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Classification of iron ore fines at Hamersley Iron's Paraburdoo Mine

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ABSTRACT

To improve its strategic position in the iron ore fines market, Hamersley Iron Pty. Ltd. investigated a number of options for improving quality of fines by reducing the level of gangue. As a result of this a processing plant was constructed to deslime the fines product from its mines at Paraburdoo in the Pilbara region of Western Australia. Improvements made to both the chemical and physical characteristics of the processed fines were also expected to improve its sintering performance.

Classification to remove ultrafine material is able to improve the quality of the fines as the predominant gangue mineral, kaolinite, has a finer size distribution than the iron bearing minerals, hematite and goethite. Lab scale and pilot plant studies indicated that 30% of the total alumina content could be removed with 10% weight loss through desliming at 0.01mm. This upgradation would reduce the alumina content of the Paraburdoo fines from 2.7% to 2.1% Al_2O_3 and the final Hamersley blend for shipping from 2.45% to 2.2% Al_2O_3.

This paper examines the background to the decisions for installing this plant as well as discussing the plant circuit and the impact of the problems associated with dewatering the cyclone underflow.

Key words : *Classification, Iron ore fines, Dewatering screen, Hydrocycloning*

INTRODUCTION

Hamersley Iron Pty.Ltd, an Australian company wholly owned by Rio Tinto, commenced mining iron ore at Mt Tom Price in 1966. From its modest start with one mine and one port and a capacity of 5 Mt/a, Hamersley has grown to its current position as a leading iron ore supplier with a capacity of around

65 Mt/a. It is currently operating six mines (Mt Tom Price, Paraburdoo, Channar, Brockman/Nammuldi, Marandoo and Yandicoogina) with 2 shiploading berths at Dampier. Crushed ore from the Channar mine is conveyed to Paraburdoo and combined with crushed Paraburdoo ore for further processing. The location of these operations is shown in Fig. 1.

