EFFICIENT AND LOW COST UPGRADING OF IRON ORE LUMP AND FINES[1]

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Abstract

Mineral processing is characterized by a constant adaptation to changing raw materials and market conditions. It is the link between the mined raw material and a marketable product. As a lot of high grade reserves are exploited, a steady deterioration of raw material quality can be observed. At the same time, the customers requirements for product purity and consistent quality increase. Over the last years beneficiation techniques for iron ore are becoming more important in order to achieve a maximized utilization of ore resources and to produce competitive products according to international standards. Allmineral has been engaged in hematite iron ore beneficiation with its gravity separators since the mid ninties. 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 as well as upstream separators for fines are in operation in Brazil, Australia, India and South Africa. Low grade run of mine and/or dump ores are being processed with alljig®- and allflux®-separators as the core equipment. The lecture describes the technology in use, the characteristics of various iron ores and the product qualities achieved. The data presented show the specific advantages of jig application on iron ore upgrading due to the possible high gravity cuts and the easy and low cost operation. The allflux®- technology provides the big advantage of high capacities and a two step process, both in a single unit.

Key words: Gravity separation; Jig; Upstream classifier; Iron ore.

ENRIQUECIMENTO EFICIENTE E A BAIXO CUSTO DE MINERIO DE FERRO BITOLADO E FINO

Resumo

O processamento de minérios é caracterizado por uma constante adaptação à evolução das matérias-primas e as condições de mercado. É a ligação entre as matérias-primas extraídas e um produto comercializável. À medida que inúmeras reservas com de alto teor de riqueza são exploradas, uma constante deterioração da qualidade destas matérias-primas pode ser observada. Ao mesmo tempo, as exigências dos clientes relativas à pureza do produto e qualidade consistente aumentam. Ao longo dos últimos anos, técnicas de beneficiamento de minério de ferro estão se tornando cada vez mais importantes, a fim de alcançar um uso maximizado dos recursos minerais afim de produzir produtos competitivos e de acordo com as normas internacionais. A Allmineral tem se comprometido em beneficiamento de minério de ferro (hematita) com os seus separadores gravimétricos, desde meados dos anos noventa. A inserção de jigues no mercado começou com o enriquecimento de minério de ferro para posterior utilização em uma Instalação de Redução Direta na Austrália. Desde então, várias outras instalações com jigues para minério bitolado e finos estão em operação no Brasil, Austrália, Índia e África do Sul. Minas com reservas mais pobres e rejeitos de minério estão sendo processados com os separadores alljig® e allflux® como os equipamentos principais do processo. A palestra descreve as tecnologias em uso, as características de diversos minérios de ferro e as qualidades do produto alcançadas. As informações apresentadas revelam as vantagens específicas da aplicação de jigues no enriquecimento de minério de ferro devido às possíveis faixas de corte em alta gravidade, operação simples e de baixo custo. A tecnologia do allflux ® proporciona a grande vantagem de altas capacidades e um processo em dois passos, ambos em uma única unidade.

Palavras-chave: Separação gravimétrica; Jigue; Classificador de contra fluxo; Minério de ferro.

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3 *Dipl.-Ing.*

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 340 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.
Depending on the arrangement of the air chambers, side- and underbed-pulsed jigs are available. allmineral supplies both types, which are compared in Figure 1. 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.

