ABSTRACTS OF ARTICLES DEPOSITED AT VINITI*

CALCULATION OF THE TEMPERATURE OF A MEDIUM IN A CLOSED VOLUME WITH A HEAT SOURCE FOR A PERIODIC VARIATION OF THE TEMPERATURE OF THE EXTERNAL MEDIUM

V. A. Orlov

UDC 532.2.01

The temperature t_i of a medium in a closed volume containing a heat source of strength $Q = Q(\tau)$ and surrounded by a medium whose temperature varies can be found from the heat-balance equation

$$K\frac{dt_i}{d\tau} + t_i(\tau) = t(0,\ \tau) + w(\tau), \tag{1}$$

where

$$K = \frac{V_i c_i}{\alpha_i F_i} \quad \text{and} \quad w(\tau) = \frac{Q(\tau)}{\alpha_i F_i}.$$

In order to solve Eq. (1) the temperature $t(0,\ \tau)$ on the inner surface of the shell enclosing the given volume must be known. This is found by solving the heat-conduction equation for an infinite flat plate with boundary conditions of the third kind which match Eq. (1) on the inner surface of the shell and the variable temperature of the external medium $t_0 = \theta_c + t_m \cos \omega t$ on the outer surface.

The heat-conduction equation and Eq. (1) are solved for an arbitrary (with the usual restrictions) given function $w(\tau)$ by taking Laplace transforms.

The transforms are inverted for the practically important cases of exponential and periodic functions $w(\tau)$.

For example, for $w = w_0 + w_m \cos(\omega\tau - \xi)$ the function $t(x,\ \tau)$ is found, and then integrating (1) gives $t_i(\tau)$ in the form

$$\begin{aligned} t_i = {} & \theta_c + (t_0 - \theta_c)\exp\left(-\frac{\mathrm{Fo}}{\mathrm{Fo}^*}\right) + \frac{t_m\sqrt{N_{0i}N_{0i}}}{\omega^2K^2+1}\Big\{[\cos(\omega\tau-\varphi) + \omega K\sin(\omega\tau-\varphi)] - \\ & - [\cos\varphi - \omega K\sin\varphi]\exp\left(-\frac{\mathrm{Fo}}{\mathrm{Fo}^*}\right)\Big\} + w_0\left(\frac{\mathrm{Bi}_2}{\mathrm{Bi}_1} + \mathrm{Bi}_2 + 1\right) + \frac{w_m}{\omega^2K^2+1} \times \\ & \times \{\sqrt{P_{0i}P_{-0i}}\,[\cos(\omega\tau-\xi-\gamma) + \omega K\sin(\omega\tau-\xi-\gamma)] - [\cos(\omega\tau-\xi) + \omega K\sin(\omega\tau-\xi)]\} - \\ & - \sum_{n=1}^{\infty} A_n(\mu_n\,\mathrm{Bi}_2\,\mathrm{Fo}^*)^{-1}\Big[\theta_c - t_0 + t_m\frac{\mu_n^4}{\mu_n^4+\mathrm{Pd}^2} + \frac{w_0\cos(\mu_n+\beta_n)}{\cos\beta_n\cdot\mu_n^2\mathrm{Fo}^*} + \\ & + \frac{w_m\cos(\mu_n+\beta_n)(\mu_n^2\cos\xi - \mathrm{Pd}\sin\xi)}{\cos\beta_n\,\mathrm{Fo}^*(\mu_n^4+\mathrm{Pd}^2)}\Big]\Big[\exp(-\mu_n^2\,\mathrm{Fo}) - \exp\left(-\frac{\mathrm{Fo}}{\mathrm{Fo}^*}\right)\Big]. \end{aligned}$$

The values of the parameters appearing in this equation are given and it is shown that the μ_n are the roots of a characteristic equation identical with the one given in [1].

---

*All-Union Institute of Scientific and Technical Information.

Translated from Inzhenerno-Fizicheskii Zhurnal, Vol. 29, No. 1, pp. 175-179, July, 1975.

LITERATURE CITED

1. V. I. Martynenko and V. A. Orlov, Inzh.-Fiz. Zh. 22, 371 (1972).

Dep. 714-75, January, 20, 1979.
Original article submitted May 12, 1972.

THERMOPHYSICAL PARAMETERS OF PLASTICIZED FILLED POLYETHYLENE

M. M. Revyako, V. Ya. Poluyanovich,
L. F. Turovets, and Z. V. Gres'ko

UDC 678.742.23.046.36.049.01:536

Measurements are reported on the thermophysical parameters of plasticized and filled low-density polyethylene; the fillers were chrysotile asbestos and aluminoborosilicate glass fiber; the plasticizer was Rubrax. The thermophysical characteristics were determined by a method described by Fogel and Alekseev [1].

