Microtrac

Total Solutions in Particle Characterization

APPLICATION NOTE

# Three Dimensional Dynamic Image Analysis

**Customer Support Laboratory**
**Microtrac, Inc**

Particle Size and Characterization Instrumentation

Application Note

SL-AN-35 Revision B

Provided By:

Microtrac, Inc.

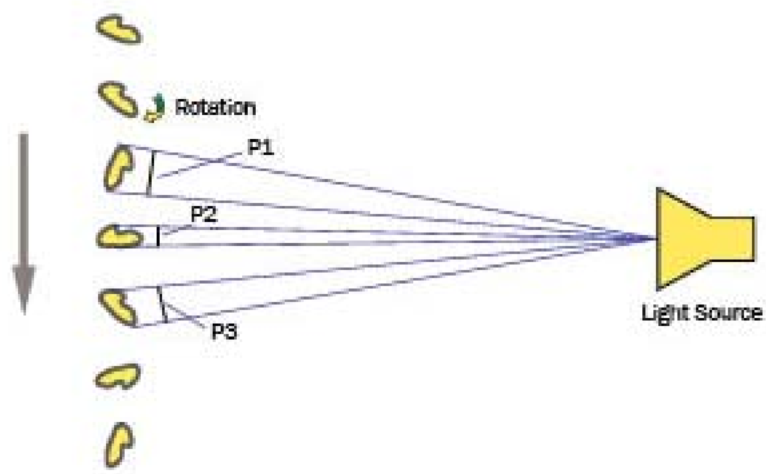
Particle Size Measuring Instrumentation

## Introduction

Dynamic Image Analysis (DIA) is a particle characterization technique rapidly growing in popularity, because it measures so much more, and so much better, than older conventional methods. With rare exception, conventional methods measure and report only one particle parameter, the Equivalent Spherical Diameter (ESD). Three dimensional DIA can report all the many size and shape parameters that two dimensional DIA can with one major addition, Thickness, or the smallest dimension of the particles. This feature is unique to the Microtrac's patented 3D dynamic image analysis technique.

## Conventional Methods of Particle Characterization

Most conventional methods for particle characterization are an ensemble measurement technique, meaning they measure some signal given off by a large ensemble of particles in the sensing zone at the same time. Laser Diffraction (LD), Sedimentation, and Sieving are three prime examples. Electrical Sensing Zone (ESZ) and Light Obscuration are exceptions in that they measure individual particles one at a time, but even these methods still report only the ESD parameter along with a number of particles count. Just as importantly, it must be noted that with these methods the particles tumble through the sensing zone in all their different random orientations. Therefore unless the particles are spheres, the data will not represent any meaningful information. A rod-shaped particle seen from its end would be reported as a sphere with a diameter the size of the smallest dimension of the rod. Seen in its longest dimension, it is reported as a sphere with that diameter. For example, if one of the rods were 3 x 1 microns in size (an aspect ratio not out of the ordinary for many particulate materials) the volume of the 3-micron sphere would be reported as being 27 times larger than the volume of the 1-micron sphere. Since the ESD is almost always reported as a volume distribution, this same particle could generate both of these answers for size - a difference of as much 9 times its actual volume depending on its orientation as it tumbled through the sensing zone!




