ABSTRACTS OF THE ARTICLES DEPOSITED AT VINITI*

REBINDER CRITERIA FOR VARIOUS FORMS OF DRYING

V. M. Kazanskii and Yu. N. Koipish

UDC 66.047.35

The Rebinder criterion Rb and the dimensionless temperature coefficient B play a major part in calculations on drying by means of Lykov's integral equations [1]; it is therefore of considerable interest to relate Rb and B to the local characteristics of the internal and external heat and mass transfer.

This topic has been discussed [2] for convective drying of an unbounded plate. The present study gives analogous relationships for other forms of drying, such as conductive, radiative-convective, and in electromagnetic fields.

Mean values for t and u are employed with specified laws for t(x) and u(x) [2] in order to solve the differential equations for the heat and water transport in various forms of drying. This gives solutions for Rb and B as explicit functions of the characteristics of the material and the parameters of the environment.

The corresponding formulas for convective drying [2] show that the mode of heat supply substantially affects the expressions for Rb and B. Consequently, the type of drying must be considered in relation to measurements and calculations on such characteristics for any material. On the other hand, the formulas do enable one to define the conditions under which a given accuracy can be obtained for Rb and B in a given form of drying, particularly if the values have been measured under convective-drying conditions. Formulas are also extremely convenient for general analysis of the effects of various factors on Rb and B.

LITERATURE CITED

1. A. V. Lykov, Theory of Drying [in Russian], Énergiya, Moscow (1968).
2. V. M. Kazanskii, Inzh.-Fiz. Zh., 27, No. 1 (1974).

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DRYING OF PACKED CUT PEAT ON A WET SUBSTRATE

V. Ya. Antonov, A. E. Afanas'ev, and G. M. Borisova

UDC 622.331:662.641.047

Measurements have been made at the Kalinin Polytechnic Institute to improve the utility of finely divided (cut) peat by folding the cut material into enlarged particles, followed by stacking in a systematic form in the drying area. The use of suitable supporting frames provides substantial improvement in the technology of peat fuel production.

The measurements were made in the radioactive-method laboratory, and the paper presents results on the mode of migration of water in the drying of packed material. The material was top sphagnum moss peat of average degree of decomposition 25-30% and particle size 3-4 mm, which was shaped into blocks of trapezoidal cross section $a \times h \times b = 10 \times 15 \times 12$ and length from 30 to 70 mm. The drying was performed in a special apparatus with free water transfer

*All-Union Institute of Scientific and Technical Information.

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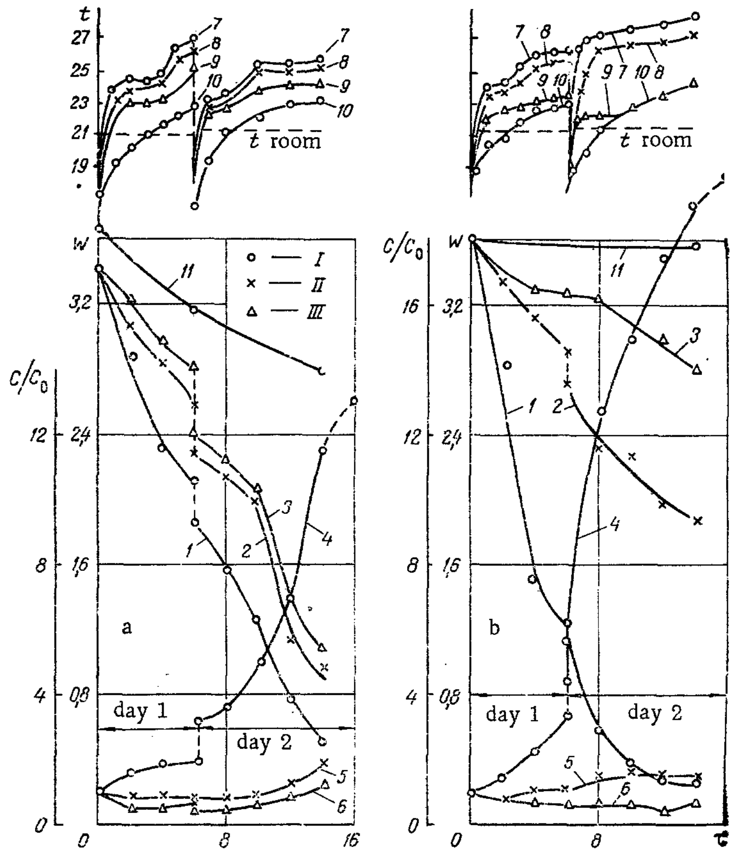

