SIMULATING FLASH BOILING NOZZLES

PROF DAVID SCHMIDT (UNIVERSITY OF MASSACHUSETTS)

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Abstract: Flash boiling nozzle flows occur in a wide array of applications including nuclear reactor accident simulation, cryogenic propellant handling, automotive fuel injection, pulsed dose metered inhalers, refrigeration systems, and failure analysis of containment of volatile chemicals. As the fluid flows through a channel the liquid phase vaporizes, decreasing the average density. This decrease in density causes an acceleration due to conservation of mass. As the fluid accelerates, the pressure drops, feeding back into the phase change process.

Simulating these kinds of flow involves multiple scales of heat, mass, and momentum transfer. Constructing a CFD solver that can handle the interplay between the thermodynamic properties and the fluid flow is made challenging by the strong feedback between pressure and the rate of phase change. This talk will discuss how we model flash boiling flows in multiple dimensions and what we learn.

This seminar will reveal the history of the modeling concepts that are used to close the governing equations using ideas that originate, apparently, with Albert Einstein. Late twentieth-century experiments using saturated steam and gamma ray densitometry revealed a correlation for a relaxation time scale that has been formulated as the Homogeneous Relaxation Model (HRM).

The seminar will explain how the HRM approach has yielded a new formulation of CFD code for simulating flash-boiling nozzles. Multi-dimensional simulations of flashing water, iso-octane, ethanol-octane blends, refrigerants, hexane, and liquid nitrogen show a remarkable generality to a model that was originally developed for one-dimensional water flow.

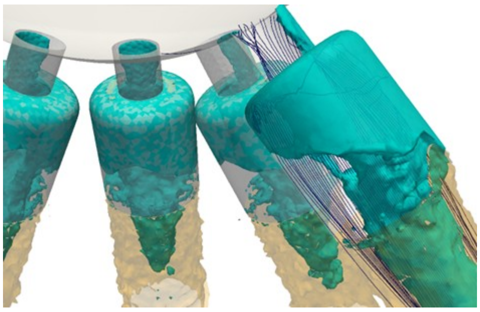
The results show how, in certain shapes of nozzles, behavior analogous to under-expanded and over-expanded supersonic flow may be observed. These predictions are consistent with experimental observations made at the University of Melbourne a few years ago.

Using a stepped-nozzle geometry, a spray can perhaps be manipulated for wider angles and better ambient gas entrainment. The seminar also discusses how the predicted behavior of flashing nozzles can be collapsed with the correct parameters.

Bio: David Schmidt attended North Carolina State University as an undergraduate. He received a Masters of Mechanical Engineering at Stanford University and his PhD. in Mechanical Engineering at the University of Wisconsin, Madison. In 1997, he helped to found Convergent Thinking LLC, a CFD firm that is currently thriving under the name Convergent Science. Concurrently, David joined MIT as a Visiting Scientist. Since 2000, he has served on the faculty of the University of Massachusetts.

Prof. Schmidt's research is in the fluid mechanics of two-phase flow. For his PhD., he studied cavitation in diesel fuel injector nozzles. Since then, he has focused more on flash boiling, external spray evolution, and wind energy. He is the winner of the Office of Naval Research Young Investigator Award, the Ralph Teetor Award from SAE, the Marshall Award from ILASS, and is an SAE Fellow.

David lives in Amherst with his wife, Tracy and their two children. His hobbies are vegetable gardening, Ultimate, and ice hockey.



Simulation of flash boiling through stepped holes.
The green surfaces show high concentrations of vapor.

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