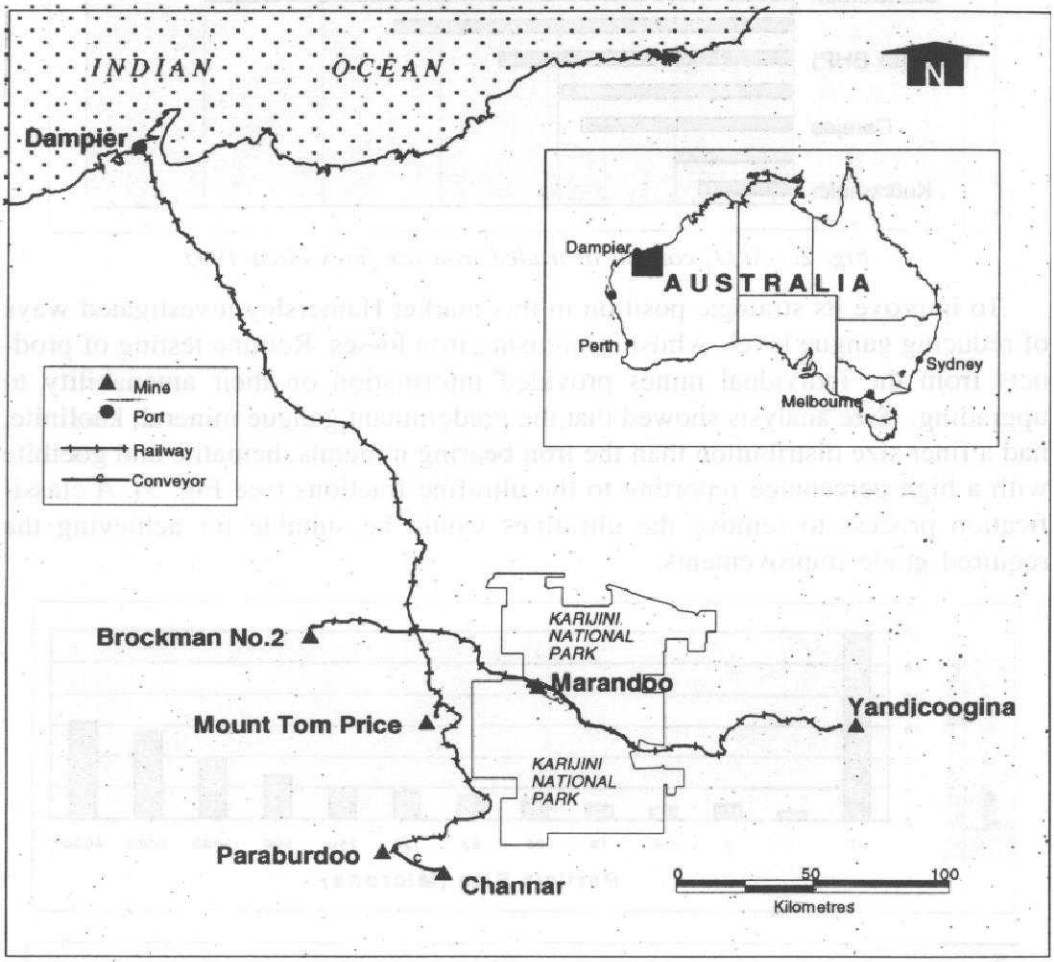

Fig. 1 : Location of Hamersley's mines, railways and port

Hamersley Iron currently produces three products: a blended lump (-30+6 mm), a blended fines (-6 mm) and, commencing in 1999, a discrete limonitic pisolite fines (-10 mm) from Yandicoogina.

Prior to 1995, in terms of quality, the blended fines product was at the lower end of the scale in relation to its major competitors, particularly in terms of alumina content (Fig. 2).

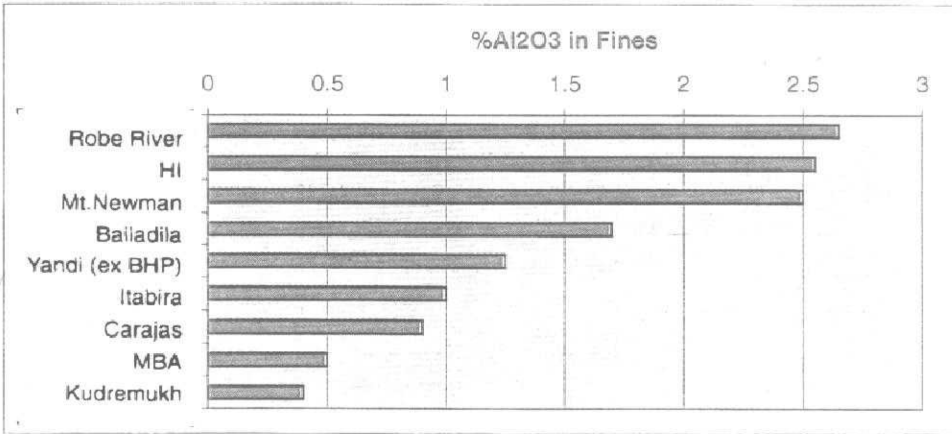

Fig. 2 : Al_2O_3 content of traded iron ore fines circa 1993

To improve its strategic position in this market Hamersley investigated ways of reducing gangue levels whilst minimising iron losses. Routine testing of products from the individual mines provided information on their amenability to upgrading. Size analysis showed that the predominant gangue mineral, kaolinite, had a finer size distribution than the iron bearing minerals, hematite and goethite with a high percentage reporting to the ultrafine fractions (see Fig. 3). A classification process to remove the ultrafines would be suitable for achieving the required grade improvements.