Fig. 1. 1-3) Water contents W (g/g); 4-6) label concentration C/C_0; 7-9) temperature t (°C) in beds of: a) pressed lumps; b) finely divided peat in RC-II drying mode. Curves 10 and 11 relate to the underlying bed. I) Top layer; II) middle layer; III) bottom.

and on a wet support. The initial cut material was also dried at the same time. The load per unit area for the dry material was 1.32 kg/m². The drying conditions simulated those occurring in the field, with purely convective and radiative–convective periods of drying with heat fluxes of 0.18, 0.58, and 0.87 kW/m². Radioactive tracers were used to examine the water migration mechanism.

It was found that the packed material (Fig. 1) showed accelerated drying on account of the various conditions for water loss from the top, middle, and lower layers of pressed blocks, in contrast to the finely divided material. The water contents in the layers of pressed blocks became substantially equal toward the end of the drying period, whereas the spread in water content remained substantial when finely divided peat was dried.

The pressed blocks showed water rising in the capillary system from the central layers to the peripheral ones, which was not hindered by the formation of a definite insulating layer.

Differences were detected in the mode of water migration in the layers of peat. In the case of the pressed blocks, the initial transport by the capillary mechanism gave way during the first day to a film–capillary mechanism and to vapor diffusion on the second day. In the case of the blocks, open surfaces arose on account of the extensive shrinking, which allows water to evaporate from the surface of the underlying peat bed, which somewhat retarded the drying of the blocks.

It was found that the evaporation rate for the blocks increased somewhat when radiative–convective drying gave way to purely convective drying, which was due to redistribution of the water. The performance of the drying for pressed blocks increased particularly under mild conditions, which improved the technology of peat fuel production.

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KINETICS OF WATER TRANSPORT BY CONTACT IN A GRANULAR BODY

D. N. Onchukov, A. P. Kuznetsov,
and V. L. Prokof'ev

UDC 532.546

An analytic solution is presented for a transport equation of hyperbolic type with boundary conditions corresponding to contact between a liquid and a body with capillary pores; an analysis is presented of computer results.

The distribution of water content along the normal to the surface varies in a regular fashion with time; the water penetrates in such a way that the water transport rate is highest at the start. The water-content distribution tends in all cases to present a maximum equal to the boundary water content.

Radioactive-tracer methods were used to examine the transfer by contact; the label was provided by tritiated water having an initial specific activity of 0.5 μCi/ml.

The experiments were performed with wheat over the temperature range from 5 to 60°C and relative humidities between 13 and 55% by weight, which correspond to production conditions.

The results are presented as kinetic curves, which indicate the diffusion of the labeled water in the sorbent on interaction with the solvent water. The main features of the water transfer are indicated, together with the mechanisms and the basic kinetic parameters.

The isotope-exchange rate was defined from the counting measurements in accordance with the formula

$$k = \frac{1}{\tau} \ln \frac{n_0}{n_0 + n_\tau}.$$

The activation energy lay in the range 0.1-6 kcal/mole. The activation energy varies with time because the mode of binding to the material alters.

The contact water-transfer coefficient D (m^2/sec) is used as the basic kinetic coefficient, this being analogous to the diffusion coefficient.

The variation in D with the water content is rather complicated; the largest value occurs at a water content of 32%, which corresponds to half the amount of adsorbed water.

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DRYING-TIME DETERMINATION BY NETWORK SOLUTION OF DIFFERENTIAL EQUATIONS FOR TRANSPORT IN A THIN POROUS PLATE

V. I. Dotsenko and T. P. Ryzhkova

UDC 669.536.24

Difficulties arise in calculating the drying time needed in technical drying processes.

A Mir-1 computer has been used to determine the drying time for thermal insulating material of thickness 15 mm, which contained the following in wt. %: quartz sand 75, clay 5, paper 10, and sulfite-spirit binder 10.

Materials of this type are used in insulating the heads of steel castings in molds.

We used the methods of [1-3] to determine the drying times for materials of this type.

We used a scheme for thermal conduction with boundary conditions of the third kind and rectangular net.

The insulating material had the following geometrical parameters: length 850 mm, width 500 mm, and thickness 15 mm.

Average values were used for the heat- and mass-transfer coefficients, while maximal values were used for the thermal diffusivity.

