Numerical analysis of multiphase flows

Similarly to the single-phase case, even a multiphase flow (i.e., flows where two or more phases – liquid, gas or solid – coexist) can be subject of numerical analysis in order to find an approximate solution of some transient problems. Starting from the Navier -Stokes equations and using appropriate models and closure equations, we can get systems of equations then numerically solved by calculator.

Among these models we remember the homogeneous model, the drift-flux model and the two-fluid model. There are also many methods for the numerical discretization of such models, in order to obtain stable codes for the simulation of different scenarios (for example, given a horizontal tube, i.e. a pipeline, which transports oil and gas and given some initial and boundary conditions, we can obtain the real-time profiles of some characteristic variables of the system, as the volumetric fraction of liquid) . Finally, through numerical analysis, it is possible to make simulations of production or flow assurance system.

So, a first step of our work activity is the implementation of stable and strong numerical codes for the simulation and prediction of multiphase flows behavior in pipes.

Inverse problem

A research field of multiphase flows currently in fast development, based on numerical codes, is represented by the search for a solution to the inverse problem, i.e. the possibility to estimate real-time values and trends of some variables of the problem (the volumetric flow rates in entrance to the pipes, some parameters, etc.) knowing only the values of some variables by measurements (especially in the industrial field, for example, in a wellbore, only the outlet variables or pressure profiles are easily measured) . To achieve this we can use the usual methods of numerical analysis for direct problems (for example the first step described above) in combination with mathematical recursive filters (sequential methods), such as the Kalman filter, which at each time step adjust the values of the unknowns of the problem, comparing them with real time measurements (soft- sensing and data assimilation problems). The solution of this kind of problems (i.e. the estimation of the trends of the characteristic values of a system knowning only some measurements, the second step of our work) will allows us, especially in the oil industry, to optimize the management of mining and flow assurance of hydrocarbons.