PARTICLE SIZE AND PERMEABILITY IN SLIP CASTING

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INTRODUCTION

Ceramic slips are suspensions of polydisperse, lyophobic particles in a liquid, with particles ranging more or less continuously from an upper to some lower size limit. Colloidal lyophobic particles aggregate readily in suspensions, owing to Brownian motion and attracting van der Waals forces, unless these forces are offset by electric double-layers or liquid-solid affinity or both. Casting slips are fluid high solids suspensions of one or more particulate materials deflocculated by one or more agents that cause development of diffuse electric double-layers. Certain other agents promote compression of double-layers and lead to coagulation. In practice, casting slip rheological and casting properties are controlled by a balance between coagulating and deflocculating agents.

Slip casting may be defined as consolidation of slip particles into a plastic mass through removal of part of the liquid by an absorbent mold, which brings the particles close enough for repelling forces to be offset by natural forces of attraction. The rate of coagulation rises sharply as the concentration of particles is increased. Casting is a form of low pressure filtration where the mold provides the driving force by suction and is a reservoir for separated liquid. Slip casting is an unsteady-state phenomenon with variable, increasing resistance to liquid flow as the cast develops. Resistance is related to a property called permeability.
Adcock and McDowall\textsuperscript{4} developed an equation which permits determination of effective specific surface of a cast or filter-cake by a permeability measurement,

$$L^2/T = 2PEG^3/5S_0^2\eta(y-1)(1-E)^2$$

(1)

where $L$ is the cast wall thickness in time $T$, $P$ the suction or pressure, $E$ the voids fraction of moist cast or cake, $\eta$ the liquid medium viscosity, $S_0$ the effective specific surface, $g$ the gravity constant, and $y$ that volume of slip containing $(1-E)$ volume of solids. The specific surface $S_0$ is related to permeability $K$ by the Kozeny equation

$$S_0^2 = E^3/5K(1-E)^2$$

(2)

Commercial casting slips are usually moderately thixotropic, attaining a loosely gelled structure within a few seconds of cessation of shearing. The structure continues to strengthen only slowly from this point and stress provided by pouring is sufficient to break the gel. Ryan and Worrall\textsuperscript{5} have demonstrated that the gelled structure plays a significant part in governing rate of cast.

EXPERIMENTAL

The experiments described here deal with the effects of degree of deflocculation, colloid content and modifiers, and size distribution on effective specific surface and permeability as determined by low pressure filtration.

(1) Porcelain Casting Slip

Fig. 1 shows particle size distribution curves for a blend of ball clays, a kaolin, and a mixture of ground quartzite and feldspar. A combination of these components constitutes the porcelain casting formula whose particle size curve also appears. Casting slips were prepared from this formula by dispersing 280 g of the ball clay in 370 ml of distilled water to which had been added 0.2 g of anhydrous sodium carbonate and either 0.2 g barium carbonate (for Series A slips) or 0.2 g precipitated calcium sulfate (for Series B slips). Fluidity was maintained during batching by drop-wise additions of an equal-volumes solution of distilled water and liquid sodium silicate ($\text{Na}_2\text{O} \cdot 3.22 \text{SiO}_2 \cdot 4\text{H}_2\text{O}$ Baume'). A 200 g portion of kaolin was next incorporated, followed by 520 g of non-clay powder. Finished slip was adjusted to a selected viscosity and thixotropy, as determined with a rotating disc viscometer, by further additions of sodium silicate solution. Thixotropy was