INNOVATIVE TECHNOLOGGIES FOR THE DENSITY SEPARATION OF LUMP IRON ORE[1]

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Abstract

Over the last years beneficiation techniques for iron ore have become more important in order to achieve a maximized utilization of ore resources and to produce competitive products according to international standards. In addition to that the mining of low grade deposits leads to an increased demand for separation technology for lump ores, sinterfeed and pelletfeed. Air pulsed jigs are frequently used for a particle size > 8 mm. Allmineral has been engaged in hematite iron ore beneficiation with its air pulsed alljigs® since the mid nineties. The delivery of jigs started for the upgrading of iron ore for its utilization in a Direct Reduction Plant in Australia. Since then, various other installations with jigs for lump and fines are in operation in Brazil, Australia, India and South Africa. The biggest of it´s kind in South Africa with 4.000 tph capacity and 24 alljigs® installed. Low grade run of mine and/or dump ores are being processed with alljig®-separators as the core equipment. The lecture describes the technology in use, the characteristics of various iron ores and the product qualities achieved. The operational results show the specific advantages of jigs like possible high gravity cuts and the easy and low operating costs. This technology provides a value addition to the development of the Brazilian Iron Ore Industry.

Key words: Gravity separation; Jig; Iron ore; Lump ore.

TECNOLOGIA INOVADORA PARA SEPARAÇÃO DENSITÁRIA DE MINÉRIOS HEMATÍTICOS BITOLADOS

Resumo

Ao longo dos últimos anos, a mineração de depósitos de baixo teor levou a uma demanda crescente por tecnologia de separação de minérios tipo NPO, sinterfeed e pelletfeed. Jigues pneumáticos são frequentemente utilizados para tamanho de grão superior a 8 milímetros. A palestra tem como objetivo descrever as tecnologias em uso, as características dos diversos minérios de ferro e qualidades do produto alcançado. Os primeiros jigues focados no processamento de minério de ferro bitolado foram desenvolvidos para a concentração de pilhas antigas de rejeito, e conseqüente utilização em uma Planta de Redução Direta na Austrália em 2004. Os primeiros resultados práticos foram obtidos em plantas piloto, onde os parâmetros principais (freqüência e amplitude do pulso de ar) para estratificação do material no leito de separação foram definidos. Esta estratificação, somada com o controle de descarga do material afundado representam os principais critérios para se obter excelentes resultados de jigagem. Serão expostos resultados operacionais da maior planta de jigagem existente no mundo, localizada na África do Sul, com 4,000 t/h de capacidade e 24 alljigs® instalados, além de resultados obtidos em escala piloto com minério de ferro bitolado extraído da região de Corumbá-MS. Os resultados operacionais mostram as vantagens específicas do alljig®, como possíveis cortes em alta gravidade, operação simples e baixos custos operacionais. Esta tecnologia oferece uma adição valiosa para o desenvolvimento da indústria brasileira de minério de ferro.

Palavras-chave: Separação gravimétrica; Jigue; Minério de ferro; Minério bitolado.

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Introduction

Iron ore mining has been widely characterized in the past by methods developed for high grade deposits and relatively small mine outputs, i.e. selective mining of the high grade material and simultaneous dumping of low grades and fines.
This scenario has been changing dramatically in recent time for a number of reasons and demands new approaches:

- Ratio of high grade/low grade in the deposits is coming down
- The specific value of % Fe in saleable product increased over the last years by more than 100 %
- Fines, frequently disregarded as waste, are becoming a valuable product considering the upcoming sintering and pelletization capacities
- Modern beneficiation processes allow for effective and low cost upgrading of lump, fines and ultrafines

