Journal of Engineering Physics and Thermophysics, Vol. 78, No. 2, 2005

INFLUENCE OF MOISTURE EVAPORATION FROM A HEATED SURFACE ON THE THERMAL REGIME OF A CAPILLARY-POROUS BODY IN THE INITIAL PERIOD OF DRYING

S. N. Osipov,[a] E. V. Korobko,[b] and V. A. Bilyk[b]

UDC 536.12:621.6

The results of experimental determination of a change in time of the intensity of moisture evaporation from the surface of a ceramic mass for soft-mud moulding in the initial period and in a portion of the first period of radiant drying are presented. Comparison between the theoretical solution obtained for the Fourier equation with the corresponding boundary conditions and experimental results has been made, which showed an agreement sufficient for practical purposes. Nomograms convenient for practical applications are presented.

Extensive investigations of the processes of heat and mass transfer in drying capillary-porous bodies, especially those undertaken in the second half of the last century by A. V. Luikov and his disciples P. D. Lebedev, O. Krisher, and other scientists, made it possible to give an answer to many questions. However, the available scientific-technical literature still has an insufficient quantity of results of investigations that deal with the initial period of drying characterized by a highly nonstationary character of all processes.

The initial period of drying, despite the short duration of this period (<10% of the total duration), lays the foundations for the quality of the product, which in a market economy is especially important in competing for the commodity market. Moreover, in production of millions of pieces of ceramic bricks each percent of spoilage costs dearly (several tens of thousands of dollars) and requires substantial consumption of raw material and energy. Therefore, theoretical and experimental investigation of the initial period of drying, when the processes of cracking formation come into play, is of great practical interest.

In drying structural clay products of soft-mud moulding, their quality depends in many respects on deformations and formation of surface cracks in the initial period, when $\mathrm{Fo_m} \le 0.2$–0.5. In view of the substantial nonstationarity of the temperature fields, this period of drying is often called the period of warm-up.

In the initial period of drying, as the surface of the ceramic mass is warmed up, an increase is accordingly observed in the intensity of moisture evaporation, which depends on the difference between the partial vapor pressures near the surface and in the surrounding medium, as follows from the Dalton law. However, under nonstationary conditions the coefficient of moisture exchange changes in time [1].

The investigations of air-drying of brick in air dryers carried out by É. Kh. Odel'skii [2] refuted the ideas advanced by T. Sherwood and W. Lewis [3], and also those of K. Terzaghi in his work [4], which was cited by A. V. Luikov in [1], that in the initial period of drying of a moist body its surface is completely wetted, and the process of drying can be likened to water evaporation from a free surface. An explanation of this difference in viewpoints can be found in [5], where it is shown that although the mechanisms underlying evaporation from a capillary-porous body and from the free surface of a liquid practically do not differ, the area of the evaporation surface can be much smaller than the total surface and approach the area of the cross section of the pores through which moisture enters into the zone of evaporation. Here, the mean temperature of the heated surface can be somewhat higher than the wet bulb temperature (t_w) because of the scheme of moisture evaporation, where a body is represented as a cellular structure.

[a]Belarusian National Technical University, 65 F. Skorina Ave., Minsk, 220072, Belarus; [b]A. V. Luikov Heat and Mass Transfer Institute, National Academy of Sciences of Belarus, 15 P. Brovka Str., Minsk, 220072, Belarus; email: snowsoft@tut.by. Translated from Inzhenerno-Fizicheskii Zhurnal, Vol. 78, No. 2, pp. 76–82, March–April, 2005. Original article submitted May 11, 2004.

