ABSTRACTS OF ARTICLES DEPOSITED AT VINITI *

METHODS OF DETERMINATION OF THE BOILING AND DEW POINTS OF STRATIFIED LIQUIDS AND GASES

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UDC 622.241.8(088.8)

The saturation pressure of stratified oils and the pressure of the onset of condensation of stratified gases are the main parameters characterizing the thermodynamic state of a stratified fluid. The exact determination of these pressures is necessary for the selection of the means and the conditions of exploitation of oil and gas-condensate fields.

The existing methods of determining the phase transitions (volumetric and ultrasonic for the boiling points and visual for the dew points) are not reliable enough.

In this connection methods are proposed for determining the moment of onset of gas liberation from a liquid filling a porous medium using the measurement of the difference in potentials at the ends of a sample of the porous medium. The potential difference arises in a porous medium under the influence of electrokinetic effects during the filtration of a liquid through it. The electrical resistance of the medium increases sharply at the moment of formation of the first gas bubbles, which causes the same sharp change in the potential difference. The proposed method was tested on propane–heptane and propane–benzine mixtures. The saturation pressure obtained using the potential difference was compared with the saturation pressure determined for the same mixtures under the same conditions by the ultrasonic method. Complete agreement in the values of these pressures was obtained.

The ultrasonic method is proposed for the determination of the dew point of a gas both in the bulk phase and in a porous medium. Pulsed or continuous ultrasonic oscillations pass through the vessel containing the gas and are received at an oscillograph through an amplifier. At the moment of the appearance of a finely dispersed mist not visible to the eye, which increased the ultrasonic conductance, a sharp change was observed in the amplitude of the ultrasonic oscillations received at the oscillograph. The determination using ultrasound precedes the visual determination of the appearance of the first liquid drops.

Instead of the ultrasonic method for the determination of the dew point of gases in a porous medium it is proposed to use the method of measurement of the potential difference at the ends of an insulated and moistened porous medium filled with a gas. The precipitation of drops of the liquid which has condensed and the formation of a hydrocarbon film lead to an increase in the electrical resistance of the porous sample and

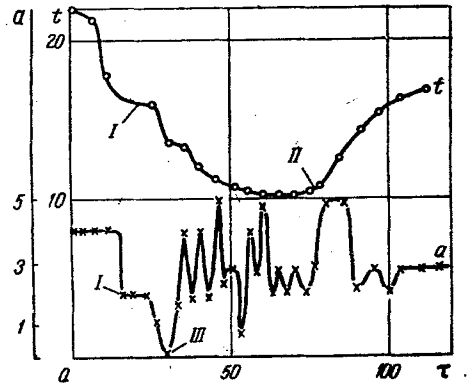

Fig. 1. Time variation in temperature and amplitude of pulsed ultrasonic oscillations for propane at a pressure of 5.5 atm in the bulk phase (I: onset of condensation; II: cooling ceases, boiling of liquid; III: first drops). a, mV; τ, min; t, °C.

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a decrease in the potential difference. The proposed methods of determination of dew points were tested on propane.

The results of the determination of the dew-point temperature of a gas placed in a glass vessel using the ultrasonic method are presented in Fig. 1.

The results obtained indicate the sufficient reliability of the methods described.

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EXPERIMENTAL STUDIES OF COEFFICIENTS OF THERMAL CONDUCTIVITY OF VARIOUS GRAPHITIC CARBON MATERIALS UNDER VACUUM CONDITIONS

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UDC 536.21

Graphitic carbon materials were studied in the form of wadding and felt obtained from spun, staple, viscose fiber with a diameter of 12-14 μ (No. 3200) and 10-12 μ (No. 6000). An experimental determination was made of the dependences of the effective and radiant thermal-conductivity coefficients of graphitic carbon felts of different brands and VV-66-95 graphitic carbon wadding on the average temperature of the layer by the steady-state "slab" method in the range of temperatures $T = 300\text{-}600°K$ with a pressure $P \approx 10^{-4}\text{-}10^{-5}$ mm Hg and a bulk density of 80 kg/m^3 of the samples.

