ThisVKIDiplomaCourseprojectdealswithcomputationalfluiddynamics. Theworkwasperformedwithinthe COOLFluiDenvironment,aVKIin-housedevelopedcode. COOLFluiD isanCollaborativeSimulation Environment(CSE)focusedoncomplexMultiPhysicssimulations. WehavebeenworkingwithCOOLFluiD’s plugincalledUFEM,that solves incompressibleNavier-Stokes equations. This projectwasmotivatedbya need ofa variable density flow solverable to solves industrial problems.

Inthisreport, we go step by step and show the path going from incompressibleNavier-Stokes code to the code that solves variable density flow. Four differentphysical models are described and solved.

Thereis a number of testcases used for validation of the code. This workdeals withfollowing testcases: lid-driven cavity flow, natural convection cavity flow (heated cavity), non-uniformly heated cavity, flow around the cylinder and convection-diffusion testcase.

TheUFEM(UnstructuredFiniteElementMethod)pluginis bothtwo-dimensionaland threedimensional, these modules were developing simultaneously. For all the computations it was used 3D module, but for simplicity all testcases are displayed 2D-like.

Forthespatial discretization the Galerkin Finite Element Method is used with standardstabilization: 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.

Theprojectmainlydealswith 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 viscositymodel (WALE). The model was implemented but not widely tested.

![Illustration of natural cavity flow](http://coolfluidsrv.vki.ac.be/coolfluid)