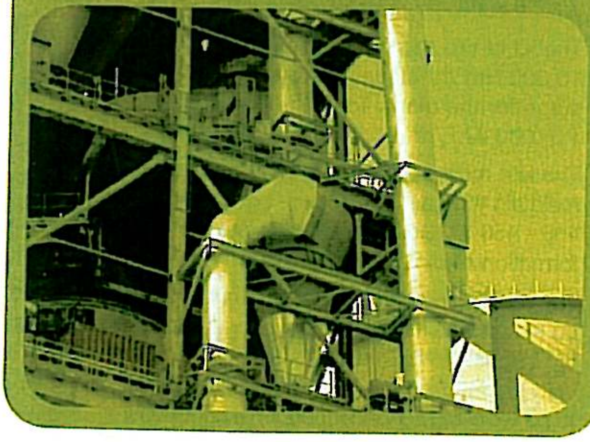
Installing a Bypass

John Scott, Fairport Engineering, UK, describes the recent installation of a **bypass system** at Castle Cement's Ketton plant.



Introduction

A new bypass system has recently been installed at Castle Cement's Ketton plant in the UK. Engineering and project management were carried out by Fairport Engineering, from the UK, in partnership with ATEC Advanced Process Technologies GmbH, from Austria, which provided the specialist process know-how.

Process objectives

Kiln 8 at Ketton is a four-stage precalciner kiln with a current output of 20 000 t per week, and a potential output of 3500 tpd.

The circulation of volatile materials such as alkalis, sulfur and chlorine within the kiln system can lead to preheater blockages and/or restricted output. The control of volatiles in the kiln system is therefore a limiting factor on kiln output and performance.

The objective of this project was to engineer and install a bypass system that would allow a high proportion of the volatiles to be removed from the kiln gas stream. The ultimate goal is to avoid blockages in the kiln and thus facilitate trouble-free kiln operation by controlling volatile levels in the hot meal leaving the lowest stage precalciner cyclones.

The process requirements can be summarised as follows:

- To minimise any reductions in kiln output as a result of the bypass operation.
- To minimise the production of bypass dust as a waste material.
- To meet the WID emissions level at the stack.

Approximately 7% of the kiln gases are diverted into the bypass system at a take-off point and cooled in an initial quench chamber. Atmospheric air is introduced as the cooling medium by a variable speed fan. The cooled, dust-laden gases are then ducted to a cyclone that separates the coarse dust particles and returns them to the kiln via a chute. A recirculation leg is included to feed the coarse dust back to the cyclone if required.

The volatiles adhere to the fine particles in the gas stream, and these are ducted from the cyclone to a second quench vessel that cools the gases before they reach a bag filter downstream. Dust is collected in the bag filter, and the gases leaving the bag filter are then returned, via a variable speed induced draft fan, to the main kiln stack for release to the atmosphere.

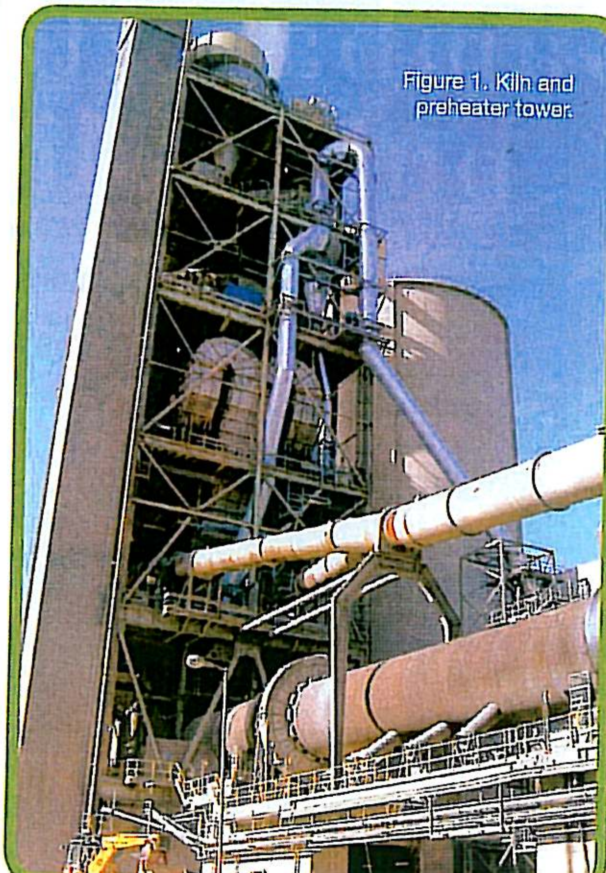


Figure 1. Kiln and preheater tower.


Figure 2. Bag filter and dust storage.

Table 1. Kiln inlet conditions	
Bypass volume	6000 Nm^3/hr
Gas temperature	1100 – 1200 °C
O_2 level	2.5 – 3% dry
H_2O level	7 – 15% (wet)
CO_2 level	15 – 20% (wet)
Dust loading	0.4 – 0.8 kg/Nm^3
SO_3 in hot meal	2 – 3%
SO_3 in clinker	Approximately 1%
Cl in hot meal	2 – 2.5%

Bypass dust is stored below the filter for transportation to landfill. The storage volume caters for 16 hours of bypass operation plus 100% (approximately 120 m^3). The dust is discharged into road vehicles via a telescopic loading chute. In order to cope with the flow under full silo conditions, the silo base features a mechanical discharger and rotary valve to assist dust discharge.

