APPLICATION NOTE

Recalculation of Microtrac data to emulate data from sieves, sedimentation and other methods

Introduction

There are multiple methods that can be used to provide particle size distributions. These include dynamic light scattering (quasi-elastic light scattering) which includes the Microtrac MRB methods of Laser Amplified Detection and Frequency Power Spectrum Analysis. Other methods include ensemble techniques (Sedimentation, Surface Area, Laser Diffraction, Air Permeability, Sieves, and single particle counters (Image Analysis, Electrical Sensing Zone, Light Obscuration). These methods can provide a view of the distribution and statistical values associated with a particulate sample. An issue that can arise involves the effects of the material on the measurement. Each measurement is designed upon the premise that particles are spherical. Since most materials are not truly spherical each method may be influenced slightly differently. The result is that one method may not provide the identical size and distribution that another method provides. This note addresses the issue of converting data from one method to another. As an example, the widely used sieve method will be compared to Microtrac Laser Diffraction data while attempting to explain why the differences exist between the methods.

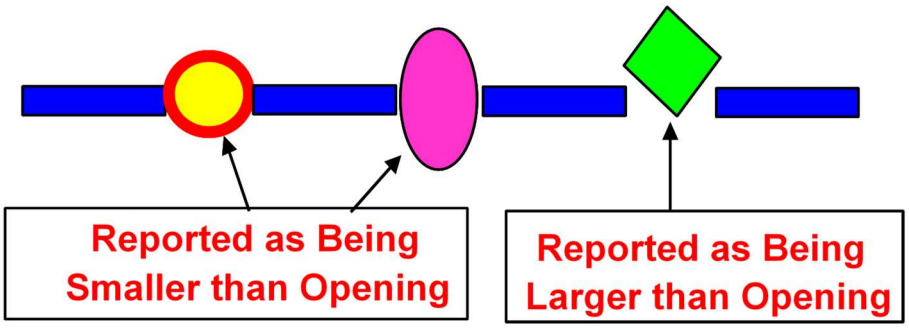
Sieve Measurements

Sieve measurements rely on the ability of particles to pass through a screen which has a number of holes that are formed by crossed wires made of metal or other material type. The holes provide an opening of a size given in microns. The sieve size, provided in mesh, is determined by the number of holes per square inch. Several screens are often used where each has a specified, but different, mesh or micron size. Each screen provides a means of separating one class of particles from another. Generally, particles that pass though (smaller than) the screen holes are said to be below a screen size and those that do not are said to be retained. The net result if many mesh sizes are used, is a distribution of mass as a function of screen size. Thus, any particle that passes through the screen is considered to be smaller than the size of the hole. For a total weight (mass) of 122 grams where all particles have the same density, the powder may exhibit the following screen data. A “pan” is present to capture particles where the smallest particles cannot be segregated according to size. These particles are captured as a mass in order to assist knowing the total mass for percent recovery calculations. A typical sieve particle size distribution calculation is shown below. Please note that many other sieve screens above and below those listed can be used.

Sieve Size	Micron Size	Weight Retained (Grams)	Weight Between Sizes	Percent Between Sizes	Cumulative Percent from Retained	Cumulative Percent Passing
20	850	0	0	0	0	100
30	600	1	1	0.8	0.8	99.2
40	425	4	4	3.2	4	96
50	300	10	10	8.2	12.2	87.8
70	212	15	15	12.3	24.5	75.5
100	150	35	35	28.8	53.3	46.7
200	75	20	20	16.4	69.7	30.3
325	45	22	22	18.	87.7	12.3
PAN		15	15	12.3	100	0

Effect of Shape

As mentioned, most particle systems are not comprised of spheres. Spheres provide a shape that allows all orientations of the particles to pass through a given size hole assuming that the particle size and the hole are same size, or the hole size is larger. Spheres can pass through the hole unimpeded. Larger particles will be retained since they cannot pass though. Particles that have shapes other than spheres will pass though by the smallest dimension. Thus, a rod-shaped particle will pass though according to the smallest diameter. Accordingly, a particle that is 20 microns wide and 100microns long will be measured as being 20 microns or smaller. This will bias the data according to the shape of the particles. This effect is shown in the figure below. Visually, the elongated particle would be considered the largest, which is in contrast to sieve information. The data can be adjusted for this bias by applying the emulation feature in FLEX software.



