기-액 분리기의 설계가 관의 단면이 직사각형인 분할형 Airlift 반응기의 성능에 미치는 영향

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Effect of Gas-Liquid Separator Design on Performances of Split-Channel Rectangular Airlift Reactors

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Introduction

The many attractive features of airlift reactors have led to increasing usage of these devices in environmental remediation technology, the chemical process process industry and the biotechnology-based manufacture [1].

The head region of airlift reactors, where the riser and downcomer interconnect, acts as a gas disengagement zone. The head region - its gas-liquid separating ability and its hydraulic resistanc - affect the difference in gas holdup between the riser and downcomer; hence, the dirving force for liquid circulation is affected. Consequently, the geometry of the head region affects all hydrodynamic and mass transfer characteristics of airlift reactors. Such characteristics include the mixing behavour, liquid circulation performance, gas holdup, gas-liquid mass transfer, heat transfer, as well as other properties. Despite its significance, few reliable systematic studies exist of the impact of gas-liquid separator design on performance characteristics of airlift devices [2].

This work focuses on comparative evaluation of hydrodynamic and gas-liquid mass transfer performance of two split-channel airlift reactors having different geometries of the head region.

Experimental

The reactors used consited of a plexiglas vessel with a rectangular cross-section divided into a riser and a downcomer by a vertical baffle as shown in Fig.1. The reactors differed only in the configuration of the head reagion. Two configurations were investigated: a basic internal-loop head region without special features for gas-liquid separation (configuration *a*) and a configuration with a 45°-inclined prism attached to the upper edge of the vertical baffle (configuration *b*). In both cases, the cross-sectional area ratio of downcomer-to-riser was 0.689. The unaerated liquid heights were equal at 1.64 m. The riser was sparged with air through a perforated plate sparger located at its base. Tap water and air were the liquid and the gas phases, respectively. The air flow rates were measured by a calibrated rotameter and the superficial gas velocity (U_{Gr}), based on the cross-sectional area of the riser, varied over 0.017-0.135 m s^{-1}. Batch operation was employed with respect to the liquid phase. All experiments were carried out at room temperature and atmosperic pressure.

The gas holdups in the riser and the downcomer were determined manometrically. The velocity of liquid circulation was determined with the neutral buoyancy flow follower technique. A small piece of plastic tuse was used as a flow follower. The mixing time was measured by the trace impulse method. The overall volumetric oxygen transfer coefficient was determined by the dynamic gassing-in method [3].

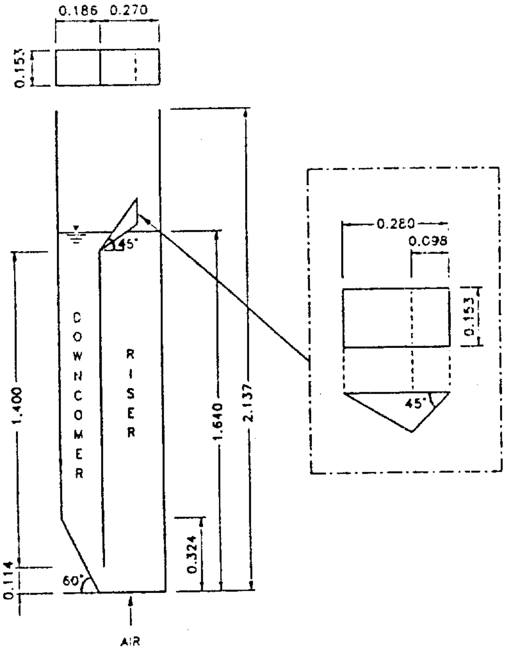

Fig.1. Schematic of split-channel airlift reactors.

Results and Discussion

As illustrated in Fig.2, the gas holdup in the riser (ε_{Gr}) was little affected by the configuration of the head region; however, the gas holdup in the downcomer (ε_{Gd}) was strongly affected. As expected, configuration *a* was the less effective gas-liquid separator and allowed a greater carryover of the gas bubbles into the downcomer, thus producing a higher downcomer gas holdup for any given conditions. Configuration *b* was a better gas-liquid separator; hence, the downco-

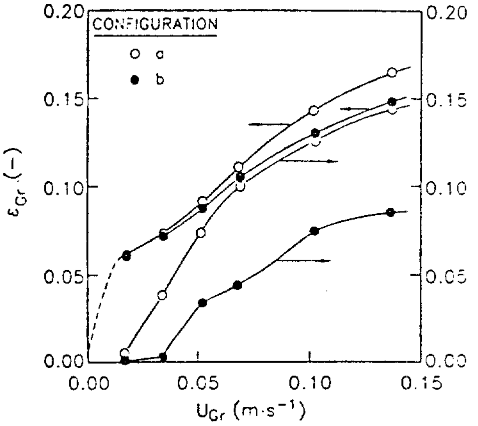

Fig.2. Effect of geometry of head on gas holdup.

omer gas holdup was lower with this design.

In coniguration *b*, although the driving force for liquid circulation was large throughout (Fig.2), the liquid flow rate was inintially lower than in design *a* because of the higher pressure drop characteristics of configuration *b*. Eventually, in Fig.3, the better gas-liquid separating ability of configuration *a* did lead to higher induced liquid circulation rate when the superficial gas velocity was about 0.04 m s^{-1} or greater.