Jigging technology | alljig®

Separation of minerals in jigging machines is based on the fact that particles will stratify in pulsating water. The upward and downward currents fluidise and compact the grains into relatively homogenous layers. Low density pieces stratify on the surface, while specifically heavy grains settle to the lower level of the bed.
alljig® jigging machines are air-pulsed, because the pulsation of the water can be generated practically wear-free and so the stroke-motion (frequency, amplitude and shape) can be adjusted within a wide range, easily during operation.
After stratification the discharge of heavy product is done by an automatic, PLC-controlled discharge system. The discharge is the second criteria essential for excellent jig performance. In this regard a precise detection of the stratified density horizons and a continuous discharge of high grade product is needed, with a product discharge rate depending on feed characteristics, but guaranteeing a constant product quality independent of feed characteristics.
alljig® -jigs are in operation for the cleaning of different raw and recycling materials. The only prerequisite is a difference in the particle density.
More than 365 **alljigs**® have been delivered to date – worldwide. They are in use for various applications ranging from iron ore to coal, sand and gravel, as well as the recovery of metal from slag. Because of the low operating costs compared to heavy media plants and the possibility of higher separation densities (> 4,0 g/cm³) jigs are considered as state of the art equipment for iron ore beneficiation.
Fig. 1 shows an **alljig**® in typical configuration for iron ore beneficiation.

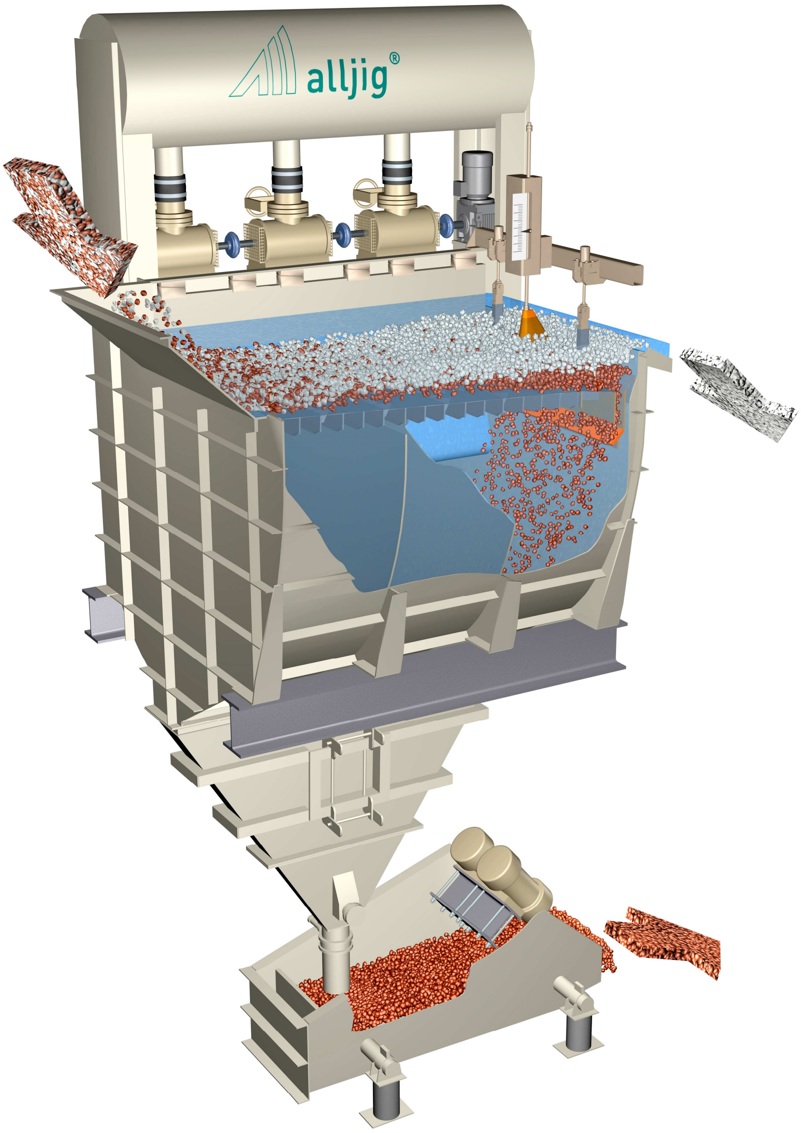

Figure 1: **alljig**® for beneficiation of iron ore.

