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BENEFICIATION OF INDIAN IRON ORE LUMPS AND FINES BY USING UNDERBED AIR–PULSATED BATAC JIGS

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ABSTRACT

After setting a target of 100 MT/yr of Steel by 2012, Indian Steelmakers and Iron Ore producers are already struggling due to the depleted grade of Iron Ore available in India. The main impurities dominating the Indian Iron Ores are SiO_2 and Al_2O_3 which should be reduced with an economical method of Beneficiation.

Jigs are the earliest type of process equipments employed in mineral separation but the newly developed under bed pulsated BATAC Jig has considerable advantages over its counterparts. There are various types of BATAC Jigs available for Lump and Fines such as Lump Ore (2 products/3 products) Jig and Fine Ore (2- product) Jig.

A South African iron ore producer recently commissioned a 10 Mtpa-capacity greenfield Iron Ore beneficiation plant with 2 Lump Ore BATAC Jigs and 2 Fine Ore with a combined capacity of 1240 tph at Assmang Khumani Iron Ore Mine in Northern Cape, South Africa. The Concentrate contains a Fe grade of > 66%. A further capacity expansion project to 16 Mtpa product is currently underway using 3 more BATAC jigs.

The first large scale Iron Ore Jig beneficiation plant in India was commissioned in 2006 at Noamundi in the state of Jharkhand. Tata Steel is already operating a 300 tph Fine Ore BATAC Jig Iron Ore Plant there. Patnaik Minerals also followed the pattern and started constructing 100 tph Fine Ore Jigging Plant at Joda, Jharkhand. There are different combinations possible in which unit operations can be arranged which include Jigs as the heart of the beneficiation process. These various types of flow sheets provided this beneficiation method with an advantage over other unit operations.

Lessons learned and best practices regarding equipment selection and operation acquired during the last 10 years are summarized to define potential BATAC Jig applications in Iron Ore. Finally, field experiences and results are analyzed to establish the best strategy to fit specific Indian Iron Ore conditions.

Keywords: *BATAC Jig, Lump Ore BATAC Jig, Fine Ore BATAC Jig.*

INTRODUCTION

Worldwide Iron Ore reserves seem to be quite vast but the grade of Iron Ore is depleting day by day. India is one such country which is blessed with high grade Iron Ore and for the last 50 - 60 years India is consuming and exporting it vastly. Now as it has set itself a target of achieving 100 MT/yr of Steel by 2012 and the required quantity of Iron Ore is projected at 190 MT/yr, the steel

makers already started experiencing pressure due to the deteriorated grade of Iron Ore because of impurities such as SiO_2 and Al_2O_3. To match the modern smelting requirements, beneficiation of the available Iron Ore should be done for cost - effective production of steel with low energy and coke consumption, and reduced slag formation. One of the most economical and effective methods for beneficiation of Indian Iron Ores is the Jigging process – using an air pulsated BATAC jig.

BATAC JIG

BATAC Jig Technology has been successfully introduced to the iron ore industry for up gradation of interlocked iron ores, lump ores as well as sinter fines, which require high separation densities to obtain marketable concentrate grades.

The stratification of randomly mixed iron ore particles according to density in a jig is based on the well known principle of sorting by the water flow which pulsates vertically through the material bed. The water movement is generated by the disc-valve controlled jigging air which acts on the water perpendicular to the direction of ore transportation from below the jigging bed.

There are some considerable advantages of BATAC Jig over other beneficiation processes such as:

1. It is a water-only process so operating cost is relatively low.
2. It can operate at cut point range from 1.3 to 7.85 making it suitable for wide varieties of ore available.
3. It has high throughput capacity, 75–90 tph/m jig width for lumps and 68–78 tph/m jig width for fines.
4. It has compact design and ranges up to 7 m in width so a considerably smaller area is required.
5. Two cut points are possible in a single machine so up to 3 products can be recovered from a single machine.
6. It can handle feed variations up to 20%, as well as variations in the percentage of water in the feed material.
7. It can be stopped instantly and restarted immediately with no effect on the process. There is no need to drain the jig after a stop, and restarting only takes a few seconds with the same operating parameters as before the stoppage.

A homogeneous feed distribution relative to quantity, density and grain size over the entire machine width is a precondition for the high accuracy of separation in a jig. The process results in the concentration of heaviest material in the bottommost layers.

