A MODERN APPROACH

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Introduction

The clinker cooler is an integral part of the pyroprocessing line of any cement plant and plays a crucial role in its operating performance. In particular, energy consumption, clinker quality, system reliability, and the productivity of the whole production line are affected by it. The clinker cooler has witnessed many technological innovations, the pace of which has been such that a mix of older and latest-generation coolers are in active service. While latest-generation coolers are the preferred choice for greenfield projects, it is always a challenge for cement producers to decide whether or not to retire their very old, yet familiar and well-maintained, cooler, and replace it with the latest one.

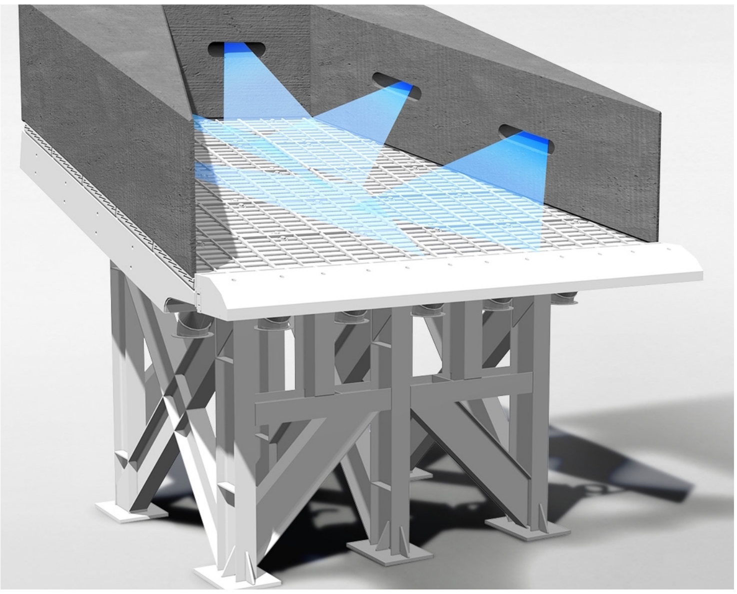

Figure 1. PYROSTATIC®: the new static grate.

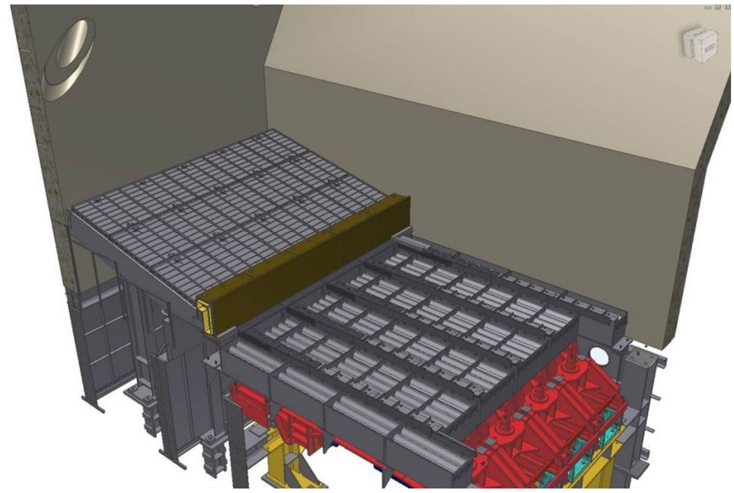

Figure 2a. Static grate before modification: smaller in area without horseshoe

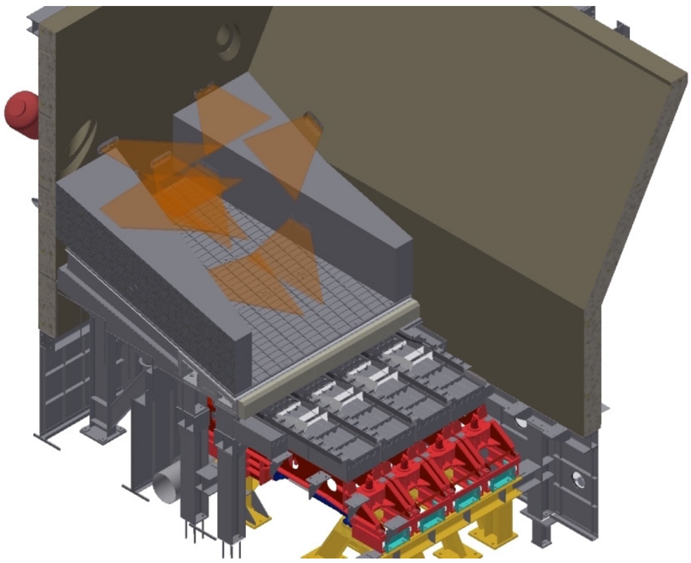

Figure 2b. PYROSTATIC® after modification: enlarged area with horseshoe.

