ity in region a relative to porosity in the region b; ρ_{Aa}, volume density of desired component A in region a; $\rho_{Ac} = \varepsilon c_{AS} + (1 - \varepsilon)\rho_T$; ρ_T, density of desired solid component A; ρ_{Ba}, volume of solvent in region a; $\rho_{Ba} = c_{Bs}\varepsilon; \rho_t$, average density of two-phase system; $\rho_t = \rho_{Aa} + \rho_{Ba} = \rho_T(1 - \varepsilon) + \rho_S\varepsilon$; ρ_S, density of saturated solution; c_B, concentration of solvent; c_{Bs}, concentration of saturated solvent; n_A, flux density of component A; n_B, flux density of component B; v_r, mass average velocity of liquid.

LITERATURE CITED

1. E. L. Piret, R. A. Ebel, C. T. Kiang, and W. P. Armstrong, "Diffusion rates in extraction of porous solids. Two-phase extraction," Chem. Eng. Progr., 47, 628-636 (1951).
2. G. A. Aksel'rud, Theory of Diffusion Extraction of a Material from Porous Bodies [in Russian], Lvov Polytechnic Inst. (1959).
3. G. A. Aksel'rud and V. M. Lyanskii, Extraction in a Solid—Liquid System [in Russian], Khimiya, Leningrad (1974).
4. I. O. Protod'yakonov, N. A. Martsulevich, and A. V. Markov, Transport Phenomena in Chemical Engineering Processes [in Russian], Khimiya, Leningrad (1981).
5. L. G. Loitsyanskii, Mechanics of Liquids and Gases [in Russian], Nauka, Moscow (1970).
6. R. Bird, W. Stewart, and E. Lightfoot, Transport Phenomena, Wiley, New York (1960).
7. Ching-Lun Huang and Yen-Ping Shih, "A perturbation method for spherical and cylindrical solidification," Chem. Eng. Sci., 30, 897-906 (1975).
8. L. B. Berliner and L. D. Berliner, "Determination of the diffusion coefficient from rate of movement of dissolving surface in a smooth-walled capillary," Zh. Fiz. Khim., 47, 2357-2359 (1973).
9. A. V. Lykov, Theory of Heat Conduction [in Russian], Vysshaya Shkola, Moscow (1967).

HEAT TRANSFER IN BOILER FURNACE, TAKING ACCOUNT OF THE SCATTERING OF RADIATION

Yu. A. Zhuravlev, I. V. Spichak,
M. Ya. Protsailo, and A. G. Blokh

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A method of zonal calculation of the radiational heat transfer in scattering media is outlined. The influence of scattering of the radiation on the heat-transfer coefficient in a furnace is considered.

The presence of a large number of particles (coal, coke, ash in the combustion of coal dust; soot in the flame combustion of natural gas and oil) suspended in high-temperature flows of furnace gases creates the preconditions for radiation scattering. Therefore, it is of practical interest (especially in connection with the appearance of detailed information on the radiative characteristics of dust flows and luminous flames; see [1-3], etc.) to solve the problem of external heat transfer, within the framework of the zonal method, taking account of scattering in complex three-dimensional multizonal systems filled with an emitting—absorbing and scattering medium.

In the present work, the zonal method is used to investigate the combined heat transfer in a furnace chamber of a BKZ-320-140PT boiler. Isotropic scattering in volume zones is taken into account using the method developed earlier in [4]. In calculating the heat transfer in real aggregates, it is necessary to take account of the complexity of the scattering index in volume zones and the reflection coefficient at boundary surfaces. Generalization of the method of [4] to the case of anisotropic scattering of radiation and nondiffuse reflection — in the presence of both diffuse and nondiffuse components in the reflection of radiation from surface zones ($R - R^{\text{dif}} + R^{\text{nondif}}$), there are both isotropic and anisotropic components in the scattering at particles in the volume zones ($\beta = \beta^{\text{is}} + \beta^{\text{anis}}$) — may be accomplished using the following system of linear algebraic equations

