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Effect of Various Parameters on the Dispersion of Ultra Fine Iron Ore Slurry. Part-2.

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Abstract

Among the list of dispersion parameters effect of solid concentration, slurry pH, stirring speed and time were studied in Part I for stablization of Dilband iron ore slurry. In Part II the study is extended to survey most appropriate dispersant and its optimal dose. In present study sodium silicate (SS), sodium hexametaphosphate (SHMP), sodium pyrophosphate (SPP), and ethylene-diamine-tetraacetatic-acid (EDTA) dispersants were used. The different doses of these dispersants were studied at solid concentration 7.5%, pH 10.5, stirring speed 2000 rpm, and stirring time 5min, as optimal conditions found in Part I. Marginal improvement in slurry stabilization with addition of SS, SHMP, SPP, and EDTA was noted, however EDTA found to be most effective in stabilizing the slurry as compared to others. For the different doses of EDTA, SPP, SHMP, and SS tested, the best disperse ability was obtained at concentration of 0.135%, 0.025%, 0.2%, and 1.25% respectively.

Keywords: Dilband iron ore, Polymeric dispersants, SS, SHMP, SPP, EDTA.

Introduction

The choice of a dispersant is an important parameter in stabilizing the slurry selectively and developing successful separation scheme. For selective flocculation, the selection of dispersant is more complicated since dispersant has to disperse the gangue mineral but should also act as poisoning agent so as to block polymer adsorption sites on the surface of the non-flocculating minerals.

Much of the earlier work on selective flocculation was carried out in the presence of inorganic dispersants, like SS, SHMP, SPP, and STPP. Among the organic dispersants, EDTA [1], versicol w13 [2], and polyvinyl pyrrolidone (PVP) [3], carboxymethyl cellulose (CMC) [4] have been tailored in the past two decades.

In separation systems involving clays, SHMP was found to be a better dispersant than SS due to its higher adsorption that leads to high surface charge [3]. Ravishanker et al [5] found SS as a selective dispersant in the separation of hematite and kaolinite. Drzymala and Fuerstenau [6] investigated the activation and deactivation of quartz with polyacrylic acid flocculant in the hematite-quartz synthetic slurry containing ferric ions and found that SHMP is not a selective deactivating agent compared with EDTA and potassium fluoride (KF). Alleviating the adverse effect of Ca^{2+} and Mg^{2+} ions in cationic silica flotation Iwasaki [7] observed that EDTA and STPP are more effective than SHMP dispersant. Gururaj et al [2] examined SPP to be a better dispersant for montmorillonite and illite as compared to SS, whereas versicol w13 dispersed the clay minerals more effectively and deliberately induced quicker settling rate to hematite. Colombo

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[8] observed STPP to be a better dispersant than SS in dispersing the calcite, apatite, and quartz present in the Sawawin Saudi Arabia iron ore. Although SS have been observed to be capable in dispersing the quartz present in iron ores of worldwide mines [8, 9, 10, 11], but the presence of calcite in iron ores, which is the major reservoir of calcium ions, has been noted to adversely affect the dispersing efficiency of it. On the other hand STPP performed the selective dispersion role in the same environment of Sawawin Saudi Arabian iron ore. Looking at selective dispersion role of EDTA, STPP, and SS in synthetic mixture of montmorillonite and hematite, and quartz and hematite Arol [1] observed that EDTA and STPP are more selective than SS particularly in the presence of calcium ions. Weissenborn [13] also found that STPP is more selective as compared to SS and SHMP during the selective flocculation of ultrafine iron ore with starch.

Literature reveals that when natural ores, consisting of one or more finely disseminated gangue particle in ore body, are grinded then coating of soft mineral over hard mineral take place. In result selective role of dispersants for particular gangue mineral(s) is lost because surface distinguish ability for dispersant now no more remains. Therefore in the dolomite-silica system and the apatite-dolomite system the use of SHMP and SS during wet grinding did not recovered the selectivity loss [3].

Materials and Method

Chemicals

Sodium Hexameta phosphate ($Na_6P_6O_{18}$), Sodium Silicate (Na_2SiO_3), Sodium Pyrophosphate ($Na_2P_2O_7$), and Ethylene-diamine-tetraacetatic-acid ($C_{10}H_{16}N_2O_8$) were used as dispersants. SHMP, SS, SPP, and EDTA are the abbreviations used for the dispersants sodium hexameta phosphate, sodium silicate, sodium pyrophosphate, and ethylene-diamine-tetraacetatic-acid respectively. All the dispersants of technical grade were provided by Merck, Germany. Stock solutions of these dispersants, having the concentration of 5mg/ml, were prepared in double distilled water. 1M NaOH, and 1M HNO_3 solutions were used as pH modifier.

Material

Dilband iron ore sample of <38μm size fractions achieved by stage wet grinding in ball mill were used in the present study. Mineralogical study revealed that Dilband iron ore is mainly composed of 46.27% hematite, 17.41% quartz 14.47% calcite, 9.24% Chlinochlore, 10.5% kaolinite, and 1.75% fluorapatite minerals [14].

