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Process Study of Joda East Washing Plant, Tata Steel

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Abstract

Tata Steel is planning for 7.0 mtpa of crude steel production from the present level of 4 mtpa. Accordingly, the iron ore requirement will also increase significantly. Moreover, to increase the blast furnace productivity, significant improvement in the quality of the iron ore is required. To meet a parts of this enhanced requirement of iron ore, both in terms of quantity and quality, a process audit study was undertaken at Joda Iron ore washing plant. The objectives of the study was to assess the process capabilities and to identify the gap areas for a) improving product quality with respect to Al_2O_3 content, size distribution, and b) increasing plant throughput. The studies were carried out at three different ore ratios. The performance of the various unit operations and ore ratios on beneficiation products are discussed in this paper.

***Keywords:** Classifier, Iron ore beneficiation, Iron ore fines, Plant trial*

INTRODUCTION

Joda East Iron Mine of Tata Steel plant was set-up with a capacity of 500 tph for producing two million tonnes of run of mine ore per year. Over the years, the plant has undergone many modifications. Some of the major changes are: commissioning of spiral classifier, introduction of double deck screen, enhancement of capacity of conveyers etc. Presently, washing plant treat around 4 million tonnes of ROM ore per year. Washing plant has two circuits namely, sized ore and classifier fine circuit. Both the circuits have capacity of 450 tph. The plant was designed to treat equal proportion of hard (specific gravity - 4.66;Porosity-36.65 %) (Das et al. 2004) and soft ore (specific gravity -4.4; Porosity–35.6 %) (Das et al. 2004).

The company plans to produce 7.0 mtpa of steel by 2007 and subsequently 10 mtpa by 2010. With the company's major expansion plan on the anvil, the demand for raw materials like coal and iron ore would increase. Therefore, efforts are being made to maximize the yield and throughput from the mines and the washing plants. For finding the scope of improvement in the present process, the efficiency and capacity of each of the unit operation in the washing plants has to be evaluated. Also, the limitation of the plant in terms of the feed and product quality has to be established.

The present work evaluates the performance of the Joda East washing plant for three different ore ratios. The paper discusses the performance of the critical unit operation of the processing plant, particularly at higher throughput, and finds enablers for increasing the throughput of the plant.

METHOD OF STUDY

The plant was designed to treat equal portion of hard and soft ore; the ratio at which ores were expected to be mined. However, this ratio varies with time as per the availability of the ores during mining. For studying the behavior of ore ratio on products three different combination of ore ratio were decided. Of the three, one is the normal ore ratio for which the plant was designed and other two were the extreme cases which the plant can take. In one of the extreme cases, maximum proportion of hard ore in the feed was taken. In the other case proportion of the soft ore was considered. The exact ore ratio taken up for the sample campaigns is shown in Table 1. For each of the three ore combinations, trials were conducted at normal and higher throughput levels. All together there were six different trials. For each trial product quality from the stream of: a) sized ore circuit and b) classifier fine circuit was assessed. For six different tryouts sample campaign was carried out for three days. Each day samples were collected for individual ore ratio at two different levels of throughput. The following are the details of the sampling points (Fig.1) and the unit operations covered in the sized and classifier fine circuits:

Table 1: Ore Ratio Maintained for the Trial

Ratio of Feed (Hard:Friable:Lateritic)	Hard Ore Ratio
60:30:10	H (High)
45:45:10	N (Normal)
30:60:10	L (Low)

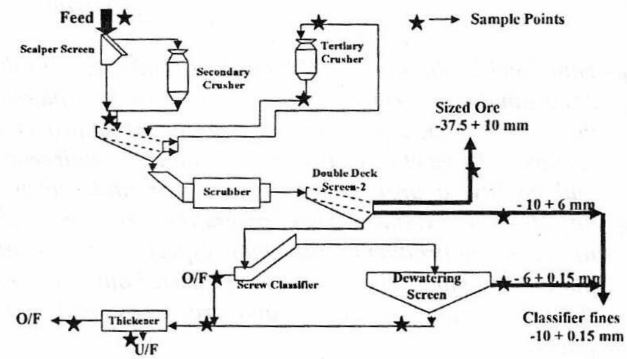

Fig. 1: Sampling Point in the Process Plant

Sized Ore Circuit

In sized ore circuit following are the major unit operations studied:

- Secondary crusher: The samples collected around the secondary crusher (Fig. 1) were size analyzed to determine to give the following
  - Feed and product size distribution of crushers
  - Mass balance of the circuit
- Tertiary crusher: The samples point around the tertiary crusher is shown in Fig. 1. The collected samples were size analyzed to determine to give the following
  - Feed and product size distribution of crushers
  - Mass balance of the circuit
- Scrubber: Data for scrubber input were reconstituted using stream across the double deck screen-1, as sample at scrubber input couldn't be collected.

