ABSTRACTS OF ARTICLES DEPOSITED AT VINITI*

EFFECTS OF THE AMOUNT OF WORKING FLUID ON THE CHARACTERISTICS OF HEAT PIPES WITH LONGITUDINAL SLOTS

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The amount of working fluid in a heat pipe has a marked effect on the major characteristics such as the maximum heat-transfer capacity and the temperature difference. The exact effect is dependent on the design and on the geometry of the capillary structure as well as on the working conditions. Published papers deal with the effects of the amount of liquid on the heat-transfer capacity but not on the temperature difference.

The effect on the temperature difference has been examined with a pipe made of AMg6 alloy with an outside diameter of 18 mm and a wall thickness of 1.5 mm. The capillary structure was composed of 45 longitudinal slots of size 0.6×0.7 mm on the inside surface. The pipe length was 0.8 m, with lengths of 0.2 and 0.26 m, respectively, for the heating and condensation zones. The heat carrier was anhydrous ammonia. The temperature pattern was determined along with the limiting heat-transfer capacity for a given amount of liquid within the tube.

Empirical relationships are presented for the effects of the amount of liquid on the temperature difference and the heat-transfer capacity. Variation of the volume between 0.8 and 1.3 of the nominal value causes the heat-transfer capacity to increase by more than a factor 3.5 and the temperature difference for a given limiting heat transfer by a factor 8. On the other hand, the temperature difference for the given transferred power alters only by a factor 2.5-3. Therefore, the exact specifications cause the amount of liquid to influence all the working characteristics considerably.

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DISSOLUTION OF A SUBSTANCE UNEVENLY DISTRIBUTED AROUND THE CIRCUMFERENCE OF A PIPE

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The dissolution of a layer of solid from the inside of a cylindrical pipe in a turbulent flow of solvent is discussed; the surface of the layer is circular but is eccentric with respect to the tube.

The equation for the dissolution kinetics [1] is put in the form

$$\frac{d\delta}{dt} = \frac{k_d}{\gamma}\,[c_s - c_i(x,\ t)], \tag{1}$$

where δ is the thickness of the dissolved part of the layer; k_d, dissolution coefficient; γ, density of the layer on the wall; c_s, saturation concentration; and $c_i(x, t)$, concentration in the solvent at a distance x from the start of the pipe at time t, and this is combined with the conservation equation

$$\frac{\partial c_i}{\partial t} + w\,\frac{\partial c_i}{\partial x} - \beta\,(c_s - c_i) = 0,\ i = 1,\ 2, \tag{2}$$

$$c_1 = c_2 \ \text{for}\ x = w\,(t - t_1), \tag{3}$$

$$c_2(\xi_1(t),\ t) = c_3(\xi_1(t),\ t), \tag{4}$$

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$$\frac{\partial c_3}{\partial t}+w\frac{\partial c_3}{\partial x}-\beta(c_s-c_3)\left(1-\frac{\varphi}{\pi}\right)=0, \quad (5)$$

$$c_3(\xi_2(t),\, t)=0, \quad (6)$$

where w is the solvent flow speed and D is the diameter of the pipe, while $\beta = 4k_d/D$; $\xi_1(t)$ and $\xi_2(t)$ are functions defined from the conditions $\varphi(\xi_1(t), t) = 0$, $\varphi(\xi_2(t), t) = \pi$.

Equation (5) arises because of the uneven disposition of the material on the inner surface and applies for any section of the pipe along with (2) after a clean surface has appeared.

Equation (5) results in a differential equation for $\varphi(x, t)$ as a function characterizing the part of the cross section where the layer of solid has been completely taken up by the solvent:

$$\frac{\partial^2\varphi}{\partial t^2}+w\frac{\partial^2\varphi}{\partial x\partial t}+\beta\frac{\partial\varphi}{\partial t}-\frac{\beta}{2\pi}\frac{\partial\varphi^2}{\partial t}=0. \quad (7)$$

A solution to (7) is given from which a relationship is derived for the time taken to dissolve the solid.

LITERATURE CITED

1. B. A. Kader and A. M. Yaglom, "A universal law for turbulent heat and mass transfer from a wall at large Reynolds and Peclet numbers," Dokl. Akad. Nauk SSSR, 190, No. 1, 65 (1970).

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RADIOMETRIC DETERMINATION OF WATER CONTENT

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Methods of monitoring water content in granular materials by means of ionizing radiation have various advantages; the γ-ray method of measuring water content employs the attenuation of γ rays by scattering and absorption. The integral and spectral characteristics of the γ-ray field can be used to determine the water content.

The changes in spectral characteristics of the γ-ray field are considered for ^{60}Co and ^{137}Cs sources. Spectra are examined to establish the contributions from multiple scattering to the total intensity. The forms of the spectra define the optimum measurement geometry. The measurements were performed with a scintillation detector consisting of an FÉU-35 photomultiplier and NaI crystal working with an AI-100 multichannel analyzer. The apparatus spectra were recorded with broad and narrow beams and show that the general relationships are not substantially altered, but the number of scattered quanta is much larger for the broad-beam geometry. The multiple scattering provides adequate information on the water content.

