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INTRODUCTION

As reported in the quarterly report of March of 1992, the relative viscosity of a Newtonian Coal Water Slurry (CWS) in the presence of an anionic polymeric dispersant is an order of magnitude higher than the prediction of the well established Krieger-Dougherty Equation which describes the relative viscosity of a non-aggregated Newtonian suspension as a function of particle volume fraction. Note that the anionic dispersant is used in such a quantity that the resulting interparticle electrostatic repulsion counter-balances the interparticle van der Waals attraction. Investigation continues to determine the mechanisms of such excess energy dissipation under shear. New experimental results are presented in this report to verify the role of the anionic polymeric dispersant in such excess energy dissipation of CWS.

RESULTS AND DISCUSSION

The coals used are Upper Freeport (Up1 and Up4), Pittsburgh Seam #8 (Pgh), and Illinois #6 (ILL), all of high volatile bituminous rank. The coal analyses are given in Table I, and the coal particle size distributions are shown in Figure 1. Both the coal analysis and the zeta potential measurement show that Upper Freeport coal is of higher rank than Pittsburgh Seam and Illinois #6. An anionic dispersant, Coal Master A23M from Henkel Corp., was first dissolved in deionized water, and then mixed in a mixer with coal particles. The resulting mixture was stirred at 500 rpm for one hour to ensure macroscopic homogeneity. The anionic dispersant used is an ammonium salt of naphthalene sulfonic acid formaldehyde polymer with a molecular weight of approximately 10,000. The slurry viscosity was measured using both Haake rotational rheometer RV2 and Burrell-Severs capillary rheometer A120.

Fig. 2 shows the relative viscosity as a function of particle Peclet number for 0.45 volume fraction suspensions of coals in aqueous solutions containing 72 wt% to 74 wt% glycerol and of sand in 80/20 wt/wt of ethylene glycol/glycerol. Since Up1, Up4, ILL coals, and sand have much narrower size distributions than Pgh coal as shown in Fig. 1, their slurries have much higher relative viscosities as shown in Fig. 2. This figure also shows that the Pgh coal slurry of 0.45 volume fraction becomes Newtonian at high shear rates. The high shear Newtonian viscosity is in excellent agreement with the prediction (6.5) of the Krieger-Dougherty Equation with the maximum packing fraction (0.72) determined in sedimentation.

In contrast, no such a relationship exists between the slurry relative viscosity and the coal particle size distribution when an anionic polymeric dispersant is used. In such slurries, the dispersant concentration becomes the predominating factor which influences the slurry rheology. As reported in the quarterly report of December, 1991, the lower ranking Pittsburgh Seam #8 (Pgh) coal requires less dispersant (0.15 wt% vs 0.36 wt%) and yields a CWS with viscosities comparable with those of the Up1 CWS despite of its much broader size distribution (see Fig. 1).

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As shown in Fig. 3, the 0.45 volume fraction Up4 CWS is more viscous at low shear rates when a lesser amount of dispersant A23M (0.15% vs 1.15% on dry coal basis) is used. The reverse is true at high shear rates. In other words, the anionic dispersant in a large quantity not only renders the CWS Newtonian, but also increases the energy dissipation at high shear rates. The same phenomenon is also seen in Pgh and ILL CWSs as shown in Fig. 3. Furthermore, for CWS with a large quantity of dispersant such as 1.66 wt% of Pgh coal, use of capillary C with a smaller diameter (1.58 mm vs 3.20 mm) than capillary D gives rise to a significantly higher viscosity, contrasting the observed good agreement between the two capillaries for CWSs in which only a small amount of dispersant is used. Thus, the quantity of dispersant used in CWS preparation should be minimized from rheological as well as economical viewpoints.