Microtrac S3500 and Sync technologies use scattered light to determine particles size. Laser light is "diffracted" at angles according to the sizes present. Smaller particles scatter light at wider angles and lower intensities than do larger particles. The intensity of light scattered at various angles provides a measure of the amount of particles present at the various sizes.

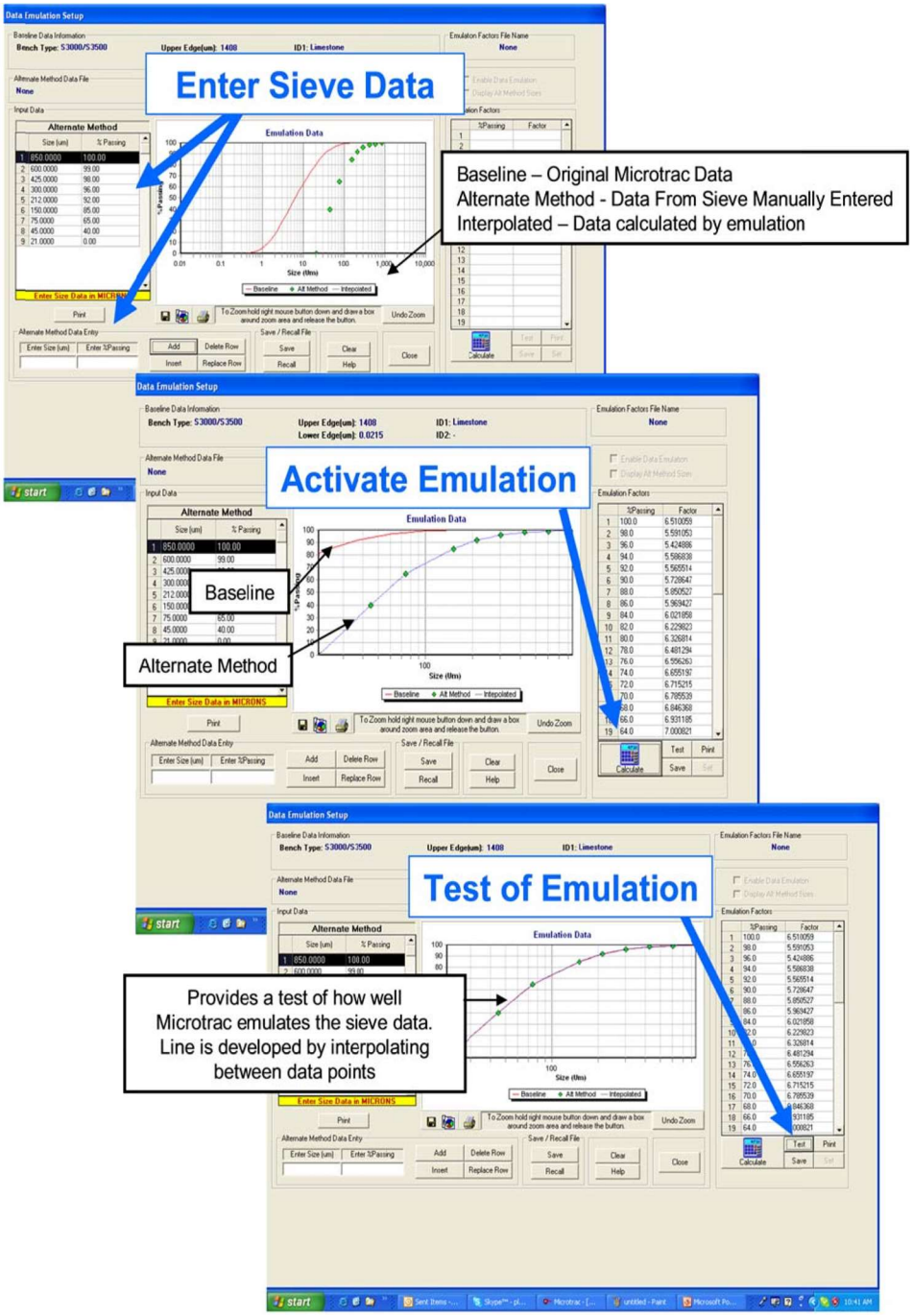
Particles in Microtrac measurements are forced to tumble during circulation or during dry powder measurements. The random tumbling intersects the laser beam during this random tumbling and thus provides the laser with many "views". Each view causes a slightly different light scattering pattern and thus allows the Microtrac S3500 to take into effect the length AND the width of the particles. Thus, the longest dimension is included as part of the measurement. This can cause sieve data to show particles as being smaller than Microtrac S3500 and Sync diffraction data. However, the distribution data will not be identical to the sieve data even when the particle system is completely dispersed.

