Particle analysis: Glossary

Particle analysis is one of the most complex technologies in bulk solids processing. To help you understand the language used by particle analysis equipment suppliers, consultants, and others, this glossary defines some major particle analysis terms.

Every particle in the universe... affects every other particle, however faintly or obliquely. Everything interconnects with everything," wrote Douglas Adams in his novel *The Long Dark Tea-Time of the Soul.* He might have been writing about dry bulk solids processing. Many of us have experienced a silo that wouldn't empty, a batch ruined by particles of widely ranging size that didn't properly blend, or a product rejected because it contained too many fines or too many oversize particles. You can avoid these problems by analyzing your particles and handling them in a way that's suited to their characteristics. This glossary aims to clarify some of the particle analysis terminology you're likely to encounter. For more detailed information, see the sources listed at the end of this article.

General terms

Inline or online analysis. Analysis of a sample conducted without interrupting a process, which usually allows quick, on-the-fly adjustments to be made to the process.

Offline and laboratory analysis. Analysis of a material sample removed from a process and taken to the analyzer. The sample may be returned to the material stream or discarded. Analysis results determine what adjustments, if any, will be made to the process.

Particle analysis. Examining a particle or group of particles to determine size or other characteristics; particle analysis is generally conducted with a material *sample* rather than the whole bulk of material.

Sample. A representative portion of a bulk material. Material may be sampled manually such as by putting a cup or scoop into a material stream or automatically with various kinds of automatic samplers. [***Editor's note:*** For information about automatic samplers, see "What you need to know to select an automatic sampler," by Richard Bassett, *Powder and Bulk Engineering,* March 2001, page 21.] A *dry sampler* presents a dry material sample. A *wet sampler* presents a dry material sample suspended or dispersed in a liquid medium.

Particle analysis measurements

Here are some of the things particle analysis can tell you about the particles in your material.

Density. A particle's mass per unit volume.

Mobility. A particle's speed, type, and amount of movement.

Moisture. The amount or percentage of liquid a particle contains.

Number. The quantity of particles contained in a representative sample.

Porosity. A particle's internal and surface space available for liquids or other materials to take up. If a particle becomes denser (through compaction, for example), its porosity decreases.

Shape. A particle's morphological characteristics.

Size. A particle's linear dimension based on mass, volume, length, surface area, or number.

Size distribution. A numerical description of the proportion of particles in given size ranges; can be described as a percent over or percent under a stated size range or proportion within established size bands.

Surface area. Measured as a particle's spherical equivalence or its actual surface area. Since a particle's surface-to-volume ratio determines the rate at which a particle interacts with its surroundings, and since most particles vary slightly or immensely from a spherical shape, the ability to measure a particle's actual surface area can be important for some types of analysis.

Volume. A particle's bulk or mass.

Zeta-potential. A measure of the charge near a particle's surface, defined in megavolts.

Particle analysis methods

Here are some common techniques used to analyze particles.

Electrical zone sensing. Used for size and count measurements, the electrical zone-sensing instrument requires a particle sample suspended in an electrolyte. The sample flows through a small aperture in the instrument, and the resistivity changes between two electrodes on either side of the aperture directly reflect the volumes of the passing particles. These resistivity changes pass in the form of pulses to the instrument's pulse-height analyzer, which counts and scales them to determine the particle size range.

Image analysis. Used for size, shape, and other measurements, image analysis employs one or more special cameras that take high-speed, high-resolution photographs of single or multiple particles as they're flowing past the camera(s). The resulting images can be magnified and studied.

Laser diffraction or light scattering. Used for size and other measurements, a light-scattering analyzer irradiates particles in a sample with a laser light beam and then measures the pattern of light scattered by the particles. The analyzer determines particle size based on this scattering pattern and Mie theory calculations. Laser diffraction has a broad dynamic range and is capable of measuring powders, suspensions, aerosols, and sprays.

Light extinction or light blockage. Used for size and count measurements, a light-extinction instrument irradiates the particle sample with a light beam or a laser beam and determines particle size by measuring the amount of light blocked off by each particle (*single-particle optical sensing*) passing through a sensing zone.

Microscopy. Used for size, shape, and other measurements, microscopy employs either an *optical microscope* or *electron microscope* (also called a *scanning electron microscope*) to examine representative particle samples on a slide. (See *Image analysis.*) While the optical microscope relies on simple visual examination of the particles, the electron microscope focuses a beam of electrons on the slide, enlarging each particle's image and making it appear to be three-dimensional. The electron microscope is capable of making even *nanoparticles* visible for examination. (A nanoparticle is 1 to 100 nanometers in length; a nanometer is one-billionth of a meter.) Measurements performed by microscopy can be automated by *image analysis.*

Photon correlation spectroscopy. A light-scattering technique that calculates particle size based on the particles' Brownian motion. This technique is ideal for particles below 1 micron.

Sedimentation. Used for size analysis, this method uses an equation known as *Stokes law* to measure the settling rate and concentration change of particles of the same density dispersed in a liquid medium. In *gravity sedimentation,* the particles are allowed to settle by gravity. In *centrifugal sedimentation,* the particles are measured while being accelerated by centrifugal force. Various instruments, including pipets, hydrometers, and photosedimentometers (which employ a light beam for monitoring concentration changes) may be used in these methods.

Sieving. Used for size and size distribution analysis, this method employs one or more shallow, round pans, or *sieves,* each with a wire-mesh or electroformed grid bottom. Typically, sieves of several sizes are stacked in descending size order so that the one with the largest grid-hole size is on top and the one with the smallest grid-hole size is on the bottom. A material sample is fed into the top sieve, and the weight of the material remaining on each sieve is measured to determine the material's particle size distribution. Sieving can be manual or automatically controlled by a microprocessor.

Surface adsorption or gas adsorption. This method calculates particle size by measuring the amount of gas needed to layer a particle with gas molecules.

Surface permeability or gas permeability. This method infers particle size from the resistance offered to liquid flow through a pressed plug of powder. **PBE**

Sources

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Chapter 20, sections 1-10, *Perry's Chemical Engineers' Handbook,* seventh edition, edited by Don W. Green, McGraw-Hill, 1997.

Michael Pohl, "Selecting a particle size analyzer: Factors to consider," *Powder and Bulk Engineering,* February 1990, page 26.

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For further reading

Find more information about particle analysis in articles listed under "Particle analysis" in *Powder and Bulk Engineering*'s comprehensive "Index to articles" (in the December 2002 issue and at www.powderbulk.com).

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