Depending on the arrangement of the air chambers, side- and underbed-pulsed jigs are available. allmineral supplies both types, which are compared in Figure 2. In terms of process efficiency, there is no difference between the two types of jigs since the same stratification is achieved with the same water movement.

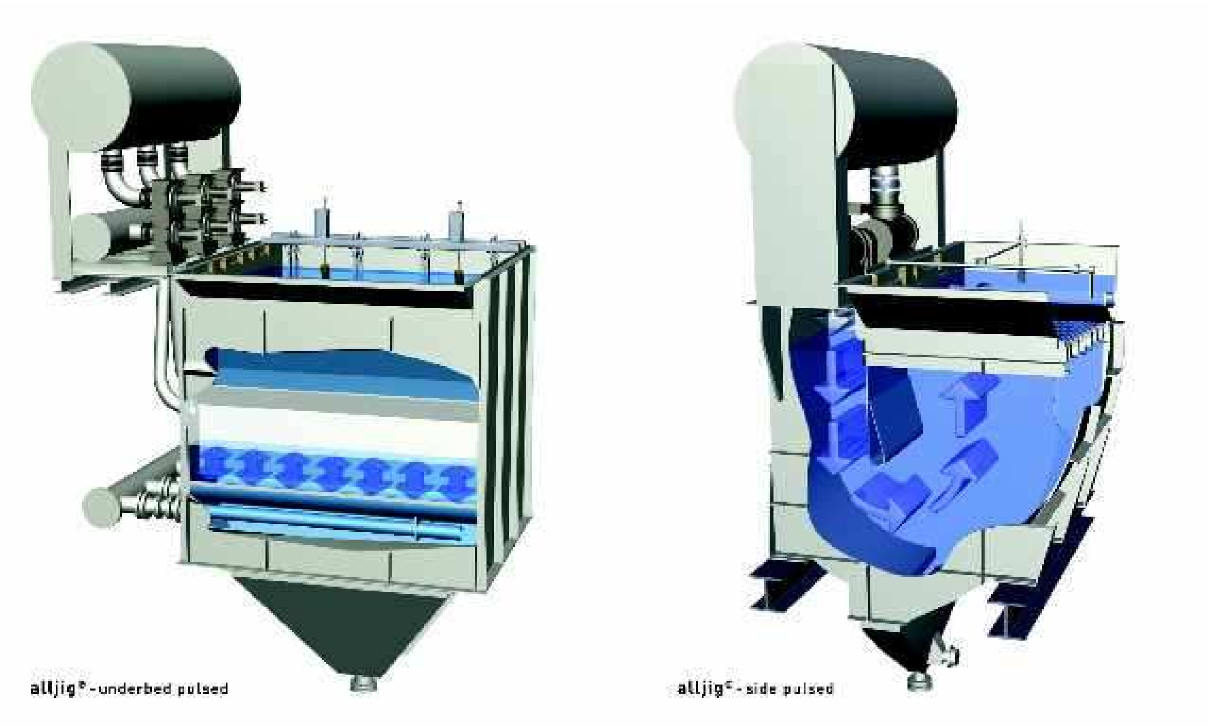

Figure 2: Comparison of underbed and side-pulsed **alljig**® machines-Schematic.

The side-pulsed Baum-type allmineral jig is limited to a jig bed width of 3 m. The largest underbed-pulsed jig supplied by allmineral is operated at a coal mine, it is 5 m wide.

The main differences concern the different position of the air chamber and type of air control. The disk valves used for the air control in the underbed-pulsed jigs need control air instead of the electrically driven rotary piston of the side-pulsed jigs. The maintenance costs for disk valves tend to be higher and even low wear leads to change in the control timing and therefore to a possible reduction in jig performance.

The control system of an underbed-pulsed jig is complex and requires a suitably qualified personel to operate it. In contrast, the Baum jig with side-pulsed action is simple to maintain and operate.

The jigs are widely used in iron ore beneficiation to reduce the amount of silica and alumina. While in South Africa, Australia and Brazil the silica content is in the focus, in India the challenge is more on the reduction of the alumina content. While the jigging technology has been in use for more than ten years in Australia, Brazil and South Africa, the Indian iron ore producers have discovered the value of this technology and are in the process of installing and commissioning.

