Powder Pointers

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

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In This Issue

The Product Fits the Bill – Successful Product Design

Getting it Right the First Time. Engineers are responsible for the design of new products. A lot of work goes into getting the chemistry right. The product is designed to achieve a prescribed behavior; in the consumer product industry, it must clean clothes as well as make the laundry smell fresh by adding heat or time activated chemicals that cling to clean clothes. In the pharmaceutical industry, it must aid in the cure of disease or ailment. In the cosmetic industry, it means the addition of particles that induce skin tightening or lubrication. These product qualities are key product attributes which must be present to achieve successful product development. Much energy is invested in the design to attain these qualities. However, the segregating and/or free flow nature of the product is given little or no thought; process engineers are left to make obsolete handling processes work with newly designed materials. This is not an optimal situation and generally results in significant delay in getting the product to market – thereby loosing considerable potential revenue. This situation can be avoided by using sound product design principles to create or maintain desired flowability prior to the final product design. Many techniques and principles are common to both product design and successful process design. In process design, is it understood that the process geometry must be based on key flow properties that describe behavior in the system. With proper data regarding these key properties models can be used to predict process behavior. Design is carried out, assuming conservative estimates of flow properties and process behavior. A similar design methodology can be utilized for product design. The properties data required are particle scale properties such as particle size distribution, moisture content, particle shape, surface hydrophobisity, and chemical or crystallization bonding between particles. Models exist that relate particle scale properties to flow property behavior. These are generally developed for mono-disperse particle systems. However, knowledge of particle interactions can be used to extend these simple predictive models to more complex systems. There is not enough room in this Newsletter to develop the complete set of product design rules, so we will highlight two and present a general approach for use when faced with product design issues.

Two Primary Product Design Rules.

- Calculate strength directly from models involving particle scale properties and by some direct measurements of bulk properties.
- Understand the role of particle scale properties on bulk unconfined yield strength.

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Are Segregation Issues Leading to Process Downtime at Your Plant?

Segregation, or separation, of granular and powder materials is one of the three main causes of process failure with systems that handle powder materials. It is a global problem, affecting all industries, and conservative estimates suggest that 30% of all unscheduled downtimes are due to segregation and quality issues. If you are experiencing downtime at your plant which handles powder or granulate mixtures, segregation is a likely culprit.

To understand the segregation that occurs in processes one must know the operation parameters, process geometry, and have some idea of the relative magnitude of each segregation mechanism present. This requires testing for various segregation mechanisms at conditions similar to those found in your process. The ***SPECTester*** measures individual components of a combined sample and then provides data to determine the magnitude, type and reason(s) for mixture separation. It achieves this by measuring the segregation

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First, designers must recognize that understanding the role of particle scale properties on bulk unconfined yield strength is a key relationship. All other important properties are affected by the degree of cohesive strength in the bulk. So, this article will focus on bulk strength. Second, the current state of modeling does not allow direct calculation of strength from particle scale properties alone. The particle system is too complex to allow this. Thus, the engineer must rely on some direct measurement of key properties and extrapolate system behavior from there. The key is minimizing the test(s) required. The goal is to measure key properties of pure components in a mixture and combine these properties in such a way as to predict the properties of any mixture containing the same components. Unfortunately, simple mixing rules quite often do not apply.

First Example. As an example, consider a two-ingredient mixture. A simple linear mixing rule suggests that the strength of the mixture would be a linear combination of the pure components. Likewise, it can be assumed that the permeability of this mixture would be a linear combination of the pure component permeability values. However, with real mixtures, such is not the case. The highest strength occurs at some mixture of pure coarse and pure fine. Likewise, the lowest permeability occurs with some mixture between these two extremes (Figure 1).