Classifier Fine Circuit

In classifier fine circuit following are the major unit operations studied:

- Screw Classifier: Screw classifier feed and discharge could not be collected during sample campaign. Screw classifier overflow collected and analyzed for
  - Reconstituting feed size distribution of classifier.
  - Mass balance of the circuit
- Dewatering screen: Dewatering screen underflow and discharge were collected, and size analyzed to find the following
  - Reconstituting feed size distribution of dewatering screen.
  - Mass balance of the circuit

RESULT AND DISCUSSIONS

Based on product quality, Joda process plant is broadly categorized in sized ore and classifier fine circuit. In the sized ore circuit, feed enters at scalper screen, and product leave at double deck screen-2 in the size range of -37.5 + 10 mm (Fig. 1). The classifier circuit consists of screw classifier and dewatering screen. The classifier product consists of two streams: 1) the double deck screen-2 output of size range -10 + 6 mm, and 2) the dewatering screen discharge having size of -6 + 0.15 mm.

Before discussing the alumina reduction of the washing circuits, the analysis of the feed to the plant is given below.

Feed Analysis

The alumina analysis of the feed for the different campaigns of varying ore ratios is given in Table-2. From the table it is observed that total alumina is high for normal ore ratio and least for low hard ore (high friable ore) percentage. Normally, as the percentage of the friable ore in the feed increases its alumina percentage increases. However, a reverse trend was observed during the trial with high friable ore ratio. This was primarily due to the fact that the friable ore used during the trail was of very good grade in terms of its low alumina content. Since high friable ore ratio trail showed a different trend, the same was treated as a special case and is being discussed separately.

Table 2: Feed Alumina Analysis

Ore Ratio (HO:FO:LO)*	% Al_2O_3 in Feed	% Al_2O_3 in + 10 mm fraction of feed	% Al_2O_3 in -10 mm fraction of feed
60:30:10 (High)	1.9	1.7	3.3
45:45:10 (Normal)	2.4	1.9	3.4
30:60:10 (Low)	1.7	1.3	1.9

* ---HO: Hard Ore: FO: Friable Ore; LO: Lateritic Ore

Sized Ore Circuit

Table-3 shows that for the normal throughput the alumina reduction for the normal ore ratio is 24%, whereas, for the high hard ratio, it is 15%. This establishes that as the percentage of hard ore in the feed increases the percentage of alumina reduction decreases. This is due to the fact that the sized ore circuit gets overloaded as the percentage of hard ore increases in the feed. This leads to poor scrubbing of sized ore fraction. Also, from the table it is observed that alumina reduction is low for high throughput.

Table 3: Sized Ore Alumina Analysis

Ore Ratio (HO:FO:LO)	Throughput	% Al_2O_3 in +10mm fraction of feed	% Al_2O_3 in sized ore	% Al_2O_3 reduction in sized ore
60:30:10	Normal	1.69	1.43	15.2
	High	1.65	1.51	8.5
45:45:10	Normal	1.93	1.48	23.3
	High	1.68	1.52	9.5

Classifier Fine Circuit

Table-4 shows that for the normal throughput the alumina reduction for the normal ore ratio is 37%, whereas for the high hard ratio it is 51%. This shows that with an increase in the percentage of the hard ore in the feed, the percentage of alumina reduction in the classifier product decreases. As the percentage of hard ore in the feed increases the load on classifier circuit reduces. As the load on classifier circuit goes down, classifier circuit is able to classify the fines better leading to a higher alumina reduction in the classifier product.

