CFD Investigation of Cross Bubbly Flow Through a Bubble Column with Rectangular Geometry

N. M. Musa[1], D. Kuvshinov[1], P. Rubini[1]

[1]The University of Hull, Hull, East Yorkshire, United Kingdom

Abstract

Impact of human activities on the climate is evident, and the recent anthropogenic production and discharge of greenhouse gases into the atmosphere is highest in history. The current climate change have had worldwide influence on human and natural systems for example; global warming, melting of ice and snow, and rise in sea level etc. (AGECC 2010, Council 2013, IPCC, 2014). Increase in the concentration of CO2 in the atmosphere has been recognized as the major contributor to anthropogenic climate change (IPCC, 2014). Coal-fired power plant has been identified as largest single stationary source of CO2 emission into the atmosphere (Lawal, Wang et al. 2010). Successful CO2 emission prevention strategies such as Carbon Capture and Storage (CCS) are necessary to stop this trend. There are three major approaches for CCS: post-combustion capture (PCC), pre-combustion capture and oxyfuel process (Wang, Lawal et al. 2011). PCC using chemical solvents is the most matured CO2 capture strategy (Wang, Joel et al. 2015).

Even though continuous progress has been made in PCC using solvents technology in recent years, it is still extremely expensive to deploy the technology commercially as it decreases overall energy efficiency of power cycle by approximately 30%. In order to make CCS technology commercially attractive, further research should be performed to enhance the mass transfer process and to improve energy efficiency. Computational fluid dynamics (CFD) studies is believed to be an important tool that can be used to provide more insight into CO2 absorption process leading to process optimization and reduction in the capital and operating cost.

Bubble columns have been widely used in as multiphase contactors or reactors in chemical, biochemical, petrochemical and metallurgical industries. The wide application of bubble column is because of its advantages compared to other categories of multiphase contactors e.g packed bed. Some of the advantages of bubble column reactors include; Simple to construct, Low operating and maintenance cost, High heat and mass transfer rate, Larger surface area, Longer retention time and Compactness.

In this study, a 2D-axisymmetric CFD simulation is presented to investigate the hydrodynamics; heat and mass transfer of a bubble enhance CO2 absorption process in a bubble column reactor with rectangular geometry. Understanding the complexity of fluid dynamics, mass and heat transfer in the bubble column will provide important information on its application in PCC process. COMSOL Multiphysics® was used to carry out the numerical simulation. The Laminar Two-Phase Flow, Level Set physics interface was

used to simulate the fluid dynamics. The Heat Transfer in Fluids physics interface was used to simulate the heat transfer. The results were presented for key numerical parameters such as phase velocity profile, temperature profile, gas phase pressure profile and gas concentration in liquid phase.