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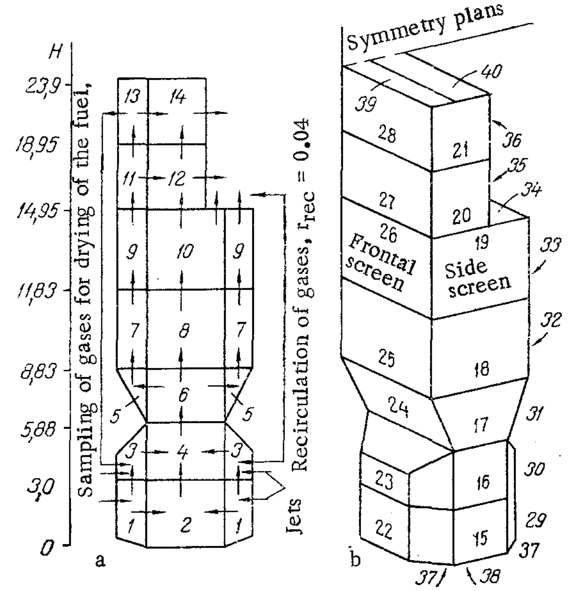

Fig. 1. Division of the furnace of a BKZ-320-140PT boiler into layers and zones: a) numbering of the volume zones and aerodynamics of the furnace gases; b) surface zones. H, m.

$$f_{ij} = \psi'_{ij} B_j + \sum_{r=1}^{m} \left(\frac{\beta^{is}}{\alpha + \beta^{is}}\right)_r \psi'_{ir} f_{rj} + \sum_{r=m+1}^{m+n} \left(\frac{R^{dif}}{A + R^{dif}}\right)_r \psi'_{ir} f_{rj}, \tag{1}$$

$$i,\ j,\ r = 1,\ 2,\ \ldots,\ m+n,$$

where

$$B_j = \begin{cases} \left(\dfrac{\alpha}{\alpha + \beta^{is}}\right)_j & \text{when } j = 1,\ 2,\ \ldots,\ m, \\ \left(\dfrac{A}{A + R^{dif}}\right)_j & \text{when } j = m+1,\ m+2,\ \ldots,\ m+n. \end{cases}$$

Here ψ'_{ij} is the generalized semiresolving angular emission coefficient, taking account of nondiffuse reflection at the boundary surfaces and anisotropic scattering in volume zones; ψ'_{ij} is determined by the method of statistical testing, under the condition that the absorptive capacity of the surface zones is taken to be $A + R^{dif}$, while the coefficients of absorption and anisotropic scattering in the volume zones are $\alpha + \beta^{is}$ and β^{anis}.

The system of equations obtained corresponds to the general case and, when $R^{nondif} = 0$ and $\beta^{anis} = 0$, degenerates to the system of equations proposed earlier [4]. In the case when $R^{dif} = 0$ and $\beta^{is} = 0$, B_j becomes equal to unity, and Eq. (1) transforms to the identity $f_{ij} = \psi'_{ij}$.

In the present work, Eq. (1) is used to analyze the influence of the Schuster number $Sc = \beta/(\alpha + \beta)$ and the proportion of diffracted radiation in the scattering of radiant energy at particles $\eta = \beta^D(\beta^{is} + \beta^D)$ on the heat-transfer coefficient in a furnace chamber.

A 40-zone model of heat transfer is used in the calculations (Fig. 1). The heat transfer is investigated for a closed pulverization system with recirculation of the exhaust gases ($r_{rec} = 0.04$) and sampling of the gases ($r_{sam} = 0.15$) from the upper part of the furnace of the furnace in the drying of coal to a moisture content of 6%. In the model, nonuniformity of the distribution over the height of the furnace is taken into account: the heat resistance of the ash deposits, resulting from the intense slag formation in the lower part of the cooling-chamber screens (with a mean contamination coefficient of 0.00344 $m^2 \cdot °K/W$ [5]) and the fixing of air (with a total fixing in the furnace of 0.05 [5]). Detailed description of the three-dimensional multizonal mathematical model of heat transfer in the furnace with liquid slag removal of the BKZ-320-140PT boiler may be found in [6, 7].

