A better kiln coating?

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After studying the kiln preheating and feeding procedures of hundreds of kilns around the world, Dynamis experts show two opposite tendencies and examine the characteristics of each one. This article discusses how the proper formation of kiln internal coating can dramatically improve the life of refractory bricks.

Sometimes one may face a pretty intriguing fact: two kilns constructed according to the same design, practically at the same time and fed with virtually the same raw meal and fuel present different behaviour. When you ask the operators which kiln is best, they will be unanimous: kiln "A" is better than kiln "B". Why do these things happen?

Every equipment has its own history. Incidents that may have occurred to one may never happen to the other. We know that, depending on the kind of incident that can occur to a kiln, its performance can be affected for a long time, if not for the rest of its working life. Particular fails demand specific maintenance solutions and the succession of different events to each part of the kiln can lead to different behaviour with identical kilns.

This article deals with one of the most important operations that will affect a clinker kiln performance, especially concerning refractory lining life: the phases of preheating and feeding a new kiln or one that has suffered a large lining change. During many years, Dynamis experts have been designing and putting to work hundreds of combustion systems for rotary kilns. During new burner start-up operations, normally following major refractory maintenances, it was very common to hear from operation managers: "Let us follow the recommended time multiplied by the temperature curve at the smoke chamber" – and also: "Don't allow that flame to impinge on the new bricks!".

The manager was totally right. But were those two recommendations enough to guarantee the desired performance of the brand new bricks? – Certainly not.

We know that the preheating and feeding of a rotary kiln are critical operations. Normally, they are conducted either with natural gas or fuel-oil until the kiln operation has reached a steady situation. The use of one of those fuels is proper for a better combustion control, making it easier to adjust temperature peak position and to follow the heating curve through an accurate handling of fuel flow. Additionally, those fuels make flame stability a lot easier under cold secondary air conditions, even at relatively low excess-air rates. Also, it is important to control the combustion gases draft, which has an important role

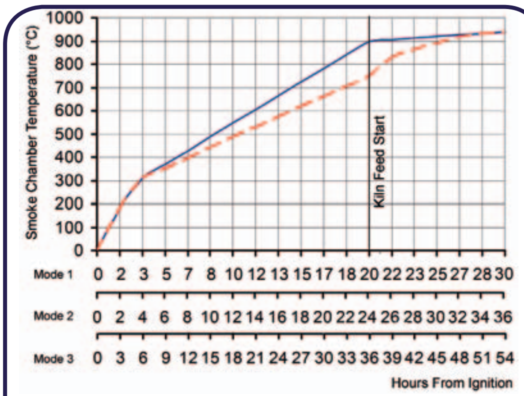

Figure 1: kiln heating variations

in the temperature profile, including both kiln and preheating tower. Normally, the oxygen content of those gases will vary within 4-6 per cent at preheater exhaust, depending on kiln characteristics (general dimensions, number of cyclone stages, false air infiltrations, etc).

Figure 1 shows some variations concerning kiln pre-heating procedures. The diagram indicates preheating can take 20 to 36 hours, depending on the type of refractory, as well as the extension of the maintenance services. Mode 1 refers to short warm-up. Mode 2 refers to a more conventional heating rate. Finally, Mode 3 corresponds to extended warm-up period, which is recommended after large refractory maintenance or after the cast of refractory concretes. In some cases the kiln is fed with 750°C at the smoke chamber (red dotted line), while in other cases the raw meal feeding starts at even higher temperatures (solid blue line).

Two main tendencies can be identified, not properly referring to the preheating itself, but concerning the flame adjustment after the desired smoke chamber temperature had been reached and raw meal feeding had started.

1. Classical procedure

Most of kiln operators had the tendency of using a narrow and soft flame, in many cases a very long one. Sometimes the flame length was a requirement, but normally it was a mere consequence of the combustion parameters that had been adopted to protect the bare lining and nothing could be done to shorten the flame, if so wanted. The lack of resources in the main burner for shaping the flame is often worsened by the cold secondary air. Figure 2 presents a diagram showing the evolution of the protective coating over the refractory brick lining in a kiln running under the so-called classical procedure.

What can we say about this procedure?

- the operator must keep the flame away from the bricks even after a significant increase in fuel flow
- as the flame tends to be long, temperature peak will probably be located at upper transition zone
- the hot meal reaches the upper transition zone and starts to form the coating that protects the bricks there
- the coating formation proceeds from upper to lower sections passing through burning/clinkering zone and then to lower transition zone
- lower transition zone bricks are put under moderate to intense heat flux for a long period of time.

