Microtrac

Total Solutions in Particle Characterization

APPLICATION NOTE

Magnetite and Iron Ores: Potential Use of Diffraction Particle Size Distributions in Combination with Simultaneous Image Analysis to Achieve Higher Energy Efficiency and Smaller Carbon Footprint

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Particle Characterization Instrumentation

Introduction

The primary ore types from which iron is obtained are hematite, magnetite, siderite and chamosite. Hematite and magnetite are the most important and abundant sources of iron. Most of the iron obtained by beneficiation is used to manufacture steel while some percentage of hematite is used in dyes, pigments as well as those products normally associated with use of magnetite. The composition, magnetic properties, source and cost determine the processes that are used in beneficiation. Magnetite exhibits strong magnetic behavior (hematite to a lesser extent) that makes magnetic separators useful to obtain iron from these type ores. Down-stream processing assures that demagnetization (de-agglomeration) occurs so that flotation can be optimized to remove silica and thus further iron oxide isolation and purification.

As always with any process, production costs are of paramount interest. Generally, crushing, grinding and magnetic separation are the primary demands (est. 70%) of electric power. Other costs are associated with sizing, screening and classification. In particular, the two items that drive the cost of beneficiation are: (1) Achieving final grind size of minus 325 mesh (45µm) by crushing and grinding "particles" that are typically 0.4meters in size. Globally, this size achievement varies over the range 25 to 150um depending upon country and the process being used to liberate magnetite and hematite from silica and other substances; and (2) the grade of the ore being used where higher grades promote higher concentration of iron making the process more economical.

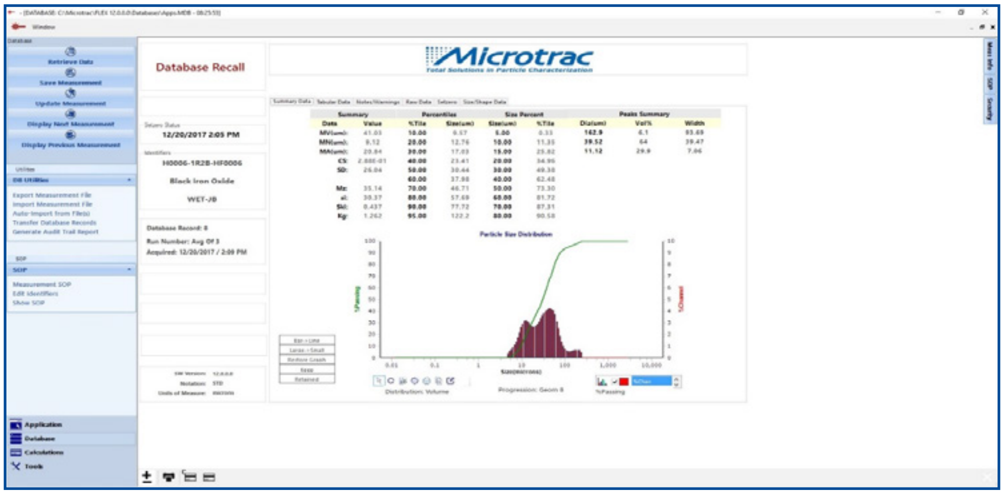
Obtaining particle size data before the demagnetization and comparing it to post-demagnetization can provide information on the conditioning readiness of the ore for flotation. Analysis of size and shape can provide an avenue to efficiency by limiting or eliminating the use of high-energy demand equipment. In addition, the benefit of highly sensitive measurements of size and shape adds to optimal use of energy. Particle size determination using diffraction is a well-accepted technique. The addition of dynamic image analysis provides another easy-to-use tool to discern when demagnetization, re-magnetization and size conditions have been achieved. Ultimately this promotes energy efficiency and small carbon footprint.

This paper discusses the value of simultaneous diffraction particle size determination with image analysis as a means to energy conservation. Same-sample measurement by such combined instrumentation precludes inappropriate decisions and actions caused by not obtaining or using perfect, representative samples and needing to make measurements on more than one sampling on separate instruments.

