EFFECT OF FUSED SILICA FLOUR PARTICLE SIZE DISTRIBUTION ON SLURRY AND SHELL PROPERTIES

Tom Branscomb, Director of Technology Buntrock Industries, Inc.

Abstract

Slurry and shell properties were measured using various fused silica flour distributions. Slurry rheology was measured with a Brookfield viscometer. Slurry and shell properties are improved when finer flour and broader distribution flour is used in place of narrow or coarse flour alone.

Introduction

The manner in which a slurry flows, coats, and drains is referred to as slurry rheology. This behavior is an important characteristic of the slurry and affects the properties of shells made from these slurries. Slurry rheology can be measured with a Brookfield viscometer. Zhan cups are excellent for everyday control of viscosity, but for measuring the complex characteristics of nonNewtonian fluids, they are inadequate.

One factor that effects slurry rheology is the particle size distribution of the flour. Three backup fused silica slurries were made using 120, 200, and 325 mesh flour. Slurry properties were measured, shell samples made and tested for strength, porosity and density. The slurries were then combined to form a fourth slurry that was again measured and shell samples produced and tested. Significant differences were observed. The slurry rheological properties are shown to result in different shell properties.

Experimental Slurries

Binder used was Nyacol 830 small particle sol adjusted to 25% SiO_2. Flours were CE Minerals 120, 200, and 325 mesh fused silica.

There are vast differences between the flours as seen in Figure 1. that shows exactly 200 grams of flour in identical jars.

These flours were mixed into the binder at a total solids content of 73% including binder solids. After two days, wetting agent was added. The slurry was allowed to mix in a closed jar and the Zahn #5 viscosity was measured for 3 weeks. The results are shown in Table 1. All slurries were adjusted to a Zahn #5 of 14 seconds, which was deemed to be a reasonable dipping viscosity.

Table 1. Zahn #5 Viscosity of Fused Silica Slurries during Cream Out Period

Age (days)	120 Mesh	200 Mesh	325 Mesh	Comments
2	33	52	22	+ Surfactant
4	19	31	17	Measured Brookfield Thinned with Binder
21	18	19	18	1.5
24	14	14	14	Measured Brookfield Dipped Bars

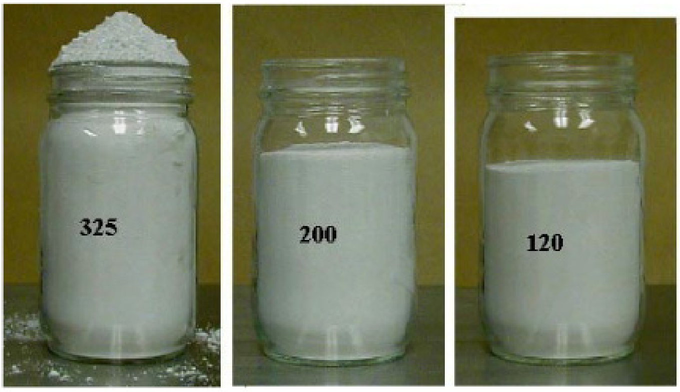

Figure 1.
Volume difference of 200 grams of 120, 200, and 325 Mesh Fused Silica Flour.

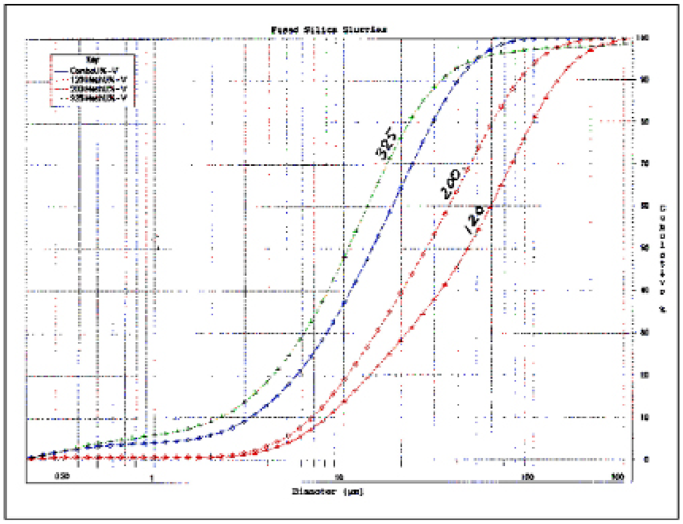

Figure 2.
shows the particle size distribution of the flours in the slurries as well as the combined slurry. Actual samples of slurry were used in the Horiba LA-910 particle size analyzer

Brookfield viscosity measurements were taken on all slurries. Figure 3 is a picture of the Brookfield Viscometer during measurement. Figure 4 shows the viscosity results. Viscosity is a function of rotational speed of the viscometer and is plotted in that manner. From a qualitative viewpoint, the 325 mesh slurry was the easiest to drain. When the slurries were combined in a ration of 2 parts 325, 1 part 200, and 1 part 120, the viscosity dropped from 14 seconds to 8 seconds and the slurry had to have about 8% flour added back to thicken it up to 14 seconds. This slurry is designated *Combo + on the viscosity graph.

