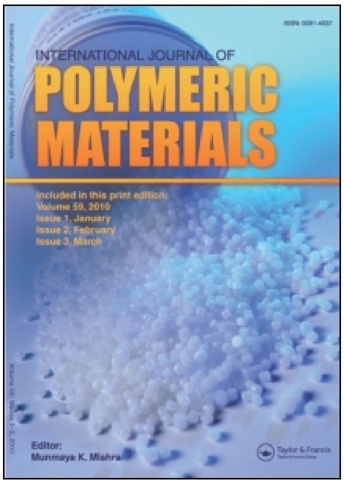

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The Effect of Polymeric Flocculants on Settling and Filtration of Iron Ore Slimes

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During the wet processing of iron ores, a substantial amount of fine particles known as slimes are generated in downstream which need to be recovered effectively for their usage and beneficiation. Besides water from slime ponds overflow remains contaminated with very fine particles which are difficult to settle and cause environmental pollution when contaminated water is discharged to the downstream river. The settling behaviour in the slime pond gets affected in particular when ore contains hydrated oxides. The above problems necessiatate to study the settling and filtration behaviour of the slimes by means of effective flocculants. The flocculants namely, amylopectin-g-polyacrylamide (Ap-g-PAM), sodium alginate-g-polyacrylamide (SAG) were synthesized by graft copolymerization using redox initiated catalyst. The high molecular weight flocculants, namely, magnafloc (1011) superfloc (N 300) were used for comparative studies. The present paper reports the settling and filtration behaviour of iron ore slimes.

The experiments show that sedimentation rate increases with increasing flocculant dose upto a certain limiting value. The settling rate decreases with increasing the pulp density. The volume of filtrate increases with increasing flocculant dose. The filtration efficiency of synthesized polymer is comparable with the commercial one, *i.e.*, magnafloc (1011) at natural pH.

Keywords: Flocculants; iron ore slimes; settling; filtration

INTRODUCTION

Water soluble starch and polyacrylamides with various ionicity play a considerable role in solid-liquid separation related to mineral

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processing and red mud treatment [1–3]. Flocculation of mineral suspensions using polyacrylamides and polysaccharides has been well investigated [4–6]. It has been established that while starch is biodegradable, polyacrylamide degrades on shearing [7]. In order to eliminate these draw backs, various graft copolymers have been synthesized at Materials Science Centre, Indian Institute of Technology, Kharagpur by grafting polyacrylamide chains on polysaccharides using redox initiated solution polymerization technique [8]. Previous studies have established that these synthesized graft copolymers are more efficient turbulent drag reducers and have better flocculation characteristics than the commercially available flocculants [9, 10]. In the present investigation, these flocculants alongwith commercial ones have been used to investigate the settling and filtration characteristics of iron ore slimes.

EXPERIMENTAL

In the present investigation, the settling and filtration studies of iron ore slime from Joda mines of M/s. TISCO Ltd., situated in Singhbhum district of Bihar (India) were conducted by laboratory synthesized flocculants and commercial flocculants. Following flocculants were used

i. Magnafloc (1011) was procured from M/s. Allied Colloids Ltd., U.K.
ii. Super floc (N-300), DOW Chemicals, USA.
iii. AP-g-PAM, SAG, CMC-g-PAM[CAm 1], and SAM-II were synthesized at Materials Science Centre, IIT, Kharagpur (Tab. I).

TABLE I Synthesis details of graft copolymers

Polymer	*Polysaccharide (gms)*	*Acrylamide (mole)*	*CAN (mole × 10⁴)*	*%ᶜ conversion*	*Intrinsic viscosity (η) dL/g*
SAG-I	2.5	0.12	1.003	83.76	6.75
SAG-II	2.5	0.12	2.006	84.58	6.63
Ap-g PAM 2	2.5	0.21	2.006	90.95	6.95
CAm 1	1.0	0.14	0.500	29.60	1150
SAM-II	1.0	0.14	0.300	88.69	820

[c] Percentage conversion is calculated from the relation: % conversion = [{wt. of graft copolymer - wt. of polysaccharide}/amount of acrylamide] × 100.

