Effect of ring baffle configurations in a circulating fluidized bed riser using CFD simulation and experimental design analysis

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HIGHLIGHTS
- Effect of ring baffle configurations on system mixing was studied using CFD model.
- Factorial experimental design analysis was used to interpret the obtained results.
- Interaction between baffle opening area-space between baffles was a key parameter.
- Regression models for response variables were obtained for further designing stage.
- Ring baffle improved the system mixing and eliminates the backflow near the wall.

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ABSTRACT
The non-uniformity of solid particle distribution in a circulating fluidized bed riser is an important problem for this type of reactor, since it leads to a poor system mixing and low chemical reaction conversion. The aim of this study was to explore the effect of ring baffle configuration parameters on the system mixing using computational fluid dynamics simulation to predict the hydrodynamic phenomena. Factorial experimental design analysis was also used for statistical interpretation of the relationship between the ring baffle configuration and the hydrodynamic phenomena. The results revealed that the ring baffle configuration had a significant effect on the system mixing and hydrodynamics. From the analysis of variance, the standard deviation of radial solid volume fraction and the averaged solid particle concentration in the system were significantly affected by the baffle opening area, the space between the baffles and the interaction between these two terms, whilst the number of baffles and the interaction between the baffle opening area and the number of baffles also effected the averaged solid particle concentration in the system, with the interaction between baffle opening area and the space between baffles being the key parameter. In addition, regression models for each response variable were obtained. With respect to the system hydrodynamics, incorporation of the ring baffle improved the system mixing and eliminated the backflow near the wall with improved heat and mass transfers.

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1. Introduction

Solid particles are widely found in many industrial applications, such as reactants, catalysts and absorbents. However, the contact efficiency of solid particles inside chemical reactors is still low [1,2]. It is, therefore, important to study and improve the performance of those employed in chemical reactors. A circulating fluidized bed reactor (CFBR) is claimed to be a high performance chemical reactor for the fast gas–solid particles multiphase system, since it is a continuous process coupled with high throughput of gas and solid particles, has a uniform temperature distribution and is an easy system to control [1,2]. The systems suited for such CFBRs are processes with a high selectivity of intermediate products, such as biomass gasification, where CFBRs are one of the most promising technologies for converting biomass into transportable and usable fuels [3–7], the drying process of agricultural products [1], and continuous gas adsorption, such as flue gas desulfurization in medium and small scale power plants [8–11] and flue gas cleaning in municipal solid waste incineration plants [12]. In the literature, there have been several reports of successful fluidized bed experiments and simulations with [13–15] and without chemical reactions [16–18]. However, these have found that there is a non-uniformity of solid particle distribution in both the