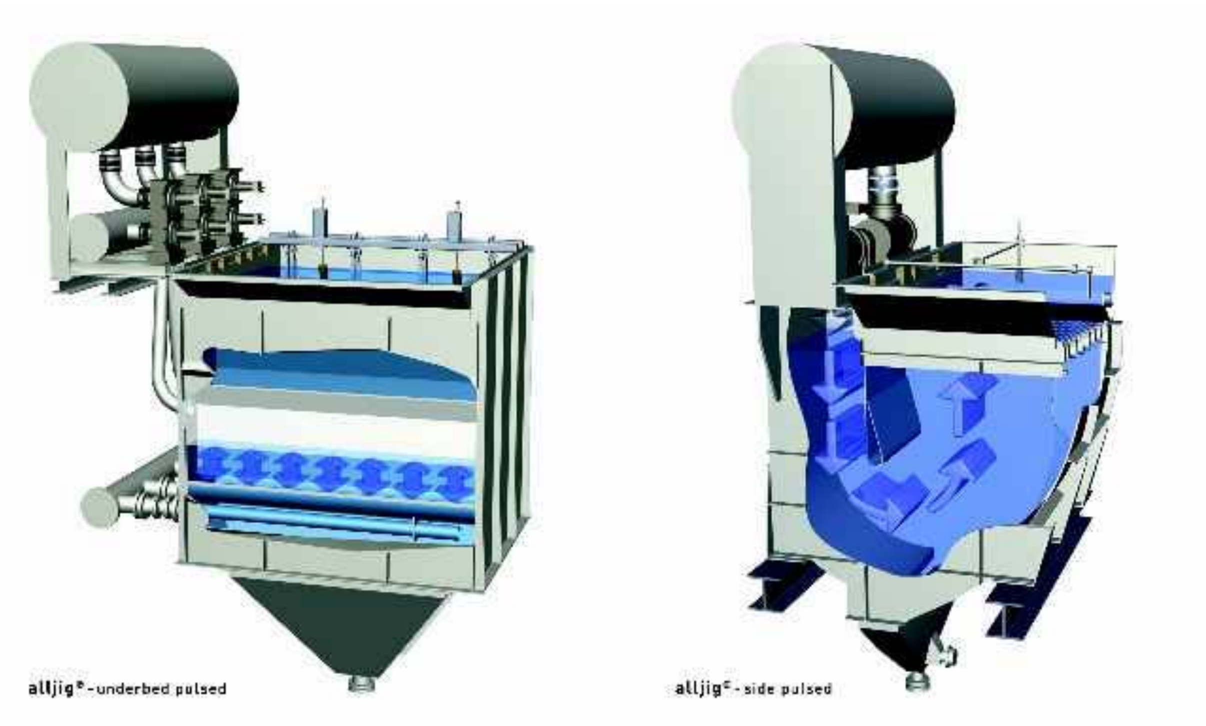


Figure 1: Comparison of underbed and side-pulsed alljig® machines-Schematic

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 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 manintenance costs for disk valves tend to be higher and even low wear leads to change in the control times and therefore to a possible reduction in the jig throughput.

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

Figures 2 to 6 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 2: 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- feed 54-59% Fe
- product 62-65% Fe
- yield 70-85%

Example 02

Western Australia | Iron ore separation

Figure 3: Iron ore jigs, Port Headland plant

Key figures

2 x 150 t|h	8 - 1 mm
2 x alljig®	F(UB) 3000 x 4000
start up	September 1996

Example 03

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

Example 04

Sarzedo, Minas Gerais | Iron ore separation

Figure 6: Iron ore jig plant, Itaminas, MG, Brazil

Key Figures

1 x 80 t/h	1 - 8 mm
1 alljig®	F 2200 x 3000
start up	March 2008

Rejects and Dump material
upgrading- feed 52-54 % Fe
- product 63-65 % Fe
- yield 60-65 %

Characteristics of different iron ores

Various samples of iron ores from Brazil and other countries have been tested regarding their beneficiation characteristics. The following test procedure has been applied:

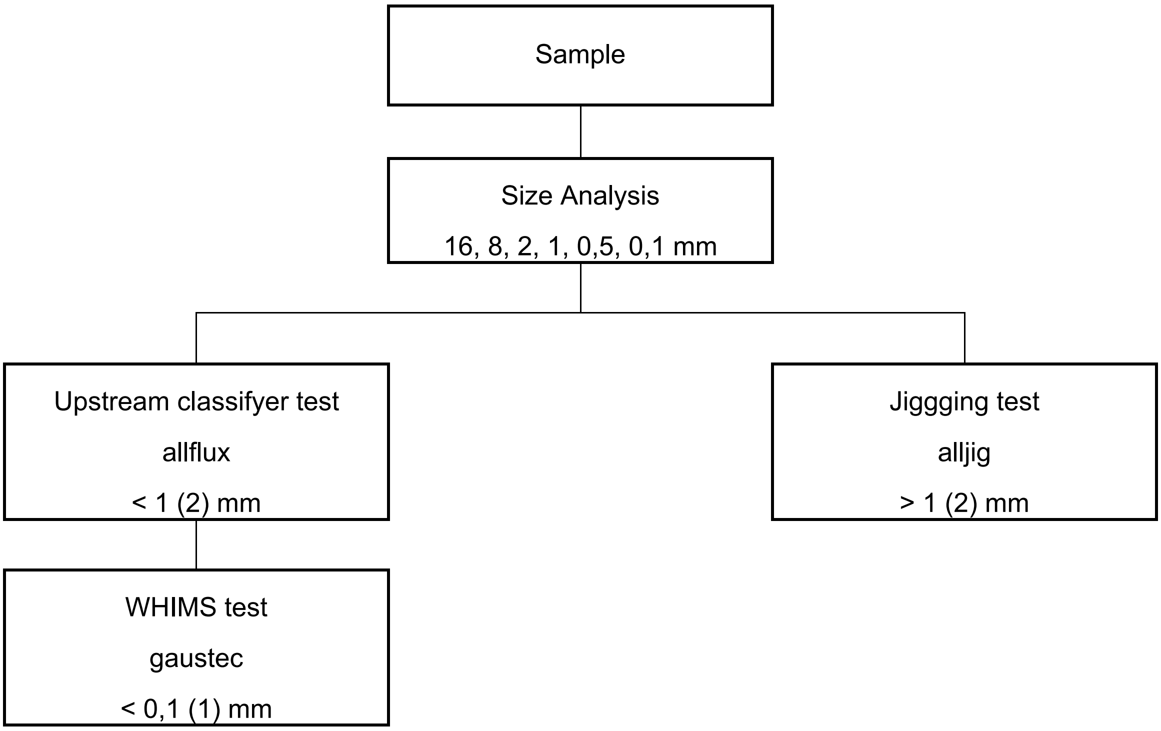


Figure 7: Iron ore test procedure

Figures 8 – 10 show some examples for jigging tests performed with various samples.