Table I

COAL ANALYSES

Analysis Dry basis	Upper Freeport Coal Up2	Up3	Up1 & Up4	Pittsburgh Seam, Pgh	Illinois #6 ILL
Volatile, %	23.1	25.2	28.4	42.4	40.6
Ash, %	16.7	9.1	5.4	3.9	4.2
Carbon, %	72.1	81.1	82.8	78.4	75.2
Hydrogen, %	4.5	5.1	5.1	5.4	5.2
Nitrogen, %	1.3	1.4	0.7	1.4	1.4
Oxygen, %	5.5	3.3	4.8	7.9	11.5
Sulfur, %	0.7	0.6	1.2	3.1	2.5
Particle size					
MMD, μm	10	12.5	4.0	9.2	7.8
VMD, μm	15.8	17.8	4.9	12.9	9.9

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UIPCOALS.PAG

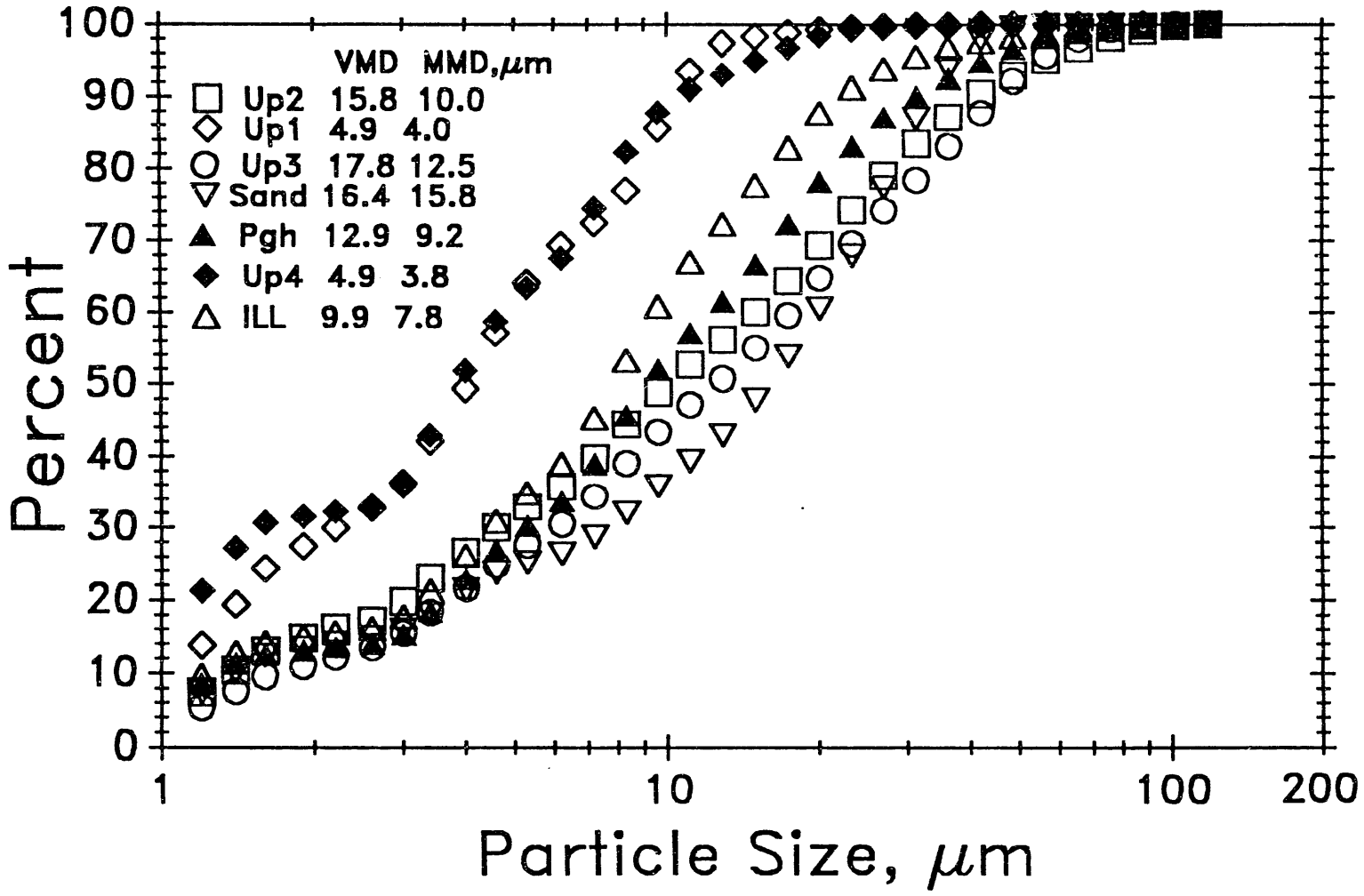

Fig. 1.