Table 4: Classifier Fine Alumina Analysis

Ore Ratio (HO:FO:LO)	Throughput	% Al_2O_3 in -10mm fraction of feed	% Al_2O_3 in classifier fines	% Al_2O_3 reduction in classifier fines
60:30:10	Normal	3.27	1.59	51.4
	High	2.13	1.37	35.7
45:45:10	Normal	3.13	1.97	37.0
	High	2.39	1.8	24.7

Low Hard Ore Feed Analysis

As explained earlier, although the friable ore percentage in the feed was high, the alumina in the feed was the lowest. In sized ore circuit the difference in alumina reduction for this low hard ore ratio feed was negligible as compared to normal hard ore ratio (Fig. 2). This indicates that with present sized ore circuit it is not possible to reduce alumina in coarse size.

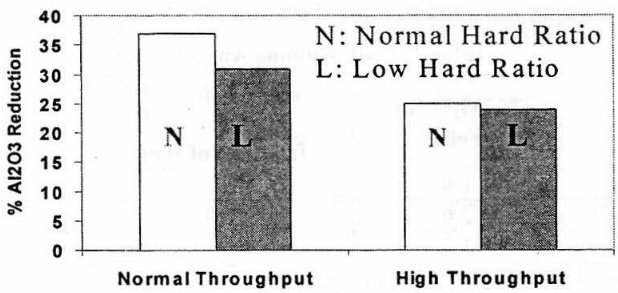

Fig. 2: Percentage Alumina Reduction for Sized Ore Circuit

The alumina reduction in the classifier circuit is also low as compared to normal hard ore ratio feed (Fig. 3). The -0.150 mm material is rich in iron and has lower alumina compared to the slimes generated for normal type of feed in the washing plant. The percentage Fe in the fraction is 63% and alumina is 3%. Simple classification or a gravity separation technique should be attempted to recover iron values from the material.

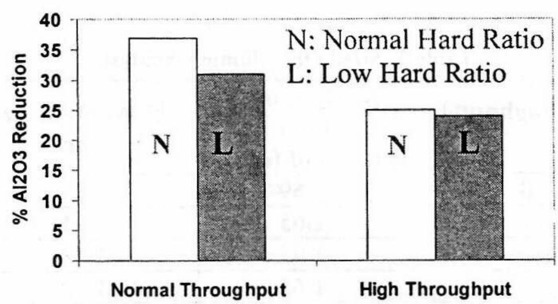

Fig. 3: Percentage Alumina Reduction for Classifier Fine Circuit

Unit Operation Analysis

Secondary Crusher

Secondary crusher performance is quantified by reduction ratio which is defined as,

$$\text{Reduction Ratio} = \frac{d_{80}, \text{feed}}{d_{80}, \text{product}}$$

Using this formula reduction ratio was calculated for both throughput and for two different ore ratio. Reduction ratio obtained is shown in Table -5.

Table 5: Secondary Crusher Performance

Ore Ratio	Reduction Ratio	
	Normal Throughput	High Throughput
Normal Hard Ore Ratio (N)	6.0	7.0
High Hard Ore Ratio (H)	7.5	7.0

From table it is clear that as throughput increases reduction ratio increases, which is an indication that more crushing is taking at higher throughput as compared to normal throughput. Also, as percentage of hard ore increases in feed reduction ratio decreases as we go for higher throughput from normal throughput. It points that crusher performance reduces with increase in percentage of hard ore and at high throughput.

Tertiary Crusher

Tertiary crusher performance is quantified by reduction ratio which is defined as,

$$\text{Reduction Ratio} = \frac{d_{80}, \text{feed}}{d_{80}, \text{product}}$$

Using this formula reduction ratio was calculated for both throughput and for two different ore ratio. Reduction ratio obtained is shown in Table -6. From the table it is observed that for normal and high hard ore ratio and for both high and normal throughput the reduction ratio is around 4.0, which shows that crusher is performing well (Lynch 1989; Wills 1997). However, it is also indicated from the table that the crusher is under loaded.

