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Designing Process for Beneficiation of Low Grade Iron Ore Samples from Orissa

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ABSTRACT: The paper deals with the results of characterization and beneficiation studies carried out on low grade iron ore samples from Orissa. Beneficiation of the two individual samples and their composite based on gravity and magnetic separation techniques resulted in products with varying yield and grade of the products. The results of laboratory studies were validated through pilot scale trials. Based on the studies undertaken process was designed for beneficiation of the composite sample, comprising 60% S1 and 40% S2, to a high grade product assaying over 65% Fe. Detailed material balance for the designed process was also undertaken.

1. INTRODUCTION

India is endowed with large reserves of iron ore which is the basic raw material for iron and steel making. Though Indian iron ore is rich in iron but it contains high alumina which is not favourable for efficient operation of blast furnace. Presently most of the Indian iron ore mines are operated by selective mining for maintaining a high grade of iron ore (Fe>60%). Presently the circuit adopted for processing of iron ores has limitations in reduction of alumina. In particular it can not handle huge quantity of low grade ores and fines available from earlier workings (Singh et al. 2004). There has been need to develop suitable beneficiation process for upgradation of low grade iron ores and fines towards their rational utilization. It is appropriate to mention that a high grade fine grained iron ore concentrate can very well be utilized through pelletisation for iron making. The present paper deals with the results of chartacterisation and beneficiations studies undertaken on the two low grade iron ore samples (S1 and S2) with a view to design process for their beneficiation to a high grade concentrate (65%Fe), suitable as feed to DRI pellet plant.

2. EXPERIMENTAL

2.1 Iron Ore Samples

The two iron ore samples namely, S1 and S2 assaying 58.29% and 61.26% Fe with alumina contents of 5.60% and 4.56% respectively and their combination (60:40) were used for the present study. The samples S1 and S2 contained 6.73% and 4.63% silica respectively. The samples consisted of lumps of varying sizes to ultrafines. The top size of the two samples were ~40 mm and 8 mm respectively. The mineralogical and liberation characteristics of the samples are discussed in the subsequent sections.

2.2 Methods

Mineralogical characterization of the iron ore samples were carried out by megascopic and microscopic techniques. For optical microscopic studies polished sections were prepared and studied under a Leitz (Leica)-orthoplan universal research microscope. Liberation characteristics of the samples were determined using a Leitz/Leica-Zoom stereomicroscope.

Bench scale beneficiation studies were undertaken on the two iron ore samples and their composite by gravity and magnetic separation methods. Pilot scale trials on the composite sample, comprising 60% S1 and 40% S2 were carried out in NML Pilot plant.

3. RESULTS AND DISCUSSION

3.1 Mineralogical Characteristics of the Samples

In hand specimens the ore-pieces appeared to be of slightly inferior grade due to relics of jaspery-laminations, lateritic impurities, limonitisation or fine clay impregnations. The colour was generally reddish brown. Under optical microscope, the ore was observed to be laminated and fine grained with hematite as the major mineral. Clay was the dominating gangue in most of the ore pieces followed by silica. Occasionally goethite and quartz/jasper were recorded. Clay occurred either as patches within the hematite mass or as cavity/fracture fillings. Figures 1 and 2 show typical microstructural features of the samples. Liberation studies on the representative samples crushed to 2 mm indicated that around 65% of the grains were liberated below 300 micron. There was significant improvement in liberation in subsequent size fractions and around 95% of the grains were liberated below 100 micron. He liberation trends for the two samples are shown in Figure 3.

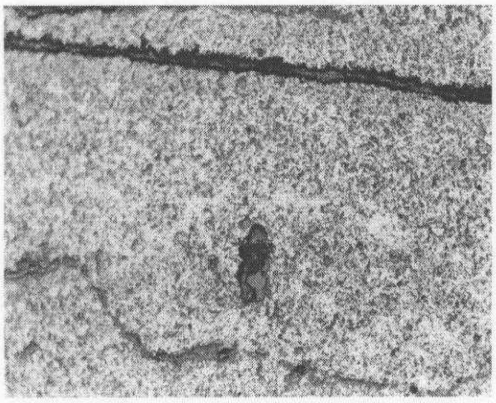

Fig. 1: Photomicrograph showing fractures that are filled with clays. A quartz grain surrounded with clay is also seen. Plane polarized reflected light X 200.

