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PRODUCTION OF HEMATITE ORE FROM RED MUD

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Abstract

Red Mud generated as a waste material in the Bayer process is a potential source of metal values. Red Mud is highly caustic residue (pH >13).Approximately 1-2 tonns of red mud are being generated per MT of alumina produced. Disposal and storage problems will prevail due to the leachable soda content and the volume of material to be handled.

Jarosite is a hazardous waste of Zinc refinery and is both difficult and costly to manage and to dispose safely. Jarosite is normally associated with sulfuric acid and Ferric iron in the waste produces additional acid on hydrolysis. Red Mud is source of hydroxyl and sodium ions whereas Jarosite is source of sulphate and hydrogen ions. Reaction between red mud and Jarosite in water will therefore produce a liquid phase containing sodium sulfate and a solid phase dominated by iron hydroxide. The liquid phase was evaporatively concentrated to precipitate salt and the solid phase was calcined to produce a ferruginous solid that could be used as an iron ore. The reaction of red mud and Jarosite produces two marketable commodities (Gypsum) & (Thenardite). In this paper an attempt is made to evaluate procedures for the preparation of iron ore and marketable byproduct salts by reacting the Balco's Red Mud and Jarosite from Hindustan Zinc of Vedanta Group.

Introduction

For every tonne of alumina produced in the Bayer processing of bauxite, 1 to 2 tonnes of red mud generated depending upon the quality and grade of the bauxite and, to some extent, the processing conditions. Red mud consists of almost all the elements present in the parent bauxite from which it is derived, many of them in enriched form, in addition to sodium compounds formed by reacting with caustic soda used for digestion, and calcium compounds if lime is added during the processing stages. It is infact a complex mixture of various oxides like Fe2O3, TiO2, Al2O3, SiO2, Na2O occurring in major amounts. Disposal and utilization of red mud are common problems for all alumina refineries in the world. Industries located far the coastal region (as is the case with alumina refineries in India) face significant disposal problems. To dispose off a huge volume requires enormous civil, mechanical and process efforts causing huge expenditure. All alumina producers are, therefore keen to make effective utilization of red mud. During metallic Zinc extraction from Zinc concentrates huge quantity of Jarosite are released universally as solid residue. The Jarosite generated in a Zinc refinery is normally associated with free sulfuric acid and ferric iron. The Jarosite mainly contains iron,sulfur,zinc, lead and calcium. Jarosite released from industrial process is complex and its quality and quantity make the of safe disposal complex. The most widely used method for disposal of Jarosite is the Jarofix Process.In this Jarofix process the Jarosite is treated with hydrated lime and then stabilized with ordinary Portland cement before dumping in a pond. At present the long term stability of Jarofix material remains unsatisfactory and when the material does break down it is likely that the trace metals will be released into the surrounding environment with potentially adverse consequences. It would be advantageous if red mud and Jarosite could be transformed into other forms less harmful to the environment.

In the present work an attempt is made to evaluate the utilization potential in developing marketable commodities using red mud and Jarosite for safe and effective waste management.

Materials and Method

Sample collection:

The solid residue, Jarosite was obtained from our group company Hindustan Zinc Limited (HZL) and Red Mud from Bharat Aluminium Co.Ltd.,Korba (India).The samples were oven dried (105-1100C) separately, sieved through 150 micron sieve. For characterization sampling was done from the oven dried sample adopting the conning and quartering method.

Characterization of chemical & Mineralogical properties:

The major constitutes of red mud were analyzed by XRF PW 2440 Phlips, Netherland. Heavy metals were detected by Atomic Absorption Spectrophotometer (AAS), SOLAAR S 4AA, and Thermo Elemental, USA with SOLAAR software package. The mineralogical analysis were carried out using PANlytical X'Pert Cubix Pro series diffractometer equipped with copper target tube,X'celerator detector and operated at 40kV and 30 mA. Diffraction data were analyzed using PANlytical X'Pert High Score plus Version 2.1.

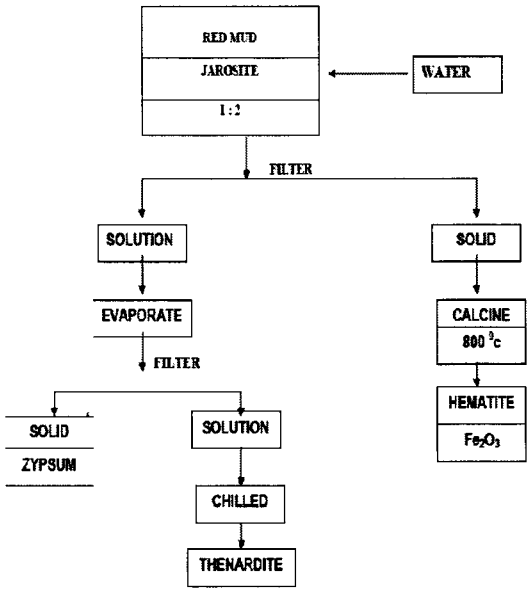

Fig.1. Schematic representation of recovery of hematite from red mud

Experimental

The process for recovery of Hematite from red mud by reacting with Jarosite is briefly outlined below:

(i) A mixture of Jarosite along with red mud and water were mixed at different ratio at ambient temperature (280C) with magnetic stirring. The ratio of Jarosite, Red Mud and Water are given in the following Table 1.

