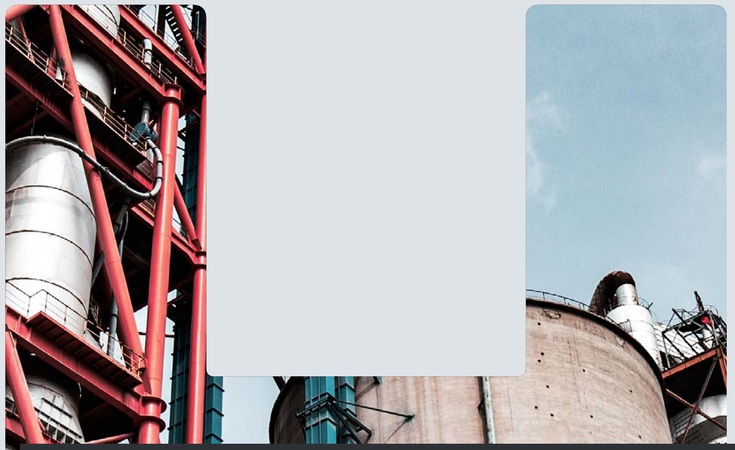
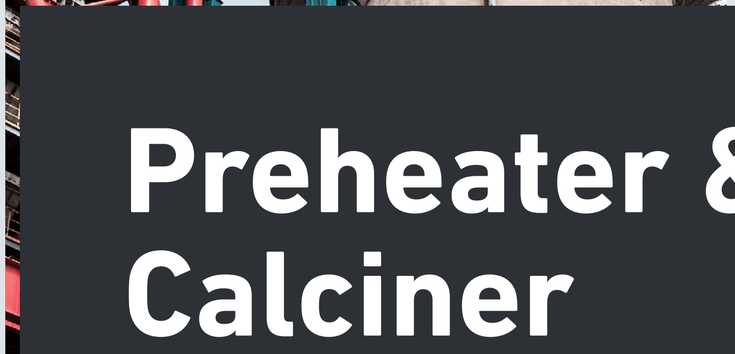
HUMBOLDT WEDAG

Get more out of your plant.





Preheater & Calciner

State-of-the art pyroprocessing equipment for every application

Preheater & Calciner Overview

KHD Humboldt Wedag was the first company to introduce multiple products to the cement industry. Most of these are still the market standard today. This fact underlines our position as technology leader and expert in the field of cement production technology. With regards to essential pyroprocessing equipment, amongst others, the preheater and the calciner were first introduced by KHD.

Today, we build on these roots with the aspiration to always provide the best solutions for our clients and their projects. At the same time we are constantly challenging ourselves to develop more efficent and more economic solutions that yield extra value for our customers.

Our pyroprocessing equipment offers the highest efficiency for lowest operating cost. And thanks to a modular concept, we are able to offer just the right solution for any project-specific requirement. No matter what production capacity, fuel concept, regional prerequisites or emission limitations, we design the best pyroprocessing solution for any application between 2000 and 14000 tpd.

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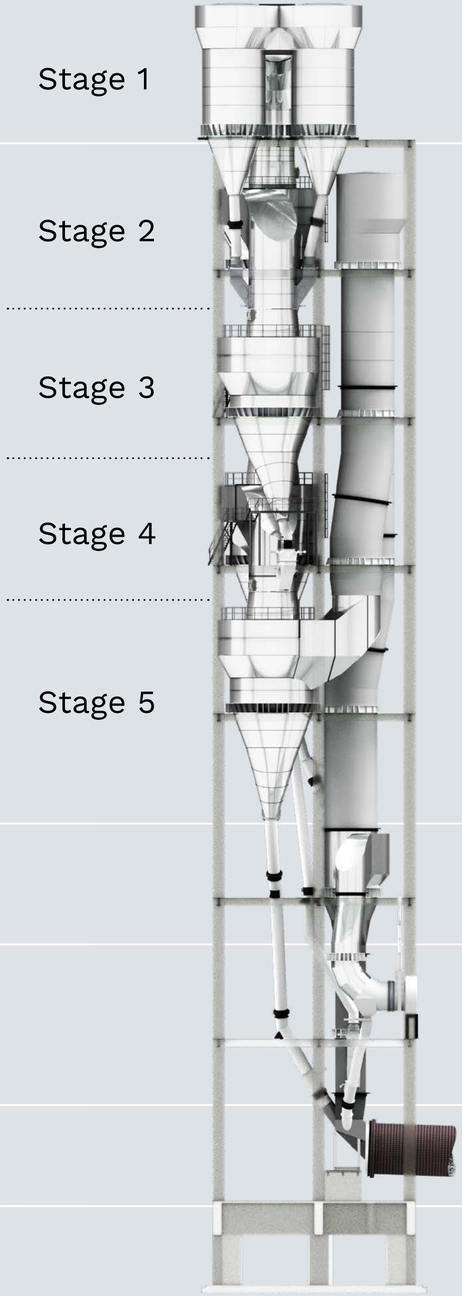
Preheater & Calciner

Stage 1

Double Separator
Waste Gas Duct

Stage 2-5



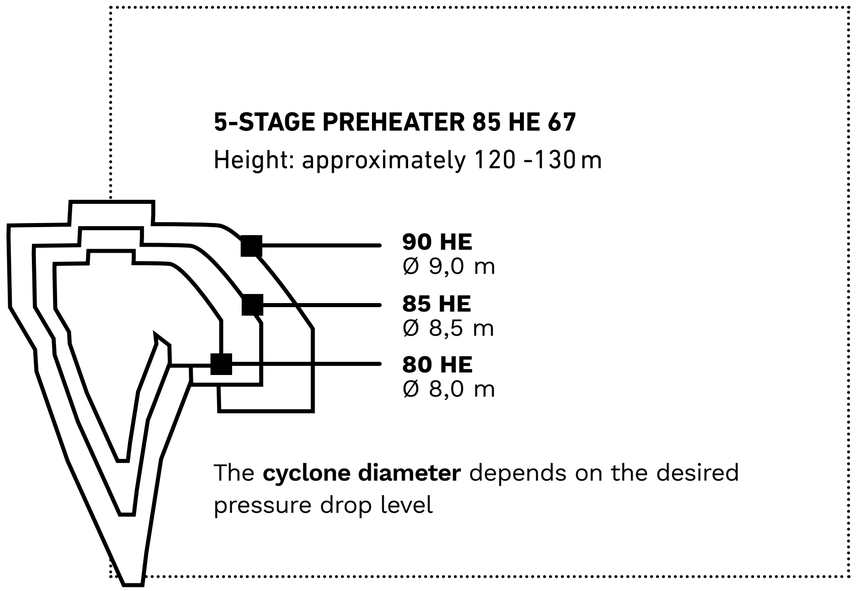
High Efficiency Cyclone
Splash Box
Pyrotop®
Pyroclon® R
Pyroclon® Lownox AF
Pyroredox®
Flash Calciner
K-Tube
Pyrobox®

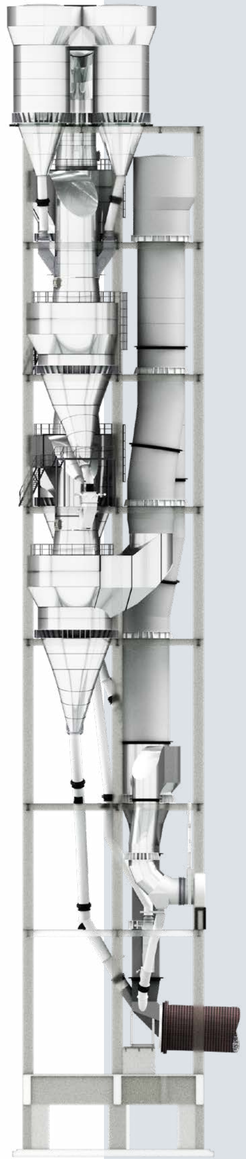
PyroIncinerator, Combustion Chamber, **Pyrorotor®**

Bypass Quenching Chamber,
Coal Distributor, **Pyrobox®**, Gas Ring Burner

Preheater Range

The goal is to achieve the best combination of heat transfer, pressure drop and building height. In modern cement production, efficient drying and preheating of raw meal is not possible without a state-of-the-art preheater.