Emulation

Realizing that specifications for a product may have been established for the sieve method and that Microtrac s3500 or Sync provide a much quicker, easier means of supplying full particle size distribution data, the ability to achieve data that "looks like" the sieve data is important. This prevents the need to change specifications and as well as eliminate exposing new numbers to personnel. Microtrac FLEX software has the ability to perform an emulation which will, by mathematical means, duplicate the sieve numbers, while not being a sieve measurement.

General Overview of Emulation

If desirable, the emulation factors can be tested when three curves will be shown representing: original Microtrac data, sieve data and the data calculated by emulation. In the figure above The Microtrac-



emulated data agreed perfectly with the sieve data. The information used to calculate the emulated distribution may be saved as a computer file for later use or the information can be used immediately. Once completed, the operator merely recalls the data record to which the emulation will be applied, and the FLEX software performs the conversion. By this means the effect of particle shape on the measurement is ameliorated.

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Other Issues Causing Data Differences

Balling-up

Some materials, when subjected to tapping or shaking by sieve analysis, cause the particles to interact in such a way that cause them to agglomerate or become stuck together. Often this is caused by static charge but may be due to moisture and capillary forces. This will cause the size to be larger than a method where dispersion can occur. The sieving must be carefully controlled in order to have the balling-up mechanics repeat and provide the same data. In such a case, the gentle settings on Microtrac Turbotrac Dry Measuring System should be used to duplicate this effect. Settings are provided in the Operator's Manual or information can be obtained from the Microtrac Applications Laboratory.

Attrition

Particles that can be squeezed between the fingers and crushed can slowly be eroded during agitation due to frictional forces. The attrition that results produces more fine particles and will bias the results and remove coarse particles from the distribution. It also will cause over-reporting of fine particles. Microtrac instruments provide for flow and energy adjustment to avoid this physical phenomenon. The wet dispersion systems eliminate most friction due to presence of fluid, and the dry measuring system has settings to allow a single-pass measurement where constant abrasion does not occur.

Density

Many materials that are measured contain particles that are very similar if not identical in chemical composition and thus the density is the same for all particles. Sieve measurements can be considered a mass distribution of particle sizes since the primary measurement is performed by weighing the particles resting upon each sieve. The sieve distribution is dependent upon not only the size of the particle, but also the density of the particle. Thus, a 100-micron particle of pure copper (density 8.9 g/ml) will weigh nearly twice as much as a 100-micron particle of Titanium (density 4.5 g/ml).

Microtrac provides measurements in volume percent. Volume is used since one definition of particle size is the volume that an object takes up in space. The volume measurements are independent of density because no weighing or masses are needed to perform the particle size measurement. The density of the particles therefore causes an effect on the distribution obtained by sieves that does not occur with Microtrac measurements. For a 50%/50% by weight mixture of 50g titanium and 50g copper the distribution will be different than Microtrac because of density. The resulting volume distribution on Microtrac will be 66% Titanium and 33% Copper because the density effect is eliminated. This provides a more realistic particle size distribution since there is no density bias.

Summary

Microtrac FLEX software can successfully provide a mathematical solution to modify Microtrac data to agree with data from other particle size methods. This allows the same specifications to be used. Data are easily entered, and correlation factors are calculated automatically. Factors may be saved as a file for later use or used immediately.