Single Bubble Dynamics in A Dense Phase Fluidized Bed Gasification Environment in the Presence of Biomass Pellets

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1. Introduction

Biomass gasification in fluidized beds is a process of important commercial value [1]–[3]. Simulation of these fluidized bed units strongly depends on establishing bubble dynamics in dense phase sand fluidized beds in the presence of biomass [4]. In the present study, a single bubble model is studied, and this to provide a phenomenological based framework for fully fluidized beds sand beds with several coexisting bubbles.

2. Methods

Prior studies were developed by our research team at CREC-UWO measuring bubbles with the CREC Optiprobe system [5] in the presence of biomass [6]. To improve bubble dynamics studies, a combination of CREC Optical Probe system and a video camera is employed. Bubble velocity, and bubble dimensions, both vertical (bubble axial chord or BAC) and horizontal (bubble frontal radius) were measured. The effects of biomass pellet concentration on bubble rise velocity (BRV), bubble size and shape are evaluated at conditions close to minimum fluidization. On this basis, two theoretical bubble models were considered. The first one is based on a spherical cap-shaped bubble with flat bubble-wake interphase, which is consistent with classic works in the matter [7] The second bubble shape model considered, has irregular bubble-wake interphase, consistent with recently obtained bubble images [8].

These phenomenologically based models use the wake fraction to relate the bubble and the wake sizes, while additionally, including a wake angle parameter. These two models allow us to provide a theoretical based bubble axial cord and bubble frontal radius predictions with air volume as the only input. Finally, bubble rising velocity as predicted in previous studies is compared with a single bubble rise velocity in the presence of biomass.

3. Results and discussion

The experimental data were collected using a 44 cm diameter and 40 cm of height fluidized bed, loaded with sand with a particle size distribution from 200 µm to 900 µm, centered at 580 µm, and a biomass pellet with dimensions 2.7 cm in length and 0.8 cm in diameter. This is an anticipated reactor geometry and biomass pellet geometry in biomass gasifiers. The measurements without any treatment show and the CREC Optiprobes as described in Figure 1 shows, an increment on the noise and a divergence from the theoretical values that grow with the injected volume. Thus, a data treatment was designed to improve the experimental data and close the bubble volume balance.

Figure 2 reports a comparison between different models of bubble rise velocity [4] and the experimental measured BRV and BAC of the bubbles produced with 5% vol. of biomass present in the bed. It is shown that the biomass makes the bubbles both smaller and slower. It is also shown that smaller bubbles are closer to the lines of the theoretical models than the bigger bubbles that tend to be more scatter and far from their predicted position in the plot.

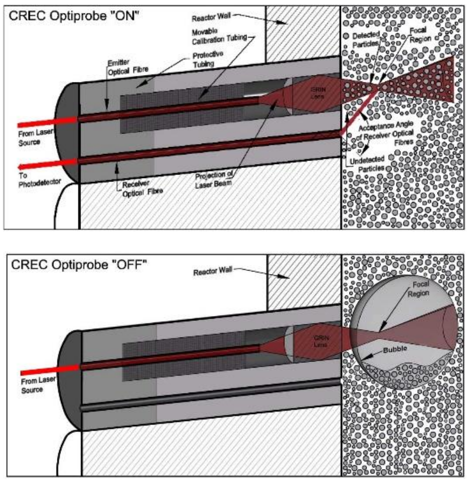

Figure 1. Schematic representation of the CREC Optiprobe ON (no bubble detected) and OFF (bubble detected).

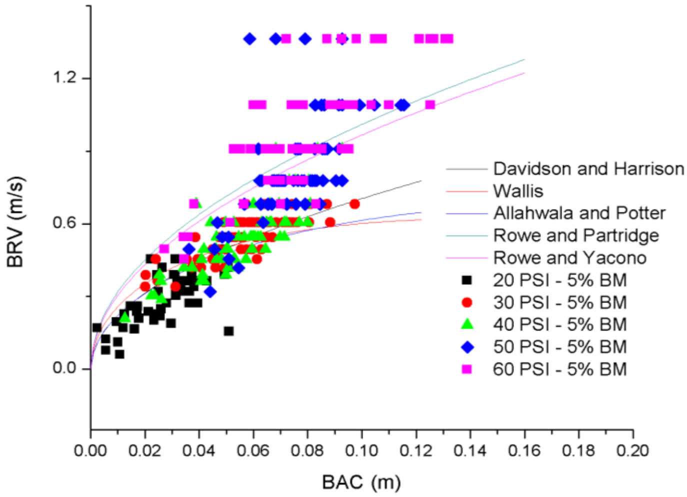

Figure 2. BRV (Bubble Rise Velocity) as a function of BAC (Bubble Axial Chord).

4. Conclusions

a) It is shown that a combined CREC-Optiprobe and video camera methodology can be employed to study bubbles in sand fluidized beds.

b) It is proven that the proposed approach can be employed for modeling tridimensional bubbles and inner bubble interfaces.

c) It is demonstrated that the proposed methodology can be employed in sand fluidized beds using analog biomass pellets in the 5v%-10v% range. This shows that calculated BACs are consistently reduced with increased biomass loading.

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