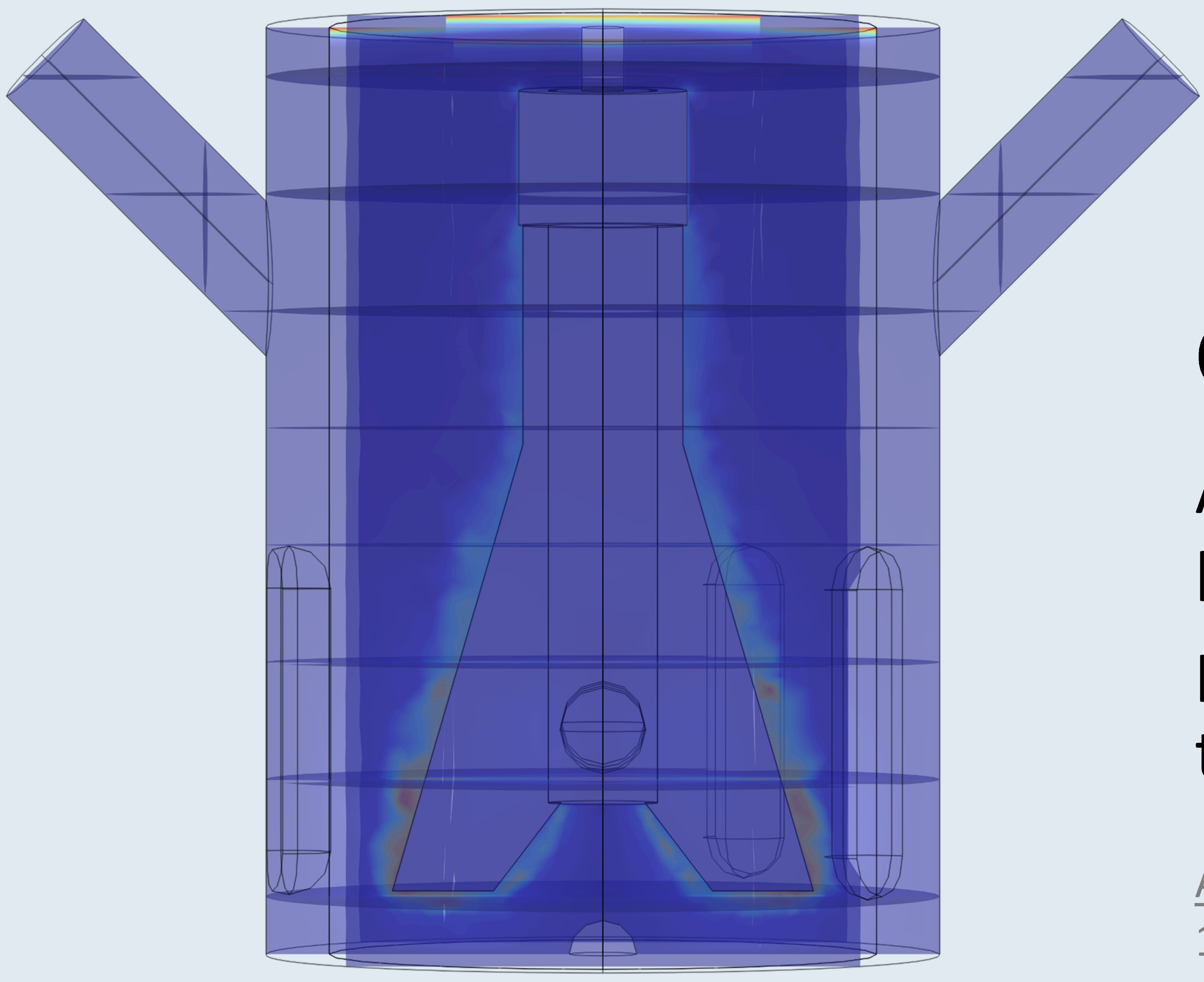

CFD Simulation of a Bioreactor in 3D

Analyzing the properties of a Corning® 250 mL bioreactor to deliver velocity field, concentration, particle movement using laminar flow and transport of diluted species.

