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DWPF Melter Feed Rheology with Frit 320 (U)

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APPROVALS

M. E. Stone, Author — Date: 9/26/01

D. C. Koopman, Technical Reviewer — Date: 9/28/01

S. L. Marra, Manager — Date: 10/1/01

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SUMMARY

The rheology of melter feed containing Frit 320 was compared to the rheology of feed containing Frit 200 to determine if switching to Frit 320 would lead to problems in the Defense Waste Processing Facility (DWPF). No significant differences were noted in the rheology of the two feeds at 43% total solids and 25° Celsius.

INTRODUCTION

The DWPF process currently combines Frit 200 with radioactive waste in a vitrification process. A new frit, Frit 320, with a higher alkali content than Frit 200 has been recommended for the process to improve melt rate [1]. Compositions of Frit 200 and Frit 320 are shown in Table 1.

Table 1. Compositions of Frit 200 and Frit 320

Oxide Wt %	Frit 200	Frit 320		Elemental Wt %	Frit 200	Frit 320
SiO_2	70.0	72.0		Silicon	32.73	33.66
B_2O_3	12.0	8.0		Boron	3.72	2.48
Li_2O	5.0	8.0		Lithium	2.32	3.70
Na_2O	11.0	12.0		Sodium	8.16	8.90
MgO	2.0	-		Magnesium	1.21	-

Past experience has shown that higher alkali content leads to higher leach rates of frit components [2]. Leaching of frit components into the melter feed could change the rheology of the melter feed and lead to problems during processing. The rheology of melter feed with Frit 200 was compared to the rheology of melter feed with Frit 320, each having approximately the same total solids content.

OBJECTIVE

Compare the rheology of the melter feed with Frit 200 to melter feed with Frit 320.

DISCUSSION

Test Methods

Feed Preparation

In order to isolate the impact of the frit change, the melter feeds for each frit must be produced in an identical manner. Approximately ½ liter of Frit 200 melter feed and ½ liter of Frit 320 melter feed was produced from the same batch of simulated SRAT product (Tank 8/40 Blend Scoping Run #4 with 125% acid) [3,4] produced during Chemical Process Cell testing. The Slurry Mix Evaporator (SME) cycle was conducted in the same manner for each batch [5]:

1. Begin water flow to condensor at 10° C.
2. Add 555 grams of SRAT product to vessel.
3. Begin agitation at 200 RPM and air purge at 50 ml/min.
4. Add 1.4 grams of 10% IIT 747 antifoam to vessel.
5. Heat vessel to 93 degrees.
6. Add 212 grams of frit.
7. Add 209 grams of DI water.
8. Add 3.7 grams of 22.62M formic acid.
9. Add 1.4 grams of 10% IIT 747 antifoam to vessel.
10. Reflux vessel for 6 hours.
11. Dewater 261 grams of condensate from each vessel.
12. Pull samples of melter feed.
13. Analyze melter feed for solids content and pH.

Rheology Measurement

The Haake RS-150 Rheostress rheometer with Haake RheoWin Job Manager software was utilized to measure the rheology of the samples using the parallel plate method (1.5 mm gap) at 25° C. Samples were run in triplicate over a shear rate range of 0 to 500 sec^{-1}.

RESULTS

The total solids content of the melter feeds produced was very similar, but the pH of the Frit 320 feed was slightly higher than the Frit 200 feed, as shown in Table 2. No differences were noted in the physical appearance of the feeds. The melter feed was produced on 9/5/01 and the rheological measurements were performed on 9/7/01.