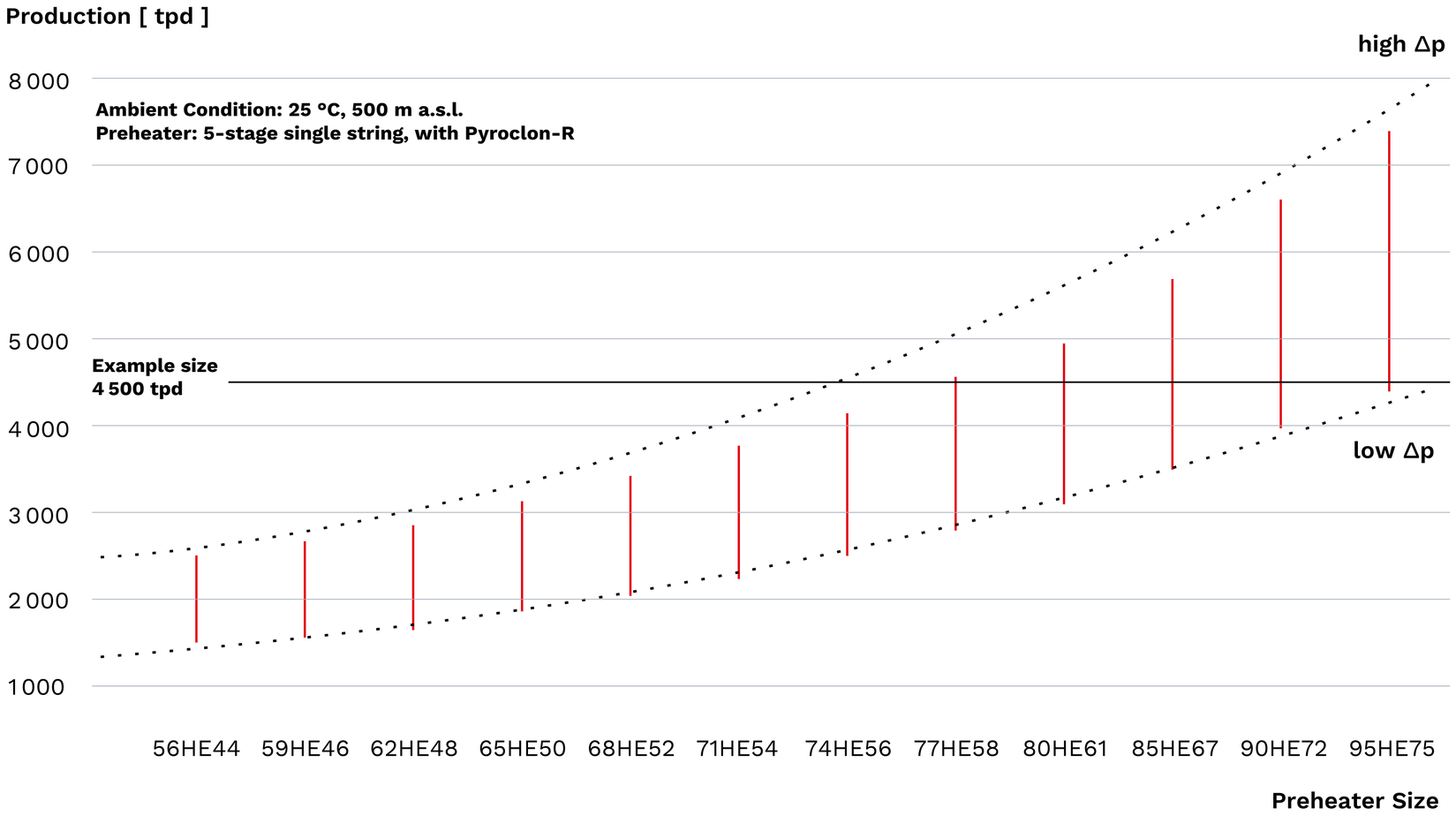
We offer various solutions for specific production capacities, based on demand or regional prerequisites.

Making the right choice
Depending on the targeted balance between investment and operational costs, KHD offers the right model for maximum customer benefit in any project. Generally, there are two approaches with regards to cost:

Reduced operational expenditure (OPEX)
The preheater requires a higher building but, due to lower pressure drop, also has reduced energy demand. This approach has a slightly higher initial investment but requires less energy and hence, yields higher operational cost-efficiency.

Reduced capital expenditure (CAPEX)
As the building is smaller in size, your initial investment and civil cost are lower. As this means the preheater operates with slightly increased pressure drop levels, the energy demand is slightly higher.

Performance range for single string preheaters



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Optimized preheater design

Our preheater design is based on four key features that ensure best-in-class performance and competitive pricing.

°C

Low Waste Gas Temperature

High Dust Separation Efficiency

mbar

Low Pressure Drop

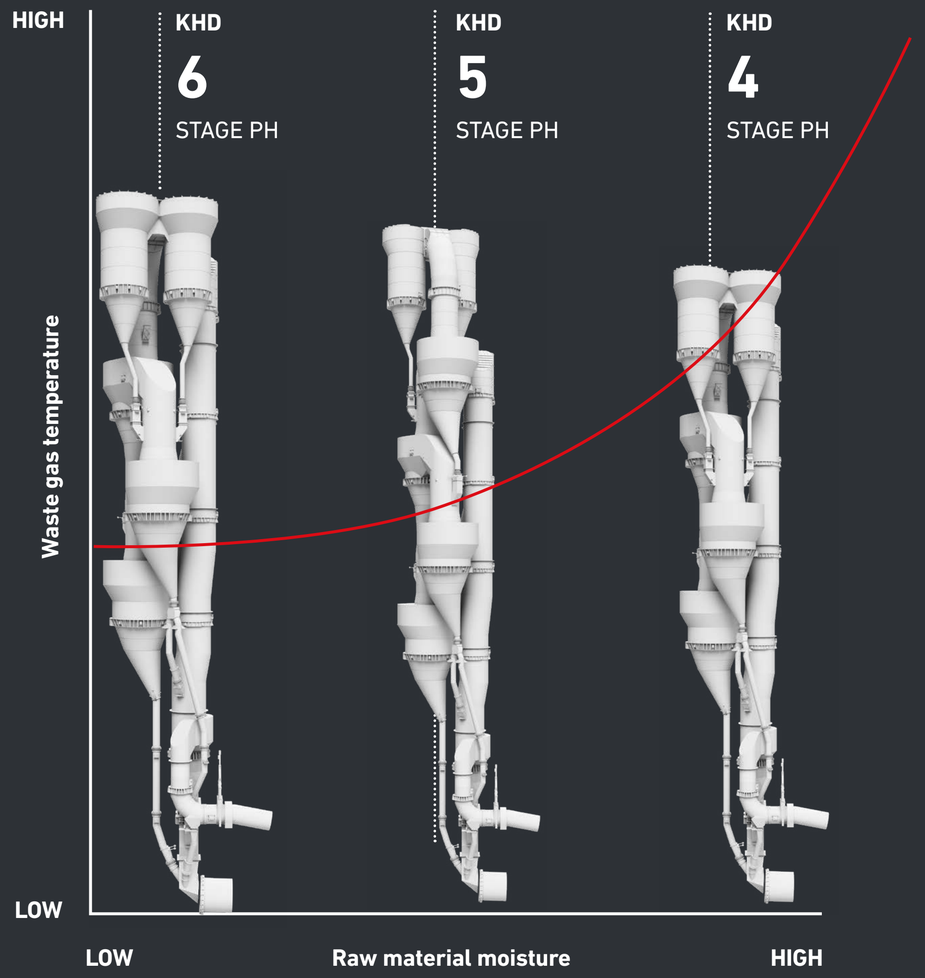
Low Civil Costs

Best-in-class performance

In direct comparison to the competition we achieve higher separation efficiency and lower waste gas temperatures after the top stage.

	KHD	Competitor A	Competitor B
Separation Efficiency	**96 %**	92 %	94 %
Stage 4 PH Waste Gas Temperature	**340 °C**	350 °C	360 °C
Stage 5 PH Waste Gas Temperature	**290 °C**	300 °C	310 °C
Stage 6 PH Waste Gas Temperature	**260 °C**	270 °C	280 °C

Influence of raw material moisture



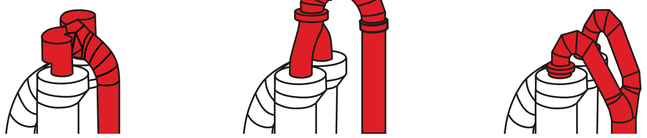
Double Separator

The prevention of dust loss is the core task of the top cyclone stage. For this reason, a double separator is used to divide the gas flow to achieve the highest separation efficiency.