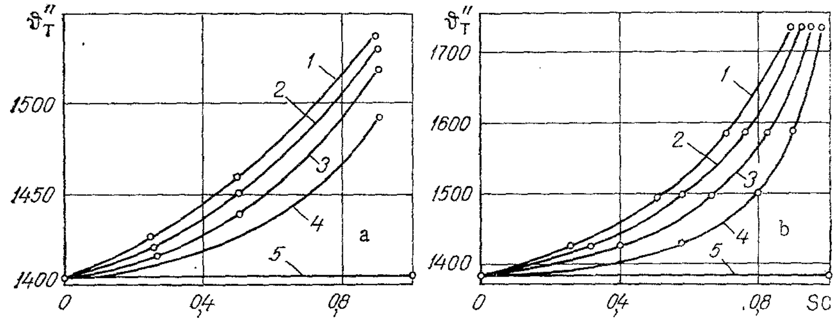

Fig. 2. Dependence of the gas temperature at the furnace outlet ϑ_T'' (°K) on the Schuster number Sc under conditions of identical distributions in the volume zones of the absorption (a) and attenuation (b) coefficients for various proportions of diffracted radiation η: 1) 0; 2) 0.25; 3) 0.5; 4) 0.75; 5) 1.0.

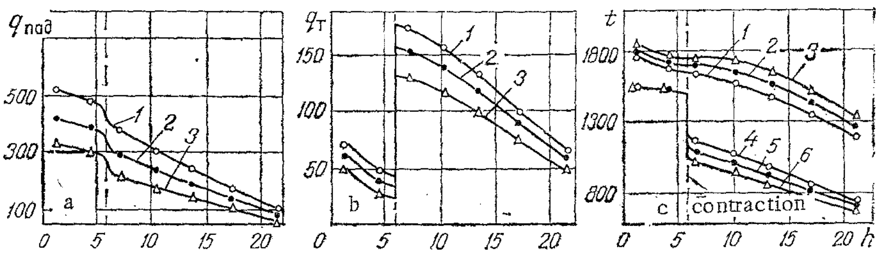

Fig. 3. Distribution of the density of the incident radiant flux q_{inc}(kW/m²) (a), the density of heat absorption by the screens q_T (kW/m²) (b), the temperature t (°K) (c) of the central layers of the furnace-gas layers (1-3) and the contamination surface at the side screen (4-6) over the height of the furnace in the case of isotropic scattering under the condition of identical distributions in the volume zones of the absorption coefficients for various values of the Schuster number Sc: 1, 4) 0; 2, 5) 0.5; 3, 6) 0.9.

The influence of the Schuster number on the heat transfer in a furnace chamber is considered for both isotropic and scattering isotropic scattering with diffracted radiation. The basic calculations are performed for Schuster parameters in the range 0 to 0.9 and a proportion of diffracted radiation of from 0 to 1. Comparison of the theoretical variants is made under the conditions of identical distribution in the volume zones: 1) absorption coefficient (α = const); 2) attenuation coefficient ($\alpha + \beta$ = const).

Note that the present work is mainly devoted to the general analysis of the influence of the radiative properties of the medium (in a broader range of their variation than is encountered in practice) on the local and integral characteristics of heat transfer.

Analysis of the results obtained for isotropic scattering and α = const shows that increase in Schuster number leads to increase in gas temperature at the furnace outlet (Fig. 2a, curve 1). On account of the screening influence of the scattering processes on the radiation transfer, the temperature field and the heat fluxes are significantly changed. It is evident from Fig. 3a that the greatest reduction in q_{inc} over the height of the furnace for the variants taking account of the scattering is observed in the combustion chamber. With increase in distance, the reduction in the incident radiant fluxes over the height of the furnace decreases in magnitude, which is due to the compensating influence of the increase in furnace-gas temperature.

