The Dispersion of Particles within Foams

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The motion of particles within foams has important industrial relevance. Froth flotation is an important separation technology in the minerals industry, as well as in paper de-inking and water treatment. The motion of the particles within the foam has a major impact on the performance of the equipment. Within these flotation froths there are particles that are attached to the air/water interfaces, as well particles that are not attached to the interfaces. The attached particles are thus predominantly associated with the films within the foam, while the unattached particles are predominantly found within the Plateau borders.

This study focuses on the unattached particles, as their motion is the most complex to model. Unattached particles predominantly follow the net motion of the liquid, but are able to move relative to the liquid by means of both settling and dispersion. Two types of dispersion have been identified; Geometric dispersion and Plateau border dispersion. The Geometric dispersion is brought about by the layout of the Plateau borders within the foam. These Plateau border form for an interconnected branching network throughout the foam and any particles must thus follow a meandering course through the foam. This results in dispersion in a direction perpendicular to the net liquid motion (Neethling and Cilliers, 2002).

Plateau border dispersion is a result of the velocity profile of the liquid in Plateau borders. The liquid/gas interfaces of Plateau borders are not necessarily fully mobile, but are able to support a certain amount of shear, either by surface viscosity or Marangoni stresses. Seeing that the interfaces of the Plateau borders are not fully mobile and, in many circumstances, can actually be considered immobile (Verbist *et al.*, 1996), the liquid velocity at the interface will be substantially different to that near the centre of the Plateau border. The liquid velocity profile across the Plateau border results in dispersion of the suspended particles in a direction parallel to the direction of net liquid motion. It is this Plateau border dispersion that is the focus of the work described here.

Optical detectors were placed on a column of foam in order to measure the concentration of particles within the Plateau borders. The foam was undergoing continuous forced drainage so that the liquid content was constant over virtually all the height of the foam. The optical sensors are sensitive to changes in both solids concentration and the liquid content. It was thus important to add the particles in such a way that the total volumetric flow rate into the foam was not affected by the solid addition. This was achieved by means of a switch that very rapidly substituted a portion of the water feed with an equal volume of solid suspension.

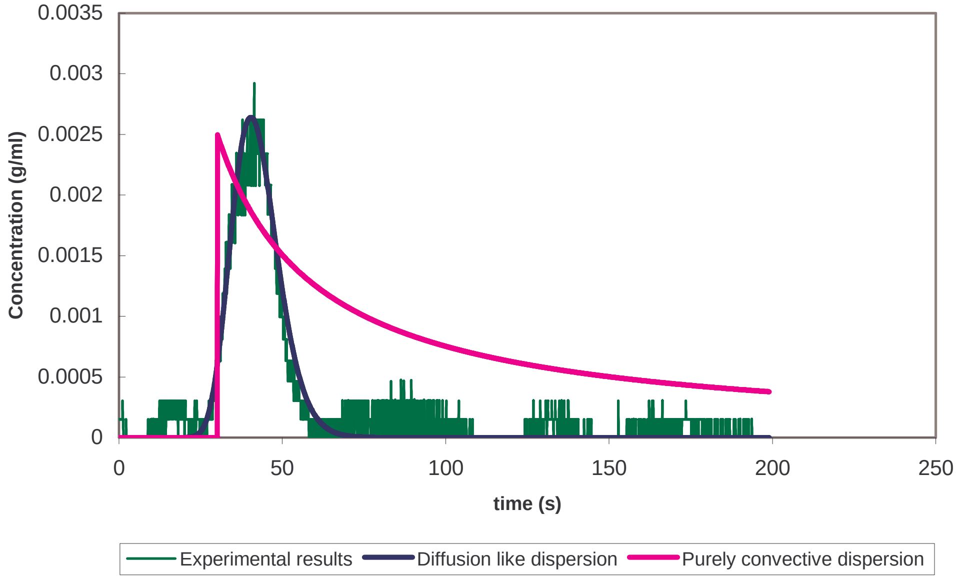

Figure 1: Experimental and Theoretical concentration vs time profiles showing that the Plateau border (axial) dispersion is diffusion like in its behaviour

The first aim of this work was discover if radial mixing within individual Plateau borders or the vertices was a significant factor in the dispersion of the particles. If radial mixing was not a major factor in the dispersion, then the concentration profile would exhibit the sharp initial peak that is characteristic of purely convective dispersion. With some radial mixing in the Plateau borders or vertices, the concentration profile would exhibit a near normal distribution that is similar to what would be obtained from diffusion. Figure 1 demonstrates that the profile obtained is very similar to the diffusion like profile and that there is therefore some radial mixing in either the Plateau borders or vertices. This is despite the fact that the flow is very laminar. Some of the potential sources of this mixing are the changing of the relative position in the Plateau borders of particles as the go through vertices, Brownian motion (as the particles are very fine), lift effects and particle-particle interactions.

