Solution of Clean Water Problem of Özberil Coal Washing Plant with Acrylamide Copolymer Flocculants

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ABSTRACT: Washing plant belonging to Ozberil Mining Co (Denizli Kale) has a capacity of 50 t/h and coal is washed with heavy media separation to increasing its quality Five settling tanks are used m the washing plant to separate slime from water by natural sedimentation Although using tanks for the wastewater, which does not contam appreciable amount of chemical pollutant Therefore, the amount of clean water which is needed for the plant can not be obtained due to very slow settling rate of solid ingredients m the tanks

The objective of this study is to get clear water for recirculating and separating fine solids in state of easy handling Therefore, laboratory flocculation experiments were carried out with the aim of designing the wastewater treatment facility for establishing optimum sedimentation conditions in this plant After the laboratory tests, engineering design was completed for the wastewater treatment plant Thus, m result of this study was found a suitable solution for the wastewater for Ozberil coal washing plant

1 INTRODUCTION

Sedimentation is the removal of suspended solid particles from a liquid stream by gravitational settling This is always the case m mineral processing where the carrier liquid is water (Kommek & Lash, 1979)

The efficiency of solid/liquid separation may be greatly improved by the application of synthetic polymeric flocculants, particularly m coal preparation where sedimentation, filtration and centnfugation processes are extensively used The term flocculation is often confused with coagulation, although the two refer to quite different processes Coagulation is basically electrostatic m that it is brought about by a reduction of the repulsive potential of the electrical double layer The term flocculation is derived from the Latm, "flocculus" literally a small tuft of wool, or a loosely fibrous structure Flocculation is brought about by the action of high molecular weight materials such as starch or polyelectrolytes, where the materials physically forms a bridge between two or more particles, uniting the solid particles into a random, three-dimensional structure which is loose and porous (Gnc & Lnc, 1978)

Nowadays, flocculants used for flocculation are non ionic, anionic and canonic polymers Non-ionic and anionic polymers cause to form big, fast sedimentation and fairly compact flocks However, it is preferable to use higher molecular weight anionic or non-ionic polymers over catıonıc flocculants for sedimentation process (Ateşok, 1987)

It is known through the literature that non ionic polymers are usually used in acidic slurries and high molecular weight anionic polymers are used in alkali slurries (Sabah &Yeşılkaya, 2000)

Although, the wastewater does not bear any appreciable amount of chemical pollutant nevertheless its appearance and very slow settling rate of solid ingredients make it unpleasant and unwelcome Thus, municipalities and inhabitants have been forcing coal washing plants to find an appropriate solution for the wastewater On the other hand, coal washing plants are advantageous find an appropriate solution, because of the cost of fully fresh water use either from wells or city network is getting unbearably high

Ozberil coal washing plant has a capacity of 50 t/h and coal, which is produced from underground, is washed to increase its quality Nowadays, this vast waste necessitates the Ozberil coal washing plant a solid-liquid separation process prior to sending the tailings to waste ponds. Liquid waste contains %5-%7 solids and of this amount with majority s'-.ng below 75 micron.

In |y o study, laboratory flocculation experiments are carried out with the aim of designing the wastewater treatment facility for Özberil Mining Co.

2 MATERIAL AND METHOD

The coal slurry sample was taken from the discharge of fine tailing in Özberil Coal Washing Plant (Kale-Denizli) and used for laboratory scale tests. Total amount of samples used in the laboratory tests were about 150 liters.

Chemical analysis indicated that sample also contained clay minerals besides coal particles and magnetite mineral. The chemical properties of the slime sample are presented in Table 1.

Table 1. Chemical composition of slime sample

Oxides	(%)
SiO_z	35.72
AI2O3	13.70
Fe_20_3	9.33
CaO	4.91
MgO	3.09
SO3	2.01
Na_20	0.89
K_20	2.17
Loss on ignition	27.88

XRD analyses are done to establish the whole characteristics of minerals in slimes (out of coal). XRD analysis indicated that sample contained major; Quartz, illite minor; pyrite, chlorite, magnetite (Figure 1).

