Effects of Swirl Bubble Injection on Mass Transfer and Hydrodynamics for Bubbly Flow Reactors: A Concept Paper

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Abstract. Bubble flow reactors (BFR) are commonly used for various industrial processes in the field of oil and gas production, pharmaceutical industries, biochemical and environmental engineering etc. The operation and performance of these reactors rely heavily on a range of hydrodynamic parameters; prominent among them are geometric configurations including gas injection geometry, operating conditions, mass transfer etc. A huge body of literature is available to describe the optimum design and performance of bubbly flow reactors with conventional bubble injection. Attempts were made to modify gas injection for improved efficiency of BFR's. However, here instead of modifying the geometry of the gas injection, an attempt has been made to generate swirl bubbles for gaining larger mass transfer between gas and liquid. Here an exceptionally well thought strategies have been used in our numerical simulations towards the design of swirl injection mechanism, whose paramount aspect is to inhibit the rotary liquid motion but facilitates the swirl movement for bubbles in nearly stationary liquid. Our comprehension here is that the swirl motion can strongly affect the performance of bubbly reactor by identifying the changes in hydrodynamic parameters as compared to the conventional bubbly flows. In order to achieve this bubbly flow, an experimental setup has been designed as well as computational fluid dynamic (CFD) code was used with to highlight a provision of swirl bubble injection by rotating the sparger plate.

1 Introduction

Bubble column reactors are a class of multiphase reactors that are commonly used in different industrial applications such as chemical, petrochemical, metallurgical, pharmaceutical, food environmental and wastewater treatment [1][2]. The multiphase reactors are generally categorized into three types namely, the trickle bed reactor (fixed or packed beds), fluidized bed reactors and the bubble column reactors [1]. In general, bubble column offers many advantages over other multiphase reactors, which include the simplicity of their construction and maintenance, low energy consumption, minimal space requirements, good mass transfer properties, and high thermal stability [3]. Interfacial mass transfer coefficient is an important parameter that affects design and operation of the columns, and this is greatly influenced by air flow rate, fluid dynamics (gas void fraction, liquid/bubble velocity, etc.), physical properties (density, viscosity, surface tension, etc.) as well as apparatus geometry [4].

The characteristics and hydrodynamics of bubble column are strongly depend on bubble size distribution, superficial gas velocity and gas distributor configuration are a few factors which govern the performance of a bubbling system. Among all these, bubble size is the most important parameter because it not only affects the bubble rise velocity but also has a direct influence on the gas void fraction and interfacial area; and also an important criterion for evaluating the efficiency of a bubble column reactor [5]. Gas void fraction is defined as the fraction of gas occupied in the total volume of the gas and liquid mixture in bubble column [6]. Due to the complex nature of interfacial processes between gas and liquid, it is an uphill task to optimize the operating parameters (e.g. gas and liquid rates, sparger geometry, bubble size and shape, liquid & bubble turbulence etc.) [7].

In generalized gas–liquid two-phase flows, bubbles are observed in different sizes and shapes, behave differently in terms of relative motion and interaction mechanisms [8]. Bubbles are categorized into various groups with its

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