Beneficiation of bauxite

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BAUXITE deposits generally occur at or near the surface and are usually covered with shallow layer of overburden. The ore is almost invariably mined by open pit methods. The usual practice is to thoroughly strip and clear the overburden, after which the ore body is blasted to permit excavation by mechanical shovels. Some deposits contain highly siliceous clays and ferruginous materials distributed intimately throughout the ore, and it is often necessary to beneficiate the bauxite to provide a desired quality of product.

A primary objective of the beneficiation process is to reduce the silica content in the ore, as the latter reacts with caustic soda during the digestion step to precipitate out as insoluble sodium aluminium silicates, e.g. $2Na_20.2Al_20_3.3Si0_2.2\ H_20$. This salt is eliminated from the process along with the insoluble iron and titanium oxides in red mud, consequently entailing the loss of valuable alumina and caustic soda from the process.

The silica present in the bauxite tends to be concentrated in the finer grained fractions, and this characteristic makes bauxite amenable to beneficiation by screening techniques. Pearson[1] has reported that in a bauxite of average composition of 1·58% silica, the minus 100 mesh fraction analysed a silica content as high as 10·30%. The beneficiation step also leads to an enrichment of the alumina content in bauxite as the finer fractions contain low alumina. From the above it is evident that the quality of ore can be improved by employment of suitable screening operations for the removal of the lower grade of fines.

Interest in the beneficiation of bauxite mined at the Indian Aluminium Company Limited's quarries at Lohardaga is traceable to 1964 when a detailed survey indicated the presence of sizeable deposits containing more than 7% silica. Preliminary test work indicated the presence of high silica and low alumina contents in the finer fractions of run-of-mine and a detailed and systematic study on the feasibility of beneficiating bauxite at the mines was carried out subsequently.

Experimental procedure and results

In order to evaluate the economics of using screened bauxite it was decided to investigate :

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SYNOPSIS

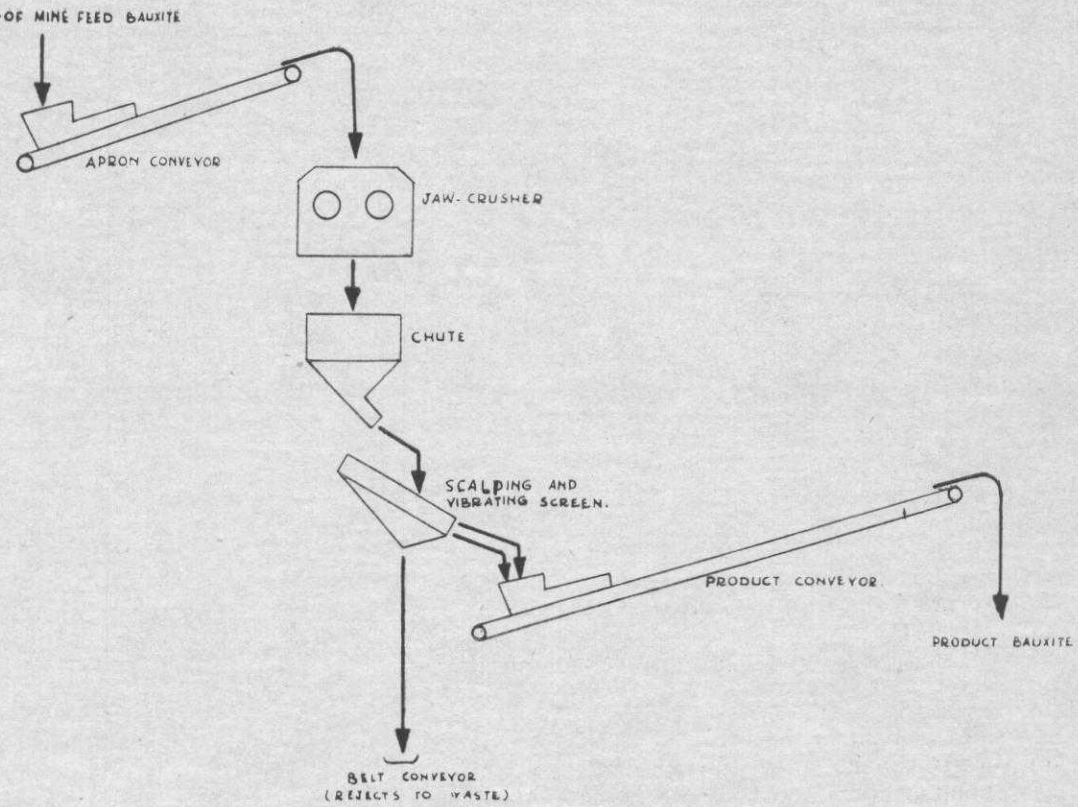
Bauxite deposits often contain a high percentage of clay and siliceous materials and it is sometimes necessary to reduce the silica content in the ore by beneficiation. The paper describes the studies carried out for the beneficiation of bauxite at the Indian Aluminium Company Ltd's mines at Bagru Hill (Lohardaga). The variation in the silica and alumina content with screen size of the run-of-mine as well as bauxite subjected to primary crushing is evaluated. A scheme for beneficiation by dry screening the crushed bauxite at the mines is described. The various factors affecting the economics of beneficiation are discussed.

