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VERIFYING AN ALGORITHM FOR THE TEST PARTICLE METHOD ON THE PROBLEM OF RAREFIED AXIAL JET FLOW PAST A CONE

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This paper is concerned with an aerodynamic calculation of supersonic gas plume flows and the determination of the forces they exert on obstacles. The paper presents a development of the test particle statistical method (TPSM) to numerically simulate supersonic gas plumes over a wide range of flow conditions. The work is based on the idea of a combined approach, i.e., the use of the gas-dynamic parameter distribution at the nozzle exit or on the conventional boundary of the dense core of the plume as input data for a TPSM algorithm adapted from homogeneous flows to plume ones. Combining methods of continual aerodynamics (inside or near the nozzle, where a continuum flow takes place) and the TPSM (where the motion is described on a molecular-kinetic level) allows one to solve supersonic plume efflux problems for arbitrarily rarefied plumes.

The TPSM plume algorithm was tested to verify its reliability on the problem of axial flow past a cone. At the initial stage of the use of the combined approach, consideration was given to a rather rarefied gas flow, for which the gas-dynamic parameters at the nozzle exit can be used as TPSM input data. The force distribution over the cone surface and the static pressure upstream of the cone were calculated. The TPSM results were found to be in satisfactory agreement with the available direct simulation Monte-Carlo and experimental data. It was concluded that using the plume velocity and density distributions at the continual zone exit found from the Navier–Stokes equations as TPSM input data would significantly improve the expected results.

This use of the TPSM in an aerodynamic calculation of gas plumes is the first in Ukraine. The TPM offers saving in computational resources: the TPSM running time depends on a variety of factors, but it is many times shorter than that of the direct simulation Monte Carlo method.

Keywords: rarefied gas dynamics, jet flow, statistical simulation, test particle Monte Carlo method, numerical calculations, flow regimes, gas-dynamic parameters, force load, flow obstacles.

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