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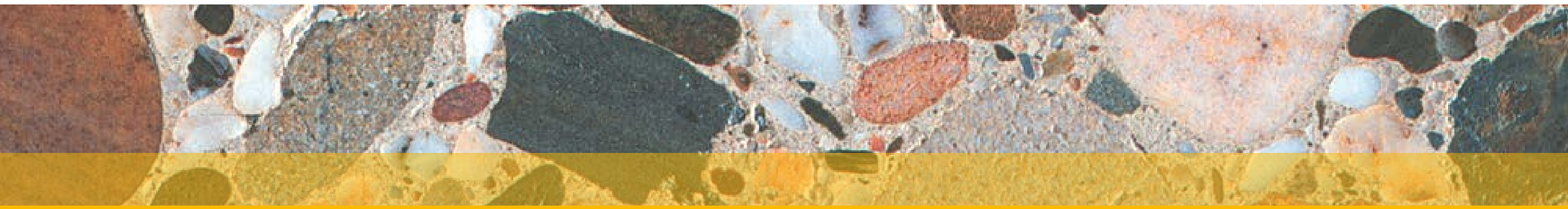
european cement research academy



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NEWSLETTER

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Upcoming ECRA online seminars:

- State of the Art Calciner Technology
  26 November 2020

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Pre-treatment of alternative fuels in calciners for more flexibility

New designs for pre-combustion chambers for thermal pre-treatment

Today, pre-calcining technology is included in the design of virtually all new kiln installations in the cement industry worldwide and in major upgrades. Precalciners provide particular flexibility, as alternative fuels can be fed at several firing places at different temperature levels. In addition to economic criteria, physical (e.g. particle size) and chemical (e.g. chlorine, sulphur, alkali and phosphate content) criteria play a decisive role in the selection of alternative fuels. Thermal pre-treatment can increase flexibility even further.

Alternative fuels are usually fed directly into the calciner. In principle, all firing positions at which fossil fuels are fed are also suitable for the input of alternative fuels. Depending on the properties of the alternative fuel to be used, some considerations have to be made. To provide optimum conditions for combustion the proper mixing of combustion air and fuel in the calciner is always of paramount importance.

Fuel characteristics

The most common alternative fuel in European cement plants is refuse -derived fuel (RDF) from industrial or municipal wastes. In its pre-processed form it is often referred to as solid recovered fuel (SRF) and can be fed directly to the calciner since it is fine enough to ensure proper combustion. The criteria must be defined for each kiln individually depending on its specific plant design. **Fig. 1**, for example, shows particle size distributions of SRF for 4 different kilns, as determined by sieving of the SRF. Between 5 and 15 % of the fuel (mass fraction) is larger than 20 mm, so these fuels are generally coarser than those for the main firing.

It may be reasonable in individual cases to subject alternative fuels to thermal pretreatment in a separate device first. This is especially useful for coarse fuels, for fuels with low ignition behaviour or in cases where fuel metering becomes complicated.

Thermal pretreatment

Basically, two types of pretreatment plants must be distinguished: In gasifiers the fuel is pyrolysed under extremely low-oxygen conditions, and the lean gas produced is subsequently fed to the calciner as fuel. In pre-combustion chambers, by contrast, a considerably higher proportion of fuel is converted at over-stoichiometric or slightly under-stoichiometric conditions. The devices for thermal pretreatment currently existing in Europe are gasifiers, such as the circulating fluidised bed from Envirotherm, and precombustion chambers from A TEC, FLS (Hot Disc), IKN (fire bed combustor), KHD (pyrorotor), and thyssenkrupp Industrial Solutions (PREPOL_SC; step combustor). The circulating fluidised bed is suited to the intake of fairly fine-grained fuels only, while most pre-combustion chambers are rather designed for coarse fuels, but fine-grained fuels can also be treated with these designs.

The choice of the most suitable system is influenced mostly by investment and operating costs, but also by fuel processing costs, the availability of the waste fuels, the removal of contaminants and substances forming cycles in the system, and safety concepts which might be required. As gasifiers and combustion chambers permit a high degree of flexibility in terms of the type, composition and nature of the fuels utilised, the number of such plants in the cement industry can be expected to grow in the long term.

