kg/kmole; F, heat and mass exchange surface, m^2; n, number of components in the mixture; R^*, universal gas constant, J/(kmole·K). Subscripts: 1) vaporization zone; 2) moisture zone; i) component of the vapor or the fluid; s) particle surface; ξ) vaporization surface; m) material; c) particle center; sat) saturation; vr) system of vapor removal; fr) free; C) capillary; f) fluid; I) initial; con) condenser; vp) vacuum pump; e) equilibrium.

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THERMAL CONDUCTIVITY OF MOIST POROUS MATERIALS

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UDC 536.246

We propose both a model and a method of calculating the effective thermal conductivity of moist porous materials made of a three-component structure with interpenetrating components.

In studying the thermal conductivity of moist porous materials, extensive use is made of the methods of modeling, which make allowance both for the structure of the material and for the heat and mass transfer processes occurring within. In the model proposed by Krisher, considerable attention is given to the significant feature of a moist porous material, and namely, the presence of both dry and moist sections within the pores of the solid skeleton, and consideration is also given here to the effect of vapor diffusion on the transfer of heat [1]. However, the Krisher model is quite removed from the geometric structure of a real porous material and contains unknown empirical parameters *a* and b which describe the fraction (*a*) of the segments oriented perpendicular to the flow as well as the fraction (b) of the skeleton wetted by the moisture. The authors of [2] have modeled the moistened material of a structure with interpenetrating components, thus making it possible to do away with the empirical parameter *a*; however, the fraction of moistened sectors, as before, was taken into consideration by means of the parameter b.

It has been demonstrated experimentally in [3] that the thermal conductivity of a moistened material must significantly depend on the nature of the distribution of moisture through the volume. A characteristic of surface wetting is generally found in the contact wetting

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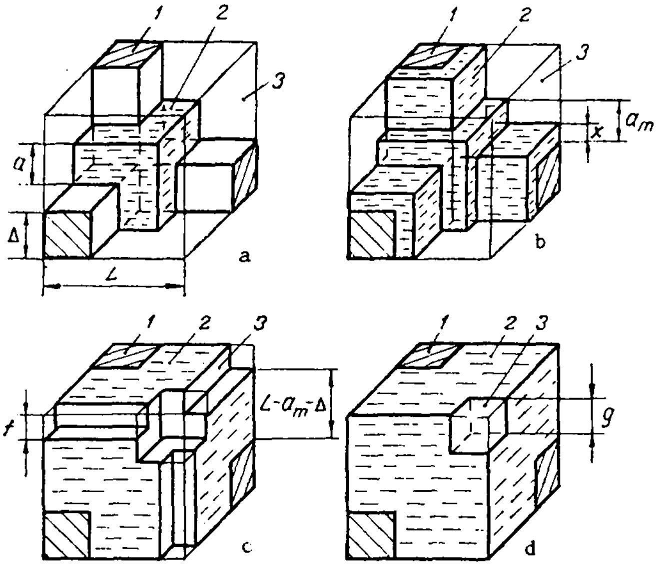

Fig. 1. Model of moist porous materials: a) $\omega < \omega'$; b) $\omega' \leq \omega \leq \omega^*$; c) $\omega^* \leq \omega \leq \omega''$; d) $\omega'' \leq \omega$. 1) Solid phase; 2) fluid phase; 3) vapor-gas phase.

