DOE/MT/92019--T6

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

Quarterly Progress Report
October 1, 1995 -December 31, 1995

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Work Performed for the Department of Energy Under
Contract #DE-FG22-92MT92019

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 the past quarter, the experimental data obtained from the previous quarter on pressure dependent atomization of Coal-water slurries and simulated fluids were analyzed.

The feed system for the simulated fluid and the CWS atomization consisted of a 5-gallon tank whose bottom feeds into a Monyo progressive cavity pump. the configuration of the fuel flow was chosen to allow accurate flow measurements in a flow regime of 1.44 gm/sec and a high flow regime of 34 gm/sec. calibration of the fluid was performed by collecting and timing tap water as it flows at a given setting of the pump. The accumulated water at each pump configuration setting was then weighed on a Mettler balance (model PJ 6000) and the flow rate was determined. Figure 1 shows the calibration curve for the fluid.

Atomizing air was provided by a general purpose air compressor which cycles between 85 psig and 150 psig. Air flow was controlled manually by turning a valve to give a line pressure. Calibration of the air flow was performed by measuring the volume of water displaced by the air as it flowed through a rotameter at 23 C. The mass of the volume of water displaced by a given quantity of air flowing through the rotameter, was determined by multiplying the volume of water displaced by the density of water at 23 C, and a calibration curve for the air flow rate was determined (Figure 2). This calibration also, allowed the measured and predicted flow rates to be matched at high, moderate and low values.

The spray data for the glycerol-water and glycerol-xantham gum solution are as shown in Figures 3 and 4. The plots indicate that the Sauter mean diameter (SMD, increase with decrease in Air/Fuel (AFR). Comparison of Figures 3 and 4 indicate that the addition of the xantham gum to the glycerol solution increases the SMD values especially in the low AFR regime.

Figure 5 compares SMD data as a function of AFR for the CWS samples under study. The data indicate that the beneficiated CWS samples atomized well, and that the SMD values obtained at all AFR were smaller than the run-off mine CWS sample.

Previous rheoloical studies indicate that all these slurries exhibit an almost identical high shear rheological behavior (Figure 6), but exhibit different viscoelastic behavior (Figure 7). This is an indication that the oscillatory measurement is able to delineate differences in the rheological characteristics of the three differennt CWS samples.

Oliver and Young-Hoon [2] have previously observed that fluids of increasing pseudoplasticity have lessened interaction between the phases and that viscoelasticity damps waves that occur in air-newtonian flow. Thus, the increase in the SMD as the storage modulus increases, is due to the fact that the restoring force must be overcome before a drop an break up sincemore energy would be required to overcome the forces associated with viscoelasticity.

In a previous report [1], theoretical analysis of the physical process governing atomization was proposed by considering an energy balance across a control volume that extended from the nozzle exit plane to the line of spray measurement. The inlet conditions were calculated using a two phase flow technique and the outlet conditions calculated by using conservation of momentum and assuming that the final velocities of the air and liquid are equal.

The final expression is of the form:

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

This expression has a term dependent on viscosity and a term independent on viscosity.

Based on this relationship, a fit of the CWS experimental data from the previous quarter was made to the above derived expression. The calculated values showed good agreement between the calculated and the measured values.

TABLE 1

ATOMIZATION DATA

COAL-WATER SLURRY MIXTURE (HEAVY MEDIA CLEANED COAL)

VISCOSITY (mPas.s)**	A/F	SURFACE TENSION dynes/cm	DENSITY g/ml	SMD µM
87.5	.427	67	1.14	24.5
87.5	.401	67	1.14	52.6
87.5	.336	67	1.14	71
87.5	.271	67	1.14	85
87.5	.207	67	1.14	193
87.5	.14	67	1.14	256

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

TABLE 2

ATOMIZATION DATA

COAL-WATER SLURRY MIXTURE (FLOTATION CLEANED COAL)

VISCOSITY (mPas.s)**	A/F	SURFACE TENSION dynes/cm	DENSITY g/ml	SMD µM
78.2	.437	67	1.16	23.6
78.2	.411	67	1.16	49.6
78.2	.340	67	1.16	75.2
78.2	.281	67	1.16	81.3
78.2	.221	67	1.16	186.3
78.2	.176	67	1.16	260