Reduction in q_{inc}, in turn, leads to decrease in the heat-absorption density and surface contamination temperature on the screens of the furnace (Fig. 3b, c), especially in the lower part of the cooling chamber, where increase in Sc from 0 to 0.5 is associated with reduction in the heat-absorption density for the side screen by 19 kW/m² and in the comtamination temperature by 69°K.

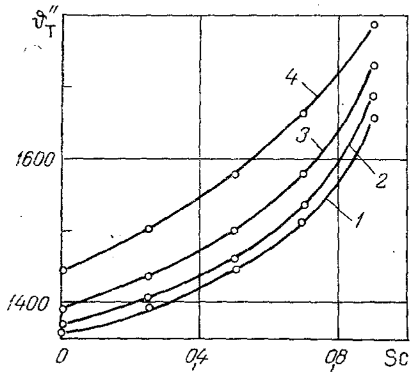

Fig. 4. Dependence of the gas temperature at ϑ_T'' (°K) on the Schuster number Sc at attenuation coefficients in the volume zones of $2.0\alpha_{bas}$ (1), 1.5 (2), 1.0 (3) and $0.5\alpha_{bas}$ (4).

The deterioration in heat transfer associated with increase in Sc leads to increase in temperature of the central layers of the furnace-gas flow, which is especially characteristic for the cooling chamber. Thus, with increase in Sc from 0 to 0.5 the temperature of the central layers of the gas flow increases by 50°K for the lower part of the cooling chamber and by 77°K for the middle part. For the combustion chamber, increase in Sc has little influence on t_G, since the reduction in heat absorption is small because of the heat insulation of the screens.

The screening influence of processes of radiation scattering also leads to increase in the temperature drop between the central and boundary layers of the furnace-gas flow. The greatest increase in temperature drop in the range Sc = 0-0.5 is observed in the middle region of the cooling chamber and is 38°K.

In the region of the outlet window, the temperature drop between the central and boundary layers of the furnace gases (temperature discrepancy) increases from 62 to 84°K when Sc increases from 0 to 0.5. Such an increase in the temperature discrepancy of the furnace gases is clearly expressed in industrial conditions in the combustion of high-ash Ekibastuzskii coal.

These data show that disregarding the isotopic scattering of radiation under the condition that the distribution of the heat-transfer coefficients in the volume zones be indentical in the given variants leads to the following changes in the heat-transfer coefficients in the furnace chamber. For Sc = 0.5, there is overestimation of q_{inc} over the furnace height by 18-22% and of the heat absorption by the screens by 11-12%, which leads to underestimation of the gas temperature at the outlet from the furnace by 57°K and of the temperature difference between the central and boundary layers of the furnace-gas flow in the region of the outlet window by 22°K. In this case, the overestimation of the surface temperature of the ash deposits in the region of intense slagging of the screens (the lower part of the cooling chamber) is 69°K.

In order to analyze the scattering processes in the case when the distributions of the attenuation coefficients for different variants are the same, it is necessary to estimate the influence of the change in absorption coefficient at Sc = const on the heat-transfer coefficients (the absorption coefficient in the volume zones of the model for the basic variant without scattering α_{bas} adopted in [7]).

Analysis of the results obtained for Sc = 0 shows that increase in the absorption coefficients in the volume zones leads to increase in the radiant fluxes incident on the screens. The greatest increase in q_{inc} over the height of the furnace occurs in the lower part of the cooling chamber and is 36 kW/m^2 when α varies in the range $(0.5\text{-}1.0)\alpha_{bas}$. Increase in q_{inc}, in turn, leads to increase in the contamination surface temperature and increase in heat-absorption density of the furnace-chamber screens. Thus, with increase in α, in the given range, t_C and q_T increase in the lower part of the cooling chamber from 1221 to 1265°K and from 161 to 173 kW/m^2, respectively.

