An alternative fuel firing solution for Asia Cement

Asia Cement has been making important strides towards environmentally friendly, sustainable cement operations by increasing its alternative fuel thermal substitution rate using waste-derived fuels. Since 2021, its Jecheon cement works in South Korea has been operating a KHD alternative fuel firing solution in the calciner, overcoming strongly varying fuel quality without the need for pre-processing, and resulting in reduced emissions.

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As one of the leading cement producers in South Korea, Asia Cement has taken the first steps to making its cement production environmentally friendly and sustainable, following the roadmap of the Global Cement and Concrete Association whose members are jointly pursuing the goal of zero carbon emissions by 2050.

The main goal of this pathway is to switch to CO_2-neutral technologies for cement production such as oxyfuel combustion in combination with carbon capture, utilisation, and storage (CCUS). However, currently the technologies that enable CO_2-neutral cement production are still under development, such as the LEILAC project in Lausanne, Switzerland,[1] or the CCS plant at Norcem Cement's Brevik cement plant in Norway.[2]

While these technologies are still in their testing phase, Asia Cement has focussed on reducing its carbon footprint by increasing its alternative fuel (AF) thermal substitution rate using waste-derived fuel (WDF).

AF and WDF are not standardised terms in the cement world and may have different meanings depending on the country or region. In this article, AF refers to all fuels used as alternatives to conventional fuels (ie, coal, gas and oil) in the cement industry. This includes hydrogen, synthetically produced fuels and WDF. The term WDF is used to describe fuels that were not initially produced as fuels, are available as waste and have a sufficiently high calorific value. There are other terms for these types of fuels eg, solid recovered fuels (SRF), refuse-derived fuels (RDF), municipal solid waste (MSW), but they are not standardised and are not used in this article to avoid confusion.

Potential WDFs include wood chips, sewage sludge, tyres, plastics or test fabrics. A mixture of these materials, common in landfills, is not uniform in its chemical and physical state. Furthermore, a WDF mixture without pretreatment has significantly larger particle sizes, lower heating values, higher moisture and higher contaminants than conventional fuels.

Before increasing the substitution rate at the main burner and calciner, it is important to determine the average fuel quality. According to the analysis, the amount, location and type of fuel substitution can be determined. For example, at the main burner high-quality WDF (Hu >4500kcal/kg and H_2O <5 per cent) can be fired without fuel preparation or adjustments to the firing system. On the other hand, fuels with lower calorific values should be avoided or used only in small quantities. For more information on the use of AF in the main burner, see References 4 and 5.

Fuel substitution in the calciner

This article focusses on fuel substitution in the calciner. Here, up to 100 per cent of conventional fuels can be replaced by WDF and fuel quality is only relevant for the selection of a suitable burner. As a guideline, the poorer the quality of the fuel, the more demanding and complex the demands placed on the burner. In such instances, the burner should offer long residency times and robustness against variable operating problems to ensure proper burnout and clean combustion. All major manufacturers offer such equipment, which is designed to allow the combustion of any WDF without pre-processing. At its Jecheon plant, Asia Cement chose to work with KHD, which categorises its burner equipment mainly in terms of WDF particle size (see Figure 1).

After an initial evaluation of the existing

Figure 1: simplified classification and requirements of typical alternative fuels and raw materials for use in the kiln burner and different Pyroclon® calciner applications

Pre-processing demand → Usable particle size

	Pyrojet® Kiln Burner	Pyroclon® R Calciner	Pyroclon® R with Pyroincinerator	Pyroclon® R with Combustion Chamber	Pyroclon® R with Pyrorotor®
Waste oil / Animal meal / Sewage sludge	✓	✓	✓	✓	✓
Biomass	max. 2×1×1 mm (3D)	max. 5×5×2 mm (3D)	max. 20×20×5 mm (3D)	max. 40×40×10 mm (3D)	max. 100×100×15 mm (3D)
Plastics	max. 2×1×1 mm (3D)	max. 5×5×2 mm (3D)	max. 20×20×5 mm (3D)	max. 40×40×10 mm (3D)	max. 300×100×100 mm (3D)
RDF / Fluff	max. 10×10 mm (2D)	max. 30×30 mm (2D)	max. 70×70 mm (2D)	max. 100×100 mm (2D)	max. 300×300 mm (2D)
Tire Chips	×	max. 40×40×25 mm (3D)	max. 50×50×25 mm (3D)	max. 70×70×25 mm (3D)	max. 300×300×25 mm (3D)
Whole Tires	×	×	×	×	✓

