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The effect of fly ash on fluid dynamics of CO_2 scrubber in coal-fired power plant

Zhisheng Chen[a,b], *Derek Yates*[a], *James K. Neathery*[a], *Kunlei Liu*[a,*]

[a] *University of Kentucky, Center for Applied Energy Research, 2540 Research Park Drive, Lexington, KY 40511, USA*
[b] *China Datang Technologies & Engineering Co., Ltd., 120 Zizhuyuan Road, Beijing 100097, PR China*

ABSTRACT

Uncaptured fly ash and/or suspended solids from wet flue gas desulfurization (WFGD) scrubbing solutions are one of several factors that will influence the performance and robustness of carbon dioxide capture systems in coal-fired power plants which will be installed prior to the exhaust stack. In this study, a 100 mm ID packed column scrubber was tested with different concentrations of ash in various chemical solutions to evaluate the influence of solids on the fluid dynamics of the packing material. Data reported here are collected from three solutions including water, 30 wt% MEA (monoethanolamine), and 20 wt% potassium carbonate. The packing selected for this study was a 16 mm polypropylene pall rings. Compressed air was used to simulate flue gas at near ambient temperature and pressure.

A series of three experiments was performed, and the results indicated that the flooding point of the packed column was significantly impacted by the addition of 1–3 wt% ash solids into the solution. Solutions (water and 20 wt% potassium carbonate) containing solids had a lower pressure drop at a given superficial gas velocity and early flooding start point (e.g., lower superficial gas velocity at the column flooding point) than that without ash. A higher concentration of ash in the solution correlated to a lower pressure drop at the column flooding point. However, the addition of ash to a 30% MEA solution caused the pressure drop to increase for a given superficial gas velocity. The liquid holdup in the column had a significant increase due to the presence of ash.

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Keywords: Fly ash; Fluid dynamics; Pressure drop; Flooding point; Liquid holdup; Carbon capture

1. Introduction

Gas–liquid counter-current flow in a packed tower plays an important role in the modern chemical industry for gas cleanup applications. Many researchers have focused on this area, and the fluid dynamics of packed columns in various configurations have been studied extensively, including structured packing as well as both classic random packing and a group of modern new random packing media (Kouri and Sohlo, 1996; Spedding, 1986; Heymes et al., 2006; Alix and Raynal, 2008; Piche et al., 2001a,b,c). Numerous experimental data can be found in the literature, with various correlations and empirical formulas developed to describe the relationship of pressure drop, column flooding point, and liquid holdup in the column.

The effect of gas and liquid loading on the pressure drop across the column packing was acknowledged in various empirical correlations associated with dimensionless parameters of Reynolds number and Froude number. Mackowiak developed a correlation to predict pressure drop in the irrigated packed columns (Mackowiak, 1990), as well as liquid holdup from the pre-loading zone to the flooding point. In a later work he established an extended channel model for prediction of the pressure drop in single-phase flow in packed columns (Mackowiak, 2009). Billet and Schultes modeled the pressure drop (Billet and Schultes, 1991) and the liquid holdup (Billet and Schultes, 1993) by using a physical model in the two-phase counter-current packed columns in 1991 and 1993, respectively. Many researchers have studied the hydrodynamic properties of carbon dioxide capture systems, such as Pascal and Raynal (2008, 2009). They introduced parameters such as liquid distribution, holdup (Alix and Raynal, 2008), pressure drop and mass transfer (Alix and Raynal, 2009) for modern high capacity packing applications. However, none of

* *Corresponding author*. Tel.: +1 859 257 0293.
E-mail address: liu@caer.uky.edu (K. Liu).
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