Asian Journal of Chemistry Vol. 16, No. 2 (2004), 928–932

Dewatering of Kaoline Wastes by Flocculation

ILGIN KURŞUN*, SAFAK G. ÖZKAN, M. FARUK ESKİBALCI, and KENAN ÇİNKU

Istanbul University, Engineering Faculty, Mining Engineering Department
34320, Avcilar, Istanbul, Turkey
E-mail: ilginkur@istanbul.edu.tr, sgozkan@istanbul.edu.tr, kenan@istanbul.edu.tr, eskibal@istanbul.edu.tr, Tel.: +90-212-473 70 69, fax: +90-212-473 70 69

Flocculation is an important sedimentation method for increasing dewatering efficiency. In this study, dewatering studies of fine grained kaoline obtained from feldspar processing plant waste at minus 20 μm in pulp was conducted to reveal flocculation properties.

Key Words: Dewatering, Flocculation, Polymer, Adsorption.

INTRODUCTION

Wastes in pulp discharged during mineral benefication generally contain around 90% water in weight. The wastes cannot be regarded as solid unless its water content is reduced to 35%. According to environmental regulations, extra cost is required if the water content is higher than 65%. Setting of fine grained minerals in the pulp by gravity forces is known as sedimentation in mineral processing. In this case, the particles in the pulp by gravitation settle according to the Newton and Stokes Laws to transform into a form containing 50–60% solid by weight[1].

During this settlement process, addition of some chemical agents makes sedimentation faster and more easy. The chemical agents are called as flocculants and they provide more efficient solid-liquid separation and less time consuming process. The particles inside suspensions formed with fine ground minerals and water move either freely or by attaching to each other inside this pulp. Both situations are not normal for the pulp, since they can be created artificially. Flocculation is a process that gathers all the particles together to form stable flocks inside the pulp or to create large enough particles to be easily filtered from the pulp[2, 3].

It is also a unit process to gain water from the waste in industrial production plants for recycling to use in future. Flocculated particles at 1 mm to 1 μm size (colloidal size) settle down very slowly due to their colloidal size and diffusion phenomena (Brown motion). In this case, forces between particles workmore effectively and play an important role for stabilisation of colloidal particles.

When two particles come too close to each other, there are various types of forces that determine the flocculation mechanism. The most important interactions are van der Waals' force and electrical forces. Although it is possible to explain the data from various flocculation experiments from this theory, there are some other situations for different types of interactions[4].

The polymers adsorbed on to surfaces of the particles may create pulsion (steric interaction) or attraction (polymer bridging); therefore it is possible to understand the flocculation mechanism by considering all types of interactions[5]. These interactions are known as: (1) van der Waals' interaction, (2) electrical interaction, (3) hydration interaction, (4) steric interaction, (5) polymer bridging.

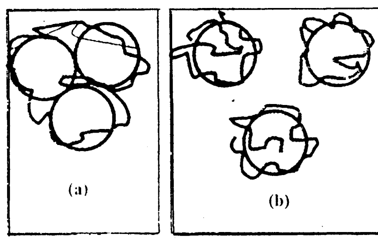

Fig. 1. (a) Polymer bridging, (b) Restabilization

EXPERIMENTAL

Materials: The sample used in the flocculation tests was collected from the fine (*ca.* 20 μm) kaoline wastes. The chemical composition of the sample is presented in Table-1. While experiments were performed the actual plant water was used in the flocculation test.

TABLE-1
CHEMICAL COMPOSITION OF THE SAMPLE USED IN EXPERIMENTS

Compound	%	Compound	%
SiO_2	66.90	K_2O	0.30
Al_2O_3	25.60	TiO_2	0.07
CaO	0.10	Fe_2O_3	1.14
MgO	0.20	LOI	4.49
Na_2O	1.20	Total	100.00

The anionic (A-130), cationic (C-528) and non-ionic (N-300) flocculants were all received from Cytec Industries Inc. and were specified to have molecular weights of $3–15 \times 10^6$, $3–4 \times 10^5$ and $3–4 \times 10^6$, respectively[6].

