Big coolers, big challenges

by Dr Daniel Strohmeyer &
Dr Yaoxing Chen,
IKN GmbH, Germany

With an annual cement consumption of about 1.85bnt, China is by far the world's largest cement market. This has created a demand for high-capacity clinker lines similar to those procured by the Anhui Conch Cement Company in autumn 2009 for its Wuhu and Tongling plants. While two lines have been erected and exceed their 12,000tpd design capacity, the third one is due to start up in April 2012. For the coolers of these new lines, Anhui Conch turned to Germany-based IKN.

The projects were carried out with well-known suppliers such as Polysius and FLSmidth for the preheater/rotary kiln and Kawasaki/Conch for the raw material grinding and the waste heat recovery system. All three lines feature latest-generation IKN Pendulum Coolers with a nameplate capacity of 13,000tpd (see Figure 1). After intense technical discussions, they were chosen because of their low specific energy consumption, reduced expected wear rates and related savings in terms of maintenance costs and higher efficiency. Furthermore, IKN's broad experience in building high-capacity units contributed to the decision.

The project/scope of work

The supply contract between Anhui Conch Cement and IKN was signed in September 2009 and comprises the key parts and detailed engineering of the cooler. IKN supplied the fixed inlets, the following Pendulum grate sections and the roller crusher for all three coolers. In addition, the grate drive including the hydraulic system and the local control cabinet as well as the required field instruments were part of IKN's scope of supply. All the structural steel of the lower and upper cooler housing, the refractories and the cooling fans were locally sourced according to IKN´s workshop drawings and specifications, respectively.

Process and design features

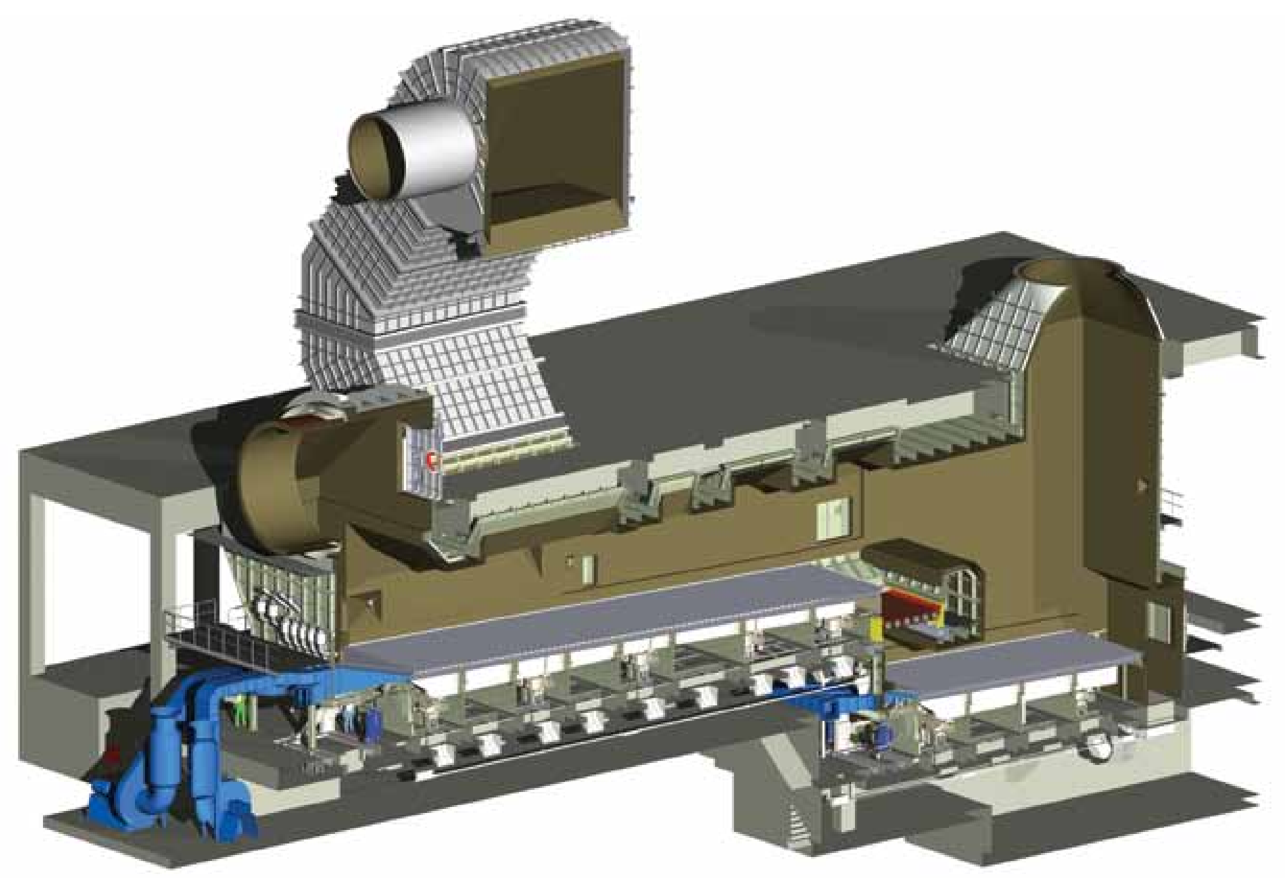
The sintered clinker leaves the outlet of the kiln with an estimated temperature of 1400°C and drops onto the 11-row static inlet called KIDS (clinker inlet distribution system) where the clinker is initially cooled and conditioned for uniform distribution to the 7.2m-wide pendulum-supported grate (see Figure 2).

