Prediction of gas holdup for the homogeneous regime in bubble columns equipped with porous sparger

N.A. Kazakis, I.D. Papadopoulos, A.A. Mouza
Department of Chemical Engineering, Aristotle University of Thessaloniki
Univ. Box 455, GR 54124 Thessaloniki, GREECE
tel: +30 2310 994161 e-mail: *mouza@cheng.auth.gr*

Abstract

This work is motivated by the need to develop reliable predictive tools for bubble column design. This type of equipment is widely used as gas–liquid contactor in a variety of practical applications such as absorption, fermentation, bio-reactions, biomedical applications etc. Gas holdup defines the interfacial area available for mass transfer and in conjunction with the bubble size distribution are important bubble column design parameters. They both depend on column dimensions, flow regime, liquid properties and type of gas sparger. Although the fine pore sparger is among the most common gas distributor, information related to the performance of this kind of sparger is limited.

It is known that, depending on the gas flow rate, two main flow regimes are observed in bubble columns, i.e. the ***homogeneous*** regime and the ***heterogeneous*** regime. The former offers a larger contact area and it is also preferable for applications involving sensitive materials [1],[2]. (i.e. bioreactors, blood oxygenators). In a previous work conducted in this Laboratory [3] the effect of liquid properties on bubble size distribution and gas holdup in a bubble column with fine pore sparger in the homogenous regime was studied experimentally. The data revealed that liquid viscosity and surface tension affect the holdup in the column and a correlation based on dimensionless groups for the prediction of gas holdup in the homogeneous regime was proposed and found to be in good agreement with the limited available data.

The scope of this work is to formulate a correlation concerning the prediction of the transition point from the homogeneous to the heterogeneous regime and to check its validity with available data. In addition, the previously proposed correlation [3] is slightly modified to take also into account the sparger pore size. To accomplish this, new experiments are conducted in a column with different geometry, sparger to column diameter ratio and sparger pore size, using a greater variety of liquids covering a broader range of viscosity (1.0-23.0 mPa.s) and surface tension (26-72 mN/m) values.

The new experimental set-up (***Figure 1***) consists of a cylindrical (ID=9 cm) Plexiglas® column 1.5 m height, equipped with the appropriate rotameters for gas phase flow measurement and control. For the injection of the gas phase, a *gas sparger* (diameter 4.48 cm) is installed at the center of the bottom plate. In the present experiments, two 316L SS porous disks (Mott Corp.) with nominal pore size of 40 and 100 μm, were alternatively used as gas spargers. The gas phase is atmospheric air for all runs. The experiments are conducted at ambient pressure and temperature conditions with no liquid throughput. The average gas holdup is estimated by measuring the bed expansion, which is accomplished by means of a digital video camera (*Redlake MotionScope PCI ®1000S*). The uncertainty of the measurements is estimated to be less than 15%. The transition point from the homogenous to the heterogeneous regime is located by applying the drift flux model [4],[5].

In light of the new findings the proposed correlation has been slightly modified. This correlation is plotted in ***Figure 2*** where both data from previous [3] and present work are included, while data from Camarasa et al. (1999) [6] and Kaji et al. (2001) [7] are also depicted for comparison. The new modified correlation is in very good agreement (±10%) with all available data for the homogeneous regime. In addition, a new correlation regarding the prediction of the transition point from the homogeneous to the heterogeneous regime has been also proposed and found to be in good agreement with available data.

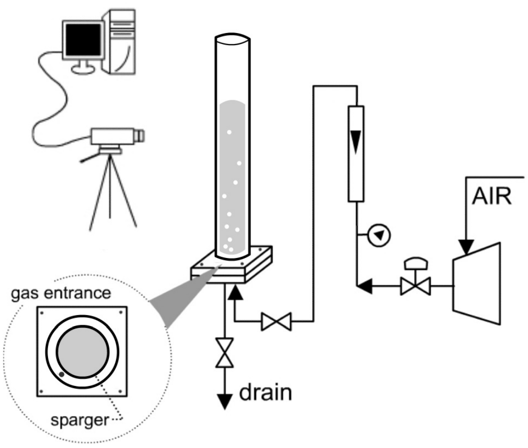

Figure 1. Experimental set-up

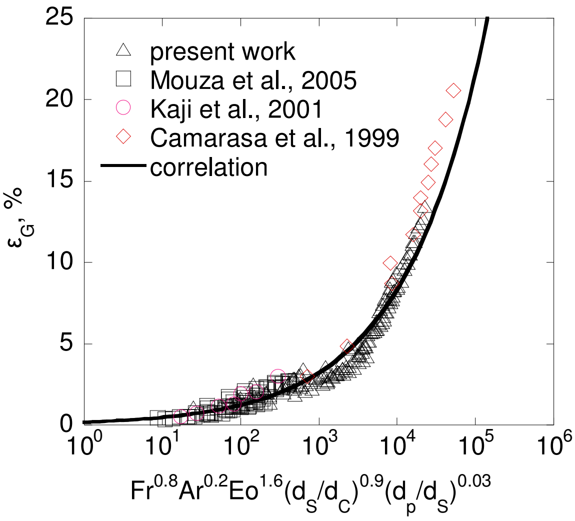

Figure 2. Gas holdup correlation for the homogeneous regime

References

[1] Joshi, J.B., Vitankar, V.S., Kulkarni, A.A., Dhotre, M.T., Ekambara, K., 2002. Coherent flow structures in bubble column reactors. *Chemical Engineering Science* **57**, 3157-3183.

[2] Olmos, E., Gentric, C., Vial, Ch., Wild, G., Midoux, N., 2001. Numerical simulation of multiphase flow in bubble column reactors. Influence of bubble coalescence and break-up. *Chemical Engineering Science* **56**, 6359-6365.

[3] Mouza, A.A., Dalakoglou, G.K., Paras, S.V., 2005. Effect of liquid properties on the performance of bubble column reactors with fine pore spargers, *Chemical Engineering Science* **60**, 5, 1465-1475.

[4] Wallis, G.B., 1969. *One-dimensional two-phase flow*. McGraw-Hill.

[5] Ruzicka, M.C., Zahradnik, J., Drahos, J., Thomas, N.H., 2001. Homogeneous-heterogeneous regime transition in bubble columns. *Chemical Engineering Science* **56**, 4609-4626.

[6] Camarasa, E., Vial, C., Poncin, S., Wild, G., Midoux, N., Bouillard, J., 1999. Influence of coalescence behaviour of the liquid and of gas sparging on hydrodynamics and bubble characteristics in a bubble column. *Chemical Engineering and Processing* **38**, 329–344.

[7] Kaji, M., Sawai, T., Mori, K., Iguchi, M., 2001. Behaviors of bubble formation from a bottom porous nozzle bath. *Proceedings of the 5th ExHFT*, Thessaloniki, Greece.