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

TABLE 3

ATOMIZATION DATA

COAL-WATER SLURRY MIXTURE (UNCLEANED COAL)

VISCOSITY (mPas.s)**	A/F	SURFACE TENSION dynes/cm	DENSITY g/ml	SMD µM
94	.441	67	1.16	38.5
94	.414	67	1.16	69.6
94	.347	67	1.16	95
94	.281	67	1.16	129
94	.186	67	1.16	195
94	.145	67	1.16	354

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

References

1. Ohene, F., Fourth Quarterly Report, DOE/DE-FG22-92MT92019
2. Oliver, R. D., and A. Young- Hoon "Two Phase non-Newtonian Flow" Transactions Institute Chemical Engineers, 46 T106-T115, 1968.

Figure 1. Calibration Curve For Fluid Flow

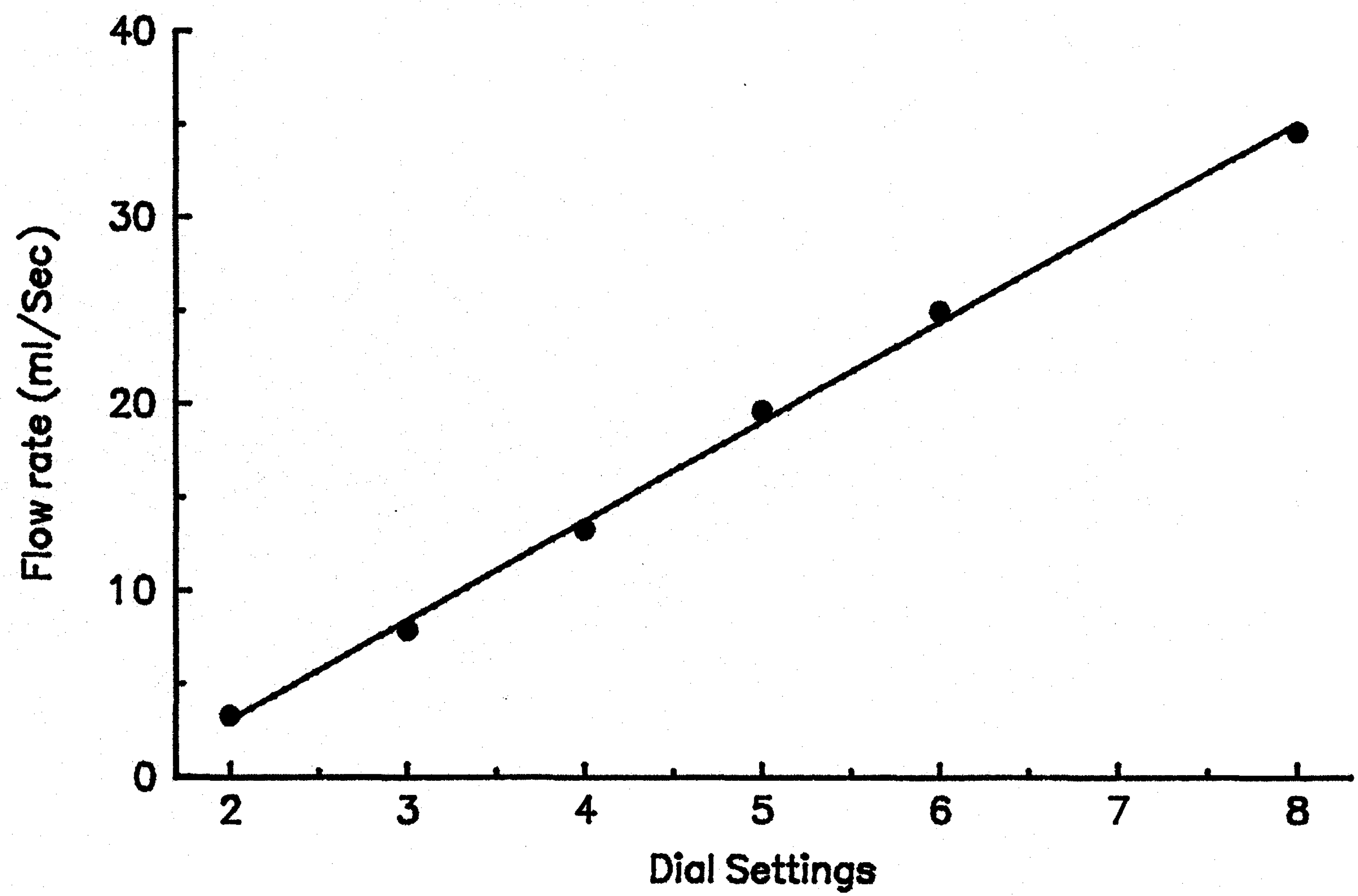