TABLE 1. Change in Heat-Transfer Coefficients in a Furnace, Taking Account of Scattering of the Radiation

Heat-transfer coefficient	Sc=0,5; η=0		Sc=0,5; η=0,5		Basic variant (Sc = 0)	Sc=0,55; η=0,75
	α=const	α+β==const	α=const	α+β==const		α=const
$\Delta\vartheta_T''$, °K	57	112	35	67	ϑ_T''=1386°K	ϑ_T''=1409 °K
$\Delta q_{inc}/q_{inc}$, %	—22,1*	—28,0	—14,3	—16,8	q_{inc}=382 kW/m³	q_{inc}=344 kW/m³
$\Delta q_T/q_T$, %	—11,0	—17,3	—6,4	—10,4	q_T=173 kW/m²	q_T=166 kW/m³
Δt_C °K	—69	—110	—41	—66	t_C=1265 °K	$t_з$=1238 °K
$\Delta\theta$, °K	22	20	13	12	θ=62 °K	θ=70 °K
Δt_G °K	50	68	31	40,8	t_G=1749 °K	t_G=1770°K

*A minus sign denotes decrease in the coefficient with respect to the basic variant.

Increase in the absorption coefficients also leads to reduction in temperature of the gases at the outlet from the furnace (Fig. 4); the strongest reduction (from 1444 to 1386°K) is observed in the range $\alpha = (0.5\text{-}1.0)\alpha_{bas}$. Considerable increase in gas temperature in the boundary layer of the furnace chamber is noted here: In this range of P, it is 44°K for the middle region of the cooling chamber and 60°K at the top of the furnace.

Analysis of the results obtained for Sc = 0.5 shows that increase in the absorption coefficients in the volume zones, as for Sc = 0, leads to the reduction in gas temperature at the outlet from the furnace, but in the given case this reduction is more considerable. Thus, in the range $\alpha + \beta = (0.5\text{-}1.0)\alpha_{bas}$, Sc = ϑ_T'' is reduced by 58°K for Sc = 0 and by 81°K for Sc = 0.5. This is because the absorption coefficients are changed from 0.5 to $1.0\alpha_{bas}$ in the first case and from 0.25 to $0.5\alpha_{bas}$ in the second, since in the first case α is zero, and in the second it varies from 0.25 to $0.5\alpha_{bas}$.

With variation in α + β from 0.5 to $1.0\alpha_{bas}$ for Sc = 0.5, increase in the incident radiant fluxes in the lower part of the cooling chamber from 237 to 275 kW/m² is observed; this, in turn, leads to increase in the heat absorption by the screens and the contamination surface temperature. Thus, in this range of variation of α + β, there is an increase in q_T for the lower part of the cooling chamber from 127 to 143 kW/m² and in t_C from 1094 to 1155°K.

The temperature difference between the central and boundary layers of the furnace-gas flow at the top of the furnace is practically unchanged with increase in absorption coefficients for Sc = const, only increasing with increase in Sc.

Analysis of the results obtained under the condition that the distribution of the attenuation coefficients in the volume zones is the same (α + β = const) shows that reduction in the absorption coefficients and at the same time taking account of the corresponding isotropic scattering of the radiation leads to a more significant change in the temperature fields and heat fluxes in comparison with the case of constant values of the absorption coefficients. Thus, with increase in Sc from 0 to 0.5, the incident radiant fluxes are reduced by 25-28% on average over the height of the cooling chamber, and the heat absorption by the screens by 17-18%. Reduction in q_{inc} leads, in turn, to decrease in contamination surface temperature, which is 110°K with change in Sc from 0 to 0.5 in the zone of intense slagging.

This increase in Sc leads to increase in gas temperature at the outlet from the furnace from 1386 to 1498°K (Fig. 2b, curve 1). In this case, the temperature difference between the central and boundary layers of the furnace gases for the cooling chamber increases, but less than in the case of isotropic scattering with α = const.

The results of comparing the heat-transfer coefficients of the variants taking account of scattering of the radiation with respect to the basic variant are shown in Table 1 (the change in q_{inc}, q_T, t_C, and t_G is given for the lower part of the cooling chamber, h = 7.4 m).

