A Study of Gas-Centered Swirl Coaxial Injectors Using X-ray Radiography

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Abstract

Gas-centered swirl coaxial injectors, a specific type of airblast atomizer, are of interest in rocket propulsion applications. These applications require good mixing of the liquid and gas to ensure complete combustion within the engine. While strides are being made on the computational front, predictions of the mass distributions achieved with this type of injector remain too costly or too inaccurate for engineering design. There has been, therefore, a reliance on experimental results. Unfortunately, the mass flow rates and the strong gas phase momentum typically encountered in rocket engines create sprays with high optical densities and render the vast majority of optical and laser techniques ineffective in the near-injector region. Data has been obtainable through mechanical patternation, but the technique has limitations. Time-gated ballistic imaging has also shown promise in rocket injectors but produces quantatitve data only on the size and shape of spray structures. An x-ray radiographic technique with a high-brillance x-ray source (Advanced Photon Source) has been applied to these high-optical-density sprays. To achieve this testing a new, mobile flow facility was constructed; this facility simulates the rocket flows using water and nitrogen instead of fuel and oxidizer. The x-ray radiography technique has been able to measure equilvent path length in gas-centered swirl coaxial injectors at a range of typical operating conditions. These results and their implications for gas-centered swirl coaxial injector performance in liquid rocket engines are discussed.

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