A focus on flash calcining

The use of supplementary cementitious material in the manufacture of green cement - including calcined clay - has been growing in popularity. In the first of two articles, FCT Combustion evaluates the different methods, opportunities and challenges of environmentally friend and more cost-effective ways of producing cement, starting with a focus on flash calcining technology.

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Cement manufacturing is a central piece in the development of infrastructure around the world. However, as with every energy-intensive industry, it is also responsible for substantial amounts of pollutant emissions, with approximately eight per cent of the world's manmade CO_2 emissions coming from cement production.

With many countries adopting stricter policies for greenhouse emission reductions, attention is increasingly focussed upon ways industry can reduce these emissions without significant cost increase or quality reduction. One possibility is to replace clinker with supplementary cementitious materials (SCMs) to create 'green cement', which is named for its environmental benefits.

FCT Combustion has developed FlashCalx technology: a suspension calciner for the thermal treatment of clay

About SCMs

SCM can be defined as amorphous silico-aluminous material with hydraulically-binding characteristics. Natural volcanic materials, limestone and industrial byproducts such as fly ash and slag have been popular choices of SCM in recent years. However, natural materials are not available everywhere, and industrial SCMs such as fly ash and slags have experienced reduced availability and increased costs.

Therefore, other types of SCM are increasing in popularity due to their wide availability and low costs. One popular alternative is calcined clay, also commonly called pozzolan, which can be used as a partial replacement for clinker. The required raw material is available virtually everywhere across the world.

This form of synthetic SCM has proven to be a sustainable alternative, offering both environmental and economic benefits to producers as well as contributing to enhanced durability and plasticity within the concrete.

Clay deposits tend to be very heterogeneous, but clays used as pozzolans typically range from 50-65 per cent SiO_2 and 17-38 per cent Al_2O_3. The content of sand and other impurities can vary enormously, usually in a range of 5-50 per cent. Several types of clay can be used with kaolinite, illite and montmorillonite being the most common types. Fineness of the clay after drying can range from a few micrometres to a few milimetres.

The main aim of the industrial processing of pozzolans is to remove hydroxy from the clay structure (as opposed to removing the carbon dioxide from the limestone structure in clinker production), leading to the activation of alumina and silica oxides. It is important to note that a low calcination temperature will not activate the clay completely and an excessive calcination temperature can cause the recrystallisation of the clay structure. Both cases substantially decrease the reactivity of the clay.

The calcination of the clay can be achieved via various methods, but two industrial solutions are the use of a rotary kiln or a flash/suspension calciner.

Evaluating the best method for processing SCM

The heating process that the clay is submitted to in both technologies is similar. However, each method has its own particularities, advantages and disadvantages. Trade-off studies should be conducted and individual projects evaluated with their own specifics and particular costs to find the best solution on a case-by-case basis.

Some of the advantages of the flash calciner are:

- tighter control over the calcination

temperatures, which in turn could lead to a better reactivity of the product.

- possibility of higher substitution rates by alternative fuel, as the hot gases required for the process are supplied by a dedicated hot gas generator.
- possibility of inert material removal during the grinding of the raw clay prior to the injection in the flash calciner, reducing the wear and specific thermal consumption.
- grinding of the calcined clay is mostly not required, as it can be fed directly to the cement mill separator (only to assure that the small fraction of oversized material will be ground).
- low thermal inertia due to the limited amount of refractory lining in the equipment, allowing for a faster start-up and production.
- easy control philosophy, very similar to a calciner in a clinker kiln.
- overall thermal energy consumption is lower than in a rotary kiln system due to less area of hot surfaces exposed to ambient and better heat recovery.
- overall electrical consumption is similar or lower than in a rotary kiln due to different requirements in grinding energy and the absence of the kiln motor drive, although it requires a larger exhaust energy.
- lower maintenance due to static equipment, and low amount of refractories.

FCT Combustion has developed both types of clay calcining technologies to support customers in the production of 'green cement', in the form of FlashCalx and RotaCalx. Having these two products in its portfolio, FCT is an unbiased partner to find the best solution in each specific project for each specific client, each specific set of constraints and especially with each specific type of clay.

The installation includes a state-of-the-art hot gas generator which provides extreme fuel flexibility

Producing 'green cement' with FCT's FlashCalx technology

FCT Combustion's FlashCalx technology is a suspension calciner for the thermal treatment of clay.

Prior to the flash calcination, raw material must be dried down to one per cent moisture. This is accomplished either by a flash dryer, a rotary dryer, or its equivalent depending on the moisture.

Clays are, by nature, a fine material. However, in some cases a dryer-grinder might be required. The selection of the dryer-grinder should be carried out case-by-case, very carefully considering the moisture, fineness and composition of the material.

The usage of a grinder also allows the possibility of inert material such as sand removal prior to the injection into the flash calciner, reducing specific thermal energy requirements and maintenance.

