

# **STUDY OF COMBUSTION IN INDUSTRIAL CERAMIC TILE MANUFACTURING KILNS**

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## 1. INTRODUCTION

Ceramic tiles are fired in continuous roller kilns, in which the tiles are subjected to a controlled thermal cycle that provides them with the desired technical and aesthetic properties.

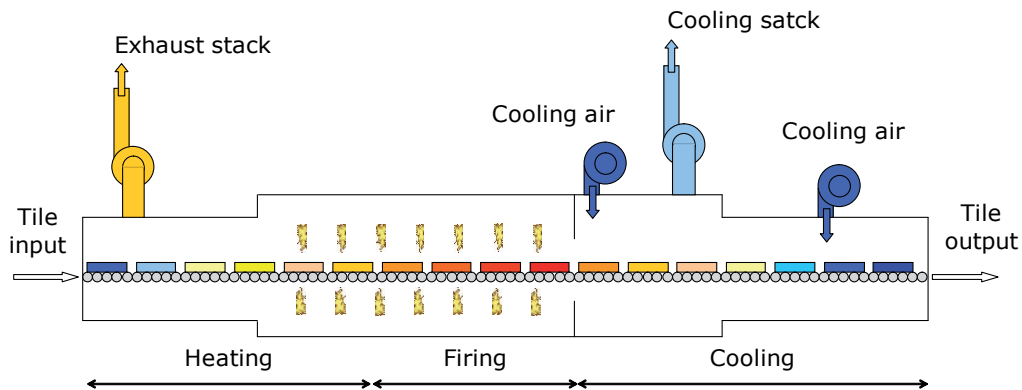


Figure 1. Schematic illustration of a roller kiln.

Heat is contributed by natural gas combustion at the burners that are distributed along the side walls of the kiln, above (top chamber) and below (bottom chamber) the roller plane.

The combustion system consists of groups of so-called ring burners. The natural gas flow at each ring is automatically regulated by a motorised valve in order to hold the programmed temperature profile. Air is typically used as an oxidiser, and the air flow rate is manually regulated at each burner.

## 2. COMBUSTION ANALYSIS

### 2.1. Method of calculating the excess air.

The combustion analysis conducted consisted of evaluating the excess air coefficient throughout a firing cycle. This parameter relates the quantity of air that is fed into a burner to the quantity of air that is stoichiometrically needed for complete natural gas combustion.

To obtain the excess air coefficient it is necessary to know the natural gas flow rate ( $Q_g$ ) and the air flow rate ( $Q_a$ ) that into the burners. This is done by experimentally determining the gas pressure ( $P_g$ ) and air pressure ( $P_a$ ) at each burner, and calculating the air and gas flow rates from the equations or abacuses provided by the burner manufacturer. Using these values, the excess air coefficient ( $\lambda$ ) is calculated from the following expression:

$$\lambda = \frac{Q_a}{Q_{asm}} = \frac{Q_a}{Q_g \cdot V_{asm}}$$

Equation 1

where:  $Q_a$  is the air flow rate ( $m_N^3/s$ ),  $Q_{asm}$  is the minimum or stoichiometric dry air flow rate ( $m_N^3/s$ ),  $Q_g$  is the natural gas flow rate ( $m_N^3/s$ ), and  $V_{asm}$  is the minimum or stoichiometric dry air volume of the natural gas ( $m_N^3$  dry air/ $m_N^3$  natural gas).

## 2.2. Results obtained.

Figure 2 shows how the excess air coefficient varies highly throughout the thermal cycle. In general, in the studied case, the average excess air coefficient in the kiln was smaller during heating ( $\lambda=1.3$ ) and larger during the peak temperature step ( $\lambda=1.7$ ).

