european cement research academy

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  in Bernburg
  November 3 - 4, 2004
- Cement Properties and Concrete Performance
  December 8, 2004

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First International Conference on Innovation and Future Developments in Cement Production and Concrete Construction

Amsterdam, November 12, 2004

The European Cement Research Academy is proud to present a promising programme for its first Conference in Amsterdam. Lecturers from throughout the world will present innovative concepts for environmentally compatible cement production and visionary design methods for concrete constructions.

Technologies and possibilities for CO_2 capture and storage (CCS)

Daniel Jansen
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and

CCS prospects and the global emission and energy benefits

Dolf Gielen
International Energy Agency

The production and use of fossil fuels contribute to 64% of the man-made CO_2 and all green house gas emissions worldwide. Fossil fuelled power plants produce about 35% of all CO_2 emissions, but also other large industrial installations like blast furnaces in the steel industry, cement kilns or chemical industry are significant CO_2 sources. For decades, industry has been working on increasing the energy efficiency of its installations – driven by high energy costs. The international discussion about climate change and required means for GHG emission reduction in all societal sectors has been accelerated by the Kyoto Protocol.

For industry, beneath primary measures aiming at increased energy efficiency of processes as well as reduced CO_2 intensity of products, end of the pipe technologies called CCS (CO_2 Capture and Storage) are discussed. Technologies for CO_2 capture are already used today, e.g., the supply of CO_2 to the food industry. This is also the case with the removal of CO_2 from gaseous process streams in the chemical industry. The costs for these technologies, however, are extremely high due to the large capital and operating costs of the capture plant. Furthermore, the reduced energy efficiency due to the energy consumption of the capture system leads to a significant increase in primary energy use.

CCS technology entails that after capture the CO_2 is not emitted to the atmosphere but transported to the storage site instead. CO_2 can be stored in gas tight natural reservoirs such as empty oil fields, empty gas fields and saline water reservoirs (aquifers). Worldwide, natural underground reservoirs have sufficient capacity for the emissions of 50 to 100 years at least. But, on the other hand, there are still many technical questions to be solved for a sustainable long-term storage of CO_2.

If the technical solutions needed can be developed in the future, costs for the technology are foreseen on a level of 50 $ per tonne of CO_2 . Modelling results show that, under the technical conditions assumed, a 30% reduction of the CO_2 emissions from fossil fuelled power plants could be achieved worldwide. Today, besides the technical questions, the extremely high costs are the main barrier preventing an implementation of this technology in the near future.

Emission reductions within the framework of Joint Implementation (JI) and the Clean Development Mechanism (CDM)

Charlotte Streck
The World Bank

Taking into account recent developments in Russia it can be expected that Russia will ratify the Kyoto protocol soon. This will certainly be a step towards entry of the Kyoto protocol into force, which has set a framework for CO_2 reduction on a worldwide level. To meet these reduction requirements in a most cost effective manner, the protocol allows industrialized countries some flexibility to meet their obligations through projects generating emission reduction (ER) elsewhere. Two provisions are of particular importance: Clean Development Mechanisms (CDM) and Joint Implementation (JI).

Project-based flexible mechanisms could be beneficial for European cement producers to be able to meet their targets under the emissions trading scheme. The World Bank's Prototype Carbon Fund is one example, how emission reductions can be produced within the framework of JI and CDM. Contributors to or participants in the PCF will receive a pro rata share of the emission reductions, verified and certified in accordance with agreements reached with the respective countries hosting the projects.

The EU cement industry saving natural resources

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CEMBUREAU

The European cement industry has been substituting natural resources with various alternative raw materials and fuels increasingly for many years. The different industrial practices are important levers for the cement industry in saving natural resources and in reducing the overall environmental impact of cement production. The use of alternative fuels in the cement industry has increased over the last 15 years and is likely to increase further in the future. Alternative materials used in the production both of clinker and cement allowed CEMBUREAU members to achieve substantial direct savings of natural mineral raw materials. Conscious of its responsibility, the European cement industry will continue to contribute to a fruitful, impartial and knowledge-based dialogue about the use of alternative materials with all relevant stakeholders.

Recent developments in Taiheiyo's Eco-cement

John Saunders
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Modern society faces an increasing difficulty of guaranteeing proper waste disposal. Its waste management is characterised by ever more complex waste handling processes. The trend towards a natural resource recycling society demands waste disposal processes allowing both the reduction of waste volume and the recycling of waste material. The technology for the production of Eco-cement brings that to reality by substituting primary raw materials by different waste materials.