Starting Premises. It is known that the pressure of a vapor (saturated) near the evaporation surface is increased with temperature [6]. However, an increase in the temperature of the evaporation surface because of its cooling due to this evaporation is quite a different process than heating of a dry surface. The investigations carried out by A. F. Chizhskii [7] and our experiments show that as a result of evaporative cooling of the heated surface of a ceramic mass at a constant flux of the energy absorbed the intensity of drying at the beginning of the process is increased following a dependences that in the first approximation can be approximated by the equation

$$j_\tau = j_{01} \left[1 - \exp\left(-\zeta\tau\right)\right] . \tag{1}$$

Then the expenditure of heat on moisture evaporation from 1 cm^2 of the heated surface per unit time (the heat flux consumed) is

$$S_{\text{em}} = j_\tau r = S_0 \left[1 - \exp\left(-\zeta\tau\right)\right] . \tag{2}$$

The value of the heat flux spent to heat a plane sample is defined as

$$S_\tau = S_0 \exp\left(-\zeta\tau\right) . \tag{3}$$

It should be noted that when the temperature of the heated surface is increased linearly in time, the vapor pressure near the surface and, consequently, the intensity of evaporation increase following a complex curve that corresponds to the empirical formula from [8] that was used by A. V. Luikov in [1]. However, in the initial period of drying of capillary-porous bodies the temperature of the heated surface is increased nonlinearly, and the temperature gradient decreases rapidly, striving to a level close to the zero value and typical of the first period of drying. Any curves depicting drying of ceramic materials begin from the zero value j_τ and in the initial period and in the first part of the first period they approximately exponentially attain the value j_{01} or close to it.

Earlier [9], to calculate the thermal regime of a plane sample in the initial period of drying, a solution [10] has been used in which a change in the temperature of the heated surface was assigned as a boundary condition according to the experimental dependence

$$t\,(0, \tau) = t_0 + (t_{\text{f}} - t_0) \left[1 - \exp\left(-\beta\tau\right)\right] . \tag{4}$$

However, this variant of calculation of the thermal regime of a plane sample with one heated surface from which evaporation of moisture occurs requires experimental verification of the behavior of the temperature on this surface, i.e., it actually excludes the possibility of preliminary calculation of a thermal regime on the basis of the supplied heat flux S_0, which prevents prediction of dehydration of the outer layers of the ceramic mass by moisture evaporation and its thermogradient transfer. Therefore, the adopted statement of the problem meets the essential requirements imposed on development of practical measures for raising the quality of drying articles of structural ceramics of soft-mud moulding.

Statement of Problem. Analytically the problem can be represented by the heat-conduction equation

$$a \frac{\partial^2 t}{\partial x^2} = \frac{\partial t}{\partial \tau} \tag{5}$$

with initial and boundary conditions

$$t\,(x, 0) = t_0 , \quad -\lambda \left.\frac{\partial t}{\partial x}\right|_{x=h} = S_0 \exp\left(-\zeta\tau\right) , \quad \left.\frac{\partial t}{\partial x}\right|_{x=0} = 0 . \tag{6}$$

Although in the scientific-technical literature [10, 12] many variants of solving the Fourier equations with different boundary-value conditions are cited, the present authors have failed to find a complete analytical solution of the problem in statements (5) and (6). In [11], general methodological instructions concerning this problem are presented and a solution for the current temperature is given.

To solve the problem, the Fourier integral cosine-transformation is given in the form

$$t_c\,(n, \tau) = \int_0^h t\,(x, \tau) \cos \frac{n\pi x}{h}\, dx \quad \text{for} \quad n = 1, 2, \ldots , \tag{7}$$

where $t_c(n, \tau)$ is the transform of the function $t(x, \tau)$ that satisfies the Dirichlet condition.

As a result of a series of transformations and substitutions, the following linear inhomogeneous equation is obtained:

$$y' + by = g\,(\tau)\,, \tag{8}$$

where

$$y = y\,(\tau) = t_c\,(n, \tau)\,; \quad y' = \frac{\partial y\,(\tau)}{\partial \tau} = \frac{\partial}{\partial \tau}\, t_c\,(n, \tau)\,;$$
$$g\,(\tau) = a\,(-1)^n\, \frac{q\,(\tau)}{\lambda} = -\, a\,(-1)^n\, \frac{S_0}{\lambda} \exp\,(-\zeta\tau)\,; \quad b = a \left(\frac{n\pi}{h}\right)^2 . \tag{9}$$