It is measured with the aid of a float that has been matched to the density of material to be discharged. The float controls the material discharge through the concentrate discharge gate systems. All material that passes the screen decks of the jigging chambers and the concentrate discharge gates is directed to the dewatering bucket elevator or an equivalent hutch discharge system. The separated light fraction (impurities) is discharged as overflow at the jig end and withdrawn by downstream mounted dewatering equipment.

Broadly speaking, the Jigs are divided into two types:

1. Lump Ore Jigs for typical size range from 38 mm to 10/6 mm, and
2. Fine Ore Jigs for typical size range from 10 mm to 1/0.5 mm

Lump Ore Jigs are further divided into two variations according to the number of products required as:

1. One Cut , 2 products (Concentrate/Reject) Jig, and
2. Two Cut, 3 products (Concentrate/Middling/Reject) Jig

LUMP ORE ONE CUT, 2 PRODUCTS (CONCENTRATE/REJECT) JIG

The low grade sized lump ore is fed to a 2-chamber Jig for recovery of high grade lumps (Fig. 1). The heavier fraction after the two chambers recovered through the discharge gate system into the dewatering bucket elevator. The overflow material after dewatering through a screen can be fed to the outgoing reject conveyor belt.

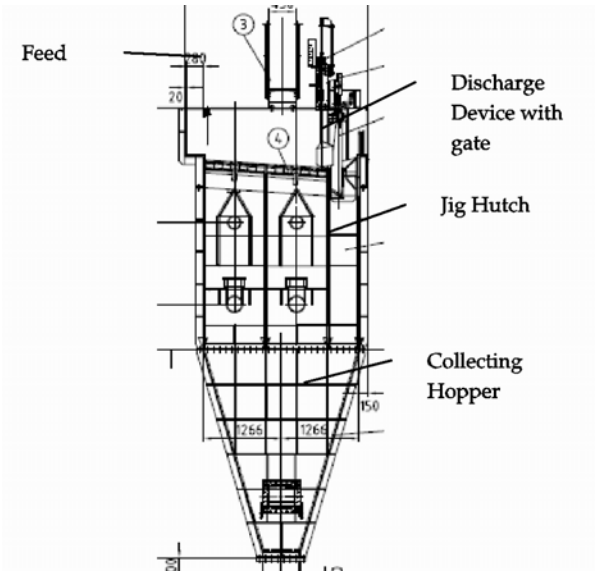

Fig. 1: Lump Ore-One cut-2 products (Concentrate/Reject) BATAC Jig.

LUMP ORE TWO CUT, 3 PRODUCTS (CONCENTRATE/MIDDLING/REJECT) JIG

Here the heavy fractions of the first two chambers are producing the concentrate, discharged through the first discharge gate system into the first dewatering bucket elevator (Fig. 2). The heavy fraction of the third chamber is a middling product which can be crushed and fed to a fine ore Jig, if requested. Here there are two underflow hutch hoppers and two bucket elevators—one each for concentrate and middling product.

FINE ORE ONE CUT, 2 PRODUCTS (CONCENTRATE/REJECT) JIG

Here low grade fines are fed to a 3 chambers Jig for recovery of high grade fines (Fig. 3). The first two chambers are discharge chambers and the third chamber is a ragging-bed chamber. The heavier fraction of the first two chambers, discharged through the gate system, generally contains fines with size 4–10 mm. Heavier fines of ragging chamber of size < 4 mm are passed through the

ragging chamber screen deck to the hutch. The recovered material from both discharge chambers and ragging chamber is mixed in the common hutch hopper and recovered through the bucket elevator or an equivalent hutch discharge system.

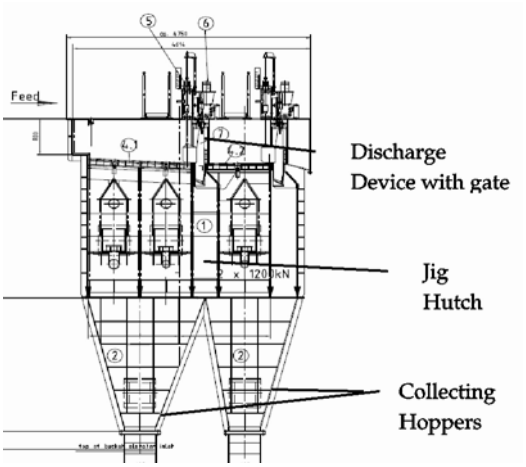

Fig. 2: Lump Ore-One cut-3 products (concentrate/middling/reject) BATAC Jig.

