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Vortex breakdown of compressible swirling flows in a pipe HARRY LEE, University of Michigan, ZVI RUSAK, Rensselaer Polytechnic Institute, SHIXIAO WANG, University of Auckland, New Zealand — The manifold of branches of steady and axisymmetric states of compressible subsonic swirling flows in a finite-length straight circular pipe are developed. The analysis is based on Rusak et al. (2015) nonlinear partial differential equation for the solution of the flow stream function in terms of the inlet flow total enthalpy, entropy and circulation functions. This equation reflects the complicated thermophysical interactions in the flows. The flow problem is solved numerically using a finite difference approach with a penalty procedure for identifying vortex breakdown and wall-separation states. Several types of solutions are found and used to form the bifurcation diagram of steady compressible flows with swirl as the inlet swirl level is increased at a fixed inlet Mach number. Results are compared with predictions from the global analysis approach of Rusak et al. (2015). The computed results provide theoretical predictions of the critical swirl levels for the first appearance of vortex breakdown states as a function of the inlet Mach number. The shows the delay in the appearance of breakdown with increase of the inlet axial flow Mach number in the subsonic range of operation.

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