Solids

The best way for chemical processes to deal with solids is to turn them into liquids. This is not always possible, so solids materials handling must consider important factors for success.

1. Solids will hang up, plug and rat hole.
2. Solids will segregate
3. Solid particles will break down and they will also agglomerate
4. When suspending solids in slurries for liquid phase transport, solid particles will settle in and plug slurry lines
5. Dust will have to be controlled

Hang Up, Plugging and Ratholing

Solids have uneven interlocking surfaces. Many solids are partially soluble in water, thus the moisture of the air surrounding the particles will dissolve the particle just enough to allow it will agglomerate with its neighboring particles. Under conditions of contact time and compression the agglomerates will create plugs. Ratholing is a partial plug that then creates a protective surface where increased particle velocity will not scour the agglomerated plug or hang up to where the agglomerated blocks break free.

Segregation

Segregation is the tendency of powders and powder mixtures to become non-homogeneous. If a blended material is going to segregate it will happen anytime there is movement at a transition, vibration, flow, aeration, mixing/de-mixing. Segregation is a critical factor in sampling. During sampling it impacts what gets in the sample container. After sampling, it impacts the homogeneity of the sample

Attrition

Solid particles may have a certain particle size distribution specification to ensure good surface area for reaction, or to keep dusts or small particles from becoming stable fumes or colloids in suspension never settling out in the solid/liquid or solid/gas separation devices. Attrition will also reduce the ability of various filtration techniques to allow cake build so that flow and particle removal efficiency can be balanced.

Characterization

Particle size distribution (PSD), bulk density (free and tapped) and moisture are the four most important characteristics of solids.

Solids Sampling

The sample must represent the bulk material. Liquid samples are homogeneous, solid or slurry samples may not be. If the sample has segregated, the large particles will be on top with a low level of fines and the bottom of the sample will have a high level of fines. The best way to take a solids sample is from a flowing stream. Take a full stream sample from a moving, homogeneous material drop for a duration long enough to get a representative sample. Use a container large enough to catch the whole stream. A partial stream samples may not be representative. Unlike liquids, do not over flow the container, the large particles will flow out resulting in a bias. For a stationary sample from a super sack or a bin take samples as you empty the container. If you are trying to determine the segregation or the uniformity in a bulk solid mass then use a grain thief or consider the container to be the whole sample and use sample reduction techniques. For large containers like rail cars and trucks, sample as container is emptied and combine the sub-samples.

Samples from mixers. The sample and sub-sample size is dependent on the process, the material and the test method requirements. The characterization method has to also consider the sample prep and sub-sampling when determining size. Usually, one uniform sample is taken from a bulk and then it is randomly split down to produce subsamples for all the various tests.

Particle Size Distribution

Particle size distribution is a representation of the relative amounts of material as a function of size. PSD can be determined by screen analysis. A representative sample is subjected to shaking and tapping action were the weight percentage retained on each screen of test series indicates particle size distribution. The largest screen is on top, and rarely are there more than seven screens in a test stack. A 100 g sample is typical for most materials

Density

There are two types of solids densities. The loose bulk density. This is measured as the natural settling compaction of the material from a flowing stream. The other is a tapped bulk density taken from a settled and tapped sample volume to allow the air and imperfect particle interfaces to reduce to the minimum void area possible. The density of a solid dry particle must not be confused with the density of a slurry containing the dry solid particles. Creating a known weight density slurry and measuring a uniform volume of a weighed slurry is a good method for determining the true density of the solid particle itself. Specific gravity is another way to characterize the mass/volume ratio of the solid. It is the ratio of the weight of a given volume solid to the weight of same volume water.

Moisture

Three types of moisture exist in any solid sample. Usually a differential scanning calorimeter is used to produce a full curve that characterizes the moisture of the sample. A moisture balance or a weighed sample in an oven can also produce reliable results. Free moisture is the water that fills the voids between particles. Bound moisture is the water that is trapped in the individual voids of each particle. Hydrated water is water that is chemically bound to the species making up the particles. Bound moisture is often characterized as hydrated moisture

even though the bound water is physically attached to the particle species where the hydrated water is chemically bound to the particle species.

Ring Shear Friction Test Indices

There are a series of flow characteristics that can be determined using ring shear testers. These include indices that can determine the bin and chute angles that will prevent ratholing and hang up and segregation.