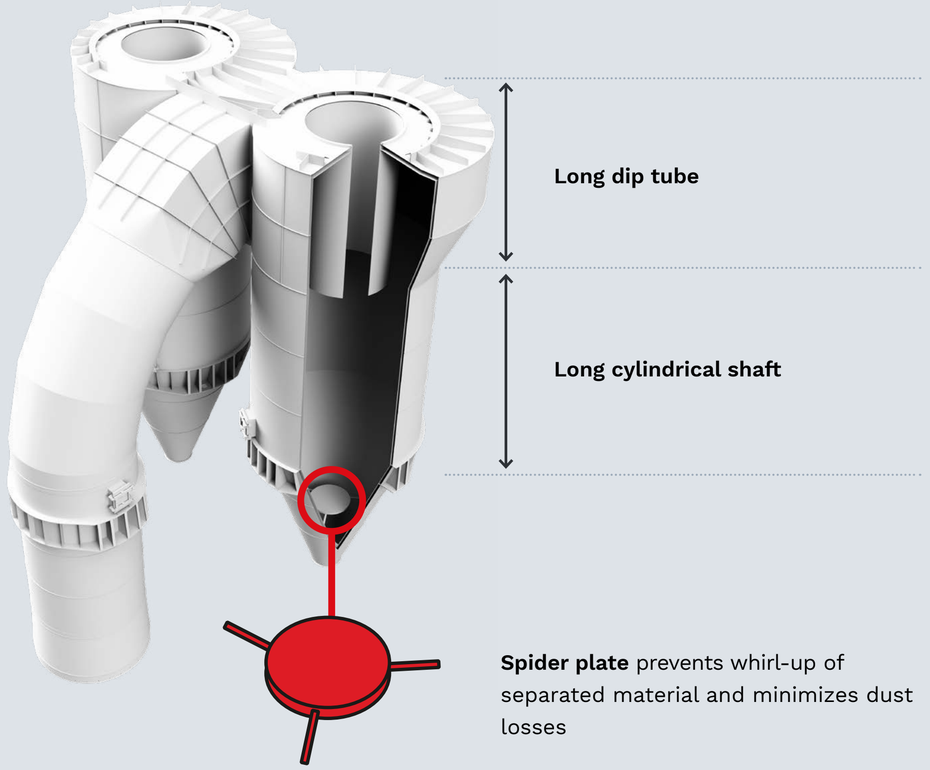
KHD‘s double separator has a small diameter-to-height ratio and a longer dip tube compared to standard system cyclones. With the combination of these design features, we achieve a separation efficiency of 96 % and are able to reduce dust losses to a level below 25 g/m³. As the high separation efficiency serves for a low meal circulation, the pressure drop and heat losses of the complete preheater are reduced significantly and we can ensure a stable and continuous operation of the pyroprocess.

Waste gas duct design

KHD‘s standard is the outlet spiral which reduces the height of the waste gas duct by approximately 60 % compared to the widely used Holderbank bend design. However, if required due to overall tower layout, we offer various alternative waste gas duct designs.



Outlet spiral **Holderbank bend** **Standard bend**



Spider plate prevents whirl-up of separated material and minimizes dust losses

Upgrade option

Top stages of older preheaters are often not properly sized.
An exchange of the top stage with a state-of-the-art double separator lowers the overall pressure drop and meal losses. Replacing the top stage is a proven and relatively simple measure to improve efficiency and increase the production. Such modifications can be executed quickly and offer a fast return of investment.

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Cyclone Design

Cyclones ensure that the heat from the gas stream is efficiently transferred to the raw meal.

With our new high efficiency design we were able to downsize all cyclones by up to two sizes while maintaining the same performance in terms of pressure drop, waste gas temperature and separation efficiency.

KHD‘s cyclones, dip tubes and gas riser ducts are optimized for best-in-class heat transfer and lowest pressure drop. They offer proven performance and extra saving potential, both already achieved at many operating plants.

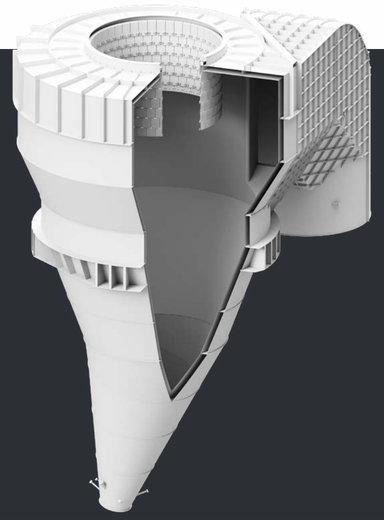
Latest design improvements

15 % Weight reduction

18 % Smaller footprint

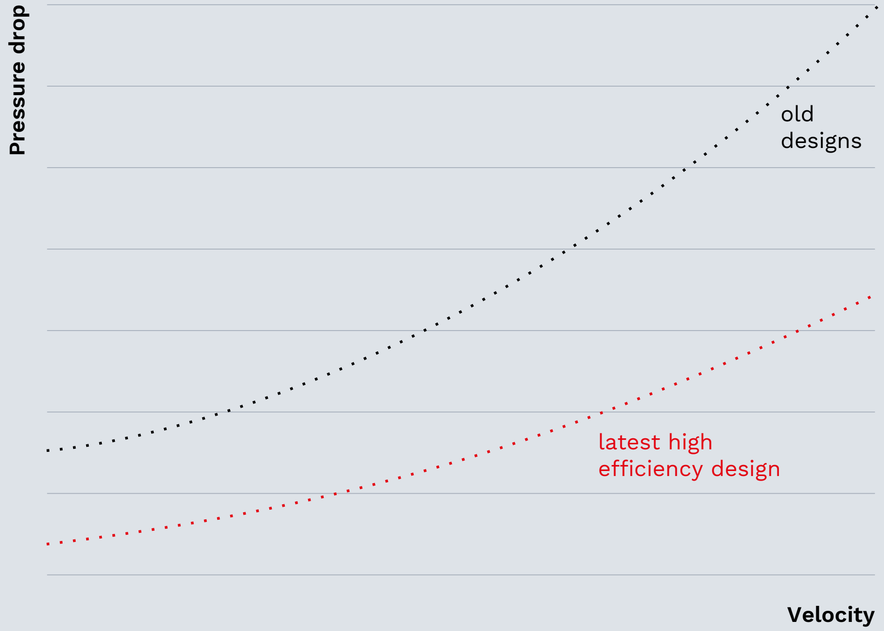
21 % Less volume

100 % Performance



Advantages of the new cyclone design

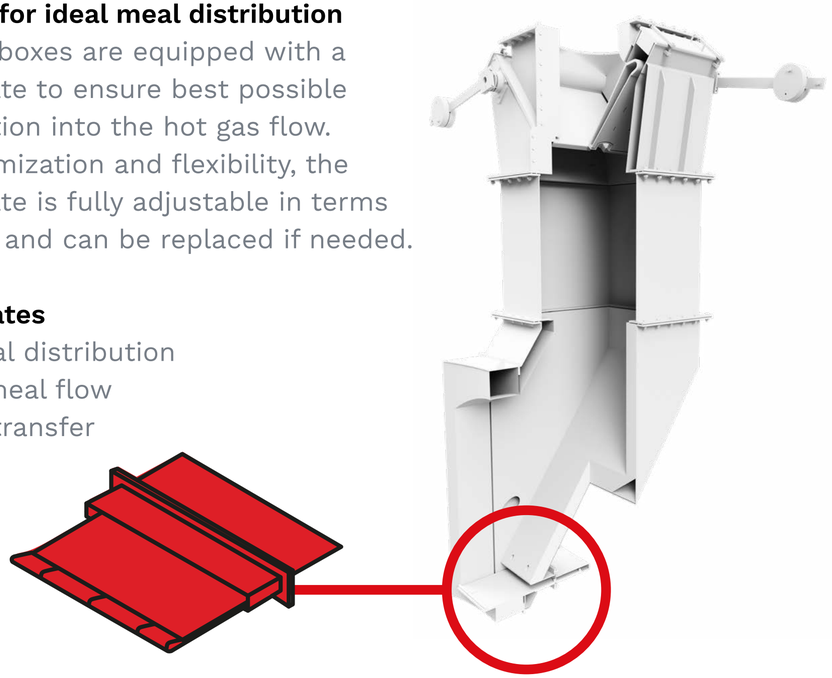
- Optimized dip tube and gas inlet geometry
- Up to 15 % reduced weight, optimized by FEA based on Eurocode III
- 70° inclination of cyclone cone to prevent material accumulation
- Bent cone tip for controlled and continuous meal flow
- No vortex breaker required as the long distance between the dip tube and cone tip prevents unwanted accumulation of material

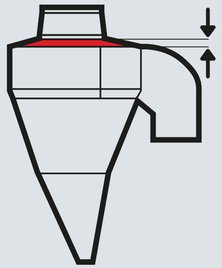


Prestressed cyclone ceiling
Standard expansion joints in the gas ducts – as utilized by other suppliers – require repeated and meticulous maintenance. The prestressed cyclone ceiling is a smart design feature by KHD that demands no maintenance, yet offers the necessary length compensation. With negligible extra effort during erection and installation, KHD‘s cyclone design reduces cost, completely eliminates maintenance effort for cleaning, and improves the operational safety of the equipment, as proper compensation for thermal stress is always ensured.

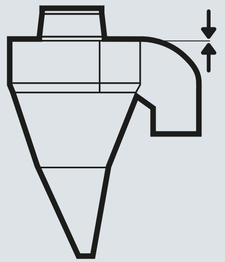
Splash boxes for ideal meal distribution
KHD‘s splash boxes are equipped with a dispersion plate to ensure best possible meal distribution into the hot gas flow. For full customization and flexibility, the dispersion plate is fully adjustable in terms of positioning and can be replaced if needed.

