CALCULATION OF THE PARAMETERS OF A GAS CARRYING PARTICLES IN THE NOZZLE OF A PLASMATRON

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Calculations on the flow of plasma carrying particles in a nozzle at subsonic velocities, without taking into account the dynamic and thermal interaction between the phases, are reported in [1, 2].

In this paper, the calculations are extended to the supersonic flow of particle-bearing plasma, taking into account the interaction between the phases. The flow of argon carrying particles of aluminum oxide (diameters of 10 μ) and Nichrome (diameters of 50 μ) in a supersonic nozzle is considered.

The calculations are based on the one-dimensional continuum model described in [3]. It is assumed that the gravitational force and the volume occupied by the particles are negligible, and that the particles are spherical and of equal radius. Thermal and mechanical interactions between the flow and the nozzle wall are neglected. The flow of the gas–particle mixture can then be described by the set of equations reported in [4].

This set is augmented by relationships [2, 5] which characterize the thermal and mechanical interaction between the phases, and is solved on a computer.

The initial conditions at entry to the ultrasonic nozzle (at x = 0) are: $p_0 = \rho_0 = T_0 = 1$; $v_0 = M_0\sqrt{k}$; $M_0 = 1.01$; $\rho_{TO} = 0$.

The calculation is carried out for two positions of the point of injection of the powder, namely, x = 1.5 and x = 9.

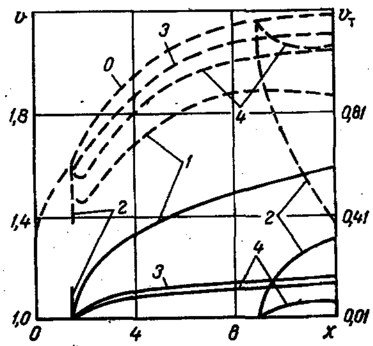

Fig.1

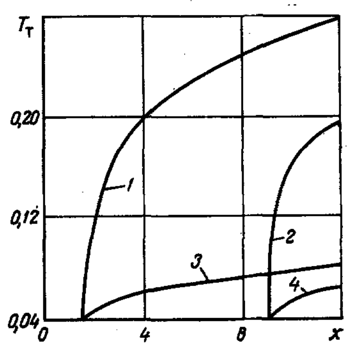

Fig.2

Fig.1. Velocity of gaseous and solid phases [broken curve) gas, solid curve) particles]: 0) pure argon; 1) argon plus aluminum oxide (10 μ), μ = 0.5; 2) the same, μ = 1.0; 3) argon plus Nichrome (50 μ), μ = 0.5; 4) the same, μ = 1.0.

Fig.2. Temperature of solid particles as a function of distance along the nozzle; numbers against curves have the same significance as in Fig.1.

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The particles injected into the nozzle have an initial velocity $v_T = 0.01$ and density $\rho_T = 60$ and 130, which corresponds to a ratio of particle and gas flow rates of $\mu = 0.5$ and 1.0.

The flow parameters at the entrance to the nozzle are (in dimensional form): $T_0 = 8000°K$ and $\rho_0 = 0.25$ kg/m^3.

The speed and temperature of particles leaving the nozzle increase with decreasing size and concentraction of these particles, and with increasing distance between the point of injection of the particles and the face of the nozzle (Figs. 1 and 2).

The notation used above is as follows: x is the distance along the nozzle; p is the gas pressure; ρ, ρ_T are the density of the gaseous phase and the particle "gas"; T, T_T are the temperatures of gas and particles; v, v_T are velocities of the gaseous and solid phases; M is the Mach number; k is the isoentropic exponent; μ is the ratio of the rate of flow of particles to the rate of flow of the gaseous phase.

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