Investigation of the Dynamics of Fluid Particles using the Volume of Fluid Method

Abstract of the dissertation by Martin Schmidtke

Two phase flows occur in many natural and technological processes. An example of a two phase flow is the free rise of fluid particles (bubbles and droplets) in a liquid. In bubble columns and extraction devices many fluid particles move simultaneously. For the simulation of their movement in such devices, models for the momentum transfer between the particles and the surrounding fluid are needed. Such models can be obtained either from experimental observations or by simulations of single fluid particles.

The simulations presented in this thesis were performed with the CFD code *FS3D* which is based on the Volume of Fluid (VoF) method. The code is validated using analytical solutions for creeping flows and a good agreement is observed between simulation and analytical solution.

In the first part of the thesis, the free rise of oil drops in water is simulated and compared with experimental observations. The results show that the rising velocities and the drag coefficients are similar in both cases, but the simulated drops are flatter (more oblate). This difference may be caused by impurities of the particle surface (surfactants) in the experiments. The simulations show that the transition from rectilinear to periodic trajectories is caused by instabilities in the wake, which lead to a periodic vortex shedding.

In the second part of the thesis, the rise of bubbles in linear shear flows is investigated. If bubbles rise in a vertical shear flow, a lateral migration can be observed. This migration is caused by the so called lift force. Sign and magnitude of the lift force depend on the size of the bubble and the material properties of the liquid. The simulation results show that the sign of the lift force on spherical bubbles can be explained by the Bernoulli effect. However, the lift force on more distorted bubbles acts in the opposite direction. This phenomenon can also be observed in the simulation. In this work several hypotheses for the reason of this phenomenon are checked.

Furthermore, most common correlation for the lift force (developed by Tomiyama et al. in 2002) is validated for fluids of known material and model fluids with arbitrary material data. The correlation is valid in a wider range of fluid material properties than proved experimentally up to now.