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γ-RAY SPECTRA OF ^{60}Co AND ^{137}Cs IN RELATION TO WATER CONTENT OF GRAIN IN VARIOUS MEASUREMENT GEOMETRIES

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Precision physical methods and instruments are required in the food industry on account of the needs of the processes; the production equipment and the quality of the product are dependent on the quality of the raw material. Therefore, exact measurements on the parameters of the raw material enable one to obtain a product with given technological features. Radiation methods of measuring water content have been widely employed in hydraulic engineering and related areas, and they have various advantages, in particular, that they are nondestructive, highly sensitive, and rapid. Radiation instruments are designed for long working lives and are economical in operation. γ-Ray measurement of water content is based on Compton interaction between the radiation and the material. A suitable measurement geometry and suitable γ-ray energy can be chosen to adjust the magnitude of the output signal to suit the changes in the object. The optimum geometry has been examined by reference to the radiation fields in grain, with determination of the contribution from scattered radiation as a function of the water content. A two-beam monitoring method has been suggested. One detector records only the direct beam, while the other records the direct and scattered radiations. The ratio of the intensities is compared, which gives a count rate proportional to the water content.

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A QUASIZONE METHOD FOR CALCULATING RADIANT HEAT TRANSFER

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By analogy with [1], the following kernel is used for the integral equation with exposure and reflection diffuse and monochromatic:

$$E_{\text{ef}}(M) = E_{\text{c}}(M) + R(M) \int_F K(M, N) E_{\text{ef}}(N)\, dF_N, \tag{1}$$

where the symbols are as in [1], with this represented as the sum of a degenerate kernel K^s and the kernel K^Γ, the norm of the latter being such that iteration is effective. As a result, the initial integral equation splits up into two systems. One system of integral equations can be solved effectively by iterative methods, because the norm of the kernel is small, while the other system can be solved by methods from linear algebra.

It is assumed that the surface F is split up into n zones, within each of which a kernel K(M, N) can be approximated as a function of M_i; then the substitution

$$K_j(M_i, N_j) = K_j^s(M_i) + K_j^\Gamma(M_i, N_j)$$

is made in (1) and transformation gives

$$E_{\text{ef}}(M_i) = E_{\text{c}}(M_i) + R(M_i) \sum_{j=1}^{n} \Big[\int_{F_j} \Gamma_j(M_i, N_j) E_{\text{c}}(N_j)\, dF_{N_j} + L_j(M_i)\, c_j \Big], \tag{2}$$

$$L_j(M_i) = K_j^s(M_i) + \sum_{k=1}^{n} \int_{F_k} \Gamma_k(M_i, N_k) R(N_k) K_j^s(N_k)\, dF_{N_k},$$

$$c_j = \int_{F_j} E_{\text{ef}}(N_j)\, dF_{N_j};$$

$$\Gamma_j(M_i, N_j) = K_j^\Gamma(M_i, N_j) + \sum_{k=1}^{n} \int_{F_k} \Gamma_k(M_i, P_k) R(P_k)\, K_j^\Gamma(P_k, N_j)\, dF_{P_k};\ i = \overline{1, n}. \tag{3}$$

Multiplication of (2) by dF_{M_i} and integration with respect to F_i gives a system of linear algebraic equations:

$$c_i - \sum_{j=1}^{n} a_{ij} c_j = f_i,\ i,\ j = \overline{1, n}; \tag{4}$$

$$a_{ij} = \int_{F_i} R(M_i) L_j(M_i)\, dF_{M_i},$$

$$f_i = \int_{F_i} \Big[E_{\text{c}}(M_i) + R(M_i) \sum_{j=1}^{n} \int_{F_j} \Gamma_j(M_i, N_j) E_{\text{c}}(N_j)\, dF_{N_j} \Big]\, dF_{M_i}.$$

Then (3) is solved by an iterative method and (4) by methods from linear algebra, and the functions $E_{ef}(M_i)$ are derived from (2) with the necessary accuracy for a small number of zones.

LITERATURE CITED

1. S. P. Rusin, Proceedings of the Fifth All-Union Conference on Heat and Mass Transfer [in Russian], Vol. 8, ITMO, Minsk (1976).

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CONVECTIVE HEAT TRANSFER AND THE TEMPERATURE PATTERN IN A THIN SHELL CONTAINING A CURVILINEAR HOLE

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The temperature distribution in a thin isotropic shell containing a curvilinear hole without corners is determined; the shell is in convection heat transfer with the environment and a boundary condition of the third kind applies at the edge of the hole. It is assumed that the median surface of the shell has a metric with Euclidean geometry near the hole, while the principal curvatures are constant.