Settling Test

The settling test following the flocculation of the particles was carried out in a 100 ml graduated cylinder by recording the movement of the suspension liquid interface as function of time. By varying solid concentration and flocculant dose, the consequent effect on settling and filtration was studied.

Filtration Test

The filtration was studied by observing the amount of filtrate passing through a memberane as function of time. The effects of varying solid concentration and flocculant dose were studied. The same flocculants were used for filtration tests.

RESULTS AND DISCUSSION

In this investigation, the suspensions of iron ore slime were taken. The particle size distribution was measured by Malvern Particle Size Analyser using gravity mode. Figure (1) shows its average size is 38.80 micron.

Settling Studies

Simple plots of height of interfaces versus time are shown in Figure 2. The effect of varying amount of flocculant is indicated in the same figure, using magnafloc (1011) in the suspension of iron ore slime of pulp density 10%. It is reported as ppm solid/solid weight basis for all sets of experiments. An increase in settling rate with increasing amount of flocculant in the suspension is due to the fact that with increasing the flocculant dose, more numbers of amide and hydroxyl groups are available to be adsorbed on the particles and to make bridges with them [11]. The above effect is also manifested when the pulp density is 15% (Fig. 3) and 20% (Fig. 4).

At 10 ppm, flocculant dose and 10% pulp density, the performance of AP-g-PAM, CMC-g-PAM and SAM-II was better than other commercial flocculants which is shown in Figure 5.

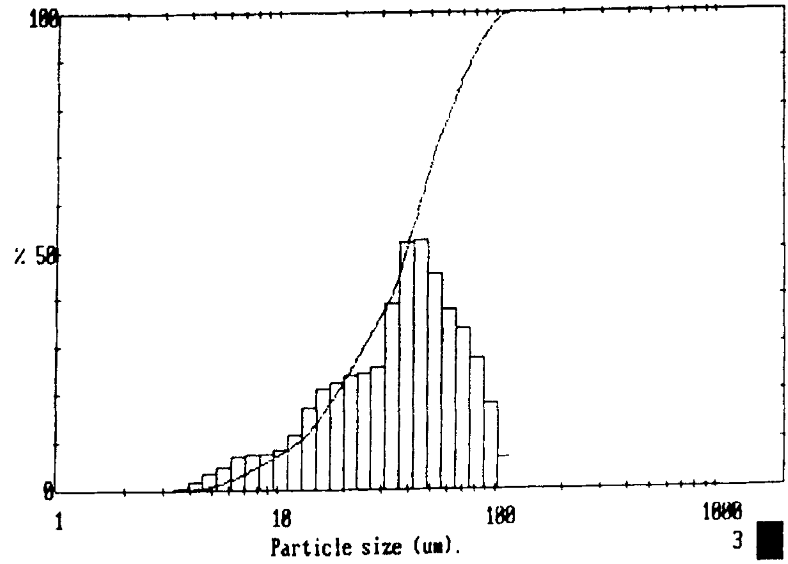

FIGURE 1 Particle size of iron slimes.