Figure 2. Calibration Curve for Air Flow

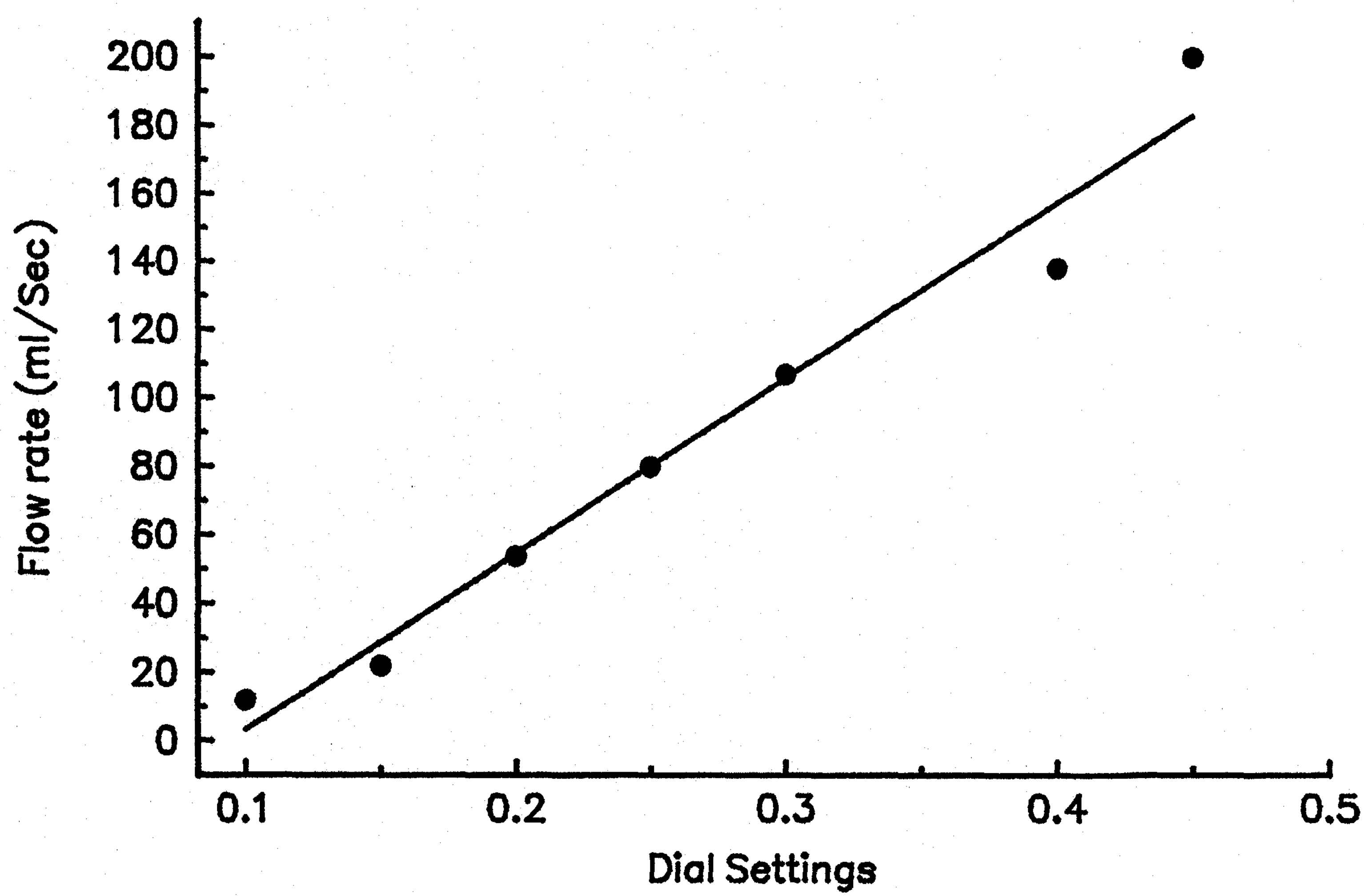

Figure 3. A Plot of Sauter Mean Diameter As A Function of Air/Fuel
(Glycerol Solution, Viscosity =600 mPas).

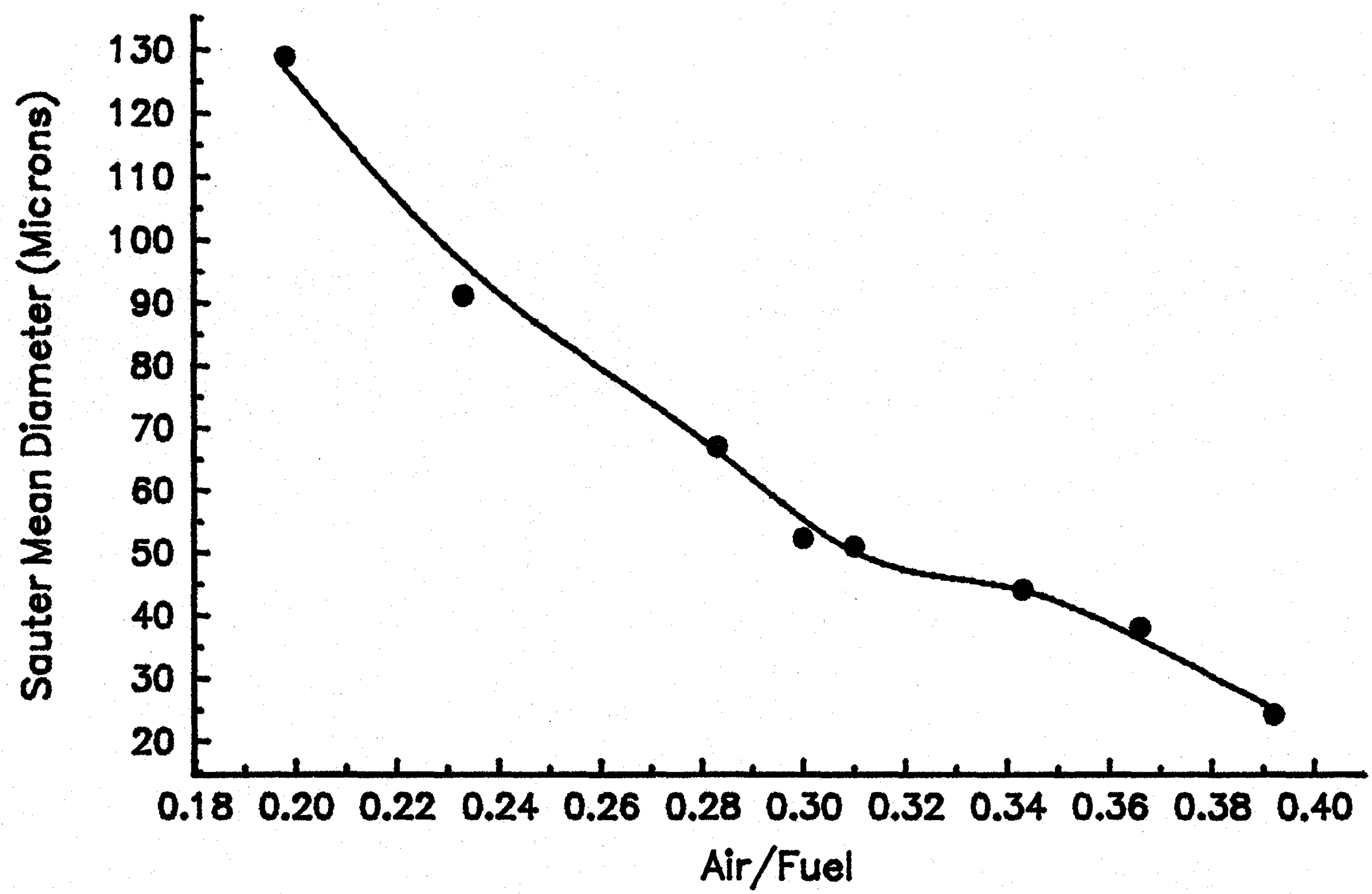

Figure 4. A Plot of Sauter Mean Diameter As A Function of Air/Fuel
(Glycerol—Xantham Gum Solution, Viscosity =450 mPas).

