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EFFECT OF COAL BENEFICIATION PROCESS ON RHEOLOGY/ATOMIZATION OF COAL WATER SLURRIES.

Quarterly Progress Report
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OVERALL OBJECTIVE:

The overall objective of this project is to perform experiments to understand the effect of coal beneficiation processes and high shear rheological 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 high shear rheological 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 this past quarter, the atomization data obtained from the previous quarters were analyzed using a model equation that had previously been developed during the course of this work.

The atomization data (Tables 1-9) were performed both at the Dow Chemical Plant in Plaquimine, Louisiana and at the Adelphi University atomization facility.

The experimental data obtained from the atomization studies were substituted into the empirical equation :

$$SMD/L = 1/3\ \rho_A/\rho_F\ We^{-1}(1+M_F/M_A) + 1/3\rho_A/\rho_F CK\gamma^n(1+M_F/M_A) \ldots\ldots\ldots\ldots (1)$$

The above equation demonstrates that there are two possible mechanisms for the breakup of the CWS. The first term is due to competition between surface tension forces and aerodynamic shearing force and the second term is due the competition between viscosity forces and surface tension force.

During the atomization studies, the surface tension and the densities of the slurries remained constant as the Air/Fuel ratio was varied. Also, the orifice of the nozzle remained constant during the course of the atomization studies.

Analysis of the glycerol-xantham gum mixture using the model equation, suggests that the empirical equation can best be represented by:

$$SMD/L=1/3\rho_A/\rho_F We^{-1}[(1+M_F/M_A)]^{0.5}+1/3\rho_A/\rho_F CK\gamma^n[(1+M_F/M_A)]^{-0.25} \quad ...(2)$$

This equation was used to fit the experimental data. The results obatained are as shown in Figures 1-4. The calculated SMD values were based on viscosities at a shear rate of 100,000 s^{-1}. The choice of viscosity values at this shear rate is based on the fact that, low shear rate viscosity data gave a very poor correlation data for the Dalavan nozzle used in this experiment. A plot of the measured and calculated SMD values for the atomization data obtained at Adelphi University, (Figures 1 and 2) correlated better with the fuel/Air ratio as compared to the data obtained from those performed at Dow Chemicals (Figures 3 and 4). This difference is due to the fact that the air and fuel flow rates could be controlled better at the Adelphi facility and therefore, the volumetric flow rate measurements made at the Adelphi facility, are more reliable than the fuel flow rates measured at the Dow facility.

Plans For Next Quarter.

Viscoelastic measurements on several formulations of the CWS will be measured and this will be related to the atomization data in subsequent studies.

TABLE 1

ATOMIZATION DATA

GLYCEROL-WATER SOLUTION (Adelphi University)

VISCOSITY (mPas)	A/F	SURFACE TENSION dynes/cm	DENSITY g/ml	SMD μM
384	.387	63	1.23	19.1
384	.367	63	1.23	22.8
384	.364	63	1.23	21.8
384	.361	63	1.23	29.9
384	.356	63	1.23	34.2
384	.305	63	1.23	40.8
384	.274	63	1.23	64.2
384	.246	63	1.23	80.0
384	.186	63	1.23	105
384	.127	63	1.23	149
410	.392	65	1.26	22.8
410	.381	65	1.26	25.3
410	.361	65	1.26	32.8
410	.312	65	1.26	45.8
410	.288	65	1.26	67.3
410	.212	65	1.26	91.2
410	.174	65	1.26	131.2
598	.412	66	1.26	20.6
598	.392	66	1.26	24.3
598	.366	66	1.26	38.2

TABLE 1 (CONTINUED)

ATOMIZATION DATA

GLYCEROL-WATER SOLUTION (Adelphi University)

VISCOSITY (mPas.s)	A/F	SURFACE TENSION dynes/cm	DENSITY g/ml	SMD μM
598	.343	66	1.26	44.2
598	.310	66	1.26	51.1
598	.300	66	1.26	52.4
598	.283	66	1.26	67.2
598	.233	66	1.26	91.2
598	.198	66	1.26	129
760	.425	66	1.28	18.9
760	.381	66	1.28	35.4
760	.362	66	1.28	47.2
760	.355	66	1.28	54.1
760	.341	66	1.28	59.6
760	.302	63	1.28	71.2
760	.288	66	1.28	83.7
760	.243	66	1.28	94.2
812	.393	67	1.28	22.8
812	.387	67	1.28	34.6
812	.371	67	1.28	44.2
812	.321	67	1.28	63.2

