JUST ADD *water*

Armin Möck, Lechler, explains how cement producers could benefit from emergency water injections in the clinker cooler in order to control increased gas temperatures.

Clinker grate coolers play an essential role in the cement manufacturing process.

Cement clinker is made by heating a homogeneous mixture of raw materials, mainly ground lime stone, in a rotary kiln at a high temperature. The products of the chemical reaction aggregate together at their sintering temperature of about 1450˚C.

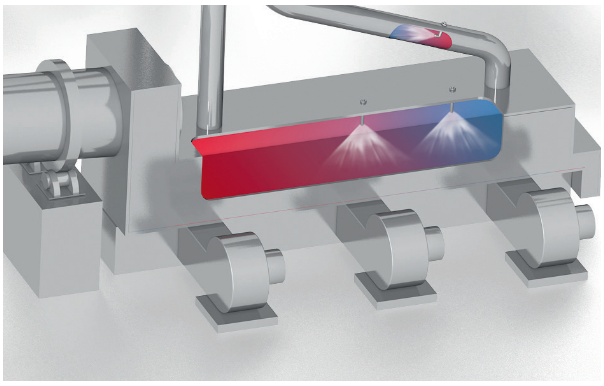
Due to the inclination of the rotary kiln, raw cement is constantly falling out of the lower end of the rotary kiln into the lower laying clinker cooler. Clinker normally forms in lumps or nodules, usually 3 mm (0.12 in) to 25 mm (0.98 in) in diameter.

Defined openings in the grates allow ambient air, which is pressurised by ventilators installed below, to flow upwards through the clinker bed to cool down the clinker to an ideal temperature of 100 – 120˚C before it leaves the cooler to be stored in silos until it is ground into the final product: cement.

Why is cold clinker needed?

The final product has to be cold at the end of the manufacturing process. The cooling of the clinker is very important, especially considering that the subsequent grinding of the clinker into cement adds additional thermal energy to the product caused by the grinding friction of the steel balls with the clinker. In addition, high clinker temperatures are disadvantageous for the cement milling process. If the clinker is too hot when entering the cement mill, it will lead to increased cement end temperatures, which can damage paper bags and lead to problems in the concrete mixing process if the cement is used immediately.

Furthermore, the cooling of the clinker is important for preventing cost intensive damage to downstream equipment like rubber conveyor belts, ducts, ventilators and dust filtration equipment.



Schematic picture of a clinker cooler.

Part of the cooling air leaving the internal space of the clinker cooler (above the clinker bed) with a greatly increased temperature of up to 400˚C goes to the kiln burner as 'secondary air' and as 'mid air' for other processes like coal milling.

The rest of the air is exhaust air which is led to a dust filtration device and then discharged into the environment virtually dust free. In many plants electrostatic precipitators (ESP) for dust filtration are still in use, but due to stricter legal regulations today, state-of-the-art baghouse filters (BHF) are more commonly used.

Common gas temperatures to the filter are 200 – 250˚C, sometimes 300˚C, depending on the kind of filter and the material of the bags. This flow of clinker into the clinker cooler and the cooling of the clinker is ideally a permanent process, running normally without large fluctuations.

Exit gas temperature peaks occur when the quantity of solids falling into the clinker cooler increases very quickly. This can happen when:

- A kiln flash occurs: A blockage of a cyclone in the preheater tower is removed and up to 20 t of hot raw material and clinker flows very quickly through the kiln into the clinker cooler.
- At certain temperatures and under certain chemical conditions, clinker that has accumulated on a specific part of the kiln inside wall (causing the clinker to form a 'ring') can come away and fall into the clinker cooler.

Then, the exhaust air temperature can increase very rapidly to 500 – 600˚C. One can imagine that this leads to serious damage – either to the steel shells of the ESPs or to the textile bags in the BHFs – not to mention the stress caused on the steel ducts and the fans. The replacement of a complete set of destroyed textile bags and a destroyed filter could be extremely costly.

Besides these short-term emergency gas temperature peaks, high exit gas temperatures are a problem that develops slowly over the years, due to extended clinker production rates without investment in a better performing clinker cooler. It is not uncommon for these undersized/overloaded clinker coolers to use water injection outside

Table 1. Types of nozzles.