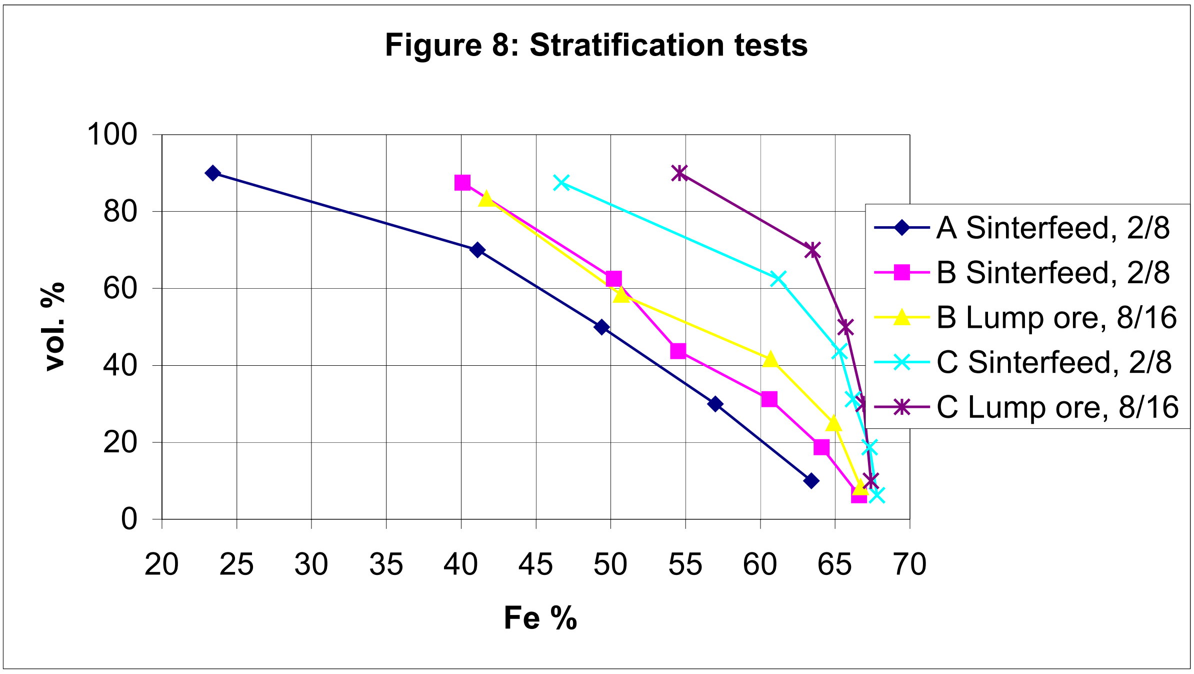
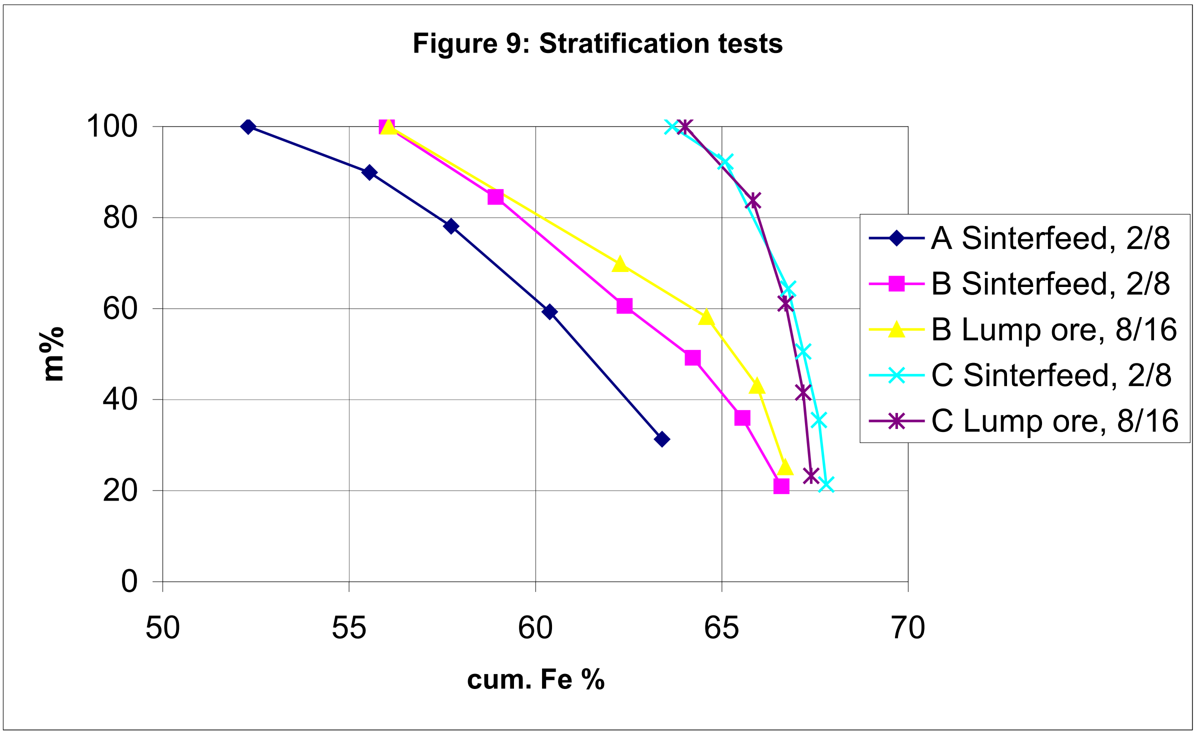
