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Analysis of high-speed rotating flow inside gas centrifuge casing

DR. SAHADEV PRADHAN, Chemical Technology Division, Bhabha Atomic Research Centre, Mumbai- 400085 — The generalized analytical model for the radial boundary layer inside the gas centrifuge casing in which the inner cylinder is rotating at a constant angular velocity Ω_i while the outer one is stationary, is formulated for studying the secondary gas flow field due to wall thermal forcing, inflow/outflow of light gas along the boundaries, as well as due to the combination of the above two external forcing. The analytical model includes the sixth order differential equation for the radial boundary layer at the cylindrical curved surface in terms of master potential (χ), which is derived from the equations of motion in an axisymmetric ($r - z$) plane. The linearization approximation is used, where the equations of motion are truncated at linear order in the velocity and pressure disturbances to the base flow, which is a solid-body rotation. Additional approximations in the analytical model include constant temperature in the base state (isothermal compressible Couette flow), high aspect ratio (length is large compared to the annular gap), high Reynolds number, but there is no limitation on the Mach number. The discrete eigenvalues and eigenfunctions of the linear operators (sixth-order in the radial direction for the generalized analytical equation) are obtained. The solutions for the secondary flow is determined in terms of these eigenvalues and eigenfunctions. These solutions are compared with direct simulation Monte Carlo (DSMC) simulations and found excellent agreement (with a difference of less than 15%) between the predictions of the analytical model and the DSMC simulations, provided the boundary conditions in the analytical model are accurately specified.

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