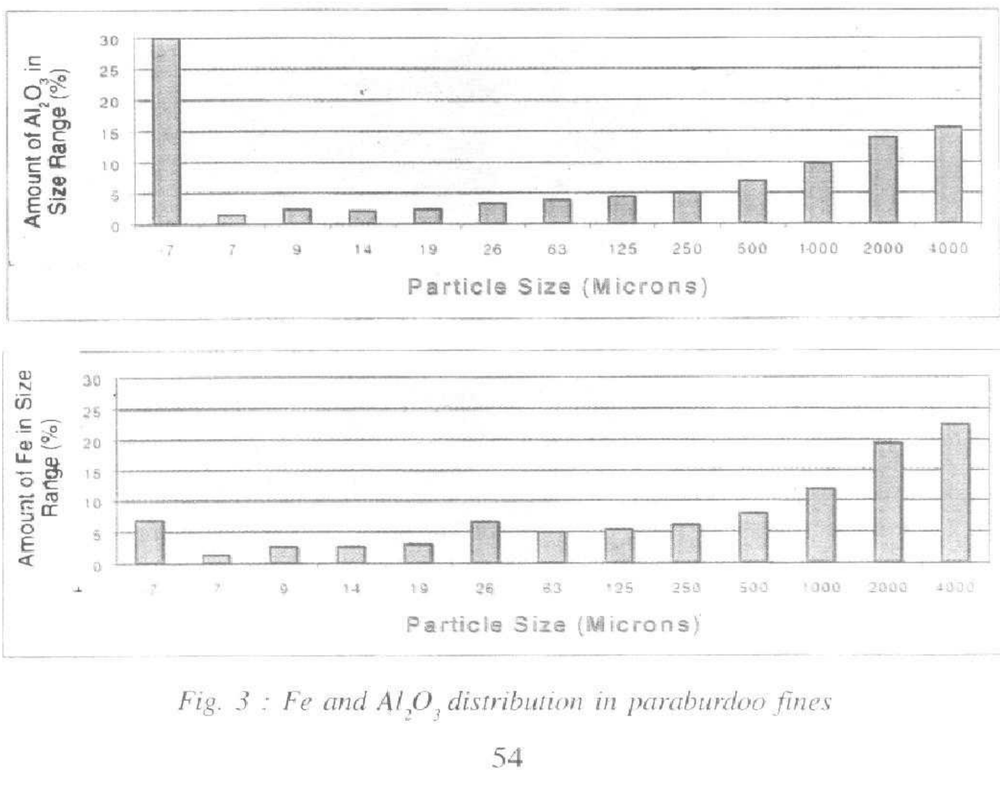

Fig. 3 : Fe and Al_2O_3 distribution in paraburdoo fines

Because of the tonnage of fines produced and the level of upgrading possible with classification, Paraburdoo Fines was selected as the appropriate stream to treat (Fig. 4).

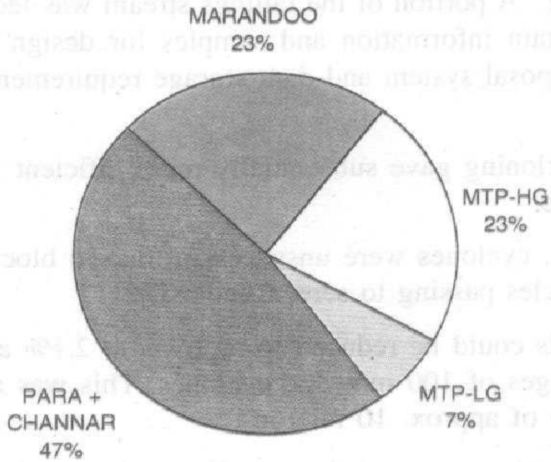

Fig. 4 : Contribution of Mt.TomPrice, Paraburdoo+Channar and Marandoo Mine to Al_2O_3 content of Hamersley fines (pre-1996)

A test work program was instigated in 1993 and following favourable results a plant to treat 13 Mt/a was designed and constructed.

The plant circuit consists of 4 modules, each containing a wet screen followed by a 2-stage hydrocyclone circuit consisting of 100 mm dia. cyclones. Cyclone underflow is dewatered on vibrating screens and recombined with wet screen oversize to form the washed fines product. Cyclone overflow is combined, thickened and pumped to a tailings dam. Each module was designed to treat up to 700 t/hr of -6 mm feed. Construction commenced in 1994 and the plant was commissioned in October 1995.

TEST WORK

Test work was carried out in three separate areas.

1. Shift composites of fines product were collected over a six month period and subjected to grade by size analysis to examine the grade / recovery relationship of size classification and its variability. Lump/ fines recovery data was also examined over the same period to determine the fluctuations in fines tonnages.

2. A 20 t/hr pilot plant was installed to wet screen fines at 0.5/1 mm and deslime the screen undersize using hydrocyclones. Feed was provided from discrete pits to test variability, and bulk samples were provided to customers for measuring the impact on downstream processes such as sintering. A portion of the tailings stream was fed to a pilot thickener to obtain information and samples for design of the thickener, tailings disposal system and dam storage requirements. Results indicated:

- 2-stage cycloning gave substantially more efficient separation than a single stage.
- 50 mm dia. cyclones were unsuccessful due to blockages from elongated particles passing to screen undersize.
- Al_2O_3 levels could be reduced from 2.7% to 2.1% at a yield of 90% using 2 stages of 100 mm dia. cyclones. This was achieved at a cut point (d50) of approx. 10 microns.

3. Handling trials were carried out at Hamersley's existing beneficiation plant at Tom Price to test the impact of stockpiling, railing and dumping high moisture material. The results of these trials were used to generate computer models to predict moistures and drainage characteristics for the proposed product at Paraburdoo. Results indicated that projected product moisture at Paraburdoo would reduce from 12% to around 8% with adequate time for stockpile drainage.

PLANT DESIGN

The plant flowsheet is shown schematically in Fig. 5. It consists of 4 identical modules, each designed to treat 700 t/hr.

From each of the four feed bins, a variable speed belt feeder discharges the unprocessed fines onto a feed preparation screen, where initial size separation at 0.6 mm is effected by wet screening involving water sprays located above each screen. Oversize (+0.6 mm) is discharged in a dewatered state from the feed preparation screens onto the product conveyor.

