Process Integration of Natural Gas Hydrate Production by CH₄-CO₂/H₂ Replacement Coupling Steam Methane Reforming

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Abstract : Significant amounts of natural gas hydrates (NGHs) are considered potential new sustainable energy resources in the future. However, common used methods for methane gas recovery from hydrate sediments require high investment but with low gas production efficiency, and may cause potential environment and security problems. Therefore, there is a need for effective gas production from hydrates. The natural gas hydrate production method by CO_2/H_2 replacement coupling steam methane reforming can improve the replacement effect and reduce the cost of gas separation. This paper develops a simulation model of the gas production process integrated with steam reforming and membrane separation. The process parameters (i.e., reactor temperature, pressure, H_2O/CH_4 ratio) and the composition of CO_2 and H_2 in the feed gas are analyzed. Energy analysis is also conducted. Two design scenarios with different composition of CO_2 and H_2 in the feed gas are proposed and evaluated to assess the energy efficiency of the novel system. Results show that when the composition of CO_2 in the feed gas is between 43 % and 72 %, there is a certain composition that can meet the requirement that the flow rate of recycled gas is equal to that of feed gas, so as to ensure that the subsequent production process does not need to add feed gas or discharge recycled gas. The energy efficiency of the CO_2 in feed gas at 43 % and 72 % is greater than 1, and the energy efficiency is relatively higher when the CO_2 mole fraction in feed gas is 72 %.
Keywords : Gas production, hydrate, process integration, steam reforming
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