APPLICATION NOTE

Replacing Sieve Analysis with 3D Dynamic Imaging Technology: Roofing Shingle Granules Application Example

Introduction: 3D Dynamic Image Analysis

The Microtrac MRB PartAn 3D software reports not only the particle width and length dimensions, but also the third orthogonal parameter, thickness. The software can be run in either the 2D mode or the 3D mode. In the 2D mode, as all other dynamic image analysis systems do, the individual particles passing the camera are photographed only once, in a random orientation. When the 3D mode is selected, each particle photographed is photographed up to 30 times which captures the particles in many different orientations as they tumble through the sensing zone. Figure 1. illustrates this process. The particle image which has the maximum length is the 3D Length. The image with the maximum width is the 3D Width, and the image with the minimum width is the 3D Thickness.

Figure 1: 3D measurement principle. Each particle is recorded in sequential photographs as they tumble through the sensing zone. This results in many images of different orientations of every particle which contain the orientations that would be considered to be the length, width and thickness of the particle.

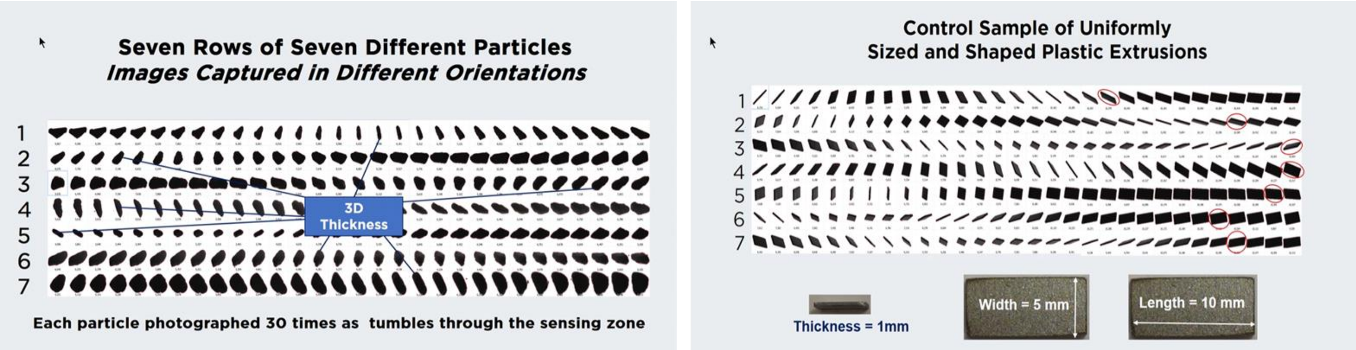

Figure 2: Left: Random orientations. The blue lines point out the 3D thickness. Images in each of the 7 rows are 30 different images of the same particle. Right: Control Sample. These are comparable images of a control sample with known dimensions measured by caliper.

Accuracy of 3D Measurement

The PartAn 3D measurements of the control sample accurately match the measurements made by calipers: 1-mm Thickness, 5-mm Width, 10-mm Length. Figure 3. Reports the 3D measurements. The median (D50) 3D values measured on the PartAn 3D are reported as 0.9-mm Thickness, 5.1-mm Width, 10.3-mm Length. Also, the distribution modes graphed for each of the three dimensions narrowly surround the caliper values.

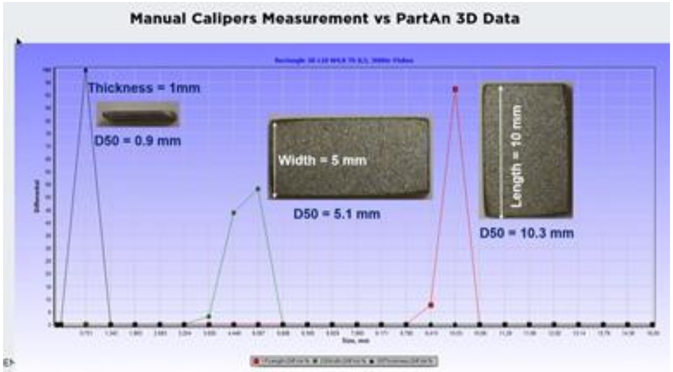

Figure 3: 3D results showing very narrow size distributions around each of the three dimensions of the control sample.