Dispersion plates
- Uniform meal distribution
- Controlled meal flow
- Better heat transfer





During erection
The cyclone ceiling is pretensioned in relation to the cyclone size.

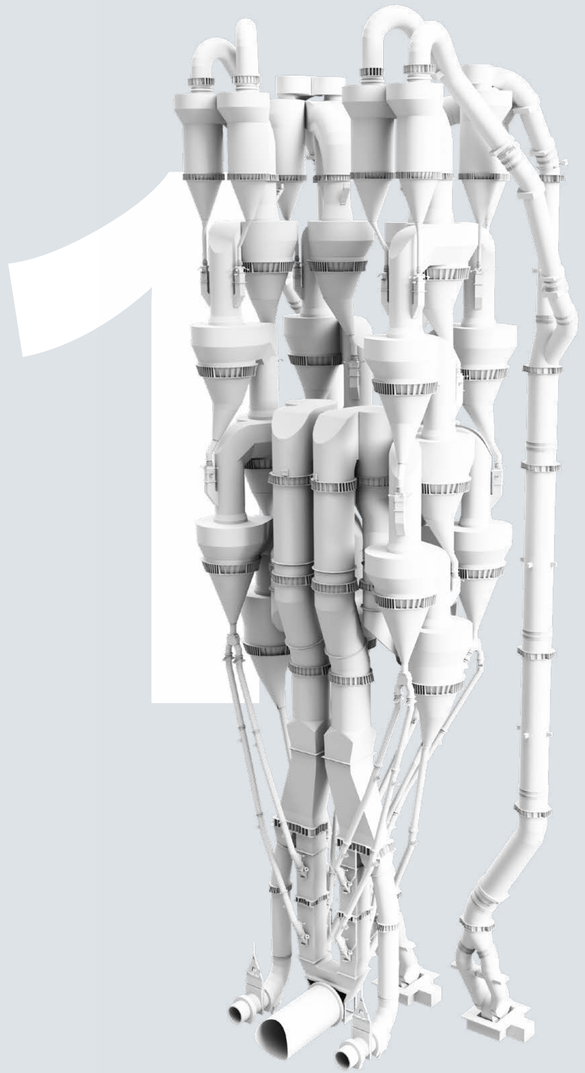


In operation
When the preheater is commissioned, the prestressed ceiling reshapes to its original dimensions as a result of thermal expansion.

Upgrade option
Our splash boxes are available as retrofit items that can be installed quickly and easily. Thanks to a short downtime and low investment cost, splash boxes are upgrades with a very small payback time in comparison to new cyclones or other extensive modifications.

Special Projects

Although we offer a wide range of standardized products for most use cases, we are often approached by clients with exceptional or challenging requests for their projects. As a technology leader and customer-focused OEM, we make sure that our clients always get the best solution possible, no matter how demanding the project might be.

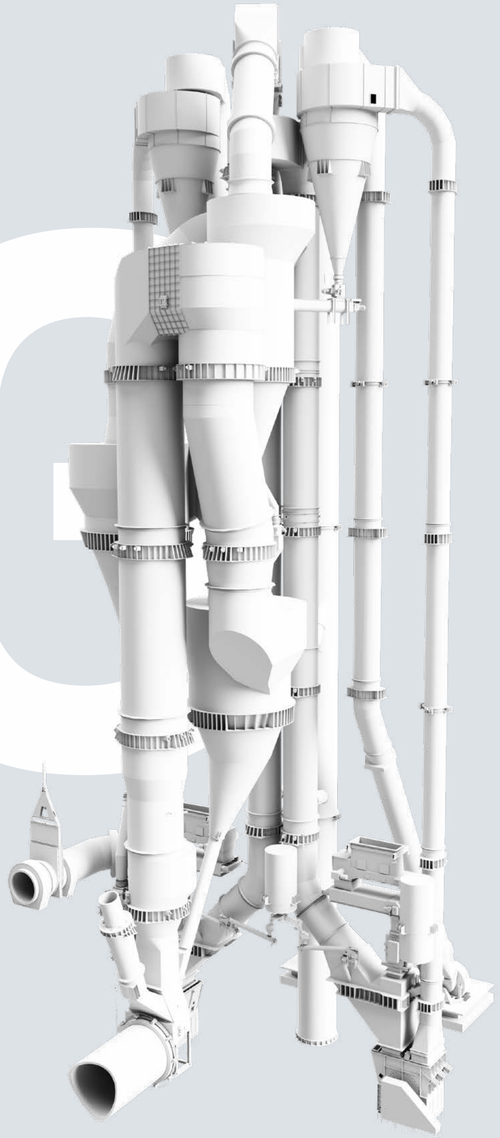


10 000 tpd in the Himalayas (1)

For a client in India we have designed a preheater that works at an exceptionally high altitude (1370 m above sea level). At the same time the client wanted a 6-stage preheater to achieve the highest level of fuel utilization and heat efficiency. On top of that, the regional administration set a building height limit for the project. Combining all of the above with a desired production capacity of 10 000 tpd the outcome was a four string preheater combined with two **Lownox calciners**.

Flexible production demands a flexible solution (2)

Based on client‘s request we developed and built a three string, 6-stage preheater that requires just a single ID fan for the entire waste gas flow. The preheater also needed to be flexible in terms of production: the client requested a capacity range from 6 000 to 10 000 tpd. To ensure long-term operation, even with the likelihood of further intensified emission level limitations, we combined the preheater with a **Lownox AF calciner** and a highly sophisticated **Pyroredox®** precalcining unit for lowest possible NO_x emissions.

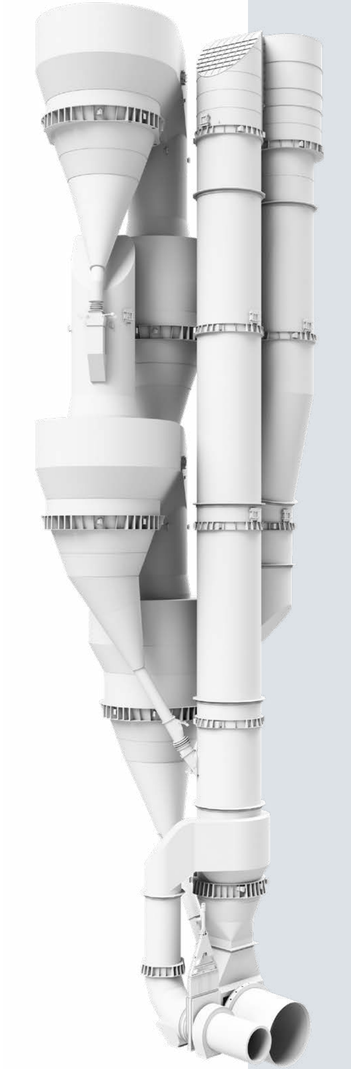


Energy-efficient production for a semi-wet process (3)

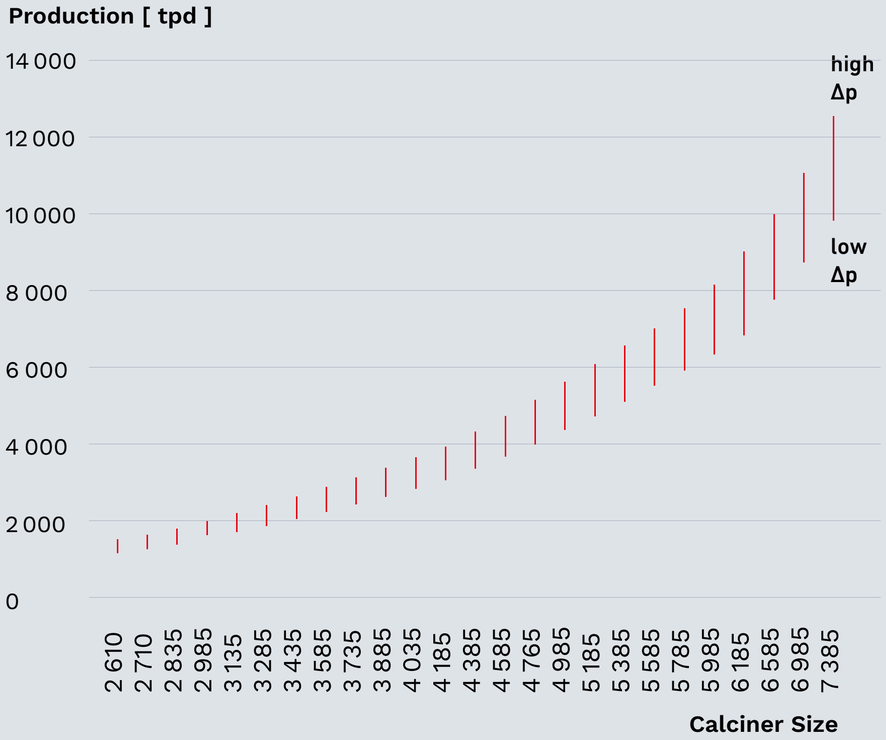
For a Russian client with slurry raw material (chalk) we designed a state-of-the-art semi-wet production line. To ensure best-possible raw material deagglomeration, grinding and drying, the preheater tower comes with two impact hammer mills. Thanks to these, a uniform particle size and composition can be achieved.