	Full cone nozzle	Twin-fluid nozzle	Spillback nozzle
Water pressure (bar)	2 - 10	3 - 5	35
Droplet distribution	Coarse	Very fine	Fine
Number of installed nozzles	6 – 12	2 – 4 (6)	2 – 4 (6)
Control concept	Cascade (nozzles on/off).	Linear/stepless, Turn-down ratio: 15:1.	Linear/stepless Turn-down ratio: 12:1.
Advantages	Low investment costs.	Regulation is very accurate and fast, and less lances are required.	Regulation is very accurate and fast, and less are lances required, as well as the use of only one control valve.
Disadvantages	Many lances, inaccurate control, many openings for lances necessary, nozzles tending to clog, many on/off valves in operation.	Compressed air necessary, higher investment costs, air and water have to be controlled, and fine spray is carried to the walls by the gas flow.	Higher investment costs.
Comments	Outdated design.	Air increases the running costs.	Most common system today.

of emergencies, sometimes with it in permanent operation.

Emergency water injection

To prevent very expensive damage, many clinker coolers are equipped with an emergency water injection system. These systems are automatically switched on when thermocouples located in the outgoing gas duct are detecting significantly increased, but not harmful, gas temperatures.

Tubes with nozzles on the end, so called nozzle lances, are installed in the cooler. The nozzle lances are connected to a water pump, providing the necessary water pressure. In case of an emergency, the nearby standing pumps are switched on and within 3 – 5 sec. the nozzle lances inject a fine spray into the clinker cooler space between the surface of the clinker bed and the ceiling. The evaporation enthalpy of the water cools down the exiting gas very quickly.

Placement of nozzle lances

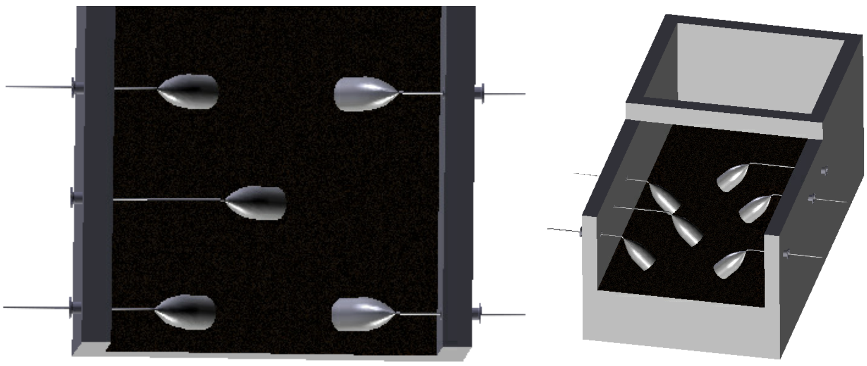
The engineering process is based on the decisions made regarding where to place the nozzle lances and is an essential part of the function and reliability of the injection system.

Requirements to be considered include:

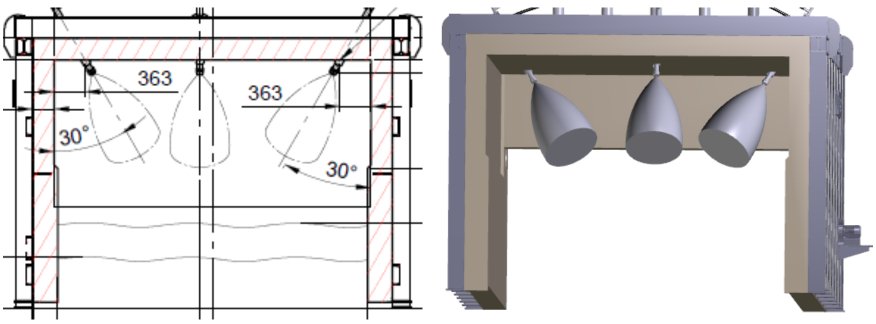
- The secondary air (and the occasionally existing mid air) which leaves the clinker cooler at the opening close to the kiln end has to be as hot as possible to improve the thermal efficiency of the kiln. Therefore, the water spray must not cool down this secondary air. Before the horizontal location of the nozzle lances can be fixed, it has to be known where the 'separation line' of the cooling air inside the clinker cooler is. Logically, no nozzle must be installed on the section where the secondary air is present. The OEM of the clinker cooler knows exactly where the separation line is due to elaborate CFD-studies. In the case of a flexible separation line, the location of the nozzle lances has to be fixed in coordination with the end customer.
- The droplets must not reach the clinker bed to prevent the reaction with the cement which would reduce the binding properties of the cement and therefore its quality. The placement and alignment of the nozzles is a crucial design part of such an injection system.
- The spray cones of the nozzles must not interfere with each other. This could lead to an accumulation of water and could generate larger droplets which would need more residence time to evaporate.
- The vertical location of the nozzle lances is also a parameter to consider. To prevent built-ups on the ceiling, nozzles are often installed as low as possible. However, it could be that a pile of clinker moving through the clinker cooler could touch/bend/damage the lances. Furthermore, the residence time of the droplets is higher when they are leaving the nozzle at a certain distance above the clinker bed.

The general rule while determining the nozzle lance position is to get as much residence time as possible from the nozzle to the exit port of the clinker cooler. The complete evaporation of the water droplets has to be accomplished inside the clinker cooler and not in the outgoing gas duct.

When the positions of the nozzles are defined, the location of the nozzle lances has to be fixed. They can be installed in the side walls or in the clinker cooler ceiling. The position of the nozzle lances depends on the width of the clinker cooler and the potential free space above the clinker cooler. This space is needed for the installation of the nozzle lances and the maintenance access.



Side wall installation example: Top view (left) and 3D image (right).



Clinker cooler inside with nozzle lances sticking in.

Types of nozzles

Many different nozzle types have been installed in clinker coolers over the years, however since the introduction of the water injection into the clinker cooler, only a few nozzle types have proven to be successful.

Injection rates and quantity of lances

The common range for the injected water quantity is from 3 – 30 m^3/h water with 2 – 6 spillback nozzle lances. Higher water quantities in large clinker coolers can be realised.

Protection of nozzles

Since the nozzles are in operation irregularly but are permanently installed in the hot environment inside the clinker cooler with a high cement dust load, they have to be protected from built-ups during the off-times. This can be done with a small ventilator (one for all nozzles) providing an air pressure of 50 – 80 mbar and a constant flow of protection air. As soon as the water injection has to go into operation, a three-way-valve closes off the protection air and opens the water flow.

After the injection period, the remaining water inside the nozzle lance must be prevented from evaporating in the lance. This would lead to the deposition of the mineral components of the water inside the nozzle lance and nozzle. After a number of these drying sequences, this mineral layer could increase, fall away, and block the nozzles.

With a short shot of compressed air after shutting off the injection system, the nozzle lances can be completely drained. This sequence of injecting water, draining and protection air is fully automated.

Spray pattern of a spillback nozzle.

Pump and control skid preassembled.

Necessary equipment

Nozzle lance

- Material: heat resistant stainless steel (up to 1000˚C).
- Special design features:
  - » Simple and stable/resistant design.
  - » Thick walled protection tube to withstand mechanical impacts.
  - » Projecting length inside the clinker cooler is adjustable.
  - » Quick release flange allowing easy access.
  - » Lances can be disassembled and maintained during normal cement kiln operation.
  - » Protection air outside the nozzle lance/inside the protection tube.

Pump and control skid

- Special features:
  - » Will be installed and pressure tested in the workshop.
  - » Short commissioning period.
  - » Information about the injected water quantity is permanently available in the central control room. ■

About the author

Armin Möck has been working at Lechler for over 27 years as a consulting and sales engineer/key account manager, responsible mainly for the applications in the cement industry. On average, Armin visits two cement plants per week in Europe, the US and other countries.

Lechler is a family owned company and the oldest ‘nozzle company’ worldwide, having designed and produced nozzles for over 140 years with affiliates and sales offices worldwide.