Research Open Journal of Mineral and Mining Engineering
Vol. 1, No. 6, October 2013, PP: 08 - 14
Available online at http://scitecpub.com/Journals.php

Research article

Beneficiation of Banded Hematite Jasper using Falcon Concentrator: An alternative to Iron ore Resources

N. P. Nayak* & Dr. B. K. Pal**

*Research Scholar & **Professor, Department of Mining Engineering

National Institute of Technology, Rourkela, Odisha, India

+918763385233(M), 91(0661) 2462605

E-mail: nirliptanayak@rediffmail.com, drbkpal2001@yahoo.com

Abstract

Iron ore resources have their own peculiar characteristics requiring suitable beneficiation process to produce quality raw material. Banded Hematite Jasper (BHJ) reserves are abundantly available in India but currently not being used for production purposes due to its high Silica content. In order to beneficiate BHJ, a systematic beneficiation strategy needs to be developed with the knowledge of characterization. Characterization becomes an integral part of mineral processing and beneficiation depends largely on the nature of the gangue present and its association with the ore. Different characterization aspects like mineralogy, textural relationship, liberation size, chemical analysis and grain size analysis are studied to develop beneficiation route. In the present study a very low grade sample i.e., BHJ was collected from Barsua area containing 35.29 % Fe, 49.12 % silica and 1.96% alumina with LOI of 1.01% was subjected to concentration using Falcon concentrator for their enrichment. The effects of two important variables, i.e., bowl rotation frequency, back water flow rate were studied on the process performance. Increasing the rotation of the Falcon bowl, enable more material to the underflow by increasing the yield, whereas, the iron content decreases steadily with increasing the rotation of the bowl. The increase in the back water flow effectively removes the clay materials from the underflow at the expense of the National Steel Policy; the life span of Hematite ore is too short. In order to achieve the zero waste concept suitable utilization of lean grade ore like Banded Hematite Jasper is need of the hour. The new genre of enhanced gravity separators overcome the problems associated with the surface-based separation processes as well as conventional gravity processes. A Falcon Concentrator is a spinning fluidized bed concentrator, which is a combination of sluice and continuous centrifuge Technically it is possible to enhance the quality of low grade as well as BHQ/ B HJ iron ores to an acceptable grade using various techniques like Enhanced gravity separation, WHIMS etc.

Keywords: Iron ore, BHJ, EGS, Beneficiation, Falcon, WHIMS

Introduction

Due to increase in demand, production of steel in India has increased substantially which in turn has put enormous pressure on iron ore producers not only to enhance productivity from existing mines, but also to find out the suitable use of alternative resources, like low grade iron ores such as banded hematite quartz (BHQ)/banded hematite jasper (BHJ), which are available in abundance but yet to be utilized in lieu of suitable process technology. Banded Hematite Jasper (BHJ) deposits are abundant reserves available in India and are currently not being used for production purposes due to its high Silica content.

India possesses hematite resources of 11,426 million tons of which 6,025 million tons are reserves and 5,401 million tons are remaining resources (Indian Mineral Year Book, 2008). Apart from BHJ and BHQ reserves. About 2,823 million tons (25%) are medium grade lumpy ore resources while 915 million tons (8%) are high-grade lumpy ore. For economic reasons, quality raw material is not only required for blast furnace operation but also for the emerging technologies such as smelting reduction and direct reduction route. Beside that, India has set itself a target of achieving production capacity of 110 MT of Steel by 2020 and the required quantity of Iron ore is projected at 190 MT. Over the next few years, demand for Indian Iron ore is expected to rise by more than 200 million tons per year to meet the internal demand and export. Iron ores across the globe are being beneficiated by several techniques such as jigs, spirals, low and high intensity magnetic separator, flocculation methods. Recently, conventional gravity methods have limitations in processing very fine material and in removal of aluminous impurities. Falcon concentrator, one of the enhanced gravity separators, can generate high 'G' force up to 300 which can effectively separate very fi ne iron particles from the aluminous clayey particles. Over the last decade, EGS have found wide acceptance to mineral industries for concentration of fines and ultra-fine minerals

Materials and Method

Samples were collected from Barsua region of the classic Iron Ore bearing formations of Odisha. The regional geological set up constitutes part of the Precambrian Meta-sedimentary Sequence, known in Indian Geology as "Iron Ore Series". The regional structure of the Iron Ore Series was assumed as an asymmetrical overturned synclinorium plunging towards north. In geological literatures this regional structural feature is known as "Horse Shoe Synclinorium". The western portion of this structure is almost continuously comprised of BHJ/BHQ, which forms the hanging wall of the Bonai Iron Ore body.