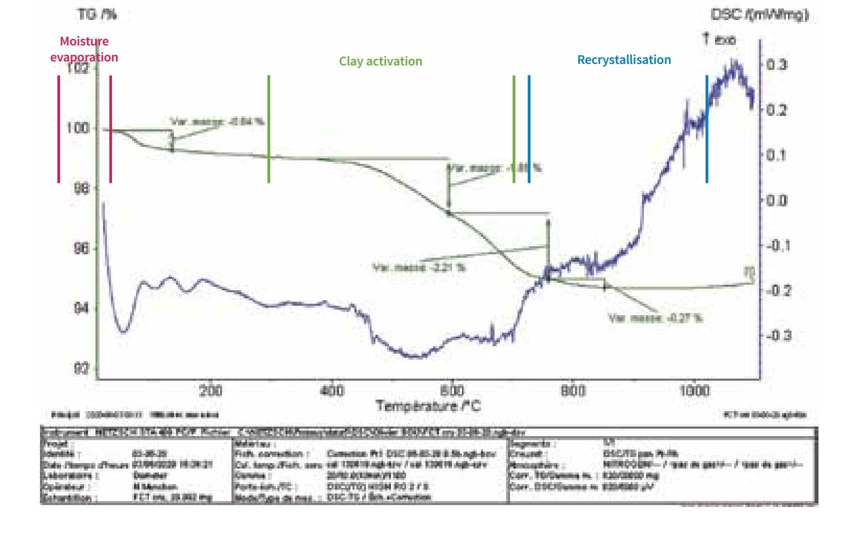
To control the colour of green cement, FCT has a proprietary solution to achieve a traditional grey hue

Clay is fed to the flash calciner and preheated in a traditional set of two preheating cyclones, where hot gases coming from the calciner cyclone transfer heat to the feedstock. This provides significant heat savings for the system. An induced draught process fan controls the transport in the preheat/calcination sections, while a baghouse filter is applied for dedusting. The gases coming out from the flash calciner installation can be used to dry and grind the raw clay, reducing the thermal consumption even further.

The installation comprises a state-of-the-art hot gas generator that gives huge flexibility on the type of fuel to be used. The hot gas generator can fire traditional fuels such as natural gas, fuel oil and pulverised fuel, lumpy coal/petcoke and alternative solid fuels, such as biomass and RDF/SRF.

Inbetween the calciner riser and calciner cyclone, the dihydroxylation of the clay is achieved. Reaction temperature is easily controlled by a temperature-fuel

Thermogravimetric and differential scanner calorimeter analysis



PID loop, normally ranging from 700-900˚C depending on the characteristics of the clay. The control of temperature in a narrow range is key to avoid the crystallisation of the calcine.

Refractory is only applied in the combustion chamber, riser and calciner cyclone, which allows for faster and cheaper heat up. This makes it possible to re-start the system from cold condition within 1-2h. All material transport through the system is either pneumatic conveying or gravity, which is translated into a low maintenance, low weight and high reliability installation.

After the completion of the reaction, the product arrives at a set of cooling cyclones, responsible for decreasing the calcining temperature while recovering heat both to the hot gas generator and raw meal drying. Another process fan controls the gas flow in the cooling section. This allows for separate control between the preheating/calcination section and the cooling section of the flash calciner, adding more flexibility to the system.

The final product can be pneumatically or mechanically conveyed to the product silos or straight to the finish mill separator to be blended with cement.

As FCT's flash calcination easily controls and prevents the melting and agglomeration of the clay, the calcination product has a high specific surface, leading to a highly-reactive pozzolan.

Controlling the colour of calcined clays in green cement

One of the past challenges in the commercialisation of calcined clay-based green cement has been the ability to keep cement's traditional grey colouring.

The iron (Fe) content often found in clay can result in the product being a reddish hue depending on how it combines to oxygen (O). Iron compounds in the form of hematite (Fe_2O_3) have a reddish hue and when in the form of magnetite (Fe_3O_4) have a dark-greyish hue. At higher temperatures, the iron is mostly in the form of magnetite. The trick is to keep the iron in the magnetite form during the cooling of the clay after calcination, somewhat similar to what is required in white clinker manufacturing.

Although the colour does not correlate with any issue of quality, it may sometimes be rejected by end-users seeking cement in the grey colour that they are used to working with, perceiving the reddish colour as of an inferior quality or strength.

There are different techniques to create the grey hue through maintaining a reducing zone during cooling using fuel injection close to the kiln discharge or in the cooler and/or injecting fuel mixed directly with the raw clay. Both methods have important setbacks and increase the plant-specific consumption. Mixing fuel with the clay input to the calciner can even generate issues with volatile organic compounds and other hazardous emissions.

Fortunately, FCT has a proprietary solution through the addition of inorganic modifiers to achieve a traditional grey hue, without impacting on fuel consumption or having a negative impact on emissions.

Specialised support

The activation of clay pozzolans are heavily dependent on three basic factors:

- mineralogical composition of clay
- crystallinity
- optimal calcination temperature.

To ensure quality expectations are met, FCT collaborates with associated laboratories to perform thermogravimetric/differential scanning calorimeter and reactivity tests, among others. These are performed at the very beginning of any clay calcination project evaluation to check which type of technology and auxiliary equipment are required. Depending on the results of these analysis, the project can become viable or not.

Pilot plants in Europe and in the Americas are available for testing, while industrial-scale tests can also be performed in a 10tph unit in Europe. The calcined clay can be shipped back to the client to allow plant-scale tests in the cement milling circuit for final proof of quality before building a full plant.

With a specialist team who have successfully commissioned a combined 12 plants around the world for calcined clay, FCT is well placed to provide specialist advice to customers to ensure smooth adoption of their chosen production method.

The process, from initial evaluations to design and supply, is as follows:

- raw material investigation looking at reactivity, colour, activation temperature, moisture and other factors
- pilot plant tests and trial LC3 cement testing
- plant scale production of calcined clay and bulk cement plant trials
- concept plant design and operating conditions, budget pricing
- design and supply, commissioning and support of clay calciner.

Summary

The use of calcined clay in substitution of clinker in cement production has many advantages, from environmental to economical aspects. However, to maximise its use, it is important to know in detail the clay activation mechanisms and its particularities. Having an experienced partner can avoid possible drawbacks and shorten the learning curve of the plant personnel. ■

SECOND PART OF ARTICLE

FCT's rotary kiln solution, the RotaCalx, will be the subject of an article to be published in *International Cement Review*, August 2021.