EFFECT OF ROLLER KILN OPERATING CONDITIONS ON TILE CURVATURE

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1. ABSTRACT

The present study was undertaken in an industrial two-channel roller kiln used in second firing a product processed by the twice-fire method. The study addressed the effect of the following firing stage variables on tile curvature: gaps in the tile deck and changes in the temperature set in the different kiln zones. It was confirmed industrially that the temperature inside the different kiln modules fluctuated over time. The kiln was therefore closely monitored during presumedly stable operating periods. Analysis of the resulting data suggests that oscillation of the valves regulating fuel gas feed to the kiln burners caused the temperature fluctuations.

2. OBJECTIVES

The objectives of the study were to characterise kiln operation by monitoring online the most significant operating variables and to determine the effect of kiln operating variables on tile curvature.

3. EXPERIMENTAL ASSEMBLY

An assembly was designed consisting of a data acquisition system that collected information online and in real time, on the position of a series of valves, temperatures and gas pressures inside the kiln. Tile curvature measuring equipment was also installed in the kiln, enabling kiln variables to be correlated with tile curvature.

4. RESULTS

4.1.- CHANGES IN SET THERMOCOUPLE TEMPERATURE

Tile curvature is affected by changes in the set kiln thermocouple temperatures. As an example of this relation, Figure 1 plots variation of tile curvature versus the change in the temperature set at one of the thermocouples (TA21) located in the top channel in the kiln peak temperature zone. This change in temperature favours sintering at the surface and top part of the tile, so that tile shrinkage increases in this region in respect of the bottom part of the tile, thus reducing tile convex curvature.

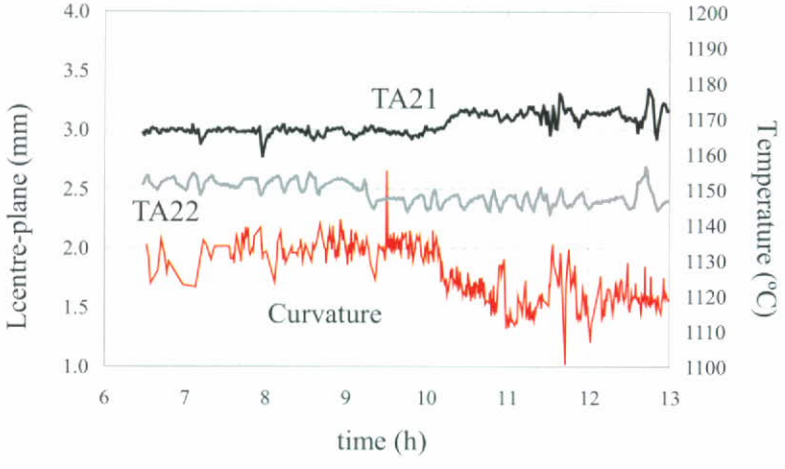

Figure 1. Reduction in tile curvature caused by changes in the set top thermocouple temperature TA21.

4.2.- EFFECT OF GAPS IN THE TILE DECK ON TILE CURVATURE

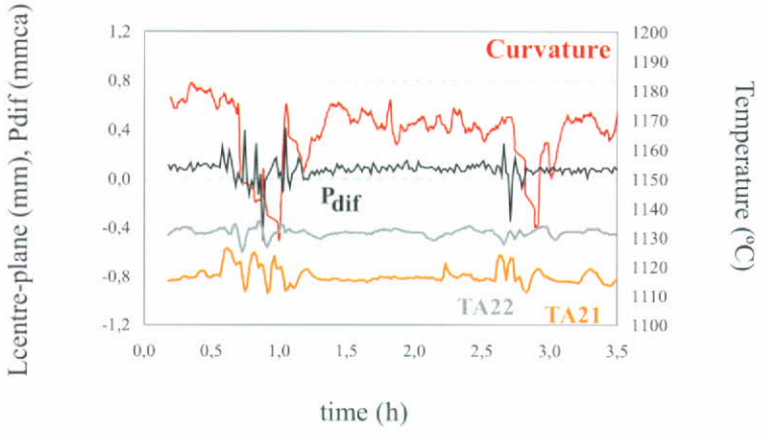

Figure 2. Effect of gaps on tile curvature.

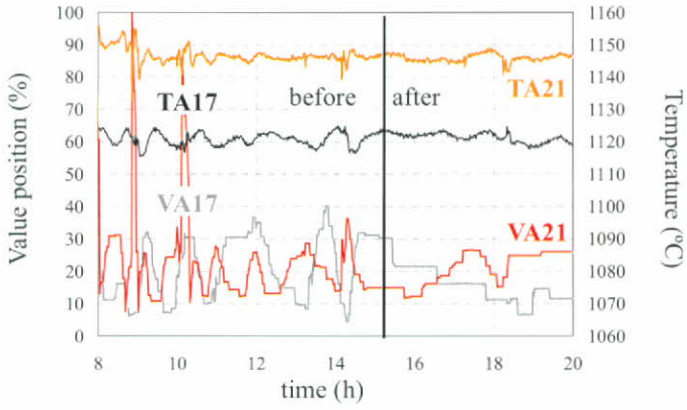

Figure 3. Modification of valve control parameters.

The presence of gaps in the tile deck in the kiln causes complete kiln destabilisation, which not only affects temperature but also the pressure curve inside the kiln, thus producing changes in tile curvature. The tiles that leave the kiln immediately after a gap do not exhibit the desired convex curvature (Figure 2). In some cases they even have concave curvature due to the arising changes in temperature in the firing as well as in the cooling zone.

4.3- STUDY OF THE CONTROL PARAMETERS REGULATING BURNER GAS VALVE BEHAVIOUR

The fast, continuous changes in temperature caused by small gaps in the kiln tile deck suggested that temperature control, mainly by opening the burner gas valve, might not be sufficiently well regulated to enable modulating these changes. Indeed, on analysing the data recorded on the valve openings, it was observed that continuous oscillation occurred in all of these. These swings, probably due to improper selection of the programmed values of the parameters in the PID controllers that regulate the position of the valves, caused continuous variations in the temperatures recorded at the different thermocouples. These parameters were studied and modified with a view to improving kiln operation. The adjustments made to the different control parameters of all the controllers are given in table 1. Figure 3 shows how, on reducing valve oscillation frequency, it was possible to achieve greater temperature stability.

PARAMETER	ACTION
Proportional band	↑↑
Integral time	↑
Servomotor dead band	↓

Table 1. Modified parameters.

5. CONCLUSIONS

1. The study showed that the changes in the temperature set in the peak temperature firing modules led to changes in tile curvature; this suggests a strategy for curvature control by measuring tile curvature and automatically acting on the selected loop

2. When gaps occur in the tile deck in the kiln, all the kiln temperatures change in an important way, hence modifying tile curvature.

3. It was found that the control parameters in all the gas valves, established by defect by the kiln builder, produced continuous temperature swings. This situation also notably reduced valve useful life.

4. The control parameters of the gas valves were determined, by making appropriate adjustments, which enabled providing an adequate response time with regard to small temperature changes. This yielded greater stability of the kiln temperature, and therefore of tile curvature.