Solution (8), after the return to the inverted transform of the function, will be written as

$$t\,(x, \tau) = t_0 - \frac{aS_0}{h\lambda\zeta}\,(\exp\,(-\zeta\tau) - 1) - \frac{2aS_0}{h\lambda} \sum_{n=1}^{\infty} \frac{(-1)^n}{a\left(\frac{n\pi}{h}\right)^2 - \zeta} \left(\exp\left(-a\left(\frac{n\pi}{h}\right)^2 \tau\right) - \exp\,(-\zeta\tau)\right) \cos \frac{n\pi x}{h}\,. \tag{10}$$

The expansion of the sum (10) for the temperature will be performed by the equation [13]

$$\sum_{k=1}^{\infty} (-1)^k\, \frac{\cos\,(kx)}{k^2 - \alpha^2} = \frac{1}{2\alpha^2} - \frac{\pi}{2}\, \frac{\cos\,(\alpha\,(2z\pi - x))}{\alpha \sin\,(\alpha\pi)}\,, \tag{11}$$

and for the temperature gradient by the equation

$$\sum_{k=1}^{\infty} (-1)^k\, \frac{k \sin\,(kx)}{k^2 - \alpha^2} = \frac{\pi}{2}\, \frac{\sin\,(\alpha\,(2z\pi - x))}{\sin\,(\alpha\pi)}, \tag{12}$$

where $(2z - 1)\pi \le x \le (2z + 1)\pi$; α is not equal to an integer.

Thus, using transformation (11), we find

$$t\,(x, \tau) = t_0 + \frac{aS_0}{h\lambda\zeta} - \frac{S_0}{\lambda} \exp\,(-\zeta\tau)\, \frac{\cos\left(\sqrt{\frac{\zeta}{a}}\,(h - x)\right)}{\sqrt{\frac{\zeta}{a}} \sin \sqrt{\frac{\zeta}{a}}\, h} - \frac{2aS_0}{h\lambda} \sum_{n=1}^{\infty} \frac{\exp\left(-a\left(\frac{n\pi}{h}\right)^2 \tau\right) \cos \frac{n\pi x}{h}}{a\left(\frac{n\pi}{h}\right)^2 - \zeta}\,. \tag{13}$$

Having introduced dimensionless parameters into Eq. (13) similarly to [10, problem No. 22], we obtain the following solution:

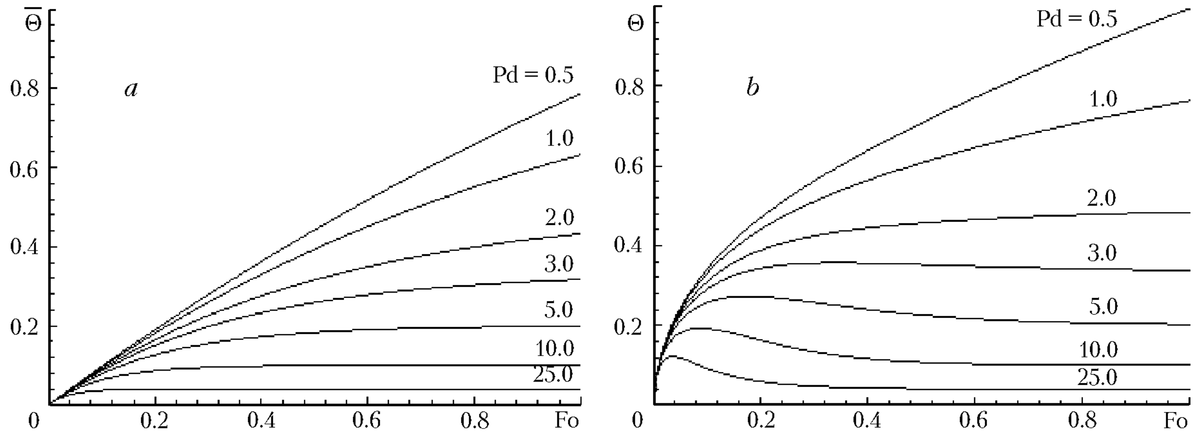

Fig. 1. Parameter of the mean temperature (a) and temperature parameter for the heated surface (b) vs. the values of Fo.

