1) Modelling and optimization of the hydrodynamics of an Anaerobic Stirred Tank Reactor

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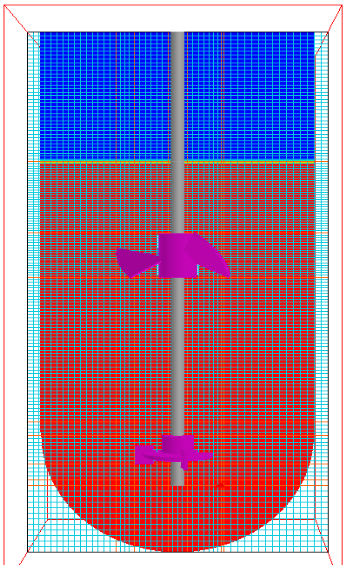
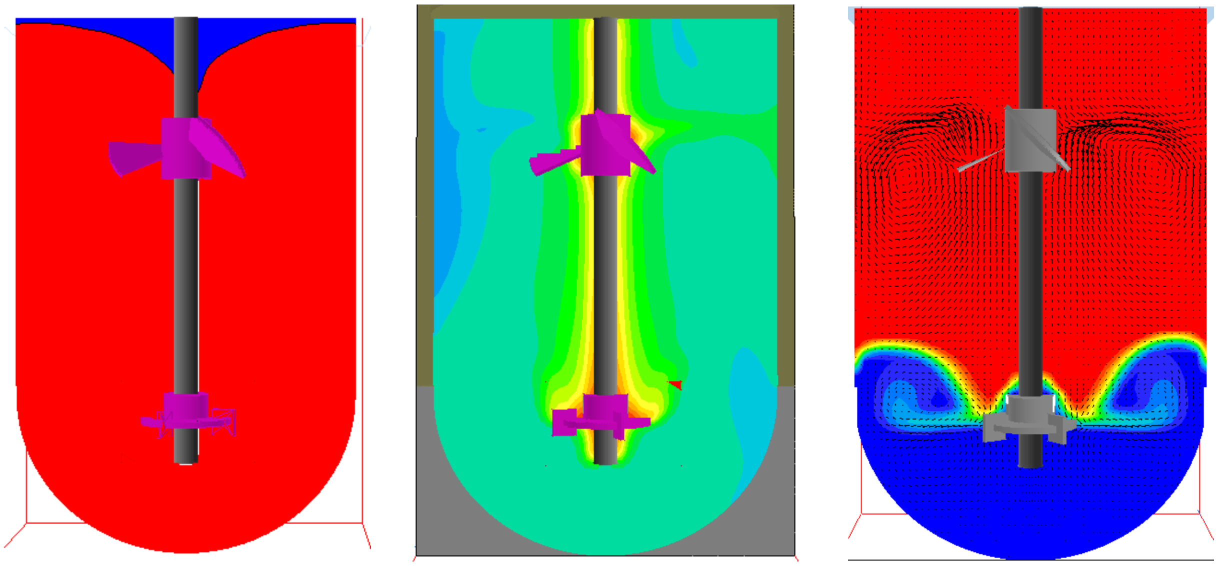
The objective of the present project is to enhance and optimize the design of an anaerobic stirred tank bioreactor for scale-up purpose and for turning batch to continuous processing. CFD constitutes in this case a useful tool to better elucidate the complex interplay between the reactor geometry and the operating conditions on the one hand, and mixing and biochemical reaction on the other hand. The figure below illustrates the design of the 5-litre bioreactor when operated with suspended straw-like biomass (left), and of the 3D mesh (right: a structured grid with 58×58×120 cells) with the two turbine impellers devoted to liquid homogenization and solid suspension, respectively.



PHOENICS software was used with MOFOR to simulate the rotation of the impeller. The study was conducted in four steps:

1. MOFOR was coupled to SEM (Scalar Equation Model) to investigate vortex formation, as an un-baffled stirred tank is used to avoid stationary solid in the region of the baffles. Anaerobic fermentation is currently driven at low rotation speed, but a minimum value is required to maintain the suspension of solid biomass, as shown below on the left side. A compromise has been found between mixing, solid suspension and vortex prevention.
2. Mixing of a passive tracer in the liquid phase was studied. Hydrodynamics was modelled using the k-ε Chen model for turbulence, using the MUSCL discretization scheme, which was shown to correspond to the best compromise between computation time and accuracy, even at low rotation speed. A typical example of tracer dispersion is shown below, in the middle. The objective was to improve the position of the impellers.
3. As biomass suspension occurred before vortex formation, this was simulated using the Algebraic Slip model in comparison with experimental data, as shown below on the right side figure, shows how the position of the bottom impeller induces solid suspension and enables the optimization of its position as a function of the amount of solid waste.



Vortex formation **Concentration profile** **Onset of solid suspension**

4. The last and ongoing step consists in implementing a simplified version of the Anaerobic Digestion Model 1 (ADM1) that describes the biochemical conversion of biomass into bio-hydrogen, assuming that glucose and inorganic nitrogen are the substrates, into PHOENICS software using In-Form facility. This constitutes a great challenge, as coupling ADM1 with CFD this has been reported only last year for the first time.

As a conclusion, the comparison between experiments and 3D simulations has shown the ability of PHOENICS to model the multi-scale phenomena involving gas-liquid separated phases, a solid dispersed phase and biochemical reaction has been assessed, even though further work is still needed implement the complete structure of the ADM1 model.

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