As is known, in practice, attenuation coefficients in which the absorption and scattering coefficients appear in the form of sums are often used in thermal calculations of boiler assemblies. However, as shown by the results of calculations, the use of attenuation coefficients instead of absorption coefficients leads to overestimation of the heat-transfer in-

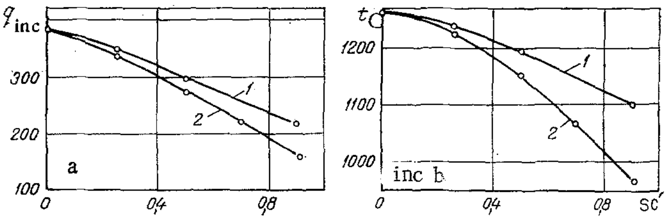

Fig. 5. Dependence of the incident radiation flux q_{inc} (kW/m^2) (a) and the contamination surface temperature t_C (°K) (b) for the side screen of the furnace at a height of 7.4 m on the effective Schuster number Sc': 1) α = const; 2) $\alpha + \beta$ = const.

tensity: first, because of the neglect of radiation scattering and, second, on account of the overestimation of the absorption coefficient due to the scattering coefficient.

It follows from this analysis that, in the presence of scattering media (which is especially characteristic of coal pulverizing furnace chambers), the attenuation coefficient must be divided into two components: the scattering coefficient and the absorption coefficient, in the case where the latter is used to determine the emissivity of the furnace-gas flow in calculating the radiative heat transfer.

The influence of isotropic scattering, together with diffracted radiation, is investigated for two cases: 1) when α = const; 2) when $\alpha + \beta$ = const. In the first case, depending on the proportion of diffracted radiation and the value of Sc, the coefficient of isotropic scattering varies according to the relation $\beta^{is} = \alpha_{bas}Sc(1 - \eta)/(1 - Sc)$. For $\alpha + \beta$ = const, depending on the proportion of diffracted radiation and the value of Sc, the coefficients of isotropic scattering and absorption vary according to the relations: $\beta^{is} = \alpha_{bas}Sc(1 - \eta)$, $\alpha = \alpha_{bas}(1 - Sc)$. Note that increase in the proportion of diffracted radiation from 0 to 1 denotes transition from isotropic scattering to a purely absorbing medium.

Analysis of the results obtained α = const and Sc = 0.5 shows that increase in the proportion of diffracted radiation from 0 to 0.5 is associated with increase in the incident radiant flux by 7-9% on average over the height of the furnace, increase in the heat absorption by the screens by 4-5%, and increase in the contamination surface temperature in the zone of intense slagging by 28°K. Around the outlet window of the furnace, the temperature difference between the central and boundary layers of the furnace gases is reduced by 9°K in this case.

The dependence of the gas temperature at the outlet from the furnace on the value of Sc is shown in Fig. 2a for different proportions of diffracted radiation. It is evident that, with increase in η, when Sc = const, reduction in ϑ_T'' is observed. Thus, with Sc = 0.5, increase in the proportion of diffracted radiation from 0 to 0.5 leads to reduction in ϑ_T'' by 22°K.

Analysis of the results obtained when $\eta = 0.5$ and Sc varies from 0 to 0.5 shows that the incident radiant flux is reduced by 12-15% on average over the height of the furnace, the heat absorption by the screens by 6-8%, and the contamination surface temperature in the region of intense slagging of the screens is reduced from 1265 to 1224°K. The gas temperature at the outlet from the furnace is increased in this case from 1386 to 1421°K, and the temperature difference between the central and boundary layers of the furnace-gas flow at the top of the furnace increases from 62 to 75°K.

Thus, the given data show that the anisotropic scattering of radiation, with "forward" scattering predominating, influences the heat-transfer coefficients less than isotropic scattering (with identical values of Sc), and its influence becomes less as the proportion of diffracted radiation increases.