Table 2. Feed Preparation Results

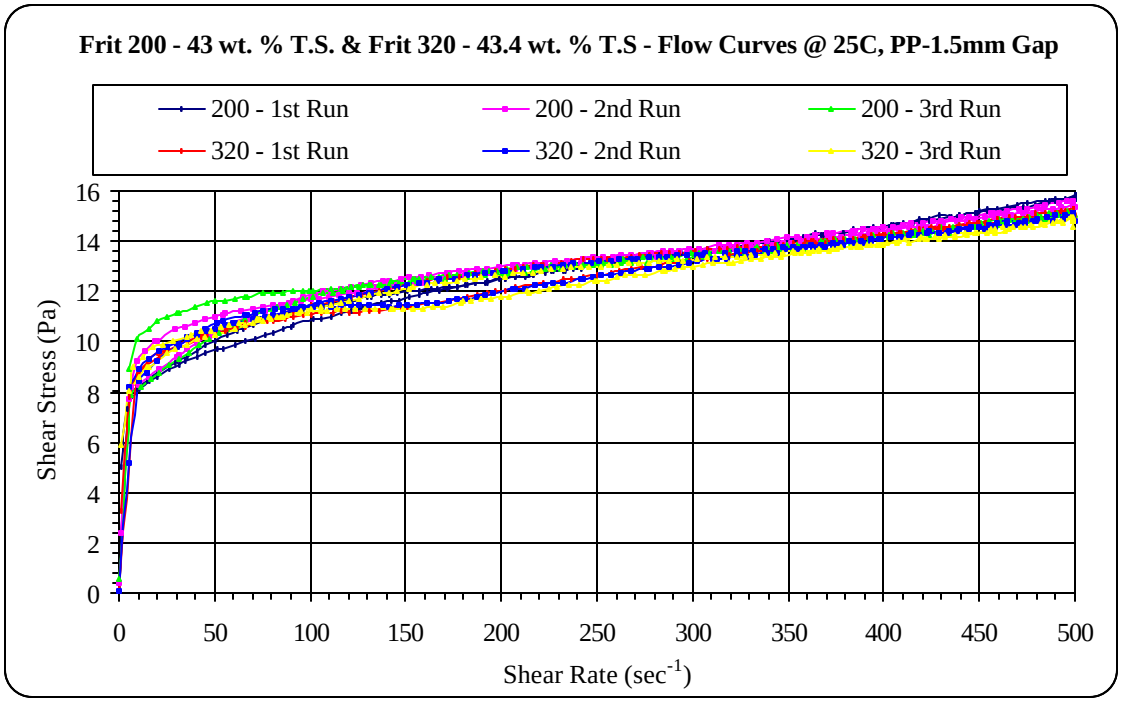
	Frit 320 Feed	Frit 200 Feed
Solids Content (wt %)	43.4	43.0
pH	8.16	7.58

The rheology of the two feeds was very similar, as shown by Table 3 and Figure 1. Individual rheograms for each flow measurement are shown in Appendix A. The yield stress was determined by the intercept of a linear curve fit on the region between the shear rates of 200 sec^{-1} and 500 sec^{-1} using the Bingham Plastic rheological model while the consistency was determined from the slope of the curve fit. The R^2 value for the fit is also shown in Table 3.