The Iron ore body was formed by secondary process of leaching and enrichment of Iron bearing rocks (BHJ/BHQ) under certain structural and meteorological controls. This process had also produced different ore types of varying physical, textural and chemical compositions. Pockets of un- replaced or partly replaced parent rocks are present in the ore body. BHJ occurs as Horses in the zone indicating the original unaltered rock.

Falcon concentrator

Falcon concentrator is an enhanced gravity concentrator, which is usually used for separation of fine valuables from tailing or rejects. In Falcon concentrator, the rotating bowl is spinned at a very high speed and the materials experience a very high centrifugal force (G). The feed streams particles are subjected to gravitational force up to 300 G's and are segregated according to effective specific gravity along the smooth spinning rotor wall. The heaviest layers pass over the concentrate bed retained in the riffles at the top of the rotor bowl. The addition of fluidization or back pressure water from behind the riffle beds enable heavy target particles to migrate to the bottom or outside of the bed and be retained in preference to the lighter particles (Operation and maintenance manual of Falcon Concentrator, 2007).

Results and Discussion

The characterization study would help to establish the evolutionary trends in the ore mineralization process which in turn help to select a suitable beneficiation route particularly in case of low grade ores. The process of beneficiation is dependent on the variation in physical, chemical and mineralogical properties between constituent minerals and their grain sizes.

The bands in the BHJ consist of alternated layers of hematite and jasper/quartz with micro-folds and faulted features dissecting each other. Bands are generally parallel, while the concentration of iron ore minerals in an "iron-rich band" is more or less uniform; in a silica-rich band" it is highly erratic (Fig.1d). The ore shows complex interlocking between hematite and jasper. The ore shows complex interlocking between hematite and jasper (Fig.1a). Secondary quartz veins of various dimensions have been observed with in Banded Hematite Jasper (Fig.1b). These quartz veins show cross cut relationships with Banded Hematite Jasper.

