

SUMMARY

In June 2013, Buzzi Cement Hranice a.s., Czech Republic, awarded a contract to A TEC for an upgrade of the preheater and calciner of the clinker production line. The contract covered engineering, supply of equipment, steel structure, erection and civil works. Installations and start-up were in February 2014. The new calciner system, comprising a separate hot gas combustion chamber and an in-line calciner with a post combustion chamber, has a retention time of approximately seven seconds. This increased retention time accounts for the combustion of alternative fuels, allowing the use of up to 100 % of solid alternative fuel in the calciner. The new system will also lower the NOx levels, as well as reducing the specific heat consumption caused by the improved combustion behaviour in the calcination reactor. An A TEC Post Combustion Chamber (PCC) was installed at the top of the calcining system, ensuring increased retention time and enhanced gas mixing. Refuse-derived fuel (main burner quality), pulverized coal and animal meal are used at the existing main burner, in addition to natural gas for initial start-up only. The calciner includes three fuel input positions, with calciner-quality RDF-material entering the hot gas chamber from the input position at the top of the hot gas combustion chamber. The input location for shredded tyres was not changed, while the current calciner burner was moved from its existing position in the calciner. Tertiary air distribution and oxygen control are carried out by a number of automatic controlled dampers. ◀

ZUSAMMENFASSUNG

Im Juni 2013 erhielt die A TEC Production & Services GmbH von der Buzzi Cement Hranice a.s. aus der Tschechischen Republik den Auftrag zur Calcinatormodifikation. Der Vertrag umfasste das Engineering, die Lieferung der Ausrüstungen und Stahlkonstruktionen, die Montage der Ausrüstungen und auch die Planung und Realisierung des bautechnischen Teils. Die Installationen wie auch die Inbetriebnahme erfolgten im Februar 2014. Das neue Calcinatorsystem, das im Wesentlichen aus der Heißgaskammer, dem Calcinator selbst und einer Nachverbrennungskammer besteht, verfügt über eine Verweilzeit von ca. sieben Sekunden. Diese erhöhte Verweildauer gewährleistet die Verfeuerung von alternativen Brennstoffen im Calcinator mit einem Anteil von bis zu 100 %. Das neue Calcinator-System soll sowohl das NOx-Niveau senken als auch wegen seiner verbesserten Verbrennungsbedingungen zu einer Senkung des spezifischen Wärmebedarfs der gesamten Ofenanlage beitragen. Im Zuge des Upgrades wurde am oberen Ende des Calcinars eine so genannte A TEC Post Combustion Chamber (PCC) installiert, die für erhöhte Verweilzeiten und eine verbesserte Gasvermischung sorgt. RDF-Material in Hauptbrenner-Qualität, Kohlestaub und Tiermehl werden in dem vorhandenen Ofenbrenner aufgegeben, wobei auch Erdgas, allerdings nur für den Ofenstart, zur Verfügung steht. Der Calcinator verfügt über drei Brennstoffeinträge für RDF-Material mit Calcinator-Qualität zur Befuerung der Heißgaskammer von oben. Der Eintragsort von geschredderten Altreifen im Ofeneinlaufbereich wurde beibehalten, die Positionierung des gegenwärtigen Calcinatorbrenners jedoch verändert. Die Aufteilung der Tertiärluft aus dem Rostklinkerkühler und die Sauerstoffkontrolle erfolgen mithilfe von feuerfest zugestellten Tertiärluftschiebern. ◀

Calciner modification including a new hot gas chamber by Buzzi Cement Hranice

Calcinator-Modifikation unter Einsatz einer neuartigen Heißgaskammer bei Buzzi Cement Hranice

1 Introduction

In June 2013, A TEC Production & Services GmbH with headquarter in Krems, Austria, was awarded a contract for an upgrade of the clinker production line of Buzzi Cement's plant in Hranice, Czech Republic. The kiln line in the Czech cement works after the implementation of the new calciner system produces 3000 t/d of grey clinker. The aim of the modification project was to increase the alternative fuel substitution rate at the calciner to 100 % as well as to reduce exhaust gas emissions up to 100 % mainly by the use of fluff in the calciner. The NO_x-emissions should be reduced below 400 mg/m³ (stp) with a new arrangement and air/fuel distribution by a separate hot gas combustion chamber without secondary gas chamber. In certain cases, an NO_x-concentration of about 250 mg/m³ (stp) using the so-called SNCR-technique will be reached. Therefore, A TEC has designed and developed a calciner modification which will be described in this article.