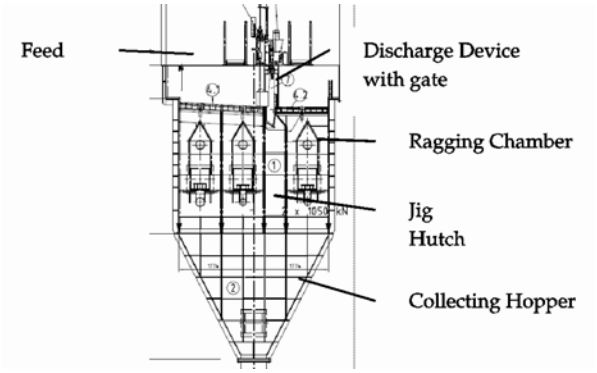

Fig. 3: Fine Ore-One cut-2 products (concentrate /reject) BATAC Jig.

Jigs are the earliest types of process equipment employed in mineral separation. Although the Baum-type jigs have been popular and efficient equipments for mineral processing for many decades, the newly developed under bed-pulsated BATAC Jig has a significant improved performance compared a BAUM Jig.

The advantages of BATAC Jig over other side pulsated BAUM Jig are:

1. Unlike a BATAC Jig, as we increase the width of a BAUM Jig > 2m height of air, pulse becomes inconsistent across the width of Jig bed due to curvature of bottom section of BAUM Jig Hutch. The Jig bed experiences higher stroke on outer section of Jig deck compared to the inner section thus making the separation inefficient. So a BAUM Jig with width greater than 2.5 m is not recommended.

2. Only 75% of total Jig width is utilized for actual separation process unlike 100% in BATAC Jig. So BATAC Jig has less CAPEX for equal throughput levels.
3. Due to its limited width, BAUM Jigs experience relatively high edge effect (area of lower performance) compared to BATAC Jigs. If we take a common 2 m wide BAUM Jig and a common 4.5 m BATAC Jig, the percentage negative edge effect is 8.0% and 3.6% respectively.
4. For a same throughput rate, the installed volume, the building volume as well as the static and dynamic loads for and inside the building are up to 45% smaller for a BATAC Jig installation compared to a BAUM Jig installation.
5. Unlike with the BAUM Jig, several discharge gates are installed over the width of a BATAC Jig for higher performance. A single discharge system ensures best performance up to a width of approx. 1.5 m. For example, for a 4.5 m wide jig 3 independent gate systems would be installed over a Jig width. This allows a sectional control of discharge, automatically controlled via a float/ultrasonic sensors device.
6. There are multiple air chambers directly under the screen bed permitting uniform distribution of air pulsations, giving greater capacity and more accurate separation than standard BAUM Jigs. Additionally the BATAC Jig is equipped with a new concept of air valves, automatically controlled, permitting infinite variations in jigging pulsations.
7. All BATAC Jigs are equipped with own PLC cabinets which allows the plant supervisor to do the jig adjustments from control room. So there are no mechanical adjustments at the jig drive required anymore like with BAUM Jigs.
8. The Dewatering Bucket Elevator in BATAC Jigs as a concentrate discharge seals the separation and discharge system completely. So there is no negative influence (downstream force) due to water release with concentrate and due to feed quality variations. So lower quantity of make-up water is required.

INDUSTRIAL SCALE PLANT ASSMANG BKM EQUIPPED WITH BATAC JIGS FOR LUMP ORE AND SINTER FINES

Assmang BKM (Fig.4) has successfully developed the greenfield Khumani Iron Ore mine on schedule and within budget. It has paved the way for a series of expansions which could see production levels rise from 8.4 million tons a year to as much as 22 million tons a year by 2015.

Khumani is situated in the Kalahari region of the Northern Cape and comprises an open pit mine with ore – treatment and dispatch facilities.

Bulk earthworks on R4 – billion phase 1 of the project kicked off in June 2006 and the first train destined for Saldanha was loaded in May 2008. By September 2008, the operation was producing to its original design capacity of 8.4 million tons a year, with all products destined for export.

The Khumani iron-ore mine operates as an open cast mine. ROM is processed through a 3000-tph primary gyratory crusher and onto a buffer stockpile. An overland belt conveyor then transports the crushed ore to the processing plant facility, 5 km away.

Ore with more than 66% Fe content is designated ‘on–grade’ while ore below 66% is ‘off-grade‘.

The on-grade ore is washed and wet-screened into three size fractions: lumpy (–32 mm to 12 mm), medium (–12 mm to 6 mm) and fines (–6 mm to 0.2 mm). Anything over 35 mm is recycled and crushed in the closed-circuit tertiary crushers. Being on-grade, these products are transported directly to the product stockpiles through the product conveyor corridor.

