

MODELING CO₂ CAPTURE FROM FLUE GAS VIA CALCIUM LOOPING IN A FLUIDIZED BED MULTIPLE REACTOR SYSTEM OPERATED WITHOUT AUXILIARY FUEL

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Global warming due to anthropogenic CO₂ emissions is stimulating the development of novel combustion and gasification technologies ready for Carbon Capture and Sequestration (CCS). A promising CCS technology is the Calcium Looping (CaL) cycle, which is based on the alternated temperature-swing uptake (in a carbonator) and concentrated release (in a calciner) of CO₂ in flue gas by a calcium-based sorbent such as limestone. A major drawback of the CaL technology is the energetic penalty arising from the calciner: the classic CaL cycle considers the oxy-combustion of an auxiliary fuel to accomplish this step. Such a solution requires an air separation unit and (if a solid fuel is used) a separation stage for ash removal. The development of a CaL cycle that does not include the use of an auxiliary fuel could then be a crucial improvement of this CCS technology. The energy needed could come from Concentrated Solar Power (CSP) systems, achieving in this way a conversion of the solar energy into chemical energy. Therefore, a similar CaL cycle could be, in principle, operated without any energy penalties and maybe even with a gain in energy arising from heat recovery in the calciner. To achieve an elevated solar energy conversion and to maintain the easiness of solid transport between the reactors, the calciner should be again a fluidized bed reactor, and hence the global system should be conceived as a Multiple Interconnected Fluidized Bed (MIFB) system. In order to fulfill this objective, a model of such a system has been developed with a first eye on the material balances. The reactors are conceived as circulating fluidized beds. The model consists of a population balance for each reactor, with one equation for each granulometric class considered. Different phenomena are taken into account, like the recirculation between the reactors, the chemical reactions, the elutriation of fine particles, the make-up of fresh sorbent and the purge of spent one. Additionally, internal exchange terms between the granulometric classes are considered, as they result from attrition/fragmentation phenomena that occur in each reactor causing modifications of the sorbent particle size distribution. Regarding the chemical reaction terms, the course of carbonation is modeled by assuming well-stirred behaviour of the carbonator, while the sorbent regeneration is modeled under the assumption of extremely fast calcination. Results of the model are expressed in terms of the mean carbonation degree of sorbent particles, the global elutriation rate and the CO₂ efficiency capture as a function of the major process parameters of the system like Ca/C inlet ratio at the carbonator, fluidization velocity and space-time of the reactors.