Table.1: Various Ratios of Jarosite to Red Mud Used in the Experiment

SN	Jarosite:Red Mud (weight ratio)	Water (ml)	pH
1	1:1	300	6.5
2	2:1	300	6.0
3	4:1	300	6.0

To investigate the possible use of these neutralization reactions two parts of Jarosite and one part of red mud were reacted for 24 hours at ambient temperature.

(ii)The neutralized slurry was filtered and washed with water.

(iii) The filtered solution was concentrated by evaporation and two minerals (Gypsum and Thenardite) could be easily separated Gypsum is much less soluble than Thenardite and can be precipitated first and removed.

(iv) The solid phase was calcined at 8000C for 2 hours to produce a ferruginous feed stock for blast furnaces producing pig iron.

The process for recovery of Hematite and Thenardite by reacting with Red mud and Jarosite is summarized in Fig. 1.

Results

The various major constituents present in Jarosite are given in Table 2 while that of the heavy metals such as Cr, Ni, Cu and Co in Jarosite are shown in Table 3. The % composition of major constituents of Red Mud and Calcined material are shown in Table 4. X- Ray diffractograms of Jarosite, Red Mud, Calcined solid (Hematite Iron) and Thenardite are shown in Fig. 2, Fig.3, Fig. 4 and Fig. 5 respectively.

The major mineral phase of Jarosite is potassium iron sulfate hydroxide (KFe3(SO4)2(OH)6) and iron sulfate hydrate (2Fe2O3SO3.5H2O) (Fig.2).The Main crystalline phase of Red Mud are : Hematite (Fe2O3), Goethite (FeOOH), Gibbsite (Al(OH)3), Boehmite (AlOOH), Cancrinite (3NaAlSiO4.NaOH), Quartz (SiO2), Anatase (TiO2) etc (Fig.3).

Table2.Chemical Properties of Jarosite (in %)

Si	2.45
Fe	24.54
Al	2.12
Zn	4.47
Ca	4.13
S	11.68
Pb	0.52
K	0.30
Na	0.35
Mg	0.28
Mg	0.16

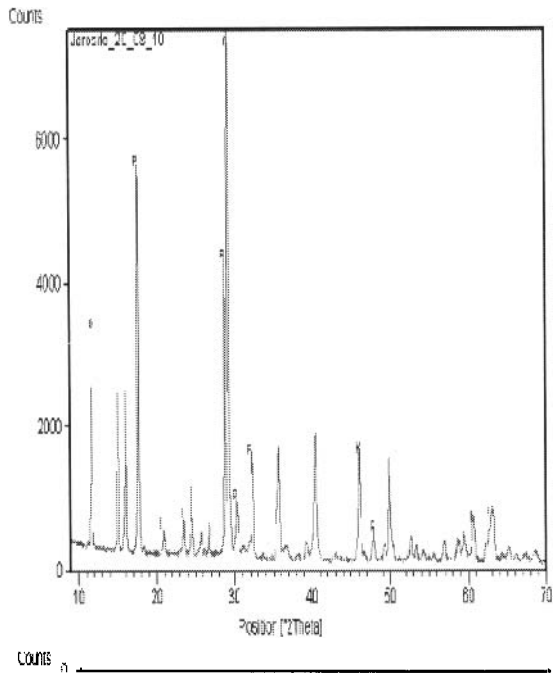

Fig.2. X-Ray diffractogram of Jarosite

Cr	165
Ni	81
Cu	980
Co	42

Table3. Heavy Metals in Jarosite (in ppm)

The Chemical Composition of BALCO's Red Mud is given in Table-4.

Constituents %	Red Mud	Calcined Material
Fe2O3	38.38	53.13
SiO2	7.21	7.10
TiO2	17.37	6.87
Al2O3	20.61	Trace
Na2O	6.39	0.26
P2O5	0.35	0.15
LOI	8.03	2.19

Table4. Chemical Properties of Red Mud and Calcined Material (in %)