Calciner Series

60 % of the fuel used at modern cement plants is required in the calciners. Having introduced flash calcination in the cement industry, KHD continues to innovate in this center of fuel consumption with efficient and project-specific solutions. KHD calciners feature the best flow and reaction conditions for continuously stable operation at lowest possible fuel cost and highest possible alternative fuel rates.



Calciner sizes and performance range



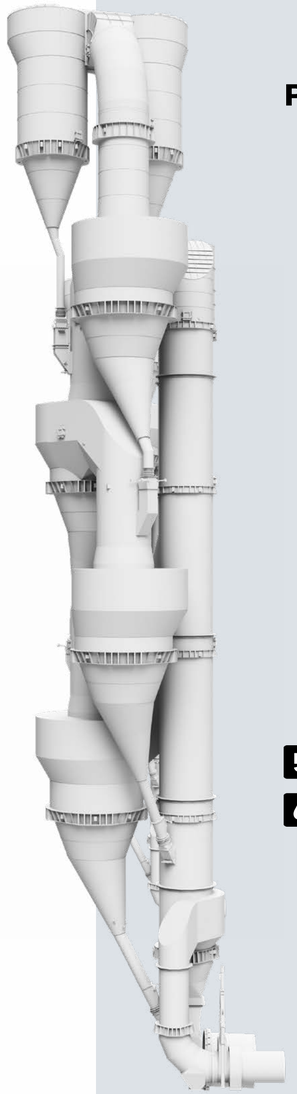
Pyroclon® R

The Pyroclon® R is KHD‘s simplest calciner with smallest building height and lowest pressure drop, making it a highly attractive low investment option. The Pyroclon® design is the basis for all of KHD‘s more sophisticated and specialized calcining solutions.

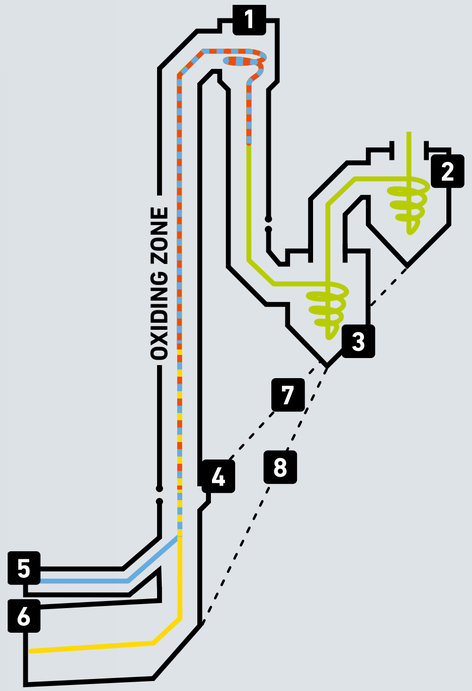
Pyroclon® R design features

- Individual, case-to-case calculation of the length to achieve best fuel residence time and a complete burn-out (> five sec)
- Aerodynamically optimized geometry for safe meal and fuel transport avoiding drop-out and pumping
- Constricted orifice in the kiln riser duct to maintain gas balance and prevent fall-through of coarse fuel
- Comes with a **Pyrotop®** compact mixing chamber for complete burn-out

All **Pyroclon® R** calciner design features above also apply to KHD‘s specialized calciner types like the **Pyroclon® Lownox AF** and addons like the **Pyroclon® Combustion Chamber**.



Pyroclon® R Process Scheme



1 **Pyrotop®**
2 Penultimate cyclone
3 Bottom cyclone
4 Fuel feed
5 Tertiary air duct
6 Rotary kiln
7 Meal to calciner
8 Meal to kiln

Exhaust gas (high NO_x level)

Lean gas (high CO level)

Tertiary air (high O_2 level)

Final exhaust gas after completed combustion and calcination (low NO_x, CO & O_2 levels)

Calciner Series

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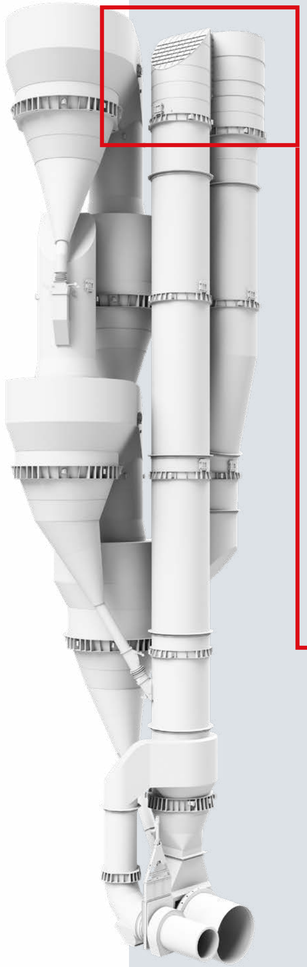
Pyrotop® Mixing Chamber

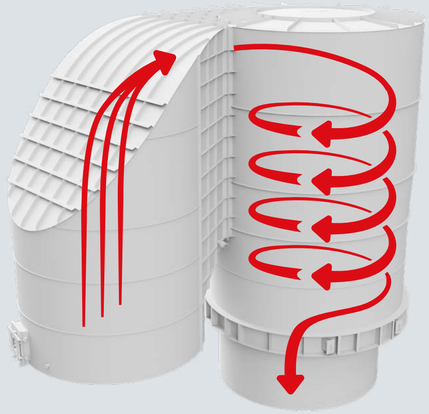
Our Pyrotop® ensures that combustion is complete before the gas stream enters the lowest cyclone stage. This is achieved by bringing together and mixing all gas strands for a complete burn-out.

Enhanced functionality at the gas turning point at the top part of the calciner

- Allows intensive mixing of meal and gas strands with lowest possible pressure loss
- Extended residence time
- Complete burn-out of CO
- Allows increased firing of alternative fuels



Optimized Gas Flow and Burn-Out thanks to Pyrotop®



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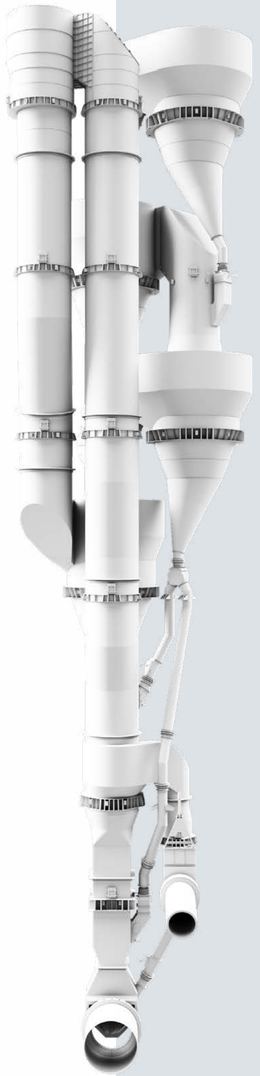
Low NO_x Solutions

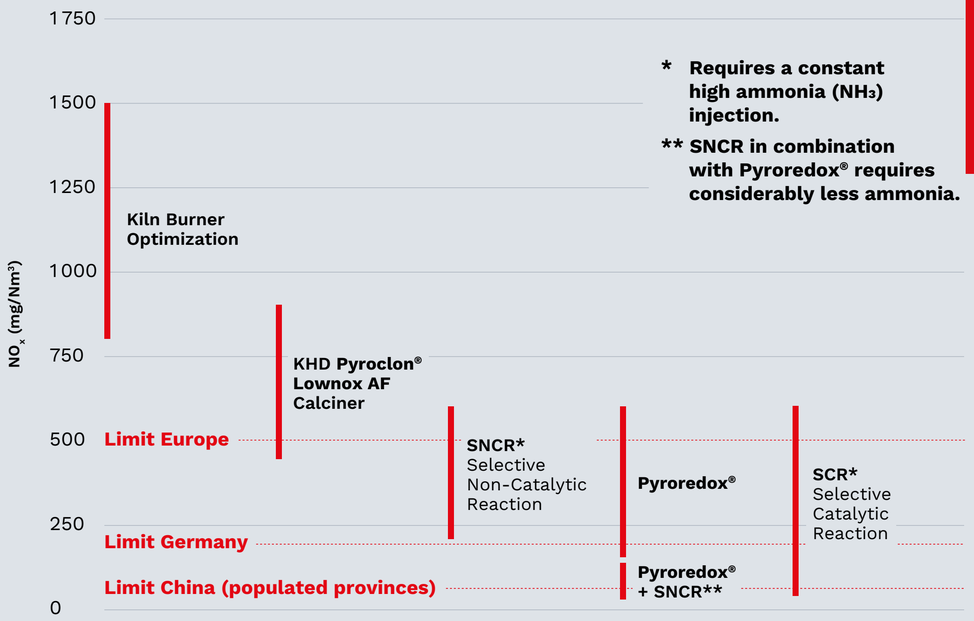
A high output of harmful emissions such as NO_x was tolerated far too long in cement production. In recent years, regulations have continuously limited acceptable emissions. This trend is certain to continue and is the right decision when looking at sustainability and our environment!