Figures 3 to 7 show examples of the operation of jigs in iron ore beneficiation.

alljig® examples

alljig® for iron ore beneficiation

Example 01

South Australia **|** *Iron ore separation*

Figure 3: Iron ore beneficiation plant Whyalla.

Key Figures

1 x 100 t/h	8 - 1 mm
1 **alljig**®	F 2500 x 3000
1 x 120 t/h	32 - 8 mm
1 **alljig**®	G 2500 x 3000
start up	August 2007

Dump material upgrading

Operation results from the lump ore jig at Whyalla

LUMP FEED					
Fe	58,86	56,77	54,47	58,8	59,54
SiO_2	6,22	8,11	6,62	6,35	5,52
Al_2O_3	3,07	3,62	4,03	2,98	2,40

LUMP CONCENTRATE					
Fe	64,2	62,9	61,5	61,4	64,2
SiO_2	3,62	4,33	4,8	3,47	2,42
Al_2O_3	1,52	2,15	2,27	2,37	1,59

LUMP REJECT					
Fe	27,0	26,5	28,0	37,9	42,9
SiO_2	26,82	33,6	27,68	21,65	15,8
Al_2O_3	13,73	9,03	8,24	9,2	7,90
YIELD	85,6	83,2	79,0	88,9	78,1

Example 02

South Africa / Iron ore separation

Figure 4: Iron ore jig plant, Sishen, South Africa.

Key Figures

4.000 t/h plant	25 – 0,8 mm
8 x 320 t/h 8 **alljig**®	8 - 25 mm G(UB) 4000 x 3000
8 x 165 t/h 8 **alljig**®	3 - 8 mm M(UB) 3500 x 3000
8 x 60 t/h 8 **alljig**®	0,8 - 3 mm F(UB) 2200 x 3000
start up	August 2007

Figure 5: Lump ore jig at Sishen jig plant, South Africa.

Operation results from the lump ore jigs at Sishen

LUMP FEED

Fe	61,11	56,83
SiO_2	6,54	16,49
Al_2O_3	3,15	1,42

LUMP CONCENTRATE

Fe	67,01	62,62
SiO_2	2,18	8,15
Al_2O_3	1,04	0,88

LUMP REJECT		
Fe	56,44	52,61
SiO_2	10,84	23,33
Al_2O_3	3,85	1,67
YIELD	44,2	42,19

Example 04

Rajgangpur, India | *Low grade lump ore processing*

Figure 6: Low grade lump ore jig at OCL jig plant, India.

Key Figures

1 x 30 t/h	5 - 18 mm
1 **alljig**®	F 750 x 3000
start up	July 2007

Low grade ore upgrading

Figure 7: Lump ore jig at OCL jig plant, India.

Operation results from lump ore jig at OCL

LUMP FEED					
Fe	60,51	57,12	58,18	55,59	54,85
LUMP CONCENTRATE					
Fe	64,03	62	62,11	62,93	61,18
LUMP REJECT					
Fe	48,6	48,25	46,83	45,9	43,29
YIELD	77,2	64,5	74,3	56,9	64,6

Pilot tests and characteristics of different iron ores

Various samples of lumpy iron ores from Brazil and other countries have been tested regarding their beneficiation characteristics in allmineral **minjig**® pilot jigs. In the **minjig**® a sample is stratified and the different layers that are obtained are analysed separately. Fig. 8 shows the **minjig**® arrangement and fig. 9 shows the sampling.

