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Compressible swirling flow states in diverging or contracting pipes YUXIN ZHANG, Washington State Univ., NOAH CYR, ZVI RUSAK, Rensselaer Polytechnic Institute, SHIXIAO WANG, Auckland Univ., New Zeland — The dynamics of inviscid, compressible and axisymmetric swirling flow of a perfect gas in diverging or contracting circular pipes is studied by global analysis techniques and numerical simulations. Inlet flow is described by profiles of circumferential and axial velocities and temperature with a fixed azimuthal vorticity. Outlet flow is a non-reflective zero radial-velocity state. We first solve the columnar flow ODE problem developed by Rusak et al. (2015) for the outlet state as a function of inlet swirl ratio, Mach number and pipe geometry. Several steady states are possible including centerline decelerated velocity states, centerline accelerated velocity, vortex breakdown states and wall-separation states. Numerical simulations using the unsteady and axisymmetric Euler equations are also conducted. They are based on Steger & Warming (1979) flux-splitting, finite-difference method. Simulations shed light on the stability of the various steady states and their domain of attraction in terms of initial conditions. Results show that increasing inlet Mach number with a fixed geometry delays the appearance of vortex breakdown and wall-separation states to higher swirl levels. Pipe divergence at a fixed Mach number promotes breakdown while pipe contraction induces wall-separation.

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