

ECRA's research on carbon capture in the cement industry

Next steps towards an industrial-scale oxyfuel kiln

For more than five years ECRA has been working on carbon capture research with a strong focus on the technical and economic feasibility of this technology. This long term research project is currently in its fourth phase and the possibility of initiating an industrial-scale oxyfuel kiln is being examined. Opportunity studies for two potential sites are in preparation and will enable the Technical Advisory Board of ECRA to decide whether and how to proceed towards such a demonstration plant. ECRA benefits from its cooperation with the Norcem Brevik plant in Norway where different post capture technology providers test their equipment under realistic conditions. In addition, the ECRA academic chair, founded at the University of Mons in 2013, is an excellent source for findings from fundamental research in CO₂ capture and the different options for its reuse.

Most of the work packages in phase IV.A of ECRA's CCS project, "Further optimisation of an oxyfuel plant" have been finalised. The packages focused on a simulation study, an advanced cooler design, future oxygen supply and the experimental verification of the sealing potential. These work packages were intended to answer remaining questions which had arisen from the CCS project so

far and prepare all necessary information for a potential next step towards a pilot plant.

An additional main focus was placed on a concept for an industrial-scale oxyfuel kiln, including its design, dimensioning and safety aspects. In particular, the question of the right size was to be answered as well as where the plant could preferably be located and how it could be built.

Steps towards an oxyfuel kiln

The outcome of its CCS project phases and work packages so far puts ECRA in the position to decide whether, and, if yes, under which circumstances this potential pilot kiln could be constructed. Against this background the Technical Advisory Board of ECRA agreed to proceed with the project stepwise and to identify a few potential sites at which such a kiln could in principal be built. Based on this, the concept for a pilot kiln will then be elaborated in considerably more detail, in particular with much more accurate cost estimates, as current estimates have been based on retrofitting existing equipment, which for many reasons will not be the best technical or economic approach.

Based on the work carried out, the optimum plant size is thought to be

between 500 and 1,000 tonnes per day, depending on the specific site. In order to prepare ECRA for discussions with funding organisations such as the European Commission, the costs for such a kiln were estimated, taking into account not only the investment but also the expenditure for the test phase, i.e. the operation of the kiln. The major driver of the operational costs is oxygen, while the investment costs strongly depend on the plant environment and the equipment that needs to be installed or needs to be modified. In total, the budget required for a 500-tonne per day testing facility is between 40 and 60 million Euros, with an estimated uncertainty of $\pm 25\%$.

These very high costs, not only for the demonstration kiln but for any full-scale oxyfuel kiln, constitute difficult circumstances for the future implementation of such a technology in the cement industry. While ECRA would be able to answer technical and economic questions, political guidance is necessary in order not to undermine the competitiveness of the plants which might apply such a technology.

Storage or reuse?

Whilst the storage of CO₂ is a difficult issue in many European countries, the question remains whether CO₂ cannot be reused instead of simply stored underground. ECRA has been cooperating with numerous partners for many years, and in 2013 it initiated a dedicated partnership with the University of Mons (UMONS), in which ECRA and UMONS sponsor the ECRA academic chair "From CO₂ to energy: CO₂ capture and reuse in the cement industry". Two PhD theses have in the meantime been assigned. The first thesis was started in 2013 with a focus on "CO₂ capture in cement production and reuse: Optimisation of the overall process". The second began in January 2014 with a focus on "The purification processes applied to CO₂ captured from the cement industry for conversion into methane and methanol". In addition, scientific studies have been carried out by undergraduate students.

On 26 November 2014 the first scientific event of the ECRA Chair was held at UMONS attended by more than 100 participants from around twenty different countries. Daniel Gauthier, the Chairman of the ECRA Technical Advisory Board, underlined the industry's view on carbon cap-



Daniel Gauthier, Chairman of ECRA's Technical Advisory Board, highlighted the role of carbon capture in the cement industry at the ECRA Chair event in Mons.

ture. He pointed out the challenges which the industry faces to further reduce its CO₂ emissions. While already existing measures like the increase of energy efficiency or the reduction of the clinker to cement ratio are widely applied and therefore limited in their contribution to further decrease CO₂ emissions, many so-called roadmaps see carbon capture as a coming breakthrough technology. For this reason ECRA has addressed the subject of carbon capture with its dedicated research project

and has placed a special focus on its technical and economic feasibility. From today's point of view, carbon capture still remains much too expensive, but ECRA has decided to continue its research and is therefore now preparing the way for an industrial-scale oxyfuel kiln.