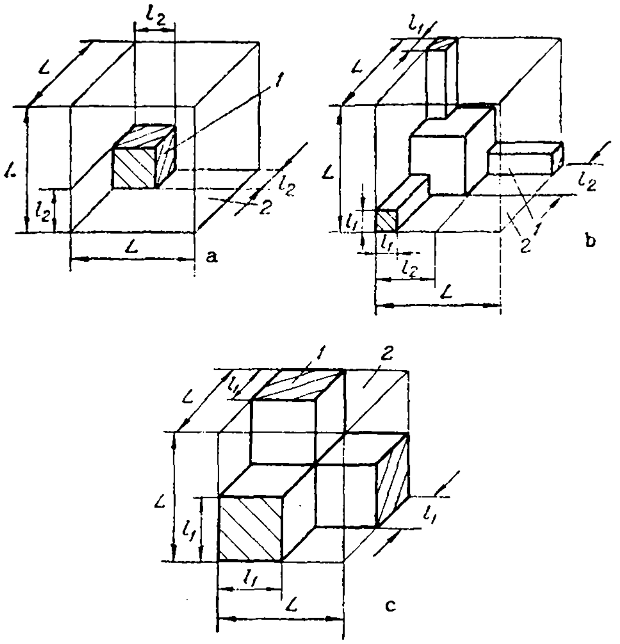

Fig. 2. Model of nonuniform system: a) isolated fluid cluster 1; b) overall view of infinite fluid cluster 1; c) system with interpenetrating components.

angle formed at the boundary between the solid, the liquid, and the gas. The thermal conductivity of the same material, exhibiting identical moisture contents, may differ severalfold, depending on the nature of moisture distribution within the material.

In [4] we find an expansion of the class of materials for which the parameter a of the Krisher model has been found, and in addition a large quantity of experimental data are given. At the same time, the presence of empirical parameters imposed a series of limitations on the utilization of the model in carrying out the calculation. In the following we propose a further development of the model of a moist porous material such as that proposed in [2], in which consideration is given to the effect of the nature of moisture distribution on the transfer processes, and in which there is also no need to utilize the empirical coefficients a and b. This development is based on a model with interpenetrating components containing the solid skeleton 1, the vapor-gas mixture 3, and moisture 2 (Fig. 1). For small moisture contents ω the liquid is distributed in the form of individual isolated inclusions or isolated clusters (Fig. 1a) which will increase with increasing ω and at some critical value of the moisture content $\omega = \omega'$ will merge into a single infinite cluster (Fig. 1b). With a further increase in the moisture content, the liquid will occupy an increasingly greater fraction of the pore space (Fig. 1c), and for values of $\omega = \omega''$ the infinite cluster will disappear from the gas and vapor mixture which will now be distributed in the pore space in the form of isolated inclusions (Fig. 1d).

We calculated the effective thermal conductivity of such a model by combining the methods of reduction to an elementary cell with the application of flowthrough theory [5, 6]. The analysis of the heat and mass transfer processes in this case of a three-component system is accomplished by successive reduction of that system to a binary system [7]. For this, in the initial stage the effective thermal conductivity of the pore space is determined; this pore space contains the liquid and the vapor-gas mixture; in the second stage, we determine the effective thermal conductivity of the entire material. It is necessary, in this case, to add that in our calculations we made no provision for the components of thermal conductivity due to the thermocapillary effect, nor to the effect of thermal diffusion, heat slippage, and a number of other components. Numerical estimates were undertaken for a number of materials at $T = 83°C$, and these demonstrated that the components of thermal conductivity due to thermal diffusion and heat slippage were smaller by an order of magnitude than the diffusion components, and the contribution of such transfer mechanisms as thermal osmosis, the thermocapillary effect, as well as the thermal-conductivity component due to the film flow caused by the wedge effect amounted to less than 1% of the diffusion component. In this connection, for the sake of calculation simplicity, we made no allowance for the contribution of these components to the effective thermal conductivity of the moist porous material.

