Split airlift Photobioreactor for High-value Microalgae Culturing: Characterization of Hydrodynamics by using (RPT) and (CT)

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Highlights

- *3D* Flow dynamics parameters in split airlift photobioreactor including the microalgae culturing.
- Non-Invasive gamma-ray measurements techniques.
- *3D* Gas-holdup distributions through the growth time.

1. Introduction

Microalgae has great potential to be used for wide range of applications, such as biofuel, wastewater treatment and CO2 fixation. They have been cultured in both open and closed Photobioreactors. For efficient growth of the targeted microalgae, the optimizing of the photobioreactors designs and operating parameters are still the major challenging. Particularly, in larger growth scale of microalgae, the technical issue is not related to cultivation aspects but also, to hydrodynamics transport and to how the physical properties of the culturing medium are varying. Moreover, the physical properties of the microalgae culturing are changeable, and that might extremely affect the flow dynamics of the multiphase flow system, this effect is not fully understood. Therefore, this work focuses on advancing the culturing of high-value microalgae and study the hydrodynamics parameters in the photobioreactor including the effected growth. And utilizing the advanced non-invasive Radioactive Particle Tracking (RPT) and Dual-Sources Gamma Ray Computed Tomography (CT) measurement techniques to investigate flow features for this system. These are the only technique capable of providing the varying in culturing medium in 3D field in a non-invasive manner and in opaque systems for the whole reactor domain. Liquid velocity field, turbulent kinetics parameters, shear stress, and cross-sectional gas-hold distribution were measured for this system.

2. Methods

In this work, *Scenedesmus* green microalgae was growing in Plexiglas airlift photobioreactors (split column) with a diameter of 5.5 in and 59 in high. A Plexiglas plate was inserted in the center of the column and divided the reactor into two equivalent areas: a riser section and a downcomer section with the clearance at the bottom of 2 inches. A 5 cm diameter of stainless steel ring sparger was used in this reactor. The sparger have 15 evenly distributed of 1 mm diameter holes, placed at the top phase of the sparger tube and it is built-up in 4 cm above the column base in the riser zone (gases injection zone). The configurations of the split column, with the dimensions, is shown in **Figure 1**. In this experiments, the sparger was used to flowing the gases (air+3%CO_2) through into a tap water at ambient conditions at superficial gas velocity (Ug) of 1.0 and 3.0 cm/sec. The measurements techniques (RPT) and (CT) were shown in **Figure 2 & 3**.

3. Results and discussion

Figure 4, **Figure 5, and Figure 6** are shows a sample of the results of 3D liquid velocity field, 3D gas holdup distribution and axial velocity behaviors. The study covered the effect of microalgae culturing on the flow dynamics parameters which is extremely effect on the overall photobioreactor performance. Furthermore, in case of culturing of the microorganism's cells the hydrodynamics coming the important tools to enhance the design and scale up, which is lead to develop the growth system. The obtained experimental results will provide a benchmarking data for the airlift photobioreactor (air-water-Algae) system for evaluation and validation computational fluid dynamics (CFD) simulation. However, more results and findings of this investigation will be presented at the conference day.

4. Conclusions

RPT and CT are a promising techniques for multiphase flow system including microorganism cell cultivation process by finding the details of hydrodynamics parameters in 3D manner in opaque systems for the whole reactor domain. The advanced information which obtained from this investigation crystallize the understanding and knowledge of photobioreactor behavior.

