Numerical simulation of low-concentration CO₂ adsorption on fixed bed using finite element analysis

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Abstract

Accurately predicting distributions of concentration and temperature field in fixed-bed column is essential for designing adsorption processes. In this study, a two-dimensional (2D), axisymmetric, nonisothermal, dynamic adsorption model was established by coupling equations of mass, momentum and energy balance, and solved by finite element analysis. The simulation breakthrough curves fit well with the low-concentration CO₂ adsorption experimental data, indicating the reliability of the established model. The distributions of concentration and temperature field in the column for CO₂ adsorption and separation from CO₂/N₂ were obtained. The sensitivity analysis of the adsorption conditions shows that the operation parameters such as feed flow rate, feed concentration, pellet size, and column height-to-diameter ratio produce a significant effect on the dynamic adsorption performance. The multi-physics coupled 2D axisymmetric model could provide a theoretical foundation and guidance for designing CO₂ fixed-bed adsorption and separation processes, which could be extended to other mixed gases as well.

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