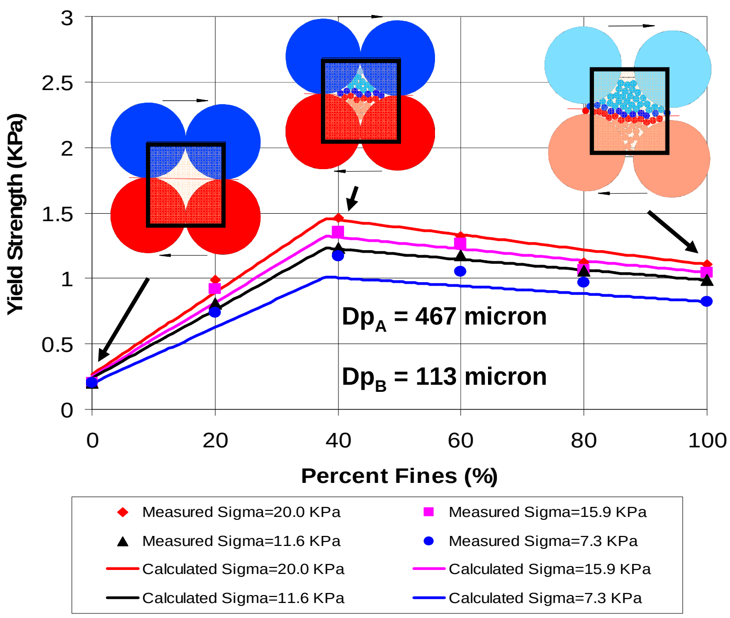

Figure 1. Effect of Fines on Bulk Yield strength

At Material Flow Solutions, we have developed mixing rules that allow us to combine the strength values of two or more components to predict the mixture strength. Figure 1 shows the measured strength for a bimodal material, indicating maximum strength at the point where all the solids voids were filled with fines. The lines are the predicted values based on our non-linear mixing rules. Similar results occur with tri-modal and poly-disperse systems. It is important to note that the prediction is made measuring only the strength of the pure components. The model takes care of rest – greatly reducing the number of tests required for traditional product design. Consider the simple bimodal mixture. Because of the non-linear behavior of the mixture, one would need to measure the flow properties of six to eight samples to accurately predict the trend in properties. Using the mixing model and just two flow property measurements, we achieve the same result. If this were a ploy-disperse system, then significantly more measurements would need to be made to characterize the flow property behavior. However, the same information could be obtained with just a few flow properties tests and the poly-disperse flow model. In very complex systems where both the moisture content and particle size vary, we can often measure flow properties at four to five conditions and be able to predict flow property behavior at literally hundreds of product compositions, moisture contents, and particle sizes using our scale mixing rules.

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Powder Pointers Preview

Coming Next Quarter – Successful Process Design

Successfully designed bulk material handling processes minimize segregation, prevent hang-ups, and ensure reliable flow. This article will discuss how bulk scale properties of key product components are used to calculate design parameters for optimal process configurations (including how to choose proper blenders, feeders, anti-segregation devices, etc). Designs consistent with material flow properties ensure best possible process operation – even during startup conditions. Properly designed processes are robust enough to allow "right the first time" operation.

Future Topics

- PAT implementation
- Successful agglomeration

We encourage and welcome your suggestions and special requests for powder flow topics which you would like to see included in future editions of *Powder Pointers.*

Contact: Susan at 352-332-9476

The Product Fits the Bill

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Second Example. Frequently, engineers find prediction of strength from first principle difficult due to one (or both) of two issues. First, surface geometry greatly affects strength. Second, particle shape greatly affects strength. However, in many cases it is possible to incorporate the shape effect into the prediction of strength. The main principle driving the effects of particle shape is that strength is directly proportional to the number of contacts-per-particle for non-spherical particles. Estimating the number of these contacts using optical techniques or other means allows estimation of the effect of shape on bulk yield strength. Figure 2 shows the effect of particle shape on cohesive flow properties. The initial case strength in this figure was based on the strength between nearly spherical particles. However, counting the contacts per particle, and taking account of the direction of those contacts, allows correction of the round strength data to be able to predict strength of irregular shaped particles (dashed line). In other words, we measure the strength of just the round particles and use the shape models to predict the strength of a bulk material made of any shape and size particle.