Designs of pre-combustion chambers

In the HOTDISC pre-combustion chamber from FLSmidth A/S, the coarse fuels are transported by a rotating disc. The disc is speed-controlled so the retention time of the fuels on the rotating disc can be varied, depending on the fuel. To cool the outer walls of the refractory-lined pre-combustion chamber, a part of the fuel of the penultimate cyclone stage is fed together with the fuel. In this way the temperature in the HOTDISC can be controlled. The air required for combustion is drawn from the tertiary air duct. The HOTDISC is flanged to the existing calciner, into which the residues of the burned fuel then fall.

thyssenkrupp Industrial Solutions AG has developed the so-called Prepol Step Combustor (SC). The basic idea is the implementation of a step-like grate surface by which a residence time of several minutes can be achieved for the alternative fuel. Hot tertiary air passes over the fuel, which dries and ignites the material and provides combustion air for over-stoichiometric combustion. An adjustable meal divider feeds uncalcined hot meal into the combustion chamber to control the combustion temperature. The fuel is fed into the combustion chamber via feeding screws and is transported further by a flexibly adjustable air blast transport system. Light and already size-reduced particles enter the ter-

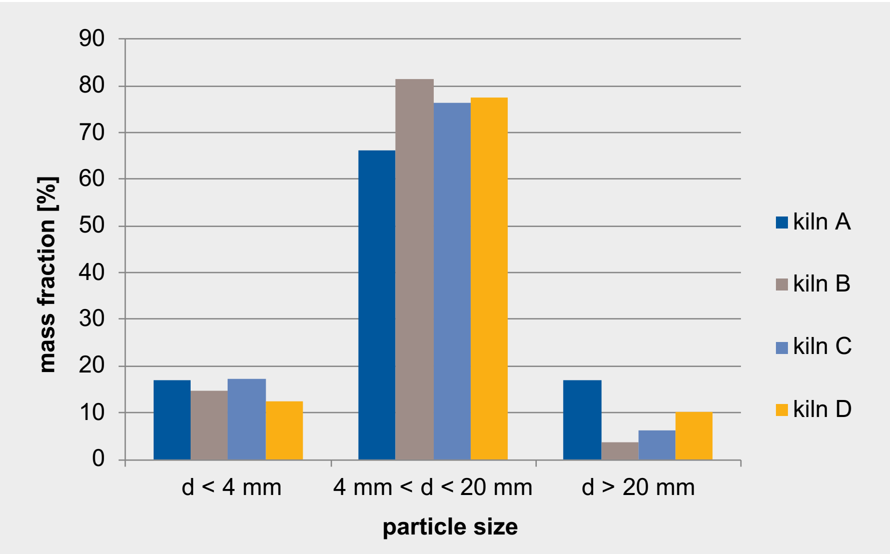

Figure 1: Comparison between different transport media for CO_2

tiary air flow and are transferred from the chamber to the calciner. As soon as the large particles are sufficiently burnt out, they also leave the chamber with the air flow.

Another device for thermal pre-treatment is the pyrorotor of KHD Humboldt Wedag International AG which is designed as a rotary reactor. The rotating drum with direct drive enables constant material movement. The speed of the rotating drum can be adjusted, so that the retention time of the alternative fuels can be optimised. The rotary reactor is installed above the rotary kiln between the tertiary air duct and the kiln riser shaft and connected to the calciner. It is operated with tertiary air which is derived from the tertiary air pipe. The coarse fuels are fed into the reactor via double screw feeders. In addition, the system has a flap for feeding whole tyres.

A different concept for the feeding of less processed alternative fuels at the calciner has been pursued by the company IKN. In the Fire Bed Combustor (FBC), fuels are fed into the combustion chamber from above and meet the tertiary air flowing in from the side. The FBC consists of a combustion chamber in which so-called wings (stairs) are inserted, which can be freely circulated by the tertiary air. While the flyable fraction of the fuels enters the calciner and releases its energy where it is needed for calcination, the non-flyable fraction dries and degasses on the wings and only then enters the calciner. The partial air flow can be adjusted to the tertiary air by means of suitable sliders.

