PHYSICS PHENOMENA ACCOMPANIED STREAMLINING OF A BODY BY THE GAS-PARTICLE SUPERSONIC JET

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Impingement of a gas-particle jet upon a solid body surface is being realized in many domains of the flight technique and technologies. For example, during a space vehicle stage separation by engines with metalized fuel, during the operation of the landing retro-rockets, during processing materials by sand-jets, at the gas-dynamics ground facility simulation of body enter into dusted atmospheres of planets.

This interaction is followed with the numerous physics phenomena which are certainly registered in modern experiments (esp., [1, 2]) – gas-thermodynamical, optical, and electrical.

This work deals with the analysis of the corresponding physicomathematical models and numerical results derived on their basis. The gas-dispersed flow in the nozzle and the interaction of the flow with a circumfluent body are investigated. The influence of the particle initial mass fraction (in the high-pressure chamber) upon the flow topology around circumfluent sphere and cylinder face is investigated on the ground of Euler equations for the carrying gas, the particle impinging the body, rebounded from it, and chaotized particles. The peculiarities of caustics forms (the layers of maximal particle concentration) is investigated, as well as the rate of the heat flux mitigation on the surface due to the layer of chaotic particles produced by inter-particle collisions (screen effect). The values of the particle initial mass fraction was chosen to be up to the 300% (in relation to the carrying gas - mass density).

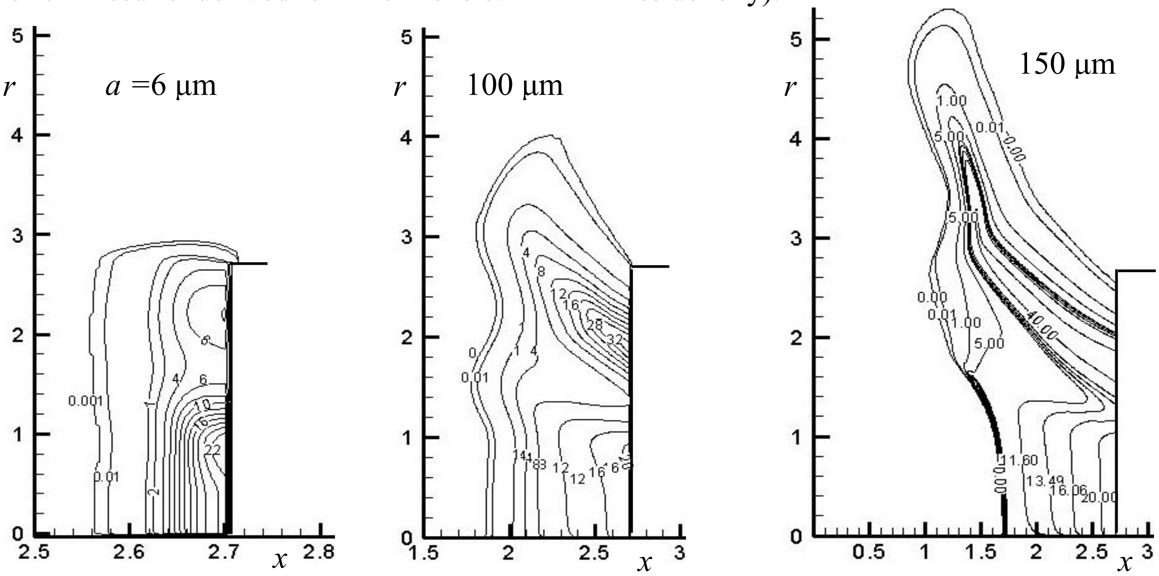

Fig. 1. Density fields of rebounded particles SiO_2 in the flow carrying 100% initial mass fraction of particles in carrying air near the cylinder face. a – particle radius

On the basis of the Navier–Stokes equations and original heuristic model for particle- body collision, the surface heat flux distribution is numerically investigated. A satisfactory coincidence with the experimental results of [1, 2] is obtained.

Scattering of the sounding monochromic radiation by particulates in the compressed layer near the body surface is investigated. As a result, the derived algorithm allows the adequate interpretation of the optical sounding of the flow tending to find spatial distribution of the particle concentration.

A qualitative description of the particle electric charging after collision with the body is suggested, spatial distributions of the electric potential and of the backward current from the rebounded particles are investigated, as well as the glow of the molecules excited by this current.

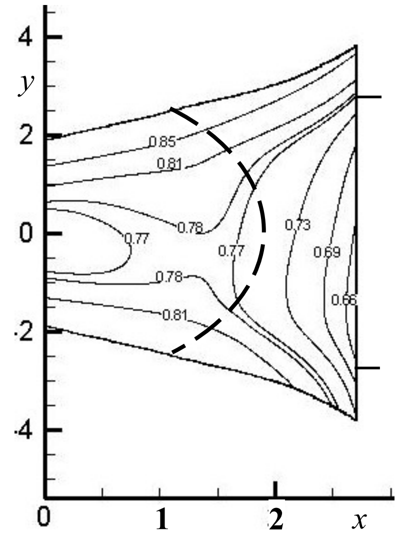

Fig. 2. Lines of equal values of extinction coefficient of the sounding radiation scattered by the incident SiO_2 particles of 1 μm radius. Dash line – shock wave near the cylinder face. The flow of the sounding light (laser sheet) falls down in the picture plane

Some flow patterns at the circumfluent bodies are presented in Fig. 1–3. The Mach number at the nozzle exit equals 3.6. The opening nozzle semi-angle 22°. The gas-particle mixture flows from the left to the right hand.

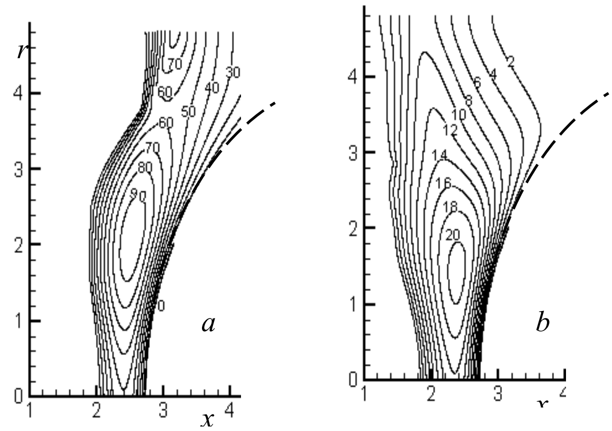

Fig. 3. Lines of equal values of particle electric potentials for particle radius 50 μm:
a) – Al_2O_3, *b*) – copper particles.
The copper body is sphere

References

[1] Kudin O.K., Nesterov Yu.N., Tokarev O.D. and Flaxman Ya.Sh. Characteristics of a high-temperature dust-laden jet and its interaction with an obstacle. *Proc. 55th Sci. Conf. MIPT (Moscow Institute of Physics and Technology).* Part VI, pp 115-117 (in Russian), 2012

[2] Vasilevskii E.B., Osiptsov A.N., Chirikhin A.V. and Yakovleva L.V. Heat exchange on the front surface of a blunt body in a high-speed flow containing low-inertia particles *J. Engineering Physics and Thermophysics.* Vol. 74, No. 6, pp 1399-1411, 2001.

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