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Pore Evolution and Compaction Behaviour of Spray-Dried Bodies for Porcelain Stoneware Slabs

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Abstract

The compaction behavior of spray-dried powders has turned into concern in porcelain stoneware manufacturing due to the increasing diffusion of large slabs. It is necessary to fill a knowledge gap between the compaction behavior with conventional presses and novel technologies. For this purpose, eighteen industrially-manufactured spray dried bodies were characterized for specific properties connected to the compaction behavior (curves of bulk density, intergranular and intragranular porosity in function of applied load, apparent yield strength). In addition, the firing behavior was investigated in order to reveal any effect of dry bulk density on firing shrinkage and bulk density of fired samples. Powder compressibility is within 50% and 55% (Carr index) and is primarily controlled by moisture. Two regimes are found: low pressure (fast density increasing by granule cave in and closure of intergranular porosity) and high pressure (slow density gain by downsizing microporosity). A peculiar mechanism is unveiled: granules squeeze in the low-P regime and further densification is achieved through microfracture around individual agglomerate. A phenomenological model is illustrated for the compaction of spray-dried powders. In conclusion, the performance of spray dried bodies during compaction is crucial to control the uniformity, in terms of porosity and bulk density, which has important repercussions on the properties of final slabs, especially differential shrinkages and deformation during firing due to density gradients.

Key-words: compaction, porcelain stoneware, pressing, spray-dried powder.

1. Introduction

Powder compaction is a key step in ceramic tile manufacturing, which governs the amount and spatial distribution of porosity in the green and dry semi-finished products. These features control the mechanical strength of unfired tiles [1] as well as the firing shrinkage and final microstructure in terms of residual porosity [2, 3]. This is particularly true in case of large slabs obtained with the novel compaction technologies and for thin or very thick tiles [4, 5].

Large slabs can be currently produced in size ranging from 120x240 cm up to 180x480 cm (so with surfaces from 3 to 9 m^2 approximately). At present, three are the technologies utilized to shape such big slabs, which are based on: die-less uniaxial pressing [4], compaction by calendering [6], or uniaxial pressing with mobile die [7]. In every case, spray-dried powders are deposited on a tape, metallic or