Liquid Mixing in External-Loop Airlift Slurry Reactors

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Highlights

- The axial dispersion coefficient is practically very useful in designing this type of reactors.
- Two different external-loop airlift slurry reactors was used in this study.
- The factors such as superficial gas velocities, fine particle concentration and flow resistance of slurry in the downcomer were investigated in the experiments.
- Based on the Kolmogoroff's isotropic theory, a model was developed to predict the axial dispersion coefficient.

1. Introduction

External-loop airlift reactor is a high effective, multiphase reactor developed on the basis of the bubble column reactors. Studies on the liquid mixing in such reactors can provide guidance in developing and designing a novel reactor for high performance[1]. In this paper, the axial dispersion coefficient in the risers of two different external-loop airlift reactors was investigated by experimental measurements.

2. Methods

The liquid axial dispersion coefficient in the risers was measured by using least square method and conductivity probes[2,3].

3. Results and discussion

The effects of gas velocity on the axial dispersion coefficient with different solid holdup and different valve opening in two reactors are investigated.

Vial et al. [4] used the mixing length model by analogy with the Taylor dispersion model to describe the liquid dispersion in external-loop airlift reactors and obtained reasonable results.

$$D_{\mathrm{a}} \approx D_{\mathrm{T}} = l u_{\mathrm{eT}} \tag{1}$$

Based on the Kolmogorov's isotropic theory[5], we have:

$$u_{\mathrm{eT}} \propto \varepsilon^{1/3} l^{1/3} \tag{2}$$

Substituting Eq. (2) into Eq. (1) leads to:

$$D_{\mathrm{a}} = k l^{4/3} \varepsilon^{1/3} \tag{3}$$

The diameter of riser as the mixing character length :

$$D_{\mathrm{a}} = k D^{4/3} \varepsilon^{1/3} \tag{4}$$

The turbulent dissipation in the riser:

$$\varepsilon = U_G g \tag{5}$$

Substituting Eq. (5) into Eq. (4) leads to:

$$D_a = k D^{4/3} (U_G g)^{1/3} \tag{6}$$

$$k = 0.31$$

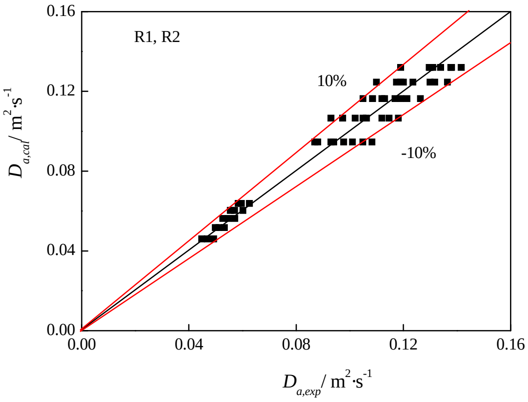

Fig. 1. Comparison of experimental and predicted values of dispersion coefficient in all operating conditions.

4. Conclusions

The effects of superficial gas velocities, fine particle concentration and flow resistance of slurry in the downcomer on the axial dispersion coefficient in the risers have been determined in two different external-loop airlift reactors by using least square method and conductivity probes. Based on the Kolmogoroff's isotropic theory, a model was developed to predict the axial dispersion coefficient, and a good agreement between the calculated and measured values was obtained. These detailed results are useful for design purposes.

References

[1] Liu Malin, Zhang Tongwang, Wang Tiefeng, et al.. Chem. Eng. J.139 (2008) 523–531.
[2] Gavrilescu M, Tudose RZ. Chem. Eng. J. 66(1997) 97–104.
[3] Kim SD, Kim HS, Han JH. Chem. Eng. Sci., 47(1992) 3419–3426.
[4] Vial C, Poncin S, Wild G, Midoux N. Chem. Eng. Sci., 60(2005) 5945–5954.
[5] Frisch U. Turbulence: the legacy of Kolmogorov A N. New York: Cambridge University Press, 1995.

Keywords
External-loop airlift reactor, Axial dispersion, Liquid mixing

Lifeng Hu, received his doctorate in 2007, and joined Process Engineering Department of Research Institute of Petroleum Processing, SINOPEC as a Senior Engineer. His research focuses on the design and scale up of multiphase reactors.