Powder Pointers

Spring 2009 Volume 3 No A

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

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Successfully Dealing with Erratic Flow Rates

Flow Rate Limitations. Industries requiring continuous and/or semi-continuous flow for proper operation are sensitive to flow rate limitations. In addition, many unit operations that claim to be based on mass control are actually volumetric processes with a mass control device attached. Volumetric processes are very sensitive to erratic flow rate issues. Normally with mass control small variations in volumetric flow rates can be easily handled with simple feedback control systems. However, fine bulk materials often exhibit very erratic flow rates that span several orders of magnitude. In these cases, volumetric control is not enough and positive flow control devices and/or feed techniques are required to bring the process under control. What causes these erratic flow rates? How can flow rate variations be limited? These are questions of paramount importance to robust process control. This is especially true when dealing with control of small additives to master batch systems, etc. Most frequently these flow excursions or limitations are due to the degree of air entrained within the flowing bulk solid material. Air may be entrained in the system even when no external source of air injection exists. A falling bulk material can entrain air during the free fall process. This air is then compressed in bulk solids voids as the falling stream impacts the free material surface. Additional material can cover this aerated material before the fine powder low permeability allows the compressed air to vent from the bulk solid. Thus, fast filling systems can generate semi-fluidized material in the storage hopper and feed system. Alternatively, external air sources can cause material aeration in feeders and hoppers. Aerated material generally flows from process equipment at velocities dictated by gravitational acceleration. Aerated flow rates can be in accordance with the following equation for conical hoppers and can produce large flow rate through small outlets.

$$Qs = \gamma \cdot A_{out} \cdot \sqrt{\frac{D_{out} \cdot g}{4 \cdot tan(\theta_h)}}$$

Aerated Material and Storage Time. Conversely, the same fine material when left in a container for long enough periods of time can deaerate. The stress levels in the process equipment first increase as the depth of the material increases and then decreases as the flowing material reaches the

(Continued on page 2)

In This Issue

Feature Article:
Successfully Dealing with Erratic Flow Rates 1
Powder & Bulk Southeast Conference and Exhibition 1
Powder Pointer Preview 2
Introducing: The *SPECTester*™ 3
Regular Feature: Learning the Trade: Critical Rathole Dimension 4

See Us at Powder & Bulk Engineering's Southeast Conference and Exhibition

Dr. Kerry Johanson will present:

"A Mechanistic Approach to Reducing Particle Size"
Tuesday, April 28: 9:00 am – Noon
Session 102

"Preventing Attrition in Process Equipment"
Thursday, April 30: 8:00 – 11:00 am
Session 502

Booth #541

Visit our booth on the exhibition floor for a demonstration of the newest and best segregation tester on the market. Just released for retail sale, the ***SPECTester*** is a marvel of technological initiative. There will be special incentives for those who stop by for a preview. We look forward to meeting with you. See page 3 of this Newsletter for a preview of the ***SPECTester***'s unique capabilities.

For further information contact: Susan at 352-332-9476

Continued from page 1

equipment outlet. Increasing stress consolidates material within the equipment, squeezing gas out of the interstitial pores of the bulk material. This excess gas leaves the top free surface of the material. The consolidated material then expands as it reaches the outlet, creating a lack of gas within the solids voids as material exits the process equipment. This expansion causes a reduction in local gas pressure, resulting in negative gauge pressures near the outlet. These negative gas pressures result in a decrease in the solids flow rate from the outlet which can produce rates two to three orders of magnitude slower than those produced from gravitational acceleration (see equation).

$$Qs_{limit} = \frac{\gamma \cdot A_{out} \cdot K_{out}}{\left(1 - \frac{\gamma_{out}}{\gamma_{max}}\right)}$$

What are the Options? Thus, the same bulk solid material will flow at high or low flow rates, depending on the material's aeration state, thereby causing fine powder materials to exhibit a condition called flooding and flushing. Flooding and flushing behavior produces erratic flow rates. Likewise, sudden collapse of ratholes can convert a fully deaerated material into a material with sufficient entrained gas to considerably increase the solids flow rate, making volumetric control impossible. Additionally, uncontrolled gas injection to local areas of the container produces zones of aerated material which eventually reach the outlet and cause sudden increase (surge) in the solids flow rate from the process equipment. If volumetric control is an important part of the process, then these surges must be controlled. This condition begs the need for special inserts to deaerate bulk materials and controlled gas injection systems in order to eliminate limiting flow rate problems. These two techniques can be used in tandem to handle many erratic flow rate issues with fine bulk solids. Often small injection rates (much less than fluidization) can overcome significant erratic flow problems. Placement and amount of gas injection are key parameters to successful flow rate problem mitigation.