Choosing to modernise

However, there are clear benefits to upgrading an old cooler. One company turned to KHD to modernise the cooler, which was part of a 3000 short tpd pyroprocessing line, amid concerns of material agglomerations occurring in the original static grate, by incorporating a PYROSTATIC® grate.

In 2013, KHD introduced the PYROFLOOR²® cooler, which features several innovations, including a new design of the static grate. The PYROSTATIC® grate (Figure 1) combines a conventional horseshoe arrangement with an improved inclination angle and a new design of the grate plates. The horseshoe arrangement allows better clinker pile formation, preventing air from escaping through the lightly loaded area on the sides and concentrating it in the centre, where the bulk of the material is located. This results in better heat exchange between the clinker and the air, optimising cooling, while maximising heat recovery to secondary air and tertiary air, thereby lowering demand for primary fuel. Air cannons are strategically integrated in the horseshoe and help to negotiate snowman formations, as they can be hit and redistributed from a close range. The new-style grate plates have an aerodynamic slot design that offers a low pressure drop. Additionally, the newly designed smooth grate plate surface and an improved (15˚) angle of inclination reduces the chances of material agglomerations on the static grate.

The newly designed grate is suitable for upgrades, in that all parts of the grate are welded during construction, and most of the parts can be manufactured locally. Additionally, all parts can be easily assembled at site and installed inside the cooler, without having to alter or cut through the existing walls and supporting columns of the lower housing.

Finding a solution

During the initial assessment, based on control-room data and production logs, KHD determined that, in addition to resolving the issue of material agglomerations (snowmen), the cooler recuperation efficiency could be also be improved by approximately 3%. Working in collaboration with the client, KHD was able to identify the following key objectives for the upgrade:

- Improve the recuperation efficiency of the cooler.
- Reduce the clinker outlet and cooler exhaust air temperatures.

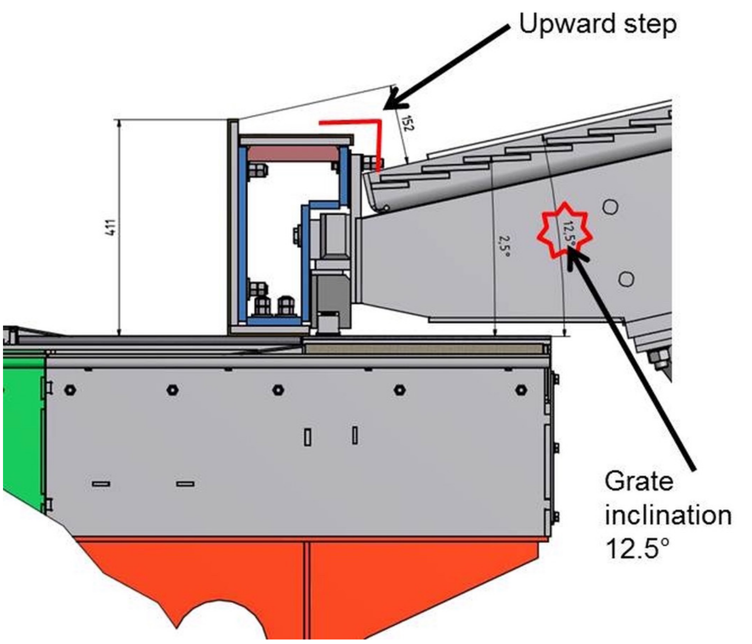

Figure 3a. Static grate: before modification.

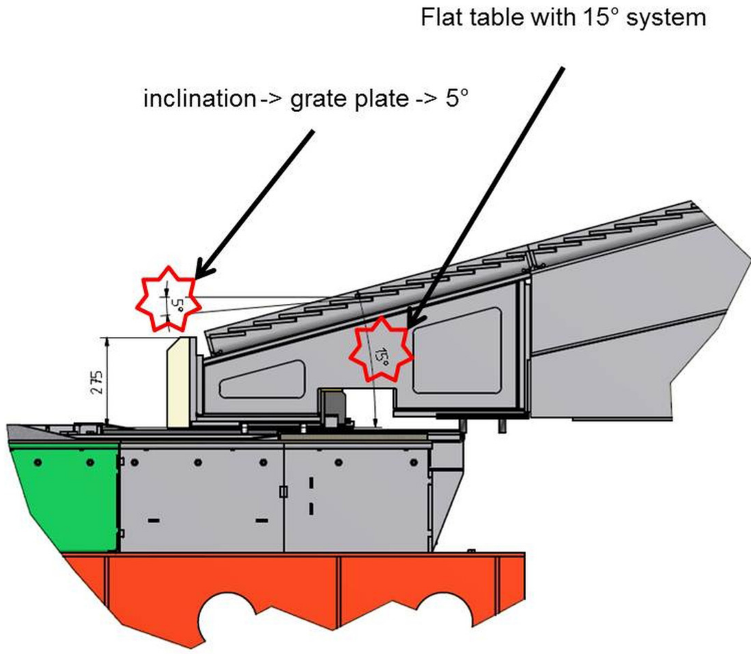

Figure 3b : PYROSTATIC®: after modification.

