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Comparison of Flow and Cavitation Processes in Conventional and Group-Hole Diesel Injector Nozzles using Numerical Simulations

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Abstract

The high speed, transient cavitating flow distribution inside diesel injector nozzles with consideration of the opening and closing needle valve is calculated using a generalized equation of state (EOS) to describe the fluid density, a homogeneous equilibrium model (HEM) for phase change, and an arbitrary moving mesh to account for needle motion. The KIVA-3V code was modified for the generalized equation of state, and an isothermal acoustic speed formulation, related to the void fraction in two phase flow, was used to account for the rate of fluid volume change due to pressure changes (dV/dP). The needle valve motion was implemented by exploiting the piston motion feature already available in the KIVA code, using the arbitrary Lagrangian-Eulerian (ALE) approach. Cavitation zone formation and development were simulated and compared in three-dimensional real-sized nozzle models for both conventional multi-hole and group-hole arrangements. The effects of geometric factors of the group-hole nozzle on the discharge coefficient, area contraction and density variation were investigated. The temporal evolution of cavitation during the opening and closing of the needle valve was also studied. It is shown that pressure waves and transient flow effects brought about by the time-varying needle motion significantly affect the flow structure and cavitation processes.

Key words: Cavitation, Homogeneous Equilibrium Model, generalized equation of state, KIVA

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