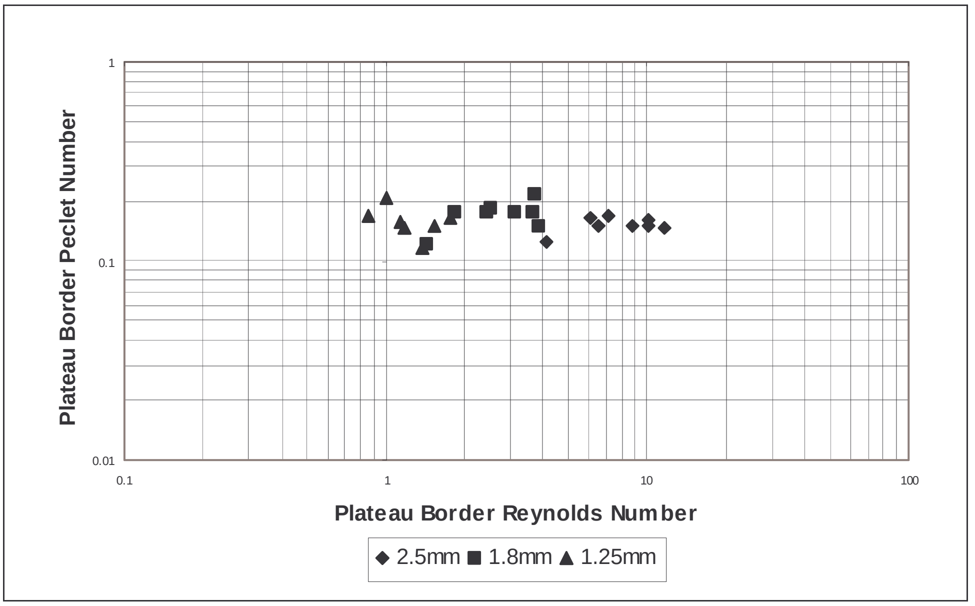

Figure 2: Plateau Border Peclet number as a function of Reynolds Experiments performed at different liquid contents and bubble sizes.

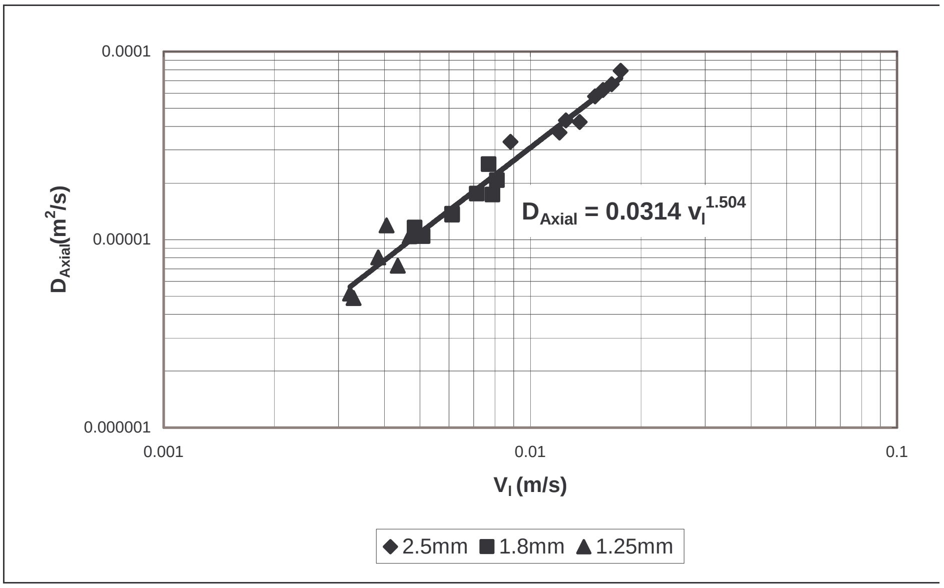

Figure 3: The relationship between the axial dispersion coefficient and the liquid velocity for fine particles (legend indicates bubble diameter).

The aim of the second portion of this work was to examine the dependence of the Peclet number on system conditions. The characteristic length scale chosen for use in the Peclet number was the radius of curvature of the Plateau border. Unlike in Packed beds, the channel (Plateau border) diameter can be varied independently of the particle (bubble) size. Figure 2 shows that the Peclet number is virtually independent of both bubble diameter and Plateau border Reynolds number over quite a wide range of conditions.

By using the foam drainage equation (Verbist *et al.*, 1996) and assuming that the Peclet number is constant, it is predicted that the Axial Dispersion coefficient would be proportional to the liquid content raised to the power 1.5. Figure 3 shows that this is indeed the case.

References

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