The event at UMONS not only addressed ECRA's carbon capture project. The EU Commission set CCS in the perspective of its research and funding strategy. Contributions on

the post-combustion carbon capture project at the Norcem Brevik plant in Norway and current research on carbonate looping at the Politecnico University of Milan also highlighted the potential to capture CO₂ in the cement industry. The overall focus on the capture of CO₂ and its reuse was underlined by the example of using CO₂ as a feedstock in the chemical industry and a systematic approach taking into account the life-cycle analysis including the view on the still lacking political framework.

Challenging mercury: Emission limits and measures

Global abatement strategies to reduce mercury emissions

Mercury is a ubiquitous element which occurs naturally and is emitted through various anthropogenic sources. It is introduced into the cement production process, occurring in both raw materials and fuels. Concentrations may vary in a wide range from one raw material or fuel to another, from deposit to deposit or even within one quarry.

Due to its high toxicity for human health and the environment, mercury emissions are being addressed on a global level by the Minamata Convention on Mercury – a global and legally binding treaty targeting the reduction of mercury emissions. The import, export and production of products containing mercury, such as batteries, switches, some medical devices and cosmetics will be banned by 2020. Plans to reduce and eliminate mercury emissions from artisanal and small-scale gold mining will be established, promoting mercury-free alternatives. Plans to minimise mercury emissions from existing industrial mercury emitters such as coal-fired power plants, cement plants or waste incinerating plants are to be drawn up, while new facilities are to install Best Available Techniques (BAT).

Mercury emission limits

Emissions of mercury are regulated in many countries. Where emission limit values are in place, they range (with few exceptions) between 0.03-0.1 mg/m³ as a daily average. In the EU, industrial mercury emissions are

covered by the Industrial Emissions Directive (IED), which has been transposed into most Member States' legislations in the last two years. They are limited to 0.05 mg/m³ for furnaces co-incinerating waste fuels, sampled over a period of 30 minutes to 8 hours. In the United States, new mercury emission limit values will come into effect from September 2015 on. Emissions for existing kilns will then be limited on a by-product basis to 27.5 kg per million (metric) tonnes of clinker produced. For new kilns, the limit is more stringent with 11.5 kg per million tonnes of clinker produced. These emission limits, based on a 30-day rolling average,

are so low that the local cement industry is being required to examine new methods of mercury control.

Mercury in the clinker burning process

Extensive investigations have led to a profound understanding of the behaviour of mercury in the cement production process, which is mainly determined by the thermal conditions between the preheater, raw mill and dust precipitator. Mercury and its compounds enter the process through raw materials and fuels, evaporate and partly react with other gas constituents, and due to their high volatility leave the preheater with the hot gas stream, (Fig. 1). In raw mill-on operation a significant share of mercury compounds condense on the raw meal. To a smaller extent elemental mercury is adsorbed on the meal's surface. Low temperatures and a high dust load favour the adsorption. Adsorbed

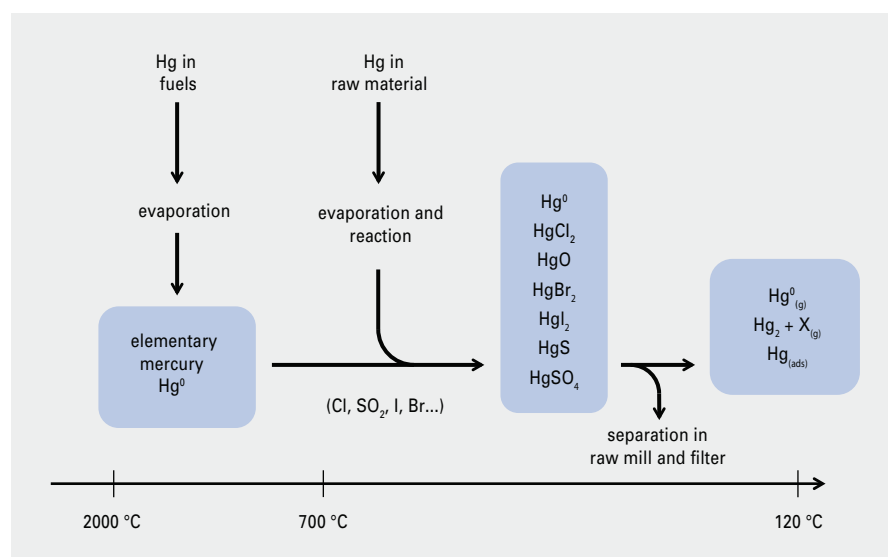


Figure 1: Behaviour of mercury and its compounds in the clinker burning process