Data

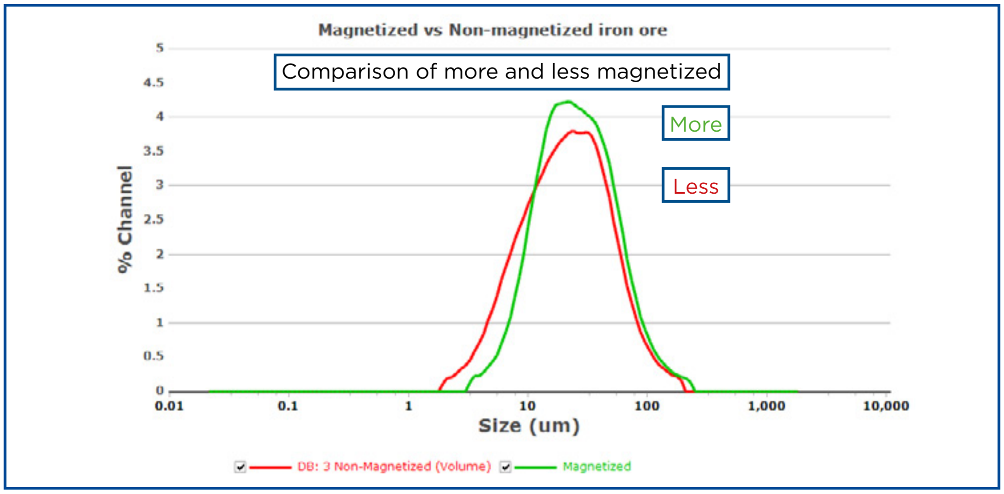
Chemical and physical treatments were used for the samples which, while initially achieved dispersion, were not stable during measurement and tended to increase in size and re-agglomerate. Subjecting the samples to a magnetic field demonstrated they had magnetic properties. Short duration measurement were made to limit interaction of the particles and magnetic attraction/agglomeration. The diffraction particle size graphical data below show a comparison of two magnetite materials at different stages of demagnetization.

Computer Display — Microtrac Sync Diffraction Analysis



SYNC Diffraction distribution display. Sample is midway in milling. Note the larger peak at approximately 40μm. This sample display is used to demonstrate reporting capability as computer display or printout. Other displays such as tabular data, Rosin Rammler fitting, trend plots, pass / fail, are available as part of software.