Under these conditions the transfer of heat through a layer of graphitic carbon materials is accomplished by two forms of heat transfer – radiation and conduction. The conductive component, which increases with an increase in the bulk density of the material, becomes negligibly small when the latter is very loose and one can then assume that the heat transfer proceeds only by radiation. The effective thermal-conductivity coefficient takes into account the combined heat transfer by radiation and conduction.

In the report it is shown experimentally that the radiant thermal conduction of loose graphitic carbon materials, like that of other loosely filamentary thermal insulators (siliceous and basaltic thermal insulators, fiberglass), with allowance for the boundary surfaces is directly proportional to the cube of the average temperature of the layer and decreases with an increase in the degree of dispersion (with a decrease in the filament diameter).

A comparison of the temperature dependences of the effective thermal conductivity coefficients of graphitic carbon felts made of the same starting filament but with different thermal processing temperatures, with the same thermal processing temperature but different diameters of the starting filament, felts for which the specific surface of the filaments is increased by activation (an increase in the number of pores), and unactivated felts showed that any means of increasing the specific surface of the filaments leads to improvement in the thermal insulating properties of graphitic carbon felts.

It is shown experimentally that the radiant thermal conduction of graphitic carbon wadding has the lowest value in comparison with other loosely filamentary thermal insulators (siliceous and basaltic thermal insulators, fiberglass) of the same or higher degree of dispersion.

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EFFECT OF GAS TEMPERATURE ON ITS DENSITY IN A CLOSED VOLUME

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UDC 536.422.4

We consider two volumes of gas I and II with densities ρ_1, ρ_2 and temperatures T_1, T_2. These volumes are connected by two one-way channels with conductances U_1 from I to II and U_2 from II to I. It is assumed that the law of thermomolecular flow is satisfied. Assuming that the temperature of the gas in volume II is the same as that of the inner surface of its container, we formulate the differential form of the mass-balance equation describing the exchange of gas between volumes I and II:

$$Vd\rho_2 = U_1\rho_1 d\tau - U_2\rho_2 d\tau, \tag{1}$$

where volume I is assumed infinitely large and volume II is denoted by V; τ is the time. We assume that the rate of decrease of the temperature T_2 is proportional to the difference $T_2' - T_2$, where T_2' is the temperature of the gas in volume II at the instant condensation begins, and the coefficient of proportionality m_T is the cooling rate defined by the equation

$$m_T = \frac{\alpha_T \Pi}{c_T}, \tag{2}$$

where c_T is the heat capacity of the container of volume II, S is the area of its outer surface, and α_T is the heat-transfer coefficient at the outer surface of volume II. Introducing into Eq. (1) the notation

$$m = \frac{U_1}{V},\quad y(\tau) = \frac{\rho_2(\tau)}{\rho_1},$$

$$k_1 = \frac{T_2}{T_1},\quad k_2 = \frac{T_{20} - T_2'}{T_2},$$

we obtain a first-order linear differential equation whose solution is

$$y(\tau) = \left[m\int_0^\tau \exp\left(m\int_0^t \sqrt{k_1 + k_2\exp(-m_T\alpha)}\,d\alpha\right)dt + y_0\right]\times$$

$$\times\exp\left(-m\int_0^\tau \sqrt{k_1 + k_2\exp(-m_T t)}\,dt\right),$$

where $y_0 = y(0)$ and $T_{20} = T_2(0)$. We denote by τ^* the value of the argument τ at which the solution $y(\tau)$ takes on the value $y_1 = (1/\sqrt{k_1}) - \delta$, where δ is a positive constant satisfying the inequality $\delta\sqrt{k_1} < 1$, and we denote by τ_1^* the lower limit of τ^*. After some simple transformations we obtain the expression

$$\tau_1^* = \frac{1}{m\sqrt{k_1}}\ln\frac{\dfrac{1}{\sqrt{k_1}} - y_0}{\dfrac{1}{\sqrt{k_1}} - y_1}.$$

