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# Density sorting of manganese ore utilizing jigging technology

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## Abstract

Manganese is an essential part of modern steel production. With the international steel consumption forecasted to rise constantly, so will the demand for manganese. This leads to further development in prospecting potential manganese sources and the revaluation of known resources. With its economy on the rise again, companies are interested in investing in Brazil's mining sector leading to opportunities for smaller projects such as the Espigão project in Rondônia, Brazil. Meridian is running a plant producing 100.000 tonnes per year of high-grade manganese concentrate for smelting and cutting.

Processing crude ore close to the mine has many advantages, one being the decreased amount of transporting capacity due to less material in need to be transported. The remoteness of the plant demands the processing plant to have high availability throughout the lifecycle, which demands the used machinery to be highly reliable and available. At the same time companies demand high throughput at the highest possible yield and content, challenging the manufacturers to increase the efficiency of their machinery while reducing breakdown to a minimum.

This paper displays the enrichment of manganese ore utilizing jigging technology, discusses the advantages of jigging over other separation methods and highlights the application of the **alljig**® in the Espigão project in Brazil.

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## Introduction

The discovery of jigging is likely to date back to the ancient Europe. Once the rich ore was no longer available, sorting by hand became a necessity, leading to the workers searching for ways to ease the work. While it became obvious that washed material was easier to separate, moving a basket containing the material up and down in water lead to the discovery of the rudimentary jigging process. In the late eighteenth century, jigging was well developed for coarse material and in the early nineteenth century, material of fine size could be separated automatically. Jigging machines like the Baum or Harz jig were established.

The **alljig**® is similar to the Baum jig, with the addition of a control system for discharge, enabling the machine to work autonomously once the control system is adjusted. Since its introduction in the late 1980s the **alljig**® has seen many improvements enabling it to process a growing array of different materials.

## Manganese

In 2016, 16 million tons of manganese were produced worldwide, the main producers being South Africa, China, Australia, Gabon and Brazil. Manganese is mainly used as an aggregate to the smelting process in steel production, either as coarse particles for direct reduction or fine particles being refined to Ferro-Manganese for blast furnaces.

This results in the main consumers of Manganese being steel producing countries, like China. Being able to satisfy their demand now, China is looking at a shortage coming up in the course of the next 10 years. With their demand for steel not forecasted to go down significantly *(Reuters, 2017)*, the demand for Manganese will open opportunities for smaller producers. In addition to that there is no satisfactory supplement for Manganese as of yet, leading to a strong dependency of the steel producing industry on a continuous supply of high grade Manganese. *(USGS, 2017)*

Brazil is looking at large reserves of high grade Manganese ore, combined with their rather low production rate this leads to the potential to supply the market for a long time. Companies like the former Brazilian Manganese Corporation, now Meridian, are looking into opportunities to increase their production to supply the apparent grow in international demand for Manganese. *(Meridian, 2016)*

# Enrichment of Manganese

With the Manganese minerals being significantly heavier than the mainly of silicate consisting waste rock, density separation is a valuable choice in processing the Manganese ore. Since the liberation is adequate in coarse fractions *(over 50 mm)* of the material, a very high grade can be achieved in the products.

*The material is classified to three fraction sizes:*

- 2 - 10 mm
- 10 - 25 mm
- 25 - 60 mm

Following up an **alljig**® is stratifying each fraction size, separating the Manganese ore from the waste rock. Figure 1 displays an **alljig**® with screen discharge as utilized in the described application.

