Greenhouse Emission Reduction by Adsorption

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ABSTRACT

The aim of this study is to develop an adsorption separation process using Aspen Adsorption. The separation process has the primary focus on capturing methane gas (CH_4). Therefore, Extended Langmuir 3 adsorption model was developed for the system. The model simulation breakthrough time and trends show a significant agreement with the experimental work where 80s of saturation time achieved i.e., the model was validated and accurately reproduced real adsorption behaviour, strengthening its credibility.
The simulation model could exactly estimate the experimental mass transfer coefficient of (0.195 s^{-1}) for methane adsorption on activated carbon.
Moreover, the separation process was optimized by studying the effect of bed design parameters on the CH_4 adsorption. The results revealed that increasing bed height from 1m to 10.5m and from 1m to 7m for Activated Carbon (AC) and Zeolite beds, respectively, at a fixed diameter of 0.037m, remarkably improved the methane retention time, reaching to maximum of 650s for AC and 450s for Zeolite. Furthermore, increasing the bed diameter from 0.0370.1m causes a direct increase in the breakthrough saturation time from 150s to 800s, respectively, with 0.91 kmol/kmol concentration. The bed diameter was systematically adjusted with changes in bed height to ensure optimal adsorption performance. Thus, the breakthrough curve analysis indicates optimal performance, with AC completing the passage of CH_4 at ~2450s, while Zeolite 5A reached methane breakthrough full saturation at ~1800s, hence demonstrating a significantly higher capacity for CH_4 adsorption. The research emphasizes its potential as a predictive and industrially relevant tool for mitigating greenhouse gases emission.

Keywords: Adsorption column; Greenhouse; Adsorption simulation; Activated carbon; Bed height; Mass transfer coefficient; Zeolite