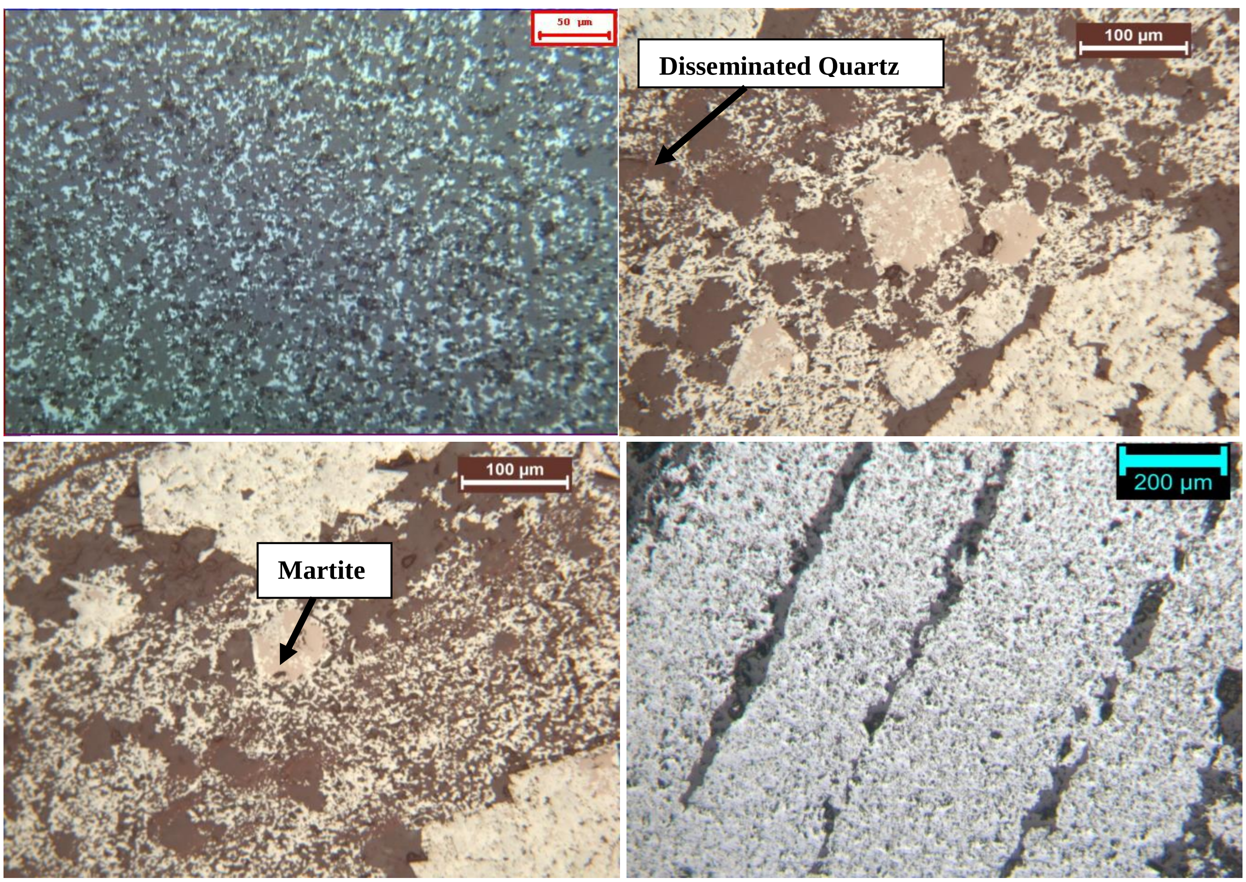

Figure 1: Photomicrographs of Banded Hematite Jasper under reflected light microscope (a) Fine grained texture shows intricate interlocking between hematite & jasper (b) disseminated quartz grains (c) Martite in BHJ (d) Micro-bands of hematite and jasper

Hematite phase in this ore is of secondary origin & is a product of oxidation of original magnetite called as martite. Martite, hematite and Quartz are in well crystalline form. Hematite appears to be a martitized. The martite, which is pseudomorphs magnetite, in most cases, retains the shape of original magnetite (Fig.1c). Disseminated secondary quartz also occurs in many samples. At places there are enriched zones of hematite. In BHJ, transformation of one mineral to another happens under the influence of heat, temperature, pressure. Crystallization proceeds almost homogeneously and a large number of small crystals are formed by recrystallization. Recrystallization of Hematite might have produced due to hydrothermal fluids (Lascelles, 2007) but here magnetite gets converted to hematite due to oxidation. Hematite appears to be a martitized product of magnetite. At places there are enriched zones of hematite. XRD patterns indicate various discrete mineral phases as shown in Fig. 2.

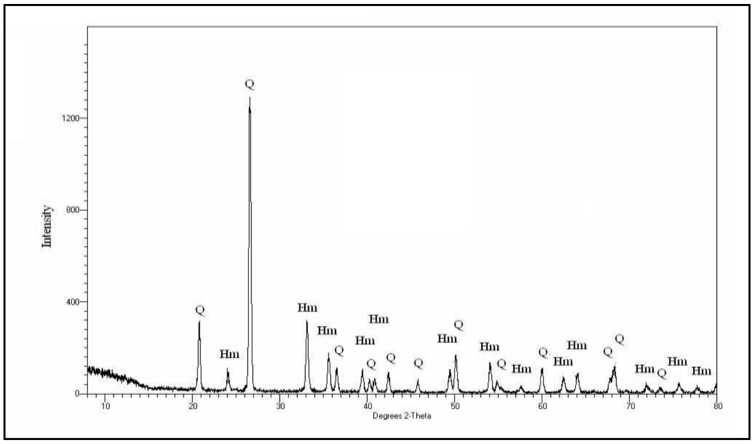

Fig.2 XRD pattern of BHJ showing Hematite & Quartz

Beneficiation of BHJ

From the detailed characterization studies, it has been observed that in BHJ, the clay content is low but silica content is very high. Consequently, the grade of the ore is very low (35% Fe). Also, the quartz is very finely disseminated rendering it extremely difficult to attain liberation. Such a low grade ore with such complex interlocking pattern may not render the beneficiation process economically viable. An elaborate flow sheet with multiple stages of comminution, classification, gravity and magnetic separation and froth flotation is required to produce a sufficiently high grade concentrate.

Gravity Separation using Wilfley Table

To study the efficacy of flowing film concentration of BHJ, it is subjected to concentration in Wilfley Table. The results obtained are reported in Table 1. It may be seen that about 45.40% solids (w. r. t. orig.) is recovered in the concentrate product. The experimental conditions, 3˚ deck slope and 1.68 cc. per cm. per. sec. water flow rate are kept constant in all tabling experiments. It is observed that the quality of the ores improved significantly by tabling. In the BHJ, the concentrate grade improved to 49% iron by processing the feed ground to <1mm.