CMGW 45. PAG
CMGW45 GRA
CMGW3AS. GRA

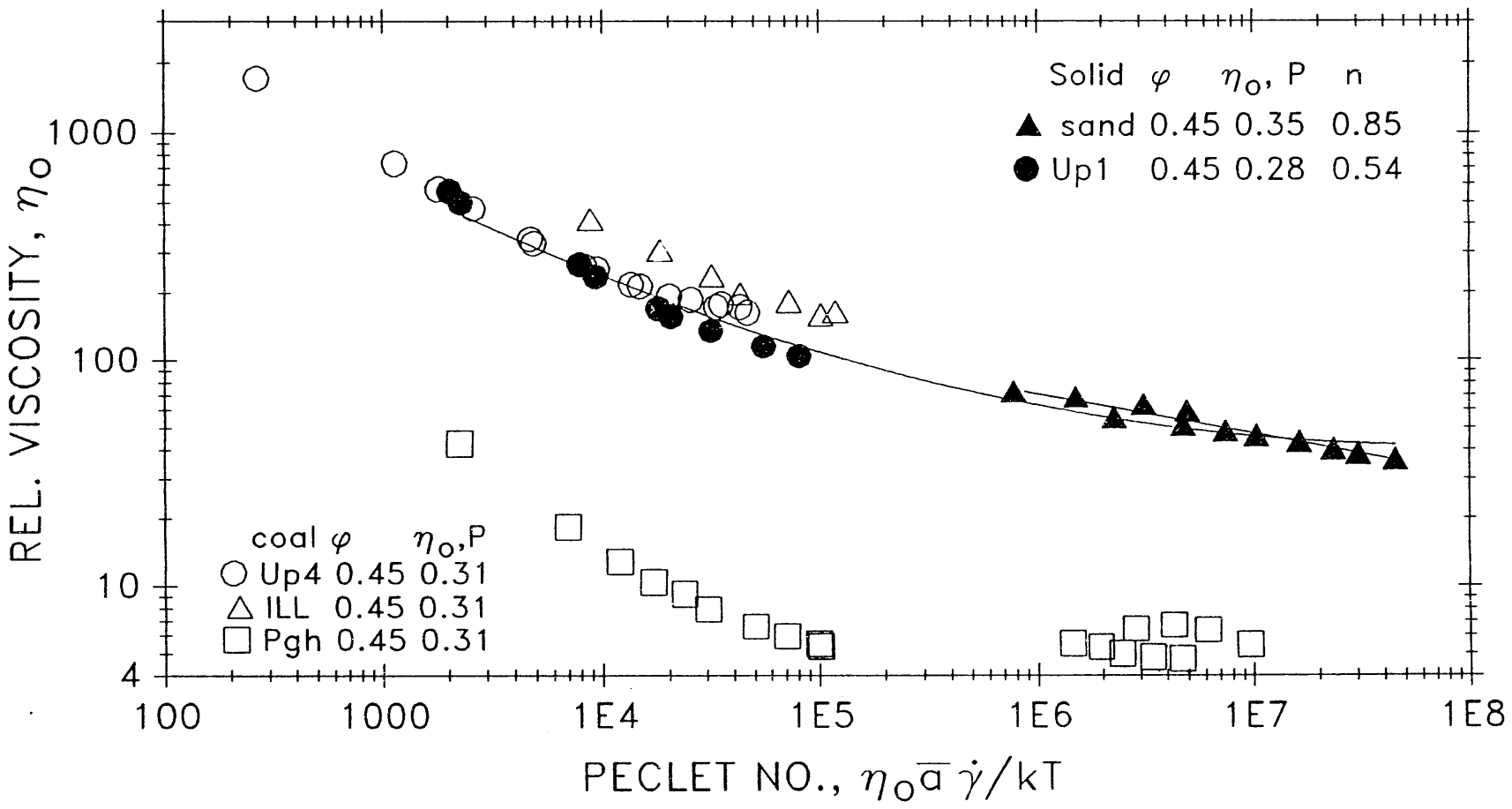

Fig. 2.

