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MICROSCRUCTURAL APPROACH TO EVALUATE RESIDUAL STRESSES IN LARGE-FORMAT TILES

E. Rambaldi [1]*, A. Filipponi [1], M.C. Bignozzi [1,2]
[1] Centro Ceramico, Bologna, Italy
[2] DICAM, University of Bologna, Italy

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*e-mail: rambaldi@centroceramico.it

Large format tiles, up to 480x180 cm, are currently produced with very fast industrial cycles that could cause post-sintering deformations due to the development of residual stresses induced by a not equilibrium in firing.
The phenomenon, today very well-known especially for the largest tiles, is easily recognized by the visible effects produced on the tiles. A method to quantitative determine the residual stresses on ceramic tiles is still lacking.
The present work aims to provide a series of quantitative measurements, based on microstructural investigations, useful to estimate and thus to prevent the risk of occurrence of residual stress that can give rise to post-firing deformation phenomena in large format tiles. Residual stresses are always present in ceramic tiles, because of the non-equilibrium firing condition. Thus, it should be more appropriate to define as "critical" residual stresses those tensions able to cause deformations after firing.
A series of quantitative analyses was carried out on fired porcelain stoneware tiles, with and without post-firing deformation. All the analyses were aimed to evaluate and possibly to quantify the microstructural heterogeneity that could generate residual stresses. In particular, for each tile, three samples were analyzed and the following characteristics were determined:

- distribution of distances between quartz grains to evaluate the degree of raw materials mixing;
- dimensional distribution of closed pores to evaluate the degree of powders compaction;
- composition of the amorphous phase and its representation on ternary diagrams (RO_2, R_2O_3, R_2O + RO) to evaluate the degree of firing.

Pyroplastic deformation was also determined, allowing a better understanding of the firing behaviour of the ceramic bodies.
Results showed that in those tiles with visible post-firing deformation, more than one microstructural heterogeneity is concomitant and concurred to reach the so called "critical" residual stress. Compared to tiles without deformation, the ones with post-firing deformation have shown more than a heterogeneity in terms of compaction, mixing, composition of the amorphous phase and, sometimes, also in terms of pyroplastic deformation.
In conclusion, the distribution of quartz grains distances, the ternary diagrams representative of the amorphous phase composition and the pore sizes distribution, resulting from different positions of the ceramic tiles, are able to highlight those heterogeneities that can create/favour critical levels of residual stresses. Therefore, the quantitative determinations proposed in this work represent an indirect evaluation of the risk of occurrence of those residual stresses which, especially in large format tiles, can give rise to post-firing deformation phenomena.

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