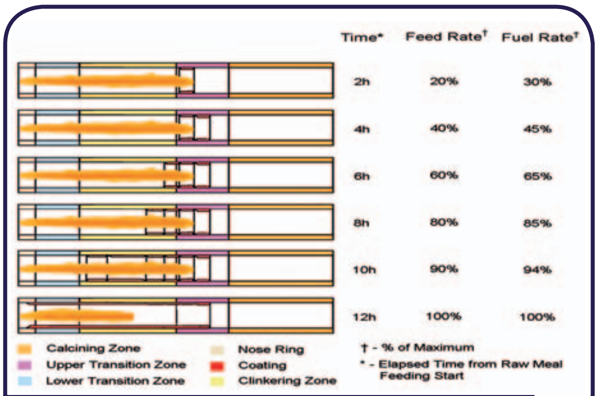

Figure 2: conventional coating formation process

2. Alternative procedure

The alternative procedure is becoming more and more common and requires a very good flame pattern control. It consists of working with a shorter flame, not only during warm-up, but mainly during kiln feed. Naturally, the care for avoiding flame impingement over refractory bricks remains a priority. Figure 3 shows the evolution of the protective coating over the refractory brick lining in this case.

What can be said about this procedure?

- the operator must have a good control on combustion conditions to place temperature peak at lower transition zone;
- once the kiln is fed, the hot meal must reach the lower transition zone as fast as possible, to start coating formation at that point and protect the bricks;
- a little 'cold blood' and confidence in the combustion system resources are necessary to the operators, who will see the raw meal approaching – but not passing through – the kiln discharge;
- once initiated, the coating at lower transition zone 'supports' the coating formation at burning/clinkering zone and then at upper transition zone;
- lower transition zone bricks are put under intense heat flux for a short period of time.

Comments

The differences between the two opposite procedures become more critical and take a more important role in the modern kilns, as SHL (Kiln Specific Heat Loading) increases. For reference, we can make a relation between dry-process kiln technologies and SHLs as follows:

Long Dry Kilns	*1 to 2 Gcal/hm²*
Preheater Kilns	*2.5 to 4.5 Gcal/hm²*
Precalciner Kilns	*2.5 to 4 Gcal/hm²*
Short Precalciner Kilns	*3.5 to 5 Gcal/hm²*

It should not be a surprise to notice that some precalciner kilns have faced refractory problems – for instance, a 90-day basic brick campaign – either at burning/clinkering or transition zones since their start-up and rendered some headaches to people involved until a solution was found. On the other hand, there are records of preheater kilns with quite good refractory campaigns – 1200 days for aluminous bricks at calcining zone and 400 days for basic bricks at transition and/or clinkering/burning zones.

Other operational factors that may have an influence on the refractory performance refer to the warm-up period, which may take 20-36 hours, depending on the extension of refractory services. Equally important is a non-interrupted preheating process, as break-offs during the operation may lead to high temperature gradients along brick thickness.

Additionally, the smoke chamber (back end) temperature at which the raw meal feeding starts is important and defines how long the new bricks at lower kiln sections are kept under overheating risk. The use of kiln shell cooling fans in combination with the readings of a temperature scanner as important tools to help operators to shape the internal coating as required. Concerning those fans, both practical observation and theoretical studies show the superiority of the high-velocity air streams from centrifugal fans over the low-velocity flows from axial fans.

Finally, adequate coating formation depends very much on the resources for flame shaping offered by the kiln burner, provided that raw meal composition is adequate, refractory "coatability" is ok, solid fuel fineness is according to the specifications and a series of secondary requirements have been met.

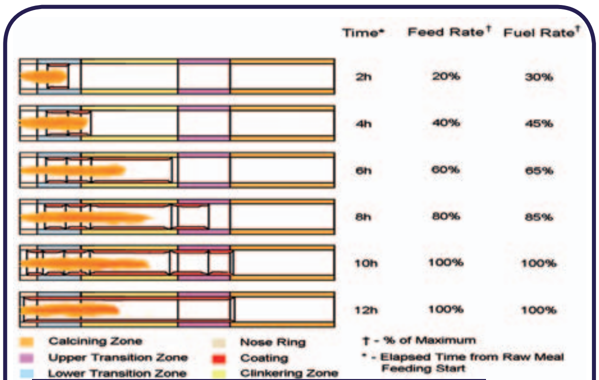

Figure 3: alternative coating formation process