Reduction of Environment Pollution in Processing of Barite

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ABSTRACT

One of the largest indigenous manufacturing plants of barium chemicals is located at Cuddapah in Andhra Pradesh. During production of barium carbonate, two types of rejects (flue ash and sludge) have been generated and accumulated for the last few decades at the Cuddapah plant. Earlier, briquetting of charge was suggested to restrict physical losses of material as flue ash. Afterwards, to generate product having >90% barium sulphate which could be reused, studies have been carried out with the rejects currently produced. Detailed investigations suggested separate treatment of sludge because the flue ash sample was found to be suitable as feed to the reduction circuit. Both gravity and flotation processes were found to generate product meeting specifications. It was also found that more than 55% of the combined rejects currently generated at Cuddapah plant could be used again for the production of barium carbonate. In the process, recovery of barite value could be more than 65%.

Key words : Processing of barite, waste utilisation, recovery of barite, multi-gravity separator.

INTRODUCTION

Conversion of waste to wealth is one of the major thrust areas in achieving sustainable development. Environmental legislation and regulations together with the economics of disposal are directing the industry to look for ways of minimising the generation of wastes and maximise the recycling of the products generated from the wastes. Different industries world wide have paid a great deal of attention and tremendous progress has been made in this direction. Implementation of clean technology in reduction or generation of wastes, effective recycling and gainful utilisation of wastes have become very important of late. In fact, continual innovation towards full utilisation of resources and residues will progressively improve the bottom line and protect the environment.

The treatment of mineral wastes and its utilisation, for the conservation of mineral wealth and protection of environment, have become very important now a day. Wastes generated by the mining, mineral processing and metallurgical industries should be disposed of with a minimum environmental degradation and at acceptable cost. Some of the metallic and mineral constituents of these wastes are valuable, and their recovery can lead to substantial conservation of resources. Present study pertains to recovery of values from wastes (flue ash and sludge) generated during recent operation at Cuddapah barite plant (Figure–1).

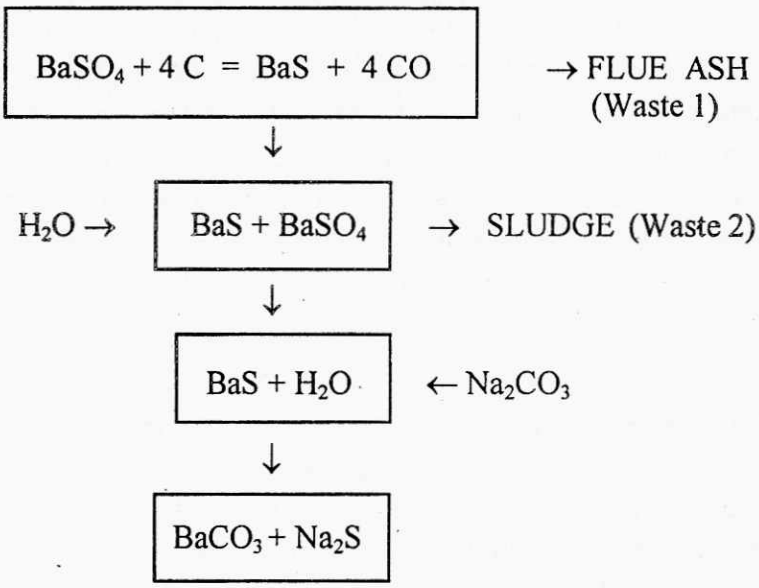

Fig 1 : Scheme adopted for processing of barite

The problem of environmental pollution caused by the rejects generated during the processing of barite could be tackled in two ways - by controlling generation of rejects itself and by development of process to recover values from the rejects, before discard, for reuse. During production of barium carbonate, two types of rejects (flue ash and sludge) have been generated and accumulated for the last few decades. It is anticipated that the total accumulated waste would be of the order of 50,000 T causing environmental pollution to the surroundings. While the reduction process of barium sulphate (barite) to barium sulphide generates flue ash, leaching of barium sulphide using hot water generates sludge as reject. The plant uses fine size barite (<250 mm) and coarser carbon particles. The types of carbons used for reduction are lecofines and LTC sludge. It has been found that composite waste (flue ash and sludge) contained nearly 75% barium sulphate in it and the sludge contained around 69% barium sulphate.

