

Cast cake rheology of ash-clay

K.G. Lee, Y.T. Kim and J.H. Kim

Dept. of Mat. Sci. and Eng., Kyonggi Univ
Suwon-Si, Kyonggi-Do, Korea, 442-760

Abstracts

Dispersion and flocculation behaviors of clay-ash powders in a slurry state were examined, and we have systematically investigated the effects of colloid/interfaces variables on slip properties and the rheological behavior of ash-clay slurry. Ash-clay slurries have been characterized on the basis of the time dependent rheology which was done out by the gel-curve test. Gel-curve for the coagulated slip shows interesting rheological behavior which was caused by the formation of the new network structure and the readsorption of the polysilicon hydroxo species on the particle surfaces.

1. Introduction

Fly ashes, which are produced from coal-fired power plants and classified as general waste, can be used as raw materials for bricks and tiles because of their compositional similarity with clays. There was a limit of substituting fly ash for clay because plasticity decreased with increasing fly ash additions.[1] Accordingly, this study tried to suggest a feasibility of enhancing the substitution ratio by controlling the interfacial properties of the fly ash.

In this work, dispersion and flocculation behavior of clay-ash powder in a slurry state were examined, and we have systematically investigated the effects of colloid/interfaces variables on slip properties and rheological behavior of clay-ash slurry.

2. Dispersion-flocculation behavior

A slurry of 70 wt% fly ash and 30 wt% clay was prepared with DI water. Zeta potentials

of the ash, clay and SiO_2 are shown in Fig. 1. Both of ash and clay have the maximum zeta potential and similar surface characteristics to SiO_2 at the pH of 9~10[2,3].

Addition of Na_2SiO_3 as a deflocculant, to the ash-clay slurry, the pH of the slurry is increase to 9~10. The ash and clay particles at these range of pH have the well developed electrical double-layer(EDL)[4] and the slurry would be stable. Moreover Na_2SiO_3 plays a role of the ion exchange interactions with the divalent cations in the slurry and formation of insoluble salt[5]. Fig. 2 shows a deflocculation curve of the ash-clay slip with the apparent viscosity of slip point F and D. Slip at point F(Slip F) is a agglomerated state with a low concentration of Na_2SiO_3 and slip at point D(Slip D) is a well dispersed state.

With the introduction of CaSO_4 into slip D(well dispersed), the viscosity rise of the slurry has been detected, which is shown in Fig. 3. Addition of CaSO_4 increases the electrolyte concentration in the slurry by the Schultz-Hardy law and caused the electrical double-layer compression, rendering deflocculant addition useless. Slip at point C(Slip C) is a coagulated state.

Fig. 4 and 5 are transmission electron micrographs of the fly ash. Lange[6] found that the salt did change the dispersed network to an attractive network, but this new attractive network was not cohesive. That is, unlike a flocculated network, the particles in this new network could easily be rearranged. As the quantity of the CaSO_4 increasing, networks are formed between the particles and became gellation caused by the readsorption of the polysilicon hydroxo precipitates which dissolved from ash and clay[7]. The morphology of cenosphere particles in fly ash has clear surface shown in Fig. 4. But the cenosphere particles in slip D are coated by Na_2SiO_3 as shown in Fig. 5.

3. Rheological behavior

Ash-clay slurries have been characterized on the basis of the time dependent rheology which was done out by the gel-curve test. A Brookfield viscometer is used at 0.5rpm and is initiated at time=0 immediately after agitation of the slip ; viscometer measurement is done for 15 minutes, the motor is switched off for 3 minutes and then back on for another 10 minutes. The gel curves of the Slip F, D, C are shown in Fig.6. Slip D shows a small change before and after the holding period. But, gel-curve for slip F shows rapid increase after the holding period which means the particle rearrangement by shear and a typical behavior of thixotropy. However, viscosity of the slip C increases continuously after the holding period. This is

caused by the formation of the new network structure and the readsorption of the polysilicon hydroxo species on the particle surfaces, as mentioned in the previous section.

Filtered cakes of slip F and C was fired at 1000°C. Microstructures of the fracture surface are shown in Fig. 7 and 8. The sintered body made from slip C shows a more uniform size and distributions of pore than that made from slip F.

Acknowledgement

This work was supported by Korea science and engineering foundation program grant No. 94-0300-01-3.

References

1. K.G. Lee, et. al., J. Kor. Ceram. Soc., 33(2), 135(1996)
2. J. Th and G. Overbeek, Colloid Science, Vol.1, Ed. by H.R. Kruyt, Elsevier, Amsterdam(1952)
3. W.D. Kingery, et. al., Introduction to Ceramics, Chap. 2, John Wiley & Sons (1976)
4. B. Lynskey, Thesis, Liverpool Polytechnic, (1972)
5. H.N. Cheong, et. al., Ceramic Powder Science III, 395, Ed. by G.L. Messing, etc., Am. Ceram. Soc. Inc. Ohio (1990)
6. F.F. Lange, et. al., Processing of the 11th International Symposium on Metallurgy and Materials Science, Ed. by J.J. Bentzen, etc., Denmark (1990)
7. R.K. Iler, The Chemistry of Silica, Chap. 2 and 3, John Wiley & Sons (1981)