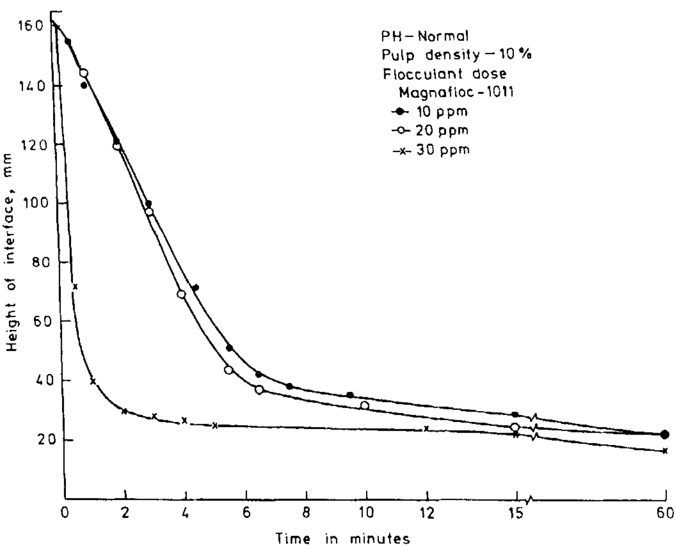

FIGURE 2 Variation of height of interface with time using magnafloc (1011) in the suspension of iron ore slimes of pulp density 10% and flocculant dose 10 ppm, 20 ppm and 30 ppm.

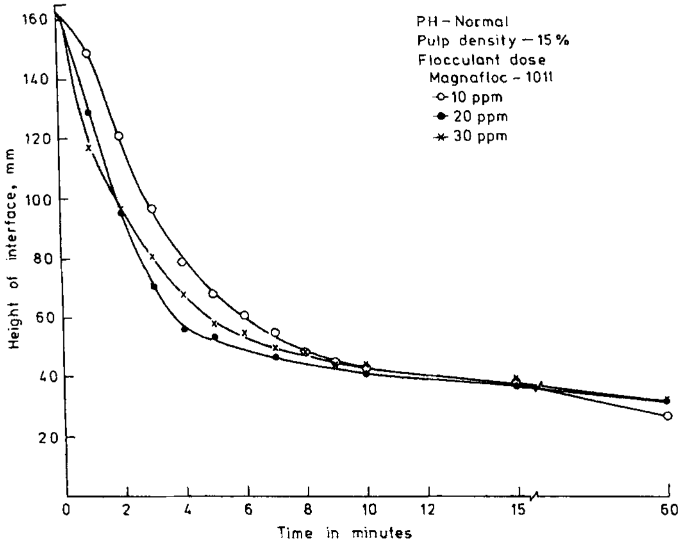

FIGURE 3 Variation of height of interface with time using magnafloc (1011) of pulp density 15% flocculant dose 10 ppm, 20 ppm and 30 ppm.

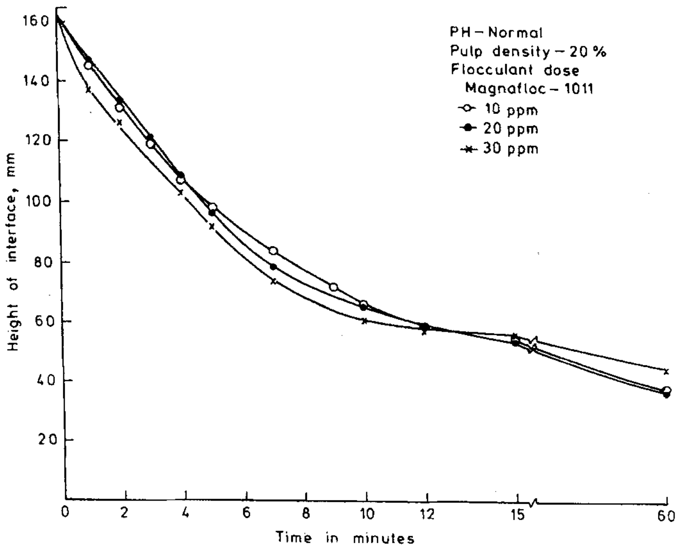

FIGURE 4 Variation of height of interface with time using magnafloc (1011) of pulp density 20% and flocculant dose 10 ppm, 20 ppm and 30 ppm.

