

# Physical Properties of Commercial Casting Slips, II

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## Introduction

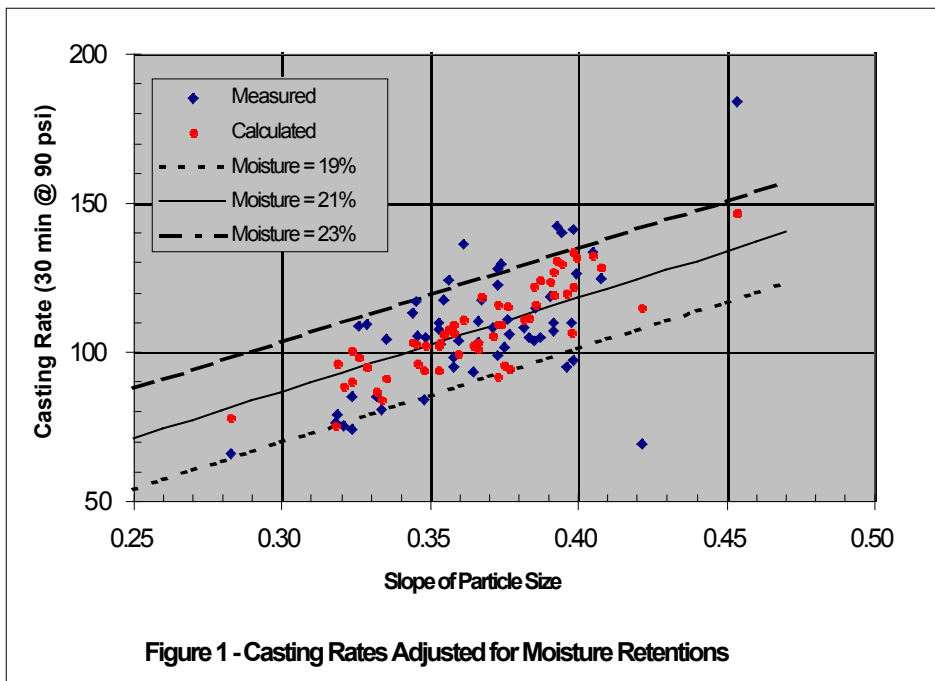
In an initial survey<sup>1</sup> of about 25 sanitaryware casting slips completed in June 1997, the relationship between particle size, casting rate, moisture retention, and modulus of rupture was studied. This second study of about 55 new samples completed in March 1998 confirmed the findings of the first study. Additional testing of a subset of 10 casting slips illustrates some of the effects of porosity and gelation on the quality of the cast pieces.

## Laboratory Testing

The slip samples were tested for particle size distribution (PSD) using the sedimentation technique for the Micromeritics Sedigraph 5100. Casting rate tests (C/R) were performed on samples using a Baroid filter press using Whatman #5 filter paper with air pressure at 90 psi for a period of 30 minutes. The results are reported in grams of filter cake after the slip was drained from the Baroid for a period of 5 minutes. Moisture retention was determined by drying the filter cake at 105° - 110°C overnight, then reweighing the cake. The moisture retention is reported on the dry weight basis. The dry filter cakes were then soaked for 72 hours in kerosene, a non-polar liquid, to determine the porosity without volume expansion of the cake, and reweighed. Curves of gelation were determined using the two-speed Brookfield test described in a predictive process control model.<sup>2</sup>

