Synchrotron X-Ray Diagnostics for Cavitating Nozzle Flow

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Poster Abstract

Cavitation plays an important role in the structure of fuel sprays. Visible light imaging and multiphase numerical simulation are the prevalent diagnostic tools. However, there remains an unmet need for higher resolution experimental data to validate models and simulations. To this end, quantitative data on the vapor distribution through the whole volume of the nozzle is required. We present a technique for measuring cavitation inside model nozzles through the use of flat-field line of sight radiography using synchrotron X-rays. Unlike phase-contrast imaging, flat field X-ray radiography operates over short propagation distances to prevent phase interference. Such an approach permits a mean quantitative measurement of the vapor fraction & distribution of cavitation zones at high spatial resolutions integrated through the full extent of the nozzle depth via a simple application of the Beer-Lambert law. Unlike raster-scan techniques, the beam is unfocused and gives a full-field depth-integrated absorption measurement in a time-mean sense rather than a time-resolved measurement at a single point. We present the first preliminary results from these new synchrotron X-ray measurements conducted at Sector 7-BM of the Advanced Photon Source at Argonne National Laboratory, Illinois. Gasoline calibration fluid is delivered at steady pressure from a piston-accumulator system and the flow is imaged with monochromatic X-rays at 8 keV. A high resolution incompressible Large Eddy Simulation of the flow has also been undertaken using the Argonne LCRC Fusion cluster. Regions of intense cavitation measured with radiographic X-ray techniques correspond well to the predicted low-pressure separation zone in the nozzle throat, as expected. Further work will include extending the comparison to compressible flow models which can then be directly validated with the experimental measurement of void fraction.

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