Steady subsonic and supersonic gas flows to condensation surface

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Intense heat-mass transfer in a gas flow to a condensation surface is studied with the consistent atomistic and kinetic theory methods. The six-moment method is utilized for solving the Boltzmann kinetic equation (BKE) for the nonequilibrium gas flow with a condensation boundary condition, while molecular dynamics (MD) simulation of a similar flow is used for verification of BKE results and the boundary condition utilized at the surface [1]. We demonstrate that BKE can provide the steady flow profiles close to those obtained from MD simulations in both subsonic and supersonic regimes of steady gas flows.
In particular MD confirms that at a specific surface temperature a steady supersonic gas condenses completely after compression by a shock front standing in reference to the surface. The shock front divides the flow on the supersonic and subsonic zones, and condensation of shocked gas happens in a subsonic regime. Conditions required for the complete, partial, and ceased condensation regimes are determined. It is shown that a runaway shock front can stop an inflow gas and condensation is ceased if the surface temperature is above a critical threshold determined by a saturation line of gas and its shock Hugoniot. We also demonstrate that the elementary theory of condensation has a good accuracy in a surprisingly wide range of flow parameters.

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