Microtrac Sync Diffraction Particle Size Distribution

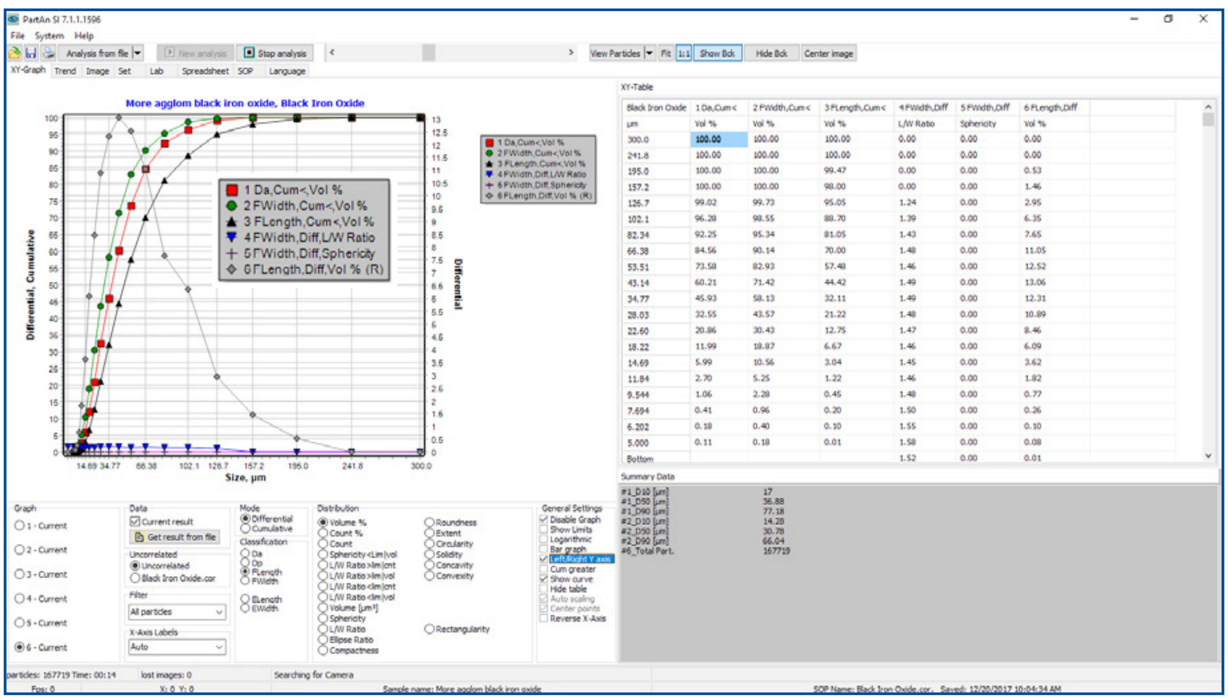


Graphing capability of FLEX software provided the comparative SYNC diffraction measurement graph. The sensitivity and ability to distinguish small distribution differences of the measurement is made apparent.

The difference in size provides evidence that demagnetization has occurred to the "less magnetized" sample and that it is adequate to forward to the flotation step. There is an apparent magnetic agglomeration of the finer particles as shown on the left side of the curve since it has moved to the right. However, it can be very important to ascertain whether the size distribution difference is due to magnetic agglomeration (or de-agglomeration by demagnetizing) or merely a change in particle size distribution perhaps due to variation or error of representative sampling techniques which is always a concern in analytical measurements. Such assurance can obviate the need for re-processing and unnecessary production cost increases.

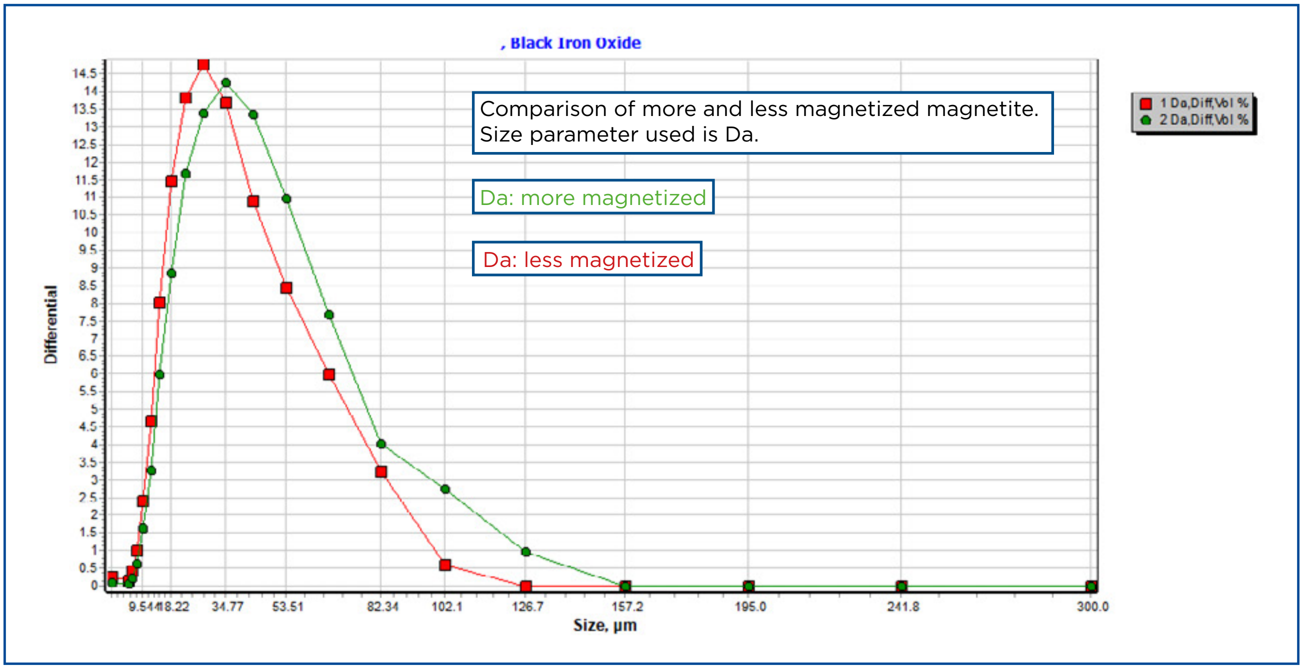
A quick approach would be to evaluate the material by microscopy, however that has the disadvantage of using another (third) sample (potential sampling issues) and does not directly address the issue of the difference in comparative data for the two samples. Microscopy also has limitations as to sample size and total particles examined. Using the image analyzer or the diffraction measurement, at least 150,000 particles are included in the measurement allowing for greater statistical validity of the measurements. To effectively answer the question of de-agglomeration / demagnetization, diffraction measurements can be performed simultaneously with Dynamic Image Analysis. In the present situation the samples were measured using the Microtrac Sync which permits simultaneous diffraction measurement with image analysis to obtain information that will lead to a decisive, positive action. The Sync image analysis size distribution plots below use the Da parameter for comparison to the above diffraction distributions.