The feed preparation screen undersize (-0.6 mm) is processed via a two stage hydrocyclone circuit to separate the -0.01 mm particles. Primary cyclone underflow gravitates to the secondary cyclone feed sumps and overflow from both stages gravitates to the thickener via their respective feed sumps where a recycle stream (Fig. 5) allows these sumps to maintain a steady head. Each module contains 4 clusters of 25 x 100 mm dia. primary cyclones and 4 clusters of 25 x 100 mm dia. secondary cyclones.

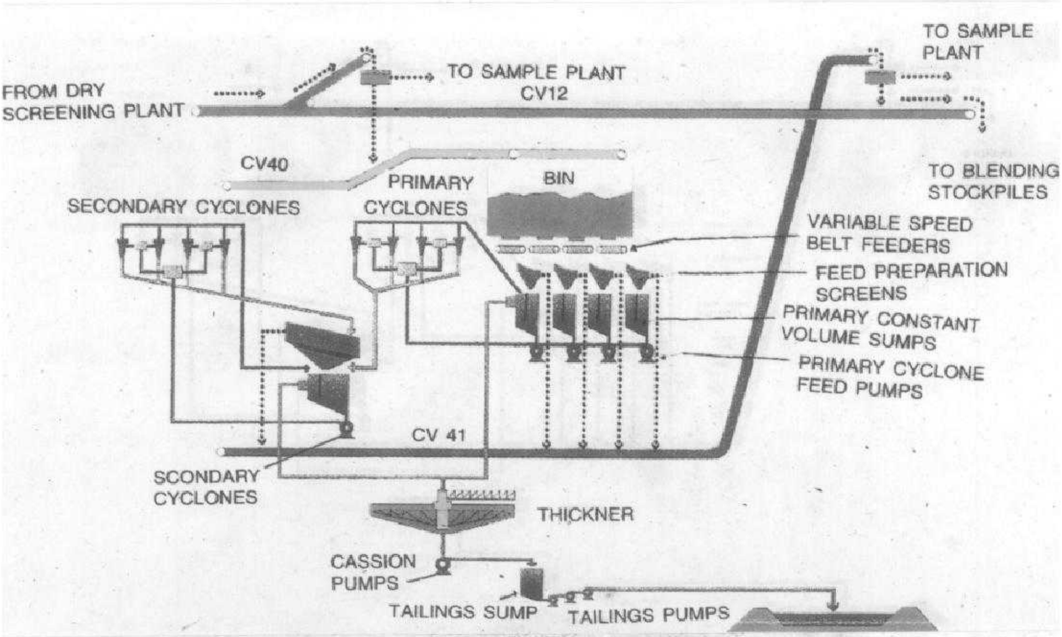

Fig. 5 : Schematic of paraburdoo fines processing plant

Secondary cyclone underflow (-0.6+0.01 mm) is dewatered on dewatering screens before discharge to the product conveyor where it joins the -6+0.6 mm product. Dewatering screen undersize is recycled to the secondary cyclones. The combined product passes through a new sampling station before joining the previously existing conveyor system to the fines blending stockpiles.

The base of each of the two 200 kt capacity fines stockpiles was modified to include an underdrainage system to recover water from the stockpiled material prior to trainloading. Contained water drains through the filter blankets to the outside edges of the stockpile where it is collected in slotted concrete pipes which run the full length of the stockpiles to a collection sump from where it is pumped back to the process plant.

The tailings fraction is flocculated and thickened in a 75 m diameter Caisson thickener. Thickener underflow is pumped to a tailings dam approximately 4 km from the plant and overflow water is recycled. An aerial view of the Paraburdoo Fines Processing Plant is shown in Fig. 6.

PLANT PERFORMANCE

Since commissioning in 1995 some operating problems have occurred that have led to variation from design projections. The major problem has been that the dewatering screens do not operate in steady state until a high circulating load (~ 450%) has been established.

