DEVELOPMENT AND VALIDATION OF A STABILIZED FINITE ELEMENT SOLVERFOR VARIABLE DENSITY FLOWS

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This VKI Diploma Course project deals with computational fluid dynamics. The work was performed within the COOLFluiD environment, a VKI in-house developed code. COOLFluiD[1] is an Collaborative Simulation Environment (CSE) focused on complex MultiPhysics simulations. We have been working with COOLFluiD's plugin called UFEM, that solves incompressible Navier-Stokes equations. This project was motivated by a need of a variable density flow solver able to solve industrial problems.

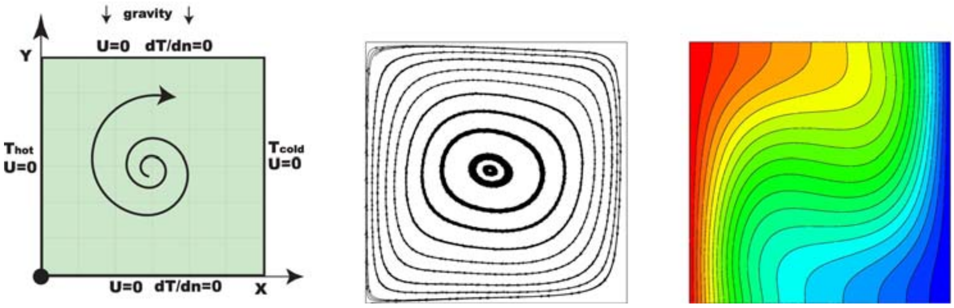
In this report, we go step by step and show the path going from incompressible Navier-Stokes code to the code that solves variable density flow. Four different physical models are described and solved.

There is a number of testcases used for validation of the code. This work deals with following testcases: lid-driven cavity flow, natural convection cavity flow (heated cavity), non-uniformly heated cavity, flow around the cylinder and convection-diffusion testcase.

The UFEM (Unstructured Finite Element Method) plugin is both two-dimensional and three dimensional, these modules were developing simultaneously. For all the computations it was used 3D module, but for simplicity all testcases are displayed 2D-like.

For the spatial discretization the Galerkin Finite Element Method is used with standard stabilization: terms PSPG, SUPG & BULK. The temporal discretization is used Crank-Nicholson scheme. All the computations are performed on the unstructured grids using triangular/tetrahedral elements.

The project mainly deals with laminar models and regimes of flow. A minor part of this project is also the connection to Large Eddy Simulation to solve turbulent flow, giving some information about LES in general and about the model that was implemented. The LES model is called Wall Adapting Local Eddy viscosity model (WALE). The model was implemented but not widely tested.



(a) Cavity Domain ***(b) Velocity Streamtraces*** ***(c) Temperature***

Figure 1: Illustration of natural cavity flow

[1] ***http://coolfluidsrv.vki.ac.be/coolfluid***