(a) The extent of fines present in the run-of-mine ore
(b) The amount and quality of fines generated during the primary crushing operation, and
(c) The variations in the silica and alumina contents as a function of size.

A number of samples were drawn from the run-of-mine ore and the crusher product streams. Screen and chemical analyses were carried out on all these samples. Screen and moisture analyses were carried out on 'as such' samples, while the samples were powdered to pass through 100 mesh and dried at 105°C for 1 hour before proceeding with chemical analyses.

In an effort to minimise variations in sampling run-of-mine material, samples were drawn from the power shovels during three successive stages of handling bauxite from a fresh blast, viz. the top 1/3 section of blasted material, the intermediate 1/3 section and the bottom 1/3 section. Samples from each stage were drawn from a full grab of the shovel comprising 2–4 tonnes of material. The plus ¾ inch size lumps were carefully handpicked and weighed. The remaining material was screened through ½ inch, ¼ inch, 1/8 inch and 10 mesh screens and weighed. Representative samples were obtained from each screen fraction by coning and quartering. A master composite was obtained by mixing samples so obtained in the required proportions from material obtained from the three different stages of handling.

Samples after primary crushing operation were drawn from a fixed length of the crusher product belt conveyor and separated into the various screen fractions des-



1 *Schematic flow diagram for proposed bauxite beneficiation plant*

cribed above. Approximately 150 kg of sample was drawn for each test.

The size distribution for run-of-mine and crushed product streams is summarised in Table I.

TABLE I Product size distribution for run-of-mine and crusher product bauxite

	Per cent Weight Fraction					
	$+\frac{1}{2}''$	$-\frac{1}{2}'' +\frac{1}{4}''$	$-\frac{1}{4}'' +\frac{1}{8}''$	$-\frac{1}{8}''$ +10 mesh	—10 mesh	—20 mesh
1. Run-of-mine	77	5	6	3	5	4
2. Crusher product	60	12	10	4	9	5

It was evident from the above data that further generation of fines to the extent of obout 5% occurred during the primary crushing operation. The additional fines produced during the crushing operation were found to be similar to those present in the run-of-mine with respect to the silica and caustic extractable alumina contents. This was determined by analysing the various screen fractions of the crusher product employing boulder feed.

The variation in silica and caustic extractable alumina contents as a function of screen size was determined on a number of run-of-mine samples and is shown in Table II.

These analyses indicated definite increases in the reactive silica content in the finer fractions of the ore. At the same time, a progressive decline in the caustic extractable alumina content is also evident with increasing fineness.

TABLE II Variations in the silica and caustic extractable alumina contents in run-of-mine bauxite

	Screen Size					
	$+\frac{1}{4}''$	$-\frac{1}{4}''+\frac{1}{8}''$	$-\frac{1}{8}''$+10 mesh	—10 mesh	—20 mesh	Composite sample
1. % Reactive silica	4·01	4·26	4·57	5·25	9·20	4·43
2. % Caustic Extractable alumina	46·25	45·70	44·93	42·60	35·70	45·29

TABLE III Economics of beneficiating bauxite containing 4·4% R. SiO_2

	Cut-off point	Extra mining costs Rs/t Al_2O_3	Extra crushing and grinding costs Rs/t Al_2O_3	Gain on bauxite costs due to lower freight, handling and consumption Rs/t Al_2O_3	Gain on caustic costs	Depreciation on equipment cost for handling rejects	Nett gain Rs/t Al_2O_3
Entire Crusher Product	-20 mesh	0·36	0·50	1·63	6·40	1·00	6·17

On the basis of the above data, detailed investigations with respect to the economic attractiveness of the project were next carried out.

Evaluation of the economics of bauxite beneficiation

The principal considerations in evaluating the economics of beneficiation may be stated as below :

(a) The additional mining costs due to the rejection of the finer fractions.
(b) Savings in caustic loss (as Na_2CO_3) due to lower silica content in the beneficiated ore.
(c) Lower bauxite costs arising from reduced consumption per tonne Al_2O_3 produced due to enrichment of the caustic extractable alumina content.
(d) The reduction of ore reserves due to the rejection of fines.
(e) Additional crushing and grinding costs due to the absence of finer fractions in the beneficiated ore.

It has been shown that there is a progressive decline quality with respect to the silica and alumina content with increasing fineness. In order to have the minimum avderse impact on ore reserves as well as additional crushing and grinding requirements, the choice of the cut off point was found to be most appropriate at the 20 mesh fraction. It was also found that the beneficiation of bauxite at Bagru would be economically attractive only for the ore containing 4 to 5% reactive silica, in the light of the criteria enumerated above. Beneficiation of bauxite containing less than 4–5% silica was not found to be justifiable especially in view of the depletion of ore reserves. A typical economic analysis for bauxite containing 4·43% reactive silica is summarised in Table III.