The calculated drying time was 2.25 h; our measurements indicated that the actual drying times for similar materials were 2.5 h when the hot air at the drier inlet was at about 185°C, i.e., the actual drying time was about 10% in excess of the theoretical value.

LITERATURE CITED

1. A. V. Lykov, Theoretical Principles of Building Thermophysics [in Russian], Izd. Akad. Nauk BelorusSSR, Minsk (1961).
2. P. P. Yushkov and L. I. Loginov, Inzh.-Fiz. Zh., 1, No. 2 (1958); in: Heat and Mass Transfer [in Russian], Vol. 5, Minsk (1963), p. 222.
3. P. P. Yushkov, Dokl. Akad. Nauk BelorusSSR, No. 3 (1957); Tr. Inst. Énerget. Akad. Nauk BelorusSSR, No. 10 (1959).
4. V. I. Dotsenko et al., Ogneupory, No. 9, 27 (1972).

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DRYING KINETICS OF CEMENT SLIME

R. N. Kutov and E. K. Vishnevskii

UDC 666.94.047

It is assumed that there is an evaporation surface within the body, which moves inwards in response to the entering heat flux and whose position is determined by the rates of evaporation and vapor diffusion through the material.

The theoretical value for the evaporation constant is

$$K_W^p = \frac{3G_0 W}{\pi d^2 \tau_t} = \frac{K_0 \exp\left(-\frac{Q}{RT}\right)}{\Delta K_W}. \tag{1}$$

A special apparatus was used to make measurements on the drying (d = 10-25 mm, W = 10-20%) at temperatures between 350 and 550°K; the time and weight change were recorded. The working equation was found to be

$$\lg K_W^p = 3.87 - \frac{1130}{T} - \left(0.87 - \frac{245}{T}\right) \lg d_1. \tag{2}$$

Data were processed to yield a general curve giving the dimensionless drying rate as a function of dimensionless time, which consists of three sections:

1) heating ($0 \leqslant \tau_1 \leqslant 0.1$)

$$\omega_1 = 10\,\tau_1, \tag{3}$$

2) constant drying rate ($0.1 \leqslant \tau_1 \leqslant 0.3$)

$$\omega_1 = \text{const} = 1, \tag{4}$$

3) falling drying rate:

a) ($0.3 \leqslant \tau_1 \leqslant 0.45$)

$$\omega_1 = 1 - 2.33\,(\tau_1 - 0.3), \tag{5a}$$

b) $(0.45 \leqslant \tau_1 \leqslant 0.83)$

$$w_1 = 0.8 - 1.84\,(\tau_1 - 0.45), \tag{5b}$$

c) $(0.83 \leqslant \tau_1 \leqslant 1)$

$$w_1 = 0.1 - 0.59\,(\tau_1 - 0.83). \tag{5c}$$

The mean integral dimensionless drying rate for the process as a whole was $\bar{w}_1 = 0.565$.

Then the drying temperature, initial water content, and grain size allow one to derive the curve for the process:

$$\frac{dW}{d\tau} = f(\tau) \quad \text{and} \quad W = f(\tau). \tag{6}$$

NOTATION

K_0, preexponential factor; K_w, evaporation constant; K_w^p, evaporation constant corrected for mass transfer; ΔK_w, mass-transfer correction; G_0, initial weight of specimen; W, water content; Q, heat of evaporation; R, universal gas constant; T, temperature; d, $d_1 = d/d_0$, diameter and dimensionless diameter of specimen; d_0 = 1 mm, maximum particle size allowing of kinetic evaporation; $\tau_1 = \tau/\tau_t$, dimensionless time; τ, τ_t, current and total times.

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Kuibyshev Polytechnic Institute, Kuibyshev.
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SORPTION DYNAMICS FOR RECTANGULAR ISOTHERMS AND KINETICS OF RATE-LIMITING DIFFUSION WITHIN GRAINS

R. N. Rubinshtein

UDC 66.021.35

A solution is presented for the case where Fick's law applies for particles of identical size and given shape. Detailed calculations have been performed for spherical particles.

