Powder Pointers

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

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Understanding Segregation Mechanisms

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. Indeed, sifting segregation is a predominant cause of separation during handling 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 is predominately at the pile's edge. However, severe sifting segregation can cause a top-to-bottom segregation pattern where the fines are beneath the coarse particles. This is especially true if inter-particle motion is induced within the material by some external means such as vibration. Typically, particle size differences greater than three to one are enough to produce significant sifting segregation problems.

Repose Angle 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. Formation of piles within process equipment causes the less frictional particle 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. Repose angles of only two degrees difference cause significant 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

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In This Issue

Material Flow Solutions announces availability of Specialized Seminars

Material Flow Solutions has prepared a set of seminar topics specifically for your process and product engineers to help them design material handling systems, design better products, and successfully select unit operations that are compatible with critical material properties. This proven approach allows your engineers to optimize plant performance and increase your plant and operation productivity. Our seminars are available in one- two- or three-day venues. Customize your seminar by choosing from a wide range of available topics that best meet your company's needs. You may further optimize your seminar by adding a half- or full-day plant visit that will include an on-site review of your current process.

For more information and a list of seminar topic options, please turn to page 3 of this newsletter.

Understanding Segregation Mechanisms

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inlet and the geometry of the vessel. Generally, fines accumulate near process vessel walls with this segregation. Figure 1 depicts a typical profile for air entrainment segregation where the fines accumulate near the wall. However, it is important to point out that this figure also shows the result of sifting segregation where the fines accumulate near the drop point. Figure 1 also indicates that several segregation mechanisms can occur at the same time producing a complex overall segregation pattern.

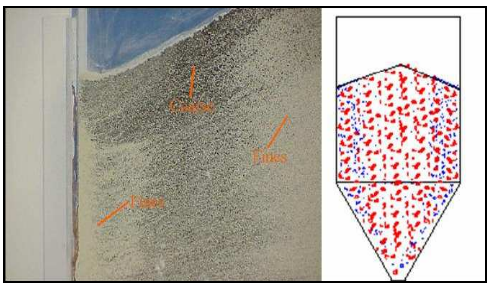

Figure 1. Typical Air Entrainment Segregation

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 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 induced by a typical well designed mass flow 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.

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.

If you would like additional information on segregation and the problems accompanying it, contact:

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Powder Pointers Preview

Coming Next Quarter - Degradation

Many unit operations involve particle size degradation. Degradation plays a key role in milling and agglomeration, segregation prevention, and product quality issues. Particle size degradation occurs through abrasion, fracture and fatigue, to name a few. Each process or set of unit operations induces a certain set of comminuting mechanisms characteristic to your unique process. Unit operation success often depends on matching the degradation test method with the process conditions. We will discuss how to accomplish this task with minimal material and greater accuracy.

Future Topics

- Optimal blender choices
- Milling issues
- Erratic flow rates
- Successful agglomeration

Specialized Seminars

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Our engineers assist you in designing a customized seminar to optimize your time and personnel investment, and assist you in increasing your company bottom line. Simply choose from our shopping list of topics and you are on your way to enhanced company profit and productivity:

- Successful powder plant design
- Successful powder product design
- Segregation prevention
- Bin and hopper design
- Feeder design
- Optimal blender selection
- Minimizing attrition
- Agglomeration unit operations
- Blender operation
- Mill operations

Enhance your company profit and productivity with customized seminars

For more information or to schedule your customized seminar:
CLICK HERE **matflowsol@bellsouth.net**

See us at the Annual AIChE Meeting in Salt Lake City

Dr. Kerry Johanson will present:
Generalizing the Relationship Between Inter-particle Forces & Bulk Unconfined Yield Strength of Poly-disperse Powders
Wednesday, November 7, 2007 at 8:30 a.m., Suite F at the Marriott Salt Lake City.

Dr. Johanson will also serve as a member on the panel discussion:
Legacy of A. Jenike's Silo Theory and Future Challenges for Silo Design
Tuesday, November 6, 2007 in the Grand Ballroom of the Salt Palace Convention Center at 12:30.

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

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

Flow behavior through a process depends on certain key properties of bulk material. One fundamental property is the material's unconfined yield strength. This key property affects hang-ups in process equipment, blending, segregation, agglomeration, milling, flow rates, 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 been able to provide 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. Join us as we discuss these new models at the up coming AIChE meeting.

It is necessary to know and understand several fundamental material flow properties in order to characterize flow behavior in process equipment. In each of our quarterly newsletters, we will discuss one of these key flow properties and its industrial application in detail.

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.

Please contact us with any comments, suggestions or inquiries you may have regarding our services. We also encourage and welcome your suggestions for powder flow topics which you would like to see included in future editions of Powder Pointers.

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