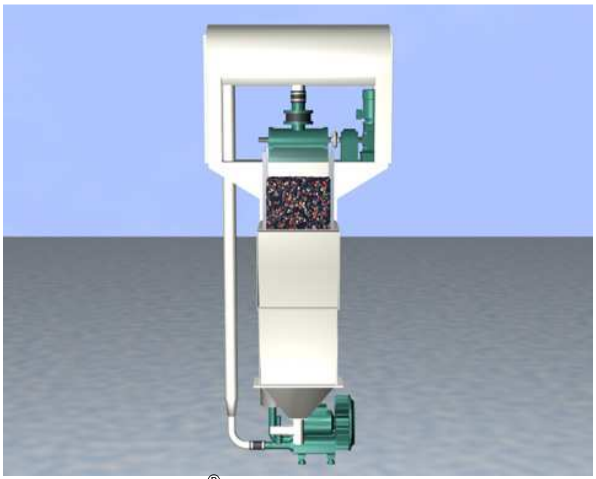

Figure 8: **minijig**®

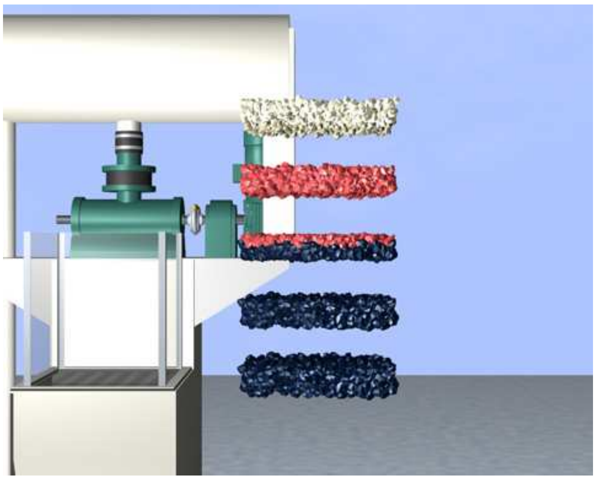

Figure 9: sampling after stratification in the **minijig**®

Figures 10-11 show some examples for jigging tests performed with various samples from Brazil.

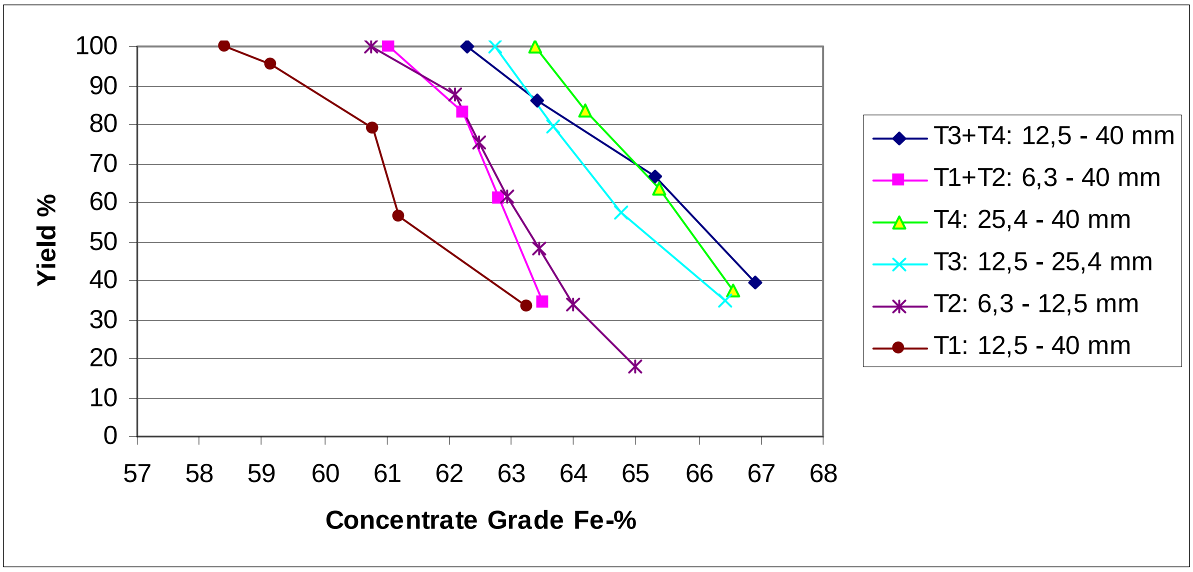

Figure 10: Stratification jig test results for different lump ores from Brazil.