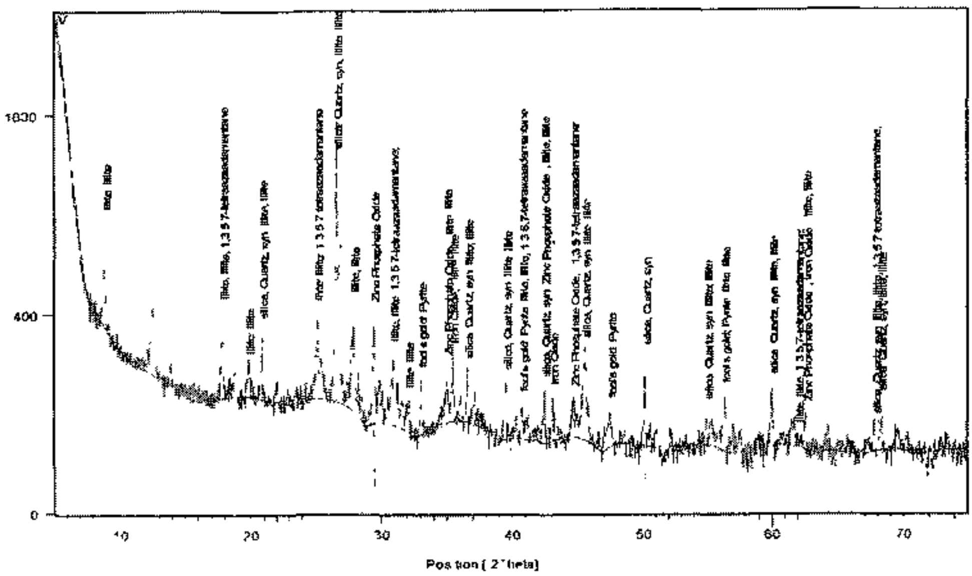

Figure 1. XRD results of slime sample

Particle size analysis of representing samples used in sedimentation experiments are shown in Table 2.

In the experiments, solid/liquid separation was carried out by using laboratory tests. In the laboratory tests, effects of pulp density, flocculant type and dosage on sedimentation were determined.

The flocculation tests were carried out in one liter graduated cylinder with one litre slurry in each test. No pH regulation was made so the tests were done at natural pH of the sample which was 8.0-8.2. Freshly prepared flocculant solutions at the concentration of 0.5% w/w were used and added to top of slurry dropwise by a pipette at pre-determined different dosage. Immediately after the addition of flocculant, cylinder was gently shaken and stirred by four upside-downs for good mixing.

The change of interface height as a function of time is record at certain periods. Sedimentation rate is found from the tangent of this straight-line (Wills, 1988).

Table 2 Particle size analysis of slime sample

Sieve Size (mm)	Weight(%)	Under Size(%)
+ 1 180	0 56	100 00
-1 180 + 0 850	0 96	99 44
-0 850 + 0 600	181	98 48
-0 600 + 0 300	5 32	96 67
-0 300 + 0 150	6 63	9135
-0 150 + 0 075	10 17	84 72
-0 075 + 0 045	3 39	74 55
-0 045 + 0038	2 99	71 16
-0 038	68 17	68 17
Total	100 00	

3 EXPERIMENTS

Sedimentation tests were done with slurry samples taken from the plant for experimental studies

Five different flocculant types were tested for five different amounts and 30 systematic sedimentation tests were applied Four Anionic flocculants produced by Ciba and one non-iomc flocculant produced by Cytec companies were used m tests Table 3 shows the flocculant type and properties in use experiments

Table 3 Characteristics of flocculants used

Commercial Name	Firm	Type	Dosage **(%)**
Magnafloc 155	Ciba	Anionic	0 02-0 1
Magnafloc 1011	Ciba	Anionic	0 02-0 1
Magnafloc LT25	Ciba	Anionic	0 02-0 1
Magnafloc LT27	Ciba	Anionic	0 02-0 1
SUPERFLOC N300	Cytec	Non-iomc	0 05-0 3

3.1 Sedimentation test related to change of pulp solid concentration (without flocculant)

The pulp solids content affects the rate of settling since it determines the number of inter particle collisions Figure 2 shows the effect of changing the solid concentration on the settling rate of slimes It is noticed that settling rate increased as the solid concentration decreased The behaviour can partially be related to the change m the pulp viscosity The sedimentation velocity decreases with increasing the viscosity of a pulp by raising its density

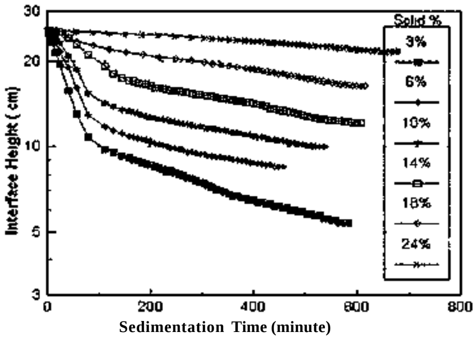

Figure 2 Sedimentation curve with different solid concentration

3.2 Sedimentation test relate to flocculant dosage and type

To establish the most appropriate flocculant type and dosage for the efficiency of sedimentation, flocculation results obtained with non ionic and different molecular weight anionic polymers are shown m Figure 3-7