$$t\,(\mathrm{Fo}, \eta, \mathrm{Pd}) = t_0 + \frac{S_0 h}{\lambda}\frac{1}{\mathrm{Pd}} - \frac{S_0 h \cos\left(\sqrt{\mathrm{Pd}}\,(1-\eta)\right)}{\sqrt{\mathrm{Pd}}\sin\sqrt{\mathrm{Pd}}}\exp\left(-\mathrm{Fo\,Pd}\right) -$$

$$-\,2\,\frac{S_0 h}{\lambda}\sum_{n=1}^{\infty}\frac{(-1)^n \exp\left(-\mathrm{Fo}\,\mu_n^2\right)\cos\left(\mu_n (1-\eta)\right)}{\mu_n^2 - \mathrm{Pd}}\,. \tag{14}$$

Here, the mean temperature of the body and the temperature gradient are defined as

$$\bar{t} = \bar{t}\,(\mathrm{Fo}, \mathrm{Pd}) = t_0 + \frac{S_0 h}{\lambda \mathrm{Pd}}\left(1 - \exp\left(-\mathrm{Fo\,Pd}\right)\right), \tag{15}$$

$$\frac{\partial t\,(\mathrm{Fo}, \eta, \mathrm{Pd})}{\partial x} = -\frac{S_0}{\lambda}\frac{\sin\left(\sqrt{\mathrm{Pd}}\,(1-\eta)\right)}{\sin\sqrt{\mathrm{Pd}}}\exp\left(-\mathrm{Fo\,Pd}\right) -$$

$$-\,2\,\frac{S_0}{\lambda}\sum_{n=1}^{\infty}\frac{(-1)^n \exp\left(-\mathrm{Fo}\,\mu_n^2\right)\mu_n \sin\left(\mu_n (1-\eta)\right)}{\mu_n^2 - \mathrm{Pd}}\,. \tag{16}$$

Numerical Simulation. To construct nomograms similar to those presented in [10], the foregoing resulting equations need some transformation. As the basic transformations we must note the change of variable $\eta = 1 - \eta^*$ (to simplify the representation of the equations, η^* is further given as η) that was performed in Eqs. (14)–(16). As an example, we give an equation for the mean temperature parameter, for the rapid determination of which a nomogram is constructed in Fig. 1a:

$$\bar{\Theta} = \bar{\Theta}\,(\mathrm{Fo}, \mathrm{Pd}) = \frac{\bar{t}\,(\mathrm{Fo}, \mathrm{Pd}) - t_0}{\dfrac{S_0 h}{\lambda}} = \frac{1}{\mathrm{Pd}}\left(1 - \exp\left(-\mathrm{Fo\,Pd}\right)\right). \tag{17}$$

For the mean temperature of the body we have the dependence

$$\bar{t} = t_0 + \bar{\Theta}\,\frac{S_0 h}{\lambda}\,. \tag{18}$$

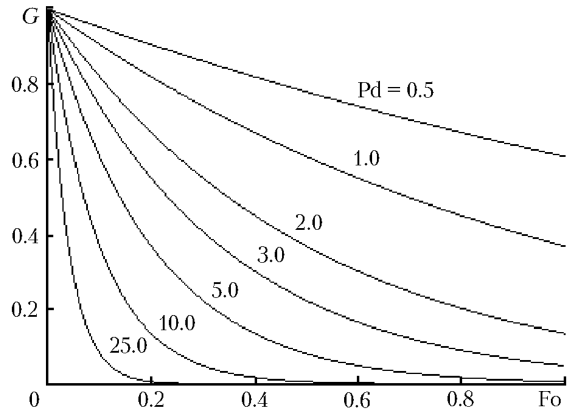

Fig. 2. Parameter of the gradient G at $\eta = 0$ vs. the values of Fo.

