Auditing Of an Iron Ore Washing Plant

C.Rudrappa¹, B.P.Ravi², M.R.Patil³, S.J.G.Krishna⁴, P.S.Kumar⁵ & C.Venkatiah⁶

¹-⁶Mineral Processing Department, VSKU PG Centre, Nandihalli 583119

Abstract: The iron ore fines assaying 54.40% Fe, 9.53% SiO₂, 5.88% Al₂O₃ and 4.77% LOI when treated in iron ore washer, yielded classifier sand failing to meet the sinter feed specifications of +60% Fe. Auditing studies indicated that the feeding of scrubbed dispersed pulp away from weir of classifier at slightly dilute density with facility of raking sand wash, vertical pulsating high gradient magnetic separation of classifier over flow and sand dewatering screen undersize pulp, could improve. The above process yielded a value added pellet grade magnetic concentrate assaying 63% Fe with 36% Fe distribution at an yield of 31.5, besides a sinter grade sandy concentrate assaying 60.5 % Fe with 44% Fe distribution at an yield of 40%. The above process modification reduced tail losses from 51.4% to 38.6% Fe besides producing the value added products increasing the yield from 60 % to 71.5%, enabling in conservation of environment and mineral. The investments for the modifications were paid back within a year of operation and turned around losses to profit.

Key Words: Process audit, performance evaluation and improvement, classification and magnetic separation of iron ores.

1. Introduction

Indian Iron ore occurs mostly as oxides in nature. The deposits are fairly well distributed in the states of Jharkhand, Chhattisgarh, Orissa, Karnataka, Maharashtra, Goa and Andhra Pradesh.¹-⁴ The lack of consistency with respect to the ratio of Al₂O₃ to SiO₂ make these ores unsuitable for direct use in the blast furnace⁵-⁶ and needs washing of clayey material. The iron ore beneficiation have resulted in production of millions of tons of slimy tails stacked tail pond necessitating a suitable beneficiation process for recovering the iron values from the perspective of mineral conservation, effective space utilization of the tailing ponds and to enhance the life of the existing operating mines. The improvement in the environmental regulations, fresh lease of land for tails impoundment is next to impossible and mitigation of vexed tailing pond management with little environmental problem of silting, dust and ground water contamination is getting complicated as the time passes on. Restriction in production of ore and Closing down Iron ore mines, spurred the mines to look for alternative routes of processing of iron ore slimy plant tails, yielding pellet grade concentrates with a possibility of partial reclamation of tailing pond area and mitigation of vexed tailing pond management problem. In this situation the iron ore washing plants have to operate in custom mode where ore variability will be high and metallurgical industries penalize for higher impurities like alumina etc and reduction in SiO₂/Al₂O₃ and Fe content less than minimum stipulated level of 60% Fe.

Audit is defined as a formal, thorough and periodic examination – evaluation of a system¹¹. The global audit is divided into geological audit, mining audit, marketing audit, energy audit, process audit and environmental-safety audit. The viability of a mineral enterprise necessitates the development of specific techno-economic model for optimum operations. The co-dependence of ore variability-process variables, interdependence of different operations in a mineral enterprise, non-quantifiable factors needs continuous monitoring. This continuous monitoring and generation of a dynamic techno-economic model is difficult. Hence, age old philosophy of improving viability by maximizing recovery and productivity seems unsustainable, till significant overall unit cost rate reduction and enhancement of overall unit revenue and profit rate is achieved. The performance improvement of the plant needs the routine auditing studies, for reducing the overall unit cost and to improve the cash flow. The review of literature on process auditing of mineral processing in general and iron ore processing plants in particular are few.¹¹-⁹ The program objectives vary due to the time, money and operating philosophy constraints of the company. The process auditing has to be flexible to cater the present needs in stages with an integrated approach in future. Table 1 outlines the steps in process audit. The aim of the present work was to conduct process auditing studies on the iron washing plant near Hospet, Ballari district, Karnataka as the washing plant reported non realization of stipulated grade sinter concentrates. The scope of process auditing studies was to evaluate the plant, carryout bench scale tests for process improvement, incorporation of recommendations in plant and evaluation of the modified process from process, economical and environmental viewpoint.
2 Materials and Methods

2.1. Ore sample and equipment

The representative feed sample collected from iron ore washing plant was subjected to standard sample preparation techniques to obtain stock sample for tests. Laboratory ferrous wheel model WHIMS.

2.2. Methods

The plant steams were sampled and were subjected to characterization to evaluate the process and prepare base line data for problem identification. Bulk feed and product samples also were collected for bench scale tests where in the samples are subjected to amenability tests to particle size refining and WHIMS. The laboratory process improvement suggestions are discussed with the plant team and are incorporated. The modified process circuit is sampled, characterized and evaluated. The benefits accrued upon modification in terms of productivity, ease of operation, reduction in operating costs if any, metallurgical process improvement, economical and environmental benefits, are evaluated and compared with base line data.