Public and private joint research and development projects, carried out between 1994 and 1998, have established Eco-cement as a technology. Eco-cement is made of burnt ash, fly ash from municipal waste incinerators and lime stone. Its production started in 2001. Per year, 62,000 tonnes of municipal waste ashes and 26,000 tonnes of industrial waste materials are processed together with lime stone, producing 110,000 tonnes of cement. This environmentally friendly cement is known as Eco-cement and its high quality meets Japanese industrial standard requirements. It can be used for various purposes just like ordinary cement.

Hydration modelling for virtual cement and concrete testing

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CEMEX

Currently, physical testing is a prerequisite to assess the quality of cement and concrete. These tests result in high costs for both material and labour. At the same time, many tests are time consuming and the results cannot easily be used to control the manufacturing process.

Today's computer power has facilitated virtual testing of cement and concrete. Many physical properties can be predicted such as strength development, degree of hydration, heat of hydration, chemical shrinkage, setting time and pore solution concentrations. The quality of the results, however, still depends to a large degree on the quality of the input data. Nevertheless, virtual testing has a huge potential and it can well be expected that in the future it will save the cement industry time and money in quality control and product development.

Underground tranport routes for the future

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In the 21st century, the city will be the most important place of residence for people. The demands on the technical infrastructure will present an enormous challenge to the urban and regional conurbations all over the world to ensure a secure and adaptable supply of water, gas, electricity, modern telecommunication services, etc. Increased needs for the transportation of goods will have to be satisfied. Already today, road capacity has almost reached its limit. The only way to solve this future problem is to install underground transport routes. All supply systems should be integrated in large walkable tubes. For the transportation of goods, the "CargoCap" system has been invented. Underground tubes with an inner diameter of 1600 mm accommodate the track for vehicles able to transport two euro-palettes each. These vehicles ("Caps") are directed through an intelligent computerised system and are moved by means of an individual electrical drive. To build both kinds of underground routes, large-size concrete pipes can be used.

Contour Crafting – Revoultion in construction by computerized fabrication

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University of Southern California

Contour Crafting is a fabrication process by which large-scale parts can be fabricated quickly in a layer-by-layer fashion. The chief advantages of this process over existing technologies are the superior surface finish and the greatly enhanced speed of fabrication. The success of the technology stems from the automated use of age-old tools normally wielded by hand, combined with conventional robotics and an innovative approach to building three-dimensional objects that allows rapid fabrication times. Actual scale civil structures may be built by Contour Crafting. Houses designed in the computer could be constructed in a single run, imbedding all the electrical, plumbing or even air-conditioning installations. No question that such constructions rely on tailor-made cements, mortars and concretes providing appropriate workability and adjustable strength development.

Experiences with the use of secondary fuels in precalciner kilns

Not only technical but also legal aspects are important for the use of secondary fuels

Today, the design of virtually all new kiln installations in the cement industry worldwide provides for the precalcining process. As the cement industry has been increasingly substituting secondary fuels for primary fuels during the last years, the Research Institute has been intensely concerned with the process technology requirements for the use of alternative fuels in the calciner.

First of all, the choice of the respective fuels depends on quite a number of apsects: their availability, the costs, their storability, their metering properties, safety requirements and the contaminants they contain. Furthermore, the physical and chemical parameters of the fuels are of importance. Dispersibility, moisture content, particle size, calorific value, homogeneity, the content of chlorine, sulphur, alkalis and phosphate, reactivity, the fuel/nitrogen content and the trace element content have an impact both on process technology and emissions.

Utilisation of secondary fuels

Secondary fuels are usually fed directly into the calciner. In principle, any firing unit used for standard fuels is suitable for their input as well. Depending on the type of fuel to be utilised, fuel metering can be fairly complicated. It may therefore be reasonable in certain cases to subject secondary fuels to thermal pretreatment in a separate plant. Basically, two types of pre-treatment plants must be distinguished: the gasifier, in which the fuel is pyrolysed under extremely low-oxygen conditions, and the lean gas thus produced is subsequently fed to the calciner as fuel. The energy required in this process is either supplied externally or released in a partial combustion process. In a pre-combustion chamber, on the other hand, a considerably higher proportion of fuel is converted at either over-stoichiometric or slightly under-stoichiometric conditions while the energy thus released is utilised to decarbonate the kiln feed. The unburnt part of the fuel (residual coke) can subsequently be fed to the calciner.

