STUDY OF MASS TRANSFER CORRELATIONS FOR INTENSIFIED ABSORBERS IN POST-COMBUSTION CO_2 CAPTURE BASED ON CHEMICAL ABSORPTION

Eni Oko, Meihong Wang*, Colin Ramshaw
Process/Energy Systems Research Group, School of Engineering, University of Hull, HU6 7RX, UK
**Corresponding Author:* Tel.: +44 1482 466688. E-mail address: Meihong.Wang@hull.ac.uk

Abstract

The unfavourable role of CO_2 in stimulating climate change has generated concerns as CO_2 levels in the atmosphere continue to increase. These concerns have paved way for carbon capture and storage (CCS) from large point sources (e.g. coal-fired power plants). With CCS, electricity will continue to be generated from secure and cheap energy sources such as coal without hurting the environment. Post-combustion CO_2 capture (PCC) based on chemical absorption is a near-term option for implementing CCS (Wang *et al*., 2011). However, conventional packed bed absorbers/strippers used in PCC processes are huge in size contributing significantly to plant footprint, capital and operating costs. For example, engineering estimates show that absorbers for a PCC plant for capturing CO_2 from a 500 MWe coal-fired subcritical power plant will have diameters up to 25 m and packing height over 27 m (Oko, 2015).

Using rotating packed bed (RPB), typical process intensification equipment, it has been predicted that packed bed volume could be reduced significantly; Joel *et al*. (2014) suggested about 12 times reduction in packed bed volume. This is due to high magnitude of mass transfer coefficient caused by the strong centrifugal force field in the RPB (Tung and Mah, 1985). Due to the presence of centrifugal force field in RPBs, mass transfer correlations for conventional packed columns cannot be used to predict mass transfer in RPBs with acceptable accuracy (Joel *et a*l., 2014). For RPBs, only a few mass correlations have been reported (Tung and Mah, 1985; Chen, 2011; Luo *et al*. 2012). Modification of mass transfer correlations for conventional packed beds by replacing the "g" term (*i.e.* gravitational acceleration) with "rw^2" (*i.e.* centrifugal acceleration) have also been suggested (Joel *et al*., 2014). Given the importance of mass transfer correlations in designing the equipment, it is necessary to explore these options and compare them concisely to identify their limitations and propose directions for improving them in the future.

In this study, we have compared existing correlations for effective interfacial area and liquid phase mass transfer coefficient against experimental data at different rotating speed and gas-liquid ratio. For effective interfacial area, RPB correlations (Lin et al. 2000 and Luo et al., 2012) and conventional packed bed correlations updated with "rw^2" term (Onda et al. 1968; Puranik and Vogelpohl, 1974 and Billet and Schulte, 1999) were assessed. It was found that Onda and Puranik and Vogelpohl gives poor prediction regardless that the "g" term is updated with "rw^2" term. Also, Lin et al. (2000) which was developed for RPBs gives a poor prediction of the effective interfacial area. Luo et al (2012) alongside Billet and Schultes gave the closest results to the data. For liquid phase mass transfer coefficient, RPB correlations (i.e. Tung and Mah 1985 and Chen 2011) and the conventional packed bed correlations updated with "rw^2" term (i.e. Onda) were assessed. All of them gave close enough predictions though at some conditions they showed some

pronounced deviation. Also, Chen and Onda gave nearly the same predictions at different conditions.

In conclusion, reported correlations for liquid phase mass transfer coefficients appear to give good results within limited conditions. Also, most of the conventional packed column correlations updated with "rw^2" term do not give acceptable prediction of effective interfacial area.

Keywords: Process intensification, Rotating packed bed, Process intensification, Post-combustion CO_2 capture, Mass transfer correlations

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