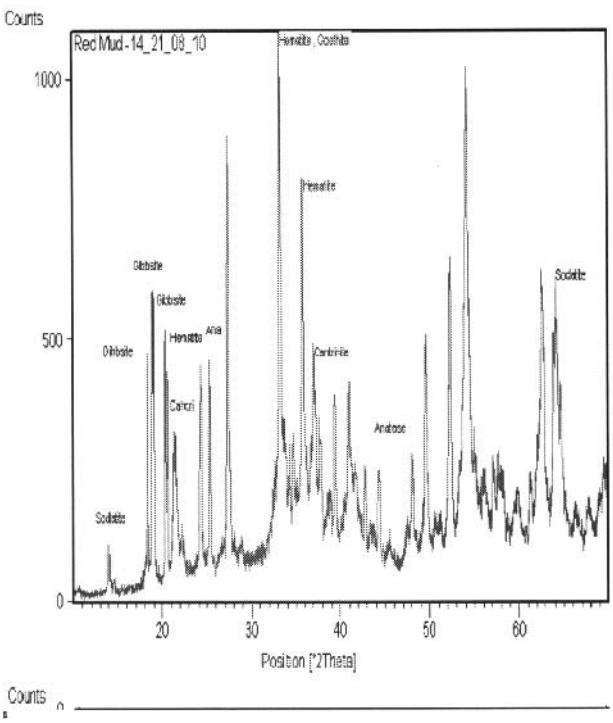

Fig.3. X-Ray diffractogram of Red Mud

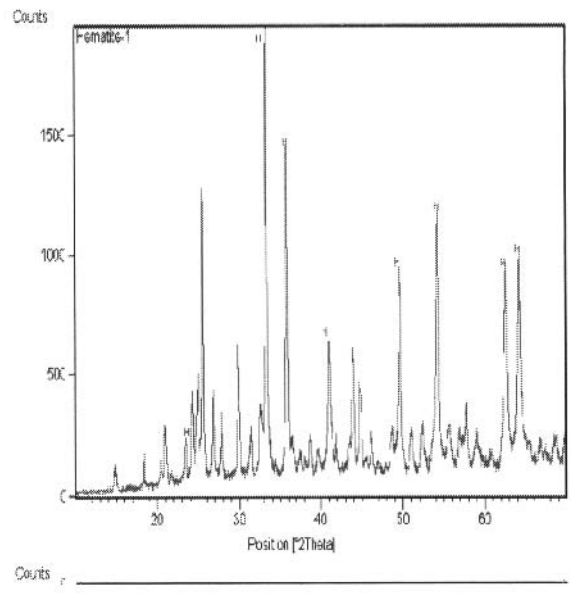

Fig.4. X-Ray diffractogram of Solid Calcined Material (Hematite)

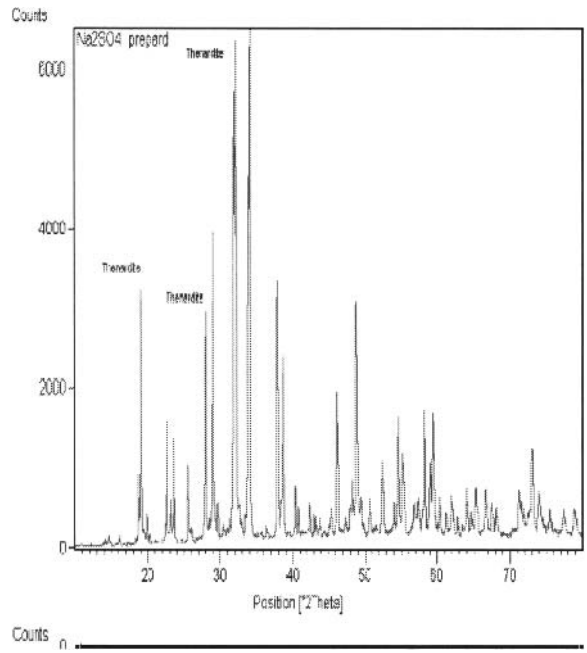

Fig.5. X-Ray diffractogram of Thenardite

Conclusions

Every Bayer process alumina refineries produce very high volumes of Red Mud, disposal of which in open fields has the potential to cause great environmental damage. It not only causes harm to vegetative sources, but also extends great health risks to both humans and animals. Jarosite wastes generated from the hydrometallurgical processes contain significant quantities of compounds of sulfur, lead, zinc, iron etc. The presence of toxic substances in Red Mud and Jarosite make these waste hazardous and causes serious problems in for their disposal. Due to weathering there is a release of toxic elements in soluble form which can ultimately contaminate the soil, ground water and aquatic life due to improper management of such hazardous wastes.

The present work shows that it is possible to efficiently and cost effectively neutralize red mud from BALCO Alumina Refinery by mixing with Jarosite waste from Hindustan Zinc refinery (HZL). Neutralization of red mud using Jarosite will reduce both the costs and the risks associated with the long term storage unneutralized red mud. This neutralized material can be stored without liability. Neutralization process will provide a variety of cost and operational benefits to BALCO and HZL including (1) Helping conserve fresh water (2) Creating a soil medium for revegetation (3) Reducing future and stock piled caustic red mud and Jarosite (4) Potentially resulting in the production of marketable sodium salts (5) Creating a raw material hematite iron ore.

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References

1. Gaines et al, Dana's New Mineralogy Eighth Edition Wiley, 1997.
2. K L Bhat, K A Natarajan,T Ramchandran, Electroleaching of Zinc leach residue, Hydrometallurgy, 1987,18,pp.287-303