CFD modeling of gas dispersion in gas-liquid agitated contactors

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Abstract

The aim of this work is to explore the potential of a general purpose *CFD* code to compute the characteristics of the flow field encountered in a baffled gas-liquid contactor agitated by a single Rushton turbine (***Fig. 1***). This type of equipment is widely used for gas dispersion in chemical and bio-chemical industry. In general, the design of agitated vessels relies mostly on empirical or semi-empirical correlations well established over the years through experiments, an approach that is both expensive and time consuming. Moreover, although the flow characteristics inside stirred vessels have been extensively studied by various researchers, the resulting empirical correlations are only applicable in the range of operating conditions from which they were determined (Kerdouss et al., 2006). It is therefore essential to develop new tools to enhance our physical understanding and use them for the optimal design of agitated gas-liquid contactors.

The trailing vortices generated by the rotation of the agitator play an important role in the process of mixing. These structures interact with gas bubbles that are introduced in the vessel, affecting their movement. The development of gas cavities behind the impeller blades significantly changes the power requirement of the agitated vessel. It is widely known (Harnby et al., 1997; Markopoulos et al., 2002) that three distinct dispersion regimes can be identified in gas-liquid stirred vessels: the flooded, the loaded and the complete dispersion regime. The operating conditions (i.e. the gas flow rate and the impeller speed) control the transition from one regime to another. The literature review reveals several attempts (e.g. Wiedmann et al, 1981; Wiedmann, 1983; Harnby et al., 1997) in characterising the type of flow, but deviations in results are believed to be attributed to the different regime definitions between researchers.

An effective tool for studying the flow pattern inside a gas-liquid agitated vessel is Computational Fluid Dynamics (*CFD*). In this presentation, a *CFD* code (namely, the commercial *CFD* code *ANSYS CFX 10.0*) is employed to study the two-phase flow inside an agitated vessel equipped with a single Rushton turbine, by taking into account multiphase turbulent flow, impeller rotation and bubble break-up/coalescence phenomena. Several attempts by the researchers have been made towards the simulation of this type of equipment. This study uses a more sophisticated turbulence model (i.e. the *SST* model) and a properly designed unstructured hexahedral grid. Simulations are performed for various impeller rotational speeds, while keeping the gas flow rate constant.

The preliminary results of the simulation are compared with experimental results by Markopoulos et al. (2002). The empirical correlations proposed by Markopoulos et al. are verified by the *CFD* code, and visual observations of the three distinct regimes are found to be in qualitative agreement with results of the present study. Moreover, the power consumption of the gas-liquid contactor is found to follow the general trend of the power curves found in the literature (Harnby et al., 1997) for stirred vessels agitated by Rushton turbines (***Fig. 2***).

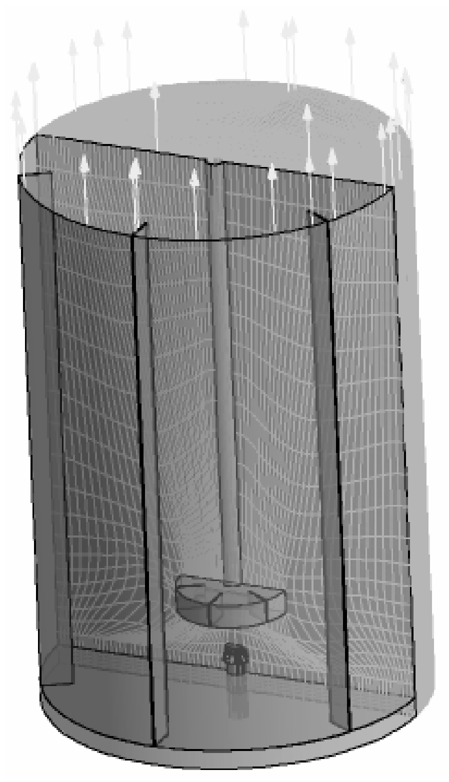

Fig. 1 A typical gas-liquid agitated vessel (computational domain)

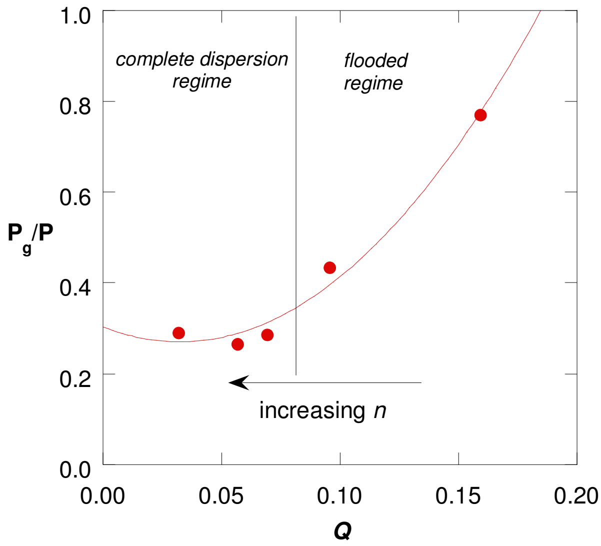

Fig. 2 Gassed/Ungassed power ratio vs. gas flow number Q (*CFD* results)

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