As market leader for sustainable and environmentally-friendly technologies, KHD supports this initiative and is the right partner to help you reduce your emission output.

Depending on the current emission limits in your country, it might be enough to retrofit a **Pyrojet®** kiln burner or a **Pyroclon® Lownox AF** calciner from KHD. But when planning long-term, you should consider our newest innovation. **Pyroredox®**, a sophisticated gasifying reactor, can sustainably reduce NO_x emissions without any negative impact on production capacity, power consumption or fuel demand! And that at a fraction of the cost of other potential solutions such as SCR systems.



Achievable NO_x emission levels with available technologies



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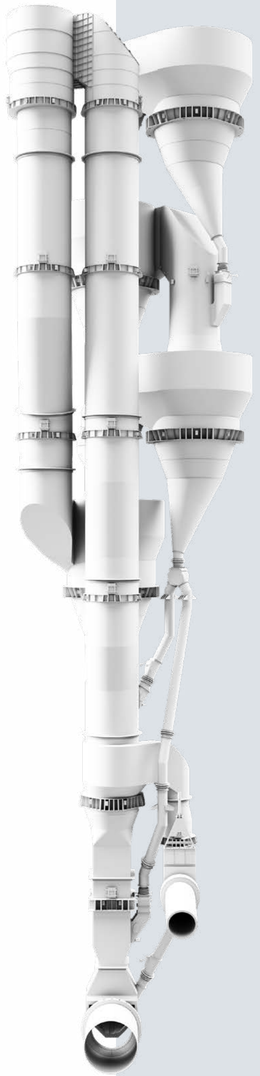
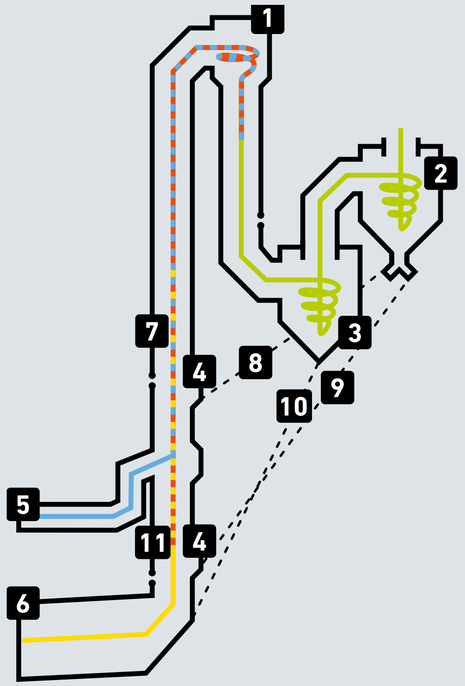
Pyroclon® R Lownox AF

The calciner that perfects the staged combustion

The **Pyroclon® Lownox AF** is KHD's core solution for low emissions without any extra end-of-the-pipe actions. Due to the additional reduction zone (in comparison to a standard calciner like the **Pyroclon® R**) the nitric oxides from the kiln can be reduced to the greatest possible extent.



Pyroclon® R Lownox AF Process Scheme



1 **Pyrotop®**
2 Penultimate cyclone
3 Bottom cyclone
4 Fuel feed
5 Tertiary air duct
6 Rotary kiln
7 Oxidizing zone
8 Meal to oxidizing zone
9 Meal to Low NO_x zone
10 Meal to kiln
11 Low NO_x Zone

- Exhaust gas (high NO_x level)
- Lean gas (high CO level)
- Tertiary air (high O_2 level)
- Final exhaust gas after completed combustion and calcination (low NO_x, CO & O_2 levels)

Basic $DeNO_x$ reactions for Pyroclon® and Pyroredox®

- $2\ NO + CO \rightarrow N_2 + CO_2$
- $2\ NO_2 + 4\ CO \rightarrow N_2 + 4\ CO_2$

Low NO_x Solutions

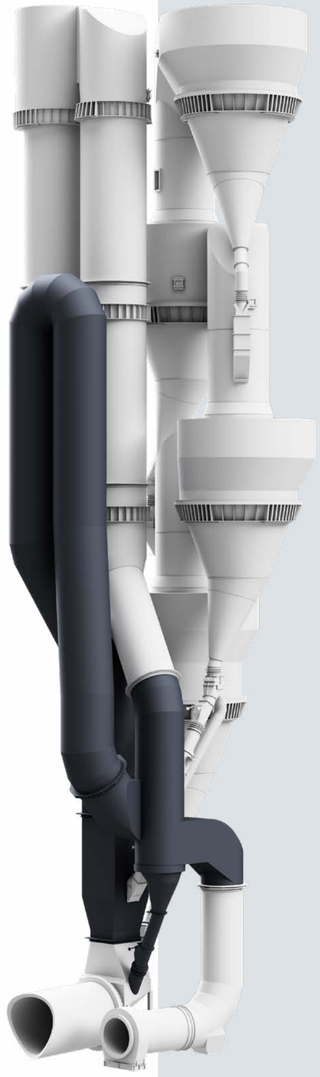
Pyroredox®

Taking primary NO_X reduction to the next level

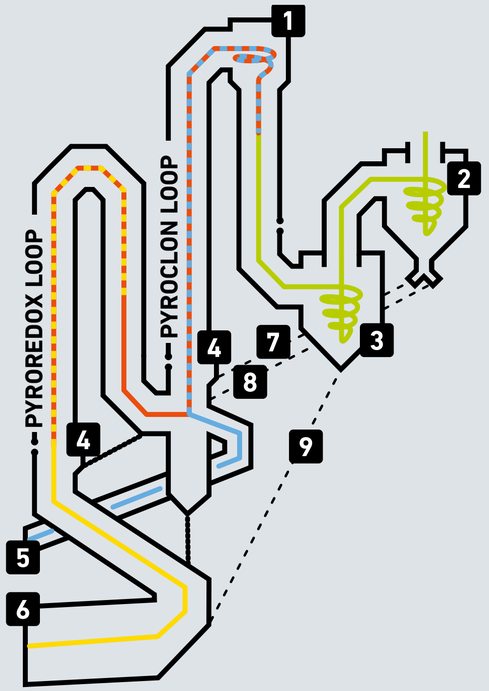
The **Pyroredox®** is our newest development for reduced emissions. **Pyroredox®** is a gasifying reactor that supports the formation of CO- and CH-radicals and therefore reduces the amount of overall NO_X emissions.

Pyroredox® offers various advantages for your calcining process:

- Suitable for all typical fuels
- Creation of a reduction zone, rich in CO- and CH-radicals
- Additional fuel residence time of approximately four seconds
- Thermal pretreatment dries and partially gasifies solid fuels
- Emission reduction in range of SCR systems
- No need for extra reagents like ammonia
- No investment for secondary measures
- Can be combined with SNCR for emission levels below 50 mg



Pyroredox® Process Scheme



More details:
khd.com/pyroredox

1 **Pyrotop®**
2 Penultimate cyclone
3 Bottom cyclone
4 Fuel feed
5 Tertiary air duct
6 Rotary kiln
7 Meal to **Pyroclon®**
8 Meal to **Pyroredox®**
9 Meal to kiln

Exhaust gas (high NO_X level)

Lean gas (high CO level)

Tertiary air (high O_2 level)

Final exhaust gas after completed combustion and calcination (low NO_X, CO & O_2 levels)

Pyroredox® loop
- Reducing zone
- Major amount of fuel
- Small amount of meal
- → DeNOX reaction under optimal conditions

Pyroclon® loop
- Oxidizing zone
- Small amount of fuel
- Major amount of meal
- → Complete combustion of gasified reaction products

Low NO_X Solutions

Alternative Fuel Solutions

Pyroincinerator

A Pyroincinerator is the most cost-efficient and quickest upgrade for alternative fuel processing. It works in any existing preheater and does not require extensive or costly conversions.

The Pyroincinerator enables the combustion of coarser alternative fuels in hot conditions (above 1100 °C). The Pyroincinerator requires no direct meal feeding, can handle a wide range of fuels and uses tertiary air as combustion air.

- Requires no extra height in preheater structure
- Fuel is mechanically dropped into incinerator; no complex feeding required
- No direct meal feeding necessary
- Adjustable temperature through variable amount of tertiary air
- Quick upgrade with short downtime
- Short payback time

Upgrade option

- Easiest & quickest AF upgrade
- Minimal height requirement

Solutions for alternative fuel processing

Processing alternative fuels is a great opportunity to reduce cost and emissions. In developed countries, the share of alternative fuels is already way above 60 % and constantly on the rise. KHD offers a wide range of solutions and retrofits, from quick upgrades for prepared alternative fuels, to sophisticated equipment that can efficiently process almost any kind of alternative fuel, even large and nearly unprepared materials or fuel with extremely poor burning properties.