The solution for the initial conditions q(X, 0) = 0 and boundary conditions U(0, T) = 1 indicates that there is a finite sorbent length X_{max} for which with $X > X_{max}(\theta)$ one has U = q = 0. If $X < X_{max}$, then $q(X,T) = 1 - \frac{6}{\pi^2}\sum_{n=1}^{\infty}\frac{1}{n^2}\exp\{-\pi^2[T-\theta(X)]\}$ $(T \geqslant \theta)$. It is found that T = θ, $\theta(X) = \theta(X_{max})$ when θ is less than 0.5; if $\theta < 0.5$, $X_{max} = \frac{2}{3\sqrt{\pi}}\sqrt{\theta}\left[1 + \frac{2}{3}\theta + \frac{4}{15}\theta^2 - \theta\exp\left(-\frac{1}{\theta}\right) + \ldots\right] + \frac{\theta}{3}\left(1 + \frac{\theta}{2} + \frac{\theta^2}{6} + \ldots\right)$ with an error less than 0.01%, $X_{max} = \theta + {}^1/_{15}$, and U = q (parallel transport mode). In the region T < 0.005, U is dependent on the single variable $\psi = T/X^2$, while for $\psi > 9\pi/4$, $U = 1 - (2/\pi)\arcsin(2/3)\sqrt{\pi/\psi}$, and for $\psi < 9\pi/4$ we have U = q = 0. It is emphasized that the solution for T < 0.005 differs from that for T > 0.5 in applying for polydispersed sorbents of any form provided that T < 0.005 is met for the smallest fraction, whereupon R takes the value R = 3/S. The solution is also derived for the same problem for kinetics described by the regular-state laws: for $X \leqslant 1/\pi^2$, $q = 1 - \exp(-\pi^2 T)$ and $U = 1 - \pi^2 X \cdot \exp(-\pi^2 T)$; for $1/\pi^2 < X < T + (1/\pi^2)$, $U = q = 1 - \exp[\pi^2(X - T) - 1]$; and for $X > T + (1/\pi^2)$, U = q = 0.

The two solutions agree to within 30% for 1 − U provided that T − X > 0.25T > 0.5

NOTATION

$U = C/C_0$; $q = a/a_0$; $X = Da_0 l/vC_0R^2$; $T = D[t - (l/\varkappa v)]/R^2$, dimensionless quantities; C, a, dimensional concentrations in the mobile and immobile phases; $C_0 = C(0, t)$ = const; $a_0 = a(C_0)$; t, time; l, bed depth; D, diffusion coefficient; v, linear velocity; R, sorbent particle radius; $\varkappa$, porosity; S, grain surface per unit volume of sorbent; $\theta(x)$, the time in which the front having concentration U = 0 travels through a distance X.

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Original article submitted May 29, 1974.

STUDY OF POROUS BODIES BY MATHEMATICAL MODELING.

PART I. METHODS OF MATHEMATICAL MODELING OF THE STRUCTURE OF POROUS BODIES.

PART II. PRINCIPLES OF MATHEMATICAL MODELING OF POROUS BODIES ON A COMPUTER

V. K. Kivran and R. I. Ayukaev UDC 51.001.57:541.182.02—405.8

By using the calculation of certain physical-structural characteristics as an example the authors have shown [1-4] the possibilities of their method of mathematical modeling of porous bodies. In order to extend this method to practical investigations of adsorbents, catalyzers, the granular packings of water-purifying filters, deposits of natural waters, etc., its theoretical bases are examined.

In the stochastic-geometric treatment of porous bodies [5] the formation of their structure can be replaced by modeling the process of random filling of a volume by geometrical elements with distributed sizes, shapes, and orientations [6]. Each element or group of elements is described by a number of geometric and physical parameters. The modeling is performed on a computer. The study of random structures by mathematical modeling on a computer can arbitrarily be divided into the following succcessive stages 1. The formulation of a stochastic model of the structure, the choice of stochastic schemes, and the formal description of the process in question. 2. The development of a modeling algorithm which is a formal description of structural formation processes and other processes enabling the most rational simulation of the stochastic model on a computer. 3. Carrying out the modeling algorithm or program on a computer. In the modeling process a record is obtained (in the internal storage of the computer, on magnetic tape, printout, or punched cards) of a set of numbers which represent the matrix of the generalized coordinates of all the packing elements of the given structure. 4. A statistical study of the physical-structural properties of porous media by appropriate models of their structure. This done by using special algorithms and experimental programs to make drawings of the generalized-coordinates matrix on the computer — the mathematical model of the structure. 5. The arrangement, if necessary, of a comparison experiment on real structures and the subsequent refinement of the formulation of the statistical model. The necessity of performing a comparison experiment is determined by the reliability with which the chosen statistical model of the structure describes certain properties of real structures. The article discusses methods, means, and principles for accomplishing the first four stages of the scheme described.

