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NEWSLETTER

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Upcoming ECRA seminars:

- Cement Grinding Technology
  11 – 12 May 2017
- Kiln Firing Systems for Advanced Alternative Fuel Co-firing
  31 May – 1 June 2017

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Future grinding technologies: Mastering fineness and flexibility

Operating a grinding plant efficiently requires a complex compromise between many different aspects

Grinding technology for cement manufacturing is often discussed against the background of electrical energy efficiency. The reason for this is the high share of up to 70 % of the electrical power demand from the quarry to shipping - including sub-processes like transportation - that is spent on comminution. Fig. 1 shows an average distribution of the electrical energy demand along the production process, with most energy spent on the finish grinding of the cement. But the challenges of grinding are manifold: operational costs for a given product fineness are not only driven by energy demand, but also by wear and maintenance costs and plant availability. Furthermore, CAPEX decisions are often influenced by considerations with regard to product fineness and production flexibility.

The available mill types for cement grinding have not changed significantly over the past years. Due to the large size of typical cement installations and the long lifespans of mills there has been a continual improvement in grinding equipment, but with no breakthrough or even disruptive innovation. The development has shown that high pressure comminution in vertical roller mills (VRMs), high pressure grinding rolls (HPGRs) and also in the Horomill is more efficient by far than in ball mills.

Grinding mechanisms

Comminution within a material bed is less efficient on a laboratory scale than single particle breakage. But when it comes to handling several hundreds of tons on an industrial scale, the ability of such devices to stress material with high probability makes comminution within a material bed more efficient. Better control of the material bed during comminution offers further potential to increase the efficiency of such mills. Corresponding concepts have, for example, been realised in the Argo mill.

New mill types for finish grinding are however still only rarely found across Europe, while a large number of ball mills from the 1970s are still in operation. What is the reason for this? The replacement of existing ball mills with new mill systems is of course in many cases not possible due to economic reasons, but even among the few new installations several ball mills can still be found. One reason for this is that VRMs and HPGRs are still assumed to be difficult to handle, especially at high finenesses. Vibrations, and thus availability, are often regarded as problematic, but the continual optimisation of operating parameters and control systems along with new drive concepts have solved most of the problems in this respect. The wear of rollers has also been minimised over the past decades and with appropriate compromises on efficiency and capacity, remarkable lifespans can be achieved. In addition, even particle size distributions (PSDs) comparable to those of ball mills can theoretically be produced. **Fig. 2** shows the PSD of a CEM I 52.5 ground in a state-of-the-art VRM (specific surface of around 5000 cm²/g according to Blaine) and an average PSD for ball mill ground CEM I 52.5 (based on 160 single measurements). On the other hand, narrow PSD can also have a positive effect on product properties when materials are separately ground and blended. In a new mill, product quality can of course be different, although not necessarily worse - and with any installation of a complex mill system a number of small problems occur here and there. These are all solvable, but require time and experience, so there is therefore still a level of uncertainty connected with every new mill installation.

Complexity and flexibility

On top of this, the general complexity of grinding operations has increased significantly. Grinding plants today produce a wide range of products and handle a number of different main constituents with different grindability. Sophisticated downstream processes in the concrete industry allow only minimal fluctuations in product quality, not only with regard to strength. The markets demand products with excellent workability, performance and durability, and furthermore, production has to be flexible enough to react to changing prices for electrical energy. With the increasing use of renewable energies (wind and solar) the efficient cement plant of the future has to be prepared for demand site management. Mills will have to start and stop depending on whether or not there is an excess of electrical energy. This means short response times, high storage capacities and products with a high energy-density, making both small mill sizes and ultra-fine grinding more attractive than ever before. Small mills also have a geographical flexibility which would allow clinker shipping and on-site grinding.

Future Grinding Technologies

In 2015 ECRA began a research project on Future Grinding Technologies in order to understand and take on the challenges of grinding in today's and tomorrow's industry. The project was launched with a roundta-

