# DEVELOPMENT OF AN EULERIAN-EULERIAN LES SOLVER FOR TURBULENT TWO-PHASE FLOWS

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Within the IWT/SBO project MuTEch (www.vki.ac.be/mutech), the VKI collaborates with Flemish academic institutions (VUB, KUL, UGent) and large industrial partners (Agfa-Gevaert, Bekaert) on the development of experimental and numerical tools to study turbulent heat, mass and charge transfer in electro-chemical reactors. This PhD project aims at fulfilling part of the MuTEch objectives, by constructing an LES/DES solver for turbulent flows in complex 3D geometries. Emphasis is put on the development of very fast solution techniques for the unsteady incompressible single and two-phase Navier-Stokes equations, on 3D unstructured meshes.

As an alternative to unsteady solvers based upon an explicit or a fully implicit nonlinear treatment of the convective terms, a fully implicit scheme has been proposed. The resulting method is of second order accurate in both space and time, has absolute linear stability and requires only a single or two linear system solution per time step. The scheme proved to be applicable, numerical results on both 2D and 3D test cases indicate that substantial savings in computational times can be realized for certain test cases. A 2D/3D incompressible stabilized Finite Element Method based Navier-Stokes solver called Morpheus has been developed for that purpose, and all the numerical aspects are successfully implemented in this framework. The method has also been published. The Large-Eddy simulation plug-in has been developed as an independent module, supporting easy reuse in different solvers. This module consists of several LES models: Smagorinsky, dynamic Smagorinsky and WALE. The validation is an ongoing process, mostly focusing on the flow past a cylinder and the turbulent channel (and its electrochemical equivalence, the parallel flow reactor).

The technology of the Navier-Stokes/LES solver has also been implemented in COOLFluiD environment and currently used in several industry-related projects. In the past year it has also been extended and partially validated for solving RANS (Spalart-Allmaras and k-epsilon models) and/or variable density flows.

Further improvements have been achieved with the unsteady, incompressible, laminar Eulerian-Eulerian two-phase flow solver. Focus has been put on the proper stabilization mechanism, which now allows computations with real material properties (like combination of water and air as primary and secondary phase). However, there are still some numerical issues, which need to be investigated.

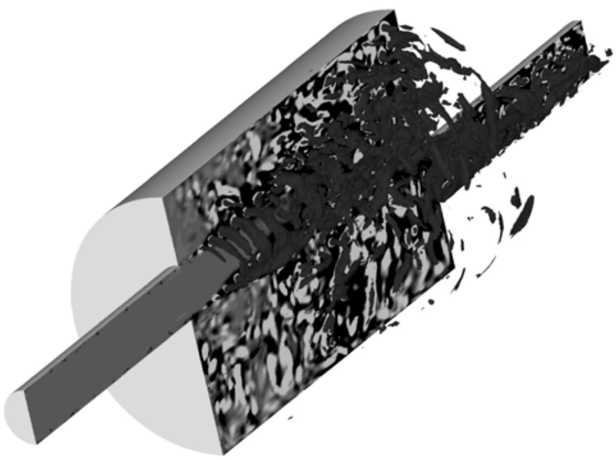

***Figure 1: LES simulation of a muffler at Reynolds number 50000 (iso surfaces of Q and greyscale contour plot of Q at the center plane)***

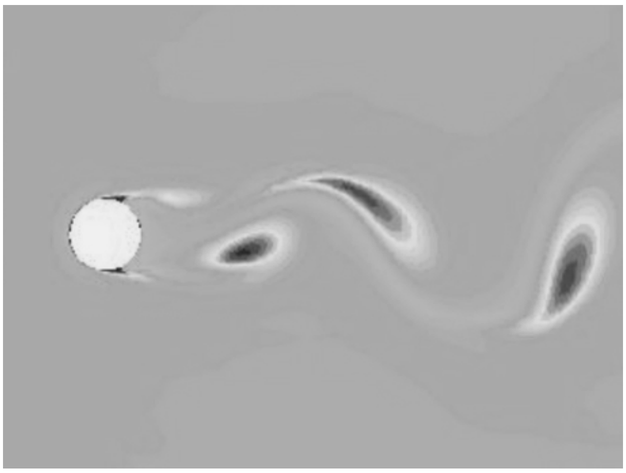

***Figure 2: Laminar two-phase flow past the cylinder at low Reynolds number (contour plot of volume fraction)***