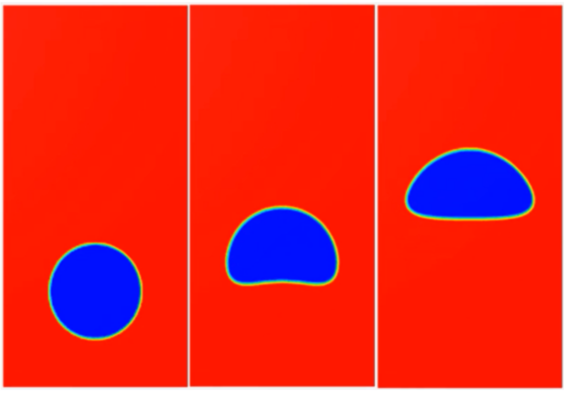
Numerical Simulation of Rising Bubble in Non-Newtonian Fluids Using the Volume of Fluid Method in OpenFOAM

Examiner: Prof. Dr. sc. nat. ETH Insa Neuweiler
Supervisor: M.Sc. Rahul Krishna

Motivation:



The behavior of bubbles in non-Newtonian fluids is of interest due to its relevance in various industrial processes, including chemical reactors, bioreactors, and polymer processing. Non-Newtonian fluids exhibit complex rheological behaviors such as shear-thinning or viscoelastic properties, which significantly influence bubble dynamics, including shape deformation and terminal velocity. Understanding and accurately modeling this behavior is crucial for improving the design and efficiency of multiphase flow systems. OpenFOAM, an open-source CFD tool, offers powerful solvers that use the Volume of Fluid (VOF) method to model multiphase flows. This study aims to leverage these solvers to simulate the rise of bubble in non-Newtonian fluids and compare the numerical results with available experimental data. The outcome will contribute to better insights into the dynamics of bubble rise in complex fluids, facilitating improved modeling approaches for industrial applications.

Objectives:

The primary objective of this thesis is to numerically simulate the rise of a single bubble in non-Newtonian fluids using OpenFOAM's VOF-based solver. The study will compare the simulation results with published experimental data to validate the accuracy of the model. Furthermore, the project will investigate how variations in fluid properties, such as viscosity and elasticity, impact bubble dynamics, shape deformation, and terminal velocity. The research will also explore potential improvements in numerical settings, such as mesh refinement and solver configurations, to optimize the accuracy and computational efficiency of simulations.

Contact:

Rahul Krishna
Tel. +49 511 762 4205
E-Mail: krishna@hydromech.uni-hannover.de

References:

[1] Zhang, L., Yang, C., & Mao, Z. S. (2010). Numerical simulation of a bubble rising in shear-thinning fluids. Journal of Non-Newtonian Fluid Mechanics, 165(11-12), 555-567.
[2] Esposito, G., Dimakopoulos, Y., & Tsamopoulos, J. (2023). Buoyancy driven flow of a viscous drop in viscoelastic materials. Journal of Non-Newtonian Fluid Mechanics, 321, 105124.
[3] Premlata, A. R., Tripathi, M. K., Karri, B., & Sahu, K. C. (2017). Dynamics of an air bubble rising in a non-Newtonian liquid in the axisymmetric regime. Journal of non-Newtonian fluid mechanics, 239, 53-61.
[4] Gamet, L., Scala, M., Roenby, J., Scheufler, H., & Pierson, J. L. (2020). Validation of volume-of-fluid OpenFOAM® isoAdvector solvers using single bubble benchmarks. Computers & Fluids, 213, 104722.