Abstract Submitted
for the DFD16 Meeting of
The American Physical Society

The critical swirl of a subsonic compressible swirling flow of a perfect gas in a finite-length straight circular pipe HARRY LEE, U. Michigan, ZVI RUSAK, Rensselaer Polytechnic Institute, SHIXIAO WANG, U. Auckland, New Zealand — Functional analysis techniques are used to rigorously determine the range of flow Mach number Ma_0 for the existence of the critical swirl ratio ω_1 for exchange of stability of a base columnar compressible swirling flow of a perfect gas in a finite-length straight circular pipe. For swirling flows with a monotonic circulation profile, it is first established that ω_1 definitely exists in the range $0 < Ma_0 < 2\sqrt{\gamma - 1}/\gamma$, where $\gamma > 1$ is the ratio of specific heats of the gas. Then, the existence of a limit Mach number Ma_{0l} between $2\sqrt{\gamma - 1}/\gamma$ and 1 is proven for a subclass of swirling flows; i.e. ω_1 does not exist and the flow is stable for all swirl level when $Ma_{0l} < Ma_0 < 1$. For example, $0.903 < Ma_{0l} < 1$ when $\gamma = 1.4$. In particular, an analytical solution of ω_1 as a function of Ma_0, γ and pipe length L for a solid-body rotation flow with a uniform axial velocity and temperature is also derived. The asymptotic behavior of this solution as Ma_0 tends to zero matches the results of Renac *et al.* (2007). In addition, Ma_{0l} of this flow is between 0.903 and 0.928 for $\gamma = 1.4$; it increases from 0.903 to 0.928 as L tends to infinity. This matches Rusak & Lee (2002) results.

Zvi Rusak
Rensselaer Polytechnic Institute

Date submitted: 27 Jul 2016 Electronic form version 1.4