TABLE 1 (CONTINUED)

ATOMIZATION DATA

GLYCEROL-WATER SOLUTION (Adelphi University)

VISCOSITY (mPas.s)	A/F	SURFACE TENSION dynes/cm	DENSITY g/ml	SMD μM
812	.302	67	1.28	70.4
812	.279	67	1.28	101.2
812	.273	67	1.28	181.2
836	.411	67	1.29	20.6
836	.392	67	1.29	26.3
836	.386	67	1.29	48.2
836	.303	67	1.29	63.2
836	.286	67	1.29	126.1
836	.234	67	1.29	209.4
836	.189	67	1.29	231.3

TABLE 2

ATOMIZATION DATA

GLYCEROL-XANTHAM GUM MIXTURE (Adelphi University)

VISCOSITY	A/F	SURFACE TENSION	DENSITY	SMD
(mPas)		dynes/cm	g/ml	μM
55.7	.402	61	1.13	14.3
55.7	.386	61	1.13	22.0
55.7	.362	61	1.13	31.0
55.7	.303	61	1.13	47.0
55.7	.245	61	1.13	95.0
55.7	.186	61	1.13	105
55.7	.127	61	1.13	152

TABLE 3

ATOMIZATION DATA (FLOATATION CLEANED COAL)

COAL-WATER SLURRY MIXTURE (Adelphi University)

VISCOSITY	A/F	SURFACE TENSION	DENSITY	SMD
(mPas.s)**		dynes/cm	g/ml	μM
.0875	.427	67	1.14	24.5
.0875	.401	67	1.14	52.6
.0875	.336	67	1.14	71
.0875	.271	67	1.14	85
.0875	.207	67	1.14	193
.0875	.14	67	1.14	256

** VISCOSITY AT A SHEAR RATE OF 100,000/S.

TABLE 4

ATOMIZATION DATA

COAL-WATER SLURRY MIXTURE (UNCLEANED COAL) (Adelphi University)

VISCOSITY (mPas.s)**	A/F	SURFACE TENSION dynes/cm	DENSITY g/ml	SMD μM
.094	.441	67	1.16	38.5
.094	.414	67	1.16	69.6
.094	.347	67	1.16	95
.094	.281	67	1.16	129
.094	.186	67	1.16	195
.094	.145	67	1.16	354

** VISCOSITY AT A SHEAR RATE OF 100,000/S.

TABLE 5

ATOMIZATION DATA

GLYCEROL-WATER SOLUTION (Dow Chemicals)

VISCOSITY (mPas)	A/F	SURFACE TENSION dynes/cm	DENSITY g/ml	SMD μM
375	.571	63	1.13	17.4
384	.712	63	1.13	10.8

TABLE 6

ATOMIZATION DATA

GLYCEROL-XANTHAM GUM MIXTURE (Dow Chemicals)

VISCOSITY (mPas)	A/F	SURFACE TENSION dynes/cm	DENSITY g/ml	SMD μM
55.7	.270	61	1.14	33.9
55.7	.257	61	1.14	34.2

TABLE 7

ATOMIZATION DATA (FLOATATION CLEANED COAL)

COAL-WATER SLURRY MIXTURE (Dow Chemicals)

VISCOSITY (mPas.s)	A/F	SURFACE TENSION dynes/cm	DENSITY g/ml	SMD μM
295	.181	67	1.14	45.6
295	.173	67	1.14	62.6

TABLE 8

ATOMIZATION DATA

COAL-WATER SLURRY MIXTURE (UNCLEANED COAL) (Dow Chemicals)

VISCOSITY (mPas.s)	A/F	SURFACE TENSION dynes/cm	DENSITY g/ml	SMD µM
384	.2867	67	1.16	31.1
384	.205	67	1.16	34.3