The values of τ^* for all cases of practical interest were obtained on a BÉSM-4 computer using the Adams method with automatic step selection. The results of the calculation show that a minimum tightness of closed volume II ($m = 1/\text{min}$) ensures the rapid establishment of the equilibrium density within it if cooling is rapid enough. For a closed volume II with a negligible exchange of gas with volume I ($m = 10^{-4}/\text{min}$) the effect of thermal inertia during the establishment of dynamic equilibrium is sharply decreased. With an increase in thermal inertia ($m_T \to 0$) there is an increase in the egress time at condensation temperature conditions which lengthens the time required to establish the equilibrium density of the gas remaining in volume II. For "instantaneous" cooling after outgassing the sealed container of volume II and the evacuation of part of the residual gas from it, it is possible to obtain a density $\rho_2(\tau)$ which, up to the beginning of condensation, will be several times lower than that outside it.

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STEADY TEMPERATURE DISTRIBUTION OF A SYSTEM OF BODIES WITH INTERNAL ENERGY SOURCES

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UDC 536.24

The distribution of mean surface temperatures is investigated in a system of bodies with internal energy sources. It is assumed that the temperature distributions of all bodies are uniform, the thermal bonds have no heat capacity, and the thermophysical and heat-transfer coefficients are temperature-independent. Mathematically, the problem reduces to solving a set of N linear algebraic equations formulated in accordance with the law of conservation of energy:

$$\begin{cases} P_1 = (\sigma_{1c} + \sigma_{12} + \ldots \sigma_{1N})\,\vartheta_1 - \sigma_{12}\vartheta_2 - \sigma_{13}\vartheta_3 - \cdots - \sigma_{1N}\vartheta_N, \\ \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \\ P_N = -\sigma_{N1}\vartheta_1 - \sigma_{N2}\vartheta_2 - \cdots - \sigma_{N,\,N-1}\vartheta_{N-1} + (\sigma_{Nc} + \sigma_{N1} + \cdots + \sigma_{N,\,N-1})\vartheta_N, \end{cases} \tag{1}$$

where $\vartheta_i = t_i - t_c$ is the amount by which the temperature of the i-th body exceeds that of the surrounding medium, P_i is the strength of the i-th internal energy source, σ_{ic} is the thermal conductivity between the i-th body and the surrounding medium, and $\sigma_{ij} = \sigma_{ji}$ is the thermal conductivity between the i-th and j-th bodies of the system (i, j = 1, 2, . . . , N; $i \neq j$).

An exact analytic solution of such a system is very cumbersome and a numerical solution is special and frequently inadequate. We therefore consider an approximate analytic method of solution based on the principle of local action. A certain j-th body is singled out from the system and the deviations of the thermal conductivities among the remaining N − 1 bodies from some level are considered as perturbations. By the principle of local action any perturbation has only a local effect. Using this principle we can calculate the temperature of the j-th body by ignoring the deviations of the thermal conductivities among the remaining bodies from some average level and ascribing to this level a value determined by other considerations. The simplest solution is obtained by assuming that all N − 1 bodies are connected to one another by infinitely large thermal bonds, i.e.,

$$\sigma_{kl} = \sigma_{in} = \infty \quad (k,\ l = 1, 2,\ \ldots,\ N;\ k \neq l \neq j). \tag{2}$$

