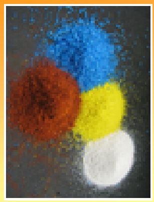

Food Facts

Fall 2013 Volume 2 No B

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

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Eliminating Caking of Food Products

Background. Food powders often gain strength during storage due to a cementing action between particles. This phenomenon is known as caking which can be defined as the process by which free flowing materials are transformed into lumps and agglomerates due to changes in atmospheric conditions or process temperatures. There are several reasons why materials gain strength. Caking can be caused by crystal growth between particles. Sometimes material passes through a glass transition during storage and handling. Other times strength is caused by cold plastic creep effects. However, in the food industry the most common cause is almost always tied to moisture ingress during production generally combined with temperature fluctuations during storage. Regardless of the underling reason, caking/ lumping product results in lost revenue due to customer non-acceptance and/or plant downtime required to resolve the production issue.

Figure 1. Powdered food products often experience caking/lumping issues during processing and handling

The first step – know the flow properties of your material. Beginning with the basics, we characterize a material for flowability and moisture sorption tendencies. Ideally these properties should be measured under conditions which mimic process operations and storage times. Additionally, the properties should be measured after exposing material to humid air and then inducing a mild temperature fluctuation to simulate typical day/night temperature storage and/or transport conditions. The properties measured should include: unconfined yield strength as a function of major principal stress at appropriate time increments (we recommend 0 hours and 24 hour with temperature fluctuation), bulk density, permeability, wall friction angles and adhesion stresses, and moisture sorption tendency. The flow properties provide the critical arching and rathole conditions required to prevent hang-up. The wall friction angles will provide information required to specify retrofit or new process equipment. These friction angles will help specify feed hoppers angles that will cause flow along bin and hopper walls. The friction test will also give information concerning the adhesion of material to equipment and walls. These friction angles and cohesive properties will indicate the velocity profiles present in your process equipment. The permeability information will provide limiting flow rate information and helps in determining the time required for material to lose entrained air.

Picture courtesy of: http://info.curtec.com/blog-en/bid/1239590

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In This Issue

Customized Seminars: Your Process – Your Personnel – Your Place

Material Flow Solutions, Inc. offers a set of seminar topics specifically for your process and product design 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 1-day, 2-day or 3-day venues. Customize your seminar by choosing from a wide range of available topics that best meet your company's needs. Further optimize your seminar by adding a half- or full-day plant visit that will include an on-site review of your current process.

Mix and Match. Our engineers will assist you in designing a seminar

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Crystal growth between particles. Caking often results as bulk materials pick up moisture during storage. Severe caking can result in the solidification of the entire mass within a silo. Moreover, consumer products such as food powders can cake during storage both prior to purchase and after initial use. Hence, the problems of handling such products are often passed on to the consumers – which most customers find unacceptable. Materials can develop high strength due to crystal growth between particles in moist environments after heat is added either in processing or as a natural result of storage. Crystallization occurs when increasing surface moisture dissolves a portion of the surface materials. Liquid bridges then form between particle contacts where a subsequent change in moisture content evaporates the liquid binder leaving crystal bridges between particles. Drink mixes and other products with high sugar or salt contents are particularly susceptible to this crystallization caking issue.

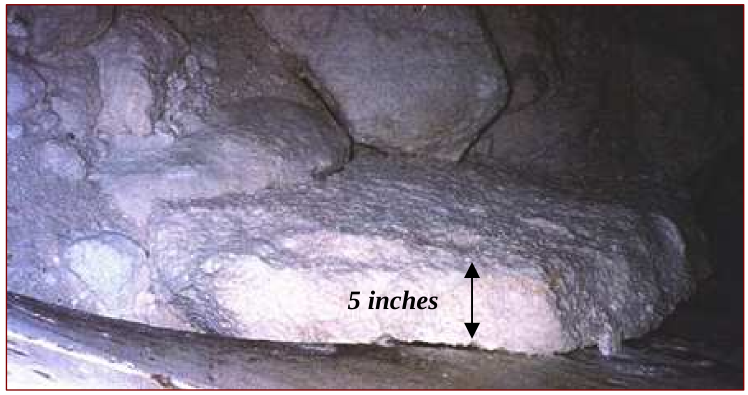

Figure 2. Moisture ingression causes material caking in processing equipment

Moisture sorption effects. There are two pieces of information that are required to fully characterize the moisture sorption effects. First, it is important to understand the equilibrium amount of moisture the material will pick-up under moist air conditions. Second, the rate of moisture pickup allows for determination of storage conditions which will result in significant caking. To acquire this data we must first measure the sorption rate factor (moisture sorption pickup rate constant) as a function of relative humidity. The moisture sorption isotherms of the material should be measured at process temperature conditions. This characterizes the potential of the material to absorb moisture during processing. The moisture sorption isotherm and the moisture rate constants measured over a full range of relative humidity values provides information necessary to predict moisture migration in process equipment as well as to determine the critical relative humidity which may cause excessive strength effects and result in caking.