In figure 10 the accumulated Fe% is drawn vs. mass %, i.e. at 100 m% the iron content in the feed of the respective sample is indicated, e.g. 61,3 % Fe for the sample T1+T2: 6,3 – 40 mm. From this diagram the yield to be expected at a certain product grade can be determined also. At 63,5 %Fe grade the yield for the sample T1+T2: 6,3 – 40 mm would be about 50 %.
Even with T1: 12,5 – 40 mm material 45 % yield can be expected at 62 % grade.

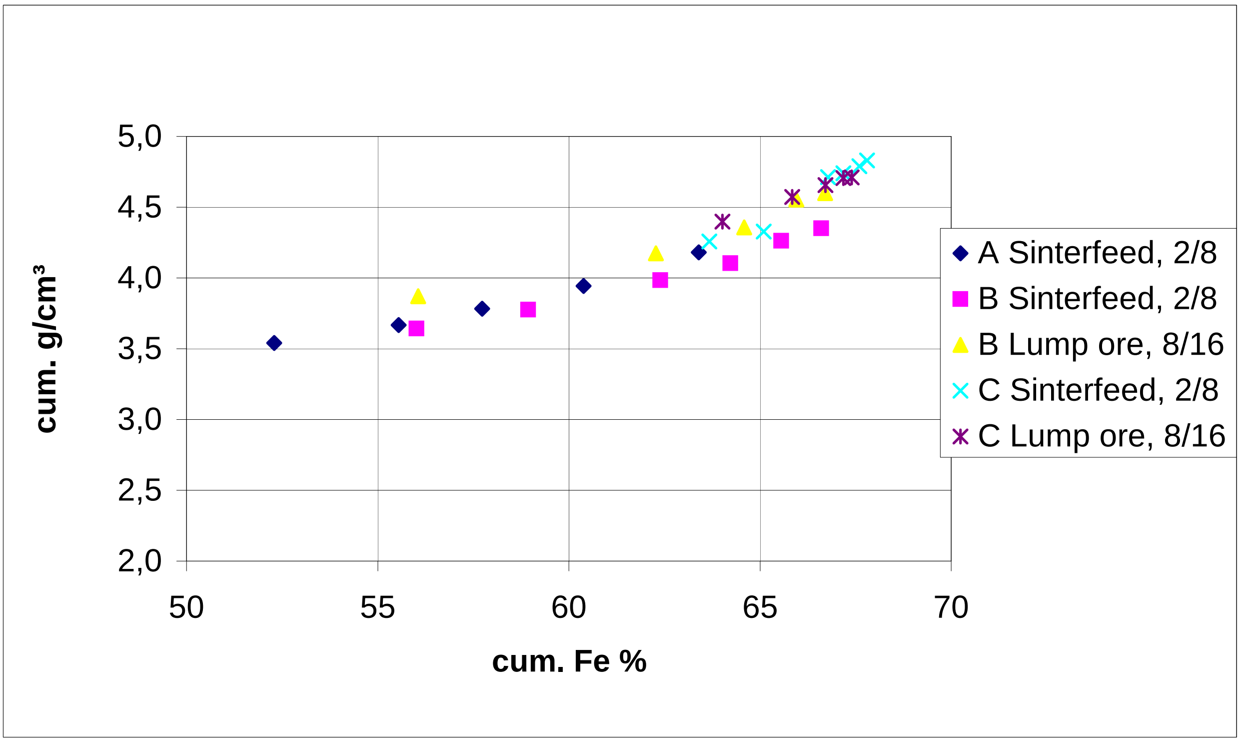

Figure 11: Stratification jig test results for different iron ores.

From Figure 11 the required cut points for a required grade can be determined. With the tested samples a cut point of > 4.0 g/cm³ is requested for product grades of > 60 % Fe, i.e. with Heavy Media processes such grades are not achievable.

Conclusion

The increased demand for iron ore concentrates in the last years as well as the mining of low grade deposits leads to a growing demand for separation technology for lump ores, sinterfeed and pelletfeed. Because of the low operating costs compared to heavy media plants and the possibility of higher separation densities (> 4,0 g/cm^3) **alljigs**® are considered as state of the art equipment for the beneficiation of lump ore and sinter fines.