We offer solutions that are great upgrades for preheaters from all manufacturers. Because available space is often an issue, some of our products, for example the Pyroincinerator, require very little height in your existing structure. Our **Pyrorotor®** on the other hand is highly flexible and can be installed inside the preheater building or positioned on an extra platform outside of the preheater, if needed.

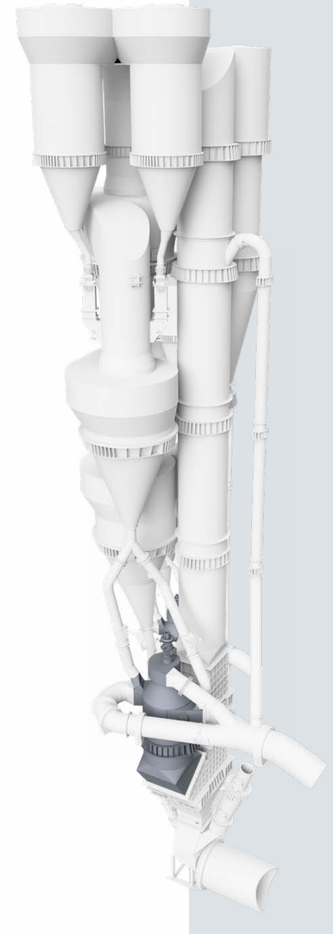
	Pyrojet Kiln Burner	**Pyroclon® R Calciner**	**Pyroclon® R** with **Pyroincinerator**	**Pyroclon® R** with Combustion Chamber	**Pyroclon® R** with **Pyrorotor®**
Waste oil / Animal meal / Sewage sludge	✓	✓	✓	✓	✓
Biomass	max. 2×1×1 mm (3D)	max. 5×5×2 mm (3D)	max. 20×20×5 mm (3D)	max. 40×40×10 mm (3D)	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	×	×	×	×	✓

HUMBOLDT WEDAG

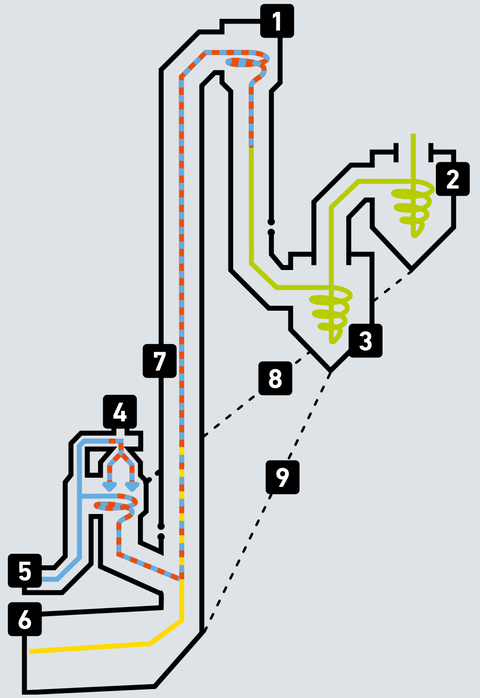
Pyroclon® R Combustion Chamber

The **Combustion Chamber (CC)** enables the firing of coarse alternative fuels in hot tertiary air. After one second of material retention time, the fuels have lost enough of their physical mass to be carried by the gas stream into the calciner, were final combustion takes place. Within the **CC** the walls are protected by a constant meal curtain to reduce wear and increase refractory lifetime.

- Start of combustion in pure air and at high temperatures (approximately 1200 °C)
- Total fuel retention time above six seconds
- Low demand for fuel preparation
- Fuel inlet feed up to 800 mm in diameter



Combustion Chamber Process Scheme



1 **Pyrotop®**
2 Penultimate cyclone
3 Bottom cyclone
4 Fuel feed
5 Tertiary air duct
6 Rotary kiln
7 Oxidizing zone
8 Meal to combustion chamber
9 Meal to kiln

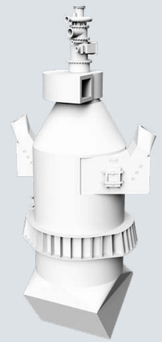
Exhaust gas (high NO_x level)

Lean gas (high CO level)

Tertiary air (high O_2 level)

Final exhaust gas after completed combustion and calcination (low NO_x, CO & O_2 levels)

Upgrade option
The combustion chamber is the perfect upgrade for a **Lownox AF calciner** as it can be retrofitted without major adaptation to the preheater building, which is already of the required height.



Alternative Fuel Solutions

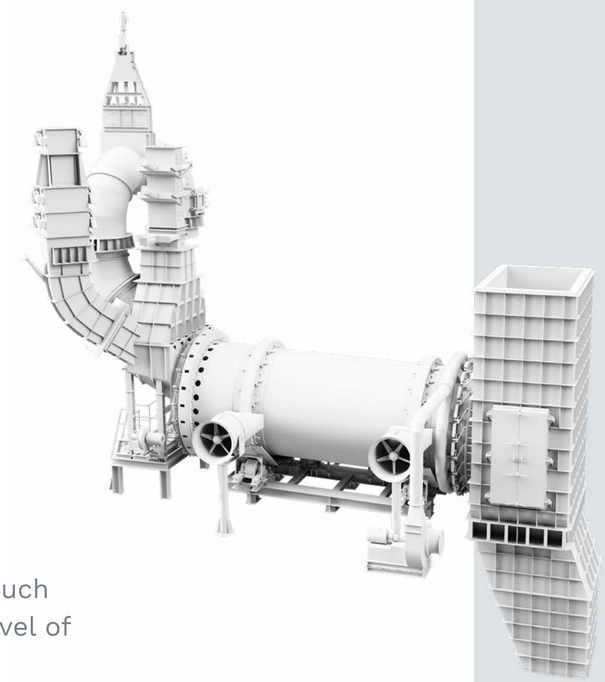
Pyrorotor®

KHD‘s most advanced technology for the processing of the coarsest alternative fuels.

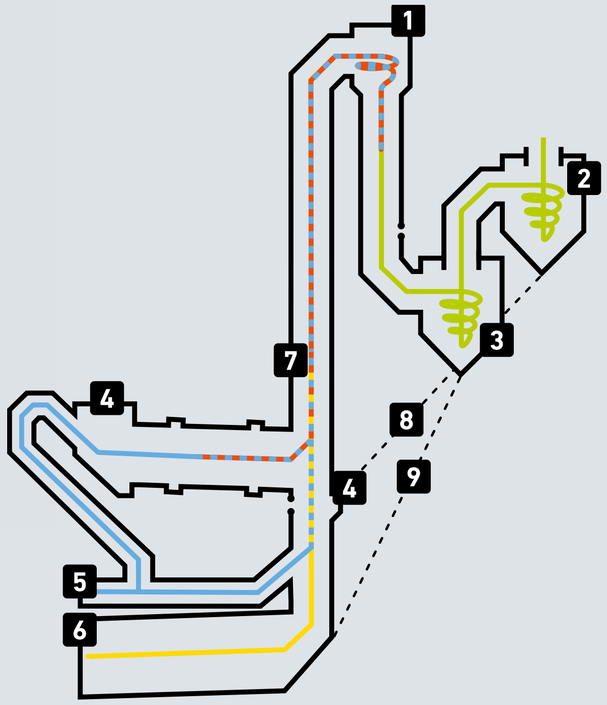
The **Pyrorotor®** is a combustion reactor that processes materials with inferior burning properties reliably as secondary fuel.
It constantly circulates fuel with sufficient retention time to guarantee a complete burn-out.

This lets you use the coarsest waste-derived materials, without any pre-processing, to produce low-cost energy. The result? More fuel options, easier procurement, less time requirement, and above all, much lower costs, giving your pyroprocess an unmatched level of efficiency and flexibility.

