Effects of Internal Cavitation on Breakup of High-Pressure Diesel Sprays

K.-S. Im[1], S.-K. Cheong[2], Christopher F. Powell[2], M.-C. Lai[3], and Jin Wang[*2]

[1] Livermore Software Technology Corp.
Livermore, CA 94551 USA

[2] Argonne National Laboratory
Argonne, IL 60439 USA

[3] Wayne State University
Detorit, MI 48202 USA

Abstract

Breakup process of liquid jets is complex and can be influenced by a large number of parameters including the details of the design of the injector, internal cavitation, flow turbulence, and the physical and thermodynamic states of both liquid and gas. For high-pressure diesel injection systems, the internal orifice geometry of injector nozzle can have a determining influence on earlier breakup and overall spray atomization, which is due to possible cavitation inside the nozzle. To understand the breakup phenomenon with the diesel injection and breakup, time-resolved x-radiography was employed to measure fuel mass distributions in the near-nozzle region of sprays for two simple single-orifice mini-sac nozzles. One has a hydroground orifice inlet, the other one was not subjected to the hydro-grinding process, which has sharp inlet edges. The injection was performed at 1000 bar of injection pressure to a spray chamber was filled with 1 atm helium gas at room temperature. For sprays with short injection duration, the spray cone angles were directly correlated with and dictated by the transient pintle motion in the injection nozzles. With longer injection duration (1 ms), drastically different cone angles were observed for the sprays from the two nozzles in the near-nozzle region (< 5 mm from the orifice exit). Most importantly, a 3D transient simulation of the nozzle internal flow with cavitation models was carried out using CFD techniques. The result has demonstrated that liquid-fuel breakup is extremely sensitive to nozzle internal geometry, especially, at a quasi-steady condition when the injector pintle is fully opened. We can attribute the different spray cone angles to the internal-cavitation-induced jet breakup, clearly demonstrated by numerical simulations of the internal cavitation flows by using the homogeneous equilibrium model.

Key words: x-radiography, cavitation,

[*] wangj@aps.anl.gov