MODEL REFINEMENT AND IMPLEMENTATION OF A PSPG/SUPG-STABILIZED FINITE ELEMENT ALGORITHM FOR INCOMPRESSIBLE LAMINAR TWO-PHASE FLOW

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Over the last years the von Karman Institute has been involved in two European Union 5th framework projects (DESINER and SPECTRUM), which deal with the development of tools for the simulation of two-phase flow in electrochemical reactors. In the present project, a solver for incompressible viscous two-phase flow is further developed. It starts from an Eulerian-Eulerian two-fluid model, based on the incompressible Navier-Stokes equations. The two phases are treated as non-mixing continua and are coupled by their volume fractions. Interactions between the phases are taken into account in terms of drag, lift and virtual mass forces.

A Galerkin Finite Element Method has been adopted in the spatial discretization. This approach was chosen for different reasons. First of all, the Galerkin method features a successful background of SUPG and PSPG stabilization techniques connected with this method. Furthermore, is is possible to couple the two-phase flow solver with a Finite Element based electrochemistry solver (MIOTRAS), which is developed by VKI contract partners.

A recently developed two-phase flow solver, which was the output of a preceding DC project, has been the basis for the present work. It was enhanced and advanced in many ways in the present project. First of all, the solver was extended to a fully implicit time integration method to increase its effciency. Then, the system of governing equations was rearranged to obtain a more consistent treatment of the volume fraction and a symmetric formulation. Moreover, an interphase coupling model in the form of additional source terms was implemented to gain a better modeling of the physical flow phenomena. Finally, the stability of the algorithm was improved by the implementation of a suitable limiting method for the volume fraction.

The algorithm was transfered from a MATLAB platform, on which the previously developed solver was implemented, to a C++ platform. This was done to implement the present solver in the MIOTRAS code. The validation of the code was performed through different testcases. The results clearly show the positive effects of the enhancements mentioned above. Figure 1 shows the pressure contour together with streamlines and velocity profiles of the gas phase for a T-junction with developed two-phase flow (50% gas) imposed at the inlets.

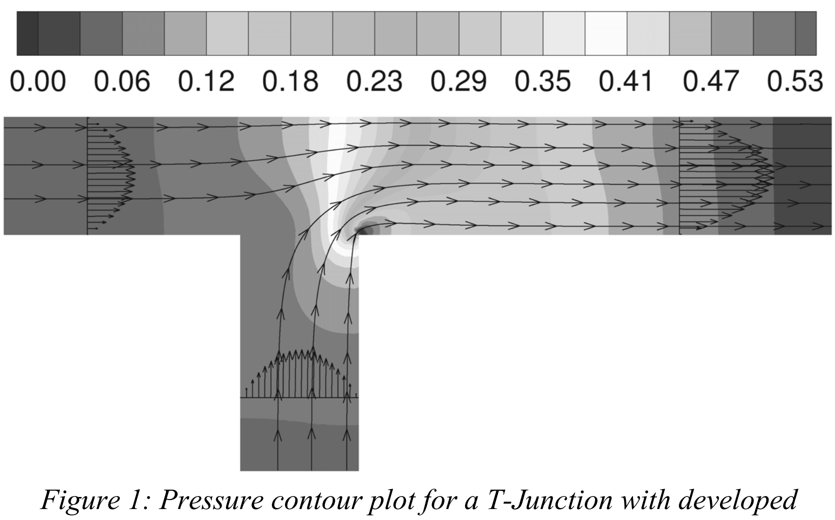

Figure 1: Pressure contour plot for a T-Junction with developed two-phase flow imposed at the inlets, Re = 100.