Table 3. Calculated Yield Stress and Viscosity

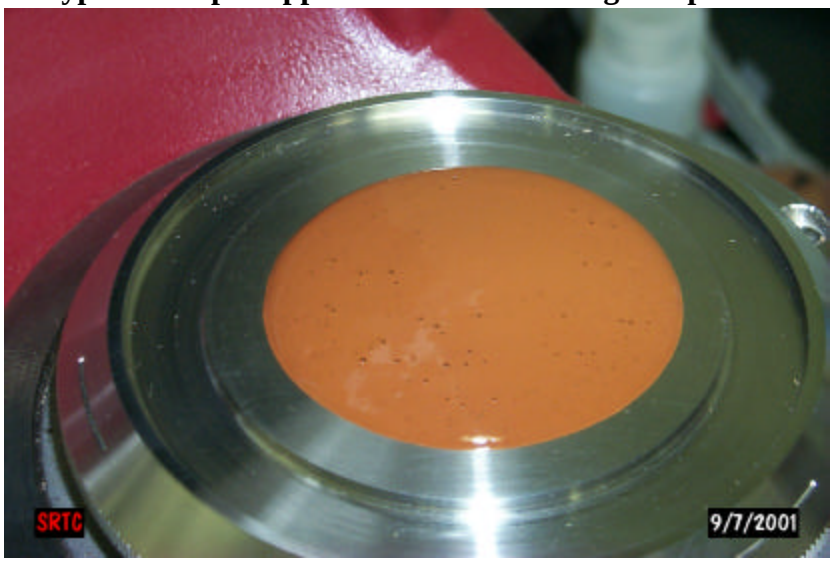
	Frit 320 Melter Feed			Frit 200 Melter Feed		
	Yield Stress	Consistency	R^2	Yield Stress	Consistency	R^2
	Pa	Cp		Pa	Cp	
Run 1	10.7	9.0	0.96	10.3	10.76	1.00
Run 2	10.7	8.6	0.96	11.0	8.84	0.99
Run 3	10.6	8.4	0.95	11.0	8.11	0.98
Average	**10.7**	**8.6**	-	**10.8**	**9.2**	-

Figure 1. Combined Rheograms



Although the results indicate excellent agreement between duplicate samples, one item of concern was noted during the flow measurements. Small bubbles, as shown in Figure 2, were observed in all samples during the testing. The bubbles can impact the rheology measurement in an unpredictable manner. Air entrainment in the feed during processing in the DWPF is expected to occur, causing the same small bubbles as seen in the samples, therefore, no attempt was made to remove the small bubbles or to determine a correction factor.

Figure 2. Typical Sample Appearance after Loading Sample on Rheometer



CONCLUSIONS

- The rheology of the melter feed is not significantly impacted at 43% solids content and 25° Celsius by switching from Frit 200 to Frit 320.

RECOMMENDATIONS

- The melter feed samples should be held for additional tests to determine if the rheological properties change over time.

REFERENCES

1. D. P. Lambert, T. H. Lorier, D. K. Peeler, M. E. Stone, Melt Rate Improvement for DWPF MB3: Summary and Recommendations (U), WSRC-TR-2001-00148, May 8, 2001.
2. M. E. Stone, DWPF Frit Slurry Mixing Tests (U), WSRC-TR-2001-00404, September 10, 2001.
3. D. C. Koopman, Sludge Batch 2 (Macrobatch 3) Flowsheet Studies with Simulants (U), WSRC-TR-2000-00398, October 9, 2000.
4. D. C. Koopman, Tank 8/40 Blend Scoping Run #4 with 125% Acid (U), SRT-PTD-2000-47, August 9, 2000.
5. M. E. Stone, Run Plan for Production of Melter Feed with Frits 200 and 320 (U), SRT-GDP-2001-00078, July 27, 2001.
6. Macrobatch 3 – Frit 320 Laboratory Notebook, WSRC-NB-2001-00135.