## Results

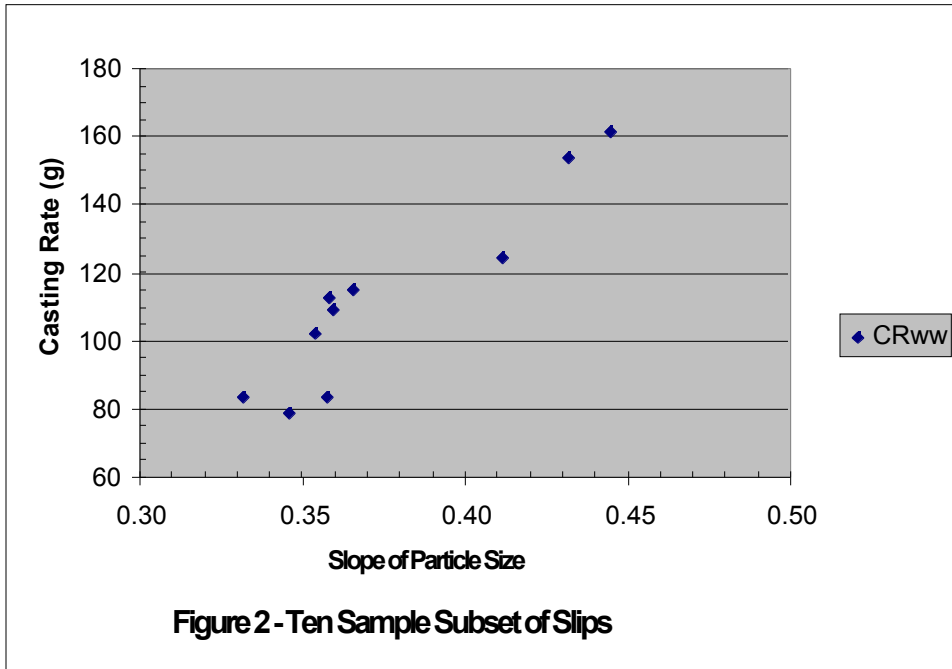
In the first paper, the correlation between the slope of the particle size and the casting rate was illustrated. The correlation became especially good when a correction for moisture retention was applied. Figure 1 illustrates the concept shown in the first paper using a new set of 55 commercial casting slips. The



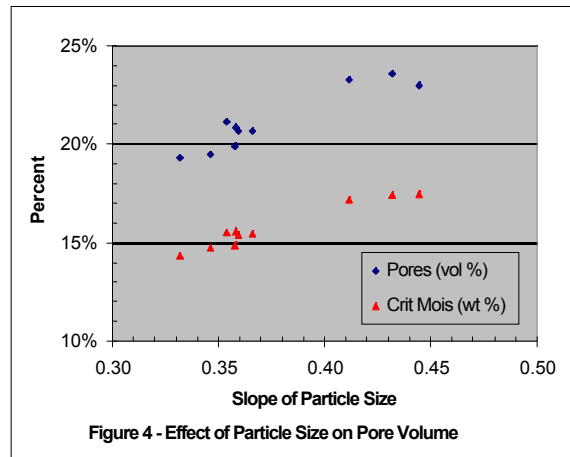
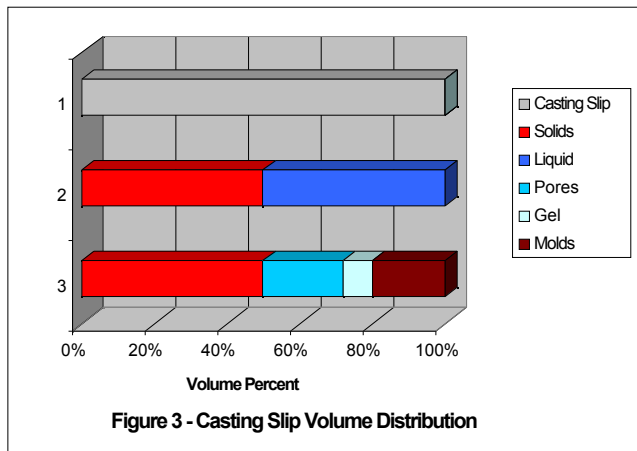
correction for moisture retention is applied and the correlation improves. “Iso-moisture” lines illustrate the predicted casting rate that is likely for any given particle size slope and moisture retention. The subset of 10 casting slip samples selected from this study are shown in Figure 2. This subset was further used to study the effects of porosity and gelation on casting characteristics which affect quality of cast. Figure 3 shows that casting slip can be thought of as a two phase system, solids and liquid. In a typical sanitaryware

slip, the volume percent of solids is close to 50%. Most engineers and technical staff members know quickly the mass percent of solids because that value is used frequently in batch calculations. Volume percents are usually not so well known.