This means physically that all N − 1 bodies are lumped together into a single so-called effective body E with some unknown temperature t_E, i.e., $\vartheta_i = \vartheta_E$ (i = 1, 2, . . . , N; $i \neq j$). It follows mathematically from (2) that the system of N equations (1) reduces to a set of two equations of the form

$$\begin{cases} P_j = (\sigma_{jE} + \sigma_{jc})\tilde{\vartheta}_j - \sigma_{jE}\vartheta_E, \\ P_E = (\sigma_{jE} + \sigma_{Ec})\vartheta_E - \sigma_{jE}\tilde{\vartheta}_j, \end{cases} \tag{3}$$

where

$$\sigma_{jE} = \sum_{\substack{i=1 \\ i \neq j}}^{N} \sigma_{ji}; \quad \sigma_{Ec} = \sum_{\substack{i=1 \\ i \neq j}}^{N} \sigma_{ic}; \quad P_E = \sum_{\substack{i=1 \\ i \neq j}}^{N} P_i,$$

whose solution is trivial. Setting j = 1, 2, . . . , N we find in succession the approximate temperatures of all the bodies of the system. The method was further justified by a statistical error analysis. It was shown that for fixed ratios of the parameters the method is not in error by more than 15%.

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IGNITION OF REACTIVE GASES BY AN ELECTRIC DISCHARGE

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UDC 536.46

Suppose a reactive gas lies between two plane-parallel electrodes of infinite extent having a constant temperature T_0. At the starting time a voltage pulse exceeding the breakdown voltage is supplied to the electrodes, as a result of which the breakdown of the gas occurs and the energy stored in the external circuit is released. As experiment [1] shows, ignition occurs in the system when the amount of energy is above some critical value $E_{\min}$. It is assumed that the reacting mixture is binary, and the mass forces, viscous energy dissipation, thermobarodiffusion, and the diffusional thermoeffect are not taken into account. The time dependence of the power of the electric discharge is assigned in the form of some function taken from experiment [2].

The mathematics of the problem come down to the solution of the following equations:

$$\frac{\partial \rho}{\partial t} = -\rho^2 \frac{\partial u}{\partial x}, \quad \frac{\partial u}{\partial t} = \frac{4}{3} \rho \frac{\partial}{\partial x}\left(\rho\mu \frac{\partial u}{\partial x}\right), \tag{1}$$

$$\rho c_p \frac{\partial T}{\partial t} = \frac{\partial p}{\partial t} + \rho \frac{\partial}{\partial x}\left(\lambda\rho \frac{\partial T}{\partial x}\right) + \rho c q k_0 \exp\left(-\frac{E}{RT}\right) + W(t), \tag{2}$$

$$\frac{\partial c}{\partial t} = \frac{\partial}{\partial x}\left(\rho^2 D \frac{\partial c}{\partial x}\right) - c k_0 \exp\left(-\frac{E}{RT}\right), \tag{3}$$

$$\frac{\partial y}{\partial t} = u, \quad p = \rho R T\left(\frac{c}{M_1} + \frac{1-c}{M_2}\right) \tag{4}$$

with the boundary and initial conditions

$$u|_{x=0} = u|_{x=x_*} = 0, \quad u|_{t=0} = 0, \quad T|_{x=0} = T|_{x=x_*} = T_0, \quad T|_{t=0} = T_0, \tag{5}$$

$$\left.\frac{\partial c}{\partial x}\right|_{x=0} = \left.\frac{\partial c}{\partial x}\right|_{x=x_*} = 0, \quad c|_{t=0} = c_0, \quad \rho|_{t=0} = \rho_0. \tag{6}$$

Here t is the time, ρ is the density, u is the velocity, $x = \int_0^y \rho dy$ is the Lagrangian coordinate, y is the spatial coordinate, μ, λ, and D are the coefficients of physical viscosity, thermal conductivity, and diffusion, respectively, T is the temperature, p is the pressure, c_p is the heat capacity, c is the mass concentration of reagent, q is the calorific effect of the reaction, k_0 is the preexponent, E is the activation energy, R is the universal gas constant, M_1 and M_2 are the molecular weights of reagent and product, $x_* = \rho_0 L$, L is the length of the discharge gap, ρ_0 and c_0 are the initial density and concentration, and W(t) is the power of the electric discharge.