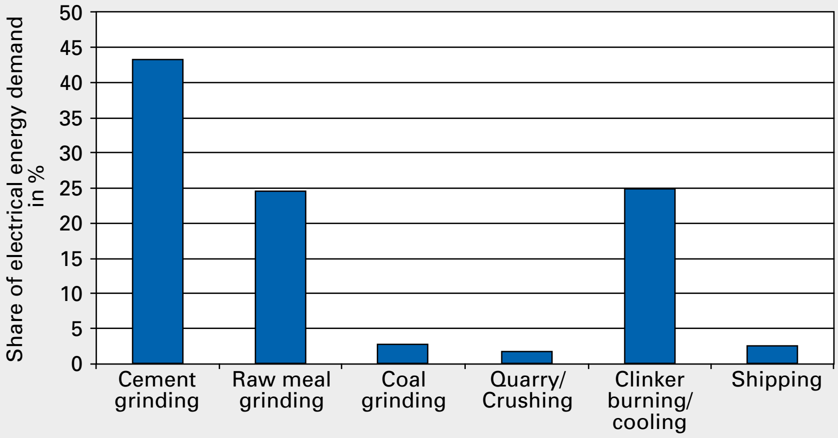

Figure 1: Distribution of electrical energy demand for cement manufacture

ble event in Duesseldorf, attended by over 50 experts from the cement industry, equipment suppliers, universities and other industries such as the mining and chemical industries to discuss the future of grinding. The importance of fully understanding and mastering the mill's impact on particle size distribution was repeatedly highlighted. As explained above, the uncertainty regarding product quality can be a driving force against the installation of new mill systems. Through better description, measurement and a priori determination of PSD along the complex processes of comminution, classification and blending uncertainties can be eliminated. This will enable a better use of existing technology to make grinding more efficient. Consequently, ECRA has begun to extensively examine comminution modelling.

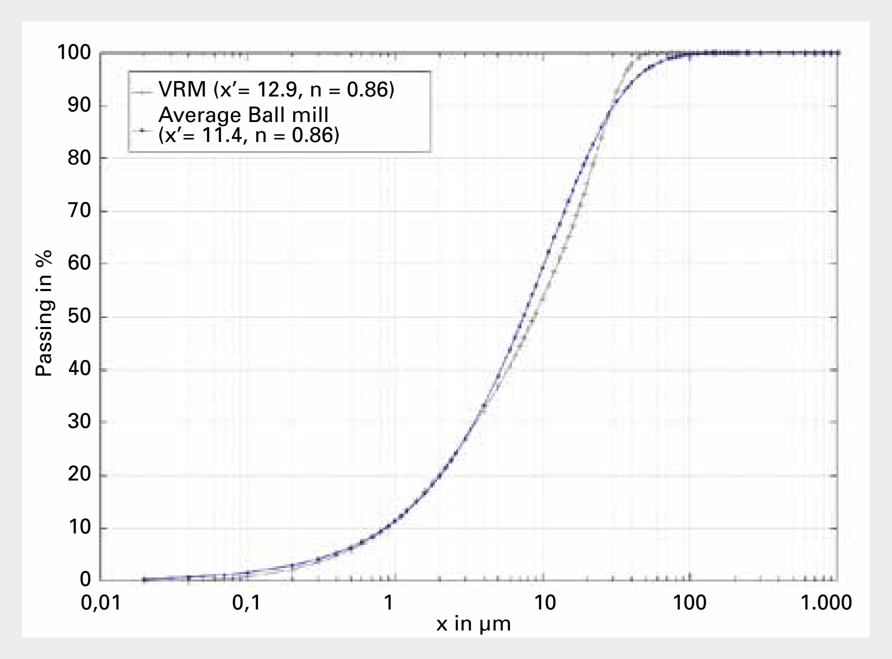

Figure 2: Comparison of PSD of CEM I 52.5 ground in a VRM and average ball mill (mean of 160 single measurements)

Burners for alternative fuel co-firing

How burner air optimisation can support the enhancement of alternative fuel substitution rates

As an energy-intensive sector, the cement industry has always made efforts to reduce its energy requirements with the goal of cutting the high fuel energy costs involved. In the past decades, high fuel costs and environmental issues have boosted the use of alternative fuels in cement plants. Despite the operating experience which has been gained, the trend of using more and more alternative fuels in cement kilns continues to challenge kiln operators and process engineers. Negative impacts on the clinker burning process, clinker quality, kiln operation and emission levels have to be minimised and correctly managed. A rapid development in burner technology has therefore been taking place with respect to the firing of multiple fuels with different combustion characteristics. The new burner generation fulfils the requirements of clinker processing with regard to these fuels and allows the compensation of adverse effects of alternative fuels through a wide range of adapting capabilities of the burner settings.

Over the years, the development of rotary kiln burners has been driven by the emergence of new fuels, the enhancement of combustion efficiency and the tightening of environmental legislation. Alternative fuel co-firing and the corresponding development in burner technology started in the 1990s (**Fig. 1**). Increasing prices for fossil-based fuels and the low-cost acquisition of alternative fuels brought economic benefits for the cement industry. On the other hand, the development of burner technology was driven by the reduction of NO_x formation in the flame. The need to reduce CO_2 emissions and use more biomass in the fuel had another impact on burner technology. In 2005 the European trade system for carbon dioxide emissions was implemented, which boosted the interest of cement plants in co-firing alternative fuels because of their low carbon dioxide emission content.

