
# Influence of Bundle of Heat Exchanging Tubes, their Configuration, and Column Size on the Gas Holdup Distributions in Bubble column Via Gamma-Ray Computed Tomography

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***Highlights***

- Imaging gas holdup distributions in the pilot-scale bubble columns with and without tubes.
- Gas holdup enhanced at the center and the wall regions of the column based on the insertion of tubes.
- Gas holdup distribution over entire cross-sectional area of the column influenced by the configuration of tubes.

## 1. Introduction

Bubble/slurry bubble columns equipped with a bundle of the heat exchanging tubes are well-fitted reactors for conducting highly exothermic reactions such as Fischer-Tropsch (FT) synthesis, liquid phase methanol (LPMeOH) synthesis, dimethyl ether (DME) production, and many others. Although there are a wide variety of applications of bubble/slurry bubble columns, designing and scaling-up of these reactors are still hard engineering tasks due to the complex behavior of multiphase flow pattern and an absence of a phenomenological model that can reliably predict the flow pattern for these columns. Additionally, the presence of dense geometry of vertical tubes inside these reactors will further alter the flow structure and mixing intensities. As a result, they make the design and scale-up even more challenging and complicated. Therefore, a comprehensive understanding of these impacts of vertical tubes on the hydrodynamics of these reactors is much needed to successfully design, scale-up, and optimize the performance of bubble/slurry bubble column equipped with a bundle of the heat exchanging tubes. Unfortunately, up-to-date, the knowledge of gas-liquid distribution for large-scale bubble column with intense vertical internals is not available in open literature. Therefore, an endeavor has been made in this communication to fill this gap through visualization and quantification for the first time by using an advanced gamma-ray computed tomography (CT) technique: (i) the impact of the bundle of the vertical internals on the gas holdup distributions and their profiles; (ii) the effect of tubes configurations (hexagonal and circular arrangements) on the gas holdup distributions and their profiles; (ii) the effect of superficial gas velocity on the gas holdup distributions and their diametrical profiles; and (iv) the impact of the size of bubble column on the gas holdup distributions and their profiles.

## 2. Methods

Gas-liquid distribution and gas holdup profiles were visualized and quantified in a pilot-scale Plexiglas bubble column of 18-inch (0.46 m) diameter and height of 144 inches (3.66 m). A schematic diagram of the pilot-scale bubble column equipped with dense vertical internals is displayed in **Figure 1**. In this study, the bubble column was fitted with a gas distributor, which is installed above the gas chamber (plenum). This gas distributor is a stainless steel perforated plate designed with 241 holes, each 3 mm in diameter, as exhibited in **Figure 2a**. A bundle of 75 Plexiglas vertical internals filling 25% of the total cross-sectional area (CSA) of the column was utilized in this study to represent the heat exchanging tubes used in the FT synthesis. Each Plexiglas vertical internal having a diameter of 1-inch (2.54 cm) and a height of 4 m. Two different geometric arrangements for these vertical internals, namely hexagonal and circular configurations, were examined in this current work, as shown in **Figure 2b** and **c**. In this work, the bubble columns with and without internals were operated at ambient pressure and temperature with continuous mode for gas (air) phase and batch mode for liquid (water) phase. In this study, a wide range of superficial gas velocity (particularly with range 5-45 cm/s) was examined to cover the homogenous and heterogeneous flow regimes. The cross-sectional gas holdup distributions and their diametrical profiles of the bubble columns in the


absence and presence of vertical internals tubes were measured at one axial level of 1.3 m (z/D=3) by using an advanced gamma-ray computed tomography (CT) technique (**Figure 3)**.

## 3. Results and discussion

The sample of the results of gas holdup distribution and their profiles for bubble columns with and without vertical internal tubes are exhibited in **Figure 4**, **Figure 5, and Figure 6**. However, more results and findings of this investigation will be presented at the conference day. the obtained experimental data will expand the database for the bubble column with vertical tubes for the air-water system and serve as benchmarking data for evaluation and validation of three-dimensional (3D) computational fluid dynamics (CFD) simulation toward enhancing the prediction of the hydrodynamics of these columns.