Figure 1: Wuhu rotary kiln and cooler

The clinker is transported by the linear strokes of the Pendulum section – every third row is moveable. The clinker bed, 550-650mm deep, travels past the tertiary air offtakes which are located separately behind the kiln hood and subsequently leaves the recuperation zone. Further down the cooler, the material passes by three additional air offtakes which supply the adjacent coal mills and the waste heat recovery system with hot gases.

After travelling two-thirds of the total grate length the clinker indicates a theoretical temperature in the range of 240°C when it meets the water-cooled intermediate crusher. The crusher has six rollers with a width of 4.8m (see Table 1). After being crushed the material's maximum grain size is 35mm and the clinker then falls onto an intermediate four-row KIDS that distributes the material bed for final cooling onto the second Pendulum grate. The transport speed of the second grate is higher compared to that of the first one due to the smaller grate width of 6.8m. At the end of this second grate the maximum clinker temperature is at 65°C above ambient

Figure 2: cooler 3D cross-section 1



and the material leaves the cooler via a chute, which discharges the clinker to the pan conveyor leading to the clinker silo. The final gas offtake, the vent air duct, merges with the outlet gas of the waste heat recovery system. The vent air de-dusting is carried out by a two-string ESP-filter.

In total 16 fans (see Figure 3) supply cooling air via ducts into the under-grate chambers and from there through the 'Coanda-Nozzles' forming the grate surface uniformly into the clinker bed. The grate drive features two separate hydraulic systems each with two cylinders simultaneously operating to provide the clinker transport. Consequently, each grate can be individually adjusted in terms of stroke length and speed. As all four cylinders are located outside the cooler housing the entire hydraulic system is well accessible and protected from clinker dust (see Figure 4). The hydraulic system, in combination with the 'Linear Pendulum

Table 1: IKN Pendulum cooler with KIDS technical data

Capacity (tpd)	13,000
Number of grates	2
Grate width (m)	7.2/6.8
Loading at nominal capacity (t/(m^2*d)	43
Grate area (m^2)	303
Installed cooling air (Nm^3/kg clinker)	2.2
Installed grate drive power (kW)	
– grate 1	2 x 132
– grate 2	1 x 110
Crusher type/location/cooling system	Roller crusher/ intermediate/water
Number of rollers	6
Crusher width (m)	4.8
Installed power crusher (kW)	6 x 15

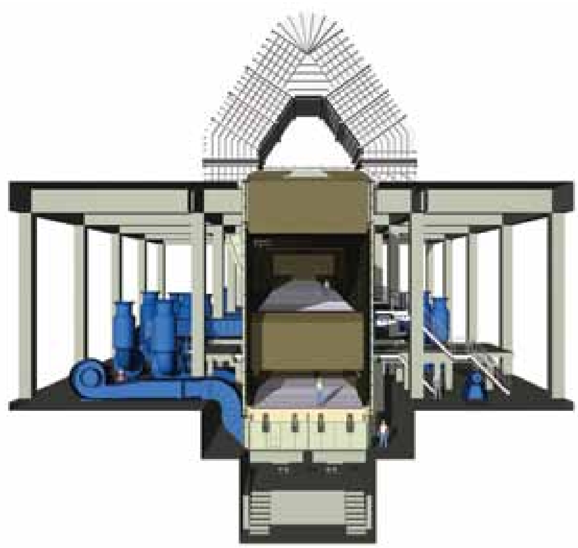


Figure 3: cooler 3D cross-section 2

Table 2: cooler operational data (3+3-day cooler test run)

