up to $4 \cdot 10^8$ W/m² to limited area metal surfaces with good thermal conductivity. Obtaining higher fluxes apparently will require use of gaps of more temperature-stable material. The maximum flux producable into a wall of silicate material comprises $\sim 1 \cdot 10^8$ W/m². The results presented may be used to optimize surface thermoprocessing of various materials. The method developed for determining the profile of the thermal flux from arc to wall and the programs for processing of the experimental data can be used to study nonsteady-state thermal fields in various high-temperature apparatus.

NOTATION

- $U$, $i$, voltage, current; $L_a$, arc length; $d$, distance between gap walls; $L$, distance from cathode; $q$, $q_m$, $q_w$, $q_s$, thermal flux, maximum thermal flux, thermal flux into wall and sensor; $r$, distance; $\rho$, $c$, $\lambda$, density, specific heat, thermal conductivity; $T_w$, $T_s$, temperatures of wall and sensor surface; $v$, velocity; $\delta$, width of action zone; $W$, energy supplied to surface; $W_e$, energy supplied to arc; $t_a$, action time; $n$, time step number; $\Delta t$, time interval; $\tau_T$, $\tau$, gas transit time past sensor and thermal conductivity time; $h$, characteristic scale of temperature drop; $a$, thermal diffusivity; $\lambda_g$, thermal conductivity of gas; $V_u$, $u$, velocity gradient and gas velocity at wall.

LITERATURE CITED

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DISTURBANCE OF LOCAL THERMAL EQUILIBRIUM
IN AN ELECTRIC-ARC ARGON PLASMA

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UDC 537.523.5

It is shown that allowance for the condition $T_e \neq T_h$ in determining the composition and transport properties and allowance for reabsorption of radiation permit refinement of the region of disturbance of local thermal equilibrium in electric arcs.

In calculating the characteristics of electric-arc devices, the choice of the arc model is very important. In a wide range of the parameters (current, gas flow rate, channel size) good agreement with the experimental characteristics can be obtained using an equilibrium model of an arc. At the same time, there are rather inconsistent data on the disturbance of local thermal equilibrium (LTE) in an electric-arc plasma. The disturbance of LTE in an...
argon plasma at atmospheric pressure for currents lower than 10 A was established experimentally in [1]. The data of [2, 3] indicate nonequilibrium in electric arcs at far higher currents. Thus, regimes with currents of 50, 100, and 200 A, channel diameters of from 0.2 to 4 cm, and gas flow rates of up to 1 g/sec were investigated in [3]. A pronounced nonequilibrium (up to 1000 K) at the axis of the arc was revealed upon a decrease in the current and the channel diameter to I/d < 100 A/cm. The distributions of temperatures $T_e$ and $T_h$ obtained lay below the experimental ones. Regimes with currents of 50-200 A and argon flow rates of 0.1-3.9 g/sec were investigated in [2]. It was noted that in an argon plasma a disturbance of LTE at the channel axis is observed at currents of $\approx 50$ A. The discrepancy between the data of [2, 3] and the experiment of [1] is explained by the inaccuracy of the transport coefficients used. We note that reabsorption of radiation was not taken into account in these papers.

In order to refine the region of disturbance of LTE in an electric arc burning in a longitudinal argon stream and to reveal the processes promoting temperature equalization, in the present work principal attention was paid to the construction of a model, the calculation of transport coefficients under the condition $T_e \neq T_h$, and an analysis of radiation transfer in the real spectrum.

The system of equations describing a partially ionized plasma in the case of $T_e \neq T_h$ is derived from the Boltzmann kinetic equations in a way similar to what is done for a fully ionized plasma [4], and it has the form

$$\frac{5}{2}k_n n_e \left( V_z \frac{\partial T_e}{\partial z} + V_r \frac{\partial T_e}{\partial r} \right) = \frac{1}{r} \frac{\partial}{\partial r} \left( r \lambda_0 \frac{\partial T_e}{\partial r} \right) + \frac{\sigma T^4}{c_s} - \Delta e - \nabla q_{cont}, \quad (1)$$

$$\frac{5}{2}k (n_i + n_a) \left( V_z \frac{\partial T_h}{\partial z} + V_r \frac{\partial T_h}{\partial r} \right) = \frac{1}{r} \frac{\partial}{\partial r} \left( r \lambda_h \frac{\partial T_h}{\partial r} \right) + \Delta e - \nabla q_r - J^i \cdot \Gamma_i, \quad (2)$$

$$\rho V_z \frac{\partial V_z}{\partial z} + (\rho + 1) V_r \frac{\partial V_r}{\partial r} = \frac{1}{r} \frac{\partial}{\partial r} \left( r \mu_1 \frac{\partial V_z}{\partial r} \right) - \frac{\partial P}{\partial z}, \quad (3)$$

$$\frac{\partial}{\partial z} (\rho V_z) + \frac{1}{r} \frac{\partial}{\partial r} (\rho V_r) = 0, \quad (4)$$

$$\frac{\partial}{\partial z} (n_y V_z) + \frac{1}{r} \frac{\partial}{\partial r} (n_y V_r) = \Gamma_i, \quad (5)$$

$$\Delta e = \frac{3n_e}{m_e} k \lambda_0 V_e (T_e - T_h), \quad (6)$$

$$E = \frac{I}{2\pi \rho \sigma r dr}, \quad (7)$$

$$\rho = m_e n_e + m_a (n_i + n_a), \quad (8)$$

Fig. 1. Temperature distribution ($10^3$~K) over the channel radius ($P = 0.1$ MPa; $I = 85$ A, $G = 1$ g/sec, $R = 0.5$ cm; solid curves: with the equation of motion (3); dashed curves: $V_z = V_{zo} (1 - r^2)$: 1) $z = 0.5$; 2) 1 cm.