VISCOUS FLOW SINTERING OF PORCELAIN STONEWARE REVISITED

Zanelli C.[1], *Ardit M.*[2], *Conte S.*[1], *Soldati R.*[1], *Cruciani G.*[2], *Dondi M.*[1]

[1]CNR-ISTEC, Faenza, Italy
[2]Physics and Earth Sciences Dept., University of Ferrara, Italy

Porcelain stoneware tiles, as porcelain items, are sintered by vitrification through viscous flow of an abundant liquid phase formed at high temperature. Such a process must be kept under strict control to achieve the desired properties of final products and prevent defects induced by pyroplasticity. This is particularly true for large tiles, which production stresses requirements of uniform densification and minimal deformations at high temperature. The present contribution will critically overview the state-of-the-art of porcelain stoneware sintering and the challenges for the development of large slabs. The level of acquaintance with different phenomena involved in viscous flow sintering will be discussed, discerning what is already known, what is recognized, but still needs to be fully understood, and what could arise from in-depth comprehension.

The KNOWNS: the evolution of microstructure and phase composition during firing is well known and phenomenological models have been developed for viscous flow densification of porcelain stoneware. Combined effects on pyroplasticity by liquid phase viscosity and solid load have been disclosed. The way by which Na/K ratio and other chemical keys of porcelain stoneware composition affect sintering kinetics is known. The role of mullite crystallization/dissolution and beta-alpha quartz transition on technological properties has been recognized.

The KNOWN UNKNOWNS: dynamic changes in composition and physical properties of the liquid phase during firing are envisaged, but vitrification and reactive sintering have not been modelled yet. In particular, uncertainties concern the actual effect on sintering kinetics and pyroplasticity due to crystals suspended in the melt according to their variable shape and size distribution. Question marks holds on: the effect of starting porosity on densification degree and kinetics; the homogeneity and miscibility of liquid phases; gas solubility in the liquid phase at the highest firing temperatures (and its role on closed porosity and bloating); the Fe^{2+}/Fe^{3+} ratio dependence on temperature and its consequence on the melt viscosity.

The UNKNOWN UNKNOWNS: modelling of densification curves and prediction of physical properties of porcelain stoneware tiles, through computational calculations, may prefigure the role of further variables not considered yet. The extension of such modelling efforts from laboratory to industrial scale may disclose the occurrence of scale effects, particularly in the case of large slabs and different shaping techniques. A better comprehension of kinetic aspects, resulting by the convolution of various factors, may unveil unexpected results, such as memory effects from raw materials or microstructural features.