Figure 4 compares the 2D with the 3D Length measurement. The 3D result, red curve, has a width from 8.8 to 10.7 mm. The 2D result, green curve, has a width from 4.4 to 10.7 mm.

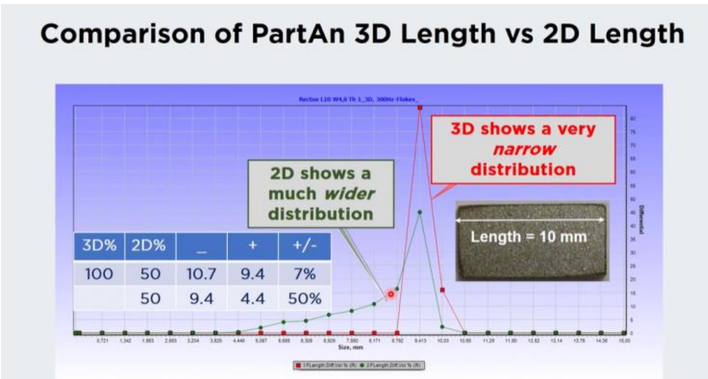

Figure 4: 3D vs. 2D comparison of the 10 mm length vs. the 2D size distributions.

Sieve Size Calculation

The PartAn 3D can perform a sieve size calculation which matches the PartAn 3D size distribution results to those of a sieve analysis of the same sample. Most particle size analyzers offer a statistical algorithm which correlates a measurement to a sieve analysis result of the same sample. The PartAn 3D sieve size calculation, however, is a direct calculation as a function of the 3D Width and 3D Thickness results on a sample. As has been shown, the 3D calculations are far more accurate with minimum deviation for the actual caliper measurements of a control sample than the 2D measurements are. Furthermore, no thickness parameter is available in 2D data.

The Sieve parameter calculation: Each size channel is calculated as Sieve (size) = (FWidth x SC) + (FThickness x (1-SC), where the Sieve Coefficient (SC) is optimized as the best fit to the actual sieve data.

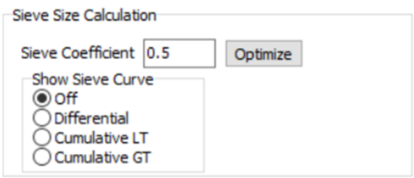

Figure 5: Sieve Calculation Software Setup. Optimize is chosen only on the initial data match attempt. The PartAn's sieve parameter can be plotted in the various distributions listed.

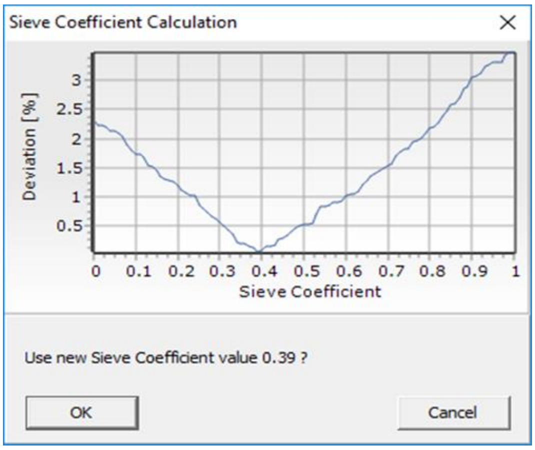

Figure 6: Results of Optimizing: in this example, the optimized sieve coefficient was calculated to be 0.39. This value will remain valid until a new sieve nest needs to have the sieve coefficient calculated from the PartAn data to match it.