The iteration-interpolation method [3] was used to solve the boundary problem (1)-(6) and for simplicity it was assumed that μ, λ, and ρD are proportional to $\sqrt{T}$ and that $M_1 = M_2$. The space–time distributions of ρ, u, T, c, and p for the ignition and nonignition modes are obtained as a result of the calculations. It is shown that a gradual increase in $E_{\min}$ is observed with a decrease in L and that a sharp rise in the minimum ignition energy occurs at some L. This distance is evidently close to the quenching distance for plane electrodes [1] and the rise in $E_{\min}$ is connected with an increase in heat transfer to the electrodes. An increase in the discharge time t_d, starting with a certain value, also leads to an increase in $E_{\min}$. This result is explained by the fact that if the time of energy release of the discharge exceeds the time of formation of the minimum nucleus of the flame for which its stable propagation is possible [1], then because of the presence of larger temperature gradients in this case there is considerable heat removal from the reaction zone and nonproductive expenditure of energy. The results obtained agree with the well-known experimental data of [1].

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Original article submitted July 17, 1974.

NUMERICAL CALCULATION OF ELECTRODE EVAPORATION IN HIGH-CURRENT PULSE DISCHARGES

A. A. Kislitsyn and A. V. Morar

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Pulse currents flow in a plane electrode and, as a result, melting and evaporation of the electrode occur. A dependence of the velocity of the evaporation front and the electrode temperature on the pulse parameters is sought. Both Joule heating in the depth of the electrode and the presence of a molten layer in front of the moving evaporation front are taken into account. A closed system of equations of heat conduction, evaporation kinetics, and energy balance on the evaporation and melting fronts is solved by a numerical method, using a computer. Calculations are carried out for copper, tungsten, molybdenum, and aluminum in the range of current densities from 10^4 to 10^8 A/cm^2.

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OPTIMIZATION OF TEMPERATURE STRESSES IN MEDIUM CONTAINING CAVITIES

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UDC 539.374

In designing certain types of fuel element, it is necessary to calculate the temperature stresses in continuous media containing cylindrical channels with parallel axes. In order to prevent stress concentrations, it is of interest to determine forms of cylindrical channels which have no sections particularly susceptible to brittle fracture or plastic deformation. We investigate the optimal form of a channel when the intensity of heat liberation q is uniform over the entire volume of the medium and the medium can expand freely, and when the system is in equilibrium and heat is removed through constant-temperature channel surfaces. The optimal form of the channels must satisfy the condition that there are no stress concentrations on the channel surfaces or that the plastic region forms over all the channel surfaces at once.

It is assumed that the channels lie at the points of a square grid, that the maximum temperature drop in the medium is small, and that the properties of the material are constant over this temperature range. The medium is assumed to be sufficiently large so that throughout the medium the stress-state picture is identical over all sections perpendicular to the axis of the cylindrical channels.

Under these assumptions, we have the following mathematical problem. Consider a square lattice having unknown curvilinear apertures with centers at the points

$$P_{mn} = m\omega_1 + n\omega_2 \ (m,\ n = 0,\ \pm 1,\ \pm 2,\ \ldots),$$
$$\omega_1 = 2,\ \omega_2 = 2i.$$

We denote by L_{mn} the contour of the aperture with center at the point P_{mn} and by D_z, the region outside the contour L_{mn}.

On the unknown contour L_{mn}, the boundary conditions are

$$T(x,\ y) = T_0 = \text{const}, \tag{1}$$

$$\sigma_n = -p,\ \tau_{nt} = 0,\ \sigma_t = \sigma_* = \text{const}. \tag{2}$$

In the case of an elastic body, the value $\sigma_* = \text{const}$ must be determined in the course of solution. For elastoplastic materials, the relation $\sigma_t = \sigma_*$ is the condition imposed on the development of the plastic zone, i.e., it coincides with the requirement that the plastic region, at the moment of its appearance, should encompass at once the whole of the aperture contour and not pass into the depth of the medium. In this case, σ_* has a specified value.