- Gas temperature depending on tertiary air flow rate, up to 1200 °C
- Operation at adjustable speed between 0.3 and 3.0 rpm allows varying fuel retention times
- Can be retrofitted into any existing plant structure



Pyrorotor® Process Scheme



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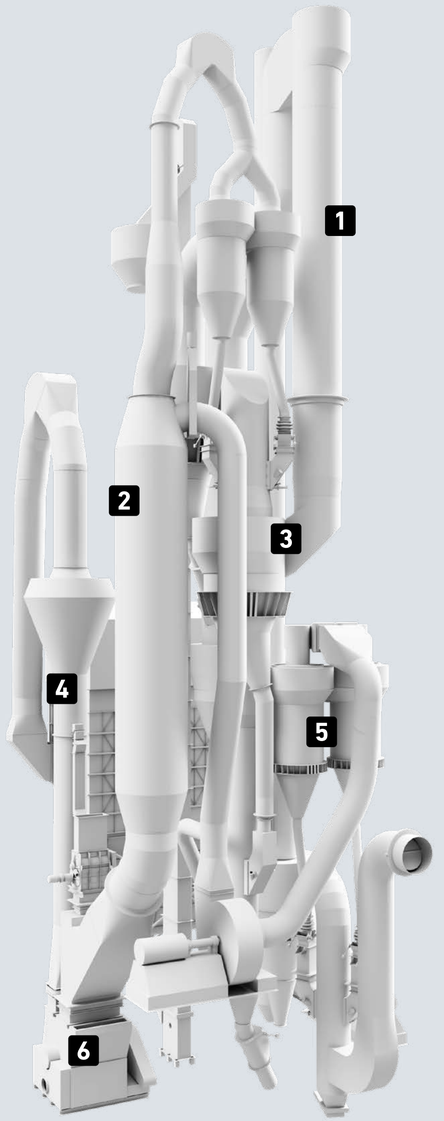
Flash Calciner

Clinker substitution has been identified as one of the key pillars in getting the cement industry to lower CO_2 levels. A promising solution relies on clay as an alternative raw material.

CO_2 emissions are a natural byproduct of the calcination of clinker. Its production will therefore always produce high levels of CO_2. Due to that, the substitution of clinker is inevitable and will occur. At the same time, the main objective remains to produce a cement that has early-strength and binding properties competitive to ordinary Portland cement (OPC).

To substitute clinker with clay is an established option. The so called LC3 cement offers the same properties as OPC, but requires 50% less clinker. LC3 consists of approximately 50% clinker, 30% clay, 15% limestone and 5% gypsum.

The calcination of clay requires a different arrangement of equipment. The 3D illustration and the following flow sheet give an initial overview of the process.



1 Flash calciner
2 Hot gas generator
3 Cyclones
4 Dryer
5 Cooling cyclones
6 Hammer mill

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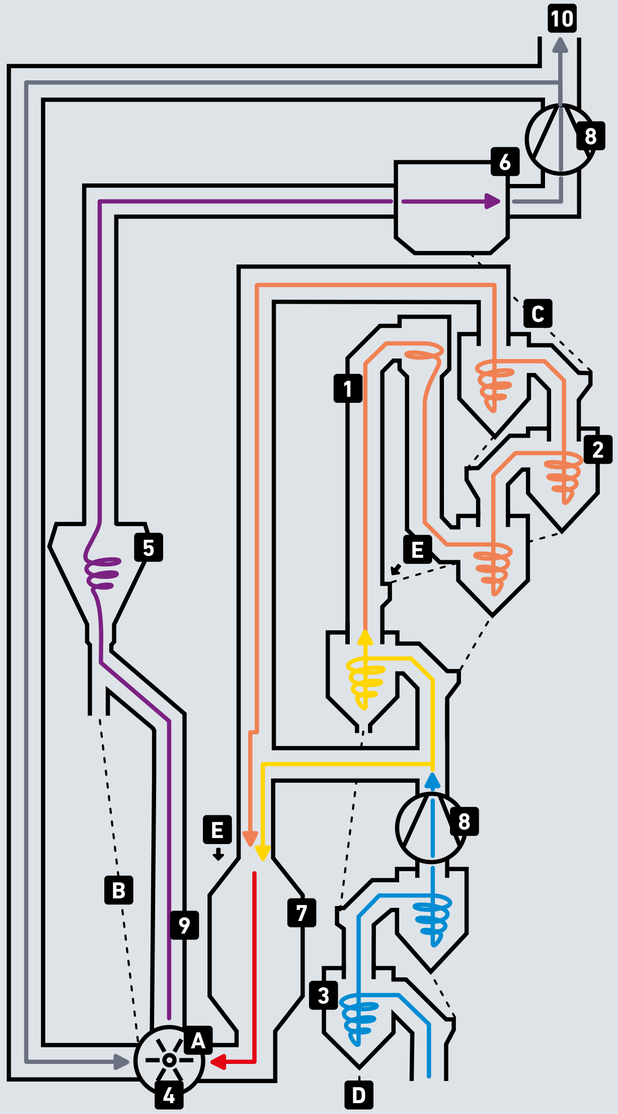
The processing of clay, ideally caolinitic clay, has a significantly lower CO_2 footprint and is not as equipment heavy as OPC clinker production. There is no need for a rotary kiln, a cooler, or even a primary burner. Hence, the production line has considerably lower investment cost and a much smaller plant footprint (given that the remaining amount of required clinker is procured and not produced).

On top of that, the operational costs of processing clay are lower because of the overall reduced energy demand. This energy saving potential is mainly influenced by the average moisture of the used clay.

Flash Calciner Process Scheme



1 Flash calciner
2 Cyclone preheater
3 Cyclone cooler for finish product
4 Impact hammer mill for feed preparation
5 Seperator for dried feed material
6 Filter
7 Hot gas generator for flash dryer
8 Fan
9 Flash dryer
10 Waste gas to stack

A Material – fresh feed
B Material – oversized particles
C Material – dry & pulverized material (to calciner)
D Material – final product
E Material – fuel

Combustion gases from calcination process

Hot combustion air from product cooler

Reheated gases for raw material drying

Fresh air

Gas with suspended material in flash dryer

Waste gas and recirculated gas to impact hammer mill

Upgrades and Modifications

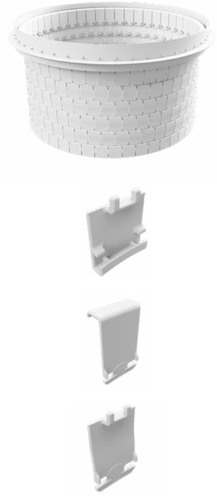
We offer a wide range of efficient and affordable products that help you boost your production capacity and plant efficiency. All of these solutions are suitable for preheaters and calciners of all manufacturers.

Preheater & Calciner Upgrades

K-Tube

Best separation & easy installation

- Sturdy cast design for longest lifetime
- Mounting made of material with ceramic-like properties
- Exceptional chemical corrosion resistance of segments and mounting
- Segments can be handled by one person thanks to small dimensions
- The installation of a **K-Tube** can be conducted in less than four days



Bypass

Prevent build-ups in the kiln system

- Extraction of sulfur and chlorine at the point of highest concentration
- Best quenching through dual tangential air flow layout
- Continuous availability thanks to advanced mixing chamber design
- Suitable for any production capacity and extraction rate

Pyrotop® Mixing Chamber

Enhanced functionality at the gas turning point at the top part of the calciner

- Allows intensive mixing of meal and gas strands with lowest possible pressure losses
- Extended residence time
- Complete burn-out of CO
- Allows increased alternative fuel firing

Splash Box

Best possible meal distribution into the hot gas flow

- Optimized heat transfer between meal and hot gas
- Dispersion plate is adjustable in position and can be replaced if needed
- Sealed design avoids false air intrusion

Firing System Upgrades

Gas and Oil Burner

Gas ring burners from KHD enable fast ignition of fuels in the calciner duct, even under challenging conditions.

- Consists of one or two burners with ignition system
- Up to eight injection units installed on the circumference of the calciner duct
- Injectors require no cooling air and can stay in place even if not in operation
- Creates a strong, two-stage flame to ignite gas even at low tertiary air and kiln gas temperatures

Coal Distributor

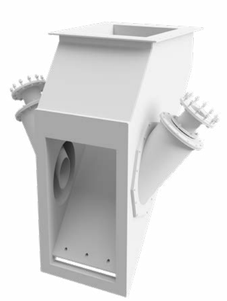
Replaces a pulverized fuel dosing system at a fraction of the cost

- Perfect for Low NO_x calciners
- Suitable for any production capacity
- Up to 50 % reduced cold air intake into the calciner
- Sturdy design for long, maintenance-free operation

Pyrobox®

Fire solid fuels without primary air

- Direct ignition and intense mixture of fuel and raw meal by unification of both flow streams
- Unified heat profile in the calciner without hot spots
- Low NO_x emissions due to low-temperature combustion
- Requires no primary air
- Suitable for all types of pulverized fuels



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Get more out of your plant.

Founded in 1856, KHD Humboldt Wedag is a global leader for cement plant equipment, technologies and services with more than 160 years of experience in the cement industry sector. Process engineering, project management and sustainable solutions are among the core competencies of the technology-focused group.

KHD offers a wide spectrum of products and services for the cement industry. With distinct focus on the development of environmentally friendly and energy-efficient solutions for the grinding and pyroprocessing sections of cement plants, KHD helps its clients to continuously improve production performance, raise efficiency and ensure long-term environmental sustainability.

The holding company KHD Humboldt Wedag International AG, based in Cologne, Germany, coordinates its international operating subsidiaries. Five Customer Service Centers and additional regional sales offices serve customers worldwide.

KHD HUMBOLDT WEDAG

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