APPENDIX A. MELTER FEED RHEOGRAMS

Figure A-1. Rheogram of Run 1 with Frit 200 Melter Feed

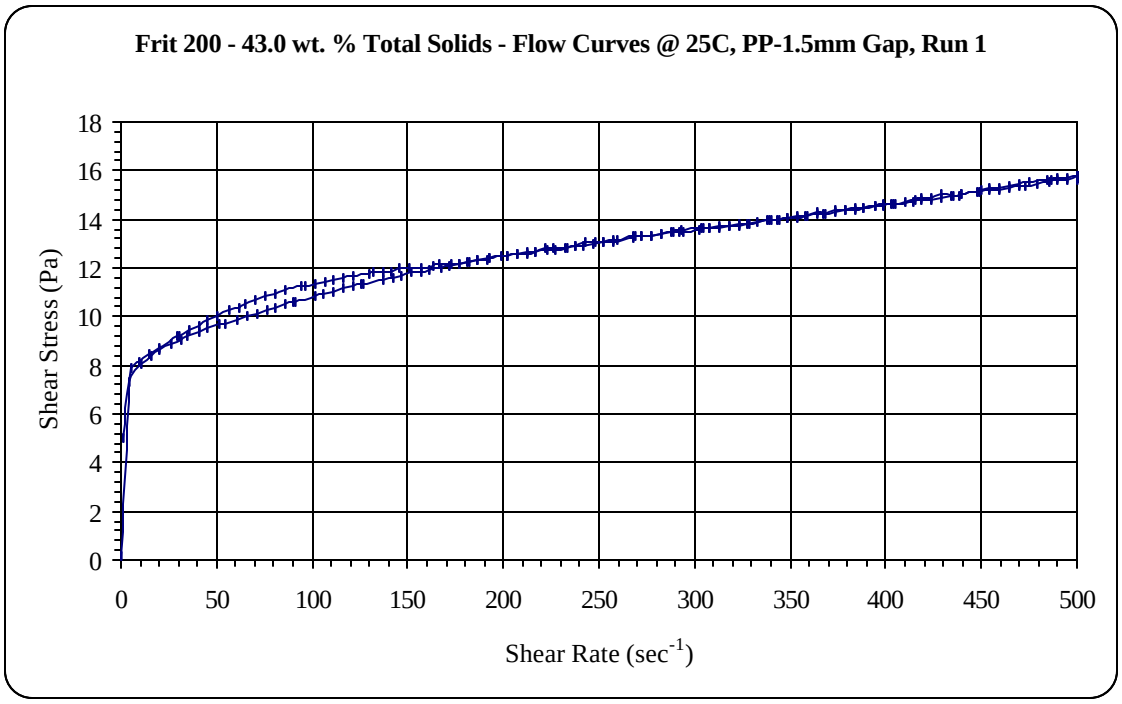


Figure A-2. Rheogram of Run 2 with Frit 200 Melter Feed

