DESIGN AND SIMULATION OF SOLAR-AIDED CACLINATION PROCESS WITH THERMOCHEMICAL ENERGY STORAGE

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ABSTRACT

Cement production is among the most energy intensive industries, accounting for ~5% of the total CO_2 anthropogenic emissions, with 2/3 of these emissions attributed to carbon dioxide produced by limestone decomposition [1]. In the course of the SOLCEMENT project [2] a novel process has been developed, where concentrated solar energy is used for limestone calcination instead of thermal energy generated from fossil fuels combustion, while a Thermochemical energy Storage Reactor (TSR) [4] is also utilized to transfer energy from daytime to the night operation. A preliminary version of the process has been outlined in [3], while an updated version is presented here. The new process enables co-integration with CO_2 capture systems by introducing a separate stream for the high-quality CO_2 produced from limestone decomposition.

The SOLCEMENT process features the use of high temperature solar heat for calcination and preheating during the day; part of the energy is moreover stored, via the $CaO/CaCO_3$ cycle, in the TSR during day and used during night for preheating the raw material. Appreciable energy savings are attained by considering a pre-calciner temperature of 1000 °C, while the overall performance is improved by shifting production towards daytime. During night-time, the solids are preheated in two separate subsystems; the first uses pure CO_2 (from the TSR and the calcination process), while the second uses flue gases from the calciner burner. This enables retrieving the stored energy from the TSR, in addition to recovery of a high-concentration CO_2 stream. The proposed partial solarization of the process and energy cascading between day and night operation, can lead to significant reduction of fossil fuel consumption and associated CO_2 emissions. The fossil fuel energy use for the SOLCEMENT process is reduced by 33% compared to the conventional process. The related CO_2 emissions are also reduced by 9%, while the output gaseous stream due to its higher CO_2 concentration is more amenable to further purification steps.

KEYWORDS: Solar Aided Calcination, Process Design, Cement Production, Process Simulation, Process Optimization, Emissions Reduction

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