Thus, let us present the pore space containing the liquid and the vapor-gas mixture as a binary system consisting of interpenetrating components. The elementary cells of such a system, for various values of the moisture content, are shown in Fig. 2, where 1 and 2 denote the components of the liquid and of the vapor-gas mixture. It was noted earlier that at low moisture contents ($\omega < \omega'$) the liquid is concentrated in an isolated cluster in a cube with side ℓ_2 (Fig. 2a), its concentration is equal to $\omega = (\ell_2/L)^3$, and the isolated clusters are themselves separated from each other through a distance $\ell_3 = L - \ell_2$. With moisture-content values of $\omega \geq \omega'$ the isolated clusters combine through transverse linkages whose transverse cross section $S_1 = \ell_1^2$ (Fig. 2b). In this case, according to flowthrough theory, there exists a limit value for the moisture content $\omega < \omega'$, at which $S_1 = 0$, while when $\omega = \omega'$ the first bridges are formed in "jumpwise" fashion, i.e., the isolated clusters link up and become infinite clusters. Subsequent growth of ω leads to an increase in the area ℓ_1^2 of the transverse cross section of the linkage until it becomes comparable to the values of ℓ_1 and ℓ_2 and the heterogeneous system will no longer change into a structure with interpenetrating components (Fig. 2c). As ω increases, we will subsequently note a reduction in the area of the transverse cross section $(L^2 - \ell_1^2)$ for the bridges of the vapor-gas component, and in the case of a liquid concentration of $\omega = \omega''$ the infinite cluster of the gas and vapor mixture disappears. Based on purely geometric constructions it is demonstrated in Appendix 1 that the values of ω' and $1 - \omega''$ in the average interval of porosity for the case in which the wetting angle ϑ is equal to 0° are approximately equal to 0.16. This conclusion is in good agreement with the results of the flowthrough theory, and on the basis of these results we find that the flowthrough threshold for three-dimensional space in the case of a two-component system is equal to 0.15 [5, 6, 8].

Calculation of the effective thermal conductivity λ_{12} of a nonuniform binary system consisting of vapor-gas mixture 2 and liquid 1 with thermal conductivities λ_2 and λ_1 can be carried out with the formula proposed in [6]:

$$\frac{\lambda_{12}}{\lambda_1} = \bar{S}_1 + \nu\left(\frac{\Delta\bar{S}}{1-(1-\nu)\bar{l}_2} + \frac{2\bar{S}_3}{1-(1-\nu)\bar{l}_1} + \bar{S}_4\right), \tag{1}$$

where

$$\bar{S}_1 = \begin{cases} \left(\dfrac{\omega - \omega_c}{1 - \omega_c}\right)^{1{,}6}, & \omega \leqslant 0.5, \\ \left(\dfrac{\omega_c - \omega}{\omega_c}\right)^{1{,}6}, & \omega > 0.5; \end{cases} \tag{2}$$

$$\omega_c = \begin{cases} \omega', & \omega \leqslant 0.5, \\ \omega'', & \omega > 0.5; \end{cases}$$

$$\bar{l}_1 = \sqrt{\bar{S}_1};\ \bar{l}_2 = \sqrt[3]{\omega_c};\ \bar{S}_2 = \bar{l}_2^2;\ \bar{S}_3 = (1 - \bar{l}_2)\bar{l}_1;$$

$$\bar{S}_4 = 1 - \bar{S}_2 - 2\bar{S}_3;\ \Delta\bar{S} = \bar{S}_2 - \bar{S}_1;\ \nu = \lambda_2/\lambda_1.$$

The subscripts 1 and 2 pertain to the liquid and vapor-gas components, respectively.

The thermal conductivity of the vapor-gas mixture $\lambda_2 = \lambda_g + \lambda_v$ is equal to the sum of the thermal conductivity λ_g of the gas and the thermal conductivity λ_v caused by the diffusion transfer of the vapor in the pore space. The value of λ_v is determined from the following relationship [1, 9]:

$$\lambda_v = \frac{DM}{\mu RT}\ \frac{P}{P - P_v}\ \frac{dP_v}{dT}\, r. \tag{3}$$

We will subsequently propose a method for the determination of the diffusion resistance factor $\mu = D/D_{por}$, equal to the ratio of the vapor-diffusion coefficient D in air and in the porous body D_{por}.

In the second stage, following the familiar formulas [5, 7], we will determine the effective thermal conductivity λ of the moist material, which can be presented in the form of a structure consisting of interpenetrating components made of a solid skeleton i = 3 and the pore space i = 1, 2 (Fig. 2c). We can determine the effective thermal conductivity of a binary system with interpenetrating components on the basis of the following formula [5, 7]:

$$\frac{\lambda}{\lambda_3} = c^2 + \nu(1 - c)^2 + \frac{2\nu(1 - c)c}{1 - c + \nu c}, \quad \nu = \lambda_{12}/\lambda_3. \tag{4}$$

The parameter $c = \ell_1/L$ is determined from the solution of the cubic equation [7]

$$m = 2c^3 - 3c^2 + 1, \tag{5}$$

where m is the porosity of the material.

