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# Effect of Surface Tension and Gas–Liquid Density Ratio on the Wave Height and Interfacial Shear Stress in Annular Flows

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## Extended Abstract

In the past decades, the liquid film characteristics of annular flow, such as film thickness and wave height, have been studied extensively. However, most experimental data and analyses available in the literature are limited to the air-water annular flows under near-atmospheric condition, thus the variation in surface tension and gas–liquid density are limited and not well-understood [1–4].

In this study, water and ethanol were used as working liquids, whereas nitrogen and HFC134a gas were used as working gases. The surface tension ranges from 30.7 to 67.4 mN/m and density ratio ranges from 27 to 434. The conductance probe method was used to measure the time-varying liquid film thickness [5]. Two sets of sensors with an accuracy of ± 5% were installed in the test section for the film thickness measurement. The base, average, and maximum film thickness, together with wave height, were obtained after post-processing. Meanwhile, a differential pressure transducer was installed to measure the differential pressure at 0.5–0.105 m downstream the inlet of the test section.

The experimental results show that the base film thickness collapses onto a single curve under the same liquid flow rate when plotted against either gas Weber number or interfacial shear stress acting on the base film, even though the surface tension and density ratio vary in current experiments. It may be concluded that the effect of the surface tension on the base film thickness is relatively small. However, both the maximum film thickness and the height of disturbance wave collapse onto a single curve under the same liquid flow rate when plotted against the gas Weber number rather than the interfacial shear stress. The reason behind this may be that the surface tension tends to retain the shape of the wave crest against the interfacial shear stress. Therefore, the shape of the disturbance wave is decided by the balance between the surface tension and the interfacial shear stress which are reflected in the gas Weber number. Additionally, a direct relationship between the height of disturbance wave and interfacial shear stress was identified, providing a potential method to estimate shear stress from wave characteristics. These findings enhance the understanding of annular flow dynamics and contribute to improving the two-phase flow modelling. Moreover, this work may also contribute to advance the understanding of two-phase flows and support to a wide range of applications, including nuclear power, aerospace, chemical industries, and the development of next-generation cooling systems.

## References

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