The temperature $T(x, y)$ in the region D_z is obtained by solving the heat-conduction equation

$$\Delta T(x, y) + \frac{q}{\delta} = 0. \tag{3}$$

The stresses in the medium may be expressed by two analytic functions of the complex variable $z = x + iy$:

$$\begin{gathered}\sigma_x + \sigma_y = 8\operatorname{Re}\Phi(z) - \alpha E T(x, y) \quad (\bar{z} = x - iy),\\ \sigma_y - \sigma_x + 2i\tau_{xy} = 4[\bar{z}\Phi'(z) + \Psi(z)] - \alpha E \int \frac{\partial T}{\partial z}\, d\bar{z}.\end{gathered} \tag{4}$$

It is required to find from the boundary conditions in Eqs. (1) and (2) the form of the aperture L_{mn} and the stress state in a medium containing cavities.

Hence, it is possible to find the form of the cylindrical channels that ensures maximum strength for several types of nuclear-reactor fuel element.

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VARIATIONAL SOLUTION OF BOUNDARY PROBLEMS FOR HEAT AND MASS TRANSFER

D. M. Yanbulatov and N. M. Tsirel'man

UDC 536.24

A system of equations of heat and mass transfer is solved by means of L. Ya. Ainol's variational principle, together with L. V. Kantorovich's method, for the region bounded by a piecewise-smooth surface, at each point of which the temperature T and mass-transfer potential θ or the densities of the heat and mass fluxes are specified as a function of time for arbitrary initial distribution of T and θ in the region.

The reduced specific heat of the material and the isothermal bulk capacity and the coefficients of heat and mass conduction are assumed to be known functions of the coordinates of the region, while the powers of the sources (sinks) of bulk heat and mass liberation are once again functions of time.

For the one-dimensional case (plates, cylinders, spheres), the form of the n-th approximation to the solution of this problem is presented, together with the system of Euler equations necessary to derive it.

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Original article submitted February 4, 1975.

INVESTIGATION OF RAPIDITY OF MELTING AND CHOICE OF OPTIMAL MEDIUM FOR THERMAL FIXING OF PARTS

V. M. Gorislavets

UDC 536.421.1

In thermal fixing, the part to be worked is held in the desired position as a result of the hardening of a fixing medium. To transfer the part to a subsequent position, the fixing medium must first be melted.

Optimization of the thermal-fixing process requires a minimum time of melting and hardening of the fixing medium. Because of its low melting point and lack of shrinkage, Wood's alloy was chosen as the fixing medium in the present work.

The system was heated internally by means of a constant-power electric coil. (The fixing medium occupied a mold that was rigidly joined to the platform on which the part was positioned.) The switching-on of the heater coincided with the beginning of the experiment and, at definite time intervals, temperature measurements were made at various points of the mold and the fixing medium.

It was found that, in the conditions of our experiment, the time to spontaneous melting of Wood's alloy was about 6 min.

An analytical investigation of the melting of a hollow cylinder heated to the melting point (in practice, heating of the fixing medium from the temperature of the ambient air to the melting point occurs only once in the initial mixture, and does not play a large part in the optimization of the thermal-fixing process) gave completely satisfactory agreement with experiment. The problem was solved in a simplified formulation for an unbounded cylinder, disregarding the heat-retention of the mold and the thermal resistance of the collector wall. Numerical solution on a Minsk-22 computer was employed.

Quite obviously, a more powerful electrical heater would accelerate the melting process. In order to decrease the heat losses in the surrounding medium, it is desirable to supply preheated air through a special channel. It is also expedient to reduce the mold thickness as much as possible.

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Original article submitted October 1, 1974.