Conditions	
Clinker production (tpd)	11,400-12,500
Ambient air temperature (°C)	4-8
Clinker litre weight (g/l)	1200-1300
Clinker inlet temperature – assumed (°C)	1400
Main and calciner burner fuel	coal
Cooler performance	
Specific energy consumption cooling fans, grate and crusher drive at counter (kWh/t)	4.68
Clinker outlet temperature (°C)	50-60
Heat recuperation (%)	79


Figure 4: grate drive 1


Figure 5: cooler foundations

Support' (LPS) which does not include any bearings and lubrication, ensures trouble-free cooler operation. Neither the grate drive nor the fans require emergency power.

Due to the accuracy of the grate surface and the minimal gaps between moving and fixed parts of the grate, the amount of clinker falling into the under-grate hoppers is negligible. However, a small tube chain conveyor is installed and in operation for approximately 40 minutes per day to extract any clinker dust from the hoppers and transport it to the clinker cooler discharge.

Commissioning

In December 2011 and January 2012, the hot commissioning of two of the three new clinker lines at Conch's Wuhu and Tongling plant commenced. The design capacity was reached and exceeded within 72hrs from first clinker in both plants. As part of the hot commissioning at Tongling, a three-day clinker production test run was carried out with the intention of achieving a stable and continuous clinker output in excess of 12,000tpd. The target was achieved with only one interruption of 80 minutes, related to the rotary kiln, between 4-7 January 2012. After the test run an additional three-day cooler optimisation was carried out, including the fine-tuning of the cooling air flow and the grate speed to achieve a clinker temperature of about 70°C at the lowest possible specific energy consumption. Additionally, a fan and grate speed table was created comprising cooling air flows, under-grate pressures and grate speeds for all conceivable production rates. The fan operating points are always related to the particular production situation (eg clinker litre weight, granulometry and mineralogy) at the individual plant and allow the cooler at the respective site to be operated in automatic mode. Further adjustments to the coolers' operating parameters may only become necessary if the clinker production changes substantially (eg changes in raw meal composition and/or clinker quality).

During the entire six-day trial, data concerning the energy consumption of the cooling fans, the roller crusher and the two grate drives were obtained and are shown in Table 2. The clinker temperature was measured – it never exceeded 65°C and settled between 50-60°C most of the time, which implies there is ample reserve in terms of increased future clinker production. Furthermore, the clinker litre weight, the ambient air temperature, production and process parameters (eg tertiary-, secondary air temperature) were monitored to allow for a proper evaluation of the cooler performance. The specific recuperation air volume amounted to ~0.89Nm^3/kg of clinker depending on the burning conditions and the specific thermal energy consumption of the kiln. The related cooler efficiency was ~79 per cent. Due to the size of the pyro-line resulting in large duct diameters and large distances inside the different parts of the kiln, accurate measurement of gas temperatures is challenging and multiple measuring points are preferred.

Figure 6: cooler grate 1 and 2 and partly-erected upper housing

Conclusions

Further high-capacity cement production lines are already in the pipeline and will be built. Such large-scale coolers present additional mechanical and process-related challenges which have to be taken into consideration. For instance, the grate drive, poor visibility in case of dusty clinker and difficult-to-measure gas temperatures and flows are worth mentioning. These require equipment suppliers to have excellent process know-how, close tolerance manufacturing capability and extensive assembly and commissioning experience. Furthermore, there is a growing tendency towards additional heat consumers using hot gas drawn from the cooler. At Conch's new Tongling and Wuhu clinker production lines, the IKN Pendulum Coolers have a total of six hot gas offtakes. Two of them, the kiln hood and the TA-duct, supply hot gases to the rotary kiln and preheater. Three further offtakes deliver energy to the coal mill and the waste heat recovery system while the remaining heat leaves the cooler via the vent air duct. This setup with different heat consumers and their individual requirements makes it essential to be flexible regarding energy distribution inside the cooler. Even more flexibility is required if the plant operation includes the use of different fuels in the burning process – a factor to be considered for clinker coolers of all capacities.

Figure 7: cooler building