It was found that the thermal conductivity of polyethylene was increased by the fillers, especially when asbestos was used. For instance, 30 wt.% asbestos increased the thermal conductivity by 20%, while the same amount of glass fiber produced only a 9% rise. This effect is due in the main to filling of part of the space by a material of higher thermal conductivity. Differential thermal analysis indicated that the filler reduces the crystallinity of the polyethylene, with some tendency to equalize the thermal conductivities of the resulting structural defects. Also, the thermal conductivity in such a system tends to be reduced because the structure of the polymer becomes more open in the presence of the filler [2].

The plasticizer also tends to reduce the thermal conductivity, which is due to effects on the intermolecular and structural interactions, which tend to open up the polymer structure further. The result is that the contacts tend to be reduced, the thermal resistance is increased, and the overall thermal conductivity of the composite is reduced [3].

The thermal diffusivity of polyethylene containing asbestos is raised only slightly, while that in the case of glass fiber is actually reduced. The plasticizer also tends to reduce the thermal diffusivity.

Filling also reduces the specific heat; the plasticizer tends to raise it. The effect of the plasticizer becomes less as the filler concentration increases, and at 20-30% filling the specific heat of the plasticized and filled material approaches that of the filled polyethylene.

LITERATURE CITED

1. V. O. Fogel' and P. G. Alekseev, Inzh.-Fiz. Zh., 5, No. 2, 35 (1962).
2. Yu. S. Lipatov, Physics and Chemistry of Filled Polymers [in Russian], Naukova Dumka, Kiev (1967).
3. Yu. K. Godovskii, in: Advances in Polymer Chemistry and Physics [in Russian], Khimiya, Moscow (1970).

Dep. 711-75, January 13, 1975.
Original article submitted June 17, 1974.

CHOICE OF MODEL AND STRUCTURAL PARAMETERS FOR RESEARCH ON THE MECHANICAL STRENGTH OF A POROUS SOLID

R. I. Ayukaev, V. K. Kivran,
and M. E. Azrov

UDC 539.4.01

Increased productivity in equipments with stationary or fluidized beds requires methods of improving the mechanical strength of the packing, as well as means of treating the bed to eliminate contaminants taken up on purifying suspensions of low concentration. Here it is important to select a suitable model and appropriate structural parameters for the porous material, which should give the best possible decription of the strength. Rebinder's model [1] is rather arbitrary, since it envisages a stochastic polydisperse system simulated by a cubic matrix packing of spheres of single diameter, which is thus of restricted use.

A method has been devised for simulating porous bodies [2], which enables one to define various structural parameters related to the strength, which include the following: the pair-element separation distribution and the distribution for pairs of elements visible one from another. The first function represents the probability of encountering a pair of elements in the system with a given distance between the centers. The second represents the probability of finding a pair of elements with no intervening elements, i.e., directly visible one from the other. These functions can give qualitative and quantitative descriptions of the sizes of the gaps and cracks, and they are of some interest in relation to the mechanical strength of granular materials and various aspects of physicochemical mechanics.

The algorithm for computing the distance distribution for pairs of particles is as follows. The mathematical model for the packing is drawn up as a sample of several hundred packed spheres or elements of any shape; any sphere is taken as the first, and the distances from the center of it to all the other spheres are calculated. Then the next sphere is taken as the first, and the procedure is repeated until all spheres have been used as the first. The numbers in particular distance ranges are tabulated. The particle pairs are stored in the computer memory in order of increasing separation. This gives the pair-distance distribution. Direct visibility is defined as a line joining two points near which there are no other points less than a certain specified distance away. In the case of spheres, this distance may be taken as the radius plus a certain allowance. The magnitude and sign of this allowance may be varied to estimate the probability of cracks and other similar defects of known width in packings of a given density and grain size composition. A computer method of calculating such parameters is presented, and examples are given for stochastic packings (various densities), and also for spheres of equal or different sizes distributed in various ways.

LITERATURE CITED

1. P. A. Rebinder, E. D. Shchukin, and L. Ya. Margolis, Dokl. Akad. Nauk SSSR, 154, No. 3 (1964).
2. R. I. Ayukaev and V. K. Kivan, Dokl. Akad. Nauk SSSR, 215, No. 5 (1974).
3. R. I. Ayukaev, V. K. Kivran, and M. E. Aérov, Dokl. Akad. Nauk SSSR, 218, No. 1 (1974).

Dep. 148-75, November 25, 1974.
Original article submitted May 29, 1974.

