Simulation of Flash-Boiling in Pressure Swirl Injectors

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Abstract

The use of pressure swirl injectors in wall-guided spark ignition direct-injection engines has emerged as a potential solution to decrease the specific fuel consumption of conventional port fuel injection systems. A major hurdle in the use of these injectors is that the spray characteristics, like the cone angle and drop sizes, are sensitive to the operating conditions, especially when the fuel undergoes a phase change process inside the nozzle. This phase change process when driven by thermal effects is known as flash-boiling. A precise control of this mechanism can be used to achieve a well atomized spray with higher cone angles and smaller drop sizes. However, such a control is extremely difficult considering the highly transient nature of the phase-change process. An accurate modeling of flash-boiling is critical if these injectors have to be used in practice. As this phenomenon is mainly driven by inter-phase heat transfer and has a time scale that is comparable to the flow-through times in the system, a finite rate model should be employed for these simulations. In this work, we have used the Homogeneous Relaxation Model to conduct transient, three dimensional simulations of a pressure swirl injector. The geometry includes the inlet swirl ports, the swirl chamber, the injector nozzle and the combustion chamber. A parametric study under four different operating conditions has been conducted and qualitative comparisons with experiments are presented. The working fluid used in the calculations is n-hexane and all its thermophysical properties are obtained from NIST databases.

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