Clean Techn Environ Policy (2013) 15:489–499
DOI 10.1007/s10098-013-0607-5

ORIGINAL PAPER

# Numerical analysis of cement calciner fuel efficiency and pollutant emissions

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Received: 30 November 2012 / Accepted: 23 February 2013 / Published online: 27 March 2013


**Abstract** Efficient mixing of pulverized fuel and limestone particles inside cement calciners is important due to the reason that the calcination process directly affects the final fuel consumption. The focus of this paper is on the numerical analysis of cement calciner's operating conditions and pollutant emissions. The paper analyzes the influence of different amounts of fuel, mass flow of the tertiary air and the adiabatic wall condition on the decomposition rate of limestone particles, burnout rate of coal particles, and pollutant emissions of a newly designed cement calciner. Numerical models of calcination process and pulverized coal combustion were developed and implemented into a commercial computational fluid dynamics code, which was then used for the analysis. This code was used to simulate turbulent flow field, interaction of particles with the gas phase, temperature field, and concentrations of the reactants and products, by solving the set of conservation equations for mass, momentum, and enthalpy that govern these processes. A three-dimensional geometry of a real industrial cement calciner was used for numerical simulations. The results gained by these numerical simulations can be used for the optimization of cement calciner's operating conditions, and for the reducing of its pollutant emissions.

**Keywords** Numerical modeling · Cement calciner · Fuel efficiency · Pollutant emissions · Calcination process

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## Introduction

Large amounts of different anthropogenic greenhouse gases, especially $CO_2$, are emitted during the cement production process. Since it is well known that $CO_2$ is the most important greenhouse gas, and that cement industry alone contributes to 5 % of global anthropogenic $CO_2$ emissions, continuous improvement of energy efficiency in the cement production process is needed (Mikulčić et al. 2013). In order to make the cement industry more greener and lower the $CO_2$ emissions, increase of the energy efficiency comes first, followed by significant increase of the use of renewable energy sources for electricity generation, transportation, and other sectors, including process industry (Vad Mathiesen et al. 2011). Therefore, policy makers should uphold the good environmental practice in process industry, in order that the applied new technology avoids the use of additional energy, chemicals, and rare catalysts (Maroušek 2012). Aside from the studies investigating the $CO_2$ emissions coming from the cement manufacturing process, several studies investigated the economical and ecological benefits of waste-to-energy technologies, e.g., using alternative fuels in cement plants. Villar et al. (2012) studied the waste-to-energy technologies in cement industry, and other continuous process industries, showing how GHG emissions and energy use can be reduced. Fodor and