Recovery of high grade barite from waste pond materials, tailings ponds and bypassed mining wastes, contaminated drilling mud, mill wastes etc. through physical /chemical route have been reported earlier [1-6]. Flotation of fine-size barite from gravity separation tailing [7], high-intensity magnetic separation of ferrous tailing from barite flotation[8] and dual centrifuge system with flocculation for mud treatment[9] have also been reported for improved barite recovery. Studies were carried out to utilise different wastes generated during barium carbonate manufacture[10]. All of the above studies were carried out abroad. Recently generation of barite waste (flue ash) was reduced[11] by using briquettes in black ash process during manufacture of $BaCO_3$ at Cuddapah

Plant, Andhra Pradesh, India. Briquetting of charge was found to restrict physical losses of material as flue ash - which was generated due to heavy draft in the furnace resulting in blowing up of fine and lighter particles of the charge continuously from the rotary furnace as flue ash. In the plant practice, using the briquetted charge an improvement of overall yield of more than 25% in comparison to the normal powder charge was reported. Studies with multi-gravity separator (MGS) to recover high grade barite from composite wastes (prepared from flue ash and sludge) and also separately from sludge have very recently been carried out[12-13]. While the desired grade could be achieved, recovery was not appreciable. Use of MGS for concentration of complex lead zinc ore in preference to conventional froth flotation has recently been reported[14].

In the present study, experiments were carried out using different gravity separators with sludge sample. Flotation studies were also carried out. Results have been presented to show the amenability of the process to produce usable product from the wastes.

EXPERIMENTAL

Sample

Two types of wastes (flue ash and sludge) were received separately at NML for the development of process flow sheet to recover barite value. Flue ash and sludge produced during recent operation were sent for study. Size and chemical analysis of the flue ash, sludge and composite sample are given in Tables 1 & 2.

Table 1 : Size analysis of as-received flue ash and sludge samples

Size in mesh	Sample Flue ash Wt (%)	 Sludge Wt (%)
+ 10	-	5.68
- 10 + 14	-	9.02
- 14 + 20	-	8.92
- 20 + 28	-	12.02
- 28 + 35	-	7.39
- 35 + 48	-	5.70
- 48 + 65	1.47	7.34
- 65 + 100	1.21	4.68
- 100 + 150	2.69	9.05
- 150 + 200	4.48	6.62
- 200	9.15	23.58
Head (Calculated)	100.00	100.00

Table 2 : Chemical analysis for different size fractions of flue ash & sludge

Size in mesh	Assay(%) Flue ash $BaSO_4$	Sludge $BaSO_4$
+ 10	-	45.62
- 10 + 14	-	49.80
- 14 + 20	-	49.93
- 20 + 28	-	52.82
- 28 + 35	-	55.49
- 35 + 48	-	58.53
- 48 + 65	86.16	64.58
- 65 + 100	88.16	76.87
- 100 + 150	87.08	80.86
- 150 + 200	86.24	79.62
- 200	91.58	96.44
Head (Calculated)	91.10	68.99

Method

It was observed, from size and chemical analysis, that more barite values were contained at finer sizes. Mineralogical studies also indicated a trend of enrichment of barite in finer sizes. So, it was decided to go for size reduction in order to achieve proper liberation of values before applying gravity methods and flotation for barite recovery. Initially, composite sample was prepared for study from as-received flue ash and sludge samples, at the proportion suggested by the sponsor. But detail investigations with as received samples suggested separate treatment of sludge because the flue ash sample was found to be suitable as feed to the reduction circuit. Accordingly, experiments were carried out with sludge sample. Experimental results using different gravity separators and flotation process are given below.

RESULTS AND DISCUSSION

Studies with MGS

Efficacy of MGS has been investigated using "design of experiment" technique which involves selection of strategy to obtain an adequate model with a minimum of experimentation. In the present study, experiments were performed considering four variables (rotational speed, amplitude of shake, frequency of shake and wash water rate) at two levels as shown in Table 3. The design matrix and the results of experiments using -200 mesh feed are presented in Table 4.