Table 9

ATOMIZATION DATA

COAL-WATER SLURRY MIXTURE (HEAVY MEDIA CLEANED) (Dow Chemicals)

VISCOSITY (mPas.s)	A/F	SURFACE TENSION dynes/cm	DENSITY g/ml	SMD µM
301	.2672	67	1.16	31.1
301	.1708	67	1.16	42.4

Fig. 1. Measured SMD as a Function of (1 + Fuel/Air)

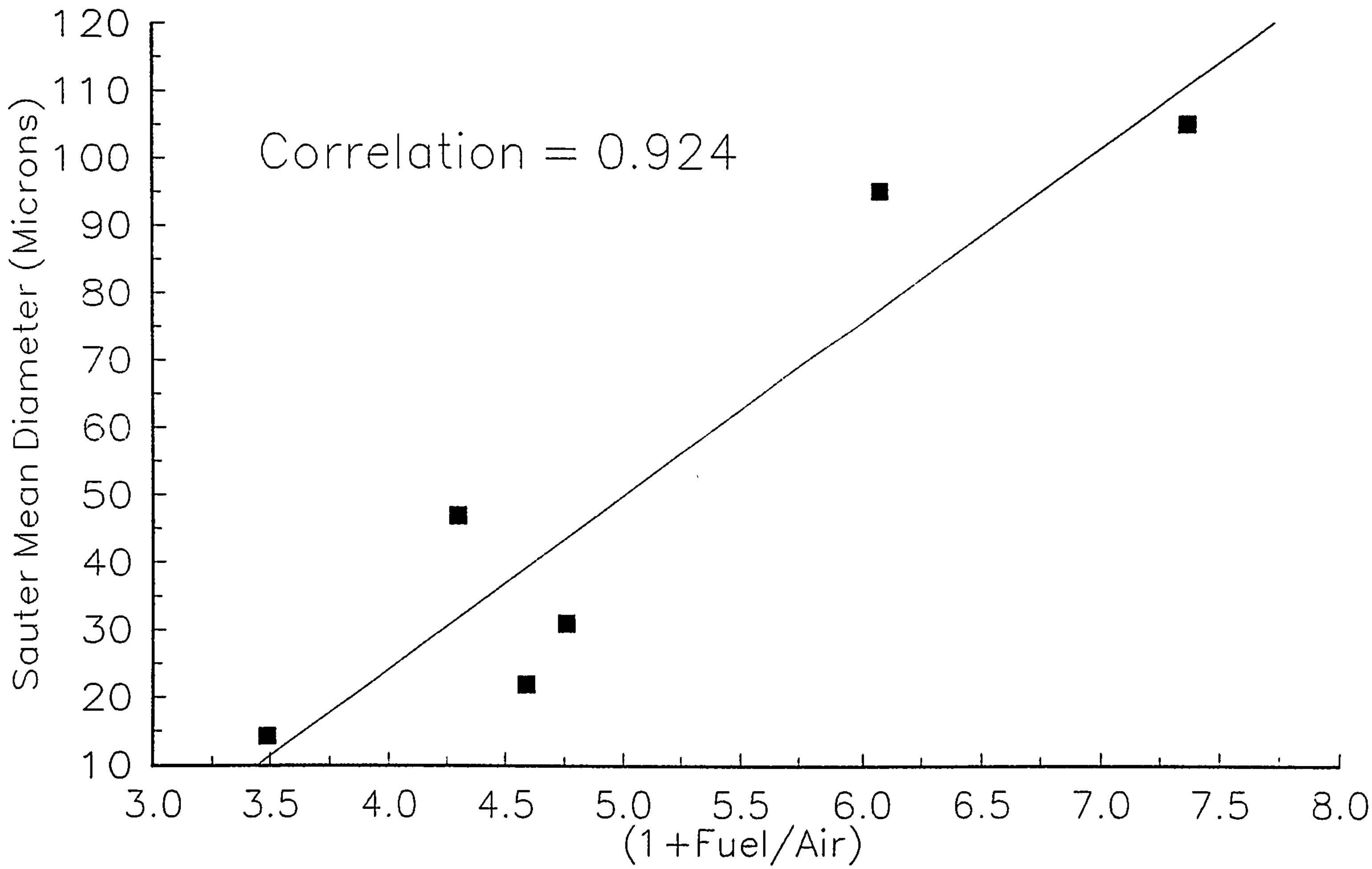

Fig. 2. Calculated SMD as a Function of (1 + Fuel/Air)