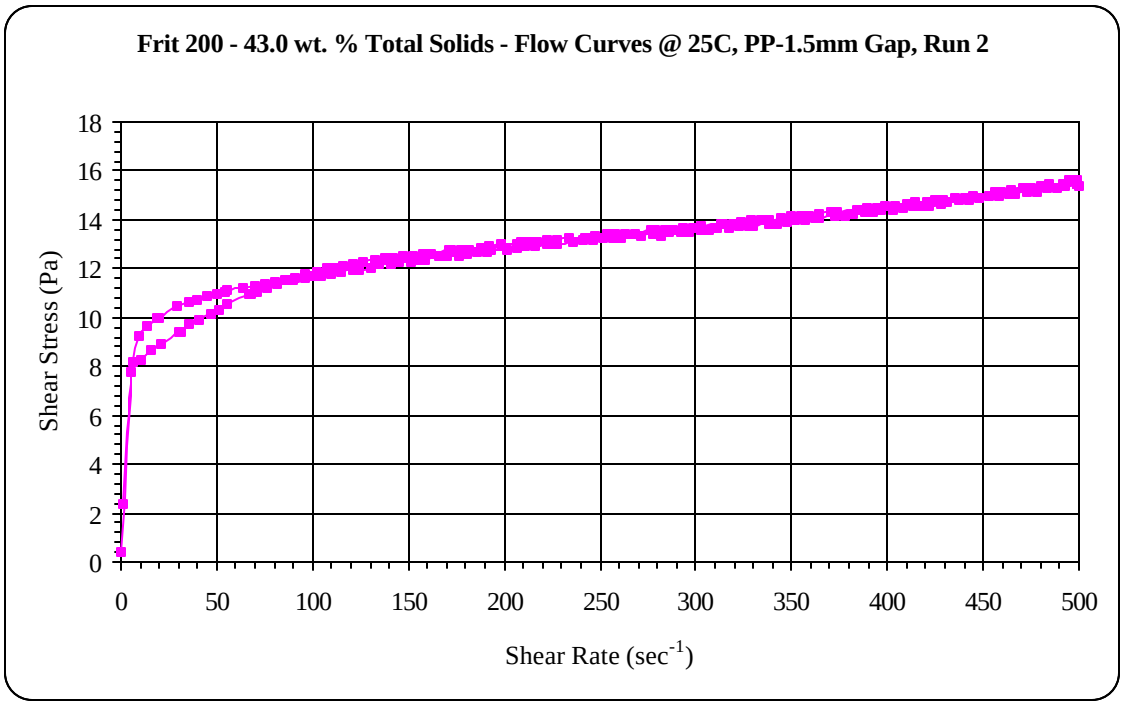


Figure A-3. Rheogram of Run 3 with Frit 200 Melter Feed

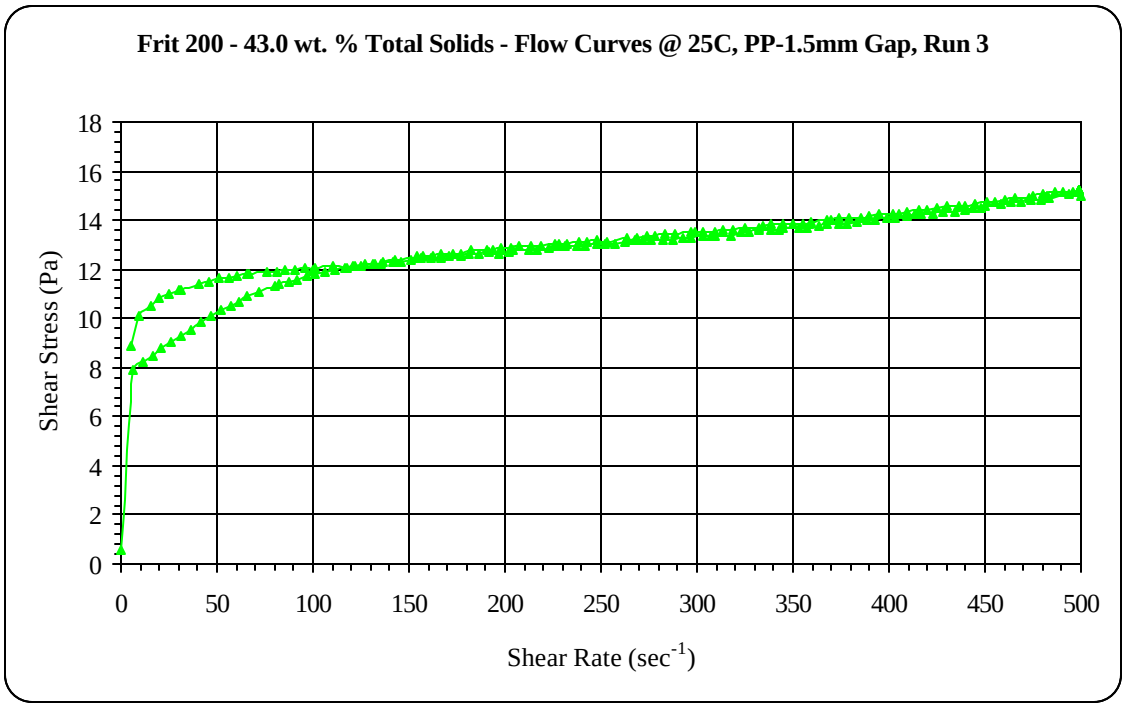


