EAH arc chamber, $kg \cdot sec^{-1}$; G_i, flow rate of gas injected between sections, $kg \cdot sec^{-1}$; G^*, gas flow rate through arc column, $kg \cdot sec^{-1}$; σ, electrical conductivity, Ω^{-1}; h, enthalpy, $J \cdot kg^{-1}$; S, heat-conduction function, $W \cdot m^{-1}$; h_{av}, average-mass enthalpy, $J \cdot kg^{-1}$; h_*, S_*, values of h and S at boundary of arc column, $J \cdot kg^{-1}$, $W \cdot m^{-1}$; 0 and ∞ pertain to quantities at z = 0 and as $l \to \infty$.

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INFLUENCE OF SCATTERING ANISOTROPY ON THE EMISSION OF TWO-PHASE MEDIA

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An approximate solution of the transfer equation in a plane medium with anisotropic scattering is compared with the exact solution. It is shown that the approximate solution agrees well with the exact solution.

Great attention is now being paid to the problem of allowing for an arbitrary scattering indicatrix in the solution of the equation of radiation transfer in two-phase media [1-5]. The solution of this problem is connected with a large volume of computational work. The development of approximate methods of solving the radiation-transfer equation with allowance for scattering anisotropy naturally becomes very desirable. For example, in [6] approximate solutions are presented for the determination of the hemispherical and directional emissivities of two-phase plane media in which the scattering anisotropy is allowed for by the parameter β:

$$\beta = \beta(\tau) = \frac{\int_{-1}^{0} d\mu \int_{0}^{1} p(\mu, \mu') I(\tau, \mu') d\mu'}{2\int_{0}^{1} I(\tau, \mu) d\mu} = \frac{\int_{0}^{1} d\mu \int_{-1}^{0} p(\mu, \mu') I(\tau, \mu') d\mu'}{2\int_{-1}^{0} I(\tau, \mu) d\mu}. \tag{1}$$

Here $I(\tau, \mu)$ is the radiation intensity at the point τ and in the direction $\theta = \arccos \mu$, $\tau = \int_0^z (\varkappa + \sigma) dz$ is the optical depth of the layer, $\varkappa$ and σ are the coefficients of absorption and scattering, respectively, while $p(\mu, \mu')$ is the indicatrix for radiation scattering on an elementary volume. In a first approximation the quantity β can be set as constant,

$$\beta \cong \frac{1}{2}\int_{-1}^{0} d\mu \int_{0}^{1} p(\mu, \mu') d\mu' = \frac{1}{2}\int_{0}^{1} d\mu \int_{-1}^{0} p(\mu, \mu') d\mu'. \tag{2}$$

As is known [6-8], in the investigation of multiple scattering processes one can use a scattering indicatrix in the form

$$p(\mu, \mu') = a + 2(1-a)\,\delta(\mu - \mu'). \tag{3}$$

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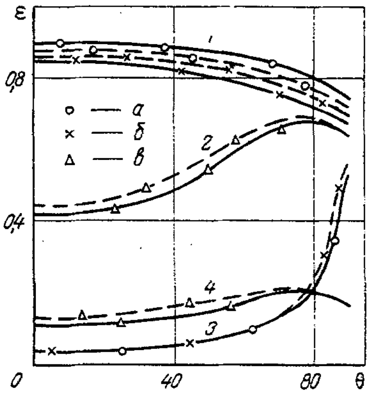

Fig. 1

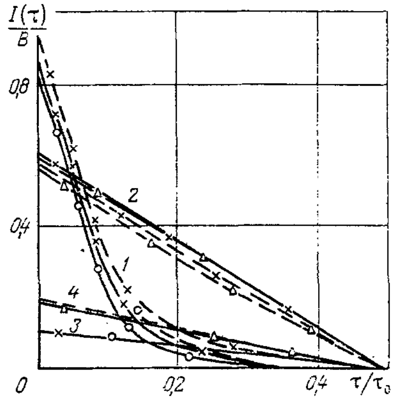

Fig. 2

Fig. 1. Angular distribution of emissivity of a two-phase plane medium. Solid curves) data of calculation in accordance with [6]; dashed curves) results of exact calculation of [5]; a) $x = -1$ ($\beta = 0.625$); b) $x = +1$ ($\beta = 0.375$); c) $x = 0$ ($\beta = 0.5$); 1) $\tau_0 = 10$, $\lambda = 0.5$; 2) 1, 0.5; 3) 0.1, 0.5; 4) 1, 0.9. θ, deg.

Fig. 2. Radiation-flux distribution within a two-phase plane medium (notation the same as in Fig. 1).