The Bottom Line of Flow Control. If volumetric control is not an important part of the process, then an alternate method of solving these erratic flow rate issues is to maintain material in an aerated condition and use positive feed control to prevent uncontrolled flow rates through the system. Each of these methods is a plausible solution to erratic feed problems. However, the successful implementation of any method depends on the flow properties of the specific material. Obviously, bulk density and permeability are key parameters that determine the limiting flow rate as well as the time material hangs onto entrained air. However, unconfined yield strength also affects this process behavior in both a positive and negative manner. More cohesive material creates a more porous material, causing material to lose entrained gas quicker. These cohesive flow properties may also prevent or limit the ability of gas injection to uniformly fluidize material, making fluidization solutions to erratic flows problematic. Cohesion can also increase the frequency of rathole collapse. We routinely measure the important flow properties that are used to predict these behaviors and can model these flow problems using our proprietary gas/solid modeling techniques. This gives us the information required to provide you with robust designs that prevent erratic flow rate problems. It is important that solutions to these erratic flow rate problems be based on sound engineering theory, principles and experience. Random or uncontrolled injection of gas can make matters much worse.

Powder Pointers Preview

Coming Next Quarter – Successful Product Design

Almost all products are a mixture of various particles. Many of the particles placed in the mixture are expected to create a particular chemical benefit for the product: i.e., color-fast bleach, taste, color, a specific pharmacological effect, UV blocking agent, etc. A great deal of study has been done internally by companies to understand these effects. However, the role these additives play in process flowability and quality assurance is not well understood. These issues, as they relate to successful product design, will be the primary topic addressed in the next issue of *Powder Pointers*.

Future Topics

- Process design
- 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

INTRODUCING…

THE
SPECTester

AN INNOVATIVE PRODUCT BY:
MATERIAL FLOW EQUIPMENT, LLC
WWW.MATFLOWSOL.COM

(patent pending)

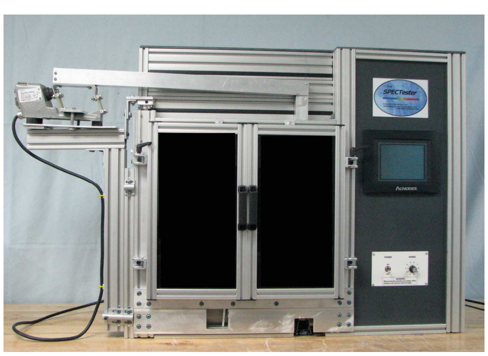
The innovative ***SPECTester*** measures your sample, of ***up to 6 unique components*** and, with a touch of the finger, reports ***how much*** as well as ***why*** your material is segregating. Fully automated, it provides data about: component concentrations, particle size differences, product uniformity, and ***up to 4 specific segregation mechanisms***. This segregation tester can be used in R&D facilities as well as in production plants for mid-stream quality control.

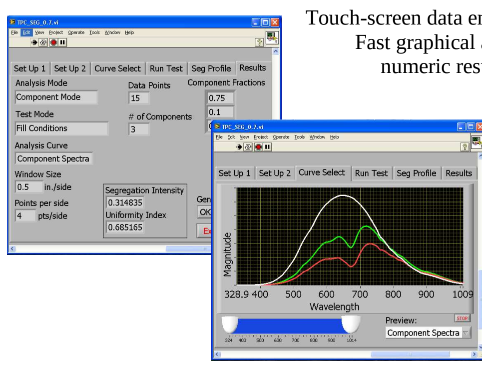
Comparison of Segregation Testers for Sale

Testing Capabilities	*SPECTester*™	Jenike Sifting Tester™	Jenike Fluidization Tester®
Segregation by particle size	**YES**	YES	YES
Segregation by chemical component	**YES**	no	no
Segregation by sifting	**YES**	YES	no
Segregation by fluidization	**YES**	no	YES
Segregation by angle of repose	**YES**	no	no
Segregation by air entrainment	**YES**	no	no
Identifies primary segregation mechanism	**YES**	no	no
Identifies process design parameters	**YES**	no	no
Identifies process quality control issues	**YES**	no	no
Results scaleable to process conditions	**YES**	no	no
Provides uniformity index for sample	**YES**	no	no
Provides segregation variance data	**YES**	no	no
Measures segregation upon hopper discharge	**YES**	YES	no
Measures segregation within hopper	**YES**	no	YES
Number of segregation points measured within sample	**50**	-	3
Number of segregation points measured on discharge	**50**	24	-
Number of components in sample	**up to 6**	2	2
USB output to printer	**YES**	no	no
Touch-screen/pad control	**YES**	no	YES
Automatic analysis	**YES**	no	YES
Additional equipment required for data acquisition	**NONE**	required	none

Materials of different sizes, shapes, colors and/or chemical compositions

The *SPECTester*™ handles them all





Touch-screen data entry
Fast graphical and
numeric results

For further information contact: Kerry Johanson 352-303-9123

THE
SPECTester™

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.

Critical Rathole Dimension. The critical rathole dimension is the diameter of the largest flow channel that will result in stable rathole formation in a funnel flow bin design. Active flow channels in a funnel-flow bin must be greater than this dimension to prevent stable rathole formation. The critical rathole dimension is a function of the maximum stress level in the bin and, hence, depends on the maximum diameter of the bin. It is important to note that ratholes can not form in mass flow hoppers. Therefore, ideal process designs include specifications that create: Funnel-flow with outlet diameters large enough to eliminate rathole formation, or mass flow where rathole formation is not possible. Engineers who understand and utilize critical rathole dimensions in design of their specific system are able to avoid costly process downtime caused by equipment hang-up due to ratholes formed in bins and hoppers.

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