Creating value chains for CO_2 capture, transport, storage and use

Carbon neutrality in the cement industry needs a complete CO_2 economy

All roadmaps towards carbon neutrality include carbon capture as a breakthrough technology to fully decarbonize cement and concrete. ECRA has addressed carbon capture early in its work, on the basis of which this technology can now be implemented step by step in the cement industry in the near future. Post-combustion technology is already available today. Compared to this, oxyfuel technology has higher energy efficiency but requires a retrofit of the kiln. The implementation of this technology in pilot or demonstration projects has begun. At the same time, however, solutions for CO_2 need to be developed in which utilisation and storage will both play an important role. Many initiatives and projects have been launched. However, all of them require an infrastructure for CO_2 comprising CO_2 hubs and transport schemes which still need to be developed. This is certainly a matter of great urgency, and ECRA has therefore now broadened its focus on carbon capture to include CO_2 infrastructure.

A typical cement plant of 1 million t of clinker/year produces roughly 2,000 t CO_2/day. It is clear that this sheer volume entails challenges in many different ways. How can this amount be utilised? Is there sufficient green energy to transform the CO_2 into chemical raw materials? Is there enough storage capacity already available? And, above all, how will the CO_2 get from the cement plant to the utilisation or storage site?

CO_2 transport

Experience with CO_2 transport in pipelines for enhanced oil recovery projects exist in the US and Canada. In Alberta, Canada, a 240 km CO_2 pipeline went into operation in 2020. It has the capacity to transport nearly 15 Mt CO_2/year for enhanced oil recovery and permanent CO_2 storage. In Europe, some countries are reserving corridors for pipeline infrastructures in their long-term regional planning, and an existing short CO_2 pipeline in the Netherlands is linked to large-scale projects which are now being proposed by North Sea ports.

In the transition period, CO_2 transport will depend on trucks, trains and, if applicable, ships for river and sea transport. However, ultimately a pipeline system will be needed as the backbone of CO_2 infrastructure to handle the amounts of CO_2 from cement production alone (**Fig.1**). For this reason the European Union is addressing the need for appropriate infrastructures in its strategy for trans-European networks for energy (TEN-E), which comprises not only electrical infrastructure but also the infrastructure for hydrogen and CO_2. Several projects are providing initial infrastructure ideas and the European Commission is starting a special geography lab in its Joint Research Centre to collect and provide comprehensive information.

The time required to develop new CO_2 infrastructure might well become the most time consuming element and the bottleneck for the implementation of applying carbon capture in process industries. Its availability could become a strategic question for the applicability of CO_2 capture for inland plant locations. In the light of the significant investments for pipelines a key question arises: How can infrastruc-tures and value chains be designed and established to realise effective and eco-

1 pipeline

50 marine ships, 250 inland ships

1,000 trains

50,000 trucks

Figure 1: Comparison between different transport media for CO_2

nomic CO_2 mitigation in good time? This question involves significant political aspects, which need to be resolved and discussed together with society.

CO_2 storage and utilisation

For the geological storage of CO_2 parallel developments in Europe are gaining visibility with new projects in the North Sea. Some of them plan to start storage operation before 2025. On the whole, significant offshore CO_2 storage capacities are envisaged (**Fig.2**) which have the potential to store CO_2 from process industries like cement and lime for several decades.

When it comes to the utilisation of CO_2, regional potential comes into focus. Currently, there seem to be only limited capacities available. However, these small volumes of CO_2 can readily be transported on trains or trucks. The respective projects are of high importance because they can help to get the whole process started. For a scale-up it will then be important to create partnerships with potential CO_2 users. Here, there is certainly sufficient potential which can be developed. The crucial aspect, however, will be access to green energy. It must be available reliably and at sufficient low costs, whether as electrical energy or already transformed into hydrogen. Excess energy from wind farms or PV plants has already today proven to be a good starting point for upcoming pilot and demonstration projects.

Initial cost indicators

The cost for carbon capture is primarily related to its energy demand at the cement plant. This depends on the technology used and the availability of excess heat available from the existing plant. But all other costs for onshore and offshore CO_2 transport, storage, CO_2 handling and conditioning must be covered too.