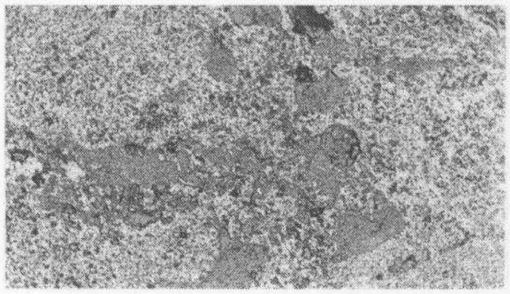

Fig. 2: Photograph showing prominent patches of clay within a matrix of fine crystallites of specular-hematite. Plane polarised reflected light X 100.

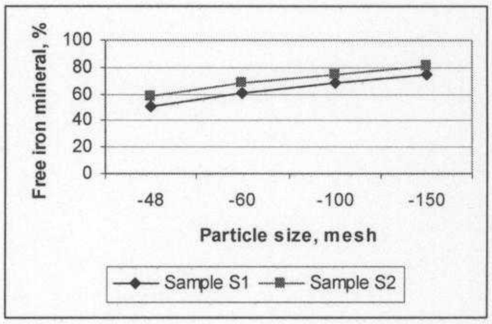

Fig. 3: Liberation of iron bearing minerals with decreasing particle size.

3.2 Laboratory Beneficiation Studies

Considering the mineralogical composition of the samples basically the beneficiation techniques such as scrubbing and washing, desliming, gravity and magnetic separation were studied for enriching iron content of the samples. Initially laboratory studies were undertaken on individual samples S1 and S2 and subsequently extended to composite sample, consisting of 60% of S1 and 40% of S2.

The as received samples were subjected to scrubbing, washing and classification. It was observed that due removal of adhering clay and fine silica, washing helped in improving iron content in the sand fraction by 3.42% and 2.41% for samples S1 and S2 while the yield of the washed sand fractions were 80.2 and 83% respectively (Singh et al. 2005). Desliming of the ground washed sand using hydrocyclone further improved iron content in the underflow by 0.5%.

Gravity concentration of the samples were carried out with varying particle size of the feed. For this purpose the washed sand was ground to different granulometry and subjected to gravity concentration using wilfley shaking table. Salient beneficiation results with sample S1 are shown in Figure 4. As it is evident from the results, due to better liberation an in increase in fineness of feed from 300 micron to 200 micron, there is improvement in concentrate grade as well as iron recovery. A further increase in fineness of feed to 150 micron, though improves iron content of the concentrate to 65.94% but with a loss in recovery. The lowering in iron recovery was mainly due to limitation of shaking table in handling fine particles resulting in increased iron loss as slimes.

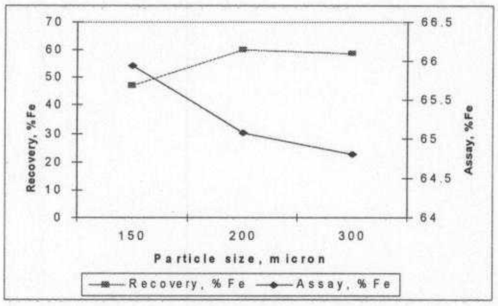

Fig. 4: Results of gravity concentration of iron ore sample S1 with varying granulometry.

Hematite was observed to be the major iron bearing mineral with the iron ore samples. Considering paramagnetic nature of hematite, studies were undertaken for its recovery by Wet High Intensity Magnetic Separation (WHIMS). Typical results showing the effects of magnetic field intensity on recovery of iron for sample S1 with a feed consisting of particles below 200 micron are shown in Figure 5. As it can be observed that magnetic field intensity plays an important role in iron recovery. An increase in field intensity from 8500 Gauss to 13500 Gauss improved recovery from 72.9% to 89.1% with a lowering in iron content of the product from 64.21% to 63.12%. Use of feed with 150 micron resulted in improvement in concentrate grade to 65.35% Fe with iron recovery of 76%. Magnetic separation studies were further extended to recover iron values from middlings and slimes resulted from gravity based techniques.

