Fine Coal Refuse Slurry: Influence of Background Chemistry on Viscosity

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Abstract

Fine coal refuse is a by-product of the coal mining process. A flocculant is added to the material to accelerate consolidation. However, the flocculant addition changes the effective grain size distribution.

This material was collected as a suspension from the coal mine without alterations for testing purposes. The solids in the suspension were approximately silt-sized (~mm).

The purpose of this study is to investigate the influence of the supernatant chemistry and solids content on the rheological properties of fine coal refuse slurries. Coal refuse at different concentrations was mixed with various background solutions: as-received supernatant, distilled water, and a dispersant. The viscosities of these mixtures measured over a range of rotational speeds with time. All suspensions were observed to have shear-thinning to near-Newtonian behavior.

Research Objective

Identify the suspension conditions which lead to either flocculation (shear-thinning) or dispersion (near-Newtonian) as a function of solids content and background solution.

Materials

- Kaolin Clay – used as a comparison material
- Coal Refuse Slurry – as-received from local site. Solids content = 0.0132.
- Background solutions – Dispersant made from sodium hexametaphosphate (mg/L), as-received supernatant solution, and distilled water (DW).

Figure 1. Fine coal refuse slurry at discharge pipe

Background

Viscosity measurements as a function of shear rate may be used to infer particle-level interactions, whether the suspended particles are flocculated or dispersed.

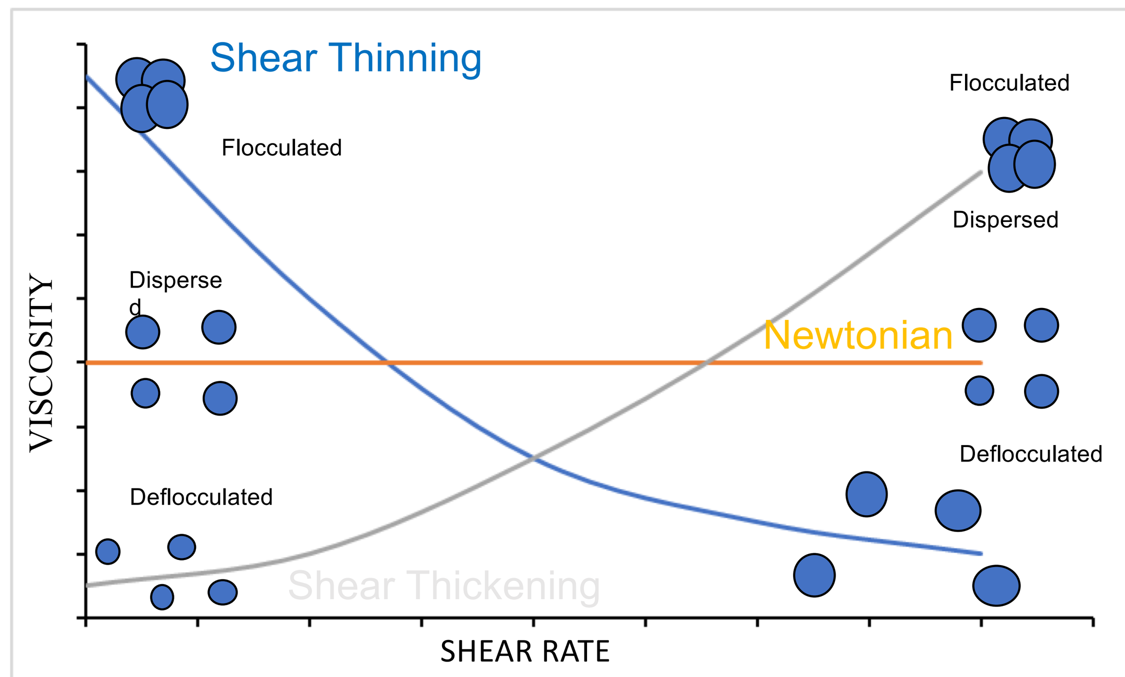

Figure 2. Suspension viscosity as a function of shear rate.

Previous work has shown (Palomino & Santamarina 2005):

- Flocculated kaolinite particles undergo shear thinning when shear rate is increased.
- Dispersed kaolinite particles show near-Newtonian response to increasing shear rate.

We hypothesize that coal refuse exhibits similar properties to kaolinite, i.e. exhibits shear thinning behavior when flocculated (supernatant) and near-Newtonian when dispersed (dispersant).

Methodology

- Solids Content, SC = $\frac{Volume\ of\ Solids}{Total\ Volume\ of\ Suspension}$
- Solutions were created with background solutions of
  - Distilled Water (DW)
  - Dispersant
  - Supernatant (decanted from the as-received slurry)
- From each slurry + background solution, solutions with varying solids content were made:
  - 50% solids content (.0066)
  - 100% solids content (0.0132)
  - 150% solids content (0.0198)
- The volume of each solution was 500 mL and tests were conducted in a 500 mL beaker.
- Viscosity of these solutions was measured at t=1 minute at 5 rpm to 100 rpm.