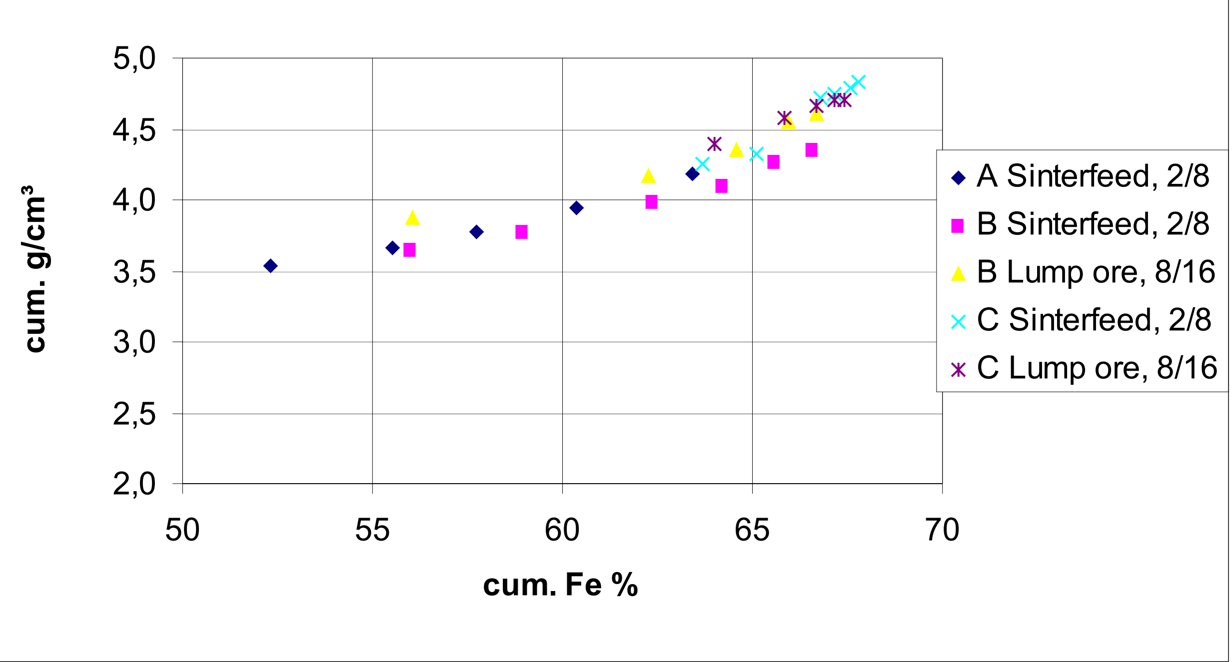


