EVOLUTION OF THE PYROPLASTIC DEFORMATION OF PORCELAIN TILES DURING FIRING

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1. INTRODUCTION

Pyroplastic deformations[1] are defined as permanent changes of shape that occur at high temperatures, associated with the flow of liquid phases[2] during the firing process of vitrified ceramic materials, such as porcelain tiles. The pyroplastic deformations exhibited by large-sized pieces are crucial to the dimensional precision of ceramic tiles, and the fabrication of this sort of products has increased significantly in the last few years.

The proneness to develop deformations during firing can be measured geometrically in laboratory tests by the pyroplastic index, which is generally determined in samples fired under specific conditions to intensify the deformations. However, this procedure just allows the quantification of the total pyroplastic deformation in the fired specimens and does not produce any information about the evolution of the deformation during the firing cycle. This information could be used to design firing cycles that would lead to smaller pyroplastic deformations. Optical systems can provide more precise measurements than the traditional method and will evaluate continually the deformation during the firing cycle. Thus, the objective of this work was to evaluate the effect of the maximum firing temperature and the soaking period on the pyroplastic deformation of a typical porcelain glazed body.

2. MATERIALS AND METHODS

An Optical Platform (ODP 868 - TA Instruments) was used to evaluate the evolution of the pyroplastic deformation of pressed samples (85 x 5 x 5 mm) positioned over rods with a 70-mm spacing (Fig.1). The deformation was determined by optical lens with resolution of 0.2 µm. The samples were prepared using a spray-dried powder with 6.5% of moisture and 380 kgf.cm^{-1} compaction pressure.

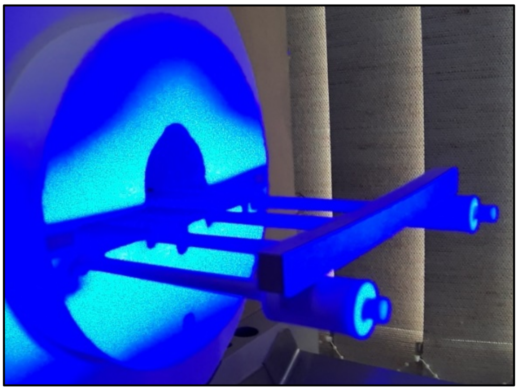

Fig.1 *Experimental setup used to evaluate the pyroplastic deformations of the samples.*

The heating rates of the firing cycles were fixed (50oC/min from 25oC to 1100oC; and 20oC/min from 1100oC to the maximum temperature) and soaking period times were 1, 4 and 7 min. Preliminary tests were carried out to determine the maximum temperature required to achieve the targeted water absorption for porcelain tiles (water absorption ≤ 0.5%) for each soaking period.

3. RESULTS AND DISCUSSION

Figure 2 shows the evolution of the pyroplastic deformation of the samples during firing. For each soaking period the maximum temperature was adjusted to achieve the required water absorption. The resulting curves represent the simultaneous effects of the variation of two variables, the maximum firing temperature and the soaking period, and reflect the dilemma that the technicians have to deal with in the development of the firing cycles, achieving simultaneously the required water absorption (≤ 0.5%) at the lowest pyroplastic deformation. Therefore, as can be seen in Figure 2 and Table 1, the shorter soaking periods required slightly higher maximum temperatures. As can be seen in Figure 2, the sample fired at the highest temperature with the shortest soaking period (1215ºC/1 min.) exhibited the smallest final deformation. The decrease in maximum temperature, from 1215 to 1205ºC, and simultaneous increase in soaking time, from 1 to 7 min., increased the final deformation.

Regarding the evolution of the deformation during the firing cycle, there was almost no deformation below 1150ºC and between this temperature and the soaking period, the deformation rate increased considerably. The increase in soaking time resulted in an important increase in deformation percentage occurring at this stage (Table 1). This behavior was expected because at, soaking temperature, the largest volume of liquid phase is present at the lowest viscosity.

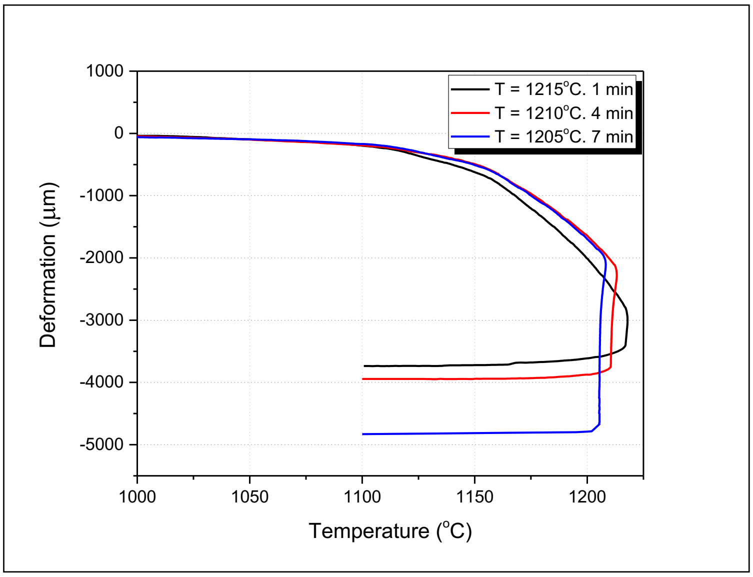

Fig.2 *Deformation of the samples during firing at different thermal cycles.*

Firing Cycle	Water absorption (%)	Pyroplastic Index (cm^{-1})	Deformation before soak time (μm)	Deformation during soak time (μm)
T = 1215ºC. 1 min	0.4	46.4×10^{-6}	2686 (77.3%)	787 (22.7%)
T = 1210ºC. 4 min	0.4	56.5×10^{-6}	2031 (54.4%)	1702 (45.6%)
T = 1205ºC. 7 min	0.2	68.1×10^{-6}	1870 (40.0%)	2801 (60.0%)

Table 1. *Data extracted from the deformation vs. temperature curves.*

4. CONCLUSIONS

The combined effect of the variation of the maximum firing temperature and duration of the soaking period on the pyroplastic deformation of a glazed porcelain tile body was studied.

- The results obtained for this particular composition suggest that:
- The pyroplastic deformation occurs above 1150ºC.
- The contribution of soaking time to final deformation increases with soaking time.
- Firing curves with very short soaking times, peak-shaped curves, result in lower final pyroplastic deformation.

5. REFERENCES

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