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The dynamics of axisymmetric swirling flows in a diverging or contracting circular pipe[1] ZVI RUSAK, Rensselaer Polytechnic Institute, SHIXIAO WANG, University of Auckland — This paper describes a study of the effect of pipe divergence and contraction on the stability and breakdown of axisymmetric swirling flows in a long, finite-length, circular pipe. The work extends the theory of Wang & Rusak (1997). The approach is based on a rigorous analysis of the axisymmetric, steady and inviscid flow equations with non-periodic boundary conditions. The analysis firmly establishes the global bifurcation of flow states in the pipe (solutions of the Squire-Long PDE) by relating it to the bifurcation of solutions of the columnar flow problem (solutions of the resulting ODE) and using a new flow force relationship between the inlet and outlet states. This technique provides a simple, yet exact, method of analyzing the complex flow behavior including transitions from near-columnar vortex states to flow fields with large separation (stagnation) zones along the pipe centerline (breakdown states) or along the pipe wall (swirl induced wall separation). Bifurcation diagrams for base vortex models including the solid-body rotation and the Burgers vortex are presented. The stability characteristics of the various branches of solutions and the flow dynamics in the pipe under various perturbations are discussed. Results show that pipe divergence or contraction significantly modify the global flow behavior in a straight pipe and shed light on the effect of pipe geometry on the mechanism of vortex breakdown.

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