The plants for thermal pre-treatment existing in Europe to date are either circulating fluidised beds suited for the intake of fairly fine-grained fuels or precombustion chambers chiefly designed for the utilisation of coarse fuels like, e.g., tyres. The operating experience gained shows that both methods work reliably, although process engineering expenditure should not be underestimated. The choice of the most suitable system is influenced in particular by capital and operating costs, fuel processing costs, availability, the removal of contaminants and substances forming recirculating systems, safety concepts which might be required, and upper limits for the possible use of the poor gas/residual coke in the calciner and main firing systems. Plant designers currently make increasing efforts to further optimise existing plants and to develop and test new concepts. As both gasifiers and precombustion chambers permit a high degree of flexibility in terms of type, composition and nature of the fuels utilised, the number of these plants in the cement industry can be expected to increase in the long run.

Legal requirements

Beyond technical aspects, an increasing number of legal and environmental requirements must be taken into account when using secondary fuels. The European Directive on the Incineration of Waste (1) adopted by the end of 2000 stipulates, e.g., the following NO_x emission limits for cement works co-incinerating wastes: 800 mg/m³ for existing plants and 500 mg/m^3 (as NO_2) for new plants. The application of primary measures to reduce NO_x emissions (e.g., flame cooling or low-NO_x burner) cannot guarantee that such low limits are always kept. Investigations of the Research Institute of the Cement Industry have shown that the application of staged combustion can help to reduce NO_x emissions significantly.

Staged combustion

The process of staged combustion can only be implemented in kiln systems with precalciner operated according to the AS (air separate) process. In these plants, the combustion air is led to the calciner through a bypasses, a tertiary air duct. For several years, the Research Institute of the Cement Industry has been conducting tests on precalciner plants of different plant manufacturers. During these tests, the gas composition was measured in several spots along the calciner. The results allowed to calculate the mass flow of NO alongside the calciner and thus to determine the exact locations where NO is formed and where it is destroyed. Having this information, one can easily be derive which factors promote either the formation or the reduction of NO by staged combustion inside the calciner.

Fig. 1 shows the results obtained from measurements at a calciner. In this type of calciner, the tertiary air is mainly fed to the lower part of the calciner together with the calciner fuel. However, by using a damper the tertiary air stream can be split up so that approximately 40% of it are led to the calciner top (top air).This measure is often referred to as “air staging”. It generates an oxygen-lean zone in the lower part of the calciner, where NO can be reduced. This area will be subsequently be referred to as the reduction zone. During the tests, three different calciner operation modes were applied: with and without air staging using a highly reactive fuel (fuel type 1), and with air staging using a coarse, less reactive fuel (mix of fuel types 1 and 2).

Figure 1 displays the NO mass flow as a function of the gas residence time in the calciner. In all three tests, a formation of NO in the lower part of the calciner and a reduction of NO in the upper part became obvious.

Staged combustion in combination with SNCR

Even though no experiences with the simultaneous application of SNCR and staged combustion in precalciner kilns had been documented so far, the BREF document considered the combination of both to be "emerging technique". Using this technique, an attainable NO_x emission level of 100 - 200 mg/m^3 is assumed. Industrial trials have shown that low NO_x concentrations could indeed be achieved, but undesirably increased CO emissions were observed at the same time. A decisive role regarding a significant decomposition of NO is attributed to a sufficient residence time of the reacting species in the right temperature window.

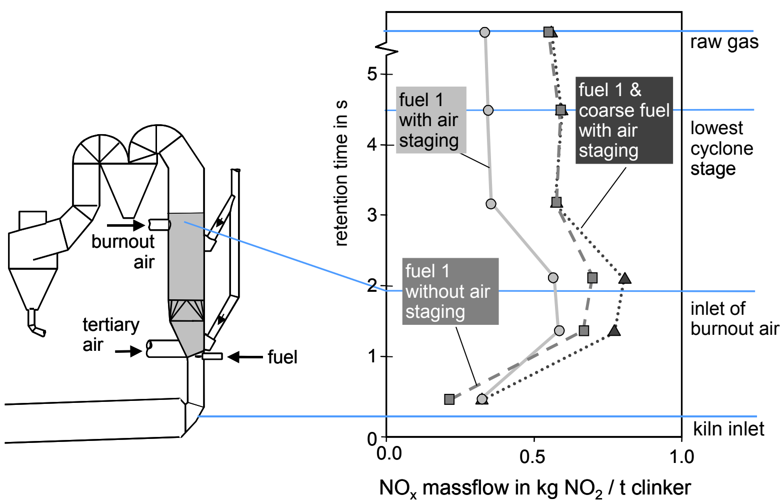

Fig. 1: NO formation and reduction alongside a calciner with staged combustion under different conditions of calciner operation