Let us examine a method for determining the diffusion resistance coefficient μ. For the one-dimensional case, according to Fick's law, the vapor flow I is proportional to the concentration gradient dn/dx and the cross-sectional area S of the flow:

$$I = D\left|\frac{dn}{dx}\right| S. \tag{6}$$

The vapor flow I_{por} through the porous body passes through twisting pores with an average cross section S_{por} and a length ℓ; Fick's law in this case can be expressed by the relationship

$$I_{por} = D\left|\frac{dn}{dl}\right| S_{por} = D\,\frac{1}{\tau}\left|\frac{dn}{dx}\right| S_{por} \tag{7}$$

Here, τ denotes the extent of pore twisting, which is associated with the thickness of the porous material L by the relationship $\ell = \tau L$.

Let us replace the real pore space by the effective rectilinear pore channel of length L, $\tau = 1$, the area S of the transverse cross section, and some effective vapor diffusion coefficient D_{por}, i.e.,

$$I_{por} = D_{por}\left|\frac{dn}{dx}\right| S. \tag{8}$$

Equating (7) and (8) and carrying out the transformations, we obtain

$$\mu = \frac{D}{D_{por}} = \tau\,\frac{S}{S_{por}}. \tag{9}$$

Formula (9) has been proposed by Krisher for the determination of μ by means of the twisting factor τ and the relative pore area S/S_{por} [1]. This formula is contradictory, since for moisture contents of ω close to 1, S_{por} tends to 0 and, consequently, μ will tend toward infinity. This latter situation is physically invalid, since with large moisture contents the vapor will actually diffuse only within the limits of the vapor-gas bubble in the pore space, and in this case will experience virtually no resistance, i.e., μ will tend toward 1.

Let us examine a method of calculating the diffusion resistance factor μ in moist porous materials on the basis of a model for a structure with interpenetrating components made of a solid skeleton and a pore space together with a liquid. We will assume that the vapor does not diffuse completely identically through the entire distance from the point of vaporization to the point of condensation, but that a portion of the vapor may condense at segments of the pore that are closer to the point of vaporization. In analogy with electrical resistance, let us introduce diffusion resistance R_D for a channel of length ℓ and of cross-sectional area S:

$$R_D = \frac{l}{DS}. \tag{10}$$

Utilizing (10) with consideration of (9) it is not difficult to obtain an expression for μ:

$$\mu = \frac{D}{D_{\text{por}}} = \frac{\tau l}{l}\,\frac{S}{S_{\text{por}}} = \frac{l\tau}{DS_{\text{por}}}\,\frac{SD}{l} = \frac{R_{D\,\text{por}}}{R_D}. \tag{11}$$

We will use $R_{D\,\text{por}} = \ell\tau/DS_{\text{por}}$ to denote the diffusion resistance of the pores.

Let us examine a pore channel consisting of two sequentially connected segments of transverse cross-sectional area S_1 and S_2 ($S_1 > S_2$), with lengths of ℓ_1 and ℓ_2 (Fig. 3a). We will carry out the adiabatic subdivision of the channel by means of surfaces parallel to the direction of the diffusion flow and coincident with the side surfaces of these segments. The vapor, on vaporization from the left boundary, will diffuse both within the channel of cross-sectional area $S_1 - S_2$ over a length ℓ_1 (in this case, on passage of length ℓ_1 it will condense on the opposite face boundary of the channel) as well as within another segment with a cross-sectional area S_2 over a distance $(\ell_1 + \ell_2)$.