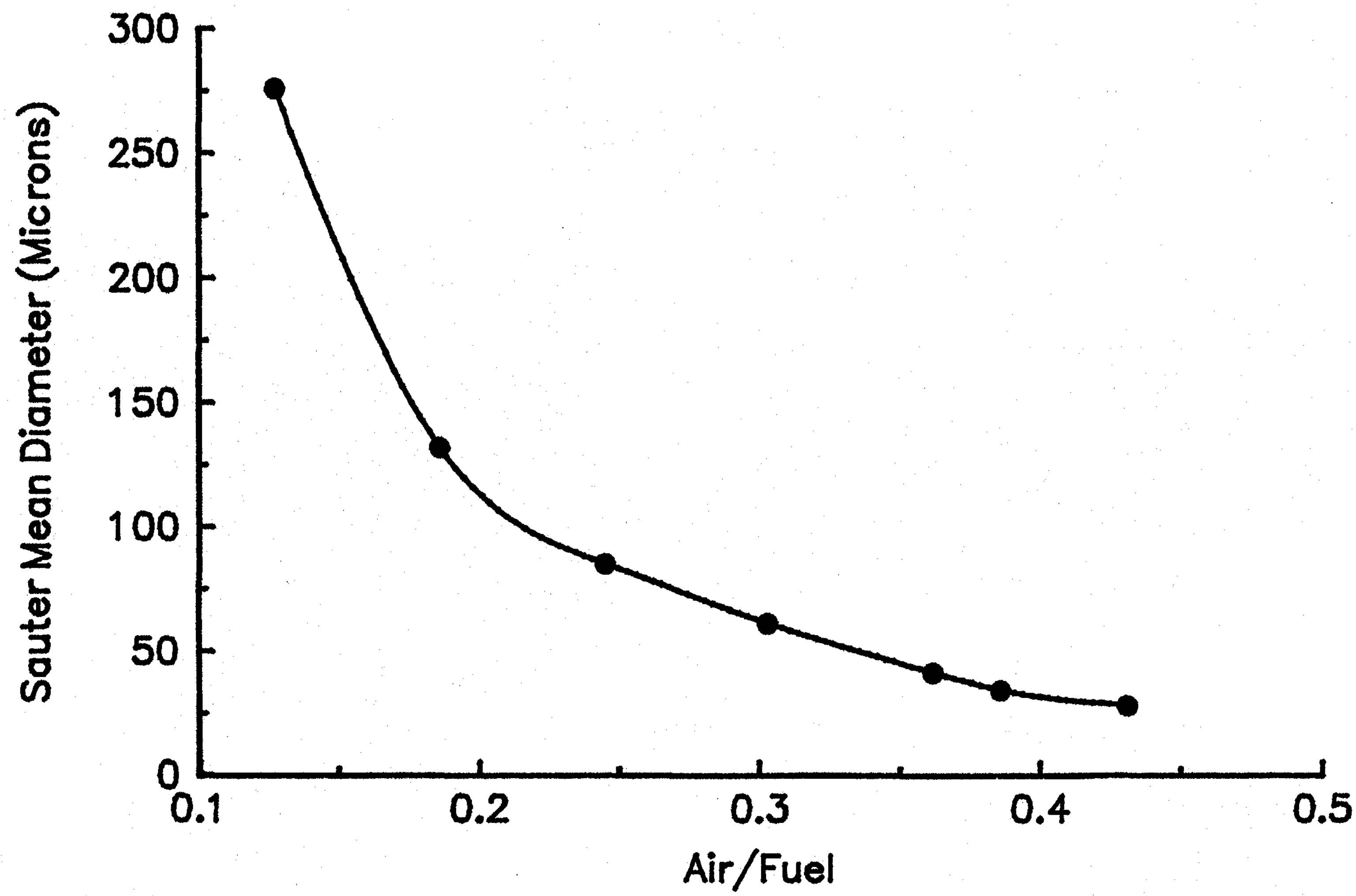

Figure 5. A Plot of Sauter Mean Diameter (SMD) As A Function of Air/F
63% CWS Samples