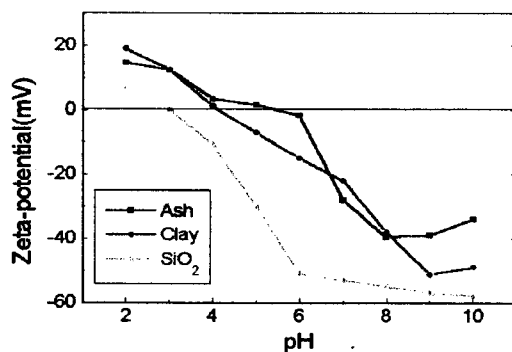


Fig. 1 Zeta-potential as a function of pH

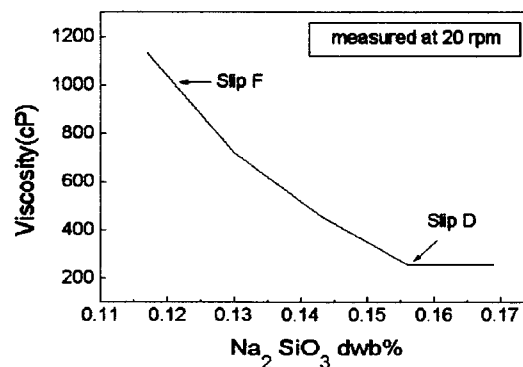


Fig. 2 Defolcculation curve of ash-clay slip with specific gravity adjusted to 1.6g/cc

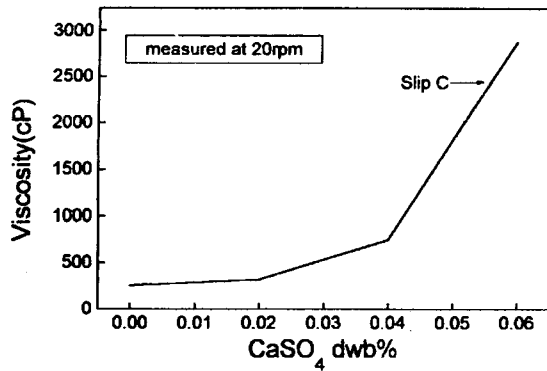


Fig. 3 Brookfield viscosity as a function of CaSO₄ level in slurry D

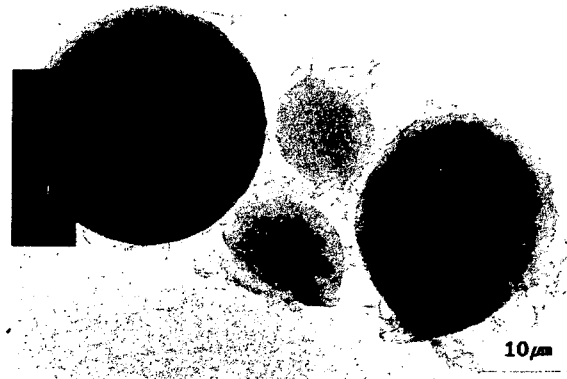


Fig. 4 TEM micrographs of cenospheres in ash

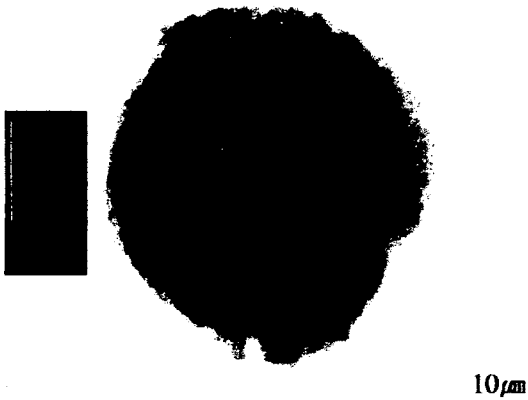


Fig. 5 TEM micrographs of cenosphere in slip D

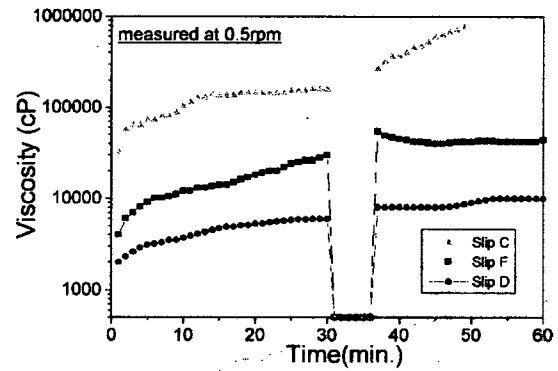


Fig. 6 Gel-curves for various slurries

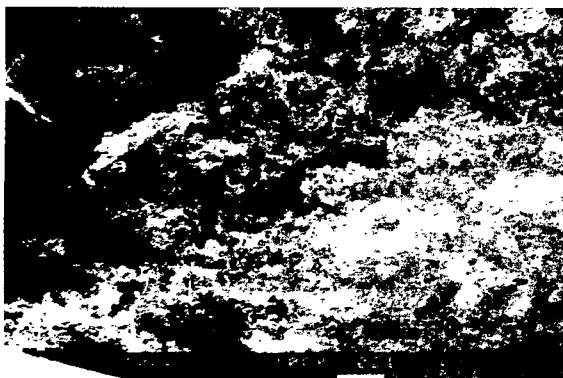


Fig. 7 SEM micrographs of fracture surface fired at 1000°C (slip F)

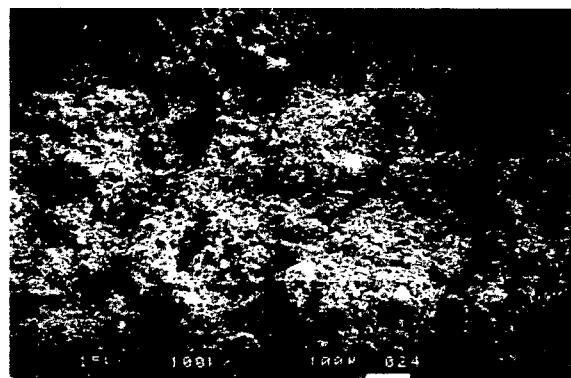


Fig. 8 SEM micrographs of fracture surface fired at 1000°C (slip C)