In Fig.4, the data for configuration *b* ara located well below the prediction of Eq.(1) which was developed for draft-tube internal-loop airlift reactors without gas-liquid separators by [4]. As shown in Fig.4, configuration *b* is an effective gas liquid separator compared to configuration *a*. However, compared to the prediction of Eq.(2) for external-loop airlift reactors [4], the configuration *b* is less effective. Date for configuration *b* followed Eq.(3).

$$\varepsilon_{Gd} = 0.89\ \varepsilon_{Gr} \tag{1}$$

$$\varepsilon_{Gd} = 0.79\ \varepsilon_{Gr} - 0.057 \tag{2}$$

$$\varepsilon_{Gd} = 1.029\ \varepsilon_{Gr} - 0.066 \tag{3}$$

The effects of the geometry of the head zone on mixing time are shown in Fig.5. Results in configuration *a* were unusal, but reproducible. Increasing gas flow rate up to about 0.05 m s^{-1} increased mixing while the liquid circulation rate remained constant (Fig.3). Futher increase in gas velocity caused small

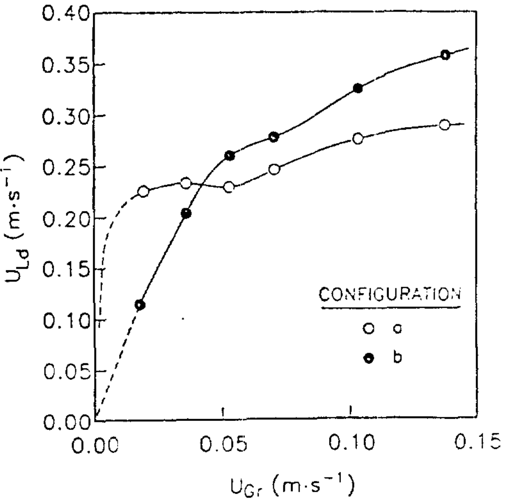

Fig.3. Effect of geometry of head region on superficial liquid velocity.

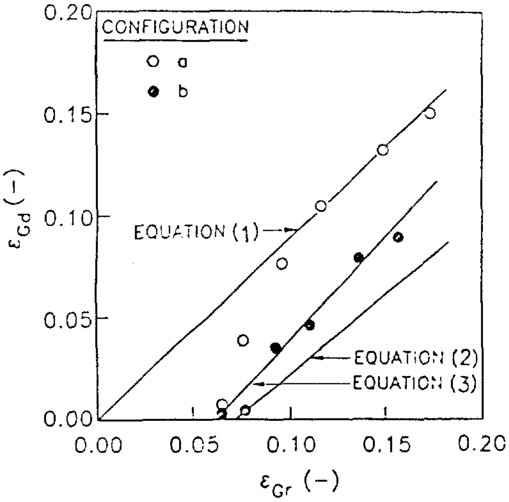

Fig.4. Relationship between gas holup in riser and downcomer.

increase in liquid circulation rate and a corresponding improvement in mixing. Visual observation showed that the liquid circulation zones in the riser and the entrance of the downcomer grew in size as the gas flow rate increased to about 0.05 m s^{-1}. These zones became unstable and growth ceased with further increase in gas velocity. For U_{Gr} > 0.05 m s^{-1}, interchange of fluid between the bulk circulating stream and the circulating 'dead-zones' improved. These visual observations were consistent with the behaviour of the mixing time curve.

The data on the overall volumetric oxygen transfer coefficient for the two configurations are presented in Fig.6. No significant difference between the performances of two configurations was noticed. In both cases, as the superficial gas velocity incresed, the overall volumetric oxygen transfer coefficient increased because of an increase in the overall gas hoildup and, hence, an increase in the gas-liquid interfacial area for oxygen transfer.

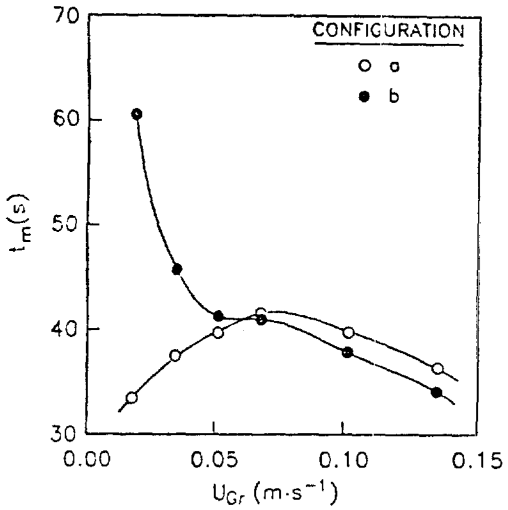

Fig. 5. Effect of configuration of head region on mixing time.

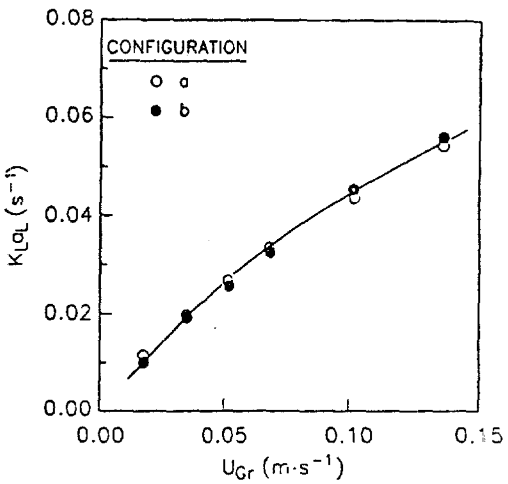

Fig. 6. Effect of configuration of head region on overall volumetric mass transfer coefficient.

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