Quantification of the Transient Mass Flow Rate in a Simplex Swirl Injector

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Abstract

When a heat release and acoustic pressure fluctuations are generated in a combustor by irregular and local combustions, these fluctuations affect the mass flow rate of the propellants injected through the injectors. In addition, variations of the mass flow rate by these fluctuations bring about irregular combustion, which is associated with combustion instability, so that it is very important to identify a mass variation through the pressure fluctuation on the injector and to investigate its transfer function. Therefore, quantification of the variation of the mass flow rate generated in a simplex swirl injector via the injection pressure fluctuation was the subject of an initial study. To acquire the transient mass flow rate in the orifice with time, the axial velocity of flows and the liquid film thickness in the orifice were measured. In an effort to understand the flow area in the orifice, the liquid film thickness was measured by an electric conductance method. In the results, the mass flow rate calculated by the axial velocity and the liquid film thickness measured by the electric conductance method in the orifice were in good agreement with the mass flow rate acquired by the direct measuring method in a small error range within 1 percent in the steady state and within 4 percent for the average mass flow rate in a pulsated state. Also, the amplitude(gain) of the mass flow rate acquired by the proposed direct measuring method was confirmed using the PLLIF technique in the low pressure fluctuation frequency ranges with an error under 6 percent. This study shows that the our proposed method can be used to measure the mass flow rate not only in the steady state but also in the unsteady state(or the pulsated state). Moreover, this method shows very high accuracy based on the experimental results.

Key words: injector dynamics, simplex swirl injector, mass flow rate, pulsation, DPMM, axial velocity, liquid film thickness, amplitude

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