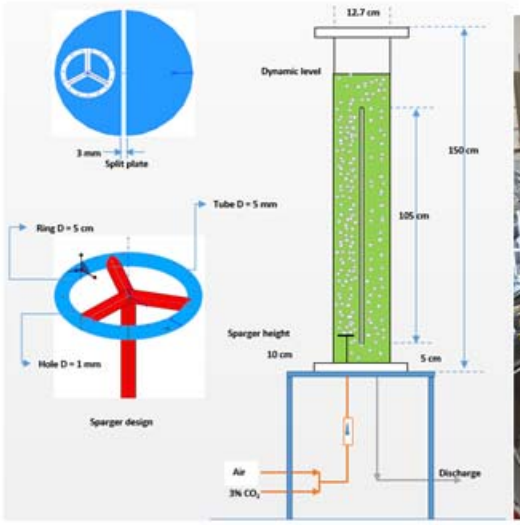

Figure 1. Schematic diagram for split airlift reactor with the ring sparger

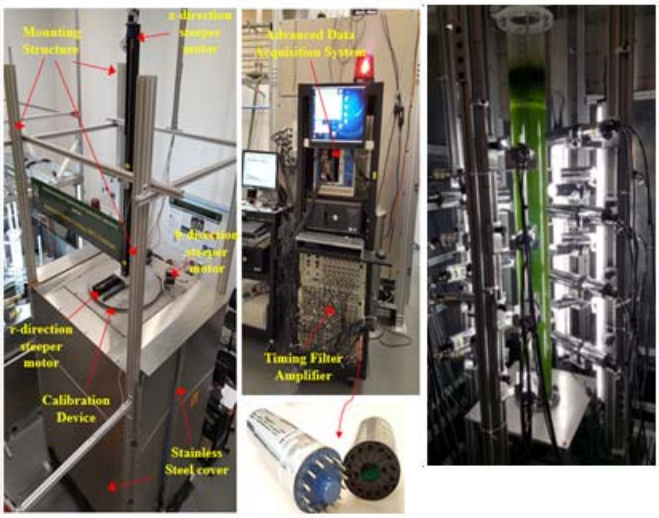

Figure 2. Advanced non-invasive Radioactive Particle Tracking (RPT)

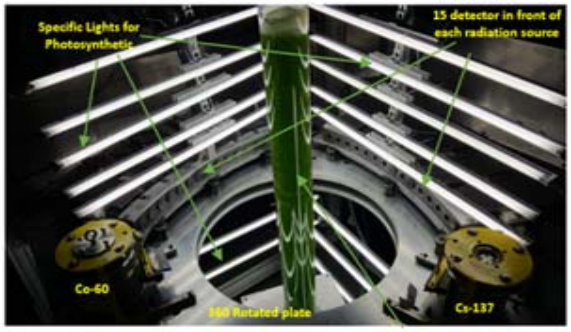

Figure 3. Advanced non-invasive Computed Tomography (CT)

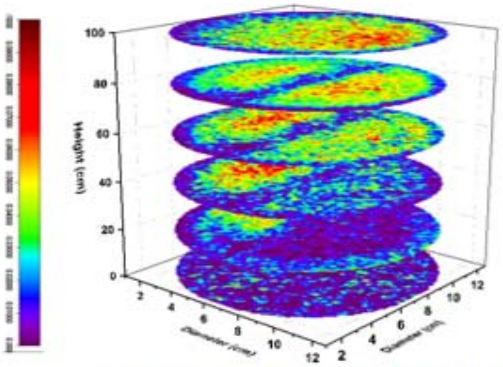

Figure 5. 3D Visualization of Gas-Holdup Distribution at superficial gas velocity 3 cm/sec, by CT technique.

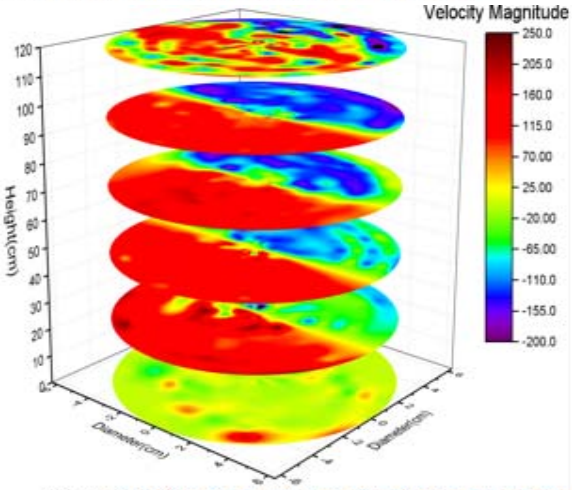

Figure 4. 3D Visualization of Liquid Flow Field at superficial gas velocity 3 cm/sec, by RPT technique.

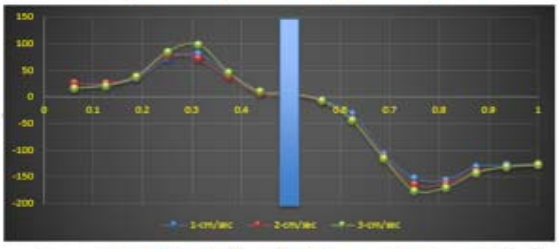

Figure 6 Axial Liquid Flow Field at superficial gas velocity 3 cm/sec, by RPT technique.

Keywords: Microalgae, Split Photobioreactor, RPT, CT, Hydrodynamics.