In drying ceramic articles of soft-mud moulding, of great value for estimating the possibility of appearance of surface cracks is the dynamics of the thermophysical parameters of the heated surface, among which, in the first place, are changes in the temperature and in its gradient.

The temperature of the heated surface of the plate ($\eta = 0$) can be found from the equation

$$t_s = t_0 + \Theta \frac{S_0 h}{\lambda}, \tag{19}$$

where

$$\Theta = \frac{1}{\text{Pd}} - \frac{\cos(\sqrt{\text{Pd}}\,(1-\eta))}{\sqrt{\text{Pd}}\sin\sqrt{\text{Pd}}} \exp(-\text{Fo Pd}) - 2\sum_{n=1}^{\infty} \frac{(-1)^n \exp(-\text{Fo}\,\mu_n^2)\cos(\mu_n(1-\eta))}{\mu_n^2 - \text{Pd}} \tag{20}$$

is determined from the nomogram shown in Fig. 1b.

The gradient of the heated surface of the plate ($\eta = 0$) is calculated as

$$\left.\frac{\partial t}{\partial x}\right|_{x=0} = -G\frac{S_0}{\lambda}. \tag{21}$$

Here

$$G = \frac{\sin(\sqrt{\text{Pd}}\,(1-\eta))}{\sin\sqrt{\text{Pd}}} \exp(-\text{Fo Pd}) + 2\sum_{n=1}^{\infty} \frac{(-1)^n \exp(-\text{Fo}\,\mu_n^2)\,\mu_n \sin(\mu_n(1-\eta))}{\mu_n^2 - \text{Pd}} \tag{22}$$

can be found from the nomogram given in Fig. 2.

To verify the correctness of the solution obtained, we used the boundary conditions of the problem from [10], under which the parameter of the mean temperature $\overline{\Theta}$ = Fo. The solution (which corresponds to Pd = 0) for the parameter $\overline{\Theta}$ at $\zeta = 0$ has the form

$$\overline{\Theta} = \frac{1}{\text{Pd}}(1 - \exp(-\text{Fo Pd})) = \text{Fo} - \sum_{n=1}^{\infty} \frac{(-1)^n \text{Fo}^n \text{Pd}^{n-1}}{n!} = \text{Fo} \tag{23}$$

by virtue of the fact that the series $\sum_{n=2}^{\infty} \frac{(-1)^n \text{Fo}^n \text{Pd}^{n-1}}{n!}$ converges in the D'Alembert number.

