application note

Case study - Analyzing gypsum slurry on the Morphologi G3 with the wet cell accessory

Introduction

Gypsum is a common mineral, widely used in a variety of industries such as building and construction, food additives and agricultural fertilizers. For some of these applications, the shape of the Gypsum particles is very important, and in particular the aspect ratio (width/length), as this can influence the mechanical properties of the final product. For example, particles with a higher aspect ratio will generally result in closer packing of the material and thus better mechanical strength. During the production process a concentrated slurry of the gypsum particles is formed, and it is therefore desirable to characterize the particles in this state in order to better understand the production process.

The Morphologi® G3 along with its wet cell accessory provides a platform for analyzing the particle size and shape of gypsum slurry.

Experimental

The Morphologi G3's wet cell accessory (Figure 1) is designed specifically for looking at wet suspensions with particle size greater than 15μm. It consists of 2 glass windows separated with a gasket and clamped together. This configuration allows a 2 ml interior volume of sample to be analyzed.

Four different samples of gypsum slurry were analyzed. Each was diluted in a saturated gypsum solution since gypsum is soluble in water. The dispersion was agitated and 'pumped' several times with the syringe, prior to extracting the sample to make sure that large particles remained in suspension. 2 mls of suspension were then injected into the wet cell through the injection port. The total sample preparation time was less than 5 min.

Figure 1: The Morphologi G3 wet cell accessory in place on the Morphologi G3 stage

The gypsum samples were measured according to a standard operating procedure (SOP) on the Morphologi G3 system which specified the analysis of a specific area of the wet cell using diascopic illumination and the 5x magnification objective. All particle images with an area of less than 100 pixels were filtered from the final results to ensure meaningful shape information was gathered. A convexity filter was also applied to remove touching particles from the final result. For each analysis 20,000 – 30,000 particles were measured in approximately 20 minutes.

Results

A comparison of the four results using the data comparison tool in the Morphologi software is shown in Figure 2. The parameter variability chart shows the variability in the distributions of the morphological parameters across the four results. The longer the colored bar in the X-axis, the larger the variability of the distribution of that parameter. The software automatically selects the parameter which is varying the most, in this case aspect ratio, and displays the frequency and undersize distributions for this parameter.

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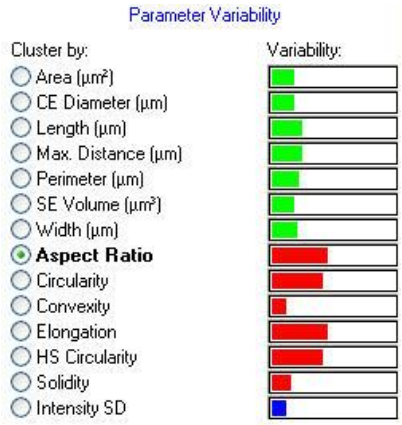
By default, the software will attempt to group the selected records in terms of this parameter in an unsupervised manner. The dendrogram is a graphical way of showing the relationships between the samples selected. In this case it shows that for aspect ratio, the samples are grouped into two sets – Samples 1 and 3 and Samples 2 and 4.

A trend graph shows how the mean aspect ratio varies across these samples. This can be useful in determining a threshold value for distinguishing between the two different sets of samples, for example in a pass/fail quality control application.

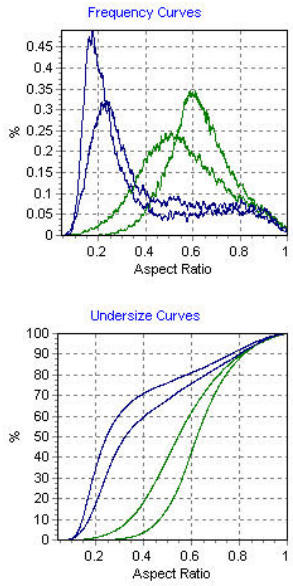
Comparing the Circular Equivalent (CE) Diameter size distributions for the four samples (Figures 3 and 4) it can be seen that sample 1 is the largest overall. Sample 4 is larger than samples 2 and 3 by volume but also contains the highest proportion of fines. Samples 2 and 3 are similar to each other and are smaller than the other two by volume.