As seen in Figure 3-7, the optimum flocculant dosage for slimes that can be subjected to solid-liquid separation is 4 ppm for MagnafIocLT27 and MagnafloclOl 1, 5 ppm for MagnaflocLT25, 10 ppm for Magnafloc 155 and 30 ppm for SuperflocN300 polymers In the tests performed m laboratory condition pH 8 and solid concentration of 6%, good results were obtained by using almost one-twenty of the anionic flocculants compared to non-ionic flocculant Because non-iomc flocculants usually hydrolyze in alkali slurry, even the use of high dosage SuperflocN300 did not provide an effective sedimentation

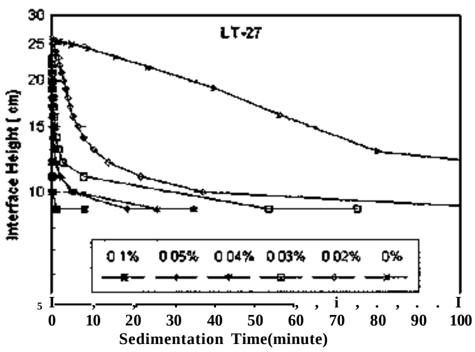

Figure 3 Sedimentation curve with different dosage in using MagnaflocLT27

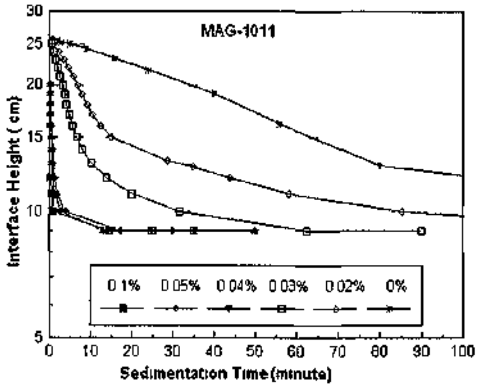

Figure 4 Sedimentation curve with different dosage in using MagnaflocIOl 1

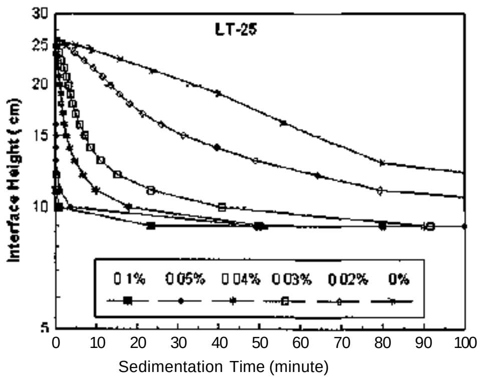

Figure 5 Sedimentation curve with different dosage in using MagnaflocLT25

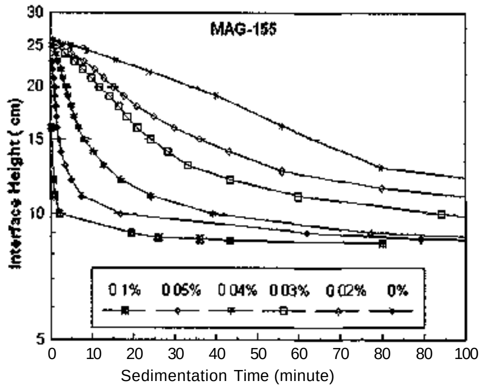

Figure 6 Sedimentation curve with different dosage in using Magnaflocl55

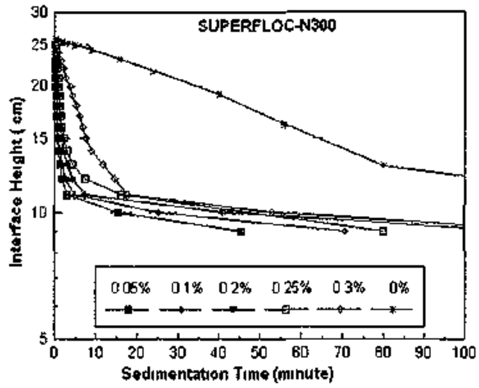

Figure 7 Sedimentation curve with different dosage in using SuperflocN300

The tests performed with four anionic and one non ionic flocculants showed relationships between sedimentation rate and flocculant dosage (Figure 8) As it can be seen in Figure 8, when 0 04% MagnaflocLT27 is used, 19 63 cm/mm sedimentation rate reached and again with the same dosage of MagnolocIOll, MagnolocLT25, Magnolocl55 and SuperflocN300, 12 74 cm/mm, 3 38 cm/mm, 143 cm/mm and 108 cm/mm, respectively

