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The three-dimensional stability of Lamb-Oseen vortex flows in a finite-length pipe WEIMIN YUAN, SHIXIAO WANG, Auckland University, ZVI RUSAK, Rensselaer Polytechnic Institute — The 3D viscous flow instability modes that appear on a Lamb-Oseen voretx flow in a finite-length straight, circular pipe are analyzed. This study extends the previous stability analysis of a solid-body rotation flow. Neutral stability lines of the axisymmetric ($m = 0$) and spiral ($m = 1$) modes are presented in a Reynolds number (Re) versus inlet swirl ratio (ω) operational diagrams for various vortex core sizes of Lamb-Oseen vortex flow. The analysis reveals the significant role of the vortex core size on the onset of the dominant flow instability. The vortex is dominated by $m = 1$ (spiral) modes for a relatively large vortex core size. This behavior shifts to dominant $m = 0$ (axisymmetric) modes for smaller vortex core sizes. The Reynolds-Orr equation is then used to analyze the various production terms of the perturbation's kinetic energy in the vortex core as well as on the pipe boundaries. It is found that for a medium or small core size of the vortex the base flow in the core is actively involved with the perturbation's kinetic energy production in the bulk and onset of axisymmetric instability, while for a large core size the core is much less active. This phenomenon is related to the observed core size effect on the onset of various types of instability modes.

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