In terms of both the length and width distributions, however, samples 2 and 3 differ in size with sample 3 being both longer and thinner than sample 2 (Figures 4 and 5). Sample 1 is contains the longest particles.

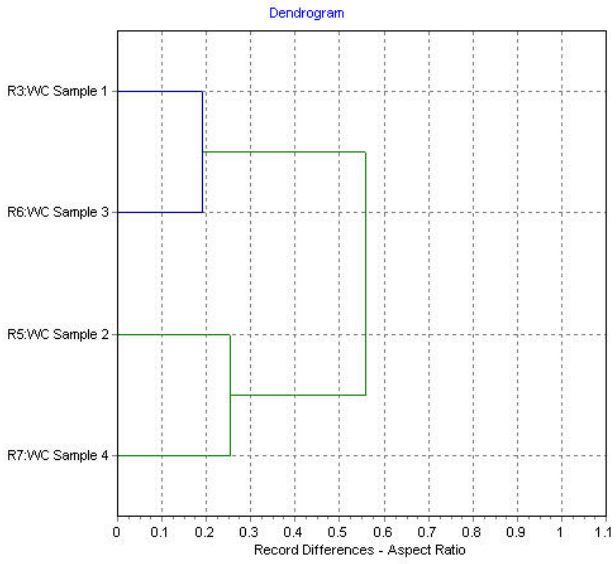
In terms of Circularity samples 2 and 4 present a much higher circularity than samples 1 and 3 (Figure 6), and the former pair also present a higher aspect ratio than the latter pair (Figure 7).



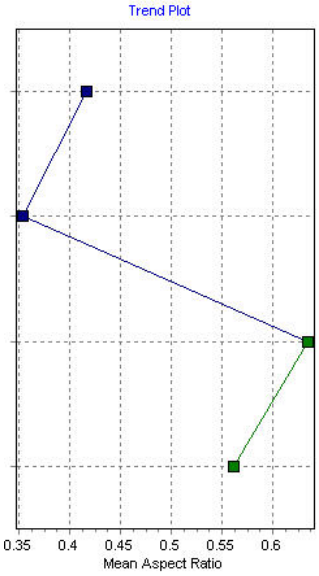
Parameter Variability Chart indicating that Aspect ratio is the parameter that varies most across the sample sets



Aspect Ratio frequency and undersize distributions



Dendrogram in terms of aspect ratio which groups the samples into two set: 1 with 3 and 2 with 4



Trend plot showing the mean aspect ratio for each sample

Figure 2: Results from the data comparison tool for samples 1 to 4. The tool shows that the parameter with the highest variability across these samples is aspect ratio, and that the samples can be grouped into two distinct sets (green and blue).