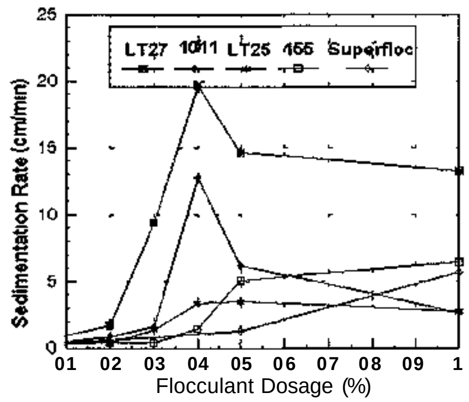

Figure 8 Effect of flocculant dosages on Sedimentation rate for different flocculant type

4 CALCULATIONS OF THICKENER AREA

Figures 2-6 show the height of the interface of the settled pulp as a function of the sedimentation time, with different flocculant dosage and without flocculant. It can be seen that the addition of the flocculant increases the sedimentation so that the final settling height of the slime slurry is readily reached.

The thickener design employed was first hypothesized by Kynch and later modified by Talmadge and Finch. Talmadge and Finch used this approach in determining the limiting flux and thus a prediction of the unit area for specific thickening applications. The value of the area (A) was developed by the following equation by Talmadge and Finch (Keane, 1986):

$$A = \frac{Q * t_u}{C_0 * H_0} \quad (1)$$

where, *A* is the thickener area, m^2

g is feed solid rate (2.5 t/h)

(„ is maximum time for underflow concentration (h)

Ho is the initial height (0.26 m)

Co is the initial concentration (0.06 kg/1)

From the definition point of view, the thickener capacity is defined as the amount of the clear solution overflowing of slime slurry.

Thickener area was calculated for each flocculant type and without flocculant and results were showed in Table 3.

Table 3 summarizes the data of the above factors, affecting flocculation behaviour of slime, the thickener area needed for dewatering. The thickener area decreases with increase in flocculant dose for all flocculant types.

5 CONCLUSIONS

Increase in the sedimentation rate with increasing the molecular weight of the flocculant may be due to increase in the adsorption of the flocculant on the accessible particle surface.

All the flocculants tested were found be importantly to flocculant concentration. The effectiveness of the flocculants tested in coal tailing slime suspension was in order:

LT27>101 l>LT25>155>Superfloc

Flocculation tests done with anionic flocculants, better flocks are obtained with high molecular weight MagnaflocLT27. Also flocculants are bound to surface of particles with electrostatic attraction forces along with polymer bridges. Consequently, with the use of MagnaflocLT27, an anionic flocculant, at concentration average 0.04%, which corresponds to 0.025 kg LT27 per ton pulp (0.31 kg per ton solid), clear water to re-use in washing plant can be obtained.

A simple solid-liquid separation system may reclaim of the water input very efficiently.

Table 3. Effect of flocculant dose on the thickener area

Name	Dose	Sediment rate	Thickener Area
	(%)	cm/min	(m*)
None	0.0%	0.172	665
	0.02%	1.738	97
	0.03%	9.42	75
LT27	0.04%	19.63	18
	0.05%	14.63	8
	0.10%	13.22	3
	0.02%	0.855	226
	0.03%	1.662	104
1011	0.04%	12.741	11
	0.05%	6.218	3
	0.10%	2.620	0.5
	0.02%	0.399	372
	0.03%	1.382	112
LT25	0.04%	3.381	48
	0.05%	3.489	11
	0.10%	2.750	5
	0.02%	0.380	373
	0.03%	0.450	112
155	0.04%	1.432	48
	0.05%	5.083	11
	0.10%	6.481	5
	0.05%	1.309	141
	0.10%	5.687	120
S.FIoc	0.2%	6.146	101
	0.25%	8.478	75
	0.30%	10.422	40

REFERENCES

Ateşok, G., 1987. Polimerlerin cevher hazırlamadaki yeri, kullanım özellikleri. *TMMOB Madencilik Dergisi.* Cilt 24, Sayı 3: 15-22.

Keane, J.M., (ed. By Mular, A.L& Anderson, M.A), 1986. Laboratory testing for design of thickener circuits. *Design and Istallation of Concentration and Dewatering Circuits,.SME,* Colarado.

Kominek, E.G. and Lash, L.D., (ed. by Schweitzer, P.A) 1979. Sedimentation, *Handbook of Separation Techniques for Chemical Engineers.* McGraw-Hill, NewYork.

Gric, N.M. and Lric, B.D., 1978.Flucculation: Theory and Application, *Mining and Quarry Journal.* Vol. 5:1-8.

Sabah, E. and Yeşilkaya, L., 2000. Evaluation of the settling behavior of Kırka borax concentrator tailings using different type of polymers *The Journal of Ore Dressing,* Issue 3-4 1-12

Wills, B A, 1988 *Mıneı al Processing Technology* Pergamon Press, 3[th] Ed , Oxford