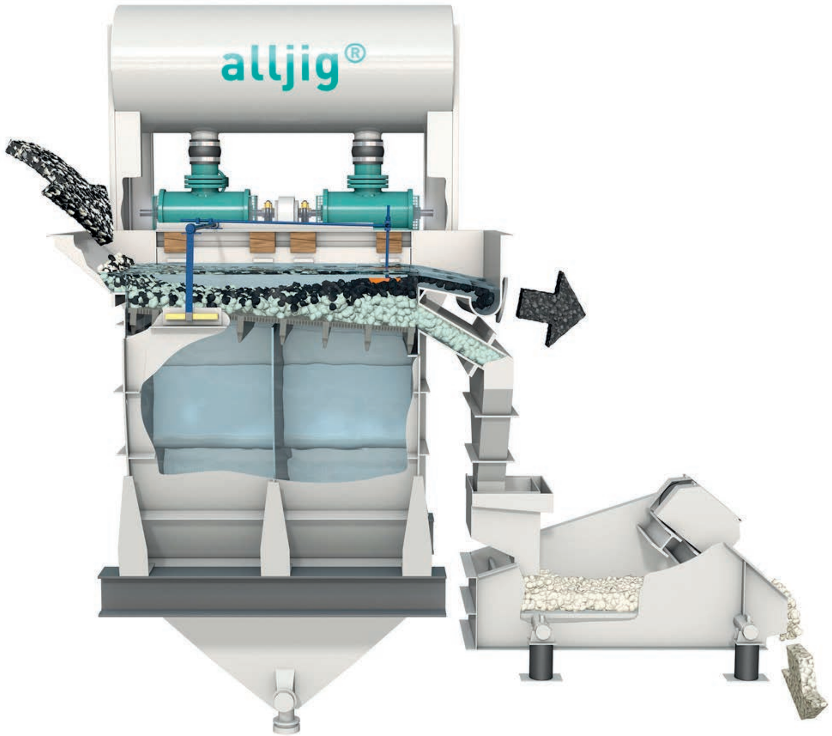


*Figure 1 |*
*Schematic drawing of the **alljig**® with screen discharge*

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## Enrichment of Manganese

The Manganese product is dewatered and discharged to a belt conveyor, heading to separate stockpiles for loading. The reject fraction is dewatered via screens, joined together and transported to a stockpile by belt conveyors.

First tests show that the **alljigs**® are able to enrich the Manganese content in the product to 53 - 57 % Manganese content while the reject fraction holds – 7 %. The product of the coarse fraction size is used in direct reduction steel production while the material - 25 mm is applied to steel production via blast furnace.

**2** | Product 2 - 10 mm

**3** | Product 10 - 25 mm

**4** | Product 25 - 60 mm

**5** | Reject fraction

***Figures 2 to 5** | products of the jigging process of the manganese ore from **Espigão project** in Rondônia, Brazil.*

## Advantages of density sorting

The applicability of coarse Manganese particles to steel production allows the mechanical processing to sort the material in coarse particle sizes, negating the need to grind the material down to flotation or leaching sizes of - 1 mm. Besides the obvious saving of time and energy these circumstances bring, the sorting by jig is less expansive, because there are no costly reagents needed for the sorting process.

In addition, the sorting by jigging demands fewer water per ton material processed compared to the sorting by flotation. Without the need for flotation reagents the circling of process water becomes viable, resulting in the sorting process needing next to no fresh water for performing. This situation leads to the sorting process conserving the immediate environment by decreasing the impact the plant has on the water reserves in its surroundings.

The same applies to the apparent competitive process for coarse particle separation, dense media separation, because the jigging process is not in need of a complicated process media recovery cycle.

The region around the Espigão project is subject to the raining season, leading to a great flux in feed material composition in dependence to the time of year. During raining season from November to March, the feed material is sticky because of its clay content, leading to agglomerates being build up in the drum screen, which then are conveyed to the sorting aggregates. The agglomerates report to a larger fraction size then their content's fraction size is intended to, diluting the manganese content of the products. Conventional sorting by flotation or leaching would be in need of additional preparation units for the sorting, increasing cost for processing while using the increased invest only half of the year. Contrarily, the jigs are more likely to be able to handle the agglomerates, resolving them during

## Advantages of density sorting

the jigging process and allowing the manganese ore to report to the heavy fraction while sending the fine slimes to the reject fraction.

Furthermore, the jigging process is not as susceptible to impurities like organics or plastic parts, they report to the reject fraction automatically, leaving cleaned products *(compare Figure 6 and Figure 7).*

Another advantage of the jigging process compared to other sorting processes like flotation, leaching or DMS is its flexibility. A plant like the Espigão project is set remote to supply lines for machinery, building material or process reagents, emphasizing the need for availability, simplicity and reliability of the used processing machinery. Processes that are more complex are in need for more component parts and larger building area, increasing the impact the plant has on the immediate surroundings. By utilizing jigs, not only is the process more simple and thus in need for less space, but also less susceptible to faults by minimizing the breakdown time because of delay of spare part delivery.

Because of this simplicity, the process with jigs is less susceptible to flux in the material feed, making it a valuable process to be employed in remote processing plants like the aforementioned Espigão project.

Continuing with the advantage of flexibility, the jigging process is easily scaled due to the applicability of the working principle to next to every mineral feed material composition. Depending on said material composition, reliable statements on the applicability of the density sorting by jigging can be made from very low sample sizes while enabling the scalability to production size machines.

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## Advantages of density sorting

6 | Reject fraction after jigging

7 | Product fraction after jigging

## Pilot testing

**alljig**® - pilot und laboratory units are available for testing purposes. In the range of stratification jigs for batch testing of the feed material with sample sizes of 30 to 50 kg, up to pilot plants processing feed rates of 0,3 to 1 ton per hour, the laboratory units of allmineral are able to display the applicability of **alljig**® - technology as the sorting process for the tested material.

**Figure 8** | displays an **alljig**® P - 400 pilot machine.

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