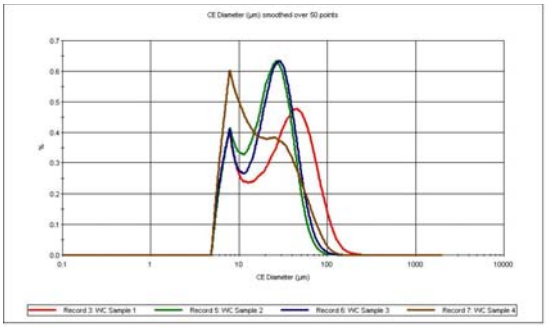


Figure 3: Overlay of the number based CE Diameter distributions

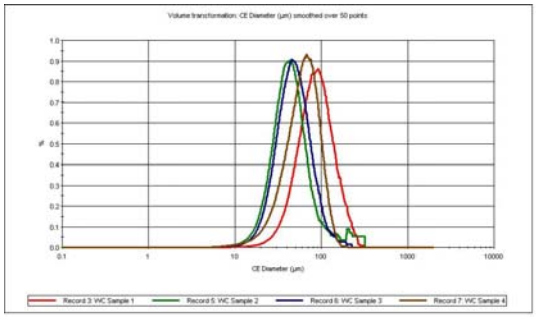


Figure 4: Overlay of the volume based CE Diameter distributions

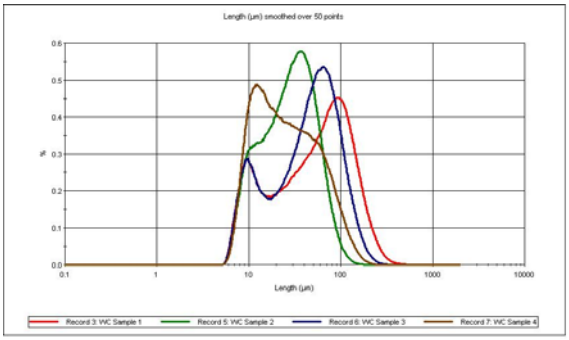


Figure 4: Overlay of the number based Length distributions

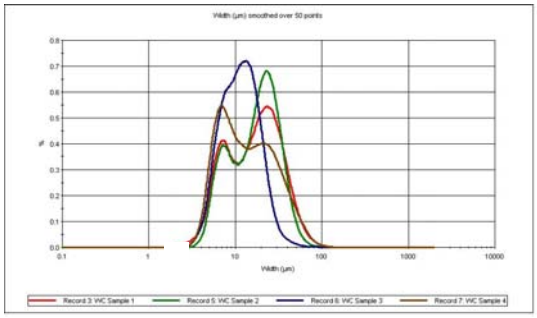


Figure 5: Overlay of the number based Width size distributions

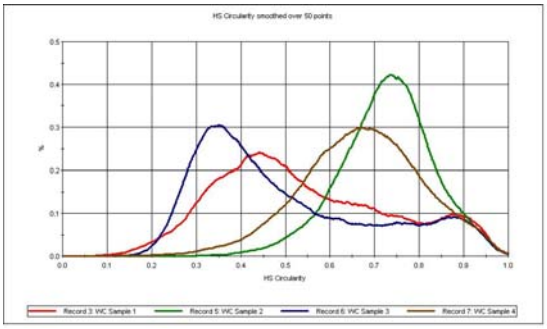


Figure 6: Overlay of the HS Circularity distributions

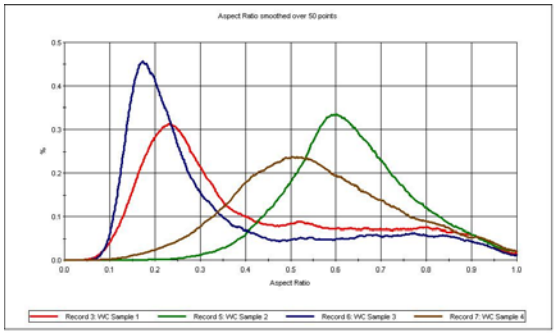
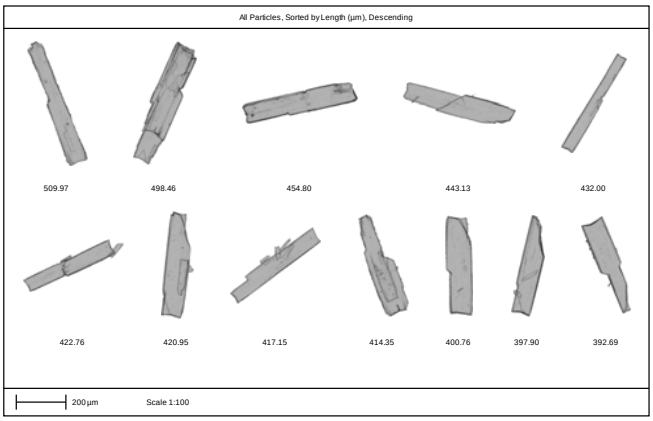


