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RHEOLOGICAL PROPERTIES ESSENTIAL FOR THE ATOMIZATION OF T1
COAL WATER SLURRIES (CWS).

Quarterly Progress Report
September 15, 1992-December 15, 1992

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OVERALL OBJECTIVE:

The overall objective of this project is to perform experiments to understand the effect of high shear and extensional properties on the atomization of coal-water slurries (CWS). In the atomization studies, the mean drop size of the CWS sprays will be determined at various air-to CWS. A correlation between the extensional and high shear properties, particle size distributions and the atomization will be made in order to determine the influence of these parameters on the atomization of CWS.

WORK DONE

During the previous quarter, it was noted that understanding the rheology of polymeric additives used in enhancing the stability of the CWS was essential in meeting the project objectives. Thus, further review of the literature was carried out to gain information on the rheology of polymeric additives, particularly at high shear rates.

Philippoff and Hess [1] reported the existence of four distinct flow regions in the behavior of flow curve analysis of polymer solutions (Figure 1). These regions are characterized by

- (1) A Newtonian Region
- (2) A non-Newtonian pseudoplastic region
- (3) A second Newtonian region at high shear rates 10^5 to 10^6 sec^{-1}
- (4) and a region of steepening slope identified as the onset of turbulence.

Efforts during this past quarter was therefore directed towards the study of high shear rheology of the CWS using an

automated HVA 6 capillary viscometer. The HVA 6 automated high shear capillary viscometer permits measurements from medium up to high shear rates ($D=10^2$ to 10^6 S^{-1}). The sample to be measured is forced through a capillary at definite pre-adjusted pressure and forced through the capillary and pressed into a burette where volume measurement takes place (Figure 2).

There have been several reports in the literature which indicate that the presence of polymer additives used to stabilize CWS exert significance influence in CWS atomization [2]. Thus, several CWS having different solids concentrations were prepared and their flow behaviors under high shear rate conditions evaluated. Typical results obtained are as shown in Figures 3-5 and Tables 1-3. Figure 5 is a flow curve of a slurry containing 61% solids, 0.3% A-23M and 0.25 % stabilizer). The flow curve obtained, shows a departure from the behaviors shown in Figures 3 and 4. It is not clear whether this behavior is due to the presence of the stabilizer. Thus, it is intended during the next quarter to perform several experiments with varying concentrations of the stabilizer in order to determine the effect of the concentration of the stabilizer on the flow behavior.

Figures 6 and 7 also show the variation of the viscosity as a function of the shear rate. In Figure 6, there is a sudden increase in viscosity at a shear rate of 10^5 s^{-1} . This sudden increase corresponds to the flow behavior in Figure 5 where an abrupt change in flow behavior occurs. Such a sudden change in viscosity could elucidate some of the factors affecting atomization.

References

1. W. Phillippoff, F. H. Gaskins, and J. G. Brodnyan, Trans. Soc. Rheol. 1, 109 (1957).
2. P. J. Winters., R. T. Bailey and K. R. Olen, "The Effect of Fuel Formulation on the Atomization Characteristics of Coal-Water-Mixtures", Proc. Seventh Int. Symp. on Coal Slurry Fuels Prep. and Util. pp 430-439 (1985).

TABLE 1

FLOW DATA FOR 62% PSOC - 1527, . 0.30% A-23

* * *

A P P A A R

H V A - 6

* * *

R E S U L T S from 17/11/1992

Operator : ohene File : OHENE1
 Sample : Ohene1 Number : 1
 Solvent : water
 Density (kg/m3) : 1200 Temperature($\frac{1}{2}$ C) : 23
 Capillary-length (mm) : 100.00 Capillary-diameter (mm) : 0.800

 HVA 6 - Table lin (measured)

No.	TAU(Pa)	TAU corr(Pa)	D(1/s)	ETA(Pa.s)	Reynolds	tv(s)
1	3.800E+02	3.749E+02	1.382E+04	0.0271	49	0.0724
2	6.600E+02	6.449E+02	2.366E+04	0.0273	83	0.0423
3	1.000E+03	9.645E+02	3.632E+04	0.0266	131	0.0275
4	1.480E+03	1.396E+03	5.578E+04	0.0250	214	0.0179
5	2.080E+03	1.898E+03	8.219E+04	0.0231	342	0.0122
6	3.120E+03	2.786E+03	1.116E+05	0.0250	429	0.0090
7	3.860E+03	3.204E+03	1.562E+05	0.0205	731	0.0064
8	5.000E+03	4.191E+03	1.735E+05	0.0242	690	0.0058

Flow Data for 61% PSOC - 1527, 0.30% A-23

* * *

R E S U L T S from 18/11/1992

```
Operator      : ohene                                     File : OHENE2
Sample       : psoc1527                                   Number : 1
Solvent      : water
Density (kg/m3) : 1200                                     Temperature(°C): 23
Capillary-length (mm) : 100.00                             Capillary-diameter (mm) : 0.800
```

