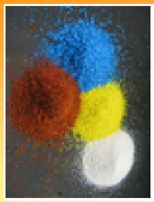

Food Facts

Spring 2012 Volume 1 No B

Brought to you by: **Material Flow Solutions, Inc.**

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Understanding Segregation Mechanisms

Segregation, also called separation, of granular and powder materials is one of three principal causes of process failure with systems that handle powder materials. It is a global problem, affecting all industries, but is particularly prevalent in the food industry where products are most often mixtures of multiple ingredients. Conservative estimates show that 30% of all unscheduled plant downtimes is due to segregation and the resultant quality issues. In process design, the solution to a segregation problem can be attacked from two angles. The process can be modified to accommodate segregation patterns caused by the various mechanisms or changes can be made to the process to reduce the cause of segregation. In either case, understanding segregation mechanisms is critical to developing robust processes to handle segregating materials.

Sifting Segregation. Materials segregate when handled for a variety of reasons. Many solids flow practitioners quickly identify the potential for fine material to sift through the matrix of coarse particles as material slides down a pile. Sifting segregation is a predominant cause of separation which occurs during handling of mixtures of differently sized particles. This mechanism usually results in a radial segregation pattern where fines accumulate near the center of a pile while the coarse material accumulates predominately at the pile edge (Figure 1). Additionally, severe sifting segregation can cause top-to-bottom segregation patterns where the fines are beneath the coarse particles. This is particularly true if inter-particle motion is produced within the material by an external means such as vibration. Therefore, particle size differences greater than three to one are enough to produce significant sifting segregation problems.

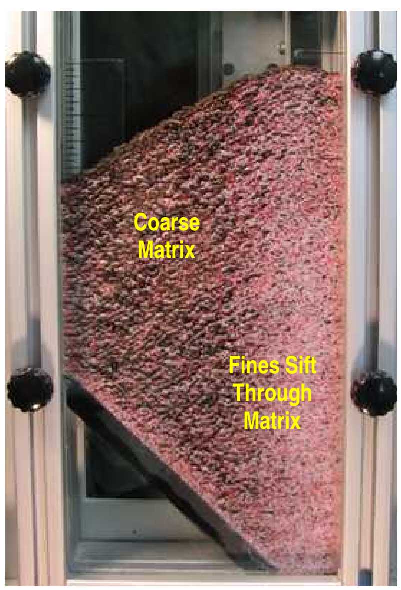

Figure 1. Three-colored sugars in a pile - example of sifting segregation

Angle of Repose Segregation. Sifting segregation is by no means the only mechanism that causes separation of particulate material during handling. Some particles have differences in inter-particle friction and, thus, form piles with different repose angles. Form-ation of piles within process equipment causes the less frictional particle

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In This Issue

RECAPTURE LOST REVENUE: SOLVE SEGREGATION ISSUES

A single instrument measures:

- *Segregation by Particle Size*
- *Segregation by Sifting*
- *Segregation by Fluidization*
- *Segregation by Angle of Repose*
- *Segregation by Air Entrainment*
- *Segregation by Chemical Composition*

The SPECTester

- FAST – 10 to 30 minutes to run an analysis.
- Measures a mixture of up to 6 unique components
- Identifies primary segregation mechanism out of 4 specific mechanisms
- Identifies segregation by particle size, sifting, fluidization, angle of repose, chemical component and air entrainment
- Provides data about component concentration, particle size differences, product uniformity
- Identifies process design parameters and quality control issues
- Results scalable to process conditions – mimics actual process conditions
- 50 segregation points measured within a sample
- Fully automated, reports how much as well as why the material mixture is segregating
- Touch-screen/pad control
- Provides uniformity index for sample, and segregation variance data
- Data can be exported in Excel format
- Certified CE Compliant

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to slide further down the pile accumulation at the pile's edge. This mechanism results in a radial segregation pattern. Materials with an angle of repose difference of more than two degrees can show significant repose angle segregation.

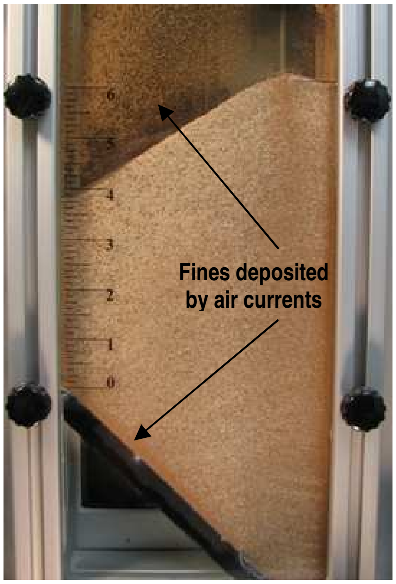

Figure 2. Four ingredient cream-of-wheat with cinnamon-sugar in a pile - example of air entrainment segregation

Air Entrainment Segregation. Air currents caused during filling may carry fine material to regions where the air currents decrease sufficiently to deposit the fine material. This air entrainment segregation can produce a radial pattern or a side to side pattern depending on the position of the inlet and the geometry of the vessel. Generally, fines accumulate near process vessel walls with this segregation (Figure 2).