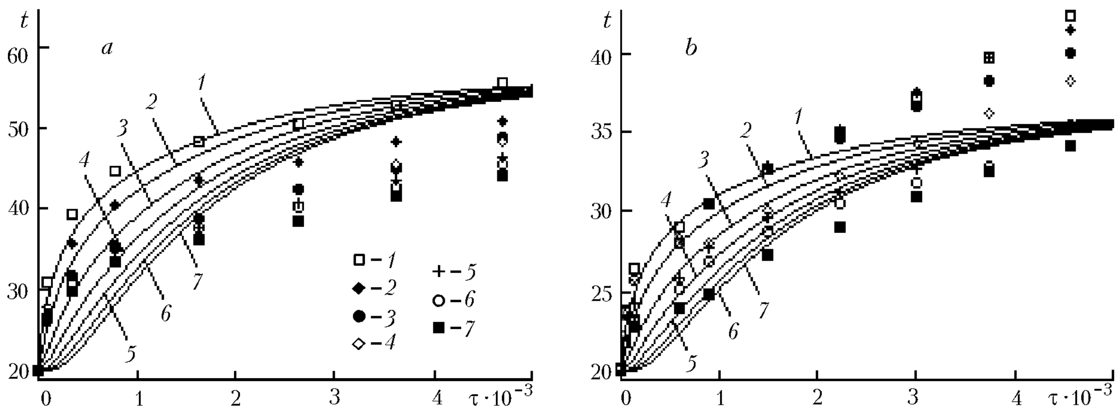

Fig. 3. Comparison of predicted and experimental values of temperature in the case of radiative (a) and combined (b) drying of plane samples from Nizhnekotel'sk clay at different distances from the heated surface: 1) 1.5; 2) 5.0; 3) 10.0; 4) 15.0; 5) 20.0; 6) 25.0; 7) 30.0 mm. h = 35 mm, t_{em} = 300°C, l_{em} = 17.5 cm, V = 2 m/sec, t, °C; τ, sec.

After transformation of the expression for the parameter of the temperature gradient, we obtain a relation similar to that given in [10]:

$$G = 1 - \eta - 2 \sum_{n=1}^{\infty} \frac{(-1)^{n+1}}{\mu^n} \exp(-\mathrm{Fo}\,\mu_n^2) \sin(\mu_n (1-\eta)) . \tag{24}$$

Similarly, the temperature parameter Θ at Pd = 0 corresponds to that obtained by A. V. Luikov [11].

The foregoing deterministic solutions of the problem set determine only the averaged parameters of the thermophysical state of heated plates and estimate the influence of the incorporated factors on the development of the process of heating. For actual quantitative description of temperature fields it is necessary to have a more general determination of the values of ζ with allowance for the curvilinearity of dependence (1), which can be based on experiments.

Experiment. Computer processing of the results of experiments carried out with plane samples moulded at the Minsk Plant of Building Materials shows that at $S_0 \approx 0.7$ W/cm^2 and h = 0.6 cm the intensity of drying $j_{01} = 2.97 \cdot 10^{-4}$ g/(cm^2·sec) and $\zeta = 0.0174$ sec^{-1} with possible standard deviations $\Delta j_{01} = 8.85 \cdot 10^{-6}$ g/(cm^2·sec) and $\Delta\zeta = 0.0001$ sec^{-1}. For plane samples made from the same moulding material at h = 2.0 cm, the intensity of drying $j_{01} = 3.69 \cdot 10^{-4}$ g/(cm^2·sec) and $\zeta = 0.00952$ sec^{-1} at $\Delta j_{01} = 1.96 \cdot 10^{-5}$ g/(cm^2·sec) and $\Delta\zeta = 0.00078$ sec^{-1}. In the experiments made by A. F. Chizhskii [7, Fig. 33], $j_{01} = 2.15 \cdot 10^{-4}$ g/(cm^2·sec) and $\zeta = 0.00975$ sec^{-1} at $\Delta j_{01} = 2.65 \cdot 10^{-6}$ g/(cm^2·sec) and $\Delta\zeta = 0.00027$ sec^{-1}. Thus, all the values considered above are approximately an order of magnitude smaller than the basic values. It should be noted that the correlation factors for the above-given initial experimental data are $r_1 = 0.83$, $r_2 = 0.86$, and $r_3 = 0.95$, respectively. Such high values of the correlation factors point to the correct choice of the approximating dependence in the form of an exponent.

To compare the calculated temperature fields with the experimental ones, we used P. D. Lebedev's data [14, Fig. 3–15] on plane samples from Novokotel'sk clay of thickness h = 3.5 cm at t_{em} = 300°C and l_{em} = 17.5 cm. The initial moisture content of the clay was $U_0 \approx$ 21–22% and $S_0 \approx 0.08$ W/cm^2.

