Dynamic Behavior and Performance of an Integrated Sorption-enhanced Steam Methane Reforming Process with Separators for H_2 Production and CO_2 Capture

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This study developed integrated sorption-enhanced steam methane reforming (SESMR) process for the H_2 production and CO_2 capture on the semi-central scale of ~48 ton H_2/day. The developed SESMR process consists of a cyclic fluidized-bed (CFB) system, heating and pretreatment systems, CO_2 capture system, and H_2 recovery system. To analyze the CFB system including a bubbling fluidized-bed (BFB) reactor and fast fluidized-bed (FFB) regenerator, a dynamic model is formulated. Then, the validated CFB model is integrated with the dynamic model of the PSA and the algebraic equations of the other units to analyze the dynamic behavior and performance of the integrated SESMR process. The high energy efficiency (82.2%) and low H_2 production cost of the SESMR process (12% reduction from that of the SMR process) are close to the prediction by the DoE. According to the performance analysis, the temperature of the BFB reactor is the most important variable because it considerably affects the product quality, CO_2 capture, H_2 cost, and energy efficiency. The results contribute to the design, optimization, control, and decision-making processes relating to centralized or semi-central H_2 production.