Impact Fluidization Segregation. If the bulk material is very fine and compressible, then it may become fluidized during filling of a process vessel. This fluidization is not persistent as it would be in a fluid bed where there is an external source of air. The material begins to lose its entrained air soon after completion of the filling process. However, these materials retain their fluid-like behavior for several minutes or even hours. Coarse particles entering the bin during this time can impact on this fluidized material and penetrate the top layer of fluidized solid before coming to rest below the top surface. This results in a top-to-bottom separation of particles in the bulk mixture, thereby creating layers of fines and coarse material.

Customized Situations Equal Customized Results. Many solids flow practitioners promote the concept that mass flow will always solve a segregation problem. This is a short-sited view. The flow pattern within a given piece of process equipment must be matched with the segregation profile (Figure 3) to achieve a process to minimize segregation during handling. For example, suppose that the material segregated by impact fluidization, forming layers when placed in a bin or a hopper. Placing a typical steep mass flow hopper on this bin would not help the segregation, but would significantly enhance the separation of bulk materials. The uniform velocity flow induced by a typical well designed mass bin would cause the coarse material to exit, followed by the fines, making the segregation problem worse. Conversely, a radial segregation pattern will be helped by converting the bin to mass flow. Material will leave the bin as it entered the hopper. There will be a segregation profile across the outlet, but at least the material at each cross-section will be the correct consistence. If better mixing than this is required, additional in-line blenders should be added to the process to achieve blend consistency.

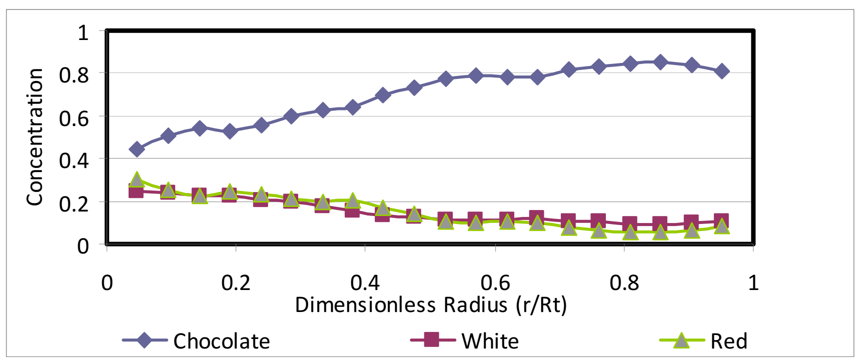

Figure 3. Segregation profile from pile center to pile edge for three-sugar mixture pictured above

Figure 4. BEFORE: Steak seasoning with -50+100 mesh salt

Summing Up. Knowing the segregation mechanism as well as the flow profiles in your process equipment is critical to solving potential segregation problems. Simple tests can be performed to measure the magnitude and type of segregation occurring in your systems. Flow properties can also be measured to determine the flow patterns in your process equipment. Using this information, a reliable solution to complex segregation problems can be designed to put you on track for quality production. Often it is as simple as changing the particle size of just one ingredient (Figures 4 – 5).

Figure 5. AFTER: Steak seasoning with -16+40 mesh salt

Mitigate Segregation with SPECTester

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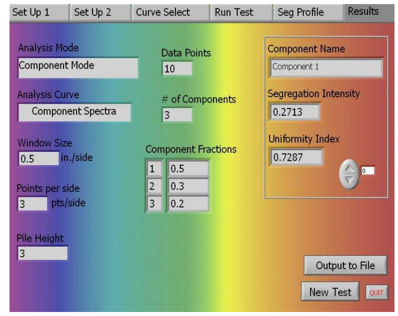
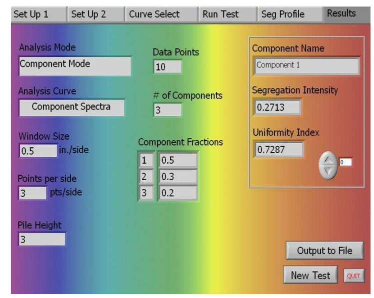
Separation (segregation) of granular and powder materials is one of the three main causes of process failure with systems that handle bulk materials. It is a global problem and conservative estimates suggest that 30% of all unscheduled process downtimes is due to segregation and quality issues. SPECTester's spectrophotometer acquires data to analyze the segregation potential of a material mixture by scanning spectral reflectance of the top layer (edge) of the material pile in the testing hopper. It compares that gathered data to the previously acquired spectral signatures of the individual ingredients in the mixture by de-convoluting the data to identify the presence and concentration of the various components and their locations in the hopper. The SPECTester will measure up to 50 squares along the pile edge, with a matrix of up to 49 points within each square. The concentration data identifies the magnitude of the segregation.