During radiative drying (Fig. 3a) without a forced air inflow up to $\tau \approx 5000$ sec, when the intensity of evaporation was preserved almost constant (the first period of drying), the coincidence of the predicted temperatures with the experimental ones near the plate surface (curve 1) for $S_0 \approx 0.09$ W/cm^2 and $\zeta = 0.6 \cdot 10^{-3}$ was very satisfactory, i.e., for the first 80 min after the beginning of irradiation (Fo ≈ 2.0, $\mathrm{Fo_m} \approx 0.2$). Precisely during this time interval after the beginning of drying, formation of cracks on the surface is most probable. The agreement between the predicted and experimental values for $\tau \le 2000$ sec is also sufficiently satisfactory ($K_{rel.v} \approx 0.05$) to a depth of the clay plate of about 15 mm from the heated surface (Fig. 3a, curves 2–4), whereas for curves 2 and 3 this coincidence is observed over an interval of up to 5000 sec. The discrepancy between the predicted and experimental temperatures is observed for deep layers ($x > 15$ mm) of the plate (curves 5–7). Here, the coefficients $K_{rel.v}$ attain 0.15. Moreover, if in the very beginning of drying ($\tau < 1000$ sec) the predicted values are under the experimental ones, then for $\tau > 1300$ sec the situation is reversed.

Such a discrepancy in the signs between the calculated and experimental values can be explained by the influence of the processes of thermogradient transfer of a heated moisture from the surface into the depth of the plate. When $\tau > 1200$ sec, this process is terminated, and gradually the flow of moisture is directed from the depth to the heated surface, which leads to a great temperature difference between the layers of clay. Moreover, it seems that there was a certain heat sink during the experiment. However, even under such conditions the total discrepancy between the predicted and experimental values is characterized by $K_{rel.v} \approx 0.1$, which should be regarded as a quite satisfactory result.

In the case of combined drying under similar conditions of irradiation of a clay plate and $V = 2$ m/sec (Fig. 3b), a very good coincidence ($K_{rel.v} \approx 0.02$) is observed for the surface layer (curve 1) up to $\tau = 3000$ sec. But in this case $S_0 \approx 0.06$ W/cm^2 and $\zeta = 0.5 \cdot 10^{-3}$, which is less in comparison with purely radiative drying. The latter is also confirmed by the decrease in the temperature of the surface layer from 36 to 26^{o}C in 200 sec of drying. This phenomenon seems to be associated with a more intense evaporative cooling when the zone of evaporation is blown by a forced air flow in comparison with natural convection. Here (Fig. 3b, curves 3–7) there is no excess of the experimental values for the temperature over the predicted ones at the beginning of drying ($\tau < 1200$ sec), but when $\tau > 1200$ sec, they are lower than the predicted ones, just as in the previous case. On the whole, the scatter of the values is characterized by $K_{rel.v} \approx 0.06$, which is somewhat less than in the case of purely radiative drying.

Discussion of Results. Comparison of the predicted temperatures with the experimental ones for the surface layers of the clay plates investigated has shown a satisfactory agreement ($K_{rel.v} \approx 0.03$); even on the whole over the entire thickness of the plate the coincidence has turned out quite satisfactory ($K_{rel.v} \approx 0.05$–0.10) for $\tau \leq 5000$ sec, which encompasses the whole initial and partially the first periods of drying ($Fo_m \approx 0.25$–0.30). However, such a heat flux ($S_0 = 0.08$ W/cm^2) appeared excessive for the Nizhnekotel'sk clay, and cracks were formed in the process of drying. We think that for defectless drying the absorbed heat flux should be reduced.

The decrease in the predicted heat flux S_0 (from 0.11 to 0.06 W/cm^2) as against that actually needed [14] for moisture evaporation in an amount of 1.6 kg/(m^2·h) in combined drying (Fig. 3b) needs special discussion. As indicated in [14], "an increase in the air velocity, for example, for $\tau = 560$ min, causes cooling of the surface: when $V \approx 0$ m/sec, $t_s = 98^o$C, when $V \approx 0.5$ m/sec, $t_s = 92^o$C, $V \approx 1$ m/sec, $t_s = 87^o$C, and when $V \approx 2$ m/sec, $t_s = 75^o$C." A similar phenomenon is also observed at the beginning of drying. Thus, 400 sec after the beginning of the experiment, when $V = 0$ m/sec, $t_s \approx 40^o$C, whereas at $V = 2$ m/sec, $t_s \approx 28^o$C (Fig. 3). However, the intensity of the combined drying during emergence into a steady-state regime is approximately 1.5 times higher in comparison with the intensity of radiative drying. Here, the characteristic features of the statement of problem (6) come into play, when the fraction of the heat flux spent on heating the mass for moulding is rigidly exponentially related to the heat spent on evaporation.