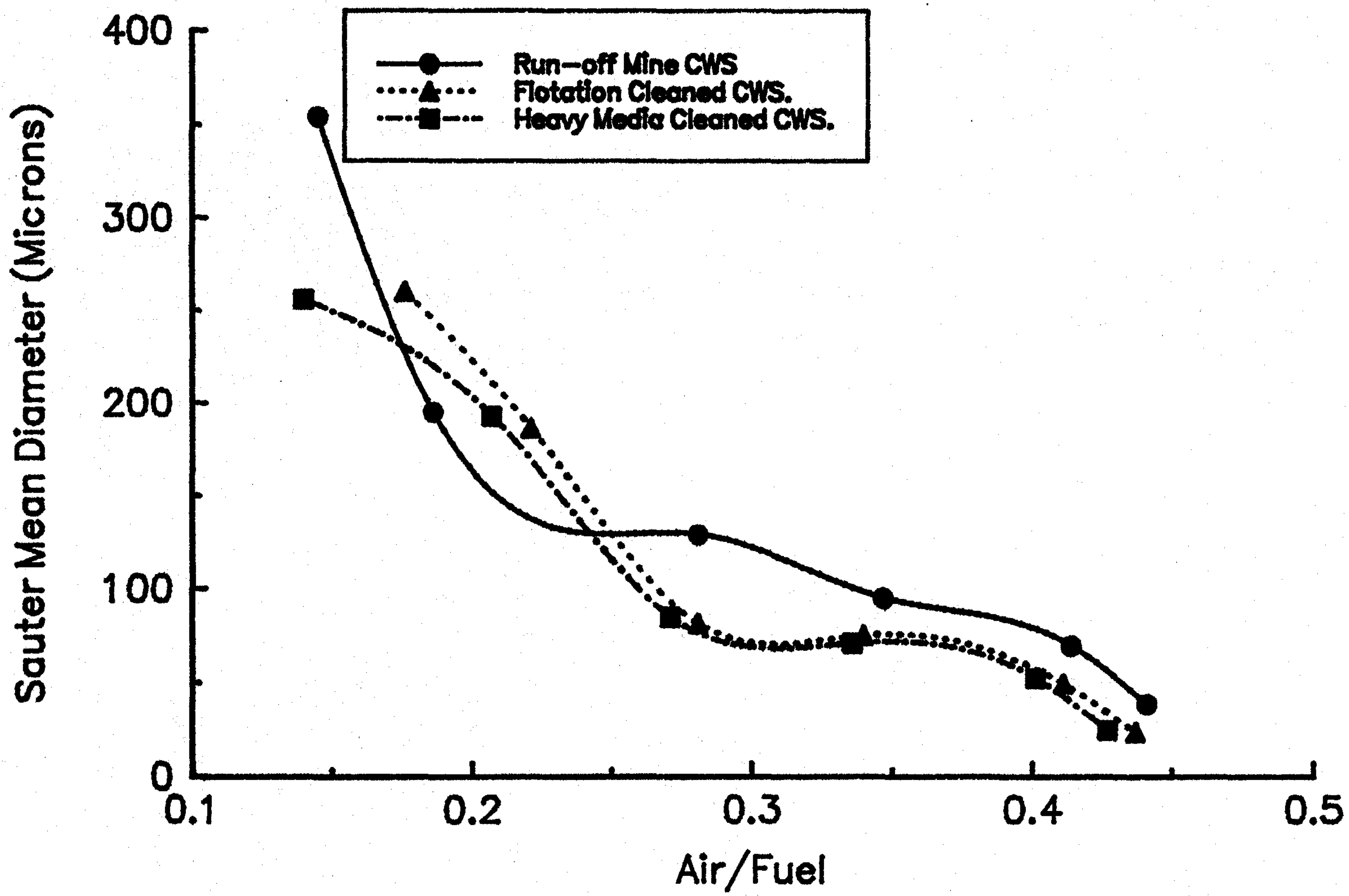

Figure 6 Comparison of High Shear Flow Behavior of CWS Samples

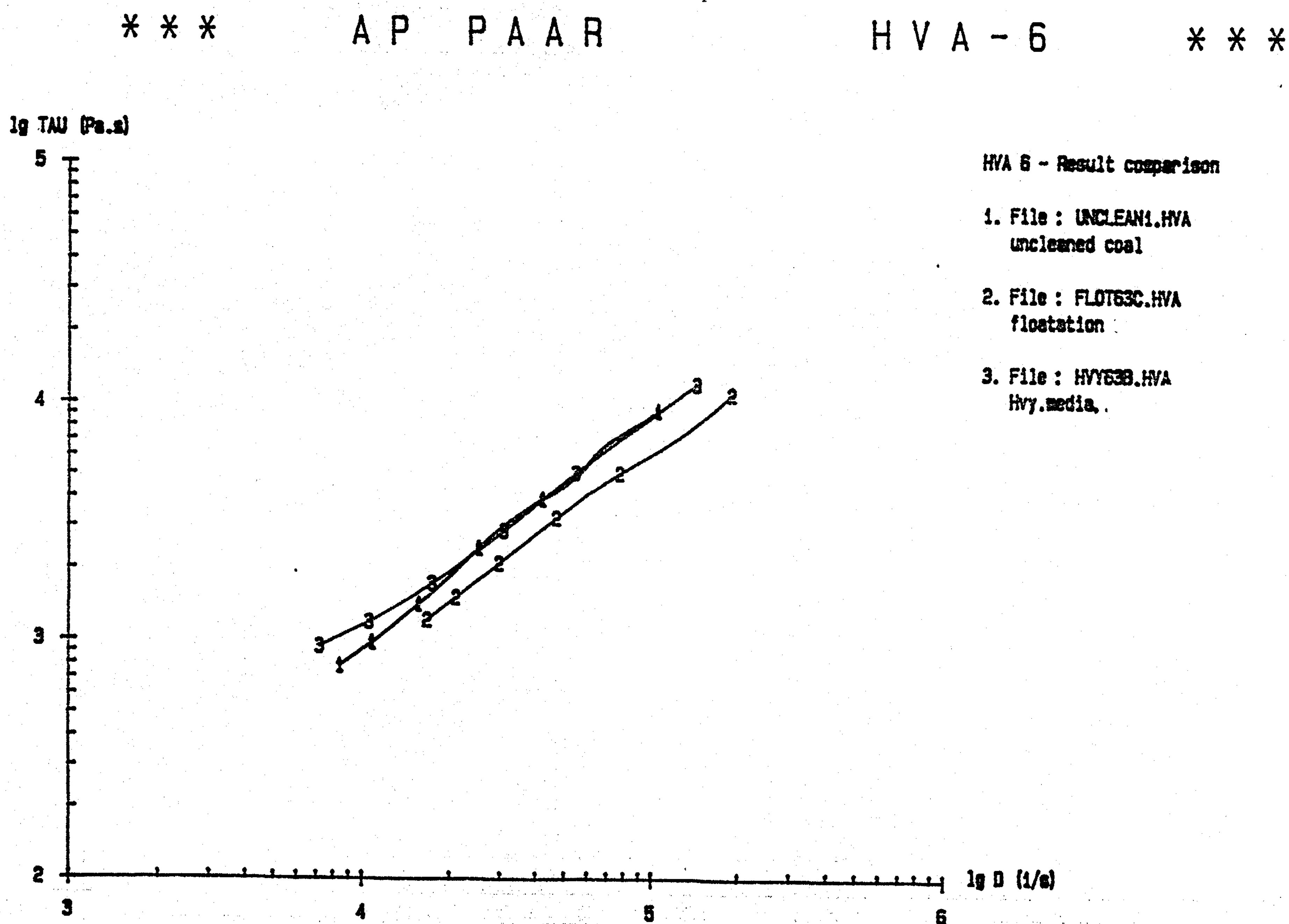