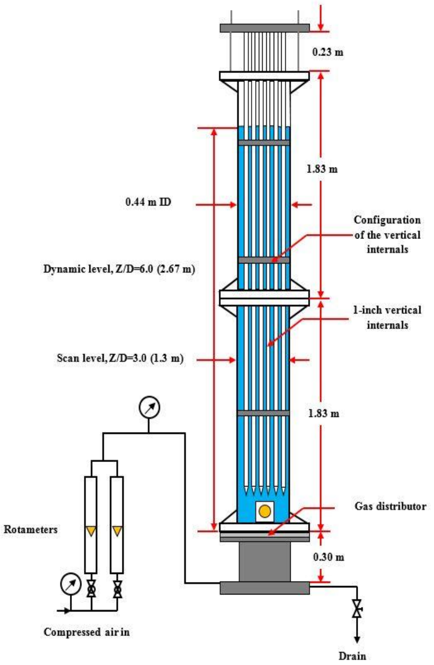


**Figure 1.** Schematic diagram of the 18-inch bubble column equipped with dense vertical internals.

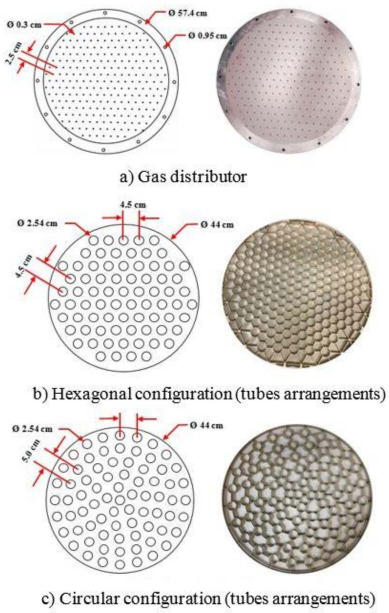


**Figure 2.** Schematic and photos of gas distributor and vertical tubes configuration

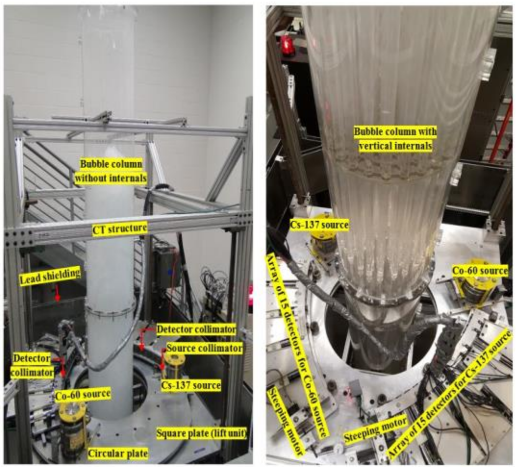


**Figure3.** Photos of DSCT technique with pilot-scale bubble column with and without vertical internals.

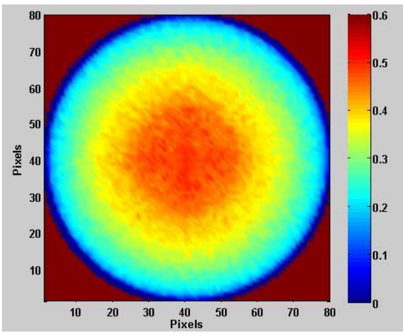


**Figure 4.** Gas holdup distribution of the bubble column without vertical tubes at superficial gas velocity of 45 cm/s

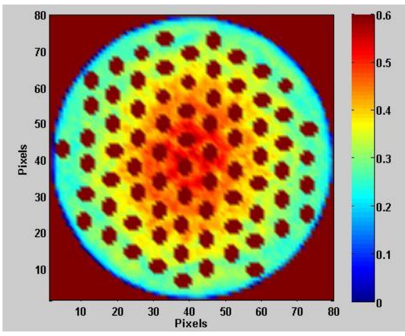


**Figure 5.** Gas holdup distribution of the bubble column with vertical tubes at superficial gas velocity of 45 cm/s

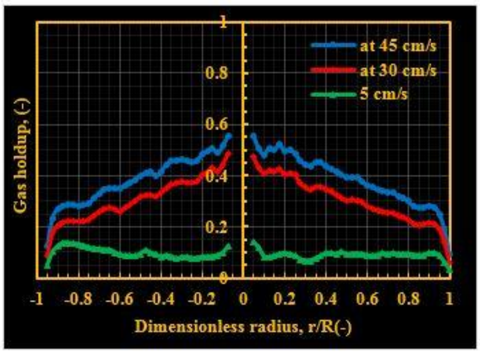


**Figure 6.** Gas holdup profiles of the bubble column with vertical tubes at different superficial gas velocities

***Keywords***

"Bubble column with vertical internal tubes; local gas holdup distribution; gamma ray computed tomography".