MONOLITHIC NEWTON-MULTIGRID SOLVER FOR MULTIPHASE FLOW PROBLEMS

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ABSTRACT

We have developed a monolithic Newton-multigrid solver for multiphase flow problems which solves velocity, pressure and interface position simultaneously. The main idea of our work is based on the formulations discussed in [1], where it points out the feasibility of a fully implicit monolithic solver for multiphase flow problems via two formulations, a curvature free level set approach and a curvature free cut-off material function approach. Both formulations are fully implicit and have the advantages of requiring less regularity, since neither normals nor curvature are explicitly calculated, and no capillary time restriction has to be respected. Furthermore, standard Navier-Stokes solvers might be used, which do not have to take into account inhomogeneous force terms. The reinitialization issue is integrated within the formulations.

The nonlinearity is treated with a Newton-type solver with divided difference evaluation of the Jacobian matrices. The resulting linearized system inside of the outer Newton solver is a typical saddle point problem which is solved using a geometrical multigrid method with Vanka-like smoother using higher order stable Q_2/P_1^{disc} FEM for velocity and pressure and Q_2 for all other variables. The method is implemented into an existing software package for the numerical simulation of multiphase flows (FeatFlow). The robustness and accuracy of this solver is tested for two different test cases, static bubble and oscillating bubble [2], respectively.

References

[1] A. Ouazzi, S. Turek, H. Damanik. *A Curvature-Free Multiphase Flow Solver via Surface Stress-Based Formulation*, Int. J. Num. Meth. Fluids. 88 (2018), 18–33.

[2] M. A. Afaq, S. Turek, A. Ouazzi, A. Fatima. *Monolithic Newton-Multigrid Solver for Multiphase Flow Problems with Surface Tension*, 6th ECCOMAS Young Investigators Conference 7th-9th July 2021, Valencia, Spain. doi: 10.4995/YIC2021.2021.12390.

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