While the pieces are casting, the water falls into three categories: the liquid that enters the molds leaving behind a cast mass with particles in closer proximity than in the casting slip, the water required to exactly fill the pores in the cast piece, and the extra water in addition to what is needed to fill the pores. This “extra” water separates particles, provides for the plasticity of the piece, and is responsible for the volume shrinkage during drying.

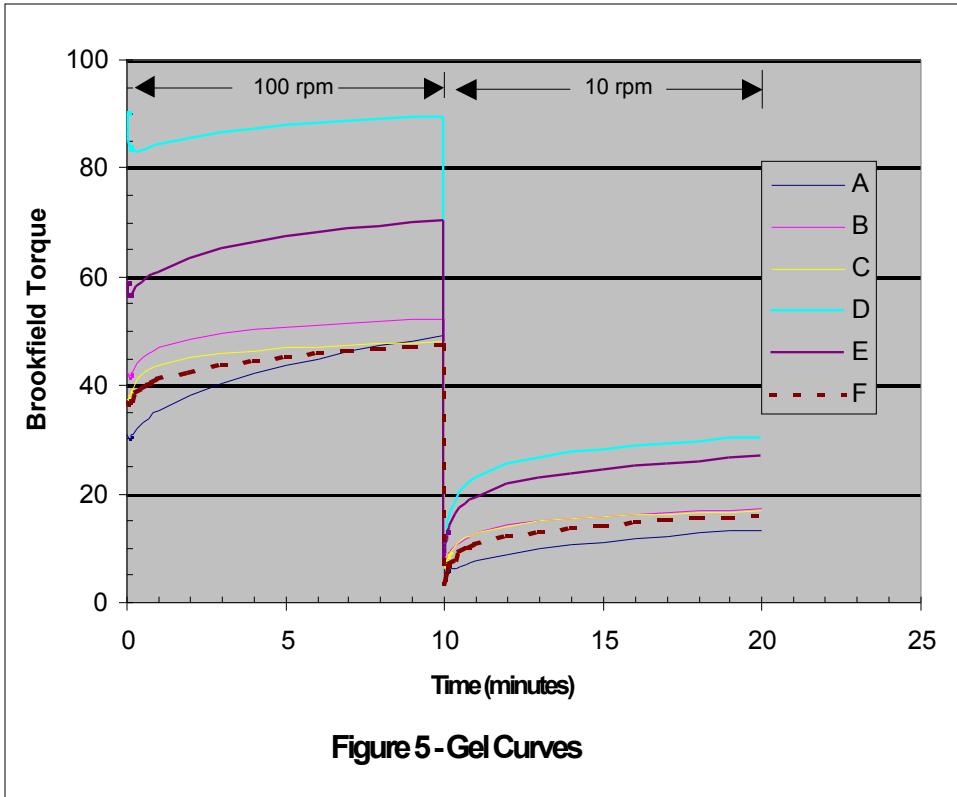


The volume of water in each of these three categories can be quantitatively determined. By measuring the specific gravity of the casting slip used and by determining the moisture retention of a filter cake by drying it, the volume of casting slip used to produce the cake can be calculated. Since the wet weight of the filter cake has been determined by filter pressing, the volume of liquid entering the mold can be calculated. The volume of non-polar liquid absorbed by the cake during soaking is the porosity. The difference between