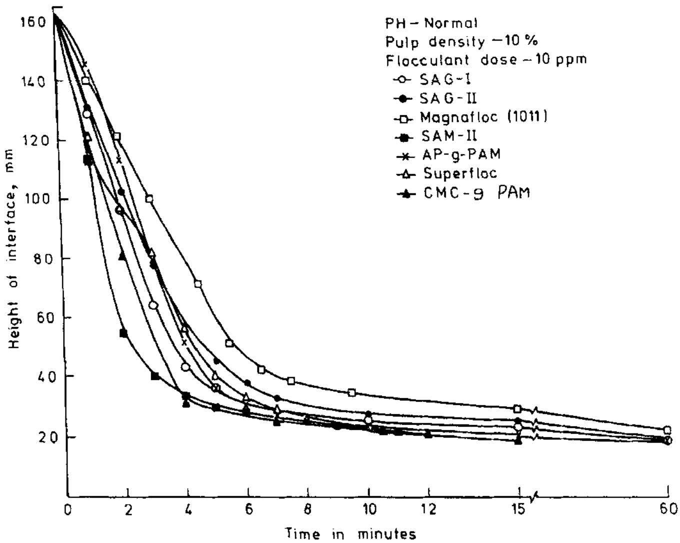

FIGURE 5 Variation of height of interface with time at 10 ppm flocculant dose and 10% pulp density using various polymeric flocculants.

Greater settling rate of particles was observed using magnafloc (1011) when flocculant dose was 30 ppm and pulp density 10% than that using AP-g-PAM, and SAM-II which is shown in Figure 6. Effect of pulp density on initial settling rate at 30 ppm flocculant dosage is shown in Figure 7. It is apparent from this figure that the initial settling rate decreases with increasing pulp density. Under the hindered settling condition, there happens to be several forces which affect the settling rate of particles. A decreasing rate in settling is generally observed at higher pulp density due to a greater buoyancy forces as well as lesser ease of liquid trickling through the particles [12]. Figure 8 shows the variation of settling velocity with flocculant dose.

It is understandable since certain amount of polymer is required for adsorption followed by bridging of the particles. The larger adsorbed amount of polymer enhances the stability by steric stabilization. In such cases as the particles approach sufficiently close to each other, the interpenetration of the chains takes place. Since the polymer chains are hydrated, overlap of the layers would cause some dehydration. Hence,

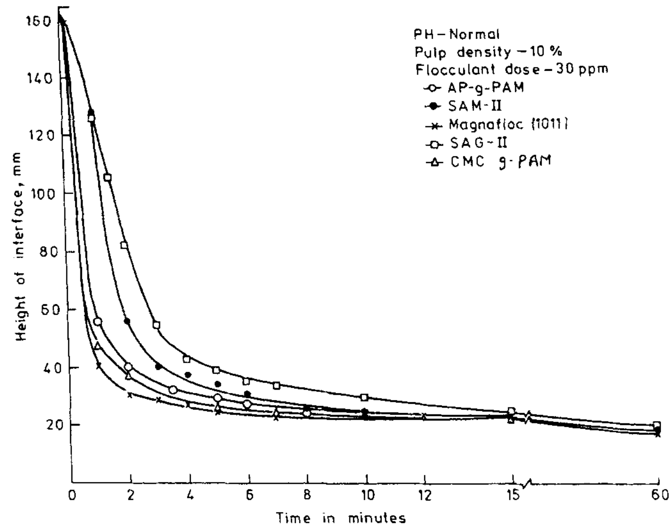

FIGURE 6 Variation of height of interface with time at 30 ppm flocculant and 10% pulp density using various polymeric flocculants.

