Analysis of a high-temperature thermochemical storage process in fluidized bed reactors

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Thermochemical energy storage is based on gas-solid reactions characterized by high heats of reaction: the endothermic reaction is carried out when excess energy is available (charge phase), while the exothermic reaction is allowed to take place when the energy demand is higher than the production (discharge phase). The efficiency of these storage systems depends on both the characteristics of the material employed and the reactor design. More specifically, the system should be capable of guaranteeing a constant outlet temperature of the gas during the discharge phase for long periods of time. Both the $CaO/CaCO_3$ and the $MnAl_2O_4/MnAl_2O_{4-\delta}$ materials have been found to be promising for application in thermochemical storage reactions. To improve the thermal management of the process, the use of fluidized bed reactors has been proposed, because of the high heat transfer rate between solid and gas and their capability of maintaining almost isothermal conditions; however, these reactors are less flexible in terms of operating conditions because of the need to maintain adequate fluidization conditions. These are, in turn, strongly affected by changes in density of the solid particles that can take place during gas-solid reactions. In this work, a model for a fluidized bed reactor operating with either the $CaO/CaCO_3$ or the $MnAl_2O4/MnAl_2O_{4-\delta}$ was developed. The effect of the degree of advancement of the reaction on the fluidization characteristics was analyzed and simplified models were developed to evaluate key performance indicators at a low computational cost.

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