Methods: The flocculation tests were performed in a one litre graduated cylinder. The settling tests, apart from studies on solid concentration, were done by adding 200 g of *ca.* 20 μm material into the cylinder, mixed thoroughly and the interface height was recorded as a function of time.

Zeta potential measurements were conducted by means a Zeta Meter 3.0 which is equipped with a microprocessor unit capable of directly measuring the average zeta potential and its standard deviation. 100 mg sample was added into 100 mL of distilled water and conditioned for 10 min. The suspension was kept stationary for 3 min and the average of twenty particles was taken as the zeta potential[7, 8].

RESULTS AND DISCUSSION

Effect of pulp densities: Fig. 2 presents the height of interface in the absence of polymer as a function of time at different pulp densities as defined by per cent solids by weight. The plant water was used as the medium at its natural pH. It is apparent that as the pulp density increases the settling rate, as defined by the initial slope in the sedimentation curve and also the interface height decrease. Despite higher sedimentation rates at low pulp densities, considering both conditions at the plant and economic capacity of the operation, 20% pulp density was considered suitable for performing the subsequent flocculation tests[9]. It is also evident in Fig. 2 that most of the sedimentation occurs during the first 15 min of the settling for all pulp densities.

Effect of flocculant type and amount: Fig. 3 presents the effect of various types of flocculants on the elapsed settling time as determined by the interface height. The amount of polymer is 20 g/t for all polymers used. Compared to the anionic and cationic polymers, the non-ionic polymers yield the best settling conditions. The settling rate further increases with increasing the degree of non-ionicity.

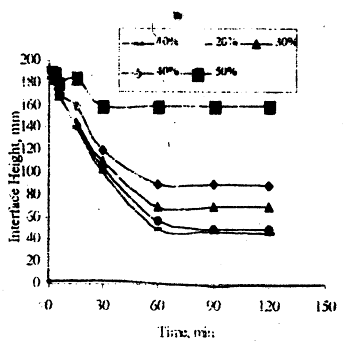

Fig. 2. Settling behaviour of *ca.* 20 μm kaoline waste against time in the absence of flocculant at different pulp densities.

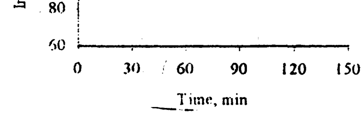

Fig. 3. Variation of interface height by use of different polymers.

Fig. 3 also further shows that the settling time is drastically reduced in the presence of polymer. Settling is almost over in less than 5 min. The same improvement was observed in the supernatant as the cloudiness was substantially reduced in the order of effectiveness shown in Fig. 2. A similar enhancement was also noted upon increasing the amount of polymer up to a certain concentration above which restabilization of the suspension was observed as reported in most flocculation studies. As the amount of flocculant with N-300 characteristics increased, the settling was improved but after 20 g/t, a stabilization was observed;

when the amount of flocculant increased to 40 g/t again with the effect of destabilization a worsening in the flocculation conditions was observed (Fig. 4).

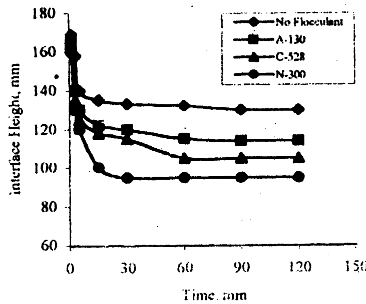

Fig. 4. Effect of the polymer amount (natural pH, N-300).

Effect of pH: Kaoline, as most other clay minerals, exhibit negative zeta potentials throughout the practical pH range 2–12. The zero point charge (zpc) of kaoline should be below pH 2, as shown in Fig. 5. Fig. 6 exhibits the settling behaviour of kaoline in the absence and presence of polymer as a function of pH. It is clear that due to scattering, no significant effect of pH is apparent both in the presence and absence of polymer.

