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DSMC Simulations of High Mach Number Taylor-Couette Flow

DR. SAHADEV PRADHAN, Chemical Technology Division, Bhabha Atomic Research Centre, Mumbai- 400085 — The main focus of this work is to characterise the Taylor-Couette flow of an ideal gas between two coaxial cylinders at Mach number $Ma = (U_w / \sqrt{kb T_w / m})$in the range 0.01 <Ma <, and Knudsen number $Kn = (1 / (\sqrt{2}\pi d^2 n_d (r_2 - r_1)))$ in the range 0.001 <Kn <, using two-dimensional (2D) direct simulation Monte Carlo (DSMC) simulations. Here, $r_1$and $r_2$are the radius of inner and outer cylinder respectively, $U_w$is the circumferential wall velocity of the inner cylinder, $T_w$is the isothermal wall temperature, $n_d$is the number density of the gas molecules, $m$and d are the molecular mass and diameter, and $kb$is the Boltzmann constant. The cylindrical surfaces are specified as being diffusely reflecting with the thermal accommodation coefficient equal to one. In the present analysis of high Mach number compressible Taylor-Couette flow using DSMC method, wall slip in the temperature and the velocities are found to be significant. Slip occurs because the temperature/velocity of the molecules incident on the wall could be very different from that of the wall, even though the temperature/velocity of the reflected molecules is equal to that of the wall. Due to the high surface speed of the inner cylinder, significant heating of the gas is taking place. The gas temperature increases until the heat transfer to the surface equals the work done in moving the surface. The highest temperature is obtained near the moving surface of the inner cylinder at a radius of about ($1.26 r_1$).

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