Particle size analysis

Horiba Laser Scattering Particle Size Distribution Analyzer (LA-300) was used for Particle size distribution of feed ore as well as sediment of dispersion tests. Before measuring the size distribution, sample was sonicated for 2 min in sample chamber.

Dispersion test procedure

The effect of different dispersants on the stabilization of iron ore slurry was studied by conducting the dispersion tests in 2000ml separating flask. Slurry of 7.5% solids by wt was agitated at 2000rpm for 5min while maintaining the pH value at 10.5. Desired dispersant dose was added to the slurry prior to agitation. Thereafter slurry was transferred immediately into separating flask and re-agitated for 1 min. Then sedimented material was collected in subsequent time intervals and dried at about 100^{o}C in oven. After weighing the sedimented material the particle size distribution and elemental analysis was performed.

Results and Discussion

The effect of solid concentration, slurry pH, stirring speed, and stirring time was studied in Part-1 [15]. The results of effect of different dispersants and their respective doses on slurry stabilization are discussed below.

Effect of ethylene-diamine-tetraacetatic-acid (EDTA)

Among seven concentration levels of EDTA tested (Fig. 1), the best disperse ability was obtained at EDTA concentration of 0.135% (wt/wt). At this concentration of EDTA, the minimum sediment wt% along with minimum %

entrapment of fine particles were observed. Increasing trend in sediment wt% and % entrapment of fine particles on both sides of this concentration is observed.

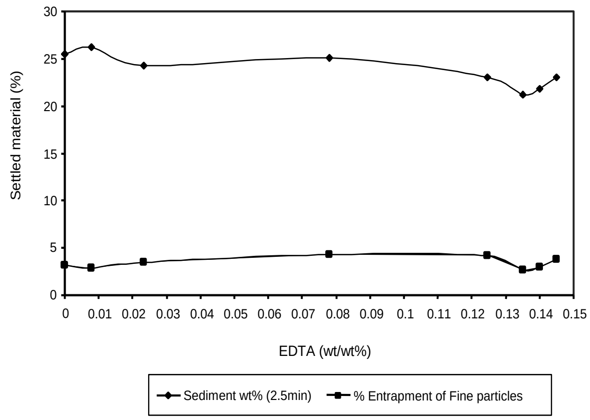

Figure 1. **Effect of EDTA concentration on stabilization of <38 µm Dilband iron ore slurry.**

Decreasing trend in sediment wt% with increasing EDTA concentration indicate that removal of calcium ions from the mineral surfaces would have been resulted, since EDTA is widely accepted as calcium complexing agent. Evidently decrease in % entrapment at 0.135% EDTA dose further confirmed the hypothesis of EDTA complexation with the calcium and magnesium ions present in ore. Whereas increasing trend in sediment wt% beyond 0.135% EDTA might be due to depletion forces resulting from osmotic effect taking place by the removal of free EDTA molecules.

Effect of sodium silicate (SS)

In case of SS five concentration level were tested (Fig. 2). Among theses concentration levels minimum sediment wt% observed at 0.05% (vol/wt).

The use of sodium silicate indicated that complexation tendency with calcium and magnesium ions present in pulp increased with increasing the concentration of silicate ions, and reached to peak level when the concentration of sodium silicate was 0.05%. Since silicate ions posses strong affinity with calcium ions, and precipitation of highly negative charged calcium silicate complex on the goethite, hematite and quartz is reported [14], therefore with increasing sodium silicate concentration the precipitation of calcium silicate complex on the mineral surface can be speculated. At 0.1% concentration, precipitation of calcium silicate might be completed and reached to peak value where detachment from the mineral surface would have been taken place by electrostatic repulsion mechanism and become the cause of pulp dispersion. Decreasing trend in % entrapment with increasing concentration of sodium silicate is supporting evidence for the above hypothesis. With further increase in sodium silicate the increase in sediment wt% indicate that sodium silicate acts as indifferent electrolyte. Increase in % entrapment after 0.05% confirmed the indifferent electrolytic behaviour of sodium silicate.

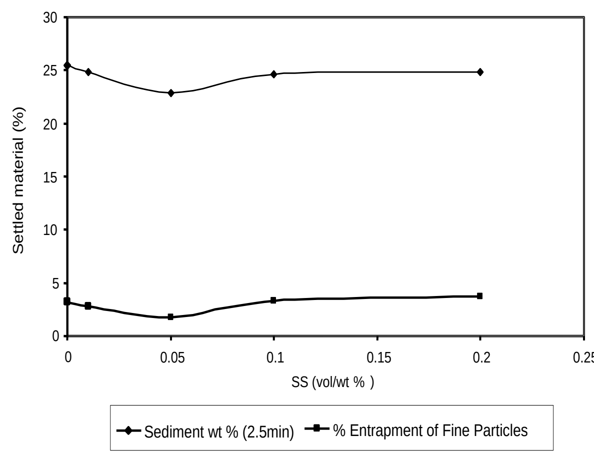

Figure 2. **Effect of SS concentration on stabilization of <38 µm Dilband iron ore slurry.**

Arol [1] has attributed the dispersion role of sodium silicate to the concentration of silicate ions at particular dose. Depending on the concentration of silicate ions the nature of the ions may be monomeric, multimertic or polymeric. In case of multimeric nature sodium silicate is believed to act as indifferent electrolyte rather than dispersant. Therefore it is quite possible that above 0.1% concentration indifferent electrolytic behaviour of sodium silicate due to its multimeric nature would have resulted. Keeping in view the charge screening action of sodium ions, when their concentration increase beyond certain limit, hetrocoagulation could also be speculated to takes place after 0.1% of sodium silicate.