- Minimise the possibility of snowman formation on the static grate.
- Execute the entire upgrade within the three week annual maintenance shutdown window.

From a control point of view, taking into account the change in the clinker flow behaviour from the static section into the movable lanes, it was also necessary to install the newest version of KHD's cooler automation system, PFCC. KHD's PFCC is a cooler control programme that interacts directly with the plant control system and automatically controls cooler operations by generating optimised set points for lane movement and aeration fans.

To address the target goals, a cooler upgrade involving the following modifications was proposed by KHD:

- PYROSTATIC® retrofit:
  - Extension of the static grate area from 5.9 m^2 to 9.3 m^2.
  - Implementation of a refractory horseshoe arrangement with integrated air cannons, over the static grate.
  - Improvement of the angle of inclination from 12.5° to 15.0°.
  - Replacement of existing grate plates with new high-efficiency grate plates.
  - Installation of an additional aeration fan for the extended portion of the static grate.
  - Delivery of drawings of the Refractory and Air Cannon Group, a flexible solution for the client to choose its usual vendors.
- PFCC software upgrade:
  - New algorithm for lane movement control with Transport Efficiency Optimiser (TEO).
  - Advanced algorithm for generating optimal flow set points for aeration fans, based on kiln feed and other process parameters.

***Table 1.* Before and after static grate modification**

	Before upgrade	After upgrade
Type of upgrade	–	PYROSTATIC® retrofit
Clinker throughput (tpd)	3000	3000
Cooling air amount ($Nm^3/kg_{clinker}$)	2.1	1.9 – 2.0
Cold clinker temperature (absolute temperature of whole fraction) (°C)	113	102
Recuperation air (SA+TA) temperature (°C)	892	940
Exhaust air temperature (°C)	237	222
Recuperation efficiency (%)	69.4	73.5

Project execution

The implementation phase of the project was the most critical, as there were less than 90 days available for KHD to complete all engineering and supply. It was essential that all parts required for the modification were onsite before the start of the annual maintenance shutdown. To ensure this, deliveries and scope of supply were split, so as to minimise delivery times. Parts were manufactured both locally and internationally, according to KHD drawings, specifications, and quality assurance protocols. Meanwhile, the upgrade of PFCC software was planned and executed via the internet, using a remote access link between the PFCC computer at site and KHD's office in Germany.

KHD developed a step-by-step presentation with 3D views of the cooler before, during, and after the installation, showing the parts to be removed and the new parts to be installed. This helped the client, contractors, and all parties involved to have a visual representation of the work to be carried out inside the cooler. The entire modification work was supervised by a KHD field expert and carried out by an installation contractor hired by the client. KHD was able to accommodate the unexpected shutdown of the kiln 7 days ahead of schedule. The new static grate frame and its extension were carefully lowered into the cooler via the kiln hood, without opening up the lateral walls of the cooler: a cost-effective solution. Installation of the new frames, seals, covers, grate plates, and start cassettes, along with the air cannons, went as planned and without any unexpected surprises that affected the schedule or scope of the installation.

As a result of excellent coordination between all involved parties, the mechanical modifications were completed within the first 10 days of the shutdown, leaving ample time for the refractory contractors to refurbish the cooler wall's refractory and form, and construct the horseshoe over the static grate. The cooler was available, complete in all aspects, on schedule for kiln preheat.

The upgraded cooler was recommissioned under the supervision of a KHD expert. Cooler operations were fine tuned; transport and PFCC aeration controllers were successfully set into automatic mode. KHD's expert worked closely with the production and automation groups at the plant to identify and programme the air cannon blasting sequences for different agglomeration scenarios, and according to the mechanical and refractory horseshoe layout for this particular client. A brief process optimisation phase followed, showing that cooling air flow was reduced to 1.9 $Nm^3/kg_{clinker}$, recuperation air temperatures increased by approximately 48˚C, and cold clinker and exhaust air temperatures were reduced by approximately 11˚C, resulting in an increased cooling efficiency of approximately 4%, and the respective reduction of cooler losses. Table 1 shows the critical parameters as observed before and after modifications.

Conclusion

When it comes to modernising clinker coolers, a retrofit of the static grate can prove to be a very cost-effective upgrade. Clinker cooler modifications can be quickly implemented and yield substantial tangible benefits, in terms of improved recuperation efficiency, reduced cooler losses, an increase in tertiary air temperature, and a reduction in clinker outlet temperature. This provided notable savings for the client, in terms of operational specific heat consumption of the kiln. In the six months following the project, the client had not been forced to shut down once due a snowmen agglomeration, which was the principal goal of the project.