In the case of combined drying, the temperature effect of evaporation can be the same as in convective drying, since the influence of the flux velocity on the entrainment of the evaporating moisture has a strong effect, as a result of which the coefficient of mass transfer is increased. In [14], the temperature of the straight-through flow of air in combined drying is not indicated, but it may well be that it substantially differs from that of the laboratory medium ($\approx 20^o$C), which also follows from analysis of the construction of the experimental setup. Thus, in convective drying of sand [14] the air temperature was 70^{o}C; therefore a considerable portion of the heat (up to 50%) needed for moisture evaporation came with air and a smaller portion of the radiative heat was used for heating the mass for moulding.

CONCLUSIONS

1. The statement and solution of the problem with account for the exponentially increasing intensity of evaporation makes it possible to attain a satisfactory (for surface layers) or quite satisfactory (for the whole plate) agreement between the predicted and experimental values of temperature.

2. Probably, the distortions are brought into the computational model by the processes of thermogradient transfer of moisture in the initial period of drying, which actually can last for several hours.

3. The solutions obtained make it possible to calculate the temperature fields and their gradients (with the practically needed precision) in a plane capillary-porous article in the initial period of radiative drying.

NOTATION

a, coefficient of thermal diffusivity, m^2/sec; b, numerical constant; Fo $\equiv a\tau/h^2$, Fourier number; Fo_m, mass-transfer Fourier number; G, parameter of temperature gradient; h, thickness of a plane plate, m; j_{01}, intensity of drying in the first period, kg/($m^2 \cdot$sec); j_τ, intensity of drying at the beginning of the process, kg/($m^2 \cdot$sec); $K_{rel.v}$, coefficient of relative variation; l_{em}, distance from the emitter to the sample surface, m; Pd = $\zeta h^2/a$, Predvoditelev number; r, evaporation heat with account for additional heating of moisture and phase transition, J/kg; r_1, r_2, r_3, correlation factors; S_0, value of the heat flux absorbed by the heated surface, W/m^2; S_{em}, value of the consumed heat flux from the emitter, W/m^2; t, temperature of the ceramic mass at the prescribed distance from the surface, ^oC; t_0, initial temperature of the heated surface, ^oC; t_{em}, temperature of the emitting surface, ^oC; t_f, final temperature of the heated surface upon onset of a regular regime (first period of drying), ^oC; t_s, surface temperature of the ceramic mass, ^oC; $t(x, \tau)$, temperature function of two variables; $t_c(n, \tau)$, transform of the function $t(x, \tau)$ that satisfies the Dirichlet condition; U_0, initial moisture content of clay, %; V, air velocity, m/sec; x, coordinate, m; y, abbreviated designation of the transform of the function $t_c(n, \tau)$; z, natural number; α, numerical coefficient; β, coefficient, sec^{-1}; Δj_{01}, deviation of the value of the intensity of drying in the first period, kg/($m^2 \cdot$sec); $\Delta\zeta$, deviation of the value of the empirical coefficient ζ, sec^{-1}; ζ, empirical coefficient at the exponent index that characterizes the rate of increase in the intensity of drying, sec^{-1}; $\eta = x/h$, dimensionless parameter of the coordinate x; η^*, dimensionless parameter of the coordinate x used in change of the variable η; Θ, parameter of temperature; Θ, parameter of mean temperature; λ, thermal conductivity, W/(m·deg); $\mu_n = \pi n$, characteristic numbers; τ, time from the beginning of drying, sec. Subscripts: 0, initial value; 01, first period of drying; rel.v, relative variation; em, emitter; f, final value; w.b, wet bulb; s, surface; c, cosine-transformation; m, mass transfer.

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