Computer Display — Microtrac Sync Image Analysis



Display information of tabular, graphical and summary data. Printout is also available. Data may be changed based upon selection of parameters for up to 6 selections.

Microtrac Sync Image Analysis Size Distribution



Graphing capability of FLEX software provided the SYNC image analysis comparison graph. The sensitivity of the measurement is made apparent. Note similarity to diffraction data for the parameter Da.

Note that the distribution data determinations in the table below are from different methods (diffraction and image analysis) that are combined and housed as a single instrument (Microtrac SYNC) to allow measurement of the same sample under identical conditions. In the table below are data that compare percentiles for the two samples “More Magnetic” and “Less Magnetic”. In general, the diffraction and the image analysis show the same trend where there is a slight but definite difference between the “more” and “less”. The particle data percentiles are very comparable suggesting that distributions are being reported properly. Both image analysis and diffraction distributions exhibit very similar data values for size distributions.

Percentile	Diffraction More Magnetic	Diffraction Less Magnetic	Image Analysis More Magnetic	Image Analysis Less Magnetic
10	10	6	17	15
50	26	22	37	31
90	69	62	77	66

Interestingly, SYNC image analysis data presented as Solidity for the two samples, provides further quantitation of the difference between the "more" and "less" magnetized samples. A search analysis for all particles having a Solidity less than 0.9 shows that the magnetic sample has a greater volume percent associated with agglomeration. Solidity is calculated as the total area divided by the CHull Area and provides indication of the rough texture of the particles over a range of 0 to 1. A value of "1" indicates a very smooth surface and little or no agglomeration. Rough texture in this case is an indicator of agglomeration due to the highly irregular surface caused by particle "grouping". A portion of the particles "selected" by the search routine is shown for each sample.

To make a final determination of agglomeration, images provide welcome support to the decision of satisfactory demagnetization. The Search results for Solidity is shown for each sample. The "less magnetic" sample shows the Solidity to be less than 0.9 for approximately 4% of the particles while the more magnetic sample shows nearly 10% of the volume (mass). Many other particles are involved but are too numerous (more than 150,000) to display. Particles having Solidity higher than 0.9 are more uniform, more smooth and not as "misshapen". Images obtained by such a search are shown in the last diagram below.