Analysis of the results obtained for $\alpha + \beta$ = const and Sc = const (Fig. 2b) shows that, with increase in the proportion of diffracted radiation there is a stronger decrease in ϑ_T'' than in the case α = const (Fig. 2a). Thus, with increase in η from 0 to 0.5 for Sc = 0.5 the reduction in ϑ_T'' is 4.1% when ($\alpha = 0.5\alpha_{bas}$; $\beta = 0.5\alpha_{bas}$) and 1.9% when α = const ($\alpha = \alpha_{bas}$; $\beta = \alpha_{bas}$). This is explained in that the values of the absorption coefficient are lower in the first case.

It is evident from Fig. 2a that Sc does not uniquely determine the heat transfer in the furnace chamber (Sc and η must be specified). With the aim of simplifying the analysis of the influence of isotropic scattering with different proportions of diffracted radiation on the heat-transfer coefficients, the concept of an effective Schuster number $Sc' = \beta^{is}/(\alpha + \beta^{is})$ is used, assuming here that the diffracted radiation is taken into account in passing. It may readily be noted that, with Sc' = const and α = const, the proportion of diffracted radiation has no influence on the heat-transfer coefficients. Using Sc' allows the analysis of heat transfer in radiating systems to be significantly simplified, by means of approximate representation of the real scattering index of the furnace medium in the form of isotropic and diffracted components.

In Fig. 5, the incident radiation fluxes and contamination surface temperature are shown as a function of the effective Schuster number for the cases α = const and $\alpha + \beta^{is}$ = const. It is evident that more considerable decrease in q_{inc} and t_C with increase in Sc' is observed in the second case.

The investigations show that the influence of the Schuster number on the total heat transfer in methods taking no account of scattering of the radiation may be estimated by means of a certain decrease in the absorption coefficients in the volume zones in calculating the generalized angular coefficients. On the basis of the given calculations, an expression is obtained for the corrected absorption coefficient α' which must be specified in the corresponding zones of the model in calculating taking no account of the scattering in order to obtain the same gas temperature at the outlet from the furnace as for the case when scattering is taken into account at specified values of the effective Schuster number (in the range from 0 to 0.55) and the absorption coefficient: $\alpha' = \alpha\,[1.57(Sc')^2 - 1.76(Sc') + 1]$.

This correction of the absorption-coefficient values allows the influence of Sc on the gas temperature of the gas leaving the furnace to be sufficiently accurately estimated. The incident radiation flux is determined here with an error of 10-14% and the heat absorption by the screens and the contamination surface temperature with an error of 2-4%.

The data obtained in the present investigation allows various patterns of heat transfer in the furnace chamber on combustion to be elucidated on the basis of the real radiational characteristics of the combustion products of various fuels and also allows the error in the calculation due to neglecting the scattering of the radiation to be estimated.

In practice, the real radiational characteristics of the furnace medium will change over fairly broad limits in the course of boiler-assembly operation. Since for coal-pulverizing furnaces, the mean diameter of the ash and coal particles (13-16 μm [1]) considerably exceeds the characteristic wavelength of thermal radiation for the furnace chambers (the diffraction parameter [1] $\rho > 20$), the scattering coefficients have strong forward extension [1, 3], and the proportion of diffracted radiation reaches values of 0.6-0.9. In this case, the Schuster number for ash particle varies in the range 0.54-0.56 [1, 8].

It is of interest to analyze the heat transfer when Sc and η are close to the real values. Consider the case when Sc = 0.55 and η = 0.75. Comparison of this case with the basic no-scattering variant (Sc = 0) under conditions when the absorption coefficients are the same shows that disregarding scattering of the radiation leads to underestimation of the gas temperature at the furnace outlet by 23°K and the discrepancy of the gas temperature in the vicinity of the outlet window by 8°K (Table 1). The overestimation of the surface temperature of the ash deposits and of the incident radiation fluxes in the zone of intense slag formation of the screens is then 27°K and 38 kW/m² respectively. This shows that it is of particular importance to take account of scattering processes in more accurate calculations of the heat transfer in furnace chambers in the combustion of slagging Kanskoachinskii coals.