LITERATURE CITED

1. R. I. Ayukaev and V. K. Kivran, Dokl. Akad. Nauk SSSR, 215, 5 (1974).
2. R. I. Ayukaev, V. K. Kivran, and M. É. Aérov, Dokl. Akad. Nauk SSSR, 218, 1 (1974).
3. R. I. Ayukaev, V. K. Kivran, and M. É. Aérov, Inzh.-Fiz. Zh., 29, No. 1 (1975).
4. R. I. Ayukaev and V. K. Kivran, Zh. Fiz. Khim., 49, No. 4 (1975).
5. L. V. Radushkevich, in: Basic Problems of the Theory of Physical Adsorption [in Russian], Nauka, Moscow (1970).
6. V. K. Kivran, Author's Abstract of Doctor's Dissertation, Gor'kii State University (1975).

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Original article submitted February 18, 1975.

SIMULTANEOUS DETERMINATION OF THERMAL CONDUCTIVITY AND VOLUMETRIC HEAT CAPACITY OF THERMALLY INSULATED MATERIALS AS FUNCTIONS OF TEMPERATURE BY COMPARING EXPERIMENTAL AND CALCULATED TEMPERATURES

L. I. Guseva and L. F. Yankelev

UDC 536.2.083

The thermal conductivity and the volumetric heat capacity of thermally insulated materials were determined from a single experiment on the assumption that the required relations are linear functions of the temperature:

$$\lambda = A + Bt, \quad c\gamma = K + Dt.$$

Specifying certain values of the parameters A, B, K, and D the temperature distribution in the sample was calculated by solving the heat-conduction equation with the boundary conditions realized in the experiment. The temperatures calculated in this way were compared with the experimental values. The linear relations A + Bt and K + Dt which gave the smallest deviations of the calculated temperatures from the experimental values were taken as the thermophysical characteristics of the material under study.

The problem was reduced to the minimization of F(A, B, K, D):

$$F(A,\ B,\ K,\ D) = \max_{j,\xi} |t_{j,\xi}^{\text{calc}} - t_{j,\xi}^{\text{exp}}|. \tag{1}$$

The minimax (1) was found by varying the required constants A, B, K, D using a program written in ALGOL by the authors.

The calculated values of the temperatures $t_{j,\xi}^{\text{calc}}$ were determined by solving the equation

$$c\gamma(t)\frac{\partial t}{\partial \tau} = \frac{\partial}{\partial x}\left[\lambda(t)\frac{\partial t}{\partial x}\right] \tag{2}$$

by the pivotal method with the boundary conditions

$$t_{x=0} = t(\tau), \quad \lambda(t)\left.\frac{\partial t}{\partial x}\right|_{x=L} = q(\tau). \tag{3}$$

The values of the temperature $t_{j,\xi}^{\text{exp}}$ were determined experimentally with standard GOST (All-Union State Standard) 7076-66 equipment. During heating, temperature readings were taken with three thermocouples on the two boundary surfaces and at the middle of the sample and a thermometer placed on the refrigerator. The tabulated readings of the thermocouples and thermometer were used in the program for solving the heat-conduction equation and in the minimization process.

The thermal conductivity λ(t) and the volumetric heat capacity cγ(t) of a calcareous–siliceous material, polymethyl methacrylate, were determined by the method described. The results were compared with data obtained by stationary thermal conductivity measurements performed at the All-Union Scientific-Research and Planning Institute for Heat Engineering Structures and the Mendeleev All-Union Scientific-Research Institute of Metrology. In both cases the results were in good agreement.

Thus, the temperature dependence of the thermal conductivity and the volumetric heat capacity can be determined from a single experiment using standard equipment. The error in the determination of λ was no more than 10%, and in cγ no more than 8%.

NOTATION

λ, cγ, thermal conductivity and volumetric heat capacity of material; q, heat flux density; t, temperature; L, thickness of sample; τ, time; A, B, K, D, coefficients determining λ and cγ.

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Scientific-Research Institute of Constructional Physics, Moscow.
Original article submitted March 28, 1975.

STUDY OF DETACHED MODES OF DUSTY JETS IN AXISYMMETRIC DIFFUSERS

A. V. Golubkovich UDC 532.51

Five detached modes of jet flow are studied in diffusers with counterflow of the gas and solid phases: a developed detached mode, a jet mode, and three transitional modes. The character of the jet flow depends to a considerable extent on the ratio of the diameter of the constriction to its height (h/d_0), the weight flow-rate concentration (μ), and the Reynolds number, and it depends to a lesser extent on the aperture angle of the diffuser and the constants of the material.

