Carbon dioxide is the primary greenhouse gas emitted through human activities; therefore, efficient reduction of CO2 is regarded as one of the key environmental challenges of the current century. Different processes have been introduced in the literature for CO2 capture; among these solid sorbent processes have shown potential advantages. In order to achieve steady CO2 capture using solid sorbents, a circulating fluidized bed (CFB) is used that consists mainly of a carbonator reactor (where the CO2 is adsorbed by solid sorbents) and a regenerator (where carbonated sorbents release CO2 and a concentrated CO2-steam mixture is produced). Different solid sorbents have been developed to be utilized in carbon capture units such as MgO-based sorbets and CaO-based sorbents. In this study, an MgO-based solid sorbent was used due to its capability to capture CO2 at high temperature (300-550 °C), which is in the vicinity of the operating conditions of advanced power plants (e.g. integrated gasification combined cycles [IGCC]). Use of Mgo based sorbent results in a lower energy penalty in the carbonation/regeneration cycle of MgO-based sorbents. In this study, three dimensional CFD simulations of the regeneration unit of the carbon capture process using MgO-based solid sorbents were investigated and the performance of the fluidized bed regenerator unit, operating at different conditions, was studied.