Figure 3. Brookfield Viscometer

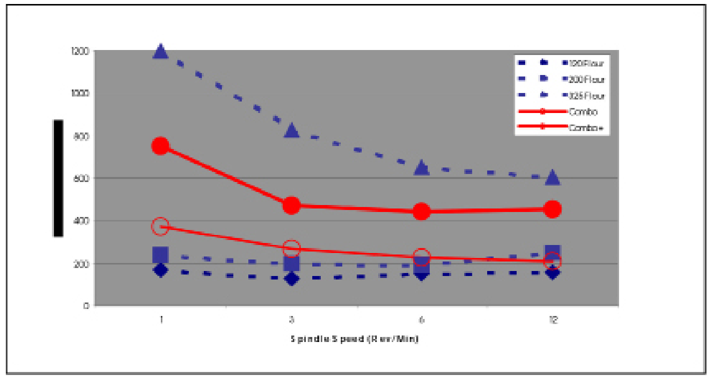

Figure 4. Brookfield Viscosity of Various Fused Silica Slurries

MOR Bar Results:

Wax bars were dipped using a prime coat of zircon/fused silica and using 50x100 fused silica stucco. Back up dips were in their respective slurries using 30x50 fused silica stucco. A total of ,7 dips and a seal dip were applied. Green, 1800 F. Hot, and Fired MOR were determined along with average thickness. Apparent porosity and bulk density were determined by mercury porosimetry.

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Slurry	120	200	325	**Combo +**
Thickness	0.212	0.188	0.210	**0.222**
Porosity	17.1	15.9	16.1	**15.5**
Density	1.677	1.702	1.697	**1.714**
GreenMOR	614	680	629	**780**
Hot MOr	1453	1851	1495	**2002**
Fired MOR	431	513	377	**476**

The slurry using combined 120, 200, and 325 mesh flour produced shell samples that were the thickest, lowest porosity, highest density, highest Green MOR, and highest Hot MOR.

Discussion

The slurries produced using straight 120 and 200 mesh flour were difficult to drain when making the MOR bars. Although not presented here, the standard deviation of the MOR values were higher with these slurries than the others. I believe this is due to the difficulty in draining. Another interesting observation was that the bars produced in 120 and 200 mesh slurries exhibited more loose stucco. This effect was attempted to be quantified by rubbing the loose sand off the MOR bars and weighing.

Slurry	120	200	325	Combo+
Grams Loose Sand	15	14	5	6

Another observation that is noteworthy is in regards to the coarser particles settling out of the slurry when agitation is turned off. Slurries that exhibit flat or decreasing viscosity with lower shear rates (lower rpm on the spindle) by definition have lower viscosity at low shear rate. This leads to coarse particles tending to settle faster when not being agitated. The opposite is true for slurries with a Brookfield curve that increased with decreasing shear rate. In this case, when agitation is ceased, the slurry thickens and the large particles settle more slowly. This was in fact observed during the dipping of the MOR bars. The 120 and 200 mesh slurries had to be stirred vigorously while soaking the sample to prevent settle out. The 325 mesh and Combo+ slurries needed little to no agitation and no settle out was observed.

I do not believe that the particular ratio of slurries used for the Combo is optimized. This ratio was arrived at by using a relatively high percentage of 325 flour that had shown positive factors and some of both the 120 and 200 flours. Certainly a lot more work could be done to optimize this distribution.

Lastly, many other factors affect slurry rheology. These include: type of colloidal silica (small particle or large particle or a combination), % SiO_2 in binder, viscosity of binder, other flours or sands in the slurry, wetting agents, and polymers

Conclusions

The use of straight 120 or 200 fused silica flour produces slurries that are difficult to work with in production and result in shells that have generally lower strength as compared to slurries with a high percent of 325 mesh flour and some coarse flour as well.

The Brookfield viscometer is useful in measuring slurry rheology.