From today's perspective, the additional CCUS cost elements can only by estimated. **Fig. 3** shows the estimates for the various carbon capture technologies, i.e. post-combustion, oxyfuel and calcium looping. Also included are cost figures for transport and storage. Still missing are figures for the utilisation of the CO_2. These figures depend on many conditions, most of which are however not clear at this time. The important factor of course will be the price for electrical (green) energy. It can be expected that this will further de-

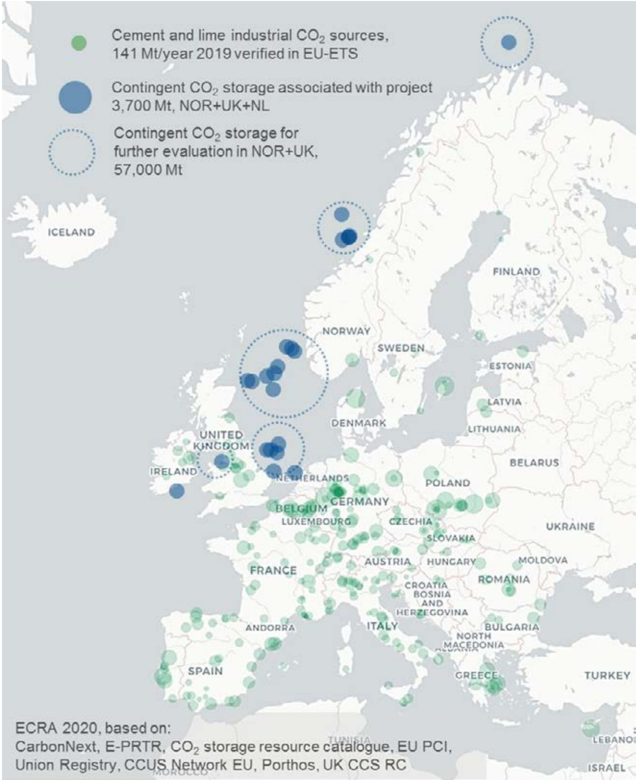

Figure 2: CO_2 sources of the ce-ment and lime industry in Europe and potential CO_2 offshore storage sites

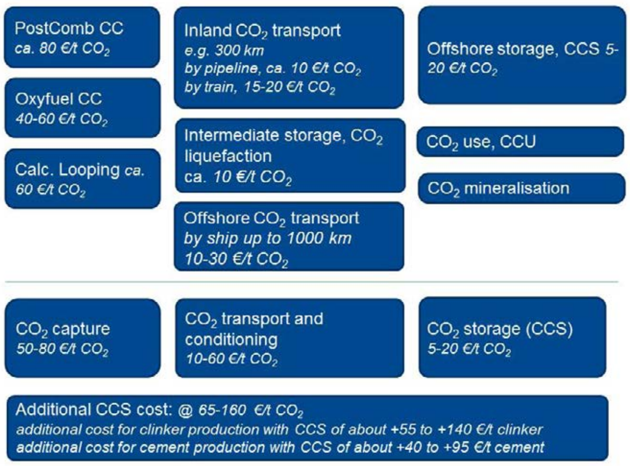

Figure 3: Cost estimates for CCUS: ECRA 2020, cost indications as example and based on estimates, CO_2 capture cost incl. CPU and compression of CO_2, based on: ECRA CCS project reports, CEM-CAP Project D4.6 and D5.2, VDZ studies and process model, Schneider 2019, ZEP 2019, CLUSTER 2019, CEMBUREAU 2050 Roadmap, Ortlepp 2017

crease over time and finally make utilisation a business case for all participants in the value chain.

The cost example given here refers to a future oxyfuel CCS application. With additional costs of 65 – 160 €/t CO_2, additional clinker costs will be in the range of 55 to +140 €/t clinker.

The figures indicate the enormous increase in CO_2 costs in the value chain of cement and concrete. Today, these figures are not reflected in the CO_2 price, which is ultimately needed to mirror the efforts taken by the cement producers. This will also imply a global carbon market, since not only all cement producers have the same target of carbon neutrality, but also other industrial sectors, including transportation and building.

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