CHARACTERIZATION OF WAKE PROPERTIES IN FREELY BUBBLING FLUIDIZED BEDS USING PARTICLE IMAGE VELOCIMETRY

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The performance of fluidized beds in many physical or chemical operations is predominantly determined by the hydrodynamics and mass transfer characteristics. However, a proper description of a fluidized bed using phenomenological models requires correlations based on many different assumptions for the bubble and emulsion phases, where most of these assumptions have not been validated thoroughly at different operating conditions. One of the most typical assumptions is the fact that the wake of a bubble rises with exactly the same velocity as the bubble and occupies a specific and constant fraction in the bed, commonly around 15% of the bubble volume (1). The wake fraction has been studied using optical techniques and the geometry of the single bubbles injected has been analysed at different experimental conditions (2). However, these results are mainly based on geometric observations, and are not based on specific properties of fluidized beds. In this study, two new methods for the characterization of wake properties in fluidized beds are developed and studied based on the dynamics of the solids phase.

Particle Image Velocimetry (PIV) allows to determine the solids phase velocity profiles in detail, which is used for the investigation of the wake properties. PIV combined with Digital Image Analysis (DIA) can provide the average solids mass fluxes throughout the fluidized bed, along with the bubble properties. When relating all positive solids fluxes to the solids carried along by the bubbles in their wakes, the average wake fraction can be obtained directly, as presented in the Figure 1. This method provides information on average results and therefore accounts for all bubbles observed during the experimental evaluation.

The second method is based on the identification of individual bubbles in the bed and the subsequent comparison of the bubble velocity to the solids velocities in the vicinities of the bubbles (Figure 2). For this second method, the fraction of the bed with a velocity within a certain range of the bubble velocity is defined as wake. This allows the wake fraction to be analysed as a function of the bubble properties and not as a function of geometry.

Both methods have been evaluated for different experimental conditions such as gas velocities or particle properties and a better fundamental understanding and correlation of the wake characteristics has been obtained.

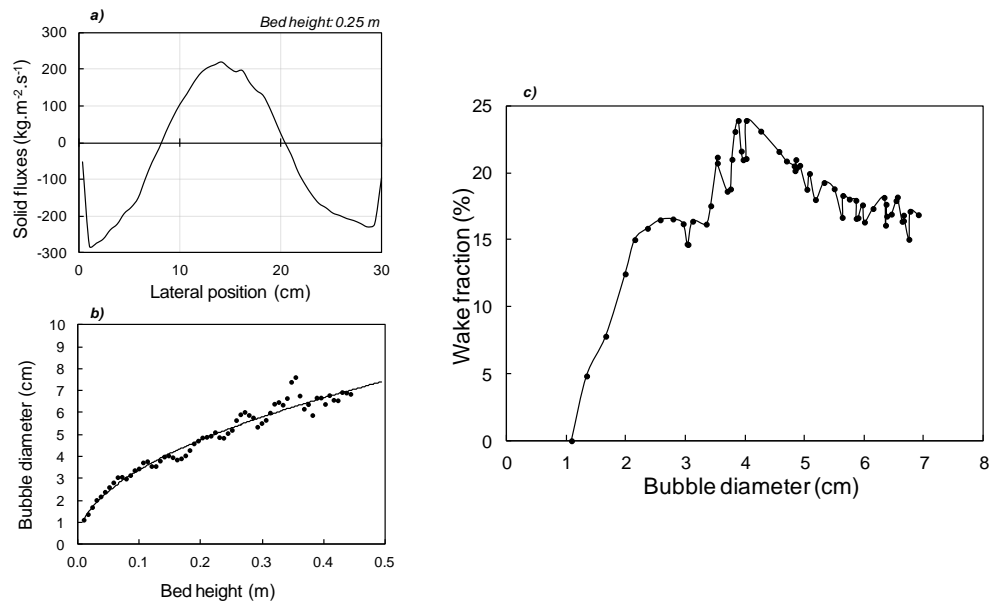SECOND PAGE: FIGURES AND TABLES OF THE ABSTRACT

Figure 1. Experimental solid fluxes at a bed height of 0.25 m (a), experimental average bubble diameter as a function of axial position (b) and wake fraction as a function of bubble diameter as calculated through method 1 (c).
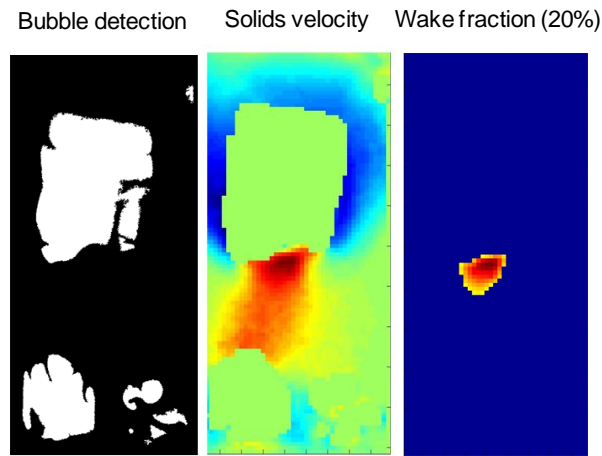

Figure 2. Description of method 2 for a proper wake determination based on the comparison between solid velocity in the vicinity of a bubble and its rise velocity

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