The problem is solved by perturbing the form of the boundary and can be reduced to a sequence of problems for a shell with a circular hole. The discussion concerns a hole of shape such that the function $\omega(\xi) = \xi + \varepsilon f(\xi)$ defines the mutually unambiguous conformal mapping of the infinite plane of the variable ξ with a circular hole on an infinite plane with a curvilinear hole. The function f and the value of ε are dependent on the shape of the hole, $|\varepsilon| \ll 1$. In particular, the class of holes is envisaged in which the form is a regular polygon with rounded corners (as well as an ellipse).

Figure 1 shows the results up to the second approximation inclusive for the integral characteristic T_1 for the steady-state temperature distribution. Here T_1 is related to the temperature of the medium $t^{(m)}$ = const ≠ 0, while the temperature of the medium at the edge of the hole is zero. The elliptical hole was taken with $\varepsilon = 1/4$ (eccentricity 0.8), while ε was 1/4 and 1/9, respectively, for the triangular and square holes. The coordinate system lies at the center of symmetry of the hole and the line $\theta = 0°$ coincides with the major semiaxis of the ellipse and passes through a vertex of the triangle or square. Figure 1 shows that the largest variation in T_1 occurs at the edge of the triangular hole.

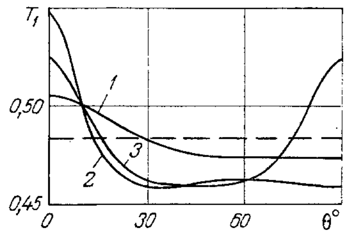

Fig. 1. Integral temperature curves T_1 at the edge of the following holes: 1) elliptical; 2) triangular; 3) square. The broken line is T_1 at the edge of a circular hole (zero approximation).

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SOLUTION OF A STEADY-STATE CONJUGATE PROBLEM IN THERMAL CONDUCTION AND CONVECTIVE HEAT TRANSFER

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Complex boundary-value problems with nonlinear boundary conditions have to be examined in research on heat transfer in a system of structures of various shapes and sizes.

A method is given for calculating the heat transfer in a system of structures of arbitrary shape subject to linear and nonlinear boundary conditions, where boundary integral equations are employed.

Consider the following system of boundary conditions:

$$\left(\frac{\partial t_1}{\partial n}\right)\Big|_{S_c} = -\frac{\alpha}{\lambda_1}\,(t_{S_c} - t_{S_l}),$$
$$\lambda_1\left(\frac{\partial t_1}{\partial n}\right)\Big|_{S_c} = \lambda_2\left(\frac{\partial t_2}{\partial n}\right)\Big|_{S_l}. \tag{1}$$

Here S_c is the surface of the body with temperature t_{S_c}, while S_l is the surface of the transition layer of temperature t_{S_l} surrounding the body, t_1 and t_2 are the temperatures on the opposite sides of the surfaces S_c and S_l, λ_1 and λ_2 are the thermal conductivities for the regions with temperatures t_1 and t_2, and α is the heat-transfer coefficient within the transition layer.

The system (1) substantially simplifies the analysis of the conduction and convective heat transfer by eliminating the inconvenient thin transition layer. The thermal conditions can then be determined as a conjugate problem, where it is possible to incorporate the mutual effects of the structure and the medium.

Boundary conditions of the fourth kind are a particular case of (1) and follow from these in the absence of the thin transition layer ($\alpha \to \infty$).

The solution to any problem in convective heat transfer involves the study of a system of equations containing the energy equation, equations of motion, the equations of continuity, and various empirical equations relating the thermophysical characteristics of the structures and environment.

The present problem for convective heat transfer is solved by iteration. Approximation m to the solution of the energy equation satisfies Poisson's equation

$$\nabla^2 t^{(m)} + f_e^{(m-1)} = 0, \tag{2}$$

where $f_e^{(m-1)}$ is a certain function defined in approximation $m - 1$ and which is dependent on temperature, the thermal conductivities, pressure, enthalpy, the density of the liquid or gas, the specific heats, and other parameters.

The solution of (2) is hardly the most complicated stage in the solution of any problem involving convective heat transfer. If the problem involves conduction or convection with constant parameters, the solution is governed by (2) alone, and the first approximation is the desired function.

When one considers an infinite extended region G that incorporates N characteristic heat-transfer features and subregions G_i with $i = 1, 2, \ldots, N$, one gets a problem in which each part is specified by its external surface Σ_i. This does not rule out the case where for any two parts m and n the condition $G_m \in G_n$ is met.

The solution is sought as a linear combination of the potentials for singly and doubly charged layers together with space charges and amounts to solution of a system of integral equations of Fredholm type:

$$q_{nj}(M_j') = I_j(q_{n1}(M_1),\ q_{n2}(M_2), \ldots,\ q_{nN}(M_N))$$

for the normal components of the heat-flux density vector $q_{n1}, \ldots, q_{nN}$ for all the surfaces in the inhomogeneous medium ($j = 1, 2, \ldots, N$).

An example is considered of the temperature distribution t inside and outside an insulated metallic sphere together with the distribution of the heat flux over the surface arising from an external point source of heat.

The method of solving boundary-value problems in thermal conduction and convective heat transfer reduces the number of dimensions by unity and allows one to solve complex problems for linear and nonlinear boundary conditions.

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