The diffusion resistances of these segments will be determined in the following manner:

$$R_{1D} = \frac{l_1}{D(S_1 - S_2)},\quad R_{2D} = \frac{l_1 + l_2}{DS_2}. \tag{12}$$

The equivalent circuit connecting the resistances is shown in Fig. 3b. In connection with the fact that the dimensions of the pores are small in comparison with the characteristic dimensions of the porous bodies and, consequently, the temperature difference across opposed pore segments is not great, which in turn leads to a small difference in the partial vapor pressure across the length of the channel, we will assume that the partial vapor pressure varies linearly through the length of the channel. Taking this into consideration, the expression for the diffusion resistance of the entire channel will have the form

$$R_{D_{\text{por}}} = \left(R_{2D}^{-1} + R_{1D}^{-1}\frac{l_1}{l_1 + l_2}\right)^{-1}. \tag{13}$$

We will substitute the diffusion resistance of the pore space between the vaporization segment and the first condensation segment into formula (11) for R_D to yield:

$$R_D = \frac{l_1}{DS_1}.$$

For a pore channel consisting of three segments, the diffusion resistance is determined in similar fashion:

$$R_{D_{\text{por}}} = \left(R_{3D}^{-1} + R_{2D}^{-1}\frac{l_1 + l_2 + l_3}{l_1 + l_2} + R_{1D}^{-1}\frac{l_1 + l_2 + l_3}{l_1}\right)^{-1}, \tag{14}$$

where

$$R_{1D} = \frac{l_1}{(S_1 - S_2)D};\quad R_{2D} = \frac{l_1 + l_2}{(S_2 - S_3)D};$$

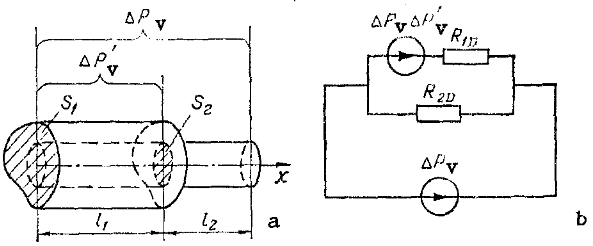

Fig. 3. Pore channel with two condensation segments: a) schematic representation of channel; b) equivalent circuit.

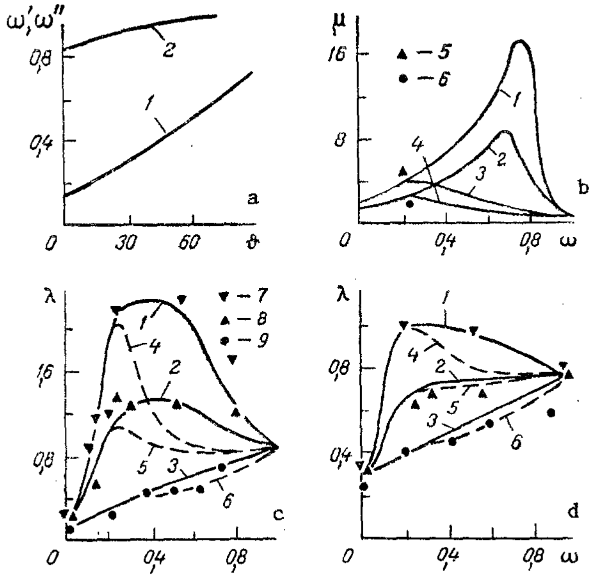

Fig. 4. Calculation and experimental results: a) critical moisture contents as functions of the wetting angle with an average porosity range of m = 0.2-0.8; 1) ω'(ϑ); 2) ω"(ϑ); b) the coefficient of diffusion resistance as a function of moisture content for various wetting angles; 1) m = 0.4, ϑ = 90°; 2) m = 0.8, ϑ = 90°; 3) m = 0.4, ϑ = 0°; 4) m = 0.8, ϑ = 0°; experimental data [9]: 5) porous glass filters (m ≃ 0.4); 6) foam concrete (m ≃ 0.8); c, d) effective thermal conductivity of moist porous materials as a function of moisture content at various temperatures: c) foam concrete (m ≃ 0.8), saturated with water; d) porous glass (m ≃ 0.4), saturated with water; 1-3) model calculation with ϑ = 0°; 4-6) model calculation with ϑ = 90°: 1, 4) T = 94°C; 2, 5) 83°C; 3, 6) 50°C; 7-9) experimental data: 7) T = 94°C; 8) 83°C; 9) 50°C. λ, W/(m·K); ϑ, deg.

$$R_{3D} = \frac{l_1 + l_2 + l_3}{(S_2 - S_3)\,D};$$

ℓ_1, ℓ_2, and ℓ_3 are the segment lengths; S_1, S_2, and S_3 are the areas of the transverse cross sections of the segments.

