$\bar{x} = \bar{d} = \frac{\pi}{2\lambda h(l+d)}. \tag{7}$$

Having determined λ using the equation for the porosity (Θ) of a permeable fiber material [1] and having substituted it in Eq. (7), we obtain the relationship for $\bar{d}$ with $l \gg d$:

$$\bar{d} = \frac{\pi^2 d^2}{8h \ln 1/\Theta}. \tag{8}$$

Consequently, the mean statistical size of the pores of thin permeable fiber material sheets in which the distribution of the fibers is subject to Poisson's rule may be calculated using Eq. (8).

Their average pore size may be established on the basis of the optical properties of thin permeable fiber material sheets. Let us conditionally call it the mean optical d_{opt}. Let us determine it, having expressed the mean statistical pore size $\bar{d}$ through the mean optical transmission factor T [1]:

$$d_{opt} = \frac{\pi d}{2 \ln 1/T}. \tag{9}$$

We experimentally tested the optical method of determination of the mean permeable fiber material pore size. The objects of the tests were specimens of thin sheets of material produced from 24-μm-diameter fibers. The optical transmission factor was determined with the use of an FM-8 photometer. The mean optical pore size of the specimen was calculated using Eq. (9). For comparison the mean pore dimensions $\bar{d}$ were also determined by calculation using Eq. (8) and by measurement with the use of a microscope of the lengths $\bar{x}$ of the optically transparent portions on an arbitrary intercept.

The data obtained (Table 1) indicate that the mean optical size of the pores of thin permeable fiber material sheets is close to the results of determination of the mean pore size by other methods.

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