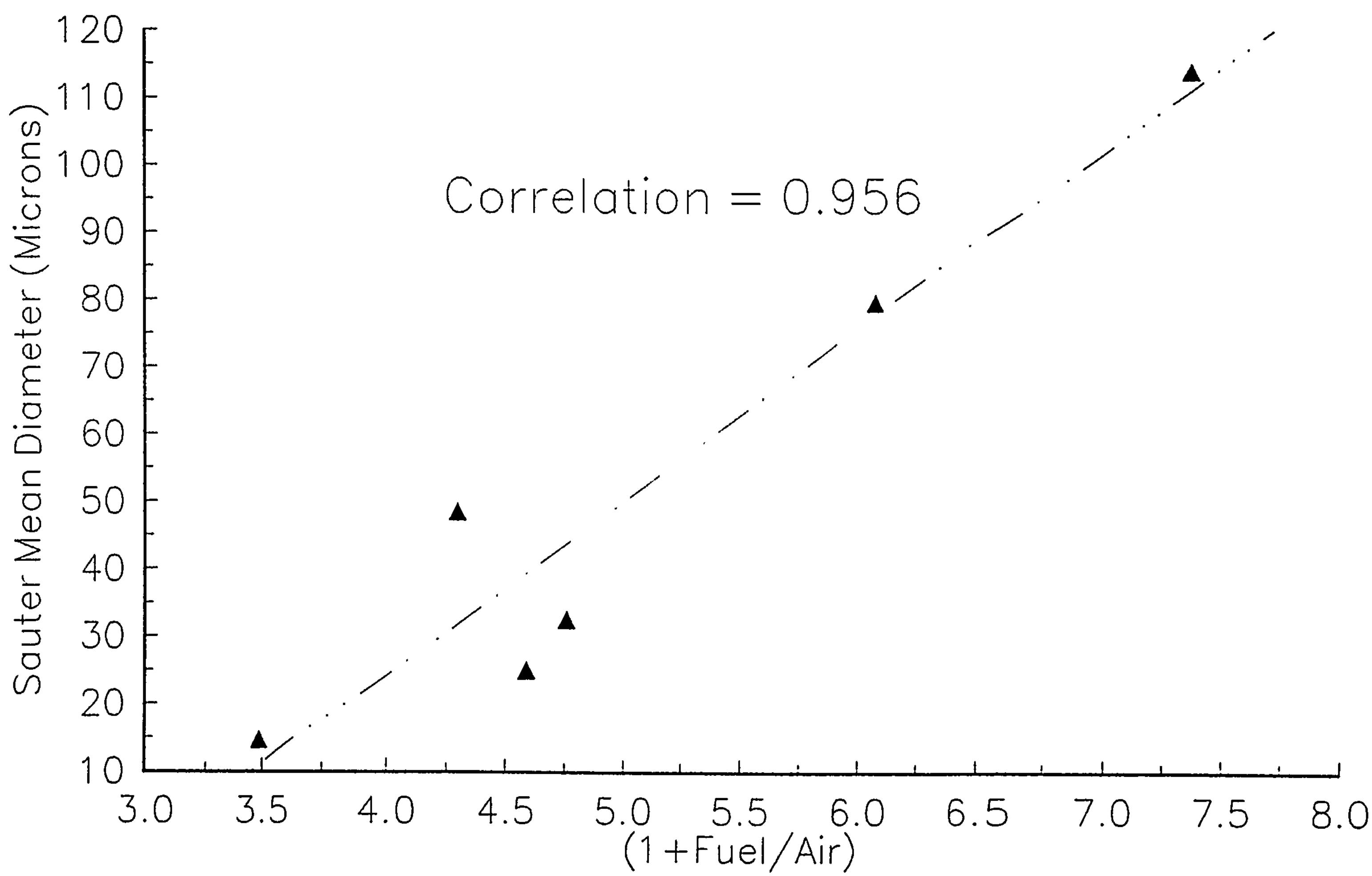

Fig. 3. Measured SMD as a Function of (1 + Fuel/Air)