2 Situation before modification

The kiln line by Buzzi Cement Hranice consists of the pre-heater with the designation COMBI 5ST, a combined calciner KKS+KKN, the rotary kiln and the grate clinker cooler. Tertiary air for combustion in the calciner is taken from the grate cooler case. The kiln line is equipped with a bypass for the extraction of accumulating elements in the system, like chlorine.

Pulverized coal and various types of alternative fuels are used as fuel for the kiln line, i.e., in the main burner of the rotary kiln as well as in the calciner burners. The original kiln line was designed for combustion of pulverized coal and was subsequently modified for combustion of a limited quantity of alternative fuels. In the past, a limiting factor for combustion of alternative fuels was particularly the calciner configuration.

3 Characterization of the fuels used

Natural gas with a lower heat value of 36 MJ/m³ (stp) is used for starting up and preheating of the kiln line. Fuel for normal operation of the kiln line is pulverized coal with a lower heat value of about 28 MJ/kg.

Table 1: The different fuels and their distribution

Fuel type	LHV	Kiln		
		Kiln burner	Bottom part	Hot gas Chamber
Unit	MJ/kg	%	%	%
Coal	28	35		4
MBM	17			
RDF kiln	20	11		
Shredded tyres	28		15	
RDF calciner	18			35
Sum		46	15	39
Total		46		54

The aim was to use the following alternative fuels: meat and bone meal (MBM), solid alternative fuel (RDF, TAP) with a different quality for the kiln and for the calcining system, and shredded tyres. Table 1 shows the different fuels and their fractions to be fired in the different feeding positions of the system.

The conditions for kiln line operation were an output of 3000 t/d with a calculated specific heat consumption of 3330 kJ/kg_{clinker} considering a gas bypass of approx. 4000 m³/h (stp).

4 Modification details

The combustion of solid alternative fuels requires a significantly longer residence time in the hot combustion zone compared to conventional fuels like pulverized coal, gaseous or liquid fuels. The retention time in the new calcining system (hot gas chamber, calciner and post combustion chamber) is approx. 7 s. This increased retention time allows the use of

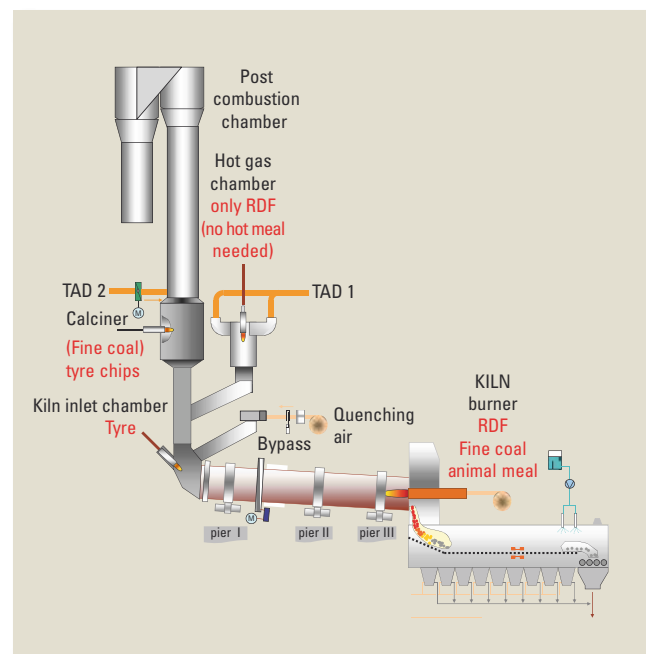


Figure 1: Fuel inputs on the kiln line

high amounts of solid alternative fuels (up to 100 % in the calciner). Additionally, the heat consumption is reduced by the improved combustion behaviour in the calciner system, avoiding unburned components entering the preheater section.

