# DETERMINATION OF OPTIMUM GLAZE MATURING TEMPERATURE RANGES(*)

**A. Escardino, A. Moreno, M. J. Ibáñez, J. Toledo**

Instituto de Tecnología Cerámica (ITC)
Asociación de Investigación de las Industrias Cerámicas (AICE)
Universitat Jaume I. Castellón. Spain

## INTRODUCTION

The optimum maturing temperature range of a glaze is currently determined by organoleptic methods, involving visual appraisal or touch, which entail a considerable degree of subjectiveness. Given the inaccuracy of these evaluation systems, it was considered convenient to seek a method that could quantitatively assess glaze surface characteristics in order to determine whether firing had taken place at a suitable peak temperature.

## EXPERIMENTAL

The glaze surface was topographically characterised by means of a roughnessmeter with a diamond-tipped pick-up, determining average roughness $R_a$ and parameter $\ell_0$ [1], [2], [3], as well as gloss ($\beta$), since this property was also assumed to be related to the stretching of the glaze.

$R_a$ and $\ell_0$ (Fig. 1) are defined by equations:

$$R_a = \frac{1}{\ell m}\int_0^{\ell m} \left|y(x)\right| dx \qquad y \qquad \ell_0 = \frac{\ell}{\ell m}$$

---

(*) This study is part of an R&D Cooperative Research Project co-funded by the Plan Tecnológico of the Generalitat Valenciana and the following companies: Taulell, S.A.; Esmalglass, S.A.; Fritta, S.L.; Gres de Nules S.A.; Talleres Foro, S.A.; Keraben, S.A.; Torrecid, S.A.; Vidres S.A. and Cerdec Ibérica S.A.

[1]. IBÁÑEZ, Mª J.; AGRAMUNT, J.V.; FELÍU, C.; ESCARDINO, A. *Using a roughnessmeter to measure the asperity of a ceramic glaze.* 8th International Symposium on Ceramics (SIMCER-92). Rimini (Italy). November, 1992.

[2]. ESCARDINO, A.; IBÁÑEZ, Mª J.; DE LEMUS, R.; MESTRE. S. *Variation of roughness and gloss in glazed tile with the intensity of the wear produced with a standard abrasion tester.* In: QUALICER 96. Castellón (Spain). 1996, pp. 727-729.

[3]. MUMMERY, L. *Surface texture analysis.* The handbook. Mühlhausen: Hommelwerke, 1990.

The tests were run on specimens obtained from unfired glazed tile bodies supplied by participating companies. The specimens were fired in an electric furnace at different peak temperatures, using a firing schedule resembling the industrial cycle typically employed for such products, with regard to the preheating and cooling stages. The values of $R_a$, $\ell_0$ and $\beta$ of the resulting specimen glaze surfaces were then measured.

## RESULTS

To verify the suitability of the proposed method, it was applied to three different types of frit selected from frits commonly used in industry for coating red-firing wall tile bodies ($1120 \leq T_{max} \leq 1140$°C):

a) A frit yielding a transparent glaze
b) A zirconium frit yielding a glossy white glaze
c) A frit yielding a matt white glaze

The variation of the three selected parameters with peak firing temperature has been plotted in Figs. 2, 3 and 4 for the resulting glaze coatings, using different heat-treatment cycles, for each studied frit. The three figures reveal a certain peak temperature range at which $R_a$ exhibits a (virtually constant) minimum value, $\ell_0$ tends to unity and $\beta$ peaks, also at a virtually constant value. Subsequently, on raising $T_{max}$, $R_a$ and $\ell_0$ rise slightly.

The $T_{max}$ ranges, at which $R_a$ (minimum), $\ell_0$ ($\cong$1.0) and $\beta$ (maximum) are constant, indicate that the glaze surface has reached its smoothest texture and therefore appropriate stretching, thus in each case showing the optimum $T_{max}$ maturing interval.

