Rebuilding of Rothe's nozzle measurements with OpenFOAM software

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Abstract

In this paper the dsmcFoam solver is tested and validated for the three main solver functionalities of 1) free-stream boundary conditions, 2) kinetic intermolecular collision including internal degrees of freedom and 3) gas/surface interactions. The free-stream utility was improved such that a spatially uniform field of particles gets inserted now yielding reliable results for the cells located close to these patches. Implementation of the collision models was validated for two test cases (monatomic gas mixtures and diatomic gas) by observing the equilibration of both the kinetic and internal energies. It was found that the present code had good agreement to the independent codes of HAWK and SMILE as well as to results by G. Bird. The validation of the present codes treatment for the gas/surface interactions was evaluated using the benchmark case of Rothe's nozzle measurements. Results show that the present version of dsmcFoam obtained good agreements for this case compared to the measurements of Rothe for density and temperature. It was also found that the Navier-Stokes solver of OpenFOAM produced reasonable results, even though the local Knudsen number of the flow exceeds the range of applicability for this method, Kn=0.1.