Methane Separation and Purification via Pressure Swing Adsorption

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Investigations on alternative energy sources have gained increasing attention due to a significant shortage in the fossil fuel reserves and an increase in the use of internal combustion engines. Natural gas, which mainly consists of CH$_4$, is playing a significant role as a short term solution. Although CH$_4$ is a greenhouse gas, it is a valuable energy source. However, CH$_4$ is not extracted from any source at 100% purity. Natural gas generally contains many other contaminants such as H$_2$O, CO$_2$, N$_2$, He, other hydrocarbons, sulphur compounds, etc. Hence, CH$_4$ needs to be purified to meet various usage specifications. To this end, the development of a cost effective pressure swing adsorption (PSA) process, utilizing commercially available adsorbents, such as activated carbon, carbon molecular sieve and 13X zeolite, is underway to recover and concentrate CH$_4$ from several sources. These sources include natural gas reservoirs, shale gas, biogas, landfill gas, coal beds, etc.

In this study the goal was to separate a pretreated CH$_4$ mixture from N$_2$ and CO$_2$. A systematic development effort was undertaken for this purpose including both mathematical modeling and experimentation. First, simulations were carried out using an in-house dynamic adsorption process simulator (DAPS) to purify CH$_4$ using a 4-bed 4-step PSA cycle schedule. This scoping work led to the development of a unique 3-bed 8 step PSA cycle schedule for CH$_4$-CO$_2$ separation that was also studied using the DAPS. Single-bed and multi-bed PSA cycle experiments were carried out to validate the DAPS simulation results. Overall, this set of DAPS simulations and experimental results proved that pipeline quality CH$_4$ (i.e., > 97% pure) at recoveries exceeding 90% can be produced by meticulously designing the PSA cycle schedule with a corresponding set of operating parameters and conditions. This presentation will provide an overview of these experimental and DAPS modeling studies.

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