Figure 3. DV II + viscometer. (www.labwrench.com)

Results

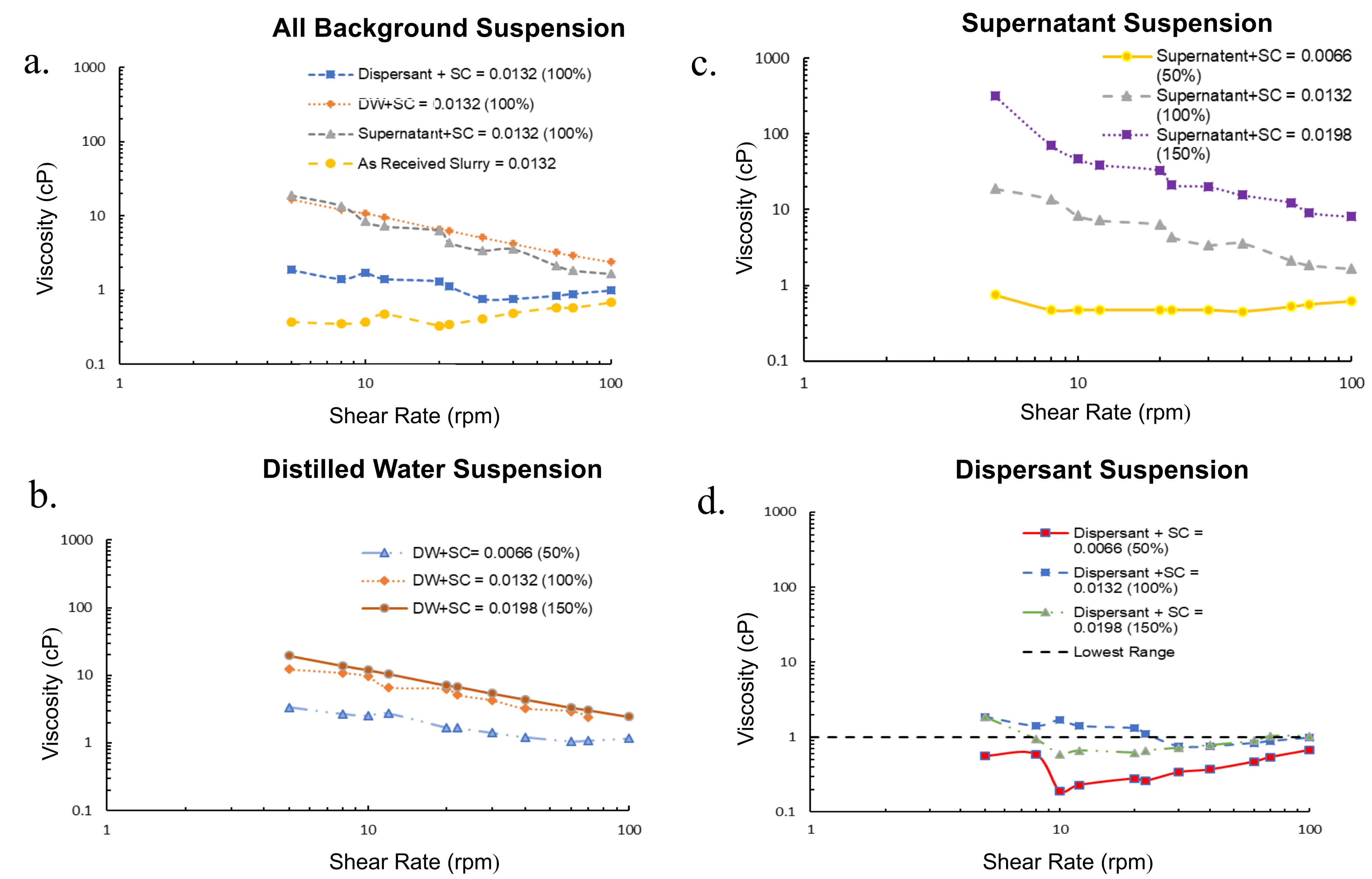

Figure 4. Viscosity measurements of test suspensions using Spindle LV1.

Discussion and Conclusions

In this study, we hypothesized that (**H1**) the relative viscosity measurements in order of increasing suspension viscosity would be dispersant solution, distilled water and supernatant solution; (**H2**) the viscosity of each suspension increases with increasing solids content; and (**H3**) the supernatant suspension and possibly the distilled water suspension would exhibit shear thinning behavior (decreasing viscosity with increasing shear rate), while the dispersant suspension would exhibit near-Newtonian behavior.

H1. Fig. 4a. The shear response observed for the supernatant and distilled water cases were similar to each other, but greater than the dispersant case for the tested shear rate range. This indicates that the particles/flocs in the supernatant/distilled water cases influence the measured viscosity more than the particles in the dispersant case. In other words, the flow unit size for these two cases is greater than that of the dispersed case. Note that the as-received FCR suspension exhibited near-Newtonian to shear-thickening response. Thus, the measured shear response of the suspensions was slightly different than the predicted behavior.

H2. Fig. 4b-4d. We observed increasing viscosity with increasing solids content over the range of applied shear rates for the supernatant and distilled water cases. However, for the dispersant solution, the viscosities of the solutions were less than the measurable range of the viscometer such that the measurement accuracy could not be maintained. Regardless of solids content, the viscosity measurements were within a very narrow range.

H3. Fig. 4b, 4c, and 4d. We observed the dispersant solution approaching near Newtonian behavior over a narrow range of viscosities. The supernatant suspensions also exhibited near Newtonian behavior at the lowest solids content range. However, all other cases of supernatant suspensions exhibited shear thinning behavior, indicating an initially flocculated suspension. Distilled water suspensions exhibited shear thinning behavior in all solids content cases.

References

Palomino, A.M. and Santamarina, J.C. (2005). "Fabric Map for Kaolinite: Effects of pH and Ionic Concentration on Behavior", *Clays and Clay Minerals*, 53(3), 209-222.

www.labwrench.com/?equipment.view/equipmentNo/4810/AMETEK-Brookfield/DV-II--Pro/