HVA 6 - Table lin (measured)

No.	TAU(Pa)	TAU corr (Pa)	D(1/s)	ETA(Pa.s)	Reynolds	tv(s)
1	7.200E+02	7.150E+02	1.358E+04	0.0527	25	0.0736
2	9.400E+02	9.321E+02	1.716E+04	0.0543	30	0.0583
3	1.380E+03	1.357E+03	2.947E+04	0.0460	61	0.0339
4	2.140E+03	2.076E+03	4.880E+04	0.0425	110	0.0205
5	2.680E+03	2.583E+03	6.007E+04	0.0430	134	0.0166
6	3.260E+03	3.111E+03	7.437E+04	0.0418	171	0.0134
7	5.680E+03	5.225E+03	1.301E+05	0.0401	311	0.0077
8	6.480E+03	5.938E+03	1.420E+05	0.0418	326	0.0070
9	7.280E+03	6.624E+03	1.562E+05	0.0424	353	0.0064

FLOW DATA FOR 61% PSOC - 1527, 0.30% A-23
AND 0.2% XANTHAM GUM

* * *

R E S U L T S from 01/12/1992

Operator	: ohene	File	: COAL3
Sample	:	Number	:
Solvent	:		
Density (kg/m3)	: 1180	Temperature (°C)	: 20
Capillary-length (mm)	: 100.00	Capillary-diameter (mm)	: 0.800

This
0.2%

HVA 6 - Table lin (measured)

No.	TAU(Pa)	TAU corr(Pa)	D(1/s)	ETA(Pa.s)	Reynolds	tv(s)
1	3.280E+03	3.168E+03	6.507E+04	0.0487	126	0.0154
2	4.040E+03	3.907E+03	7.099E+04	0.0550	122	0.0141
3	5.200E+03	4.977E+03	9.187E+04	0.0542	160	0.0109
4	6.920E+03	6.387E+03	1.420E+05	0.0450	298	0.0070
5	8.460E+03	7.783E+03	1.600E+05	0.0486	311	0.0062
6	1.002E+04	9.276E+03	1.678E+05	0.0553	287	0.0060

FIGURE 1. A High Shear Flow Curve For A Dilute Polymer Solution [Ref. 1]

MECHANICS AND ELECTRONICS OF THE HVA 6

FIGURE 2

FIGURE 3. Flow Curve for 61% PSOC - 1527 - A - 23

***** A P P A A R

H V A - 6

lg TAU (Pa.s)

R E S U L T S from 17/11/198

File : OHENE1.HVA

Number : 1

Operator : ohene

Sample : Ohene1

Solvent : water

Density (kg/m3) : 1200

Temperature (°C) : 23

Capillary-length (mm) : 100.00

Capillary-diameter (mm) : 0.800

lg D (1/s)

6

5

4

9.

FIGURE 4. Flow Curve for 62% PSOC - 1527
0.3% A-23

*** AP PAAR ***

HVA - 6

lg τ (Pa.s)

lg D (1/s)

RESULTS from 18/11/198

File : OHENE2.HVA

Number : 1

Operator : ohene

Sample : psoc1527

Solvent : water

Density (kg/m³) : 1200

Temperature (°C) : 23

Capillary-length (mm) : 100.00

Capillary-diameter (mm) : 0.800

FIGURE 5. Flow Curve for 61% - PSOC - 1527,
03% A-23 and 0.2% Xantham Gum

*** A P P A A R

H V A - 6

lg TAU (Pa.s)

R E S U L T S from 01/12/198

File : COAL3.HVA

Number :

Operator : ohene

Sample : VE COAL

Solvent :

Density (kg/m3) : 1180

Temperature (°C) : 20

Capillary-length (mm) : 100.00

Capillary-diameter (mm) : 0.800

lg D (1/s)

6

5

4

FIGURE 6. Variation of Viscosity as a Function of Shear-rate
61% PSOC - 1527, 0.3% A-23

*** A P P A R

H V A - 6

R E S U L T S from 18/11/198

File : OHENE2.HVA

Number : 1

Operator : ohene

Sample : psoc1527

Solvent : water

Density (kg/m3) : 1200

Temperature('C): 23

Capillary-length (mm) : 100.00

Capillary-diameter (mm) : 0.800

FIGURE 7. Variation of Viscosity as a Function of Shear rate
61% PSOC - 1527, 0.3% A-23 and 0.2% Xanthan Gum

A P P A R

H V A - 6

R E S U L T S from 01/12/198

File : COAL3.HVA

Number :

Operator : ohene

Sample : VE COAL

Solvent :

Density (kg/m3) : 1180

Temperature (°C) : 20

Capillary-length (mm) : 100.00

Capillary-diameter (mm) : 0.800

END

**DATE
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4/1/1993