A proposed scheme for beneficiation by dry screening

A schematic flow diagram for the proposed beneficiation plant is given in Fig. No. 1. In the proposed installation, the run-of-mine ore would be fed to a Double Pitman Jaw Crusher by means of an apron conveyor. The crushed bauxite would be first chuted down to a scalping screen where the larger lumps up to 2-inch size would be separated. The undersize containing minus 2-inch fractions would be further processed in a vibratory screen provided with 20 mesh screens. The oversize from the scalper and 20 mesh screens would constitute the product bauxite, while the fines passing through the 20 mesh screens would be disposed of as rejects by means of a belt conveyor.

Reference

1. Pearson, T. G. : "The Chemical Background of the Aluminium Industry."

Discussions

Mr **M. S. Kothari** (Sikkim Mining Corporation, Sikkim): The author has presented the relative costs i.e. the increased cost of grinding versus the reduced costs of consumption of caustic soda in the Bayer process achieved as a result of beneficiation. It would appear from these figures that the grinding costs are very small as compared to the savings in caustic soda costs. This would appear to permit a finer grinding than the proposed −20 mesh, in order to reduce the loss of alumina in the process of beneficiation. I wonder, therefore, whether it would not be advisable to consider a cut off point finer than −20 mesh.

When comparing the factors for and against the proposal of beneficiation, the loss of 5% bauxite in the rejects should be incorporated quantitatively, which has not been done. In the event of having any difficulty in size separation, the technique of size separation by fluidization may be attempted.

Dr **S. S. Prasad** (Author): The cut off point has been decided after testing the screening characteristics of various mesh fractions. In laboratory tests it was found that the finer fractions blinded the screens. Our tests indicated that it would be possible to dry screen the −20 mesh fractions without undue blinding of the screen cloth. At this cut off, the loss of bauxite would be 5% as shown in Table I of our report. This rejection would mean that higher quantity of bauxite is consumed for every tonne of Al_2O_3 produced. Arising from this the processing costs would increase due to factors such as extra mining, crushing and grinding costs which are summarised in Table III of our report. The additional cost due to the above is shown here as Re 0·86 per tonne Al_2O_3.

We are not aware of any commercial operation of fluidised bed application of size separation for bauxite beneficiation.

Mr **C. Sharma** (National Metallurgical Laboratory): Mr Prasad has mentioned that they have looked into the removal of silica in bauxite ore through screening at 20 mesh size where only 5% bauxite is the loss. However, they may have to go down to 10 mesh or 1/8″ coarser sizes because of difficulties of blinding of screens, etc. at 20 mesh, but then he mentioned the losses of alumina would be 10% and 20% in the rejects. Would it be justifiable to lose such high contents of alumina in the rejects for a gain in savings in caustic consumption in digestion of alumina, when we have limited ore reserves of bauxite in the country?

Dr **S. S. Prasad**: I have pointed out the disadvantages of going to coarser cut off fraction i.e. the sharp increase in bauxite loss due to rejections. The selection of the 10 mesh or $\frac{1}{8}$ in. fraction would require an assessment of the economics of the process, i.e. whether the saving in caustic soda costs would be off-set by the additional mining, crushing and grinding costs and depletion of ore reserves. The last mentioned consideration is particularly important in view of the limited known ore reserves in India. Our studies have indicated the optimum cut off point as 20 mesh, and consideration of a coarser cut off would arise only if the 20 mesh separation is not possible due to blinding of the screens in actual plant operation.

Dr **P. Dayal** (Directorate General of Technical Development, New Delhi): I would like to know if any attempt has been made to find out the percentage of gibbsite or diaspore in the rejection of 5% alumina at 20 mesh.

Has any attempt been made to beneficiate lower grades of bauxite? Our reserves of high grade bauxite are not inexhaustible and we should try to beneficiate the lower grades.

Dr **S. S. Prasad**: We have determined the extent of silica and total caustic extractable alumina (i.e. gibbsite and boehmite) that is present in the rejections. This is shown in Table II of the paper. The amount of diaspore present has not been studied.

Our studies have been limited to the beneficiation of bauxite containing 4-5% silica. We have not looked into the feasibility of beneficiating even lower grades of bauxite.

Dr **K. Bhaskara Rao** (The Madras Aluminium Co., Metturdam): Our experience also supports the fact that screening of −20 mesh fines from bauxite is advantageous to the process. I would like to know from the author whether their aim in screening of fines fraction is to avoid the interference of silica impurity into the final product or to bring down the interfering organic carbon or to bring down the caustic soda losses by lowering the silica content.

What is the soluble silica content in the —20 mesh fines and the residual coarse fractions?

What are the efficiencies of extraction and soda loss with fines fraction separately and core fraction separately?

Dr **S. S. Prasad**: The beneficiation process has been recommended as a means of reducing caustic soda costs by reducing the silica content in the beneficiated bauxite. The silica distribution in the —20 mesh fraction was 9·20% as shown in Table II.