In the case of a production rate of 3000 t/d and fuels according table, an effective gas flow of 210 m³/s would result. Therefore to hand this gas amount in the calcination reactor properly, the calciner was designed with a diameter of 4250 mm in the upstream as well as in the downstream duct. At the top of the calcining system, the A TEC Post Combustion Chamber (PCC) for optimized gas mixing and retention time increase was installed.

The enlargement of the calciner volume is the basis for a functional DeNOx system by using tertiary air in the hot gas chamber in order to create a sub-stoichiometric combustion atmosphere at the fuel inlet. This leads to the benefit that due to the lack of oxygen, the NOx production is minimized in the hot combustion zone. Furthermore due to this effect, a significant amount of CO and hydrocarbon radicals (CxHy) is formed which can act as an NOx reduction agent when the CxHy radicals are mixed in the calciner with the NOx-rich kiln gas, according to the following reaction:



This reaction is favored by a high temperature in the mixing zone with the kiln gas which is realized by a staged meal inlet (avoiding a cold spot at the reaction zone). Remaining unburned components are reduced by the addition of the remaining amount of tertiary air after the mixing zone and a complete combustion (avoiding high CO levels) is realized by the A TEC Post Combustion Chamber (▶ Figure 4). Currently no secondary NOx reduction system is installed as the system can reach 400 mg/m³ (stp) which is sufficient at the current stage. However, the system is prepared for an SNCR system in the calciner to reach even lower values.

Table 2: List of the calculated process data

Designation	Unit	Calculated value
Kiln throughput	t/d	3000
Spec. heat consumption	kJ/kg	3330
Spec. gas quantity in front of ID-fans	m ³ /kg (stp)	2 x 0.8
Static pressure in front of ID-fans (in clean condition)	kPa	8.0
Temperature top stage	°C	360 ... 370
O ₂ content after top stage	%	3.5
Kiln inlet gas quantity	m ³ /kg (stp)	0.7
Temperature kiln inlet	°C	1150
Bypass rate	%	< 5
Orifice area	m ²	3.65
Temperature tertiary air	°C	> 800
Tertiary air quantity	m ³ /kg (stp)	0.42
Heat input main burner	kJ/kg	~ 1515
Heat input hot gas chamber	kJ/kg	~ 1315
Heat input kiln inlet	kJ/kg	~ 500

5 Fuel and air inputs

At the existing main burner, alternative fuels with the quality of RDF as well as pulverized coal, meat and bone meal and natural gas (only for start-up) are used. On the calciner side there are three fuel input positions. The main fuel input is from the top into the hot gas chamber. At this position RDF-material of calciner quality is used. There is no need for any preheated raw meal from the upper stage with this configuration.

The intake for shredded tires at the kiln inlet is unchanged. The existing calciner burner for pulverized coal and natural gas was moved from its existing position into the calciner.

The tertiary air distribution is done by two dampers. TAD 1 and TAD 2 are controlled for oxygen control. There are two inlet tertiary air ducts into the hot gas chamber. In certain cases with those configurations NOx- emissions of 250 mg/m³ (stp) using the SNCR-technique could be reached. Fig. 1 shows the feeding points at the kiln and the calciner. Table 2 lists the calculated process data.

6 Scope of supply

A TEC's scope of supply was mainly based on mechanical turnkey. The execution of the project was done in collaboration with the company Aliacem s.r.o. Přerov, Czech Republic.

Services and supply by A TEC:

- ▶ Engineering
- ▶ Supply of mechanical equipment
- ▶ Supply of key equipment
- ▶ Supply of duct works, cyclones and hot gas chamber
- ▶ Supervision of process and commissioning

Services and supply by Aliacem:

- ▶ Supply of steel structure
- ▶ Supply of refractory lining
- ▶ Erection of all components such as mechanical equipment, key equipment, duct works, steel structure
- ▶ Structure and refractory lining
- ▶ Supervision of erection and site coordination

The main construction work was done during the normal operation of the kiln line. Only for the interconnection between the new and existing equipment was there a short stoppage of the kiln line necessary. ▶ Figs. 2 and 3 show the calciner upgrade.