Burner technology

The desire to reach higher thermal substitution rates led plant operators to call for a new generation of rotary kiln burners. Since the 1990s burner design has evolved from the first multi-channel and Low NO_x burners to last generation high-momentum burners. Since then, rotary kiln burners have had to fulfil the following design requirements:

- warranty of clinker quality
- achievement of the desired clinker capacity
- minimum specific energy consumption
- stable process conditions
- minimum environmental impacts
- flexibility to fire different fuels efficiently

Alternative fuel co-firing

Alternative fuels for rotary kiln firing systems can come from different sources, e.g. municipal waste, commercial and industrial waste, agricultural waste, etc. The portfolio of alternative fuels used nowadays around the world comprises for this reason many different kinds of waste streams. Lumpy materials such as solid recovered fuels (SRF) are how-

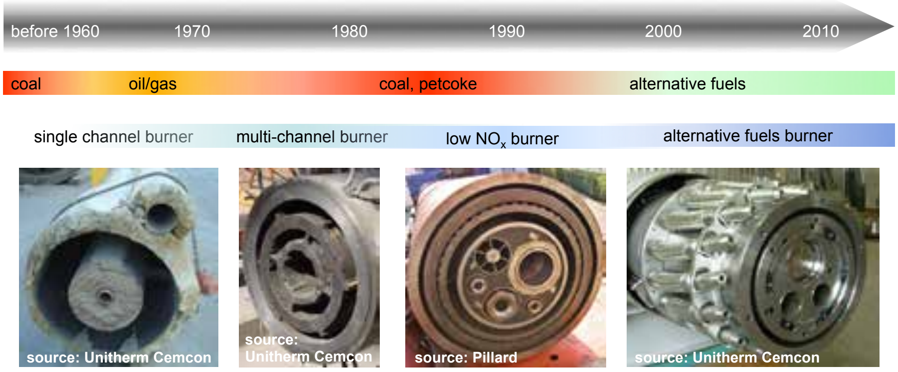

Figure 1: Burner technology and fuel evolution

ever frequently found in the cement industry and are retrieved from industrial, commercial and municipal waste. They consist of plastics, shredded paper and paper board, foils, textiles and rubber and may contain metallic and mineral impurities. Contrary to other solid fuels like animal meal and sewage sludge, which are homogeneous and have suitable specific surfaces, or liquid and gaseous fuels, SRF are characterised by:

- high moisture content
- low specific surface,
- significant heterogeneity (substantial distribution of physical and chemical properties)

Fig. 2 shows a typical SRF sample from waste. Its heterogeneous properties have contributed to a sophisticated fuel treatment and quality scheme in the plants which allow high thermal substitution. Together with the respective burner and flame control, a safe and smooth kiln operation can be maintained.

Multi-fuel burners

Nowadays, state-of-the-art kiln burners consist of multiple channels and pipes which enable the firing of different fuel mixtures at different rates (these are usually called multi-channel and multi-fuel burners). This multitude of channels and air nozzles provides the necessary flexibility to fire ground or coarse solid fuels, and also liquid, paste-like and gaseous fuels. The intensity of heat supplied by the fuels and the temperature profile in the rotary kiln are influenced both by the combustion performance of the fuels, e. g. their physical and chemical properties, as mentioned above, and by the setting of the rotary kiln burner. Shaping the flame and consequently enhancing the combustion behaviour is therefore possible thanks to the precise control of burner air injection. Flame geometry, temperature distribution and also fuel combustion can be controlled by the geometry of the outflow system and by the volume flows and velocities of primary air streams at the burner's tip (axial air and swirl air momentums).

Impacts of burner air optimisation

Alternative fuel utilisation in cement clinker production continues to progress and is an ambitious challenge for plant operators, process engineers and burner constructors. Recent research shows that the change of burner settings enables cement plants to increase their thermal substitution rate. However, care must be taken with regard to NO formation and clinker quality. Already known relationships regarding NO formation in the main firing system using conventional fuels can also be applied to the use of alternative fuels.

Increasing the axial momentum of the burner air (increase of axial air) permits higher alternative fuel usage rates but tends to promote NO formation. This can be explained by the fact that more hot secondary air is mixed into the flame with rising axial momentum, which in turn increases the oxygen concentration in the flame and the sintering zone temperature. On the other hand, swirl momentum was shown to apparently have only a slight influence on NO formation when firing solid alternative fuels. Moreover, even with an optimised flame shape, the increased use of solid, coarse alternative fuels may in some cases lead to locally reducing firing conditions and may also change the clinker quality.

New generation burners permit the setting of an adequate high axial momentum and therefore flame shaping in accordance with the fuel mixture characteristics (chemical and physical characteristics). Active flame shaping is thus a cost-effective way to achieve high alternative fuel rates.

Figure 2: A typical SRF sample

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European Cement Research Academy

Tannenstr. 2 · 40476 Duesseldorf
P.O. Box 30 03 32 · 40403 Duesseldorf
Germany

Phone: +49 (0)211 2 39 83 8-0
Fax: +49 (0)211 2 39 83 8-500

info@ecra-online.org
www.ecra-online.org