Application of 3D Sieve Parameter to Composite Roofing Shingle Granules Industry

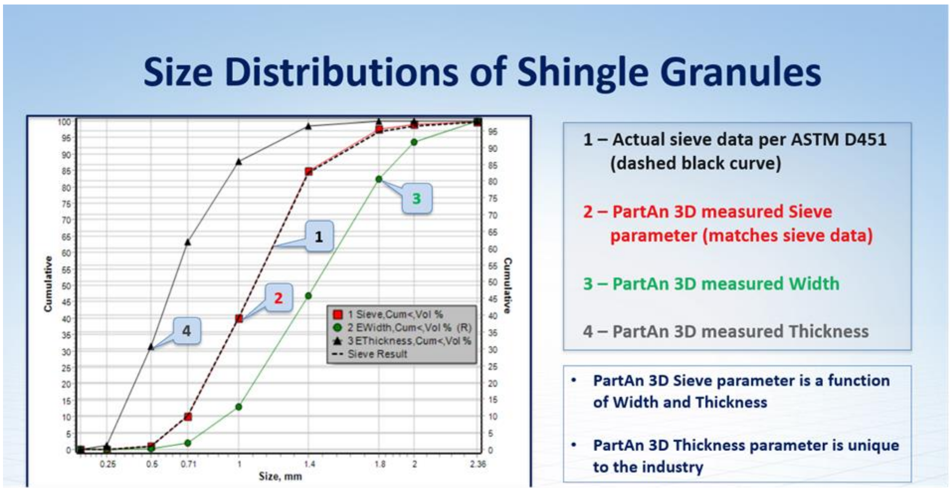

Figure 7: Cumulative % Finer Size distribution for Roofing Shingle Granules. 3D Width (#3, green) and Thickness (#4, black) distributions. Curve #2 (red) is the PartAn calculated sieve parameter shown exactly overlaying the actual sieve data (#1, dashed black curve).

Composite roofing shingles are composed of mineral granules covering a layer of asphalt which has been applied to a fiberglass or cellulose mat. Modern shingles almost exclusively use fiberglass mat. The mineral granules provide protection from damage, wear and drying out of the bottom layers.

This industry has more than one location in their process where the use of the Sieve parameter is giving more accurate and consistent results of size distributions than the sieve analyses were giving. One is in the process plant itself and the other is at their truck and rail car loading docks. The Sieve parameter calculation is available in the software of both the 3D lab and on-line process (PRO) models. The PRO models are most often installed at the rail car loading docks and the lab models in the process plants. But each can be installed and function at either location.

Properties of Composite Shingles:

- Composite Shingles:
    - Mineral Granules, Asphalt, Fiberglass or Cellulose Mat
- Granule loss from Damage or Wear
    - UV sunlight drying asphalt layer
    - Shingle blistering
    - Mechanical damage
    - Hail or other storms
    - Normal aging
    - Defective roofing product
- Mineral Granule Requirements
    - Opaque, to prevent UV sun damage
    - Size distribution per ASTM D451 to ensure optimum coverage / protection
- Available Coatings
    - Reflect UV radiation – prevents drying of shingles
    - Reflect IR radiation – prevents overheating of roof / building
    - Prevent black streaks from algae coatings

Roofing Granule Size Requirements:

The size distribution that needs to be measured and reported for shingle granules is given in ASTM D451/D451 M - 17, shown in Table 1. below. The size interval measured goes from a top size of 3.35 mm down to 150 µm and is made up of the sizes matching the list of sieves given in the table. Sieve analysis however is an expensive, error-prone (transcription and calculation errors), time consuming way to measure particle size distributions. The PartAn 3D Dynamic Image Analyzer from Microtrac MRB overcomes these shortcomings while utilizing a direct calculation which matches the sieve data. This means that the problem with sieve wear, which requires that the sieve nests be recalibrated on a regular basis, is no longer any concern. The PartAn 3D is available in both lab on on-line process (PRO) versions.

D451/D451M – 17

TABLE 1 Report Form

Retained on Sieve		Passing Sieve		Percent
3.35-mm	(No. 6)	...	...	...
2.36-mm	(No. 8)	3.35-mm[A]	(No. 6)	...
1.70-mm	(No. 12)	2.36-mm	(No. 8)	...
1.18-mm	(No. 16)	1.70-mm	(No. 12)	...
850-µm	(No. 20)	1.18-mm	(No. 16)	...
600-µm	(No. 30)	850-µm	(No. 20)	...
425-µm	(No. 40)	600-µm	(No. 30)	...
300-µm	(No. 50)	425-µm	(No. 40)	...
212-µm	(No. 70)	300-µm	(No. 50)	...
150-µm	(No. 100)	212-µm	(No. 70)	...
		150-µm	(No. 100)	...
Total				

[A] Designates U.S. Standard Sieve.

Figure 8 Required Size Distribution to be measured and reported according to ASTM D451/D451M.

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