The off-grade material is separately screened at the same sizes and upgraded by gravity separation in a pulsating jig plants. The lump ore is delivered to 2 Lump Ore BATAC Jigs of 300 tph nominal capacities (each) of 4 m working width and 3 jigging compartments. The concentrate is separated in the first 2 compartments into a common hopper from which it is discharged by a dewatering bucket elevator directly onto the concentrate conveyor belt. The tailings flow over the jig together with the entire make up water which is dewatered by screens and conveyed to the tailings dam.

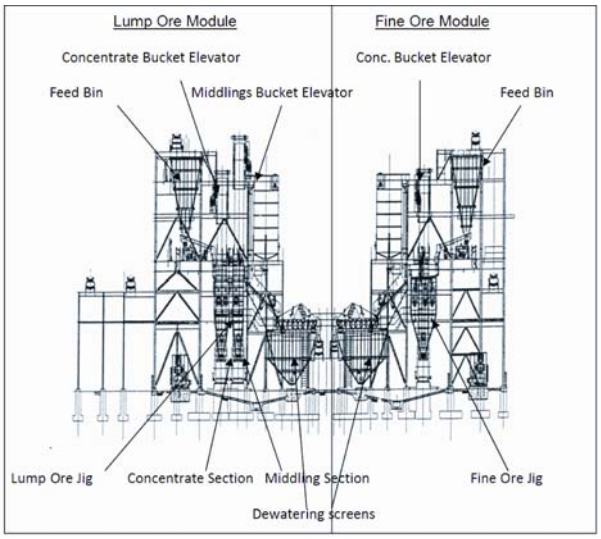

Fig. 4: Assmang plant layout.

The middling is separated in the 3rd jigging compartment which is equipped with its own bucket elevator. This product is crushed in High – Pressure Grinding Rolls and the combined concentrate is transported by overland conveyor and stockpiled by means of three stackers.

The fine ore is delivered to 2 Fine Ore BATAC Jigs of 270-tph nominal capacities (each) of 4 m working width and 3 compartments—the first 2 of which being discharge chambers and the third one a genuine ragging chamber. The fines concentrate is again separated in the first 2 compartments and heavier fines collected through the ragging chamber screen deck are mixed together in a common hopper. The final concentrate is discharged by a dewatering bucket elevator directly over the concentrate conveyor belt and tailings conveyed to the tailings dam. The slimes from both washing and screening plants are cycloned with the dewatered underflow joining the fines product.

A further capacity expansion is being under execution which includes 2 more Lump Ore Jigs and 1 more Fine Ore Jig.

TATA STEEL INDUSTRIAL SCALE PLANT FOR BENEFICIATING IRON ORE FINES

The Jigging Plant (Fig. 5) was commissioned in 2006 for reduction of Alumina content in the fines produced by operating Noamundi Scrubbing and Screening Plant is designed for a nominal capacity of 280 tph containing about 64.5% Fe and 4 % Al_2O_3 and will according to the flow sheet shown in figure for producing of Sinter feed of minus 2.4 % Al_2O_3 grade.

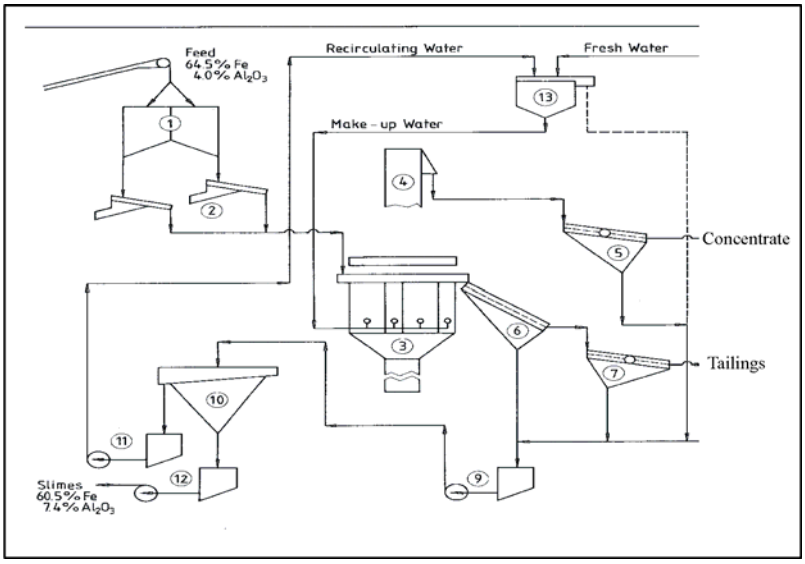

Fig. 5: Tata steel jigging plant.