## Shape Factor

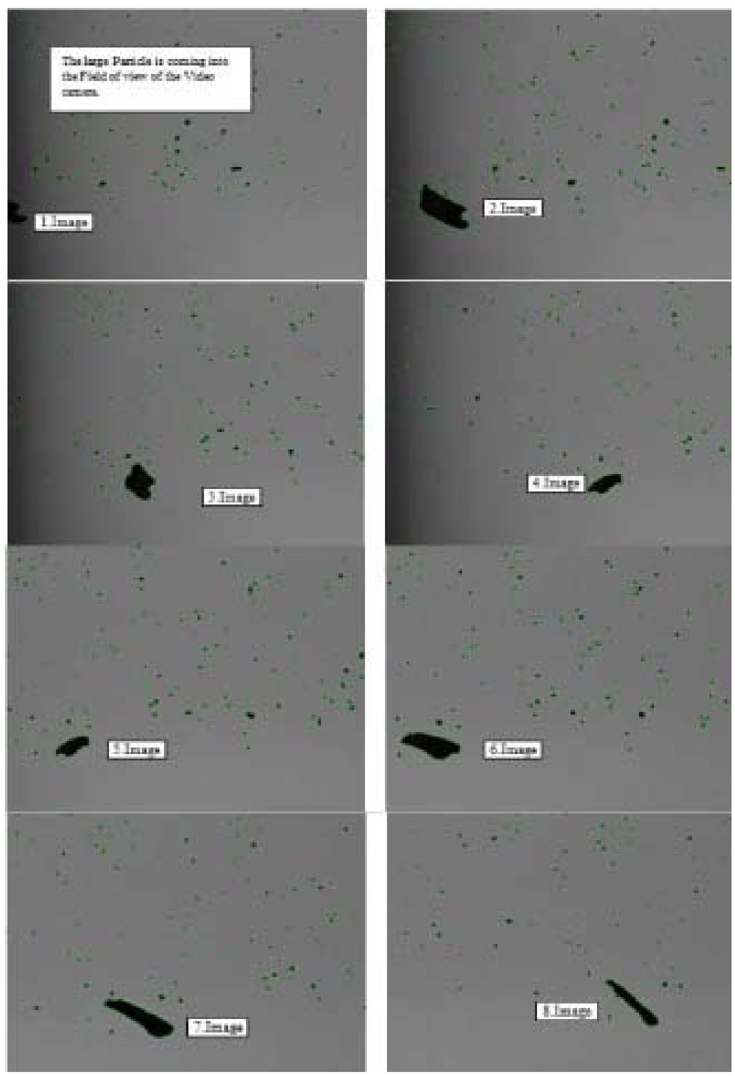
There are many terms that are useful to describing a particle shape including acicular (needle shape), angular (garnet abrasive), crystalline (geometric shape), dendritic, granular, spherical, etc. The calculations lend definition to these terms rather than the less descriptive observational characteristics. Shape-factor can be defined as a value that is affected by an object's shape but is independent of its actual dimensions. Shape factor is calculated from measured values such as area and perimeter. While, many shapes can represent the same area or perimeter, the calculations attempt to describe variations as a single value. Often the resulting value generated will be dimensionless but will represent the degree of difference from an ideal shape such as a sphere or circle. The many different types of calculations represent different approaches to expressing aspect ratios. Often, the values are normalized or converted to a ratio to provide a value between 0 and 1 for easiest evaluation. Often, but not always, the lower the value is the less similar it is to the object being used for comparison.

## Dynamic Image Analysis (DIA)

DIA is commonly considered the most recent and advanced commercial particle characterization technique, and rapidly becoming the most widely used technology in the industry.  It has considerably higher resolution than most conventional techniques because it measures each particle individually, arguably providing infinite resolution. DIA can report upwards of some 25 different size and shape parameters for each particle. This technique is also uncomplicated and easy to use. Quite simply, photos of each particle are digitized and stored in a viewable image file then “measured” by counting the number of pixels. The physical size of each pixel is known and used by the software to calculate the size of all the particles in the viewing window. No other particle characterization method is so straight-forward. The first DIA instruments became commercially viable with the advent of inexpensive, high-speed, high-resolution CCD (and now CMOS) cameras coupled with affordable high-speed, large mass-storage computers. The remaining hurdle was to develop software to quickly calculate all the traditional particle size and shape parameters that microscopists had been reporting for years. But unlike manual microscopy, with DIA technology a user can view large statistically valid samplings of particulates and automatically evaluate them in a few short minutes.

## Particle Orientation for DIA

The problem is that most DIA products suffer from the same random orientation of particles that plague the older conventional methods. This adds noise to the data, making the information of little value for particles not shaped like spheres. A few DIA products do employ techniques that keep the particles oriented with their largest two dimensions (or largest projected area) toward the camera, thus giving noise-free data. However, these techniques make it impossible to measure the smallest particle dimension, Thickness (T), as this dimension lies along the focal axis and can’t be seen by the camera. These products are therefore only two-dimensional DIA analyzers.

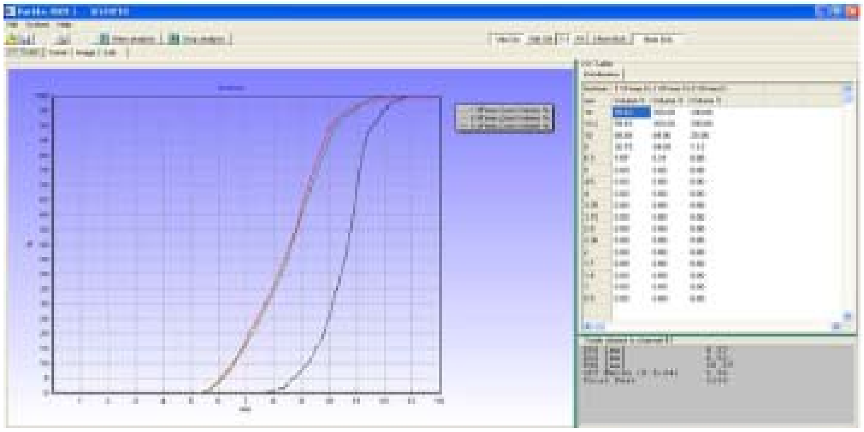


## True 3 Dimensional DIA

The PartAn 3D analyzer by Microtrac is the only 3-D DIA analyzer commercially available. It is an affordable replacement for sieves that can add all the correct standard size and shape measurements that dynamic image analysis has always provided for non-randomly oriented particles, plus the third dimension - Thickness.