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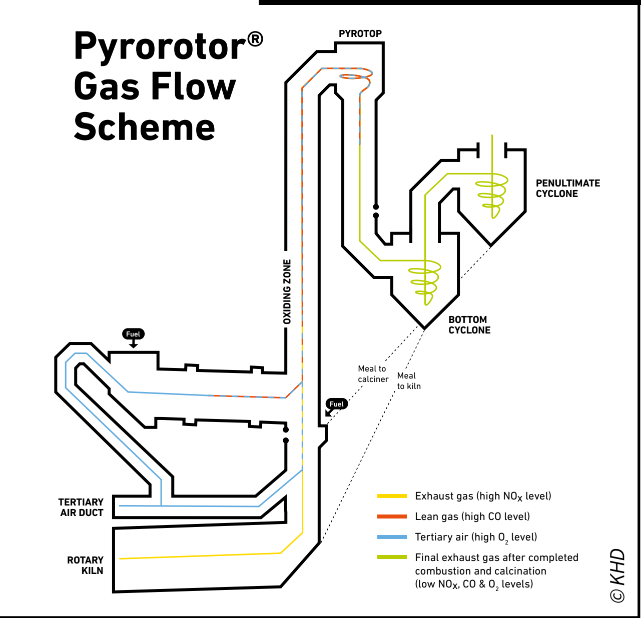
Figure 2: schematic drawing of the gas flows of a plant with a Pyrorotor®



equipment at the Jecheon works (ie, an Mitsubishi Fluidized Calciner (MFC), which only allows low substitution rates due to the short residency times), Asia Cement decided to replace it with a KHD Pyroclon® R with Pyrotop® and a Pyrorotor® as an alternative fuel firing solution.

Pyrorotor

Process specifications

Figure 2 shows the installation layout and gas phase modifications that occur during Pyrorotor operations. A portion of the tertiary air is drawn from the primary branch and channelled into the Pyrorotor, providing the essential combustion air and temperature for WDF combustion. The fuel-to-air ratio is adjustable and enables the system to adapt to fluctuations in fuel quality, either to ensure complete burn-out, or to stage combustion.

After an adequate amount of time, larger WDF particles undergo complete thermal decomposition into ash. This ash subsequently falls into the kiln riser, joining the kiln inlet material. Meanwhile, smaller entrained fuel particles exit the reactor with the combustion gases and burn in the calciner's second combustion stage. This staged combustion process is energy efficient, as heat is transferred to the raw meal over an extended distance, without temperature peaks. Additionally, by controlling the fuel-to-air ratio to produce an exhaust gas with high CO concentration, NO_x emissions can be controlled.

The efficiency of NO_x reduction is further increased if the tertiary air duct is supplied above the Pyrorotor.

Case study

Since spring 2021 a Pyrorotor has been installed at Line 3 of the Jecheon works. The before and after installation performance values are shown in Table 1.

While output remained the same, the thermal substitution rate in the calciner increased from 23 to 86 per cent. Figure 2 shows an example of the burned WDF, most of which was partly flyable plastic waste, with some larger pieces also present. Due to the high moisture content of the burned WDF, exhaust gas flow increased, resulting in higher exhaust gas temperatures and higher energy demand. In the case of Asia Cement's Line 3, energy demand increased by four per cent.

To estimate the impact of this retrofit in terms of environmental sustainability, the amount of substituted coal was determined (11tph), as well as the resulting CO_2 emissions savings (20tph). Total CO_2 emissions savings from the plant were approximately 20 per cent – a good first step toward CO_2 neutrality. Moreover, given recent rises in fuel prices, the Pyrorotor is also an interesting investment in terms of controlling fuel costs.

Finally, NO_x and CO emissions have been significantly reduced after the modification. The reduction in NO_x emissions is achieved thanks to the staged combustion in the Pyrorotor, while CO emissions have fallen due to the calciner rebuild and installation of the Pyrotop, which leads to mixing of the exhaust gases halfway through the calciner and to burn-out of the remaining CO.

Summary

The retrofit of the Jecheon plant with a KHD Pyrorotor, and the associated increase in the thermal substitution rate, can be rated as successful. The retrofit enables a saving of up to 20 per cent fossil CO_2, with a simultaneous reduction in NO_x emissions.

Even with strongly varying fuel quality, the Pyrorotor enables stable operations without the need for costly pre-processing. Following the success of this project, Asia Cement is already planning to increase substitution rates at the main burner as well. This move will be more challenging but is the next important step on the pathway to net zero cement production. ■

REFERENCES

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Figure 3: coarse waste-derived fuel (WDF) can be fed into the Pyrorotor without pre-processing thanks to high residency time that allows for complete burn-out

Table 1: Pyrorotor installation at Jecheon – before and after performance results

	Before Pyrorotor	After Pyrorotor
Clinker production (tpd)	4000	4000
Thermal AF-substitution calciner (%)	23	86
Heat consumption (kcal/kg of clinker)	775	805
Fossil CO_2 savings (tph)	0	26 (approx 20%)
NO_x @ 13% O_2 (ppm)	242	166
CO @ 13% O_2 (ppm)	511	454