University of Stuttgart
Institute for Combustion Technology (ITV)

Bachelor or Master Thesis

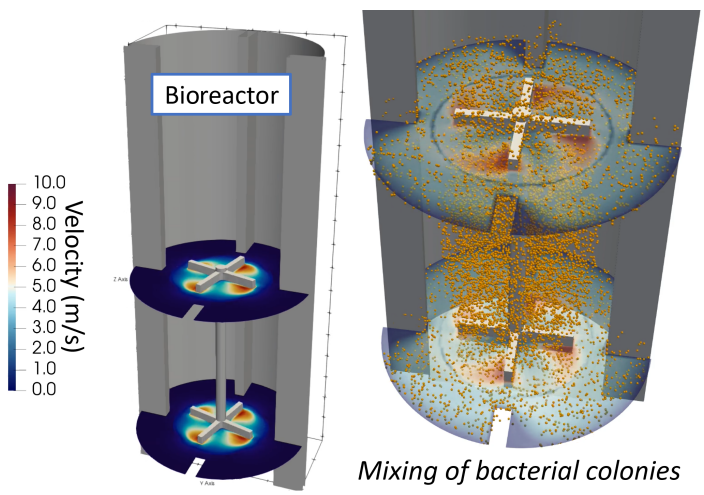
Simulation of Bioreactors

Motivation

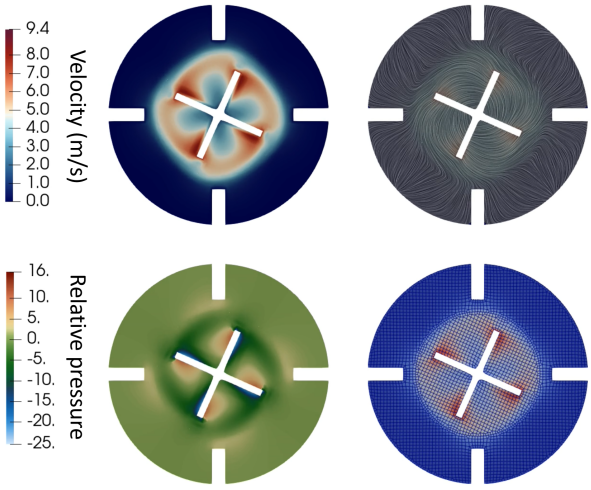
Bioreactors are an important part of many industries. They are used in medical applications for the production of vaccine components, in the food industry—like beer brewing—the production of biogas for providing sustainable energy or the treatment of sewage and waste recycling. They work by having microorganisms or enzymes submerged in a liquid, which is continually provided with oxygen, nutrients and reactants. To better understand the processes inside bioreactors and to optimize current reactor designs, simulations of the conversion inside the reactors can be performed. However, the complex physical processes and the different time scales governing industrial-scale reactors make detailed simulations with current computing power difficult.

Project description and research goals

The aim of this project is to set up generic simulation setups for laboratory and industrial-scale bioreactors with the industry-standard simulation tool OpenFOAM. The Figure below shows simulation results of a bioreactor used in an industrial process. The reactor itself is filled with water and nutrients, which are mixed with the bacterial colonies using two impellers (figure on the left showing the flow inside the reactor). The bacterial colonies (yellow spheres in the second picture) move with the flow field and distribute throughout the reactor while consuming the reactants and oxygen. The figure on the right shows a more detailed analysis of the flow and pressure in the vicinity of the impellers.



(a) Simulation of an industrial cylindrical bioreactor with two impellers for mixing, filled with water and bacterial colonies (yellow spheres)



(b) Analysis of flow field around the impellers.

There are many open research questions regarding the simulation of bioreactors, like which models can best describe the bio-chemical processes, which simulation approach can successfully reduce overall simulation times and how can the overall process be optimized.

Tasks

- Do a literature review to learn about bioreactors and numerical simulations with OpenFOAM
- Perform numerical simulations of the flow and bio-chemical processes inside bioreactors
- Assess different models with regard to accuracy and simulation times
- Evaluate and analyze the simulation results
- Write a thesis and present your results

Prerequisites

- Basic knowledge in fluid dynamics, programming with Matlab, Python or similar
- Beneficial: knowledge in C/C++, experience with computational fluid dynamics (CFD), OpenFOAM

Contact

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