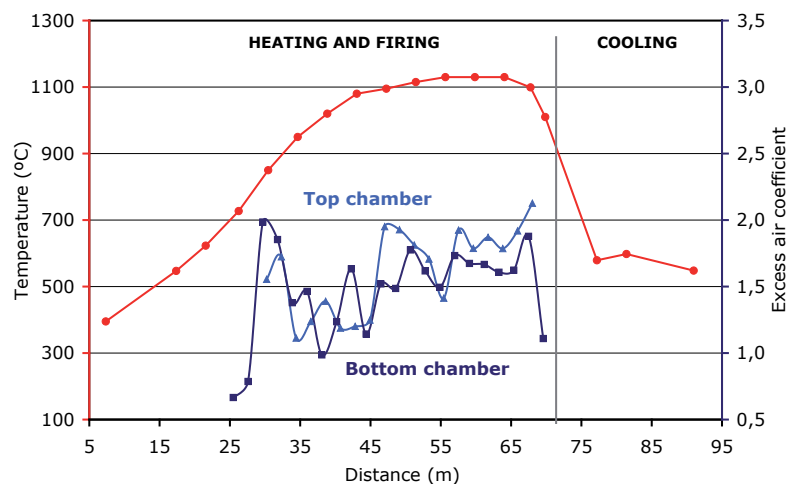


Figure 2. Excess air in the kiln.

In table 1 it may be observed that some burners display a lack of air: this means that part of the natural gas feed is burned in the kiln and not at the burner. This situation is not to be recommended for safety reasons. In others, however, there was a great surplus of air, which is of no interest from an energy saving viewpoint because this leads to increased natural gas consumption. In general, the analysed kiln displays 45% ( $\lambda=1.45$ ) excess air, a value higher than the generally recommended value for this type of facility, which is 10-20% ( $\lambda=1.1$ -1.2).

| Chamber | $\lambda_{\text{minimum}}$ | $\lambda_{\text{maximum}}$ | $\lambda_{\text{average}}$ | $\lambda_{\text{kiln average}}$ |
|---------|----------------------------|----------------------------|----------------------------|---------------------------------|
| Top     | 1.1                        | 2.1                        | 1.6                        | 1.45                            |
| Bottom  | 0.7                        | 2.0                        | 1.4                        |                                 |

Table 1. Excess air coefficients.

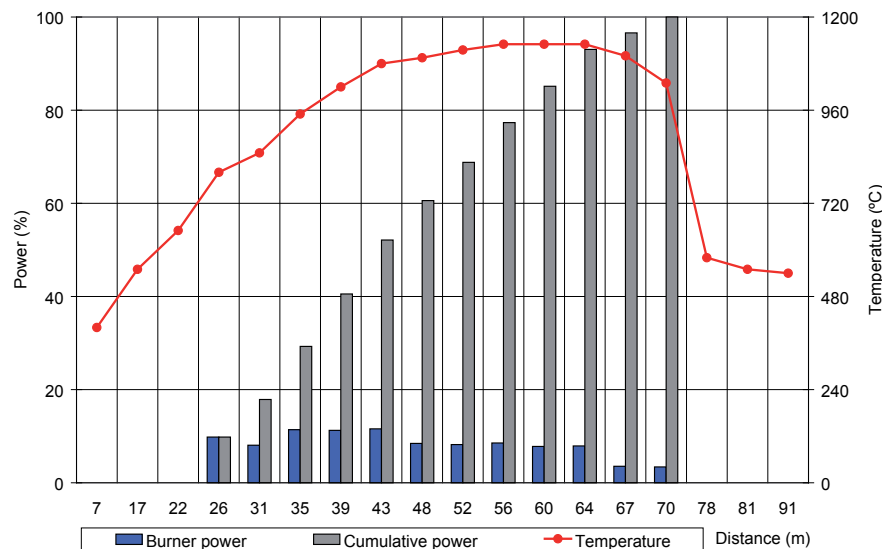


Figure 3. Burner thermal power.

The working thermal power of the burners in each kiln zone (considering both chambers), as well as the cumulative power, has been plotted together with the programmed temperature curve in the kiln in figure 3. It may be observed that the first kiln rings provide more energy than the rest. With regard to cumulative power, heating is observed to account for 52% of all the energy consumed in the kiln. The peak temperature step accounts for the remaining 48%.

### 3. CONCLUSIONS

Analysis of the combustion system allows the excess air in each kiln ring to be determined. This parameter is customarily not taken into account in kiln regulation; however, these controls allow situations of risk and situations with high excess air to be detected.

Reduction of the excess air flow rate leads to a reduction in kiln energy consumption, though this operation must be performed with care, because other kiln operating parameters could be affected. It has been experimentally verified that 2% reduction in the oxidising air flow rate entails a decrease of the order of 5% in the natural gas flow rate.

### REFERENCES

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