NOTATION

α, β, absorption and scattering coefficients, m^{-1}; R, reflective capacity; A, absorptive capacity; f_{ij}, reduced resolving angular radiation coefficient; ψ_{ij}', generalized semiresolving angular radiation coefficient; $Sc = \beta/(\alpha + \beta)$, Schuster number, $\eta = \beta^D/(\beta^{is} + \beta^D)$, proportion of diffracted radiation in the scattering of radiant energy; m and n, number of volume and surface zones in the system; h, distance over the furnace height, m; ϑ_T'', gas temperature at the outlet from the furnace, °K; q, density of the radiant flux; kW/m²; q_T, density of heat absorption of the furnace screens, kW/m²; t, temperature, °K; t_C, contamination surface temperature (corresponding to the slag film in the combustion chamber and the ash deposits in the cooling chamber), °K; θ, temperature difference between the central and boundary layers of the furnace-gas flow in the region of the outlet window, °K. Indices: i, j, r, zone numbers; dif, diffusional; nondif, nondiffusional; is, isotropic; anis, anisotropic; D, diffracted; inc, incident; G. Gas.

LITERATURE CITED

1. A. G. Blokh, Thermal Radiation in Boiler Equipment [in Russian], Energiya, Leningrad (1967).
2. V. A. Krivandin, Luminous Natural-Gas Flames [in Russian], Metallurgiya, Moscow (1973).
3. D. Deirmendzhan, Scattering of Electromagnetic Radiation by Spherical Polydisperse Particles [Russian translation], Mir, Moscow (1971).
4. Yu. A. Zhuravlev, "Determining the characteristics of radiant heat transfer in multizone systems, taking account of isotropic scattering," Inzh.-Fiz. Zh., 31, No. 3, 463-470 (1976).
5. Thermal Design of Boiler Apparatus (Normative Method) [in Russian], Energiya, Moscow (1973).
6. Yu. A. Zhuravlev, "Development of a zonal mathematical model of heat transfer in furnaces of boiler assemblies and investigation of its properties," Izv. Akad. Nauk SSSR, Energ. Transp., No. 6, 133-139 (1976).
7. Yu. A. Zhuravlev, F. K. Sidorov, and M. Ya. Protsailo, "Application of zonal method for calculating the heat transfer in a boiler furnace," Teploenergetika, No. 11, 35-39 (1980).
8. A. G. Blokh and L. D. Burak, "Primary radiational characteristics of the principal ranks of solid fuel," Teploenergetika, No. 8, 48-53 (1973).

REGULARIZATION IN THE PROBLEM OF DETERMINING EXTERNAL HEAT-TRANSFER CONDITIONS

M. R. Romanovskii

UDC 536.24:517.946

Questions are considered of the accuracy in determining the heat-elimination coefficient and the temperature of the environment by using the method of regularization according to the scheme of partial matching with elements of a set of observations.

A characteristic feature of many experimental investigations is the complexity of executing direct measurements of the desired quantities. Among such cases, for instance, is the known problem of determining the heat-transfer coefficient. Taking account of factors of nonstationarity of the process, nonlinearity of the thermophysical properties, and the spatial distribution of the heat complicates the application of traditional methods [1-3]. In this connection, methods based on the solution of the inverse heat-conduction problem are used to find the conditions for external heat exchange by means of measuring the temperature within the specimen in [4-7].

The problem of reproducing the cause according to the consequence being observed occurs constantly when studying the broadest class of phenomena. The isolation of inverse heat-conduction problems into a separate group and the development of a theory for identification of thermal processes [8, 9] is associated firstly with the complexity of obtaining final computational formulas since we only have available knowledge of certain model relationships implicitly expressing the connection between the temperature being observed and the parameters to be determined.

On the basis of the fact that the temperature field is a result of the properties of the test object and the conditions of its interaction with the environment, such model parameters

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