Correspondingly, the resistance coefficient μ in this case will be equal to:

$$\mu = \frac{R_{D\,\mathrm{por}}}{R_D} = \frac{\left(R_{3D}^{-1} + R_{2D}^{-1}\dfrac{l_1 + l_2 + l_3}{l_1 + l_2} + R_{1D}^{-1}\dfrac{l_1 + l_2 + l_3}{l_1}\right)^{-1}}{R_D}. \tag{15}$$

Using this method, we will determine μ as a function of porosity m, moisture content ω, and the wetting angle ϑ, employing the model of moist porous materials (see Fig. 1). We will subdivide the elementary cell by planes parallel to the diffusion flow of the vapor,

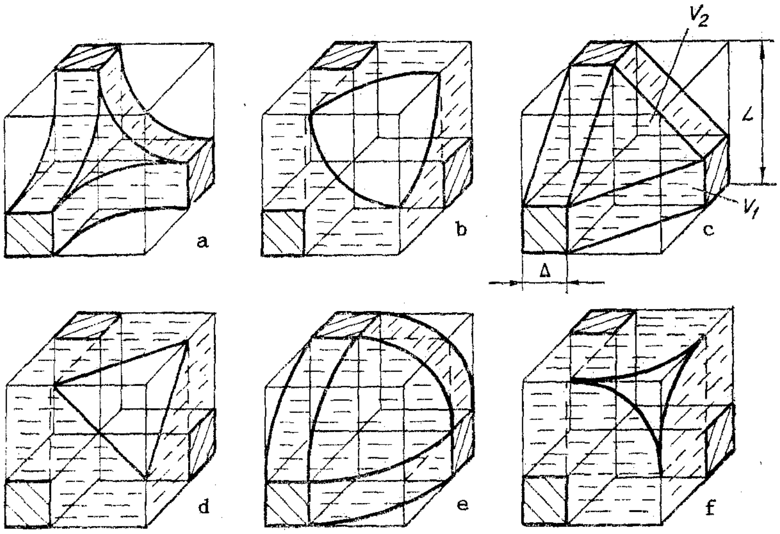

Fig. 5. Distribution of the fluid in the skeleton and pore space of the structure for critical values of the moisture content and for various wetting angles: a) $\omega' = 0.16$, $\vartheta = 0°$; b) $\omega'' = 0.85$, $\vartheta = 0°$; c) $\omega' = 0.41$, $\vartheta = 45°$; d) $\omega'' = 0.96$, $\vartheta = 45°$; e) $\omega' = 0.72$, $\vartheta = 90°$; f) $\omega'' = 0.99$, $\vartheta = 90°$.

and in this case a number of pore channels connected in parallel are formed with a transverse cross-sectional area S_i and length ℓ_i (i denotes the number of the channel).

The values of S_i and ℓ_i for each of the channels is determined from the dimensions of the structural elements in the model of moist porous materials. Further, having determined the diffusion resistance R_{iD} of these channels and using formulas (13)-(15), we find the coefficient of diffusion resistance μ as a function of m, ω, and ϑ. The relationship between the geometric parameters of the structure and the concentration of the components is given in Appendix 2. Figure 4b shows the calculated relationships between μ and ω for the cases $m = 0.8$ and $m = 0.4$ when $\vartheta = 0$ and 90°.