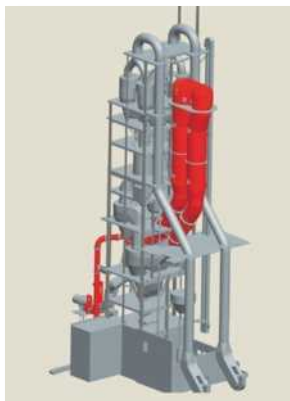


Figure 2: Calciner loop duct with Post Combustion Chamber (PCC)

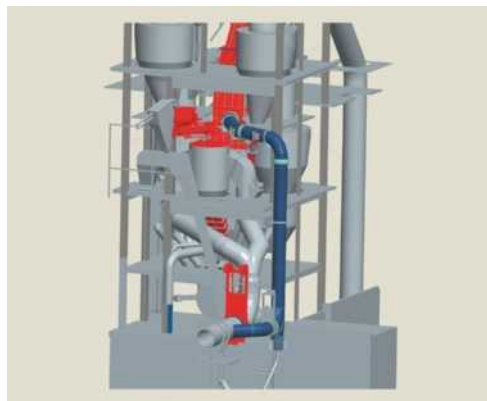


Figure 3: Hot gas chamber



Figure 4: Specific design of the A TEC Post Combustion Chamber (PCC)

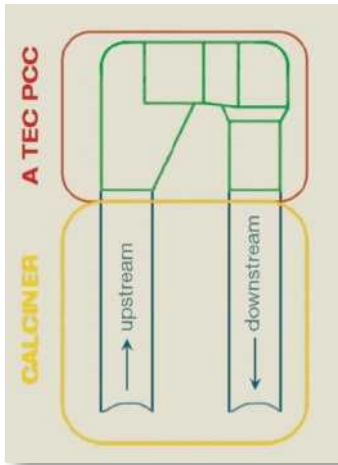


Figure 5: Arrangement of the post combustion chamber on the calciner top



Figure 6: Calciner loop with the post combustion chamber in the Hranice kiln line

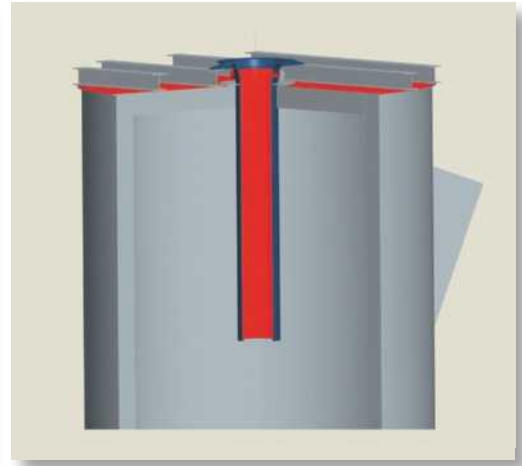


Figure 8: Jacket tube for feeding the hot gas chamber

7 Key components used in the upgrade project

7.1 Post Combustion Chamber (PCC)

Challenging combustion conditions in the calciner have to be handled properly. Kiln gas has to be mixed with calciner fuels and tertiary air which is in many cases not successful due to the high viscosity of the kiln gas. Current and future fuel compositions tend to be originated from low grade solid fuel fractions or alternative fuels, such as RDF waste fractions. High residence time for complete combustion leads to massive calciner length extensions.

Placed on the top of the calciner, the post combustion chamber (Fig. 4) effectively improves the calciner combustion performance by lengthening the residence time and improving the mixing of the gas stream. Compared to a conventional calciner duct, this installation saves space and weight while the combustion step can be completed by effective mixing of any unburned components with residual oxygen.