In the developed detached and jet modes the dusty jet separates from the diffuser and forms a detached cavity in which closed circulation of the gas and solid phases is observed. The dimensions of the detached cavity and the character and intensity of circulation of the gas and solid phases in the detached cavity and in the apparatus depend on the type of mode.

The transitional modes, which are characterized by the formation of a low-stability detached cavity, are excited at increased values of the parameters h/d_0 and μ. In this connection the character of the circulation of the solid and gas phases changes, with the "distributed" circulation of the solid phase in the detached cavity, which is characteristic of the first two modes, being changed to "packet" circulation. Ejections of the "packets" occur at the lateral surface of the diffuser.

The ranges of the five modes are determined. On the basis of a simplified physical model of a free sink of particles a theoretical dependence is obtained for calculating the maximum velocity of the developed detached mode and one of the transitional modes.

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Original article submitted December 19, 1974.

SOLUTION OF TURBULENT TRANSPORT EQUATION NEAR INITIAL SECTION OF A CONVECTIVE JET

M. V. Petraevskii and A. V. Mashkov UDC 697.957

A solution of the turbulent transport equation in a rectangular region of two-dimensional space is presented in the article for the determination of the field of concentrations near the initial section of a plane thermal jet. On the basis of the general solution obtained, particular solutions are constructed for uniform and nonuniform boundary conditions. From these solutions, in turn, solutions are obtained for a half-sheet, as well as a solution for a stream moving toward the initial section of a plane thermal jet, with an approximate exponential distribution of the concentrations near the source of heat and gas production located at the boundary of the source.

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Original article submitted November 13, 1974.

EFFECT OF VARIABILITY OF VELOCITY AND OF COEFFICIENTS OF VISCOSITY AND THERMAL CONDUCTIVITY OF GAS ON THERMAL CONDITIONS OF BODIES IN TURBULENT STREAMS

A. M. Azizov UDC 536.244:532.417.4

The effect of the variability of the velocity and the coefficients of viscosity and thermal conductivity of a gas on the thermal conditions of bodies in turbulent streams under conditions when the temperature and velocity of the stream represent steady and steadily correlated random processes is examined in the article. Equations are introduced establishing the relationship between the mathematical expectations of the local temperatures of the body and the temperature of the medium. Two-sided estimates are obtained for the dispersions of the local temperatures of the body.

The results presented are important in the study of the thermal conditions of bodies under the conditions of high-intensity temperature pulsations.

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Original article submitted November 13, 1974.

APPROXIMATE CALCULATION OF THE TEMPERATURE DISTRIBUTION IN A CIRCULAR PERFORATED FIN

V. A. Kirpikov and I. I. Leifman UDC 536.242;536.12

The following is the form of the exact solution for the one-dimensional stationary temperature distribution in a solid circular rib for α = constant:

$$\frac{\vartheta}{\vartheta_0}=\frac{I_0\left(\frac{r}{l}\sqrt{\mathrm{Bi}}\right)K_1\left(\frac{r_2}{l}\sqrt{\mathrm{Bi}}\right)+I_1\left(\frac{r_2}{l}\sqrt{\mathrm{Bi}}\right)K_0\left(\frac{r}{l}\sqrt{\mathrm{Bi}}\right)}{I_0\left(\frac{r_1}{l}\sqrt{\mathrm{Bi}}\right)K_1\left(\frac{r_2}{l}\sqrt{\mathrm{Bi}}\right)+I_1\left(\frac{r_2}{l}\sqrt{\mathrm{Bi}}\right)K_0\left(\frac{r_1}{l}\sqrt{\mathrm{Bi}}\right)}, \tag{1}$$

where

$$\mathrm{Bi}=\frac{2\alpha l^2}{\lambda\delta}.$$

We see from (1) that the temperature distribution is dependent on the curvature only via parameters of the type r_i/l; if r_1 increases without limit (while the other parameters remain unchanged), the circular rib degenerates into a straight one, and (1) gives the standard solution for a straight fin by virtue of the asymptotic behavior of the Bessel functions. However, on passing to the limit in this way, Bi remains unchanged and represents the relation between the thermal conductances representing the heat transport by convection and conduction.

