Detailed Numerical Analysis of X-ray Radiography in Sprays

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Abstract

Recent studies of spray-related flowfields using synchrotron-based x-ray radiography at the Advanced Photon Source (APS), Argonne National Lab, have produced useful results related to fuel mass fraction. For some, however, it is not clear whether or not the technique can observe intact structures (e.g. a liquid core) inside a spray or not. Here we simulate x-ray radiography using a code that solves the full diffraction problem (Maxwell's equations subject to assumptions that apply in this case) to model accurately several common spray architectures found in the literature. One important finding is that radiography detects the total mass along a line of sight, including intact liquid, drops and in some cases vapor and gas. Under appropriate conditions, radiography reveals liquid mass fraction which is related to the spray breakup rate and gas entrainment; both critical for understanding of sprays. The single point system used at the APS provides a spatially and temporally resolved (but averaged over a number of injections) determination of liquid fuel mass fraction. The potential for confusion between local signal reduction by diffraction and local signal reduction by absorption is also discussed. The issue is not unusual in such circumstances. This potential background problem can be avoided by careful arrangement of the experiment and it is clear that it does not affect the results produced by the Advanced Photon Source.

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