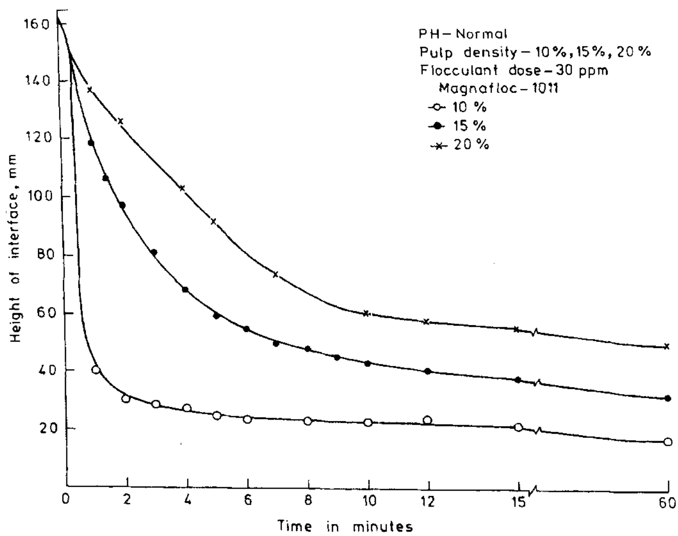

FIGURE 7 Variation of height of interface with time using magnafloc (1011) at 30 ppm flocculant dose and 10%, 15% and 20% pulp density.

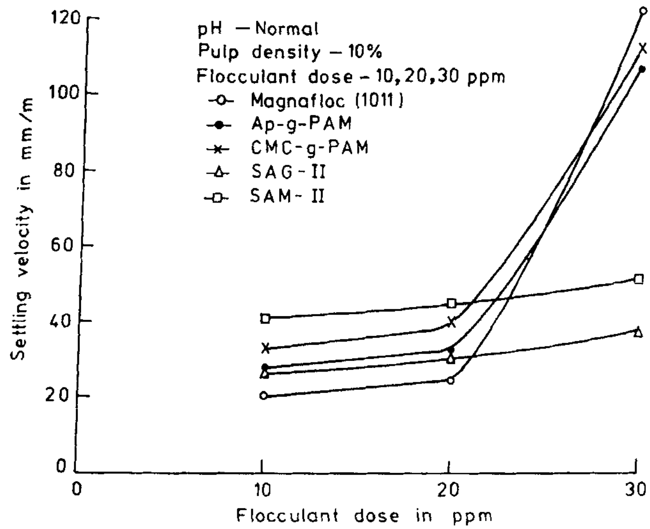

FIGURE 8 Variation of settling velocity with flocculant dose using various polymeric flocculants.

TABLE II Variation of maximum settling velocity with flocculant dose

Flocculant	*Flocculant dose*	*pH*	*Pulp density*	*Settling velocity*
Ap-g-PAM	30 ppm	Normal	10%	107 mm/m
SAM-II	30 ppm	Normal	10%	51 mm/m
SAM-II	20 ppm	Normal	10%	45 mm/m
SAM-II	10 ppm	Normal	10%	41 mm/m
Magnafloc(1011)	30 ppm	Normal	10%	122 mm/m
SAG-II	30 ppm	Normal	10%	37 mm/m
Magnafloc(1011)	30 ppm	Normal	15%	42 mm/m
Magnafloc(1011)	30 ppm	Normal	20%	22 mm/m
AP-g-PAM	20 ppm	Normal	10%	32 mm/m
Magnafloc(1011)	10 ppm	Normal	10%	20.6 mm/m
Magnafloc(1011)	20 ppm	Normal	10%	23 mm/m
AP-g-PAM	10 ppm	Normal	10%	28 mm/m
SAG-II	20 ppm	Normal	10%	30 mm/m
SAG-II	10 ppm	Normal	10%	27 mm/m
CMC-g-PAM	30 ppm	Normal	10%	112 mm/m
CMC-g-PAM	10 ppm	Normal	10%	33 mm/m
CMC-g-PAM	20 ppm	Normal	10%	40 mm/m

an increase in free energy and a repulsion between two particles takes place which ultimately results in the stabilization of the colloidal system [13].