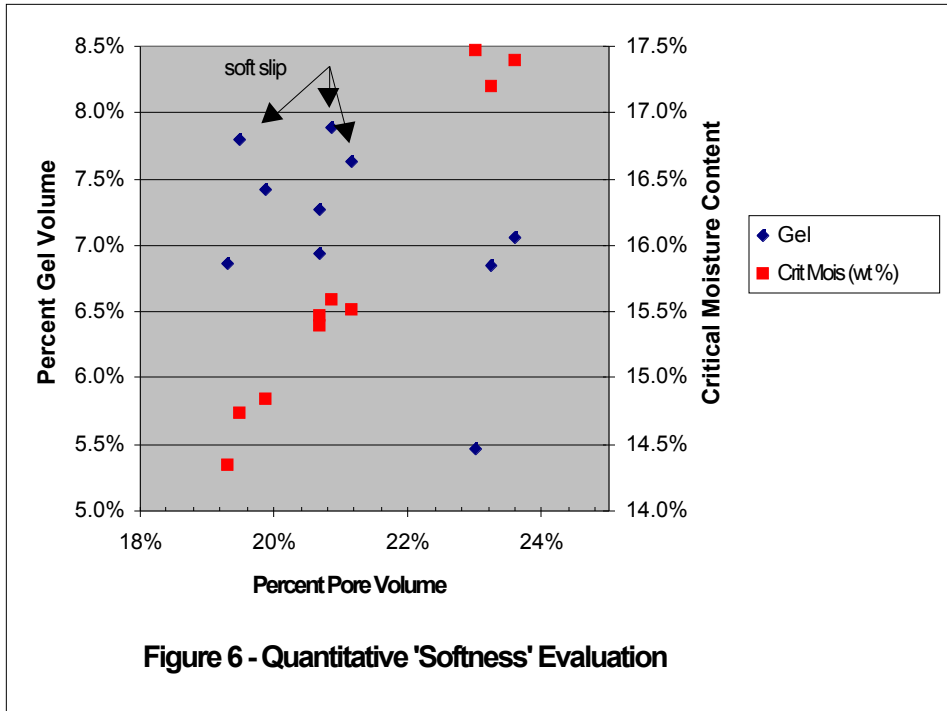
the moisture retention volume and the pore volume is the gel volume, or the volume responsible for the

shrinkage and plasticity. That does not mean that the pore water does not gel. The “extra” water, however, because it separates particles, can produce softness in the cast piece if the gel fails to have the strength required to maintain the integrity of the article’s shape.



Gel curves were determined as shown in Figure 5. The variation in viscosities of these slips is significant, but the dominant feature affecting the softness or firmness of the resulting cast pieces is the amount of gel that is formed immediately after the viscometer speed is changed from 100 rpm to 10 rpm. This test method was originally designed for control of slips that have already been controlled physically, that is, for particle size and specific surface area. The curves then give the operators positive control of the chemistry of the casting slip. The comparison in Figure 5 compares slips of very different particle sizes in order to illustrate the substantial differences between various industrial plants.

Figure 6 exhibits the expected relationship between the critical moisture content and the percent pore volume of a slip system. This relationship is based on physics alone. In the case of the gel volume versus the pore volume, however, the relationship is based on the state of dispersion. Under-dispersed systems show an high gel volume. In practice, high gel volumes in casting slips with low pore volumes tend to produce soft pieces.



Conclusion

The use of porosity volume data is helpful in determining the quantities of water that are distributed between molds and cast pieces and to determine an estimate of the critical moisture content. Faster casting slips can be formulated with high gel contents without extreme softness of cast if sufficient pore volume is achieved.

References

1. Landon, T. E., Thomas, R. J., Physical Properties of Commercial Casting Slips, presented at Fall Meeting of Materials & Equipment and Whitewares Divisions, San Antonio, TX, November 1997.
2. Funk, J. E., Dinger, D. R., Predictive Process Control, Kluwer Academic Publishers, Boston, 1994.
3. H. C. Spinks Laboratory Procedure, *Method for calculating Critical Moisture Content & Volume Percent Water Distribution*, October 1998.