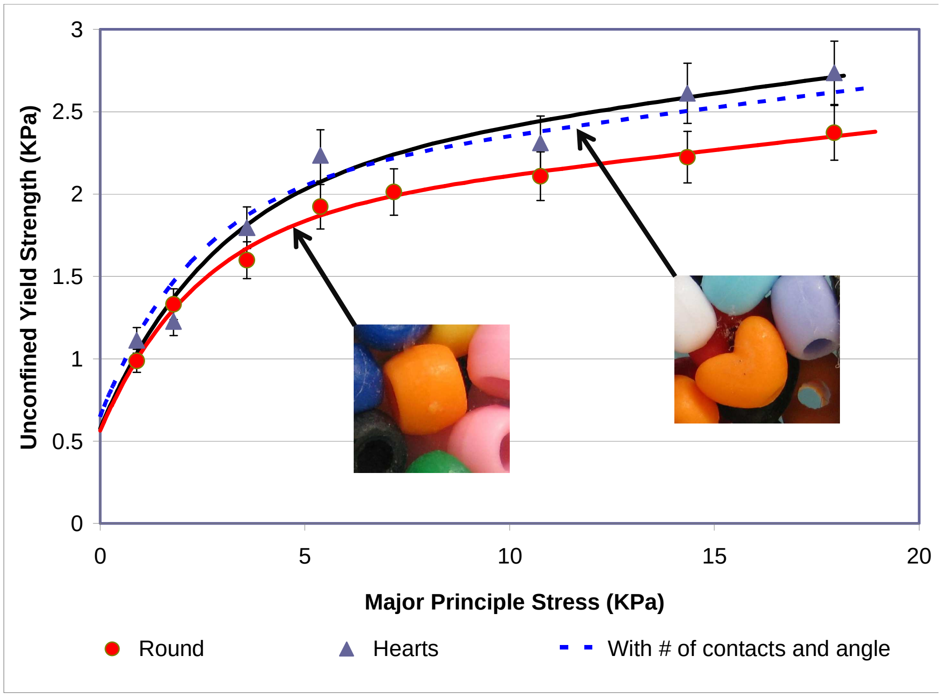


Figure 2. Effect of shape on strength of bulk materials

The Bottom Line. The examples in this article are simplified to show the technique. However, we have applied these scale laws to real mixtures such as clays, detergents, pharmaceuticals, food mixtures, plastics, and granular and powder fuels with very good success. We can also predict and measure segregation tendencies with a variety of bulk mixtures. Engineers who understand and utilize this methodology shorten the time to market as they are able to control processes based on accurate scale up equations, thereby increasing company revenue. Let us help you design your next product to enhance flowability, or let us provide you with custom design constraints specific to your material to prevent bad acting product. ***For more information, contact: Kerry Johanson (352) 303-9123***

Are Segregation Issues Leading to Process Downtime at Your Plant? *Continued from Page 1*

*Dr. Johanson with the **SPECTester** in Atlanta*

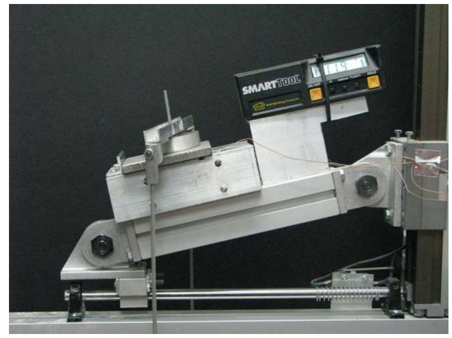
potential of a bulk composite material of up to six components. With ***SPECTester***, segregation potential can be measured using as little as 1.5 L of powder mixture.

Recently, at the 2009 Powder & Bulk Show in Atlanta, Georgia, ***SPECTester*** garnered significant interest as attendees watched it measure, evaluate and report segregation data for a 3-component sample in UNDER 20 minutes. ***SPECTester***'s ability to analyze mixture samples of multiple ingredients is significant because it can be used not only during the formulation process, but actually on the production line as a quality control measure. ***SPECTester***, used on the production line, allows plant personnel to detect changes in product quality in real-time. No more process downtime while waiting for time-consuming, outdated in-house sifting or lengthy outsourcing to exterior labs for testing. Save revenue. Increase company bottom line. Acquire your ***SPECTester*** today.

For further information, or to evaluate the potential of your materials to segregate in typical process conditions, contact Kerry Johanson at 352-303-9123.

Learning the Trade

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.



As the sample slides down the incline, the angle measured from the horizontal is the wall friction angle.

Wall Friction Angle. Bulk solids obey a columbic frictional behavior against container and process equipment surfaces. Wall friction angle is the angle of slide under normal gravity flow for a given bulk material against a particular wall surface finish. It is a function of the stress level applied to the wall surface as well as the temperature of the bulk material and wall surface. It is measured by heating material to a given temperature, placing it in a cell on a given wall sample plate, applying a normal pressure to the bulk material, and then inclining the plate until the material slides. The angle measured from the horizontal is the wall friction angle. It is used to determine mass flow / funnel flow behavior in bins and hoppers. Friction angle is also used to determine velocity profiles in process equipment. Successful production is dependent on the engineer's ability to design both a process and product which will avoid system hang-up and product segregation. Knowing the friction angle of a proposed material, allows the engineer to design feeders, chutes, and process system transfer points to yield the desired results and get it right the first time – thereby maximizing company bottom-line by avoiding costly process down-time.

For further information, contact: Kerry Johanson (352) 303-9123

3-for-2 Coupon

($1300 - $2600 value)

Standard Material Property Testing

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Send us three samples for material property testing. We will measure the bulk density, permeability, unconfined yield strength, and wall friction angle of your samples and issue you a report with our findings and conclusions – and only charge you for the first two materials because the third is **FREE**

Offer Expires August 31, 2009