

Defining Particle Size

Introduction: Particle size (PS) is an important consideration for many applications of chemical salts. Particle size distribution (PSD) is also regarded as a critical parameter in some applications where either the fines or the coarse material may impede the results that the customer is trying to achieve.

Particle size can be measured and discussed in various ways. When considering average particle size, it is important to realize that many measurement instruments give values as if all particles are spherical in shape. The various instruments each give different values because of subtle differences in their method of determining the particle size.

Types of Measuring Equipment: For chemical salts, there are two major ways of measuring and expressing PS: sieve size and laser diffraction. The results from these two types of PS determinations are expressed quite differently. A sieve size study gives results as a mesh designation. For example, 10% on a 60-mesh sieve can be shown as 10% +60 mesh. A PS laser diffraction device gives average PS in microns. It can be a median or mean average PS or can give PS percentage at different sizes such as 50% < 20 microns (d_{50}) and 100% < 100 microns (d_{100}).

Sieving: For sieve size measurements, there are basically two methods commonly used: Rotap and air jet. These methods can give different results for the same screen size. In Rotap, several screens are normally stacked and the screen openings get successively smaller from top to bottom. The sample is placed on the top screen and the instrument taps or shakes the stack of screens for a defined period of time. This tapping moves the sample around the first screen and the material that is smaller than the sieve size and shaped and oriented properly falls to the next screen. This continues until the original sample has been separated into its various sieve size fractions. The results are expressed as the percent on the various screens. For example the results of a typical sample may be expressed as:

MESH	%
+20	20%
+60	45%
+120	30%
-120	5%

This result shows that 20% by weight is retained on the coarsest screen, the 20 mesh, while 45% is between 20 and 60-mesh. The “+” sign means the percentage held on the screen and the “-” sign means the amount that passes through the screen. Other times the terminology used is “ON” which means the amount held on the screen and “THRU” which means the amount that passes through the screen.

Another complicating factor is these laboratory sieve sizes are normally in US Standard screens, which are used in laboratories in the US and many places around the world. However, there are two other commonly used types of screens, Tyler and Tensile Bolting Cloth (TBC), which are used in manufacturing around the world. These production screens give different values. Although 60-mesh still means 60 openings per linear inch, the size of the wires are different thus giving different size holes and thus different results.



Air Jet Sieve

Another instrument that measures particle sieve size is an air jet sieve apparatus. This device uses vacuum below the sieve and pulls the product through the screen. For example the product is placed on the top of a 60-mesh screen and the vacuum applied below the screen. The finer particles go into

the vacuum while the +60-mesh remains on the screen and is weighed giving the +60-mesh result. This gives a good value for the +60-mesh. Because of the use of the vacuum, there is a more efficient separation of the finer particles which yields a number for the +60 that is closer to the actual value than using the normal Rotap which allows some hang-up of the smaller particles (e.g. static electricity). Air jet sieving is designed for one screen at a time. The results may be expressed like this:

MESH	%
+40	10.2%
+60	46.6%
+80	1.2%
+100	12.6%
+120	14.4%
-120	15.0%

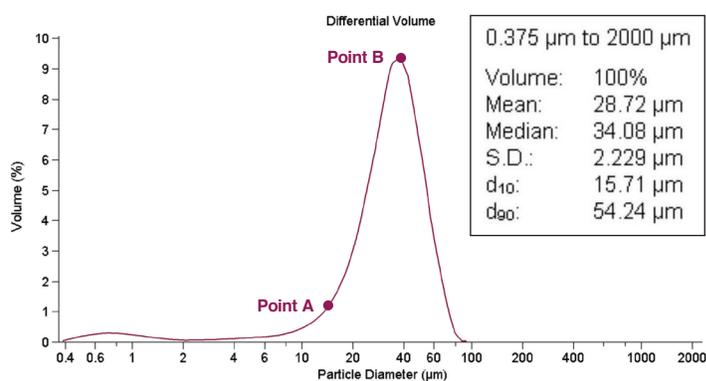
Sieving results can vary slightly from test to test. Sometimes fine particles that may pass through the screen in one instance may get hung up in the bulk of the product retained on the screen in another instance and not fall through. Also many particles are longer in one direction (rods, fibers, etc.) so they must be oriented properly for them to pass through the screen pore. Normally this variation is not a cause for concern. For most chemical salts, successive samples give very similar results.

Laser Instruments: The other major source of PS determination is with instruments that use lasers to measure particle size. The common laser diffraction instruments are Microtrac, Malvern, and Beckman Coulter. The product is suspended in a solvent in which the product is not

soluble. The laser provides a diffraction pattern. Through mathematical modeling the particle size is determined. Many of these instruments can measure the PS as a dry powder also. Each of these instruments and methods give somewhat different values.

The graph below shows the PSD of a typical product. The results give the actual amount in each PS diameter. The graph shows 10% of the particles are smaller than 15.71 μm (point A) and 90% are smaller than 54.24 μm (point B). From this data, one lot can be compared to another. This comparison may be critical if one is tableting the product and it requires a certain percent of coarse material and a very small amount of the fine material. The summary in the table can give an experienced person the basic PSD of the sample.

Graph of a typical result:



The normal results from screen sieve size are given in mesh while the results from laser diffraction are in microns (μm). The table below compares some values.

U.S. STD. MESH	INCHES	MICRONS
6	0.1320	3360
10	0.0787	2000
14	0.0555	1410
20	0.0331	841
30	0.0232	595
40	0.0165	400
50	0.0117	297
60	0.0098	250
80	0.0070	177
100	0.0059	149
120	0.0049	125
140	0.0041	105
170	0.0035	88
200	0.0029	74
270	0.0021	53
325	0.0017	44
400	0.0015	37

The data from different types of laser PS equipment are not equivalent. Care must be taken if specifications are set with one type and the customer uses another type of PS equipment. The Malvern, Beckman Coulter and Microtrac each give slightly different distributions.

Particle Size and Specific Surface Area (SSA): Particle size would relate exactly to SSA if all the particles were spherical and had no pores. A simple calculation is all that is needed to go from particle size to SSA for each particle. Unfortunately, it is not that easy in the real world of powders. Particles are not normally exactly spherical and are not all the same size. There is a general correlation that the smaller the particle size, the higher the SSA, but that only goes so far. Particle size determinations by laser diffraction devices will report surface area as SSA. SSA by laser diffraction has a separate and distinct meaning from surface areas determined by gas or liquid adsorption techniques such as Brunauer-Emmett-Teller.

CASE STUDY

Jost was asked to assist a customer to increase the viscosity of their finished product. The customer would occasionally dispose of batches of finished product if the viscosity was too low. Since the chemical salt from Jost was the largest component in the product formula, the customer believed that the biggest impact might come from changing the particle size distribution of the chemical salt. After nine months of measuring and recording the particle size distribution, calculating the resultant surface area and measuring the viscosity of the finished product, the customer was able to correlate the calculated surface area with the viscosity of the finished product. The customer confirmed that the small change made in the particle size distribution resulted in a higher average viscosity in the finished product and no rejection of any finished product.

Conclusion: Particle Size and Particle Size Distribution are often useful parameters of powders. There are several methods to determine and define these parameters. Care must be taken to understand how the measurement is made and how that will relate to the property that is considered critical for the use of that product. **Jost Chemical Co.** has the expertise to determine these parameters and help the customer understand how they can be used in their individual application.