The special design, consisting of the increase of the cross-section upstream, reduces the gas velocity. Larger unburned fuel particles can stay in the upstream section because of the increased residence time. The entrance to the downward loop duct is designed eccentrically (Fig. 5) which produces a high mixing potential without effecting the pressure drop. This is a big advantage for the reduction of CO emissions as well as for minimizing any unreacted SNCR reagent emis-

sion. While Fig. 6 shows a photo of the realized post combustion chamber on the top of the calciner at the Hranice kiln line, Fig. 7 gives an impression of the gas flow in the calciner loop.

7.2 Hot gas chamber with jacket tube

The hot gas chamber significantly improves the combustion process by using tertiary air with 21 % oxygen. Another advantage is the increase in retention time, which allows improved combustion of bigger particles. No special burner is used for feeding the hot gas chamber. The RDF-material from the weigh feeder to the hot gas chamber is fed by gravity using a jacket tube (Fig. 8). This hot gas combustion chamber has a unique design, as it is not equipped with hot meal. The hot meal is added downstream in the calciner (staged meal inlet to avoid cold spots). The benefit of this system is that also fuels with a comparably low quality and high moisture can ignite comparably fast and the required hydrocarbon radicals (CxHy) are formed very fast, already before mixing with the kiln gas in the lower calciner section happens. The increased reactivity with this arrangement provides a higher flexibility for operation as the amount of the produced radicals and process conditions can be effectively adjusted by the amount of tertiary air to this combustion chamber.

The advantages of such a design are:

- ▶ Combustion at a very high efficiency level
- ▶ Use of low quality fuels



Figure 7: CFD analysis of the gas flow in the calciner loop of the post combustion chamber



Figure 9: Photo of the DeNOx and hot gas chamber



Figure 10: Tertiary Air Duct (TAD) gate



Figure 11: Pendulum flaps gate

- 】 Combustion of bigger particles
- 】 Perfect control of atmosphere for NOx-reduction

Fig. 9 shows a photo of the DeNOx and hot gas chamber.

7.3 Tertiary Air Duct (TAD) gates

An effective and accurate control of combustion air for the calciner in a modern clinker production plant is essential to meet controlled product quality, steady state operating conditions as well as to meet the required emission limits. For economic and ecologic reasons, preheated, tertiary air from the grate clinker cooler is used.

Air flow regulation devices, so called Tertiary Air Duct (TAD) gates (Fig. 10), which can be loaded with clinker dust, are exposed to the rough conditions that are present at extremely high temperatures. Therefore tertiary air duct gates very often suffer under these conditions and end up with high maintenance efforts being required to maintain proper operation. A TEC tertiary air duct gates are specially designed for these conditions to minimize wear and maintenance.

The blade, which is affected by the highest stress, is specially designed to minimize internal stress and cracks caused by temperature changes. This is realized by using a monolithic ceramic with a hexagonal mesh on both surfaces. Prior to the delivery, the carrier material for the ceramic is tempered to reduce additional thermal stress. This system eliminates problems due to steel expansions and leads to less sensitivity to temperature changes and pressure fluctuations. Another focus is set on easy maintenance work, which is realized with inspection openings. The blade can be replaced at site.

The A TEC tertiary air duct gate is a completely closed system: The used chain drive ends at a rod that is connected to the blade. The chain drive solution has shown itself to be a very robust solution to the effects of dust and heat. The rod is sealed to the housing by a gland packing. This ensures a dust-free operation.

7.4 Pendulum flaps gate

In cyclone preheater towers, the pendulum flaps gate (Fig. 11) is one of the most important pieces of key equipment for effective operation during the clinker production. Installed in the meal pipe – which connects the solid particle outlet of a cyclone separator to the next, lower, riser duct or the kiln inlet – it avoids any counter gas flow upward in the meal pipe which would significantly lower the efficiency of the cyclone separators.

The flap is actuated by weight, which means that the mass of the solid particles opens the flap. After the particles have passed the flap, it closes automatically by means of the adjustable counter weights. Beside the application for cyclones in preheater towers, the implementation of the A TEC pendulum flaps gates attracts interest concerning various applications for particle handling at high temperatures.

The expansion joints used are designed for high temperature application and therefore also for the required dilution. The expansion joint is made partly of stainless steel, whereby for the inner parts a refractory lining is used.

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