Table 6: Tertiary Crusher Performance

Ore Ratio	Reduction Ratio	
	Normal Throughput	High Throughput
Normal Hard Ore Ratio (N)	4	4
High Hard Ore Ratio (H)	4	3

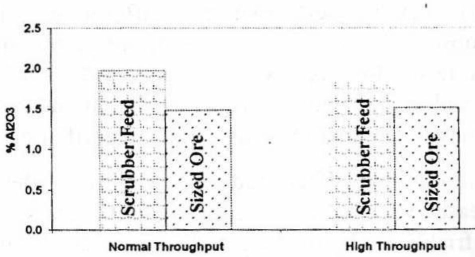

Fig. 4: Scrubber Performance

Scrubber Performance

The purpose of scrubber is to remove the adherent material from the surface of lump by tumbling action in the scrubber. By removing the lateritic material alumina percentage goes down in the lumps. Fig. 4 shows the percentage of alumina for scrubber feed and sized ore for normal and high throughput and for normal feed ratio. From the figure it can be seen that the difference between % Al_2O_3 reduction of scrubber feed and sized ore for normal throughput is higher compared to the difference for the high throughput. This indicates that as throughput increases percentage alumina reduction decreases.

Screw Classifier Performance

Screw classifier performance was determined only for normal ore ratio. Since screw classifier is classification equipment, its efficiency is determined by plotting the partition curve (Wills 1997). Efficiency calculated for the two throughputs shows that for normal throughput it is around 79%, whereas for high throughput it is 62% (Fig. 5). This reflects that for normal throughput screw classifier is working effectively, but the performance deteriorates at higher throughput.

Dewatering Screen Performance

Performance of the dewatering screen was determined for the normal ore ratio trial. Screening efficiency (Records 1978) calculated for the two throughputs show that for normal throughput the efficiency is around 69%, whereas for the high throughput it is around 66%. This establishes that for the normal throughput the screw classifier is working effectively. At higher throughput, its performance declines. However, the decline in the performance at higher throughput is only marginal compared to the normal throughput (Fig. 6).

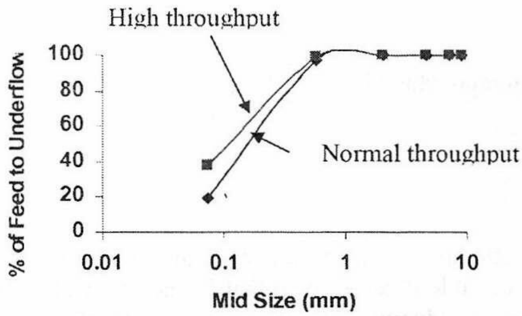

Fig. 5: Screw Classifier Performance

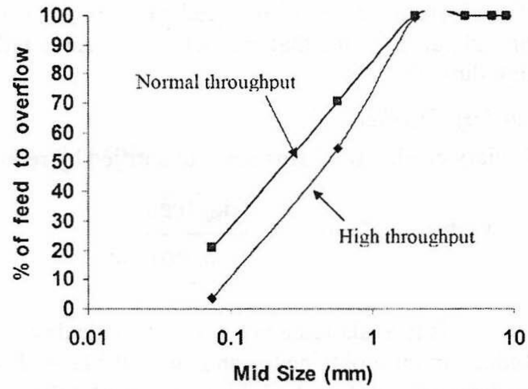

Fig. 6: Partition Curve for Dewatering Screen

CONCLUSIONS

In this work, the performance of different unit operations was studied. As the ore ratio is changed, it was observed that the sized ore circuit performance deteriorates with increase in hard ore percentage in the feed. However, with increase in the hard ore percentage in the feed, the sized ore circuit gets overloaded and as a consequence of this the load on classifier circuit decreases. Because of this the percentage alumina reduction in the classifier circuit improves.

The throughput effect study reveals that in the classifier fine circuit, percentage alumina reduction decreases with increase in throughput. This study shows that iron value can be recovered from the high friable ore by treating it in simple classification or gravity separation process.

REFERENCES

[1] Das, B., Reddy, P. S., Das, S. K., Rajeev, Mohapatra, B. K., and Misra, V. N., 2004, Physico-chemical and mineralogical characterization studies of iron ore samples from Joda region (Unpublished report).

[2] Lynch, A. J., 1989, Mineral crushing and grinding circuits – Their simulation, optimization, design and control, Elsevier Scientific Publishing Company.

[3] Records, F. A., 1978, Sieving Practice and The Gyratory Screen, Process Technology, 18, pp.47

[4] Wills, B. A., 1997, Mineral Processing Technology, Butterworth Heinemann, Oxford.