Performance criteria

The maximum clinker production rate of the kiln is 3500 tpd. The following performance parameters were set:

- Clean gas to the stack to contain less than 5 mg/Nm^3 dust during normal operation. (Requirements of the WID directive must be met).
- The ID fan to pass 60 000 Nm^3/hr + 10 000 Nm^3/hr clean air with adequate pressure surge for the plant. Total filter flow rate is 115 000 Am^3/hr at 220 °C.
- The first mixing chamber and air quench fan to maintain the gas temperature between 400 - 450 °C. Good mixing helps to prevent the formation of dioxins and furans.
- The second mixing chamber and multi-position slide valve on the quench air inlet to control the temperature entering the bag filter in the range of 200 - 220 °C. An emergency cold air bleed is fitted to the secondary quench chamber to protect the filter under abnormal conditions.

Process equipment specifications

Currently, approximately 50% of the thermal load is delivered by the main burner. The kiln inlet conditions are shown in Table 1.

Due to the potentially corrosive nature of bypass gas, all equipment was supplied to suitably resist the materials being handled. The kiln take-off duct, first quench chamber, and interconnecting ducting are all refractory lined as far as the first quench chamber. All ducting and pipework includes expansion joints and dampers to allow safe maintenance of the bypass system whilst the kiln is in operation. Thermal insulation was included as necessary on all equipment to maintain plant items above the acid dew point and for personnel protection.

The cyclone was designed so that the dust stream entering the bag filter contains approximately 80% alkali salts at 100% bypass rate, and it allows adjustment of the recirculating solid stream into the cyclone riser.

The remainder of the cyclone stream is returned to the kiln inlet via double pendulum flap valves that provide a gas seal. A bypass chute, with similar valves, is also provided to enable recirculation of the coarse dust back into the hot meal duct above the first quench chamber.

The overall plant layout was designed to allow space for the later addition of a conditioning tower after the air injection point and before the bag filter. This would introduce calcium hydroxide and sodium bicarbonate (up to 200 kg/hr each) into the gas duct after the cyclone as a potential means of reducing SO_2 and HCL in order to meet WID emission limits. The conditioning tower is approximately 5 m dia. x 26 m high with the capability to achieve an outlet temperature of 130 – 150 °C. However, to date, this has proven not to be required.


Figure 3. Bypass ducting.

The second quench chamber is upstream of the bag filter to offer temperature protection. Fresh air is drawn in through a modulating damper to lower the gas


Figure 4. Bag filter and dust storage.

stream temperature, and an emergency fresh air valve is installed downstream to protect the bagfilter from insufficient cooling.

The baghouse was designed to accommodate a draft of 115 000 Am³/hr (at 1200 °C), cooled to 220 °C at 24 mg/Nm³. The bags and filter as a whole were designed to withstand a continuous maximum temperature of 260 °C (peaking at 280 °C for 5 mins), and have a maximum dust capability of 100 mg/Nm³. The cleaned air was to have a maximum dust loading of 5 mg/Nm³. The membrane bags were made from PTFE with support felt/substrate suitable for use in typical bypass gases, usually laden with SO_2 and HCL. These would be upset conditions for a short period and not experienced during normal operation.


Figure 5. Bag filter from preheater tower.

The storage silo and dust handling equipment were designed to be suitable for high alkali chloride and sulfate bypass dust, with concentration levels as detailed above. The silo is integral with the bag filter, forming a natural base below it. The base of the silo features a rotating auger and a central outlet with a rotary valve, screw conveyor and telescopic vehicle loading chute to enable despatch of the high chloride dust to disposal. Vehicles are loaded with dust at 30 tph.

In order to cope with 'upset' conditions, the ID fan is frequency controlled and rated at 10 000 Nm³/hr above the operating rating with 20% reserve pressure capacity and adequate power rating at 240 °C.

The exhaust duct was designed to enter the kiln main stack in such a way as to minimise back pressure on the main kiln fan (because the final kiln fan is at maximum capacity and negative pressure currently exists in the base of the stack).

Fairport's responsibilities included the design and engineering of the civil bases and foundations for all items as necessary, including the access road for dust disposal vehicles.

All instrumentation, electrical and control panels, local isolators and cabling were designed and supplied as part of the project.

The plant has a total installed power of 550 kW, and absorbs approximately 400 kW when operating at 100% capacity.

Experience to date

The bypass system was started up in February 2006, and significant process parameter measurements have been taken. Several 24 hour performance test runs have been made, during which the plant was set to run at or very near 100% capacity.

Throughout this period, kiln production was relatively stable at 3000 tpd. The bypass system was operated 24 hours per day for 75% of this time, averaging approximately 16 hours per day for the remainder.

The results over the period were very encouraging:

- The precalciner tower hot meal potassium oxide (K2O) level dropped from 4.6% (mean, 8.2% peak) to 2.6% (mean, 4.6% peak), with a similar drop in clinker alkali levels.
- The clinker chloride level dropped from 0.035% (mean, 0.065% peak) to 0.015% (mean, 0.048% peak).

These results satisfied the project requirements with capacity to spare. In addition, precalciner blockages were substantially reduced.

Conclusion

The conclusions drawn from from the performance results to date are very favourable and reflect a significant improvement in the operability of the kiln overall. The kiln bypass installation has provided a technically efficient, environmentally friendly and cost effective addition to the cement production process. This turnkey project was completed on time and within defined cost constraints.