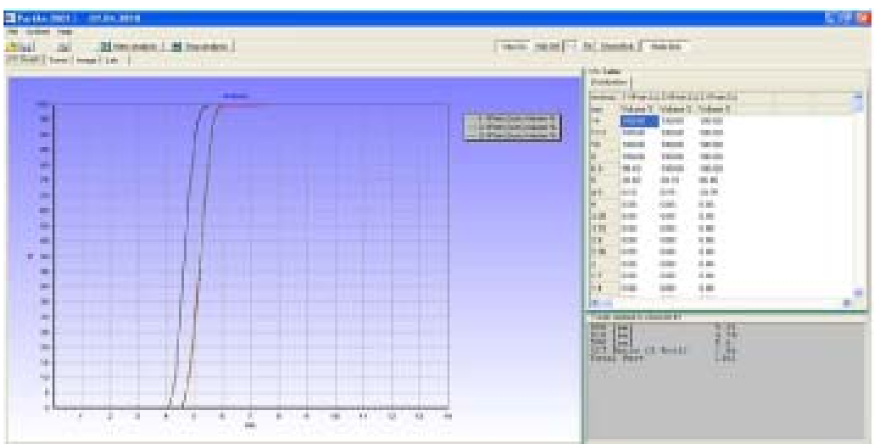
The series of photos on the right taken by our patented particle tracking technique follows one particle as it tumbles through the sensing zone of the field of view of the camera. Each image of this particle is stored sequentially by row in the image file. All size parameters for each image are calculated. The largest **Length, Width, Area** and **Perimeter** parameters as well as the smallest **Thickness** parameter in this series of seven orientations were assigned to the particle as its size parameter set. All shape parameters are then calculated from these size parameters. The same is done for every particle measured in the sample.

**The results below of the Microtrac PartAn DIA run in both the 2-D and 3-D modes on a sample of shell pasta, an elliptical shape, point out the difference in the accuracy of both measurement techniques.**



The three results shown in these two graphs are cumulative % finer curves of the particles measured. In each graph, the 2-D measurements are shown (red and green) at 2 different measurement times - 30 & 100 seconds - showing no significant difference in the result. In the top graph the 3-D measurement (black), at 100 seconds, gives a significantly larger size result for the maximum dimension, an indication that this dimension wasn't artificially lowered by including smaller-than-maximum projected areas in the calculation.

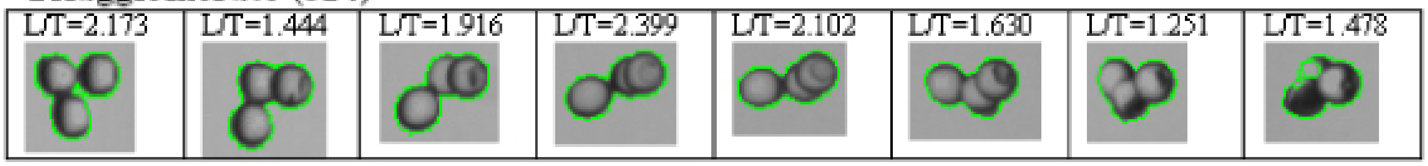
**Graph of largest dimension, comparing 2-D and 3-D methods.**



In the lower graph, the minimum measured dimension is shown, measured under the same conditions as above. Here the 3-D (black) result gives a smaller size for the minimum dimension, an indication that the result wasn't influenced by using larger-than-minimum projected areas in the calculation.

**Graph of smallest dimension, comparing 2-D and 3-D methods.**

Triagglomerate (824)




This is a series of digital photos of one particle (fused glass bead) tumbling through the field of view of the 3-D DIA. The progression is left to right in the sequence. The first photo, on the left, shows the largest projected area of the particle. This is the photo that will be used to assign to the maximum distance (Length) of the particle and also the maximum distance perpendicular to the Length (or Width). The fourth photo in the series shows the minimum distance (Thickness) to be assigned to the particle, thus giving the particle the correct quantitative dimensions of all three of its major axes.

## Summary

The dimensions of all three of the major axes of a three dimensional particle can be measured correctly only by the method of particle tracking performed by Microtrac's PartAn 3D DIA. Any 2-D analysis will average all the different orientations of randomly tumbling particles, biasing the largest dimensions to report incorrect smaller values, as well as the smallest dimensions to report incorrect larger values. Image analyzers that only employ largest projected area orientation cannot measure the Thickness dimension because it extends along the focal axis behind the particle and out of view of the camera. Shape parameters reported by image analysis are ratios of the different measured size dimensions of the particles. Therefore correct shape parameters can only be calculated by the patented three dimensional Dynamic Image Analysis technology employed in the Microtrac PartAn 3D DIA.