

## **Spray Nonuniformities in Gas-Centered Swirl-Coaxial Injectors**

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### **Abstract**

Experimental studies of gas-centered swirl-coaxial (GCSC) injectors have revealed five basic types of nonuniformities in the spray. Designers must be able to predict and, likely, avoid these nonuniformities if these injectors are to be used in their intended application—rocket engines. In rocket engines nonuniformities can lead to catastrophic failures of the engine. The observed nonuniformities may be grouped as affecting the spray centerline—leaning, bouncing and oscillating—or affecting the temporal distribution of mass—axisymmetric and asymmetric pulsing. Centerline altering behaviors—leaning, bouncing and oscillating—produce sprays whose centerline is not aligned with the injector centerline. Non-uniformities in the temporal mass distribution are termed pulsing and may be asymmetric or axisymmetric depending on the tangential distribution of the film disturbance which leads to similar distributions of the disturbances in the spray's mass. The details of these behaviors are discussed as are possible driving factors and design criteria for avoidance. Centerline disturbances appear largely controlled by operating conditions and can, in general, be minimized or eliminated by operating at high momentum flux ratios. Meanwhile, careful selection of the thickness of the lip initially separating the gas and liquid phases is suggested for minimizing pulsing. Overall, design recommendations for minimizing nonuniformities are made which include high momentum flux ratio operation, moderate lip heights and a move towards smaller injector outlet diameters (within the range tested).

Key words: Air-breathing Engines and Rockets, Instabilities, Swirl, Airblast Atomizers

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