Figure A-4. Rheogram of Run 1 with Frit 320 Melter Feed

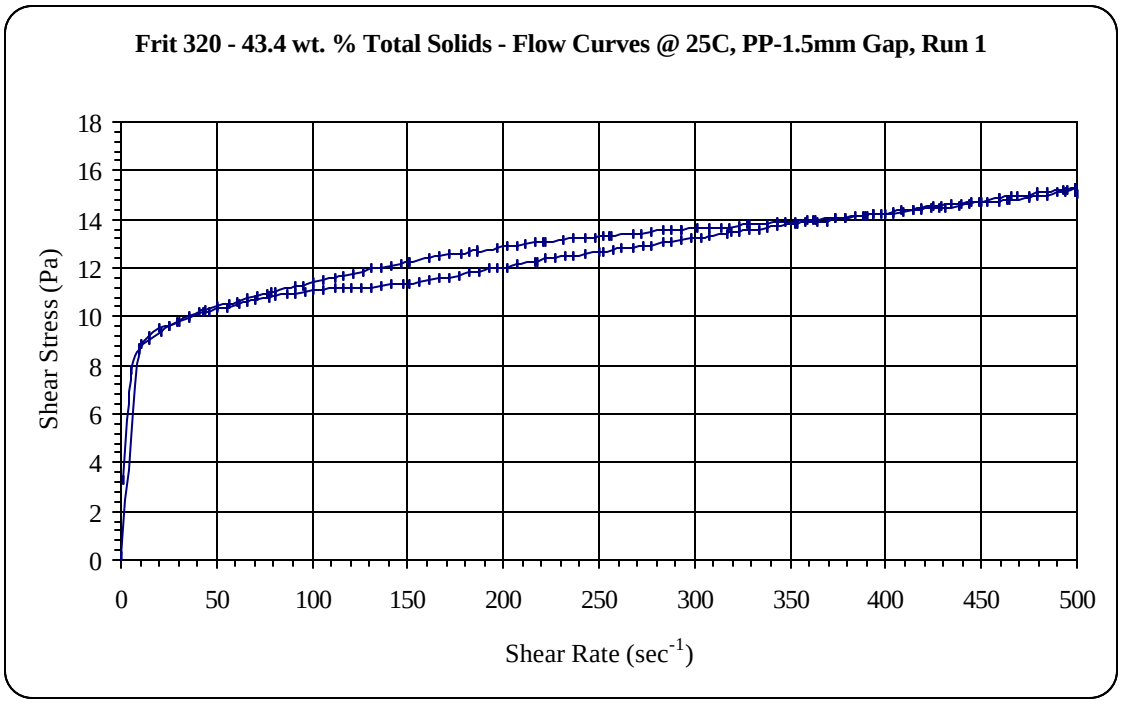


Figure A-5. Rheogram of Run 2 with Frit 320 Melter Feed

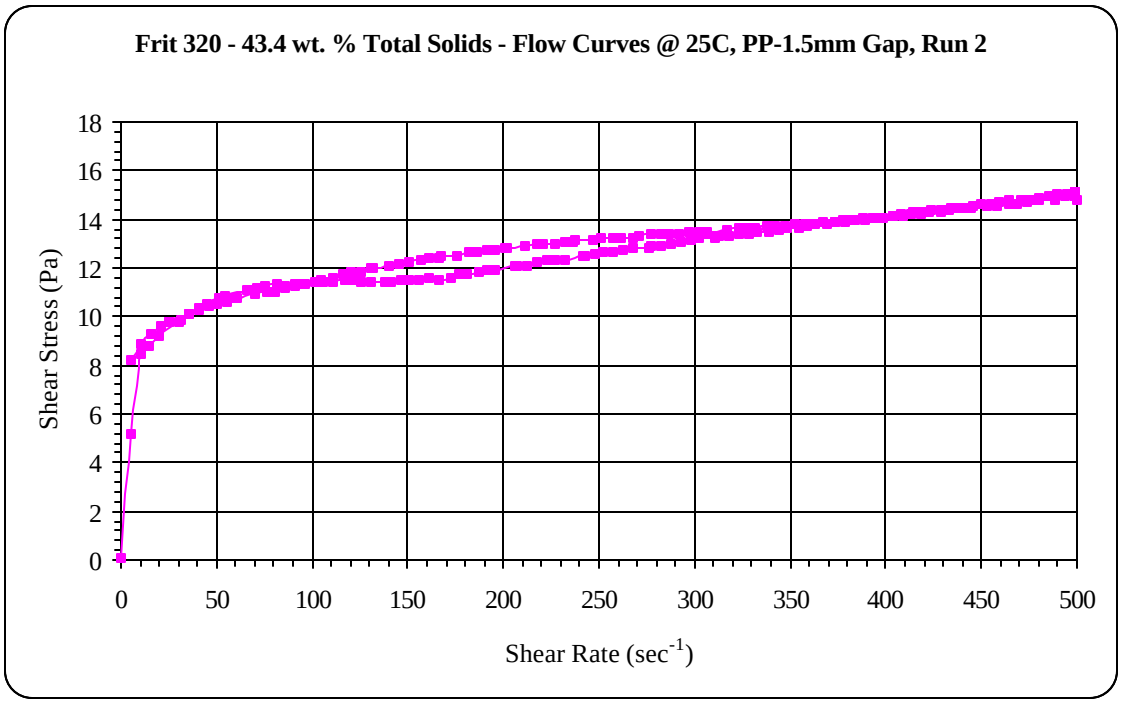
