Progress in numerical methods for multidimensional two-phase flows: Conclusions from the EU-project ASTAR

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> Need for improved multidimensional two-phase flow simulation

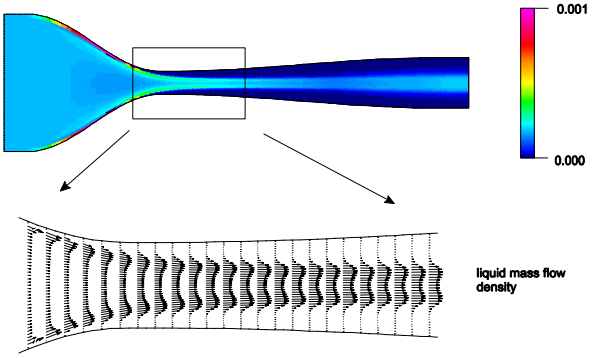
Current thermal-hydraulic system codes are limited by an oversimplified modelling of complex two-phase flow processes and by limitations of the numerical solution methods used in those codes.
A new generation of tools with multidimensional capabilities and improved numerical methods, and the ability to model non-equilibrium flows in an accurate and robust way are developed. Their coupling with existing system codes will further improve the capability of engineers to simulate realistic safety issues. These topics were investigated in the 5th FP EU-project ASTAR (**A**dvanced 3D Two-Phase Flow **S**imulation **T**ools for **A**pplication to **R**eactor Safety, Sept. 2000 – Nov. 2003, FIKS-CT-2000-00050, CEA JRC EDF GRS VKI MMU PSI).

> Advanced numerical methods

Characteristic based upwind methods (hyperbolic methods) were developed and tested in the partners' different codes (OVAP at CEA, *FLU*BOX at GRS, ATFM at JRC). The hyperbolic methods were examined in Benchmark test cases for their suitability for the simulation of multidimensional transient two-phase flows. The methods are of higher order in space and time.

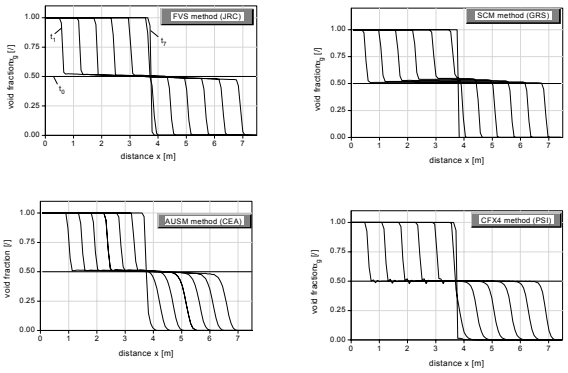
> Examples of simulations

o Multidimensional dispersed flow



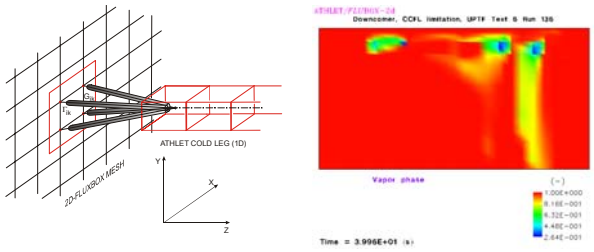
Liquid volume fraction distribution and liquid mass flow density near the nozzle throat; two-dimensional calculation, second order Flux Vector Splitting scheme (JRC)

o Counter-current flow: phase separation



Phase separation problem: time-evolution of void fraction, comparison between FVS (JRC), SCM (GRS), AUSM schemes (CEA) and CFX code (elliptic method).

o Coupling of a multidimensional code with a system code



Coupling of a multidimensional module with a system code: prototype work between ATHLET and *FLU*BOX, example of an application to the UPTF Test 6 case.

> Conclusions:

Accurate and robust hyperbolic numerical solution methods for two-phase flow simulations have reached a high degree of maturity. Their application in multidimensional CFD simulations will allow realistic representations of reactor safety relevant flows.

More information, including proceedings of the International Workshop on Advanced Numerical Methods for Multidimensional Simulation of Two-Phase Flow, can be found at: www.grs.de/astar.

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