Table 3 : Levels of variables

Variable	Level		
	-1	0	+1
Feed Pulp Density (x_1) (% solid)	25	30	35
Slope (x_2) (degree)	2.0	3.0	4.0
Wash water (x_3) (lpm)	1.0	2.0	3.0
Rotation Speed (x_4) (rpm)	160	200	240

Table 4 : Design matrix

Experiment	x_1	x_2	x_3	x_4	Y_{obs}	Y_{cal}
1	-1	-1	-1	-1	87.05	84.92
2	+1	-1	-1	-1	80.38	84.92
3	-1	+1	-1	-1	86.25	87.20
4	+1	+1	-1	-1	90.56	87.20
5	-1	-1	+1	-1	90.63	89.81
6	+1	-1	+1	-1	88.67	89.81
7	-1	+1	+1	-1	92.04	92.09
8	+1	+1	+1	-1	92.48	92.09
9	-1	-1	-1	+1	73.26	72.27
10	+1	-1	-1	+1	73.16	72.27
11	-1	+1	-1	+1	73.17	74.55
12	+1	+1	-1	+1	74.06	74.55
13	-1	-1	+1	+1	72.11	72.43
14	+1	-1	+1	+1	73.68	72.43
15	-1	+1	+1	+1	74.12	74.71
16	+1	+1	+1	+1	74.56	74.71
17	0	0	0	0	82.27	81.01
18	0	0	0	0	80.72	81.01
19	0	0	0	0	80.04	81.01
20	0	0	0	0	78.87	81.01
21	0	0	0	0	80.44	81.01

Regression equation (1) considered and the response equation (2) obtained, after dropping out insignificant terms by t-test, are given below:

$$Y = b_O x_0 + b_1 x_1 + b_2 x_2 + b_3 x_3 + b_4 x_4 + b_{12} x_1x_2 + b_{13} x_1x_3 + b_{14} x_1x_4 \quad ....(1)$$
$$+ b_{23} x_2x_3 + b_{24} x_2 x_4 + b_{34} x_3x_4 + b_{123} x_1x_2x_3 + b_{124} x_1x_2x_4$$
$$+ b_{134} x_1x_3x_4 + b_{234} x_2x_3x_4 + b_{1234} x_1x_2x_3x_4$$
$$Y = 81.01 + 1.14 x_2 + 1.275 x_3 - 7.496 x_4 - 1.173 x_3x_4 \quad ....(2)$$

Response equation (2) was found, by F-test, to fit the experiment. One can see, from Table 4, that it was possible to achieve the required grade of $BaSO_4$ (>90%).

Studies with Hydrocyclone

As seen in Table 2, -65 mesh fraction of sludge sample contained considerable barite value. Accordingly, -65 mesh fraction was screened out from sludge sample and ground to 86% -200 mesh and subjected to hydrocycloning. Design and operating parameters were optimised to generate product containing more than 90% $BaSO_4$ in it. It was observed that at lower feed pulp density, product containing >95% $BaSO_4$ could be achieved with recovery of $BaSO_4$ around 54%. But to improve recovery, feed pulp density was increased as high as 30% (which reduces consumption of water to a great extent) - still it was possible to achieve product containing nearly 92% $BaSO_4$ with recovery of $BaSO_4$ more than 86% of feed. It was also observed that recovery could be further improved by second stage of hydrocycloning with the underflow product.

Flotation Studies

For this purpose, the –10 mesh sample was wet ground (–200 mesh) in laboratory rod mill and was floated to produce rougher concentrate which was subjected to two cleaning flotation with oleic acid emulsion as collector for each cleaning. The Cleaner Concentrate I assayed 89.1 % $BaSO_4$ with 77.5% distribution. Second cleaning further improved the grade over 92 % $BaSO_4$. In order to study the effects of regrinding on selectivity of separation another cleaning flotation experiment was also carried out. In this case the Cleaner Concentrate I analysed 90.7% $BaSO_4$ with 74% recovery. The second cleaning showed an improvement in grade to 94% $BaSO_4$. The reagent requirement was found to be less in comparison to the cleaning flotation without regrinding. This might be due to dilution of reagent during the process of regrinding and also due to the generation of new mineral surfaces on grinding. Again, recycling of the middlings in a continuous circuit is expected to improve recovery. The losses in the primary tailings was 10-14%.

CONCLUSIONS

From the above study it can be concluded that :

(1) Flue ash and sludge samples should be treated separately for best possible recovery of barite values.

(2) More than 55% of the combined wastes currently generated at Cuddapah Plant can be recycled for the production of $BaCO_3$. In the process, recovery of barite value could be more than 65 %.

(3) In the present study, process has been developed at the bench scale level for currently produced wastes only and should be validated through pilot plant trials before implementation.

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