Figure 7: Overlay of the Aspect ratio distributions

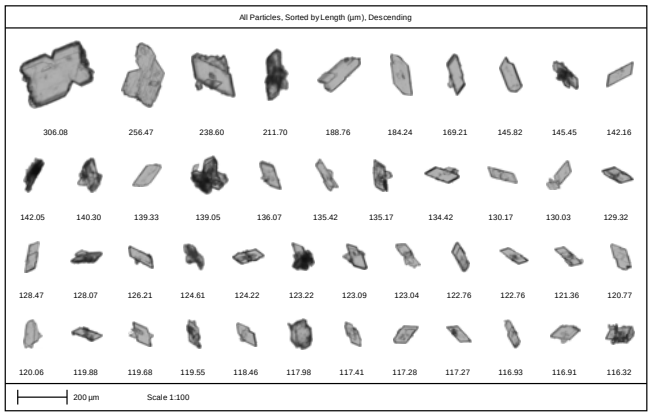
An image of every particle analyzed on the Morphologi G3 is stored and can be viewed to provide a qualitative view of the result. Example particle images of the longest particles from each of the four samples are shown in Figure 8. It can be seen that samples 1 and 3 contain particles which are more needle-like than samples 2 and 3 agreeing with the statistical results. Since samples 2 and 4 contain higher aspect ratio (less needle-like) particles they are likely to be better for packing than samples 1 and 3.

Summary

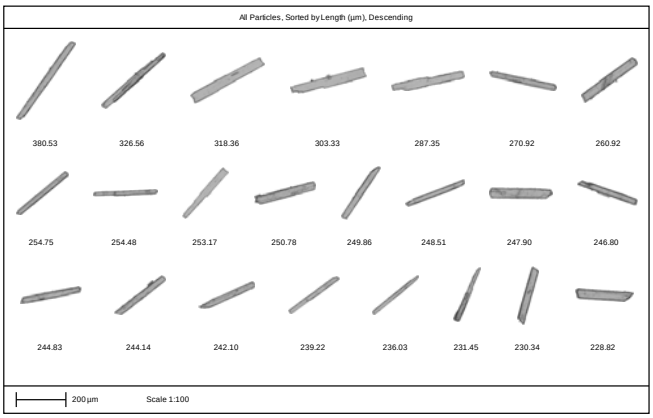
The Morphologi G3 with the wet cell accessory is ideal for analyzing wet suspended samples, such as gypsum slurries, in order to monitor both the size and shape of the particles which are important factors in the packing behavior of the particles. In this example, whilst the particles in samples 2 and 3 were very similar in terms of CE Diameter, they differed in terms of aspect ratio and circularity and therefore are likely to pack in different ways.



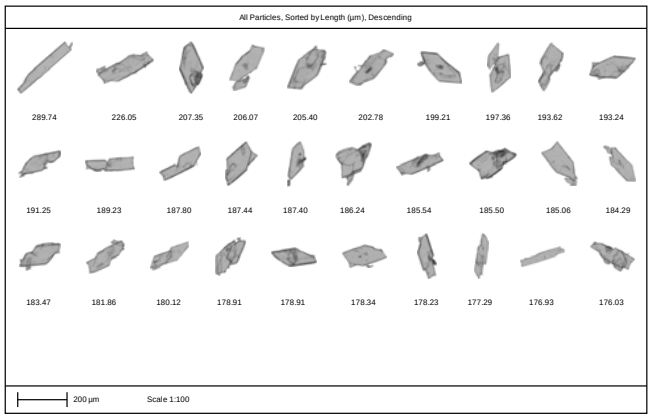
Sample 1



Sample 2



Sample 3



Sample 4

Figure 8: Example particle images from each of the gypsum samples displayed in order of descending length

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