Analysis of different multiphase CFD models for aerated stirred bioreactors

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Biopharmaceuticals are a rapidly growing market with enormous potential in the pharmaceutical industry. The oxygen supply of the cells has a significant influence on cell growth and product yield. For this reason, biopharmaceutical manufacturers and their bioreactor suppliers are interested in optimizing the oxygen supply.

Computational Fluid Dynamics (CFD) was used to calculate the oxygen mass transfer rate in stirred bioreactors with bubbling aeration via a bottom-mounted sparger. To calculate the oxygen mass transfer rate, OpenFOAM 7 was used for these complex simulations, whereby the calculations were performed in parallel on a High-Performance Computer.

Preliminary investigations have shown that both the VOF model (*interFoam*) and the compressible VOF model (*compressibleInterFoam*) are unsuitable for the calculation of oxygen mass transfer due to their lack of accuracy. Simulations with the Euler-Euler model (*twoPhaseEulerFoam*) showed significantly better agreement with experimental data, but the calculated oxygen mass transfer rate was still about 50% higher than in the experiments. One reason could be the missing consideration of gas bubble breakup and coalescence. Therefore, various investigations were carried out using a population balance model (PBM) coupled with the Euler-Euler model (*reactingTwoPhaseEulerFoam*). The results were in better agreement with the experimental data when compared to the standard Euler-Euler model.

In order to verify the generality for all sizes of bioreactors, further validation work such as *Shadowgraphy* to determine the gas bubble size and the measurement of the oxygen mass transfer rate will be carried out. With the help of the successfully established PBM-coupled CFD model, it is possible to calculate the oxygen gas mass transfer for stirred and aerated bioreactors. Thus, bioreactor and process design can be accomplished before prototyping and time-consuming and cost-intensive laboratory experiments can be reduced.