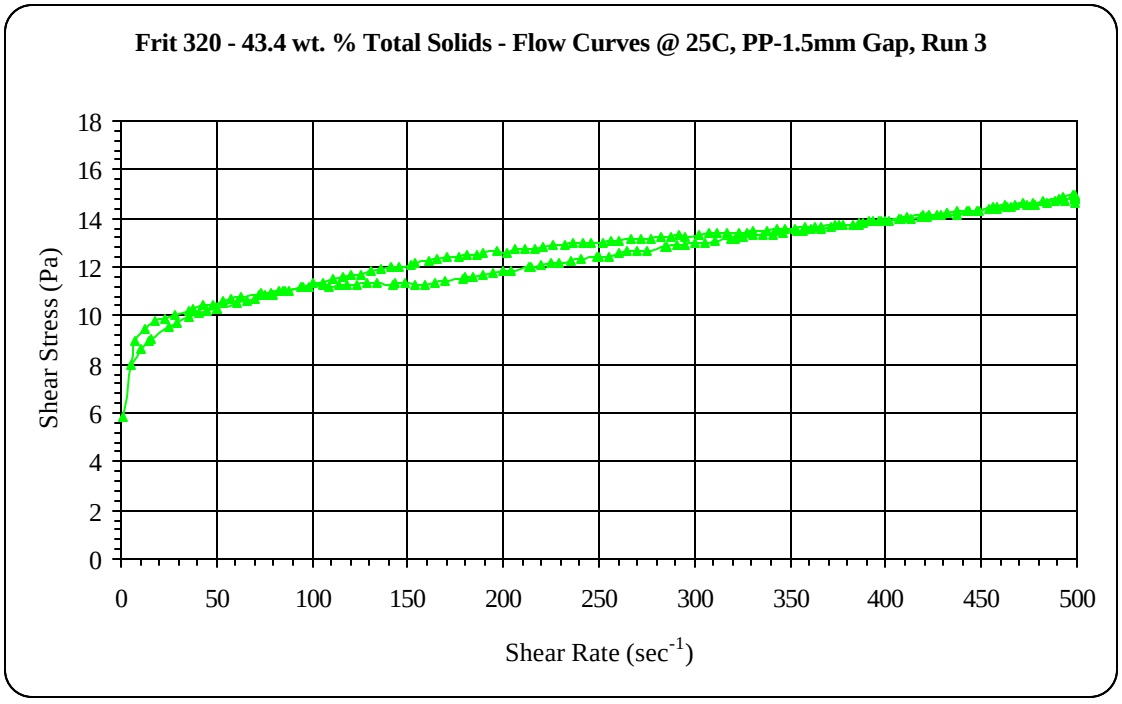


Figure A-6. Rheogram of Run 3 with Frit 320 Melter Feed



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