ESTIMATING ENERGY IN NONLINEAR PROBLEMS OF HEAT CONDUCTION

V. N. Lagun

UDC 517.951:536.2

Let a finite energy $2\varepsilon_0$ be released instantaneously, at some initial moment of time, at the plane boundary of two media with different thermophysical properties. An approximate solution is obtained for the distribution of energy in the two media over time, when the energy transfer in each medium is regulated by a nonlinear heat-conduction equation.

The formulated problem (a system of two partial differential equations with nonlinear boundary conditions) is transformed to a system of integrodifferential equations. For approximate solution of this system, the temperature in each medium is written in the form characteristic for self-modeling solutions,

$$T(x,\ t) = f(\xi)\, g(t),\ \xi = \frac{x}{x_f(t)}, \tag{1}$$

where t is time; x is a coordinate; $x_f(t)$ is the coordinate of the front. This allows the problem to be reduced to the solution of a single implicit ordinary differential equation.

Since the assumption in Eq. (1) is rather coarse, the scheme outlined can only be used to obtain rough estimates.

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Original article submitted January 13, 1974.

PROPERTIES OF A FAMILY OF TEMPERATURE CURVES

Yu. P. Kotel'nikov

UDC 536.12

From an approximate solution [1] the temperature at an arbitrary point of a cylindrical wall can be written as a function of the temperature of its surface. The temperature curves $\theta = \theta(\eta)$ form a family and the coordinates of their centers do not depend either on time or on the curvature of the cylindrical wall.

The present paper gives analytic expressions for the coordinates of the centers of the family and the coordinates of the points of intersection of the tangents to the temperature curves constructed at an arbitrary cross section of the wall. .

The results obtained broaden the available concepts of the laws of the normal stage of heat transfer [2] and the character of the temperature distribution in a wall, and can be employed, in particular, to develop graphical methods for solving heat-conduction problems.

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BREAKUP OF A LIQUID IN STATIC CAPILLARY SYSTEMS

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UDC 532.66

The gradual drying up of a liquid in a finely divided system constituting a model of contiguous spheres of various sizes is examined neglecting film adsorption.

If all the pores are filled with liquid, surface evaporation leads to distortion of outer menisci. One meniscus is enough to lower the pressure in any size system.

The radii of the outer menisci and, consequently, the pressure in the liquid phase are determined by the sizes of the largest spheres at the surface.

We consider the possibility of the breakup of liquid in individual capillaries. Calculation shows that the liquid can break up only in capillaries having a dilated portion. At the instant of breakup a bubble can be formed here which under certain conditions will be stable. An expression is given for the critical radius of this bubble.

The possibility of the breakup of liquid in a finely divided system is examined on the basis of relations obtained for individual capillaries. Here breakup is possible in voids in which empty bubbles of radius $\rho = nR$ can be formed, where for cubic packing $n > 0.73$ and for hexagonal packing $n > 0.414$, and where R is the radius of the spheres. In this case, as the bubble grows, the cohesive forces between particles will decrease and the absolute pressure in the liquid will increase.

After the whole void is free of water, internal menisci begin to form between the spheres bounding the void. The absolute pressure in the liquid is decreased and breakup begins with the formation of empty bubbles in the spaces between spheres. The presence of an internal void ceases to affect the pressure in the liquid. This cavity has an effect only on the strength of the whole system, very similar to the effect of blisters in a solid.

The empty bubbles formed in the spaces between spheres decrease the cohesive forces between spheres and, consequently, also the strength of the system. However, these bubbles cannot be considered as blisters, since breakup by a bubble and to continuous water require the same force.

As the liquid dries up further, capillary contacts involve only a group of particles in the form of a ring. A liquid in a ring cannot break up with the formation of empty bubbles.

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EQUATION RELATING THE ADIABATIC SATURATION TEMPERATURE TO THE PARAMETERS OF MOIST AIR

Ya. S. Opman

UDC 621.036.7

In certain cases mathematical models of heat- and mass-transfer devices contain the variable temperature t_W.