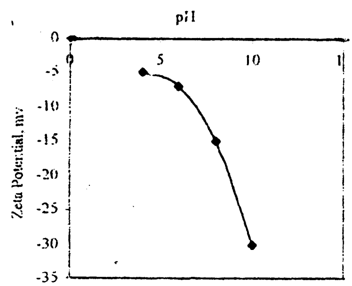

Fig. 5. Zeta potential measurement.

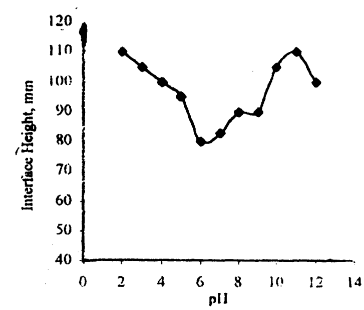

Fig. 6. Settling behaviour of *ca.* 20 μm kaoline waste versus pH (settling time: 5 min., polymer concentration: 5 g/t).

Conclusions

This study aimed at determining flocculation characteristics of *ca.* 20 μm waste kaoline. The conclusions reached are as follows:

During the experiment if it observed that as the solid fraction increased in the pulp, the settling was worse. The best settling ratio is found at 20% solid fraction in pulp. Therefore the best fitted solid fraction in pulp is assumed to be 30% and experiments were carried out based on this value. The sedimentation took place very fast in the first 15 min. As, no flocculants were used in these experiments clear water layer, at the top, is observed only in quite low solid fractions. As the solid concentration increased, more particles settled and the suspension settling speed decreased compared to a single particle under hindered settling conditions.

The best result was obtained with N-300 flocculants. As the amount of flocculants with the nonionic characteristic increased, the settling was improving but, after 20 g/t, a stabilisation was observed, when the among of flocculation increased to 40 g/t; again with the destabilisation, a worsening in the flocculation conditions was observed.

Effect of pH in flocculation of the sample was investigated during this group of experiments. The experiments were carried out using 20 g/t, N-300 polymer type, 20% solid fraction in pulp. Flocculation characteristic of the sample is better in natural pH values.

REFERENCES

1. K.J. Ives, in: Ladislav Svarosky (Ed.), Coagulation and Flocculation Solid-Liquid Separation, 3rd Edn. (1990).
2. I. Kurşun, Y. Kaytaz, B. Ipekoğlu and M.S. Çelik, Flocculation Behaviour of Fine Albite Concentrate with Various Polymers, Changing Scopes in Mineral Processing, İzmir (1996).
3. W. Stumm, G. Furrer and B. Kunz, *Croat. Acta*, **58**, 593 (1983).
4. B. Yarar, in: K.L. Mittal and E.J. Fendler (Eds.), Polymeric Flocculants and Selective Flocculation in Solution Behaviour of Surfactants, Plenum Press, New York, pp. 1333–1364 (1982).
5. G. Gür, Tinkal Cevherinden Bor Tuzlari Üretiminde Safsizliklarin Flokülasyon Davranişlari, Ph.D. Thesis, İTÜ (1995) (in Turkish).
6. Cyanamid Flocculant and Dewatering Aids USA, Mining Chemical Handbook, Cyanamid (1989).
7. M.S. Çelik, S. Ahmad and H.S. Al-Hashim, *J. Petroleum Sci. Engg.*, **6**, 213 (1991).
8. M.S. Çelik and E. Yaşar, *J. Colloid Interface Sci.*, **173**, 181 (1995).
9. J. Gregory, Fundamentals of Flocculation in Critical Reviews in Environmental Control, C.R. O'Melia (Ref.), vol. 19, pp. 185–230, CRC Press Inc., London (1989).

(*Received*: 04 August 2003; *Accepted*: 15 December 2003) AJC-3293