Filtration Test

Like settling, filtration is also influenced by solid concentration type, amount of flocculant and pH *etc.* However, the flocculant dose giving optimum result in case of settling may not give same result in case of filtration as the requirements for settling and filtrations are different. Figure 9 clearly shows the increase in volume of filtrate at the flocculant dose is increased due to better flocculation at higher concentration of the flocculant. The effectiveness of SAM-II [12] is compared with SAG-II and magnafloc (1011) at normal pH which is shown in Figure 10. It is clearly indicated that the performance of SAM-II is much better than SAG-II and magnafloc (1011) at normal pH. It is observed that filtration rate increases sharply with the higher flocculant doses. This is because of the increase in bed porosity (loosely packed bed as a result of better flocculation) [11]. The increase in the filtration rate with increasing amount of the flocculant in the suspension is due to the fact that with increasing the flocculant dose, a

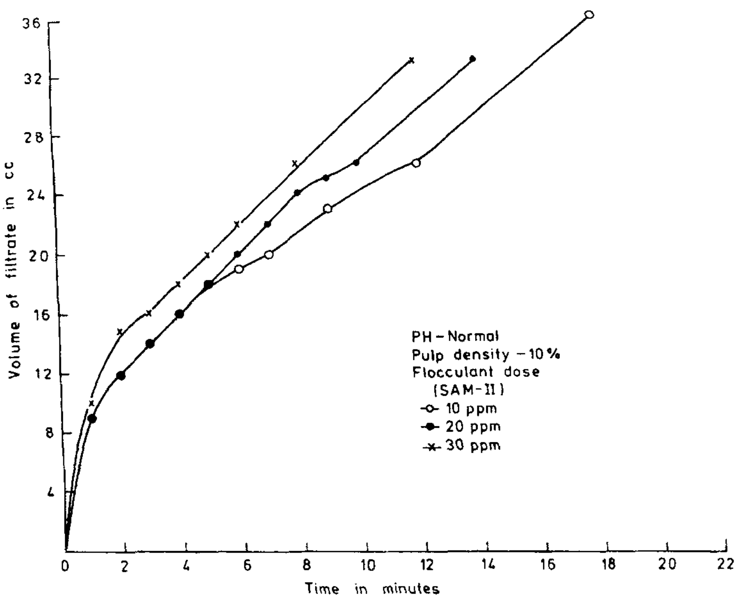

FIGURE 9 Variation of total volume of filtrate with time using SAM-II at 10 ppm, 20 ppm, 30 ppm flocculant dose and 10% pulp density.

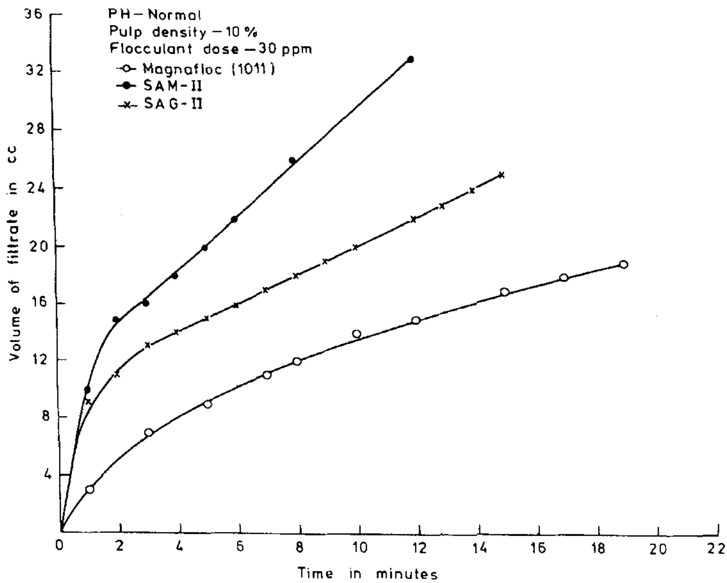

FIGURE 10 Variation of total volume of filtrate with time at 30 ppm flocculant dose and 10% pulp density using magnafloc (1011), SAM II and SAG II.

large number of functional groups are available to be adsorbed on the particles and form bridges with them.

CONCLUSION

The settling rate increases with increase in the flocculant dose upto a certain limiting value, after which the improvement is marginal. The volume of filtrate increases with increasing flocculant dose, after which the improvement is marginal. This phenomenon suggests an optimum level for the sedimentation/filtration following floculation. The settling rates decreases with increasing the pulp density.

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