AXISYMMETRIC AND NON-AXISYMMETRIC ANNULAR CURTAIN STABILITY

- BIFD 2011 -

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ABSTRACT

A temporal stability analysis is carried out to investigate the stability of an axially moving viscous annular liquid jet subject to axisymmetric and non-axisymmetric disturbances in surrounding viscous gas media. The effect of liquid viscosity, surface tension, gas-to-liquid density ratio, inner-to-outer radius ratio, and gas-to-liquid viscosity ratio on the stability of the jet is studied. Increase in liquid viscosity is found to decrease the growth rate of the unstable disturbances. However, an increase of the most unstable wavenumber with Re is predicted for both small and large viscosity ratios. The surrounding gas density, in the presence of viscosity, always decreases (increases) the growth rate for axisymmetric (non-axisymmetric) disturbances. For axisymmetric disturbances, there exists a critical value of the density ratio, above which the flow becomes stable for very small viscosity ratio, whereas for large viscosity ratio, no stable flow appears in the same range of density ratio. For thin annular jet, the curvature has a significant destabilizing effect on the jet for axisymmetric flow disturbances, whereas for relatively thick annular jet, the maximum growth rate decreases as the inner radius increases, irrespective of the surrounding gas viscosity. The non-axisymmetric disturbances exhibit an opposite tendency with the curvature effect. Surface tension has a strong effect on the degree of instability in the presence of gas viscosity for axisymmetric disturbances, whereas surface tension inhibits the instability of annular jet for non-axisymmetric disturbances. The viscosity ratio stabilizes the flow for both axisymmetric and non-axisymmetric disturbances. However, the dominant wavenumber increases with increasing viscosity ratio. The range of unstable wavenumbers is affected by only the curvature effect in axisymmetric flow, whereas all the stability parameters control the range of unstable wavenumbers in non-axisymmetric flow. Neutral curves are plotted to separate the stable and unstable domain. Finally, comparison between theory and existing experiment leads to good qualitative agreement. A more accurate comparison is not possible given the difference in flow conditions.

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