Table .1 Wilfley table test results with3˚ deck and 1.68 cc. per cm/sec water flow

Product	**Fe%**	**Yield (%)**
Conc.	49.0	45.40
Middling	27.0	43.24
Tailing	22.0	11.36
Feed	35.29	100

The Tabling concentrate was subjected to processing using Falcon concentrator for their enrichment. The effects of two important variables e.g. bowl rotation frequency, back water flow rate and were studied on the process performance where as the per cent solid was kept constant. The results are outlined in Table.2 .

Effect of frequency of the rotor bowl

In these experiments, the back water flow rate and per cent solid were kept constant at 15 psi, and 10 per cent respectively. As it is evident from Figure 1a, an increase in the frequency from 40 to 80 rpm, increases the yield wt. per cent from 54 to 68%. On the other hand, the percent Fe decreases from 61.08 to 52.76 with increase in the frequency from 20 to 80 Hz.

Table .2 Falcon result of -100 μm Size Ground Feed under Different Condition

Experimental Condition						
No of Tests	**Bowl rotation(HZ)**	**Back water pressure**	**% solid**	**Product**	**Yield%**	**Fe%**
1	40	9	10	Conc.	63.4	55.73
				Tail	36.60	37.20
2	60	9	10	Conc.	65.30	51.76
				Tail	34.65	31.05
3	80	9	10	Conc.	72.9	49.14
				Tail	28.01	36.31
4	80	12	10	Conc.	72.1	51
				Tail	27.88	35.70
5	60	12	10	Conc.	65.10	52.35
				Tail	34.88	37.09
6	40	12	10	Conc.	57.62	58.79
				Tail	42.38	32.09
7	40	15	10	Conc.	62.40	61.80
				Tail	37.60	37.83
8	60	15	10	Conc.	63.78	54.03
				Tail	36.22	36.31
9	80	15	10	Conc.	68	52.76
				Tail	21.89	43.23

With increase in spin frequency, the centrifugal force acting upon the particles increases. It leads to increase in particle momentum which increases the probability of passing of more particles to O/F side. In this condition, there is an increase in yield of concentrate but dilution of grade happened.

Effect of back water pressure

The effect of back water pressure of the Falcon concentrator was carried out and the results are given in Table-2. An increase in the back water pressure from 9 to 15 psi decreases the per cent yield of the underflow from 63.4 to 62.4per cent. On the other hand, the per cent Fe increases from 49.14 to 61.80 with increase in the back water flow rate from 9 to 15 psi. Higher backwater flow rate enables the heavier particles to wash thoroughly by removing the slimy and alumina rich fraction to the overflow making the underflow concentrate rich in iron with a reduction in yield.

Results under optimized condition for using Falcon concentrator (40HZ, 15 Psi)

Product, per cent	Falcon UF	Falcon OF
Yield, Wt.	62.40	37.60
Fe	61.80	37.83
SiO_2	3.9	7.8
Al_2O_3	2.1	10.5

Conclusion

The study on the iron ore slime led to some important conclusions as given below

- Falcon produced a concentrate with Fe 61.80 per cent at yield of 62.40 per cent under optimum conditions.
- The falcon concentrate still needs further refinement in order to lower down the silica and alumina content which are little high in Indian context.
- 40 HZ and 15 Psi is found to be the optimized condition for best result i.e. low rpm and high back water pressure condition.

References

[1] Nayak, N. P., Das.A and Pal, B. K (2013) "Characterization Driven Processing of Indian Iron Ore Slime, published in International Journal of Research in Chemistry and Environment, Vol.3, Issue 2, pp.120-127

[2] Nayak, N. P., Das. A and Pal, B. K (2012) "Feasibility of Beneficiation of Banded Hematite Jasper of Eastern India", published in International Journal of Engineering resource & Technology", Vol.1, Issue 9, pp.1-11.

[3] Nayak, N. P and Pal, B. K (2013) "separation behaviour of iron ore fines in Kelsey centrifugal jig", published in Journal of Minerals & Material characterisation & Engineering, Vol.1, Issue 3, pp.85-89.

[4] Laplante, A R (1994) "A study of the falcon concentrator. Canadian Met. Quarterly" 33(4), 279-288

[5] Wills, B. A., Napier-Munn, T. (2006) Mineral Processing Technology, Elsevier Science & Technology Books.

[6] Rath et al. (2007) "Efficacy of enhanced gravity separator in processing Indian iron ore slime" XXV international mineral processing congress (impc) 2010 proceedings, pp.1165-1170.