EFFECTS OF FIRING CONDITIONS AND BULK DENSITY ON OVERFIRING IN PORCELAIN TILE

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1. ABSTRACT

The phenomenon of overfiring occurs in porcelain tile and other products with a high degree of vitrification as a result of the expansion of the gases occluded in closed pores during sintering, bloating the pieces, which, in addition to dimensional problems, can impair the mechanical properties and stain resistance of polished products[1]. Providing the low water absorption demanded of porcelain tile without incurring the overfiring is no easy task, particularly when very fast firing cycles are used. This study was undertaken to evaluate the effects of bulk density and the firing curve (heating rate and residence time at peak temperature) on the development of this phenomenon. To do this, the Design of Experiments (DOE) statistical tool was used The differences between the temperatures needed to obtain 0,5% water absorption (Tv) and maximum density (Tc)[2] were considered to determine the temperature range before overfiring (ΔT). The results indicated that this range was significantly influenced by the time that the tiles dwelt at peak firing temperature and by the bulk density of the unfired bodies, which is a way of reducing closed porosity in the fired bodies and, therefore, preventing the production of overfired porcelain tile.

2. INTRODUCTION

Figure 1 shows the typical variation of linear shrinkage and water absorption with firing temperature, indicating the temperatures required to obtain 0,5% water absorption (Tv) and maximum density (Tc), after which the overfiring process begins, and the difference between them (ΔT).

3. METHODOLOGY

The methodology was divided into two stages, in which n^k factorial design was used to comparatively analyse the effects of:

1) heating rate and residence time: To identify the effects of these variables, the effects of the following levels were evaluated: heating rate of 5 and 70°C/min; and residence time of 3 and 60 minutes;

2) residence time and unfired density: Taking into account the results of the first stage, the effects of residence time were evaluated again at two levels (2 and 8 minutes), these being closer to those used in industrial practice. In addition to residence time, bulk density of the unfired pieces was included in the design at 2 levels: Dap = 1,88 and 1,97 g/cm^3.

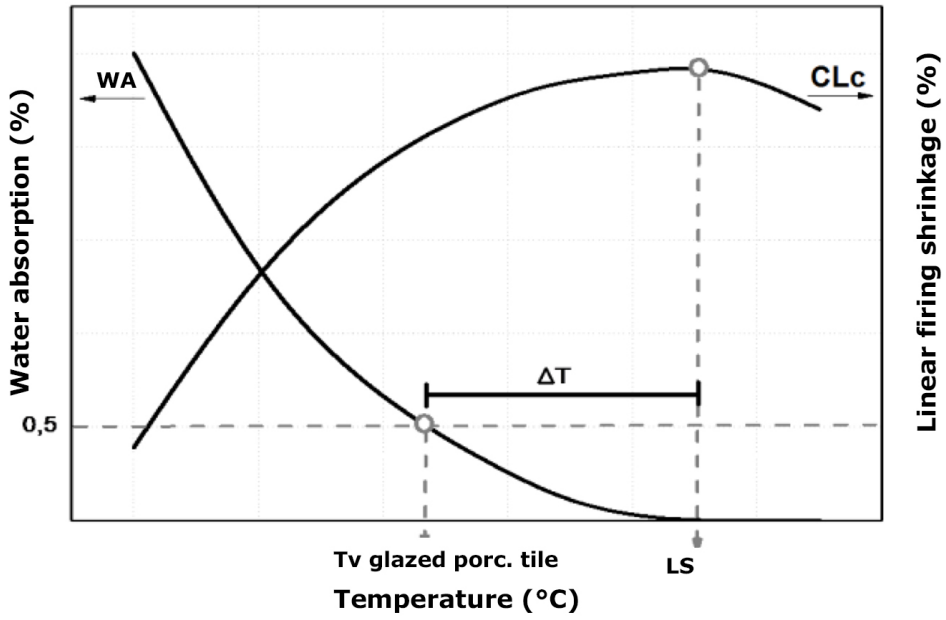

Figure 1. *Typical variation of linear shrinkage (LS) and water absorption (WA) with firing temperature of porcelain tile, indicating Tv, Tc, and ΔT.*

4. RESULTS

Comparison of the effects of the firing cycle on the difference between Tc and Tv shows that residence time had a more significant influence (Figure 2 (left)) on the results. Faster cycles, evidenced by high heating rates, and shorter times generated narrower temperature ranges (ΔT) in which the porcelain tile water absorption specification was reached without overfiring. In the second stage of the work, it was found that this temperature range could be extended by increasing residence time in the firing zone and bulk density of the unfired piece. For the analysed levels of these variables, unfired body density (Dap) was found to have a more significant influence than residence time on the temperature range between Tv and Tc.

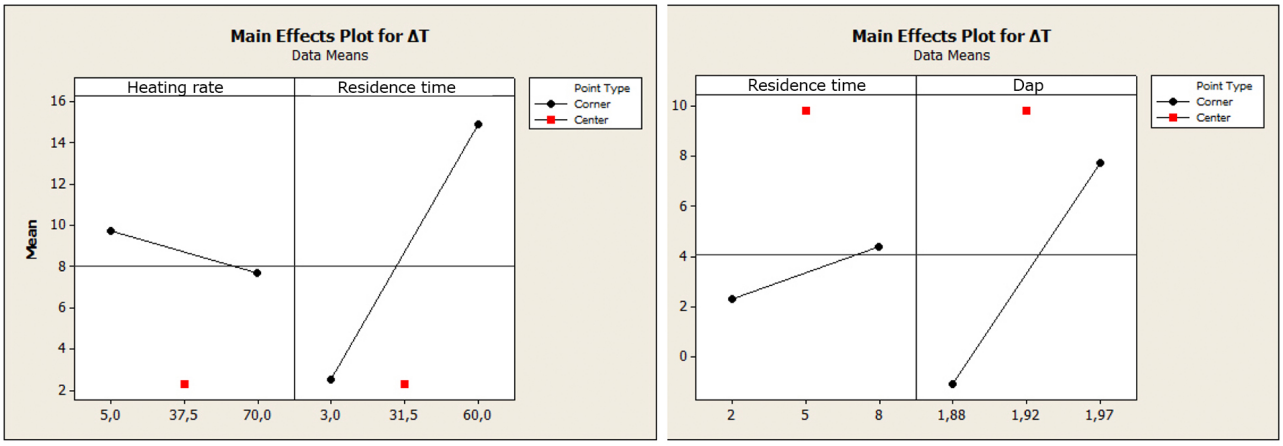

Figure 2. *Statistical analysis: Effects of the initial factors on ΔT.*

5. CONCLUSIONS

The combination of very short residence times in the firing zone with low bulk densities in the unfired pieces favoured the phenomenon of overfiring in porcelain tile, owing to the narrowing of the temperature range between Tv and Tc. To minimise the problem, it is suggested, in addition to increasing tile bulk density, to use firing curves with longer residence times in the firing zone, including if preheating is accelerated.

REFERENCES

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