The iron ore washing process was to wash crushed / natural iron ore fines to obtain sinter grade concentrate assaying +60% Fe with Max 10% -0.1mm material. The process comprised of drawing the ore from bin via feeder at 100 tph and fed to screen for removing 10mm over size. The screen under size and water was added to the feed port of 0.48 m dia spiral classifier bypassing a drum scrubber. The reason for circumventing drum scrubber was to reduce the energy cost and bottleneck due to maintenance of rollers of scrubber. The 0.48 m dia classifier was flared over flow type with 0.72 m wide and 120% dia submergence at maximum weir level and 70% submergence at minimum weir level. The spiral was twin pitched with pitch of 0.25 dia. The rpm of spiral was found to be 6. It was reported that the washability performance of classifier was poor. The iron ore fines assaying 54.40% Fe, 9.53 % SiO₂, 5.88%Al₂O₃ and 4.77% LOI when treated, yielded muddy classifier sand assaying 56.40% Fe, 8.33 % SiO₂, 5.08%-Al₂O₃ and 3.77% LOI with 62.2% Fe distribution, at wt% yield of 60. The slimy tails assayed 52.77. As the product failed to meet the specified grade of +60% and exceeded the 10% limit for -0.1mm size. Fig 1 shows the process flow sheet of the iron ore washing plant.

Fig.-1: Schematic flow sheet of washing plant

3. RESULTS AND DISCUSSION

3.1. Base line data

During the plant visit it was noticed that the classifier was not fed properly dispersed pulp. Further the feed point was close to weir affecting the settling. Fig 1 shows the flowsheet of washing plant. A representative sample was subjected to characterization studies. The base line results are shown in Table 2. The results confirmed the problems stated by the site engineers where in muddy spiral concentrate failed to meet the specifications. The scrubber was bypassed to save the power and avert maintenance problems. The present aim was to produce a minimum 60tph spiral sands irrespective of granulometry of feed.

<table>
<thead>
<tr>
<th>Process</th>
<th>Wt. %</th>
<th>% Fe</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Assay</td>
<td>Distn</td>
</tr>
<tr>
<td>Classifier U/F conc</td>
<td>60.0</td>
<td>56.40</td>
</tr>
<tr>
<td>Classifier U/F tails</td>
<td>40.0</td>
<td>51.40</td>
</tr>
<tr>
<td>Feed</td>
<td>100.0</td>
<td>54.40</td>
</tr>
</tbody>
</table>

3.2. Characterization and beneficiation of feed

The iron ore fines assayed 54.42% Fe, 9.53 % SiO₂, 5.88% Al₂O₃ and 4.77% LOI. The feed sample was subjected to size analysis and products were assayed. The results are given in Table 3 which indicate D₅₀ 0.6 mm and the slimes -0.053 mm assayed a meager 48.77 % Fe at 45.2 wt.% yield. The sample is amenable to destiming yielding sinter & fine sand with +60% Fe. Further preliminary diagnostic amenability test on dried-0.15 mm
fraction indicated that the sample is amenable to both sink and float tests and Frantz iso dynamic magnetic separation tests producing concentrates assaying +60% Fe. The -0.15 mm fraction of feed was subjected to lab WHIMS using 6mm matrix, at 25% S, 9800 gauss yielded a magnetic concentrate assaying 63.25% Fe with 28.6 % Fe overall distribution with overall 25 wt.% yield, indicating that the pellet grade concentrates may be obtained from classifier O/F slimes.

### 3.3. Short term and Medium term modifications

As a short term and medium term modification, the plant feed was scrubbed in the scrubbed. The scrubbed and dispersed pulp fed max feed port away from weir. Facility for raking sand slay washing was provide and sand was dewatered using dewatering screen. The dewatering screen under flow was gravitates to cyclone feed pump. The classifier overflow was pumped to a cluster of 125 mm cyclones [cut size D<sub>50</sub> 15 microns] available in the plant. The results of short and medium term modifications is shown in Table 4. The short term modifications yielded a composite sandy concentrate of U/F from spiral and cyclones assaying 60.92% Fe with 72% Fe recovery at wt.% yield of 60.0, meeting the specifications and improving the grade and yield from base line data.

### 3.4. Long term modifications

As the short term modifications yielded the desired grade and yield, it was decided to incorporate the vertical pulsating high gradient magnetic separation of spiral classifier overflow as value added pellet grade concentrate may be obtained. Scrubbed and dispersed pulp fed max feed port away from weir. The classifier overflow pumped to a 2m dia VP WHIMS, 1.5 mm rod matrix, 10000gauss Back- ground intensity at 25% S. The results of final process of scrubbing, screw classification, VPWHIMS of O/F, dewatering of WHIMS products is given in Table 5. The modified process yielded a value added pellet grade magnetic concentrate assaying 63% Fe with 36% Fe distribution at wt. % yield of 31.5, besides a sinter grade sandy concentrate assaying 60.5 % Fe with 44% Fe distribution at an yield of 40%. The final slimy nonmagnetic tails assayed 38.6% Fe with 20% Fe distribution at wt. % yield of 28.5. The investments for the modifications were paid back within a year of operation turned around 30% loss into 20% profit by producing readily salable sinter grade concentrate, producing value added pellet grade concentrate. Similar benefits were reported while auditing of iron ore beneficiation plants by previous workers [2 & 8].

### 4. CONCLUSIONS

A 100 tph iron ore washing plant at Hospet, Ballari district, Karnataka, India, failing to yield stipulated +60% Fe sinter grade concentrate was subjected to process auditing. The modifications in scrubbing, spiral classifications, VPHGMS of slimes, yielded a composite concentrate assaying 61.54% Fe with 80% Fe distribution at 71.5 wt.% yield. Auditing turned around loss making plant into profit making plant, meeting the aim of audit of improving profitability, conservation of mineral and environment.

### ACKNOWLEDGEMENTS

We are thankful to the Iron washing plant management team for associating in the process auditing work.

### REFERENCES


