CHALMERS
UNIVERSITY OF TECHNOLOGY

CEMENTA
HEIDELBERGCEMENTGroup

PROCESS OPTIMISATION OF AN EXPERIMENTAL ROTARY KILN

Master thesis project with Cementa and the Energy Technology division, Chalmers.

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Background: To reach the governmentally set target of net-zero greenhouse gas emissions within Sweden by 2045, drastic changes in the near future of the industrial sector are required. Cement production is globally one of the heaviest emitting industrial processes of greenhouse gases and Cementa, a cement producer, is Sweden's second largest single emitter of carbon dioxide. While emissions of carbon dioxide are inherent within the cement production in the calcination step ($CaCO_3 \rightarrow CaO + CO_2$), combustion of fossil fuels is used to supply the process with the required heat for the calcination and clinker formation. The clinker formation occurs today within a rotary kiln, a cylindrical, horizontal and rotating furnace through which the bed material passes and is heated. The heat transfer within the rotary kiln is very complex since it includes convective, conductive and radiative heat transfer as well as a moving bed material and wall. Additionally, the clinker formation chemistry is complex and challenging to describe and connect to the heat transfer problem.

Cementa aims to reach climate neutrality already in 2030, i.e. with no CO_2 emissions during the lifetime of the cement product. In order to reach this target several collaborative project is on-going. One such project exists between Chalmers University of Technology and Cementa with the aim to exchange the current burners to plasma torches, changing the fossil fuel for electricity. Such plasma reaches temperatures far higher than a conventional flame and such a change would cause some uncertainties of how to operate the process. Depending on the working gas used for the plasma and the plasma torch placement, the heat transfer within the rotary kiln will be affected, mainly the radiation, and may cause changes of the bed chemistry. Due to the radiative properties of CO_2 and the fact that it will be emitted from the calcination, CO_2 could be a suitable working gas for the plasma torches. Capturing the CO_2 from the process and ensuring the usage of renewable electricity for the plasma torches, net-zero emission could possibly be reached for the cement industry. Simultaneously, large hot gas and material flows are present within the cement production. By redirecting or recirculation of some gas flows, heat could potentially be used in a more efficient manner and the required fuel/electricity for the process could be lowered.

The Master thesis work:

The Master thesis work will examine if alternative heating sources are possible to use at industrial scale production. Tests with a smaller kiln, an experimental kiln (named Kiln 9) are to be conducted. Kiln 9 is a unique pilot kiln suitable for advanced research experiments, but Kiln 9 is newly built and not yet fully characterized. The main focus for the master thesis work is to characterize, set-up energy and mass balances and to optimize production parameters of the kiln for future experimental tests. Kiln 9 has been modified to resemble a modern clinker production kiln with the aim to enable research on calcination and clinker production. It is of outermost importance to know the production parameters relation so that an optimum evaluation is possible. Knowledge of heat losses and optimal feeding rate to reach the best heating transfer to material is knowledge needed to enable good testing results.

The thesis will include:

- Feasibility study to be utilized in spring 2020 within CemZero plasma research project.
- Calculations of heat losses, material and gas flows, temperature profile, and energy input for calcination and cement clinker formation. Relate the parameters for kiln 9 with full scale production.
- Given parameters are; feeding, calcination degree, angle and rotation speed of kiln. Those are to be decided for optimal output for research projects.

The goal of the thesis:

- To optimize production parameters for kiln 9 and to minimize energy losses.
- Based on optimum feeding, rotation speed and angle of kiln, with given energy input, suggest how to reach specified calcination degree.

The experimental work will be conducted at Cementa Research in Slite, Gotland with supervision from Chalmers and Cementa.

The long term goal is to develop an effective and credible tool able to evaluate raw material related to CO_2-emissions and energy consumption, a tool that will in the long term help Cementa reach its zero emission mission.

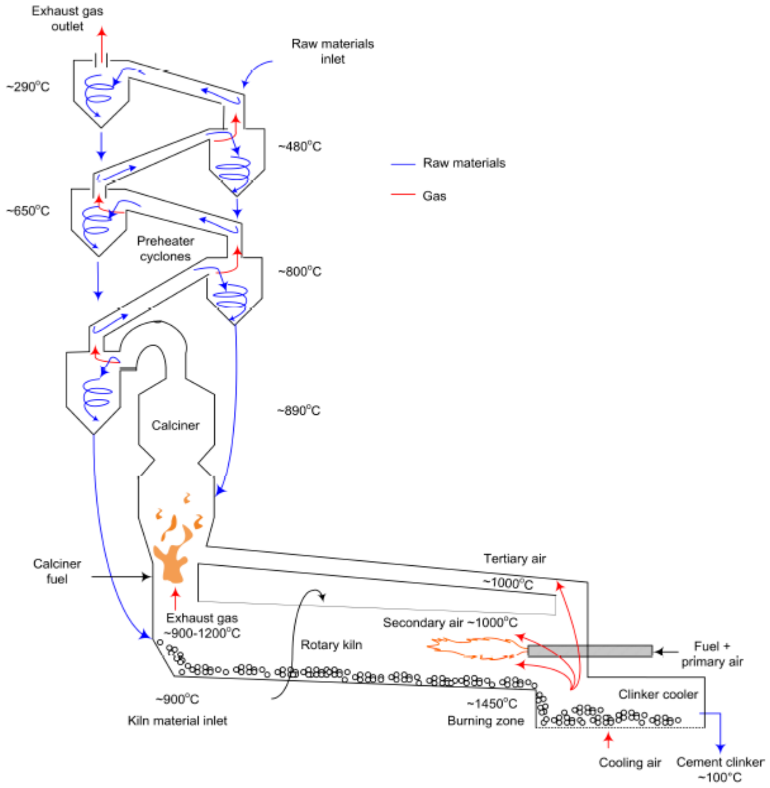

Figure 1: Schematic view of the present cement production process used at Cementa.

Accommodation and travel costs are provided by Cementa.

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