A TWO-PHASE FLOW SOLVER BASED ON TWO-FLUID MODELS AND CONSERVATIVE UPWIND RESIDUAL DISTRIBUTION SCHEMES

Dante Tommaso Rubino, Italy
Supervisors: H. Deconinck & M. Ricchiuto

The background of this project is the necessity to improve existing Thermo-Hydraulics codes, for the simulation of the cooling circuit of nuclear power plants. Indeed it is the aim of the ASTAR project (Advanced 3D Two-Phase Flow Simulation Tool for Application to Reactor Safety) supported by the European Commission and involving several European Research Institutes, among which the VKI.

On the other hand, a new Conservative formulation for the Multidimensional Upwind Residual Distribution Schemes has been recently developed in VKI, for which the conservative property no more relies on the existence of a Roe-type linearization. Along with this, a consistent upwind discretization of the source terms has been proposed, which retains the linearity preservation property, and thus second order accuracy at steady state, also for inhomogeneous problems.

The objective of this DC project was therefore to investigate the application of the new Conservative Residual Distribution (CRD) schemes to complex inhomogeneous systems like the two-phase two-fluid model proposed by Städtke, which guarantees hyperbolicity thanks to the particular modelling of the interfacial momentum non-viscous interaction between the two phases.

As a first step, a one dimensional Euler solver has been developed and tested. The non entropy satisfying character of the scheme was pointed out, and a suitable entropy fix was proposed, as the traditional Harten's entropy fix is inapplicable in this case. Boundary conditions and source term implementation was validated on typical inhomogeneous problems.

The two-fluid model was then implemented in a two-phase solver making use of the same numerical approach. Nevertheless, this extension is not straightforward, and difficulties of different kinds had to be overcome, mainly related to stiff source terms and singularities occurring in the eigenstructure of the system of governing equations in certain flow regimes. Finally the two-phase solver has been successfully tested and validated on several steady and unsteady benchmark problems defined in the ASTAR project.

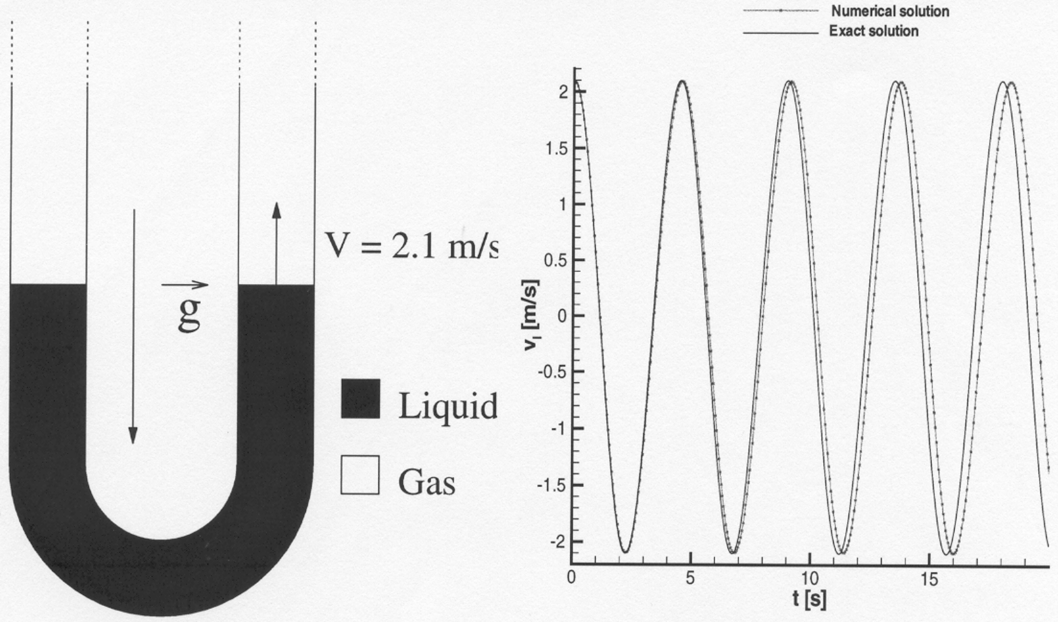

*Figure 1: Oscillating manometer problem. Left:Schematic.
Right:Comparison between analytical and numerical solution for the liquid velocity*