Graduation project on

Modelling Two-Phase Flows

Analysis of several test cases on the onset of waves

Parties involved are:

Introduction

Two-phase flows of liquid and gas can be found in many kinds of industrial processes, such as chemical reactors, oil- and gas pipe lines and water disposal lines. Often these processes contain a stratified flow regime (where the lighter gas flows on top of the heavier fluid), and an unstable phase where waves are formed at the gas/liquid interface. For the design of two-phase flow systems it is of key importance to know which flow regime will occur, as this determines for example the forces on the construction. Experiments and computational modelling will give more insight into the transition from stratified flow to unstable flow with waves. Presently, 1D models are used to predict flow behaviour inside long pipe lines. However, these models are not capable of providing full insight on when transition between the flow regimes occurs, and the current attention has swiched to full 3D models.

Outline of the project

The focus of the project lies on the modelling of two immiscible fluids (like water-air or oil-water) and in particular the transition from stratified flow to wavy flow. At the TU Delft, a method[1] for two phase flows has been developed in the shape of a Fortran program. The MCLS method uniquely combines the advantages of two classical two-phase flow techniques while simultaneously reducing the impact of their individual disadvantages.

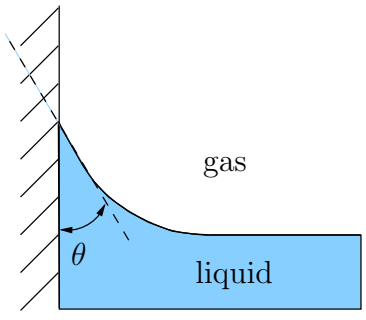

Figure 1: The contanct angle θ at a solid wall in a real life situation.

However, the present code is simply a proof-of-concept and is therefore limited to a small number of test cases. We would like to extend it to be able to do a variety of real life test cases on the

[1] This method is called the 'Mass Conserving Level Set method', or MCLS method. For more info, see the paper 'Computing Three-Dimensional Two-Phase Flows with a Mass-Conserving Level Set Method' by S. van der Pijl.

onset of turbulence. Certain physical aspects therefore require more elaboration: the modelling of the fluid interface near a solid wall for example (see figure 1). At the moment, the interface near the wall is always orthogonal to the wall, but in many cases this is physically incorrect, and several options exist for improving the level of realism. Therefore, this problem requires not only the reprogramming of parts of the code, but also some fundamental physical research.

The project will roughly entail:

- A thorough literature study on current methods (Level Set/Volume-of-Fluid) for two-phase, immiscible flows, and the associated problem on boundary conditions for the level set approach.
- Formulation of a number of boundary condition candidates for the MCLS method.
- Implementation of the boundary conditions in the MCLS code.
- Simulation of several test cases (with a focus on the transition to wavy flow, for example so called Kelvin-Helmholtz waves: see figure 2).
- Validation of the results.

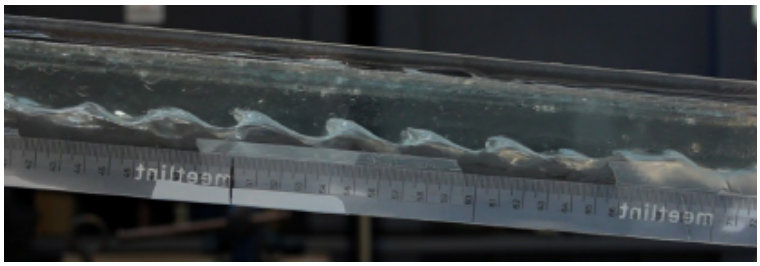

Figure 2: An early sign of transition to wavy flow are perturbations called Kelvin-Helmholtz waves.

Time line

The following provisionary time line is proposed.