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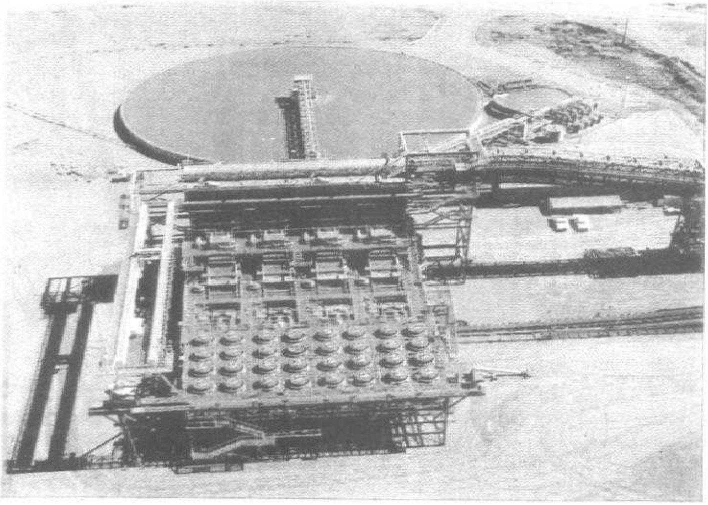

Fig. 6 : Paraburdoo Fines Processing Plant

This has led to high secondary cyclone feed densities (>35% solids) that have resulted in reduced recoveries (84%) and reduced capacity (600 t/hr/module). An increase in the cyclone d50 cut point to ~ 25microns has led to an increased rejection of the low density gangue that has improved product alumina grades beyond expectation. This is illustrated in Fig. 7 which shows product Al_2O_3 grades decreasing from2.8% to 2.0% Al_2O_3 following the installation of the plant.

Reduced recoveries have led to a significant increase in tailings tonnages. The thickener and tailings pumps have coped with this increase but extra expenditure has been required to increase tailings dam capacity. The high circulating load from the dewatering screens was evident in pilot plant test work but was thought to be due to the pilot screen not producing adequate bed depth as a result of the screen deck containing over 30 times the required screen area for the tonnage being treated. *(The pilot dewatering screen was installed to facilitate sample handling rather than to be used for design purposes)*. The actual reasons for the high circulating loads compared to other Rio Tinto operations appear to be:

- different dewatering characteristics between Paraburdoo/Channar ore (20-30% goethite) and other ores (Mt Tom Price - <10% goethite) with which Hamersley had previous dewatering experience;
- finer material than that with which design engineers had previous dewatering experience.

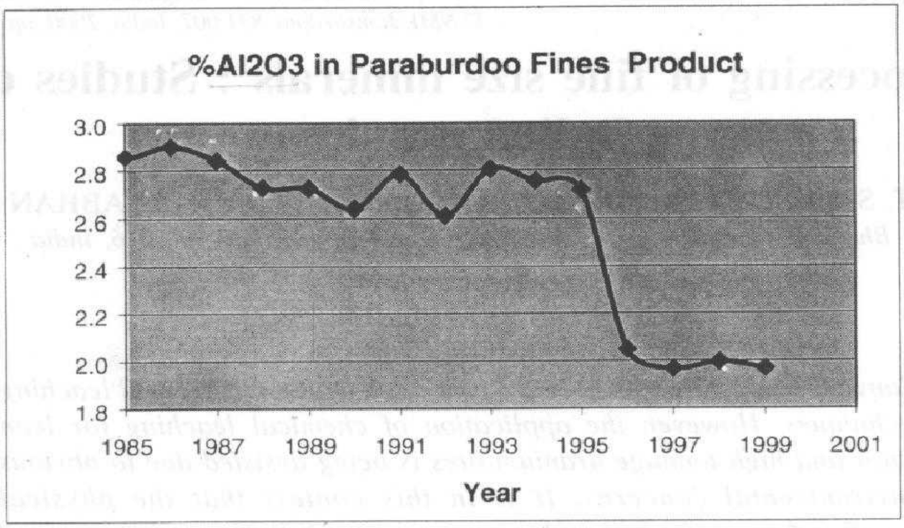

Fig. 7 : Reduction in Al_2O_3 after installation of Fines Processing Plant

Another issue that has caused concern is that of product moisture. Product drainage has also been less effective than projected (~10% final moisture compared to 8%) for similar reasons to the differences in dewatering screen response mentioned above.

POTENTIAL PROCESS CHANGES

A number of studies have been carried out to improve the performance of the dewatering screens and to reduce the moisture level of the product. The use of belt filters was considered but could not be justified unless an increase in production tonnage was required.

Larger cyclones (250 mm and 600 mm diameter) are also being considered for trials. Their use would reduce the amount of ultrafines in the screen feed and thereby assist the dewatering screens to lower the circulating load as well as moisture levels.

CONCLUSION

To achieve the objective of improving the fines quality some operating problems have occurred. It has been found that the dewatering screens selected do not operate in steady state until a high circulating load is established which has led to cyclone feed densities being higher than design. As a result the cyclone cut point operates at 0.025 mm causing the mass recovery to reduce to 84% and gangue rejection to increase. The preferential separation of lower density minerals to cyclone overflow in the -0.06+0.01 mm size fraction has had a positive effect on the final product grade, reducing the alumina content to around 2.0%.