Figure 8 shows the iron content in the various horizons of the material bed in the jig after stratification. The Fe values in the lowest horizon reach from 64 to 67.5 %. Depending on the feed composition these values degrade to the upper horizon to 24 % Fe minimum resp. 55 % Fe maximum.



In figure 9 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. 52 %Fe for sample A Sinterfeed resp. 64 %Fe for the C sample From this diagram the yield to be expected at a certain product grade can be determined also. At 65 %Fe grade the yield for the C sample material would be about 90 %, for B about 50 resp. 60 % yield could be achieved at 64 %Fe. Even with Sinterfeed A material more than 50 % yield can be expected at 62 % grade.

Figure 10: Stratification tests



From figure 10 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.

Flowsheet development and metallurgical balance

Based on the a.m. test results the flowsheets and the corresponding metallurgical balances shown in figures 11 and 12 have been developed. The examples taken, Sample A Sinterfeed and Sample C, show the wide range of feed material that can be processed economically with appropriate gravity separation equipment. With both materials, even with 51.5 %Fe in feed only , quality grades of 62 resp. 65 %Fe can be obtained at yields of 50 resp. more than 60 %.

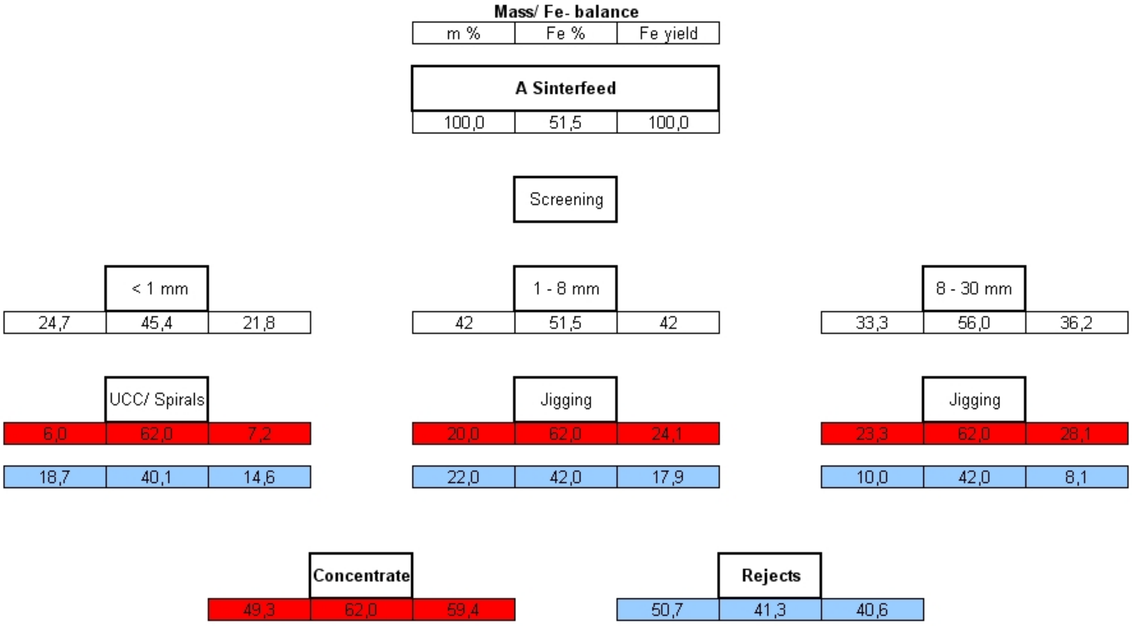


Figure 11: Flowsheet for Sample "A"

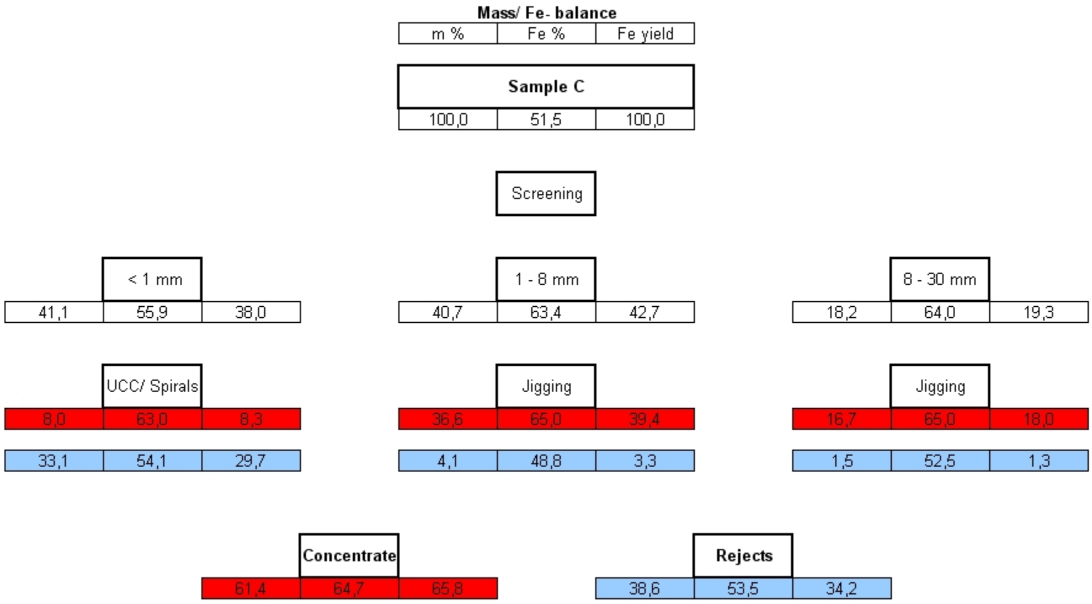


Figure 12: Flowsheet for Sample "C"

allflux®

The first idea for the allflux® separator was born in 1988. The patent was registered in 1990, and the first industrial unit was installed in 1991. More than 50 units are in operation worldwide.
Since the introduction of the allflux® technology to the concrete sand industry more than ten years ago, many more applications have been discovered. Fine coal recovery from ponds, iron ore and mineral sand concentration and high quality glass sand sizing are just a few examples of this unique technology.

