Computational Analysis of Hydrodynamics and Light Distribution in Algal Photo-Bioreactors

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Abstract

Microalgae can be directly used in health food or as biofilters for waste water treatment. They also have numerous commercial applications in cosmetics, aquaculture and chemical industry as a source of highly valuable molecules, e.g., polyunsaturated fatty acids [1]. Moreover, they are increasingly recognized as a promising source for biodiesel production [2]. To realize the full potential of microalgae, optimal operating conditions for their cultivation in photo-bioreactors (PBR) need to be identified in order to maximize productivity, lipid content, and efficiency of photosynthesis. The most important parameters affecting PBR performance are reactor shape, light intensity distribution, algae growth and other metabolic properties.
The presented study aims at optimizing these parameters using Computational Fluid Dynamics (CFD) simulations with the COMSOL Multiphysics® software. Specifically, flat panel photo-bioreactors with turbulent mixing due to air sparging and one-sided lighting are studied. First, flow profiles of both liquid and gas phases are computed using the Turbulent Bubbly Flow interface for analyzing the air sparging and detecting potential dead zones for different shapes of flat panel PBR. Then, light intensity distributions are calculated inside the PBR, based on absorption and light scattering by algae and gas bubbles. Subsequently, the Particle Tracing Module is used to determine the paths of individual algae cells and the environmental conditions they are exposed to being recorded over time, in particular aeration and light intensity. Results of the above described simulation stages will be presented and discussed.

Reference

[1] Spolaore et al., Commercial applications of microalgae, J. Biosci. Bioeng., Vol. 101, pp. 87-96 (2006).

[2] Bitog et al., Application of computational fluid dynamics for modeling and designing photobioreactors for microalgae production: A review, Comput. Electron. Agr., Vol. 76, pp. 131-147 (2011).

Figures used in the abstract

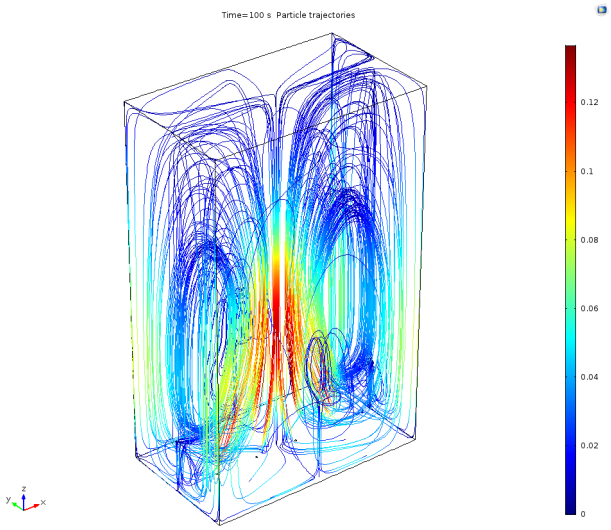

Figure 1: Trace of 25 particles starting from different initial locations for 100 seconds.