In investigating and optimizing such models it is necessary to have available the dependence of t_W on the parameters characterizing the state of the moist air: the temperature t and the moisture content d.

The value of t_W as a function of t and d is uniquely determined graphically from a t vs d diagram. However, it is difficult to use graphical or discretely tabulated data in studying models with a computer. Therefore, in such cases it is expedient to have available an equation for t_W as a continuous function of t and d.

To derive an equation $f(t_W, t, d) = 0$, the thermodynamic equations of moist air were first used to derive an expression for the moisture content of saturated air as a function of its temperature $d_S = d_S(t_W)$. The values of the coefficients in the equation relating the partial pressure of the vapor and the temperature of the mixture were taken from data in [1, 2].

A second expression for d_S in the form $d_S = d_S(t_W, t, d)$ was obtained by equating the enthalpies of moist and saturated air during its adiabatic saturation by water vapor. The values of the coefficients in the equations for the specific heats of dry air and water vapor were taken from data in [3].

Equating the first and second expressions for d, gives an implicit equation for t_W in terms of t and d:

$$\frac{0.622\exp\left(13.7489-\dfrac{5116.1}{t_W+273}\right)}{1.033-\exp\left(13.7489-\dfrac{5116.1}{t_W+273}\right)}=\frac{0.99t+93\cdot10^{-6}t^2+1.83td+31\cdot10^{-5}t^2d+2500d-0.99t_W}{1.83t_W+2500}.$$

By using this equation, t_W can be found for normal barometric conditions and any values of the parameters t and d determining the state of the moist air.

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ERNST METHOD FOR DRYING BUILDING WALLS

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We present the main results of investigations of various aspects of the capillary rise of solutions of electrolytes in porous systems, performed in connection with the problem of the increased moisture content of building walls.

Studies of the potentials arising from the capillary rise of a 10^{-3} N solution of KCl in quartz powder diaphragms (fractions 10-20, 20-50, and 50-100 μ) and changes in the concentration and composition of the solution in the meniscus region lead to the conclusion that the total increase in the concentration of the solution and the change in composition of the electrolyte appearing as a result of the interaction with the surface in the capillary rise process are the origin of the concentration and diffusion potentials and can be explained by the potential difference between the foundation and walls of a building, observed by various investigators. The observed changes give rise to a further electroosmotic and capillary-osmotic transfer of the solution and thus exert an appreciable effect on the kinetics of the rise of a solution in a porous body.

Study of the interaction of capillary rise and electroosmosis in porous bodies (quartz powder diaphragms of various particle sizes and ceramic diaphragms) showed that the effectiveness of electroosmotic action on capillary rise in porous bodies is greater than in single capillaries.

Experiments on masonry walls on certain objects in Leningrad in most cases showed an appreciable decrease in moisture content after grounding.

Apparently, the height of the capillary rise of moisture in a wall above the groundwater level when there is no waterproofing is not large enough to account for the high moisture content of the wall. However, the gradual buildup of salts in the meniscus region leads to an appreciable capillary and electroosmotic transfer of moisture. As a consequence of these effects, masonry walls become appreciably damper with time. After buildings have been in use for many years, the moisture level can reach the second story. Therefore, as a rule, a high moisture content of walls is observed only in old buildings. The grounding of the masonry of a moist wall as proposed by Ernst for drying by lowering the diffusion potential eliminates the process which adds to the capillary electroosmotic transfer of moisture and thus decreases the moisture content of the masonry.

However, if as a consequence of a high level of groundwater or constant leakage from water or sewage pipes the height of the capillary rise is by itself rather large and is the cause of the high moisture content of the wall, grounding cannot appreciably diminish the moisture content. Combatting capillary rise in this case requires a stronger electroosmotic counterflow and this can be obtained only by applying an external electric field with an appreciable potential gradient. In such cases it also appears to be necessary to restore the damaged layer of waterproofing in one way or another.

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