CWS45. PAC
CWS45. GF
Pgh45
Up45
ILL45

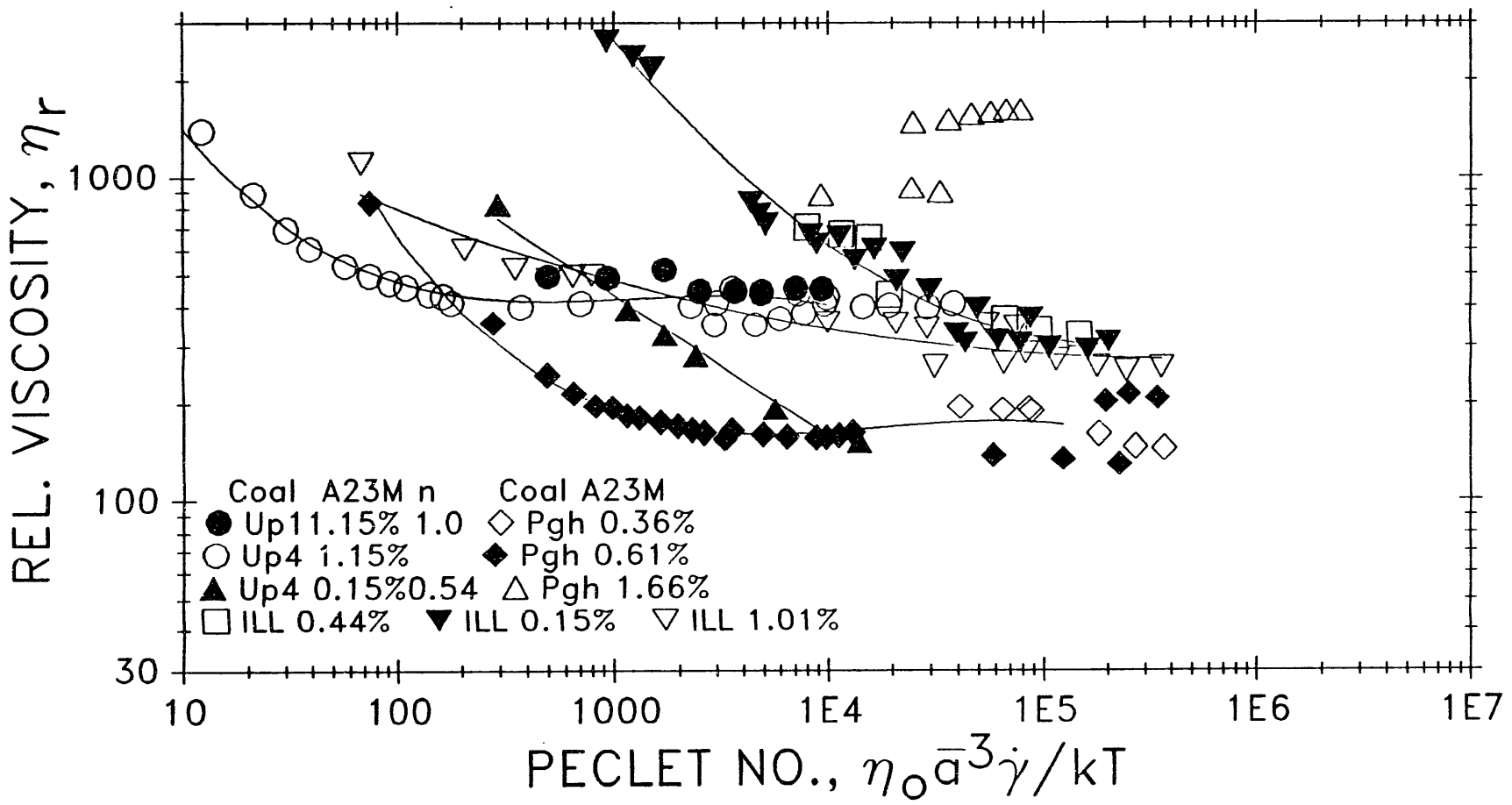

Fig. 3

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