The substitution of (3) into Eq. (1) defines the connection between β and a:

$$\beta = \frac{1}{2} a.$$

The approximate solution obtained in [6] was compared with the exact solution [9, 10] for a semiinfinite medium with $\beta = 1/2$ and $\beta = 1/3$. Fully satisfactory agreement was obtained. The problem of the emission of a two-phase plane medium of finite optical depth was solved numerically in [5] for two types of indicatrix: 1) $p(\gamma) = 1 + x \cdot \cos\gamma$ and 2) $p(\gamma) = {}^3/_4(1 + \cos^2\gamma)$. Moreover, an approximate method of calculation was also proposed in that report. For the first type of indicatrix, for which $x = \pm 1$ was taken, we compared the exact results with the approximate equations from [6]. In this case

$$\beta = \frac{1}{2}\left(1 - \frac{x}{4}\right). \tag{4}$$

The data of this comparison, with different optical depths of the layer and probabilities $\lambda = \sigma/(\varkappa + \sigma)$ of escape of a quantum, are presented in Figs. 1 and 2. From Fig. 1, where the angular distribution of the emissivity of a two-phase plane layer is presented, it is seen that the accuracy of the approximate equations obtained in [6] is quite high. It should be noted that at observation angles close to $\theta = \pi/2$ the dependence of the escaping radiation on the anisotropy of the scattering in an elementary act of interaction of the radiation with matter must be retained, in constrast to the data of [5]. This also follows from the equations presented in [5]. The disputed question of the applicability of the approximate equations of [6] is unambiguously resolved in favor of the latter, as shown by Fig. 1. The radiation-flux distribution within a layer with different optical characteristics of the medium is also well described by the approximate equations from [6] (see Fig. 2).

In conclusion, we note that the approximate method developed in [5] is considerably inferior to the method proposed by the authors [6] in accuracy and in the volume of computations.

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AIR COOLING OF A TURBINE GUIDE VANE FOR A STATIONARY GAS-TURBINE PLANT (GTP) WITH A HIGH GAS PRESSURE

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A guide vane for a proposed stationary GTP is calculated with π_r = 80, 100, and 126 and T_g^* = 1673°K. The unsuitability of the convective blade cooling used up to now is noted.

One of the most promising directions in the development of gas turbines is an increase in the temperature and pressure of the gas ahead of the turbine. The tendency of an increase in the gas temperature in gas-turbine plants (GTP) has developed most clearly in recent years: Whereas temperatures of 800-850°K predominated in the 1950's, in the 1970's the temperature level for a base-load GTP has reached 1050-1150°K, while in peak-load GTP it has reached 1100-1250°K. The mastery of gas temperatures on the order of 1500-1600°K is anticipated in the near future. And the achievement of these temperatures will depend mainly on the cooling of the turbine and primarily of its blade apparatus.

The research of the Moscow Higher Technical School devoted to the creation of high-temperature GTP [1] has shown the following:

1) The efficiency of a plant and its specific power grow with an increase in the gas temperature T_g^* ahead of the turbine when there is a corresponding increase in the degree of pressure rise π_r. The efficiency can reach 47-49% in nonregenerative gas-turbine plants with multistage compression and expansion when T_g^* = 1500°K and π_r = 130°.

2) The intensity of heat exchange between the gas and elements of the flow section grows sharply with an increase in the absolute pressure of the gas ahead of the turbine when the hydraulic, thermodynamic, and geometrical parameters of the stage are unchanged.

3) With appropriate design of the cooling system the gas temperature ahead of the turbine can reach 2000°K.

As shown by calculations made earlier, experiments, and tests of turbine operation, the highest coefficient of heat transfer from the gas to the wall of a blade is observed at the leading (inlet) and trailing (outlet) edges, and it is far lower on the side (concave and convex) parts of its surface. The use of deflector vanes with transverse flow of the cooling air yields the best results in cooling the narrowest parts of the vane surface, mainly the leading edge, since in frontal onflow the coefficient of heat transfer from the wall to the cooling air increases by two to three times in comparison with its value for turbulent flow in a smooth channel.

In the present article we present the results of a calculation of a deflector guide vane with T_g^* = 1673°K and π_r = 80, 100, and 126. We analyzed a vane whose wall is made of a promising heat-resistant alloy having a melting temperature of 1473°K and λ = 45.4 W/m²·deg. As a result of gasdynamic and strength calculations we determined the following: l = 0.0662 m, D_{av} = 0.66 m, s = 0.096, $\bar{t}$ = 0.65; z = 33.

In the calculation it was assumed that the stagnation temperature of the gas at the vane, the conditions of external heat exchange, and the distribution of cooling air along the length

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