Figure 7 A plot of Storage Modulus as a Function of Frequency for CWS Samples

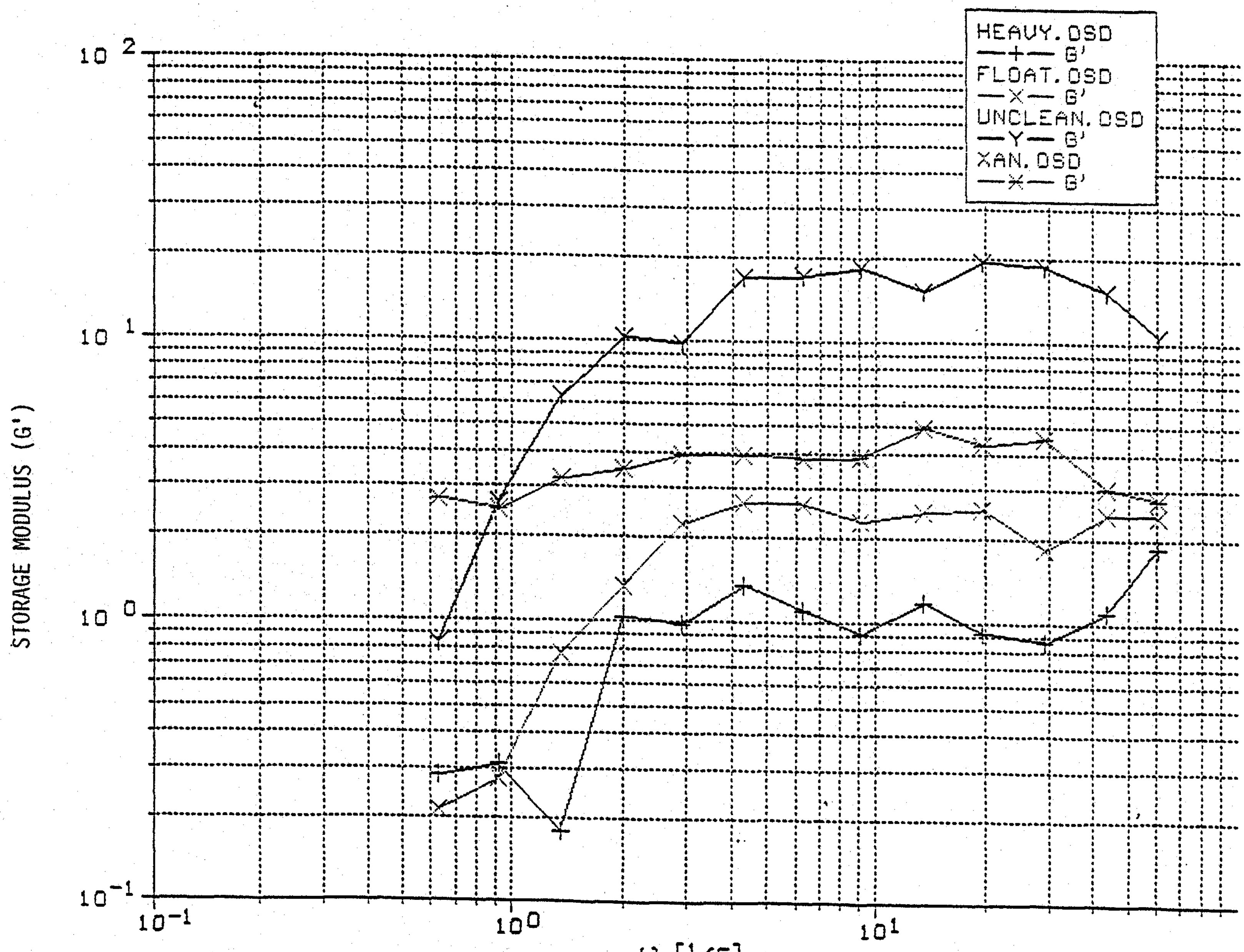

Figure 1. Storage Modulus as a Function of Frequency.

Date: 29.07.93, 03:07 Operator: Sample: HEAVY
Sensor system : Q45 System : CV20