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CEMENTA
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REDUCTION OF CO2 EMISSION IN CEMENT PRODUCTION USING A THERMAL PLASMA

Master thesis project at the Energy Technology division, Chalmers.

For 1-2 students from Mechanical, Chemical or Chemical Engineering with Engineering Physics.

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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 therefore required. Cement production is globally one of the heaviest emitting industries 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.

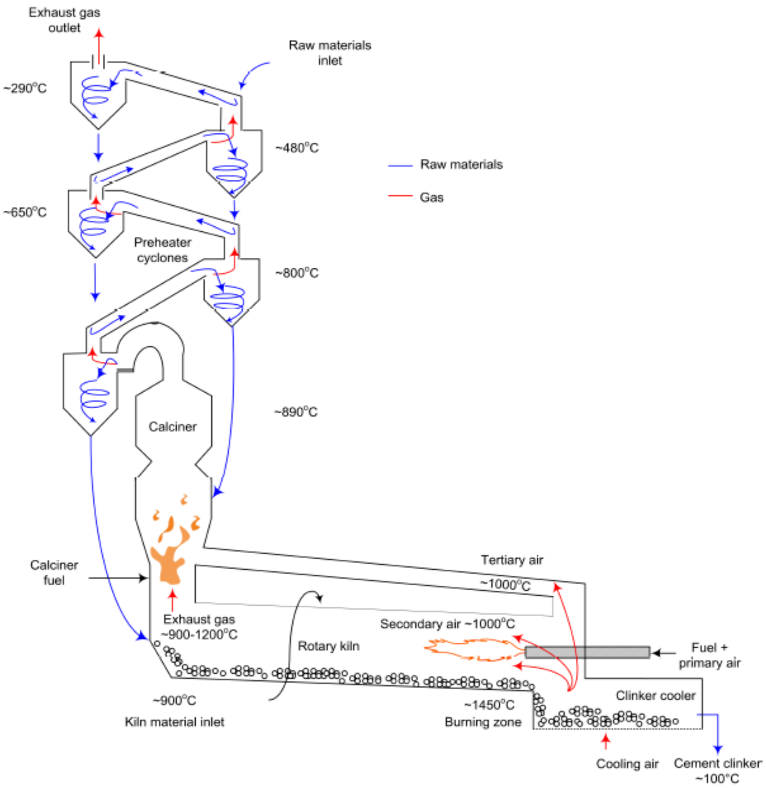
Cementa aims to reach climate neutrality already in 2030, i.e. with no CO_2 emissions during the lifetime of the cement product. In order to reach this target a collaborative work between Chalmers University of Technology, Cementa and Vattenfall has been started. To lower the greenhouse gas emissions, one suggestion has been 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.

Suggestion for the Master thesis work:

Examine the potential to lower the required fuel in the present cement process configuration or electricity for an alternative production configuration by recovering heat in hot gas streams and by recirculation of such gas streams. Further, the thesis aims to come up with potential suggestions for alternative process schemes with reduced energy requirements. Changing from a fossil fuel burner to a plasma torch will be connected to changes in gas and material flows as well as on the total heat transfer on the process. There will be a possibility to examine the bed heat treatment for various working gases by performing sensitivity analyses and parameter studies. A heat transfer model developed in Matlab, describing the heat treatment of the bed material within the rotary kiln, will be available and may be developed further within the thesis.

The thesis would aim to close the energy and mass balances of the cement production on both the product and gas sides of the process and further increase the understanding of the heat transfer using a plasma in rotary kilns and to find suggestions for how the process should be operated using a plasma.

The thesis will be conducted at the division of Energy Technology, Chalmers, with supervision from Chalmers and Cementa. There might be an opportunity to visit the Cementa production site at Slite, Gotland.



Figur 1. Schematic of the present cement production process used at Cementa.

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