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Abstract

Bioreactors play a crucial role in cultivating biological cells for various applications, such as pharmaceutical production and tissue engineering. Optimizing the cultivation process requires a deep understanding of the flow characteristics within the bioreactor medium. In this project, the goal is to create a comprehensive simulation for a specific bioreactor that investigates the effects of different parameters on cultivation within the affected bioreactor. Using Computational Fluid Dynamics (CFD), specifically utilizing the Laminar Flow and Transport of Diluted Species interfaces in COMSOL Multiphysics®, the complex flow patterns and distribution of particles within the bioreactor are analyzed. The simulation provides valuable insights into the dynamics of laminar flows, particle transport, and particle behavior, which are crucial factors for processes like cell growth and productivity.

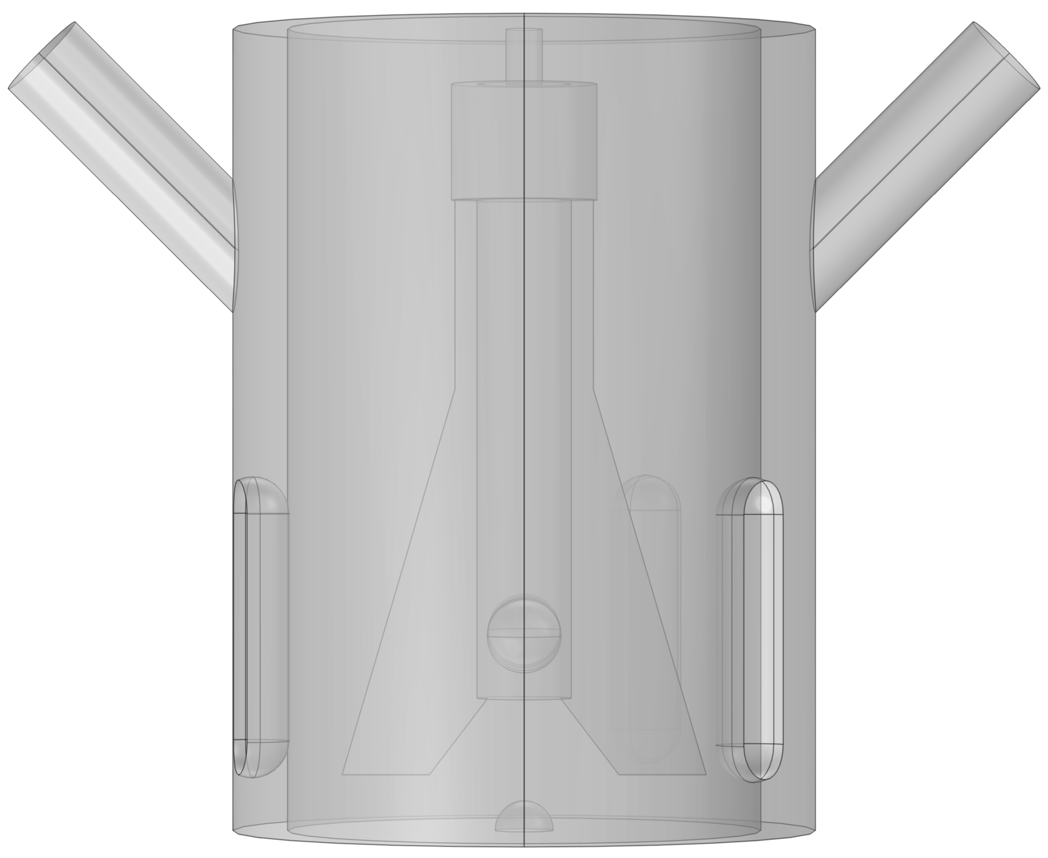


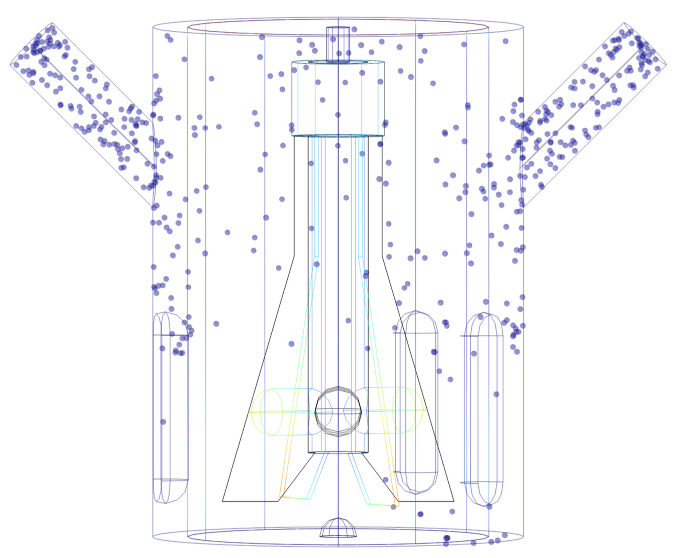
FIGURE 1. Final 3D geometry

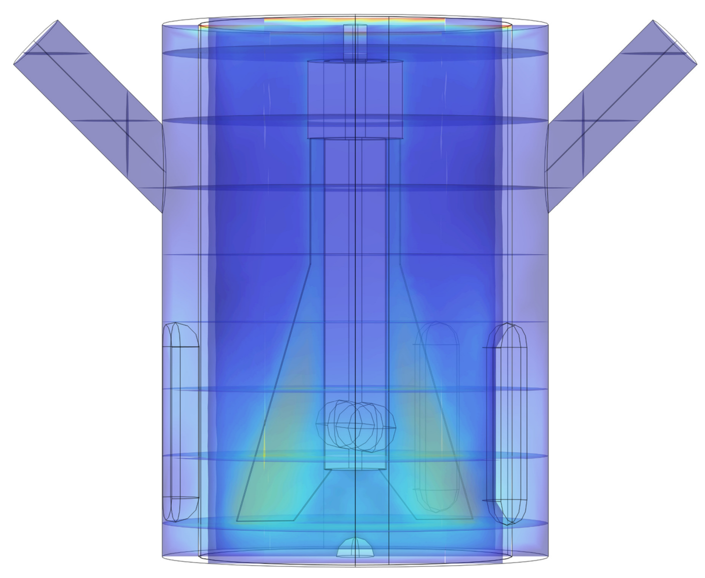
Methodology

Using Laminar Flow and Transport of Diluted Species the basic properties of this bioreactor were analyzed and investigated. The rotor speed was set to 20 RPM and water was selected as material to investigate the basic environment. For the motion of the rotor a