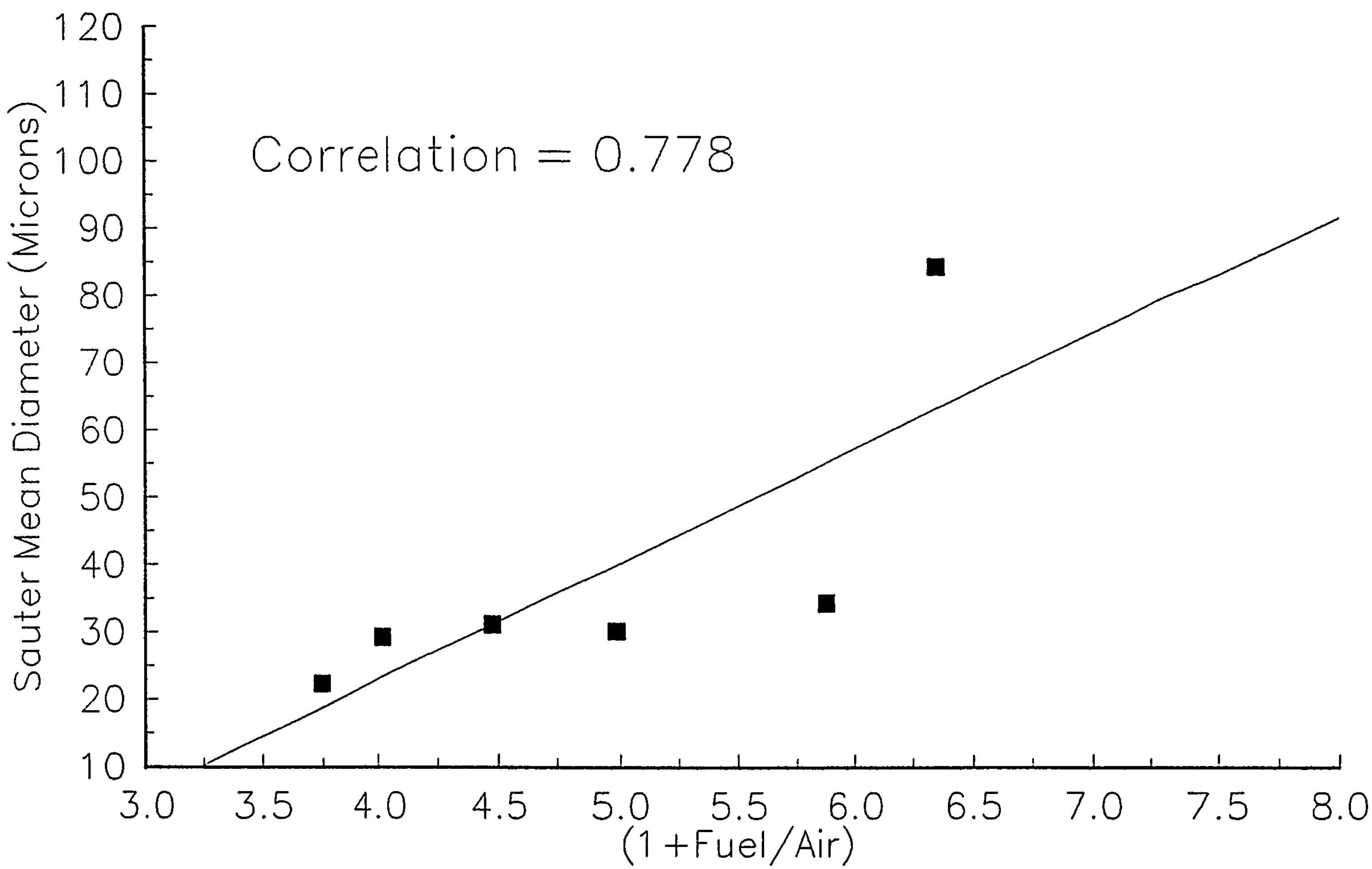

Fig. 4. Calculated SMD as a Function of (1 + Fuel/Air)