It has been shown [1] that the steady-state temperature distribution in a straight perforated fin may be considered approximately as one-dimensional and calculated from the corresponding relationship for a solid fin, provided that Bi is defined by

$$\mathrm{Bi}=\frac{2\alpha l^2}{\lambda\delta}p, \tag{2}$$

where

$$p=\frac{b}{c}\left(1-\frac{\pi a^2}{4bc}+\frac{\alpha_1\pi a\delta}{\alpha 2bc}\right)\left(\frac{2b}{\sqrt{b^2-a^2}}\operatorname{arctg}\sqrt{\frac{b+a}{b-a}}-\frac{\pi}{2}+\frac{c-a}{b}\right).$$

The holes alter the relation between the thermal conductances on account of the change in surface area, and also from the changes in heat-transfer rate and in the cross-sectional areas. All of these effects are incorporated by the perforation parameter p, so one can assume that one can correct for the perforation in a circular fin for r_1/l large by calculating Bi in the form of (2) as for a straight fin, and therefore (1) can be used. Of course, this assumption requires experimental check for $r_1/l \approx 1$.

The measurements were made on an electrolytic model, which reproduced the geometry of a circular perforated fin with $r_1 = l = 200$ mm, $b = c = 30$ mm, and $a = 10$ mm on a 10-fold and larger scale. The temperature distribution had approximate central symmetry (to 2%). There was satisfactory agreement between the observed and calculated temperature distributions (potential distributions) subject to $\alpha = \alpha_1$ ($p = 3.18$), and also for α unchanged and $\alpha_1 = 0$ ($p = 1.03$).

Then (1) and (2) can be used to calculate the temperature distribution in a circular perforated fin with an accuracy sufficient for engineering purposes. In that case, the heat flux from the surface of the circular fin (in the absence of a flux from the end surface) and the efficiency are defined, respectively, by

$$Q = -\lambda 2\pi r_1 \delta \left(\frac{d\vartheta}{dr}\right)_{r=r_1} = 2\pi\,(r_2^2 - r_1^2)\left(1 - \frac{\pi a^2}{4bc} + \frac{\alpha_1 \pi a \delta}{\alpha 2bc}\right)\alpha \vartheta_0 E \tag{3}$$

and

$$E = -\left\{ I_1\left(\frac{r_1}{l}\sqrt{\mathrm{Bi}}\right) K_1\left(\frac{r_2}{l}\sqrt{\mathrm{Bi}}\right) - I_1\left(\frac{r_2}{l}\sqrt{\mathrm{Bi}}\right) K_1\left(\frac{r_1}{l}\sqrt{\mathrm{Bi}}\right) \times \right.$$
$$\left. \times \left[\frac{b}{c}\left(\frac{2b}{\sqrt{b^2-a^2}}\,\mathrm{arctg}\sqrt{\frac{b+a}{b-a}} - \frac{\pi}{2} + \frac{c-a}{b}\right)\right]\right\} \times$$
$$\times \left\{ I_0\left(\frac{r_1}{l}\sqrt{\mathrm{Bi}}\right) K_1\left(\frac{r_2}{l}\sqrt{\mathrm{Bi}}\right) + I_1\left(\frac{r_2}{l}\sqrt{\mathrm{Bi}}\right) K_0\left(\frac{r_1}{l}\sqrt{\mathrm{Bi}}\right)\left[\left(\frac{r_2 + r_1}{2r_1}\sqrt{\mathrm{Bi}}\right)\right]\right\}^{-1}. \tag{4}$$

LITERATURE CITED

1. V. A. Kirpikov and I. I. Leifman, "Temperature calculation for a perforated fin," Inzh.-Fiz. Zh., 23, No. 2, 316 (1972).

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Moscow Chemical Plant Institute.
Original article submitted November 21, 1973.

EFFECTS OF HEAT-TRANSFER-FACTOR FLUCTUATIONS IN THE STATE OF THERMAL STRESS IN A CYCLICALLY HEATED SOLID

N. M. Belyaev and I. N. Manusov

UDC 536.21:539.43

The state of thermal stress is considered for bodies of simple geometry in the quasistationary state of cyclic heating, which includes fluctuations in the heat-transfer factor α.

An approximate solution to the thermal-conduction problem is derived by small-parameter methods from the classical scheme. The thermal stresses are derived from the quasistatic theory of thermoelasticity. The method has been applied to the heating of a plate subject to harmonic synchronous variations in the external temperature and α. Numerical calculations show that the third approximation is of an accuracy sufficient for practical purposes even when the small parameter $k = 1$ ($k = \mathrm{Bi}_1/\mathrm{Bi}_0$, where Bi_1 is the pulsating component of the Biot criterion, and Bi_0 is the stationary component of that criterion).