The functions $\lambda = \lambda(\omega, T)$, calculated by means of the proposed method based on formulas (1)-(4) and Fig. 4a, b for a broad range of the wetting angle $\vartheta = 0$-90°, and the experimental data for the foam concrete ($m = 0.8$) and the porous glass ($m = 0.4$), saturated with water at various temperatures T, are shown in Fig. 4c, d. Good agreement is shown between the results from the calculations and the experiments for the case in which $\vartheta = 0°$. As we can see from the plots, the curves for $\vartheta = 0$ and 90° up to moisture contents on the order of 0.2 are virtually coincident. For large values of ω the thermal conductivities of the moist materials may differ significantly, depending on the wetting angle. Analogous results were obtained for disperse materials by the authors of [3] in which it is demonstrated that, depending on ϑ, the value of the thermal conductivity may differ by a factor of more than 4. This is explained by the influence on λ of the nature of the liquid distribution in the pore space which, in turn, is determined by the wetting angle ϑ. An example of the calculation of λ is presented in Appendix 3.

APPENDIX 1

Determination of Critical Moisture-Content Values ω' and ω''. Let us examine the influence on the threshold values of the moisture content in moist porous materials as exerted by the magnitude of the wetting angle of the liquid from the solid skeleton. Figure 5 shows the elementary cell of the structure divided into eighths, with interpenetrating components for critical moisture-content values of $\omega = \omega'$ and $\omega = \omega''$ for wetting angles of $\vartheta = 0$, 45, and 90°. The magnitude of the moisture content ω is associated by definition with the liquid volume V_ℓ and the pore volume V_{por} by the relationship $\omega = V_\ell/V_{por}$. We will find the value of ω' for one of the cases such as, for example, $\vartheta = 45°$. It follows from Fig. 5c that $V_\ell = 3V_1 + V_2$, $V_1 = 0.5\Delta(L - \Delta)^2$, $V_2 = (L - \Delta)^3/6$. The pore volume is equal to $V_{por} = (L - \Delta)^3 + 3\Delta(L - \Delta)^2$. Consequently, the critical value of the moist content ω' for the case under consideration is equal to

$$\omega' = \frac{\frac{1}{6}(L-\Delta)^3 + \frac{3}{2}(L-\Delta)^2\Delta}{(L-\Delta)^2(L+2\Delta)} = \frac{1}{6}\,\frac{1+8c}{1+2c},\ c = \Delta/L.$$

We can obtain the values of ω' and ω'' in analogous fashion for other wetting angles. Figure 4a shows ω' and ω'' as functions of ϑ.

APPENDIX 2

Determination of the Relationships between the Geometric Structural Parameters and Component Concentrations. Let us examine a model of a moist porous material for the case in which $\omega < \omega'$. Let us assume that the liquid in the form of isolated inclusions is to be found at the corners of an ordered lattice. For simplicity we will assume that the liquid assumes a shape in the form of the totality of rectangular parallelepipeds of altitude a (see Fig. 1a). Let us establish the relationship between the relative dimension $A = a/L$ and the moisture content ω. By definition $V_\ell = m\omega L^3$. Let us express the volume V_ℓ in terms of a, i.e., $V_\ell = a^3 + 3a^2\Delta$, and from these expressions we will find the relationship linking ω and A:

$$A^3 + 3A^2c = m\omega.$$

By solving the derived cubic equation for given values of ω and m we can determine A. Let us assume that when $\omega > \omega'$ the increase in the volume of the liquid in the central portion of the cell is curtailed and liquid interlayers of thickness x begin to form along the cross bars (Fig. 1b). The value of $B = x/L$ as a function of ω and m can be determined from the following expression:

$$L^3m(\omega-\omega') = 3x^2(L-\Delta-a_m) + 6x\Delta(L-\Delta-a_m),$$

where a_m is the maximum value of a corresponding to the moisture content ω'. Solving the given quadratic equation, we find B:

$$B = \sqrt{c^2 + \frac{m(\omega-\omega')}{3(1-c-A_m)}} - c,\ A_m = a_m/L.$$

With a further increase in ω we will assume that the increase in the liquid volume comes about without touching the central portion of the cell, but only as a consequence of filling the segments of thickness f between the crossbars (Fig. 1c). The volume of air contained in the pore space of the elementary cell $L^3m(1-\omega)$ will be equal to

$$L^3m(1-\omega) = (L-a_m-\Delta)^3 + 3(\Delta+a_m)f^2.$$

Solving the obtained equation for $F = f/L$, we find:

$$F = \sqrt{\frac{m(1-\omega)-(1-A_m-c)^3}{3(c+A_m)}}.$$

For a moisture content of $\omega^* = 1 - [(1-A_m-c)^3/m]$, F will be equal to 0. Correspondingly, when $\omega > \omega^*$ the vapor gas mixture in the pores will appear in the form of isolated inclusions. Let us assume that these inclusions are in the shape of a cube with an edge length 2g (Fig. 1d). The quantity $G = g/L$ can be determined from the equation

$$L^3m(1-\omega) = g^3.$$

Correspondingly, the relative dimension G will be equal to

$$G = \sqrt[3]{m(1-\omega)}.$$

APPENDIX 3

Calculation of Foam-Concrete Thermal Conductivity (m = 0.8) When ω = 0.2, T = 83°C, ϑ = 0°. From formula (3) we will determine the diffusion component of thermal conductivity λ_v for T = 356 K; from handbook sources we find [10]: M = 0.018 kg/mole; R = 8.31 J/(mole·K); P = 101,300 Pa; P_v = 53,000 Pa; dP_v/dT = 2150 Pa/K; $r = 2.30 \cdot 10^6$ J/kg; μ = 2.8 (see Fig. 4b), $D = 3.5 \cdot 10^{-5}$ m²/sec.

As a result we obtain $\lambda_v = 0.92$ W/(m·K) with consideration of $\lambda_g = 0.03$ W/(m·K), $\lambda_2 = 0.95$ W/(m·K). Using formulas (1) and (2) we will determine the effective thermal conductivity λ_{12} of the pore space [assuming the thermal conductivity of the liquid $\lambda_1 = 0.65$ W/(m·K)]. For convenience in calculation we will exchange the subscripts for the components. Here $\lambda_1' = \lambda_2 = 0.95$ W/(m·K), $\lambda_2' = \lambda_1 = 0.65$ W/(m·K), $m_2 = \omega = 0.2$, $\nu = \lambda_2'/\lambda_1' = 0.68$. From the formula we determine $\lambda_{12}/\lambda_1' = 0.97$, so that consequently, $\lambda_{12} = 0.92$ W/(m·K).

In the second stage of the calculation, using formula (4), we find the effective thermal conductivity of the moist porous material. Here $\lambda_1 = 2.33$ W/(m·K), $\lambda_2 = \lambda_{12} = 0.92$ W/(m·K), $m = 0.8$, $\nu = \lambda_2/\lambda_1 = 0.39$. From the formula we determine $\lambda/\lambda_1 = 0.48$, so that consequently $\lambda = 1.1$ W/(m·K). The differences between the calculated relationships and the experimental data fall within the limits of the initial information (20%).

NOTATION

λ_v, diffusion component of thermal conductivity, W/(m·K); D, coefficient of vapor diffusion in the air for an unbounded space, m^2/sec; D_{por}, vapor diffusion coefficient in air for the pore space, m^2/sec; M, molecular mass of the vapor, kg/mole; T, vapor temperature, K; R, universal gas constant, J/(mole·K); P, total vapor pressure in the air, Pa; P_v, partial vapor pressure, Pa; r, heat of liquid vaporization, J/kg; I, vapor flow in an unbounded space, kg/sec; J_{por}, vapor flow in the porous body, kg/sec; n, vapor concentration, kg/m^3; S, area through which the vapor diffuses in unbounded space, m^2; S_{por}, area through which the vapor diffuses in the porous body, m^2; ℓ, length of the pore segment along which the vapor diffuses, m; τ, twisting factor of the pores; μ, coefficient of vapor diffusion resistance in the porous body; ω, moisture content; ω', ω'', critical moisture-content values; m, porosity; L, length of 1/8 of the elementary cell, m; V_ℓ, volume of the liquid phase, m^3; V_{por}, volume of the pore space, m^3; Δ, dimension of the skeletal crossbar in the elementary cell, m; c, parameter which links the geometric dimensions of the model of the porous body with porosity; ϑ, wetting angle, deg; R_D, diffusion resistance, sec/m^3.

LITERATURE CITED

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