Effect of sodium polyphosphate (SPP)

Similarly effectiveness of SPP on the stabilization of slurry was investigated. Among the six doses of SPP (Fig. 3), the minimum sediment wt% was observed at 0.025%.

When SPP was used as dispersing agents in the present work, it was found that sediment wt% decreased with increasing concentration of pyrophosphate ions (Fig. 3). Since SPP belongs to similar broad family of poly phosphate dispersants to which STPP belongs, so decreasing trend in sediment wt% could be attributed with increase in soluble complexation tendency of calcium and magnesium ions in similar way to that reported for the STPP [1]. Above 0.024% SPP increase in sediment wt% indicate that amorphous calcium poly phosphate complex might be precipitating on the mineral surface and causing the decrease in repulsive forces. It is also possible that SPP, by possessing polyelectrolyte character like STPP, at higher concentration would have caused the de-stabilization through charge-patch mechanism where individual molecules adsorb on the surfaces forming localized region of opposite charge. Whereas increase of STPP plateau in sediment wt% after certain dose could be attributed with the plateau in zeta potential observed by Arol [1].

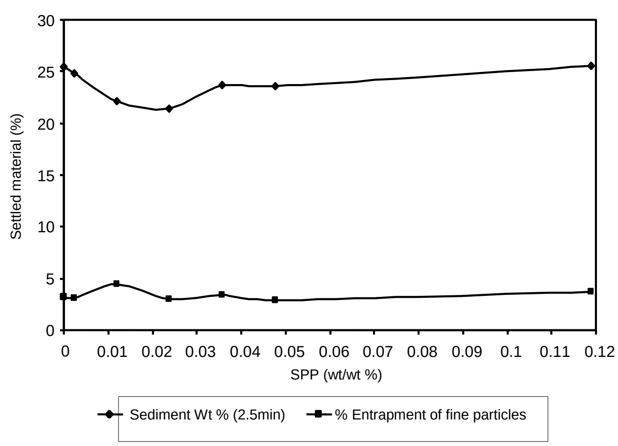

Figure 3. **Effect of SPP concentration on stabilization of <38 µm Dilband iron ore Slurry.**

Effect of sodium hexametaphospahte (SHMP)

Investigating the effect of SHMP, seven concentration levels were tested (Fig. 4). Similar to SPP, SHMP belongs to poly phosphate dispersant family therefore decreasing trend in sediment wt% with increasing SHMP indicate that dissolution of calcium poly phosphate complex is matured when the concentration of SHMP is reached to 0.2% and 1.5% in first part and second part of study. The significant change in the % dose between the SHMP used in first part and second part may be regarded to the grade of the dispersant like EDTA. Formation of amorphous complex above 0.2% or 1.5% might be the phenomenon behind the increasing trend in sediment wt%. It is also possible that dispersion of the slurry at optimal SHMP dose is resulted from the adsorption of phosphate ions on the mineral surfaces as reported in case of deactivation of quartz in presence of ferric ions [2]. Above optimal SHMP dose increasing trend in sediment wt% suggest that coagulation or hetrocoagulation might be taking place due to increase in ionic concentration[13].

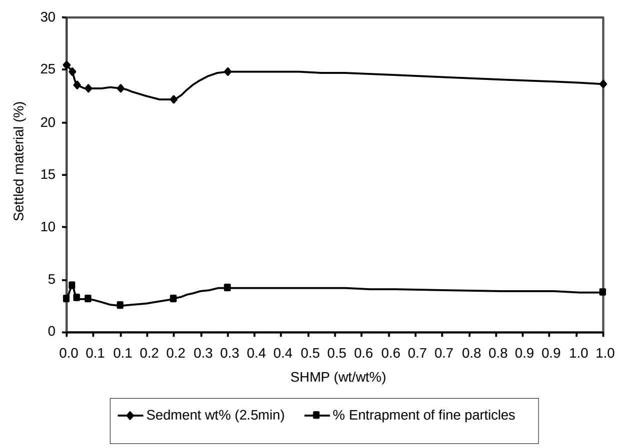

Figure 4. **Effect of SHMP concentration on stabilization of <38 µm Dilband iron ore slurry.**

Conclusion

The general conclusion drawn from dispersion tests is that:

- The optimum doses of the EDTA, SSP, SS, SPP, and SHMP dispersants were found to be 0.135%, 1.25%, 0.05%, 0.024%, and 0.2% respectively.
- At optimal doses of dispersants the difference in sediment wt% and % entrapment was very marginal.
- Thus selection of most effective dispersant could not made. Therefore it would be quite reasonable to evaluate their effect during flocculation stage.

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