A SEMIEMPIRICAL FORMULA FOR THE THERMAL-DIFFUSION SEPARATION IN A BINARY GAS MIXTURE

A. F. Bogatyrev, N. D. Kosov,
and E. E. Makletsova

UDC 533.15;621.029.341

The elementary kinetic theory of gases has been examined, and a semiempirical formula has been derived for the separation by thermal diffusion in a binary gas mixture without invoking the thermal-diffusion constant and the mean temperature:

$$\Delta c = \frac{2c_1^0 (z^k - 1)}{z^k + 1}, \tag{1}$$

where $k = (b - 1)^{-1}$, and z is the root of the equation

$$z^{2k+1} + d_1 z^{k+1} - d_2 z^k - d_3 = 0. \tag{2}$$

Here

$$d_1 = (1 - 2c_1^{(0)});\quad d_2 = [(T_2/T_1)^{1-a/2}]\cdot(1 - 2c_1^{(0)});\quad d_3 = [(T_2/T_1)^{1-a/2}]^{1/k};$$

and a is a semiempirical coefficient, which is a linear function of the mixture concentration and virtually independent of temperature: $a = A \cdot c_1^{(0)} + B$ (A and B are constants). Then a can be calculated if at least two sets of reliable values for the separation are available for two concentrations of a given pair of gases; then from a one can find the separation for any concentration and any temperature by solving (2) by chord or parabola methods.

We calculated a from experiment (about 280 values for the range 290-1000°K), which we had previously recorded for helium–argon, helium–nitrogen, helium–hydrogen, and hydrogen–argon at a variety of compositions and temperature differences. We also calculated values for a for various gas systems for which the literature gives consistent data. The most detailed measurements are available for the helium–argon system, and we compared the a calculated from the measurements given by various workers for a wide range of temperatures and concentrations. The differences between the values did not exceed 3%.

The paper gives values found by least-squares fitting for A and B, which are needed in deriving a; the results apply to 22 pairs of gases.

NOTATION

$c_1^{(0)}$, initial concentration of light component; $b = \sqrt{m_2/m_1}$, m_1 and m_2, masses of the molecules of the two components; T_1 and T_2, temperatures of the cold and hot regions.

Dep. 149-75, December 12, 1974.
Original article submitted January 28, 1974.

β-RAY MEASUREMENT OF INTERNAL WATER TRANSPORT IN DRYING A POWDER

N. I. Gamayunov and L. I. Il'chenko

UDC 66.047

There are certain difficulties in determining the integral phase-transition criterion for internal water transport, primarily due to the need to distinguish the liquid and vapor fluxes within the material [1, 2].

We have used sulfur-35 in the compound $Na_2S^*O_4$ as label for the liquid phase; the data provided by radioactive and other labels for the liquid were tested by examining possible diffusion effects. We used a modified equation for one-dimensional convective diffusion, which is convenient for practical calculations [3], which showed that diffusion at drying rates of $i \geq 1 \cdot 10^{-5}$ g/(cm^2·sec) can be neglected for practical calculations in which errors less than 0.1% are acceptable.

The above integral criterion ε_i was measured for quartz sand for the following fractions; the fluxes of heat and water were strictly one-dimensional. The air-flow speed in these experiments varied from zero to 3 m/sec, while the air temperature varied from 293-393°K. The following expression for ε_i is derived from the convective-diffusion equation

$$\varepsilon_i = 1 - \frac{i_l}{i} = 1 - \frac{\rho(1/F)\cdot dN/d\tau}{i(C_x/C_0)C_0},$$

where $1/F \cdot dN/d\tau$ is the transport rate for the radioactive label in the surface layer of the material due to the liquid flux $i_l = \rho v_l$, ρ is the density of the liquid phase, $i = 1/F \cdot dW/d\tau$ is the drying rate, and C_x/C_0 is the relative label concentration.

These measurements showed that ε_i takes nonzero values in the period of constant drying rate and in the absence of a temperature gradient; here ε_i is dependent not only on the structure of the pore space but also on the drying rate, since it tends to a limit for $i \geq 1.5 \cdot 10^{-4}$ g/cm^2 · sec, which indicates a change in the transport mechanism.

LITERATURE CITED

1. A. I. Veinik and A. S. Shubin, in: Heat and Mass Transfer in Capillary-Porous Bodies [in Russian], No. 8, Énergoizdat, Moscow–Leningrad (1957).
2. N. V. Churaev, Inzh.-Fiz. Zh., No. 12 (1962).
3. N. I. Gamayunov, Author's Abstract of Doctoral Dissertation, Kalinin Polytechnic Institute (1967).

Dep. 150-75, December, 2, 1974.
Original article submitted December 12, 1973.