Data is presented numerically and graphically





Using state-of-the-art spectroscopic technology, the innovative SPECTester measures samples containing up to six unique components and reports how much, as well as why, your material is segregating. Fully automated, the SPECTester identifies: component concentrations, particle size differences, differences in chemical composition, product uniformity, and up to four specific segregation mechanisms.

WIN A FREE SEGREGATION ANALYSIS

The first three individuals who respond to this mailing with a segregation inquiry will receive one free segregation analysis (including report) of their product – up to 6 unique ingredients – using the SPECTester

Food Facts Focus

Coming Next Quarter – Particle Breakage

Many unit operations involve particle size degradation or breakage. This breakage plays a key role in milling and agglomeration, segregation prevention, and product quality issues. Particle size degradation/breakage occurs primarily through abrasion, fracture and fatigue. Each process or set of unit operations induces a certain set of breakage mechanisms characteristic to the process. Successful unit operation often depends on matching the degradation or breakage test method with the process conditions. In next quarter's Food Facts newsletter, we will discuss how to mitigate breakage in processes or predict breakage with greater accuracy.

Future Topics

To put you at the cutting-edge

- Eliminating caking
- Controlling packaging weight
- Moisture pick-up and control
- Maintaining consistent flow rates

We welcome your suggestions and special requests for material flow and handling topics which you would like to see included in future editions of *Food Facts*.

Contact: Susan at 352-379-8879

Generalizing the relationship between inter-particle forces and bulk unconfined yield strength of poly-disperse mixtures

The Problem. Ideally we analyze the materials that will pass through a process and then specify the process design based on sound scientific models relating the measured flow properties to process behavior. However, since that material frequently does not exist until the process system is designed and in full operation, engineers are faced with the daunting task to create a production process without testing a representative sample of the material that will pass through the process.

From raw grains and flours to bread – designing the process depends on the flow properties of raw ingredients.

Flow behavior through a process depends on certain key fundamental properties of bulk material. One such property is unconfined yield strength. This key property affects hang-ups in process equipment, blending, segregation, flow rates, agglomeration, milling, and adhesion to system surfaces. Thus, understanding what parameters affect strength and how strength affects processing provides guidance on how to design processes without having representative samples to test.

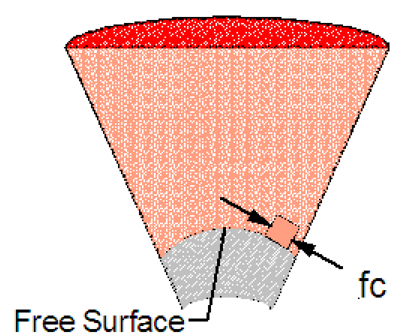
Strength can be described in the framework of a bulk continuum where it is the stress required to initiate yield of a bulk material. However, a more useful framework would be to relate bulk strength to inter-particle forces. The net effect of all inter-particle forces is to provide a resistance to shear. Thus, understanding the dynamics of this adhesion process, and the relationship between shear and particle assembly structure, provides the basis of predicting bulk yield strength from inter-particle forces.

The Solution. In a nut shell, we must determine the number of particles involved in shear, the forces acting between these particles, and the structure of the particle assembly. Past researchers have provided us with very simple models that predict strength only for processes where all the particles within the system are the same size. Poly-disperse systems are significantly more complex as they result in shear zones that do not cause inter-particle motion between all particles within the pore structures. Instead, some particles within the pore structure simply translate with the surrounding larger matrix of particles. Understanding this complex structure allows us to create new models that relate cohesive yield strength material with a range of particle sizes, thereby allowing engineers to predict the strength of real material systems.

Learning the Trade – Bulk Unconfined Yield Strength

Knowing and understanding key material properties is power to characterize bulk material flow behavior. We will empower you quarterly as we discuss one of these fundamental flow properties and its industrial application.

Bulk Unconfined Yield Strength. Bulk unconfined yield strength is the major principle stress level that will cause bulk material in an unconfined (unsupported) state to fail in shear. It is the primary flow property that governs the development of hang-ups in process equipment and is generally a significant function of the compaction pressure which has been applied to the material in order to induce failure. It is used to compute critical arching and rat-hole dimensions for a given material in a hopper or bin. All hang-ups in process equipment result in formation of a free surface. By definition, the stress acting normal to any free surface is zero. However, stresses acting along the free surface may not be zero. In a hang-up condition, the material on a free surface is supported by stresses that act along the free surface and are equal to the unconfined yield strength of the material. Therefore, measured values of material strength under stress (unconfined yield strength) are critical to proper design and utilization of both process system equipment and product characterization.



Typical arch in process equipment

For more information Contact: Kerry Johanson at 352-303-9123