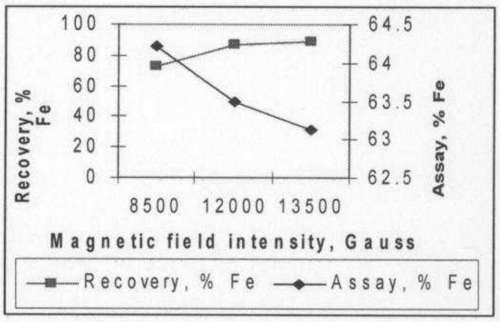

Fig. 5: Effect of magnetic field intensity on concentration Sample S1.

Pilot Scale Studies and Process Design

The laboratory studies undertaken on the individual and composite iron ore samples helped in developing basic process routes for beneficiation of low grade iron ore samples which were validated through pilot scale trials conducted on the composite sample (Singh et al, 2005). Based on the studies undertaken beneficiation process was designed and material balance was computed. The beneficiation process is schematically shown in Figure 6. The process basically involves two stages of crushing, closed circuit grinding, hydrocycloning, spiralling of deslimed feed, wet high intensity magnetic separation of middlings and tailings from spiralling operation followed by dewatering of the products. The final iron concentrate analysed 65.44% Fe with 65% iron recovery. Another process studied consisted of split processing of coarse and fines using wet high intensity separation. In this case iron recovery was improved to 69% with an assay of 65.28% Fe in the product.

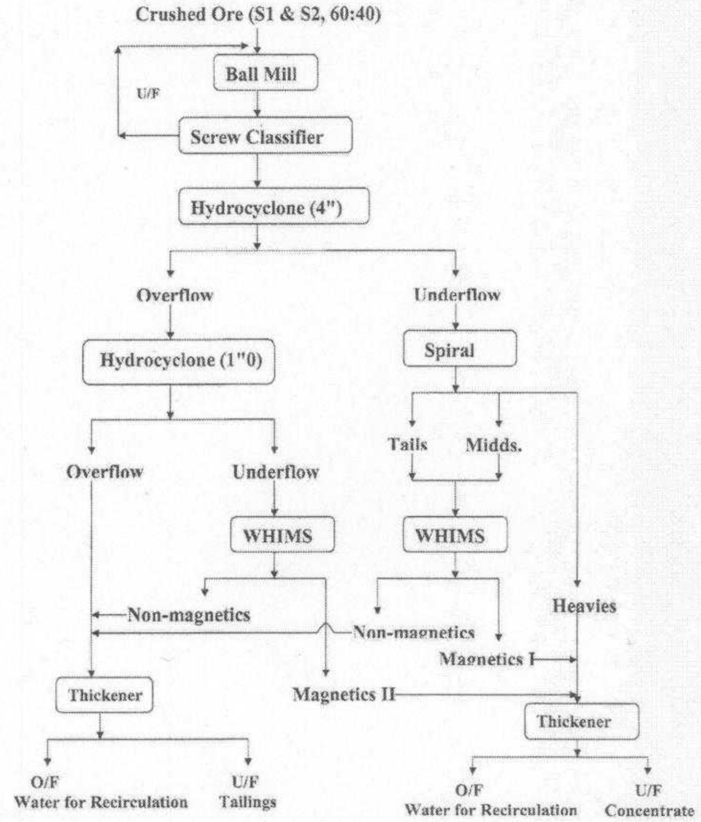

Fig. 6: Schematic representation of process for beneficiation of composite iron ore sample

4. CONCLUSIONS

Characterisation and beneficiation studies were undertaken on low grade iron ore samples. The samples contained hematite as the major mineral with clay as the dominating gangue. Beneficiation of the samples based on gravity and magnetic separation techniques resulted in products with varying iron recovery and grade of the concentrate. Laboratory results were validated through pilot scale trials. Based on these studies beneficiation process was designed and material balance was computed. The two processes developed gave products with over 65% Fe with iron recovery of 64% and 69%.

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