The relationships show a marked effect of the fluctuations in α on the temperature and stress distributions in cyclic heating: in the quasistationary stage, there are complex oscillations in the temperature around the steady-state value, which exceeds the mean temperature of the heating medium. The amplitudes of the temperature fluctuations and of the thermal stresses deviate from the corresponding values for α = const to an extent dependent upon k, the discrepancies being as much as 50% for k = 1.

The relationships are reasonably simple and can be used in practical engineering calculations.

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Arsenichev Industrial Institute, Dneproderzhinsk.
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THERMAL CONDUCTION IN WELDING

V. F. Lyashenko, T. I. Nikolaeva,
I. F. Istratov, and P. T. Checha

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The thermal aspects of contact welding in plastic tubes are considered, in which the temperature distribution has to be derived for an unbounded hollow cylinder having a constant initial temperature, with the outer surface insulated and the inner maintained at a constant temperature (by a flowing liquid); or else the internal surface is insulated and the outer surface is maintained at a constant temperature (straight end of tube).

The solution given in Lykov's monograph "Theory of Thermal Conduction" [Vysshaya Shkola, Moscow (1967)] is in dimensionless form; this has been used for the types of polyethylene tube commonly welded in practice, and a computer program has been written to derive nomograms to give the following relationships important in welding: the temperature as a function of time at given points (thermal cycle), the temperature distribution in the wall thickness at given instants (isochrons), and the variation in the distance of an isothermal surface from the welding instrument as a function of time, in particular, the melting depths in the components.

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EQUATION FOR THE TEMPERATURE DISTRIBUTION IN MILL ROLLS IN THE PRESENCE OF AN AXIAL TEMPERATURE GRADIENT

V. I. Pogreb and L. I. Borovik

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A derivation is given for the equation defining the temperature distribution in the rolls of a rolling mill in terms of the current theory of thermoelasticity; Green's function methods are employed. Initially, published evidence is used to construct the two-dimensional axially symmetrical temperature Green's function for a cylinder of finite length having insulated ends and boundary conditions of the third kind on the cylindrical surface. Then the equation of thermoelasticity is solved to derive the thermoelastic potential for the displacements, and the Love function is introduced, after which the components of the stresses corresponding to such functions are calculated. The constants of integration are derived from the boundary conditions at the cylindrical surface. The boundary conditions at the ends for the tangential stresses are satisfied, but the normal stresses are found to be nonzero. In order to meet these latter boundary conditions, a third solution is superimposed on the other two. Also, the equation is derived for the temperature distribution in a roll for a single instantaneous heat source, and then the superposition method is used to derive the equations for the temperature distributions in the case where the heat fluxes are supplied to the surface by periodic pulses of trapezoidal and rectangular shapes.

Examples are given of steady-state and transient temperature distributions as calculated by computer, and methods are given for estimating the time needed to reach the steady state, which indicate that the temperature distributions constructed in this way are more uneven than those derived by grid and parabolic-approximation methods.

LITERATURE CITED

L. B. M. Budak, A. A. Samarskii, and A. N. Tikhonov, Collected Problems in Mathematical Physics [in Russian], Moscow (1956).
2. H. S. Carslaw and J. C. Jaeger, Conduction of Heat in Solids, 2nd ed., Oxford University Press (1969).
3. A. V. Lykov, Theory of Thermal Conduction [in Russian], Vysshaya Shkola, Moscow (1967).
4. W. Nowacki, Thermoelasticity, Addison-Wesley (1963).
5. V. K. Belosevich and N. P. Netesov, Advances in Cold Rolling [in Russian], Metallurgiya, Moscow (1971).

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SOLUTION OF THE INVERSE HEAT-CONDUCTION PROBLEM FOR A TWO-LAYER PLATE

M. P. Kuz'min and O. L. Chistyakov

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We discuss a method for solving the inverse heat-conduction problem by which the variation of the heat-transfer coefficient between a stream of gas and the surface of a plate can be determined. The following data are required to solve the problem: the time dependence of the temperature of the opposite side of the two-layer plate, the values of the thermophysical characteristics of the plate materials, the dimensions of the layers of the plate, and the time dependence of the temperature of the stream of gas.

The method of solution is based on an electrical analog which replaces the thermal problem by the problem of finding the electrical behavior of a circuit containing resistors and capacitors. Analytic relations are obtained which describe the time dependence of the output signal in terms of the circuit parameters and the magnitude and form of the input signal. By using the solution in reverse order, i.e., by determining the input signal for a given output signal, the required variation of the heat-transfer coefficient can be found.

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