rotating mesh was set. The geometric dimensions were measured and taken from the actual bioreactor in the lab and incorporated into the COMSOL project accordingly. For this project a time-dependent study was implemented (30 seconds in steps of 0.1 seconds) to optimally capture the details of the bioreactor during the simulation.

Results

The velocity field is as expected, with the velocity being highest near the rotor and decreasing as moving further away from it. A precise velocity can not be anticipated initially, as it depends on various factors, including the geometry of the reactor, the rotor itself, and other reactor properties. In the pressure profile, it can be observed that the highest pressure is located near the walls, which was expected. This can be explained by the fact that the rotor generates an axial flow through its rotations, which moves the fluid from the center of the bioreactor towards the walls and then back up towards the rotor. The incorporation of three baffles into the bioreactor plays a crucial role in reducing pressure in the walls. First investigation of particle concentration shows good homogenization, but further studies are required.





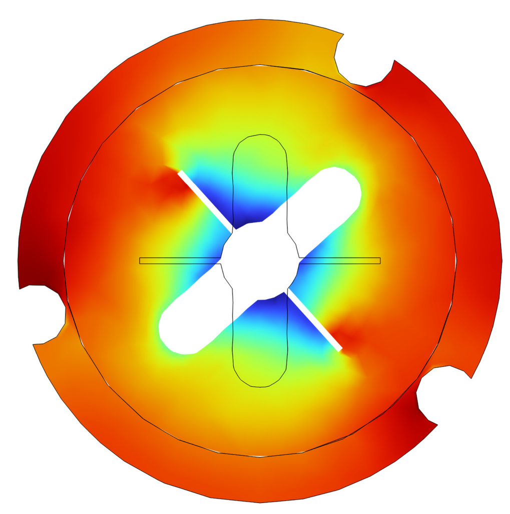


FIGURE 2. Upper left: 3D particle concentration, upper right: 3D Velocity field. Bottom right: 2D pressure

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