Advantages of the allflux®

The performance of the allflux®-separators exceeded its engineering objectives, including:

- high separating efficiency
- high capacity reaching 2.000 m3/h
- consistent high product quality
- automatic operation and control of discharge systems and water feeds
- high solids content of discharged products
- low wear
- low energy consumption

Another benefit results from the relatively independent processing of coarse and fine material. It allows either fraction to be processed or stockpiled separately, or they may be blended to meet special applications. Even with variations in raw material composition, the ability to offer a consistent product is
greatly enhanced.
Perhaps the most important advantage of the allflux®-separator is economic. By combining high efficiency and high capacity with multiple processing stages, a reduction in specific production cost is realized. Overall plant size is minimized and hence investment and operation costs are reduced. The efficiency of the allflux® extends the boundaries for feasible sand and fine particle processing, it may allow some previously uneconomic reserves to be mined.

Figure 6: allflux®-750, Hagenbach Sand and Gravel plant, Germany

Technical Description

The allflux® separator is a round, center feed process vessel that is sized according to the hydraulic load. The process uses a unique combination of rising current and fluidized bed techniques and can be divided into three stages. The principle of an allflux® separator is schematically shown in the following illustration.

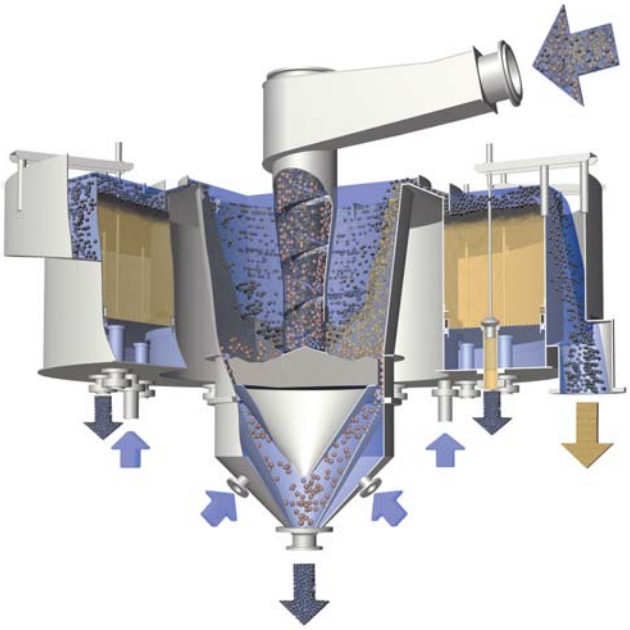


Figure 6: allflux®-Schematic

allflux® for iron ore beneficiation

Example 01

South Africa / Iron ore separation

Key Figures

540 t/h plant	0 – 2 mm
3 allflux®-1000	3 x 180 t/h
start up	March 2004

The characteristics of the feed and products are;

- Solids SG	4.280 kg/m3
- Feed slurry pulp density	1.270 kg/m3
- Feed slurry solids	28%
- Feed Fe content	56 - 60%
- Product Fe content	64 - 65%

In 2008 allmineral has delivered six allflux® Type 750 Up-Current Classifiers for a Iron Ore producer in Western Australia.
The units treat 170 t/h each of minus 1 mm hematite ore. The plant start up is scheduled for the end of 2008.

Biography

Heribert Breuer
studied mineral processing from 1971 to 1975 at the Technical University of Aachen, where he got his doctor degree in 1980. After two years as »R&D« engineer with »KHD« | Cologne, he became head of the mineral processing department at »MAN-GHH« | Oberhausen.
Since 1988 he is Managing Director of »allmineral Aufbereitungstechnik GmbH« | Duisburg.

Andreas Horn
studied mineral processing from 1986 to 1992 at the Technical University of Aachen, where he got his master degree in 1992. He started his professional career with Rigips GmbH finally as production manager in a gypsum plasterboard factory. In 1997 he changed to Hüttenzement GmbH. As a project manager he was in charge for the design, erection and commissioning of two grinding plants for slag cement.
Since 2003 he is Technical Director of »allmineral Aufbereitungstechnik GmbH« | Duisburg.