Design Biogas Upgrading Process using Low-Temperature Distillation While Capturing CO_2

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As the world moves towards renewable energy generation, biogas and biomethane play a significant role in meeting energy requirements shortly. The study aimed to design a biogas upgrading process to produce higher-purity biomethane while producing Carbon dioxide as a by-product. The design and simulation were performed in Aspen Plus V.12 software. Three different concentrated biogas feed systems were analyzed, with typical biogas concentrations of 50% (mol mol^{-1}), 60% (mol mol^{-1}), and 75% (mol mol^{-1}) methane concentrations. The water removal from raw biogas was carried out by designing a flash drum unit, and a low-temperature double-distillation approach was designed and analyzed as the primary biogas upgrading step. The refrigeration cycle was designed to maintain a low temperature for the purification process, and Nitrogen was used as the working fluid in the design. The simulation was carried out to find the sensitivity analysis and optimizations of the operation conditions in each processing unit. Based on sensitivity analysis results, the maximum water removal can be achieved at around -35 ^{0}C at 8 bar pressure in Flash drum operation, and the 10 and 9 stages for the series-operated distillation columns were required to perform a smooth distillation process without freezing the carbon dioxide at any stage. The optimal distillate-to-feed flow ratios in the first distillation column were 0.54, 0.62 and 0.78 and the corresponding ratios for the second distillation column were 0.922, 0.920 and 0.915. These ratios were determined for systems 01, 02, and 03, which utilized 50%, 60% and 75% CH4 methane feed biogas respectively. All three designed systems, operating at a feed rate of 1000Kmol hr^{-1}, consistently produced methane with a purity of 98.5% (mol mol^{-1}) while generating a high-purity Carbon dioxide stream as a valuable by product. The major limitation of the system was the freezing conditions of Carbon dioxide, and the simulation was optimized to maintain a Carbon dioxide frozen-free environment up tp the optimum operating level.

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