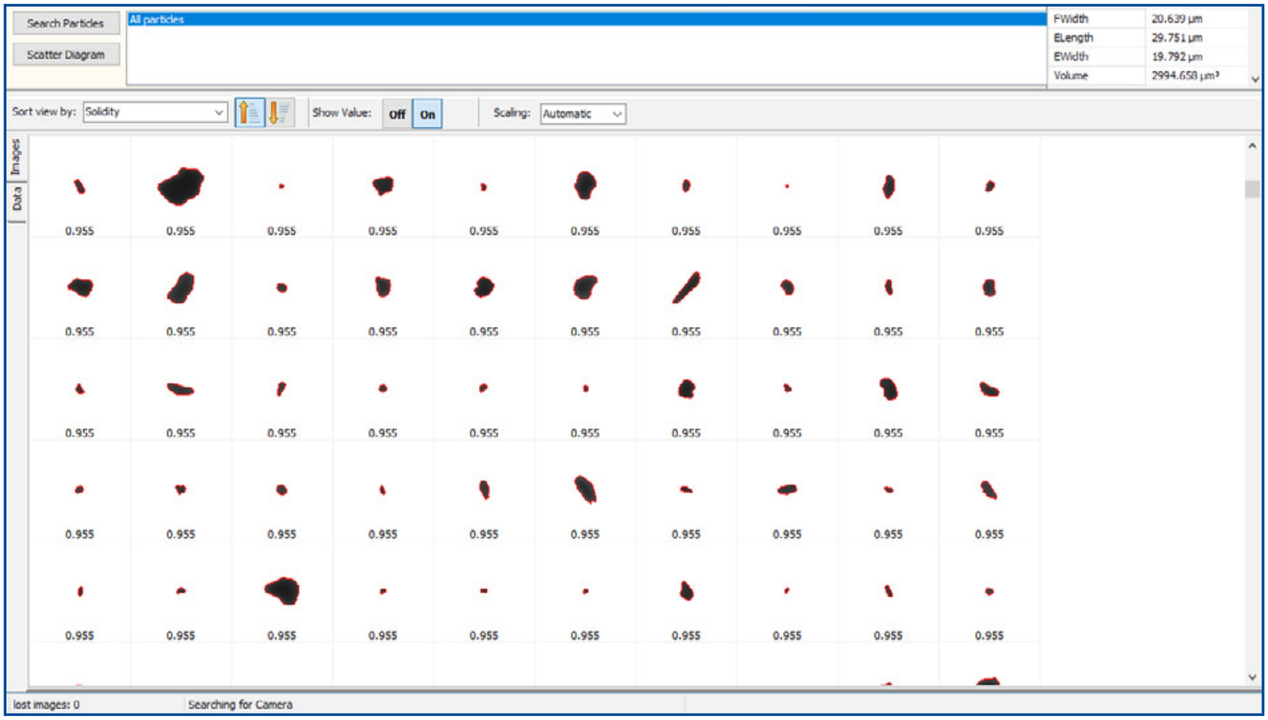
Less Magnetic

Sample images from Microtrac SYNC for Less Magnetic sample showing evidence of agglomeration. Selection parameter used was Solidity where a value of “1” indicates smooth surface. Agglomerates such as those shown have much lower values than “1”. The Search function indicates that approximately 3% (by volume) of the sample has a solidity of less than 0.9.

More Magnetic

Sample images from Microtrac SYNC for More Magnetic sample showing evidence of agglomeration. Selection parameter used was Solidity where a value of “1” indicates smooth surface. Agglomerates such as those shown have much lower values. The percent less than a Solidity is shown by the Search function to be approximately 9%. This indicates greater magnetic agglomeration than the previous sample.

Computer Display — Microtrac Sync Image Analysis



Sample of images from Microtrac SYNC for Less Magnetic sample showing particles of low agglomeration. Selection parameter used was Solidity where a value of "1" indicates smooth surface. Highest value attained for this sample was 0.99. The Search function indicates that approximately 97% (by volume) of the sample has a solidity of greater than 0.9.

Summary

The use of particle size distribution information with the addition of particle images and shape calculations provides a means to efficient use of energy during processing and beneficiation of ores. Microtrac Sync Diffraction particle size in combination with SYNC image analysis provides parameters and associated values that maximize the opportunities to determine when the objectives of size and magnetic condition are achieved. These analyses avoid expending more energy than necessary producing the lowest possible carbon footprint. Consolidation of diffraction measurements with imaging measurements on the same sample provides information on the identical sample (single sampling – not separate samples) to provide the best opportunity to better understand particle characteristics. There is no requirement to use different samplings. The advantages of high-speed, well-accepted particle size measurement by diffraction is enhanced by the application and use of image analysis data. Noteworthy is the concept that perfect representative, duplicate sampling is not possible, thus increasing the importance of the combined measurement on the same sample.