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Experimental Study on the Internal Flow Stability for Tangential Entry Conditions in a Swirl Injector

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Abstract

Many theoretical and experimental studies have been conducted to investigate elements of the hydrodynamic process, such as variations in liquid film thickness or air core diameter. From these studies, some theoretical relationships have been established through an approximated analytical solution of flow hydrodynamics in a swirl nozzle. However, experimental studies on elements such as internal flow have not produced conclusive results. In swirl injector, the internal flow is significantly influenced by the tangential entry conditions. Because the tangential entry conditions have influenced on the liquid film thickness, air core formation, spray angle and mass flow rate, it can be said to one of the most important parameters of swirl injector. From the previous study, we confirm that air core shape and liquid film thickness are directly related. Thus, it is possible to investigate the internal flow characteristics for various tangential entry conditions through the visualization of air core in the swirl chamber and the measurement of the liquid film thickness in the orifice. The measurement of liquid film thickness and the visualization of air core formation were conducted using a specially designed injector based on the electrical conductance method and a high-speed camera system, respectively. The swirl injector used in this study was designed and manufactured to have an easily adjustable swirl chamber length or diameter, tangential entry number or diameter. Generally, mass flow rate increased as the water injection pressure increased, the stability of internal flow and the limit point of increase in mass flow rate can be changed by the tangential entry conditions. Unstable internal flow was detected by visualizing air core formation and the liquid film fluctuations of about 10 kHz were detected in specific tangential entry condition. The relation between the variations of liquid film thickness in the orifice and the pressure fluctuations in manifold were analyzed by FFT(Fast Fourier Transform) method. The fluctuations in manifold pressure showed a same tendency with that of liquid film thickness. We analyzed the stability of internal flow with respect to initial inlet angular momentum. From these results, the stability boundary map for the internal flow presented.

Key words: Tangential Entry, Liquid Film Thickness, Air Core, Angular Momentum

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