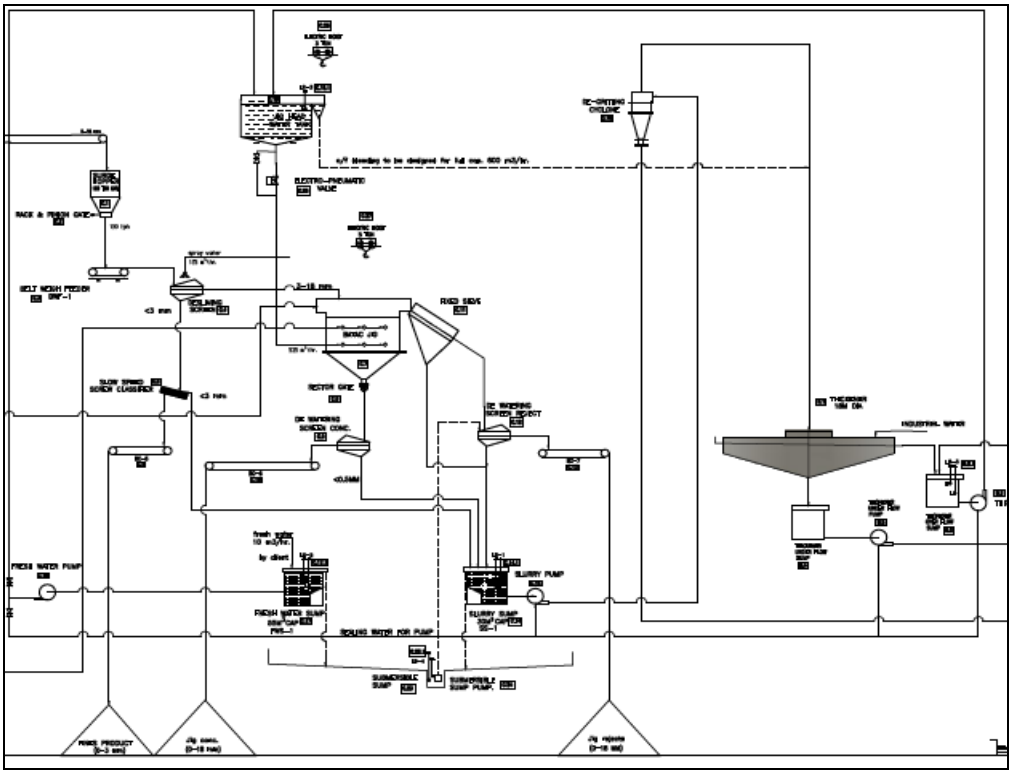

Fig. 6: Patnaik Minerals Jigging Plant.

In the plant, 2 vibrating feeders (Item 2) provide uniform feed out of the feed bins (Item 1) onto a BATAC Jig of 4 m working width and 3 m working length (Item 3) into which a two product separation is effected in 2 discharge chambers and followed by 1 ragging chamber. The sink product (concentrate) is collected and dewatered through a Bucket Elevator (Item 4) followed by the vibrating dewatering screen (Item 5).The float product (Rejects/tailings) is overflowing out with the entire make–up water admitted to jigging chamber is dewatered by a static dewatering fixed sieve (Item 6) and followed by one dewatering Screen (Item 7).

Now with some modifications Tata Steel is running the same Jigging plant at 340 tph.

PATNAIK MINERALS INDUSTRIAL SCALE PLANT FOR BENEFICIATING IRON ORE FINES

Patnaik Minerals is constructing 100-tph Jigging Plant (Fig. 6) at Joda, Jharkhand, consisting Fine Ore BATAC jig of a 1.5-m working width and a 3-m (3 compartments) working length.

CONCLUSION

The extensive laboratory test work executed with several samples on jigging of fines and lump ores using the laboratory and pilot BATAC jigs together with the experience gained in commercial BATAC Jig plants over 10 years in South Africa, India and elsewhere in the world has demonstrated that this gravimetric technique is very suitable process for separation of Iron Ore lump and fines at high separation densities. It is a welcome supplement to conventional separation methods such as Baum jigs, Heavy Media separation and Spiral concentrators.

Furthermore, this innovative technology also offers excellent opportunities for the treatment of old tailings dumps, which in addition, contributes for improving environmental situation of Iron Ore processing plants.

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