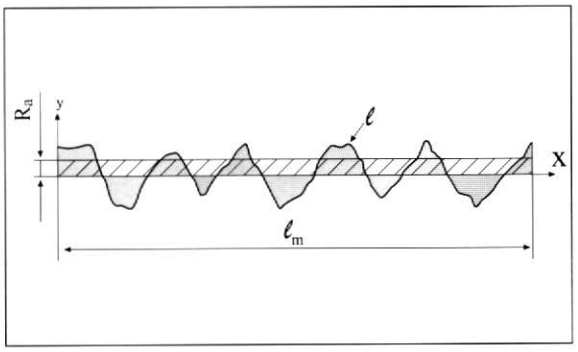


***Figura 1.*** *Topographic surface profile.*

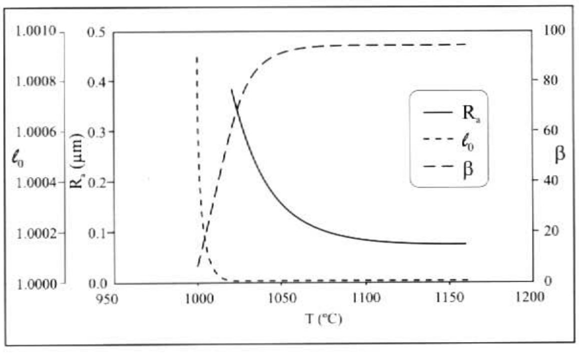


***Figura 2.*** *Variation of $R_a$, $\ell_0$ and $\beta$ with $T_{max}$. Transparent glaze.*

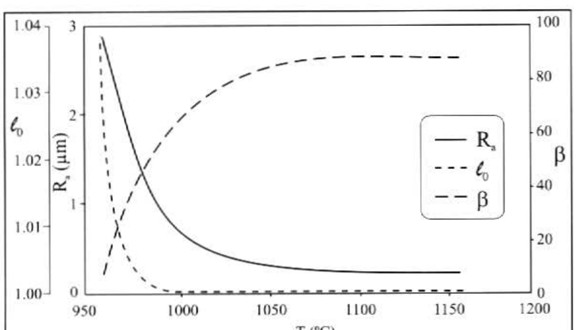


***Figura 3.*** *Variation of $R_a$, $\ell_0$ and $\beta$ with $T_{max}$. Glossy white glaze.*

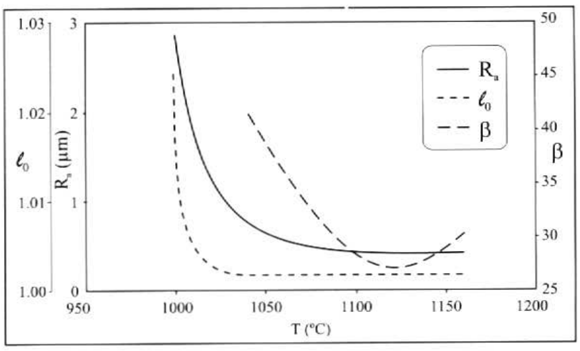


***Figura 4.*** *Variation of $R_a$, $\ell_0$ and $\beta$ with $T_{max}$. Matt white glaze.*

The width of the optimum $T_{max}$ range was not the same for the three studied frits, nor did it start at the same $T_{max}$, as these frits have been designed to produce glazes with different characteristics, under different firing conditions. Nonetheless, the temperature range in which industrial firing takes place (1120-1140°C) lies within the optimum range found in the respective plots.

The minimum values found for $R_a$ and $\ell_0$ of the matt glaze ($\beta$=41) exceeded the minimum values obtained for these parameters with glossy transparent and zirconium white glazes ($\beta$=96 and 90).

A wide $T_{max}$ range, in which $R_a$, $\ell_0$ and $\beta$ remain practically steady, ensures absence of defects in the glaze texture as a result of possible transverse temperature gradients in the industrial kiln.

In view of the results and above remarks, the conclusion can be drawn that diagrams $R_a$; $\ell_0$ ; $\beta$ versus $T_{max}$ of the cycle can provide useful information, obtained by objective quantitative methods based the use of a roughnessmeter and a glossimeter, regarding the optimum temperature range for suitable maturing of any glaze. The most appropriate frit can be selected for each body by using these graphics together with the body's sintering diagram (variation of shrinkage and water absorption of the body with $T_{max}$ of the firing cycle).