$$\frac{dq}{dt} = K_g \cdot (q^* - q)$$

Where:

- q^* is the equilibrium moisture content for the prescribed relative humidity
- q is the current solid moisture content at the current time (Wt_{H2O} / Wt_{Solid})
- K_g is the Gluekhauf Factor (1/sec)

Glass transition effects. Glass transition occurs in bulk materials when increasing surface moisture induces a lowering of the glass transition temperature of the solid material, changing a hard crystalline phase into an amorphous plastic phase where particles are cemented together by plastic creep. Basically, the moisture creates a soft material and the stresses between particles press adjacent particles together, causing them to bind to each other, resulting in a solid mass. A subsequent change in moisture content raises the glass transition temperature, solidifying the amorphous mass. Many foods and nutraceutical products are subject to this mechanism as they experience variations in temperature and moisture exposure during processing and storage. When a customer opens a box of cake mix, for example, and needs to use a knife or fork to pry clumped mix from the corners of the box – glass transition has occurred in storage as a result of moisture ingress during handling and packaging.

Figure 3. Glass transition is frequently the cause of lumps in final food products

Picture courtesy of: http://aforkineachhand.com

Cold plastic creep effects. Creep (sometimes called cold flow) is the tendency of solid material to move slowly or deform permanently under the influence of applied stresses, such as the weight of a food product as it piles in a process bin or hopper, or in the final packaging during shipping or as it sits on the store shelf. Creep can occur as a result of long-term storage and is more severe in materials that are subjected to heat for long periods – it always increases with temperature.

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SPECTester Receives US Patent

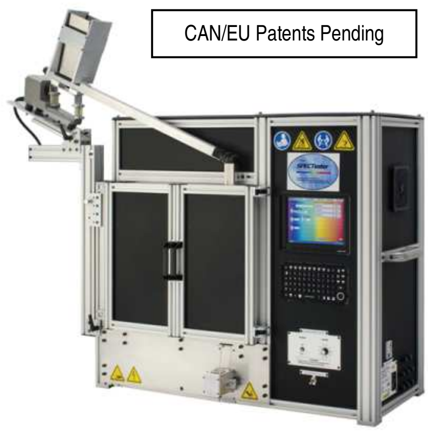
Material Flow Solutions is pleased to announce the granting of:

US patent 8,467,066

MIXTURE SEGREGATION TESTING DEVICES AND METHODS

Abstract: "Methods and devices are provided to measure segregation in solid particulate mixtures. Light energy is projected through a transparent barrier and reflected off a surface of a mixture volume. The constituent fraction in the mixture is determined by analyzing the mixture reflected light spectral contents and intensities. This is accomplished at multiple surface locations to provide constituent fraction data over the mixture volume surface."

CAN/EU Patents Pending



The 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. It supplies information not only about WHAT a mixture is doing in the processing system, but WHY it is behaving this way. This is important because, in order to design an optimal production system and/or product, engineers and formulators MUST understand how a mixture of ingredients will interact with the process to form the desired final product. To gain this understanding, tests must be performed that quantify some basic characteristics of the powder or granulate components of the product.

- ***YESTERDAY***: Industry waited two, four, or more **weeks**, outsourcing testing to busy laboratories, for answers concerning the how and why of product segregation issues.
- ***TODAY***: In just 15 to 30 minutes, the SPECTester, a revolutionary technological testing breakthrough, answers the quality control questions – what, where, when, how, and why products segregate in the process system – On-site and in real time.

Customized Seminars:

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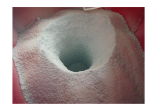
program to optimize your time and personnel investment, and assist you in increasing your company bottom line. Simply choose from our shopping list of topics and you are on your way to enhanced company profit and productivity. We will travel to your facility with a customized presentation that exactly meets your needs and parameters. Our goal is to help you "get it right the first time" through education.

Avoid these costly plant down-time issues

Arching



Ratholes

Segregation

Some Available Seminar Topics

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

Schedule your Customized Seminar today: contact Susan (352) 379-8879

Fiber Focus Answers

Coming Next Quarter – Controlling packaging weight

In the food and nutraceutical industries, it is critical that a package contain at least as much product as the advertized content displayed on the label. Almost all packaging systems operate in a volumetric mode, making density control during packaging critical for proper system operation. In our next issue of Food Facts, we will address the primary causes of density variations during packaging, and how to prevent this significant quality control issue.

Future Topics

To put you at the cutting-edge

- 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

Eliminating Caking – Continued

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Solving caking issues in the food industry. Since the solution to a caking problem depends on the root cause behind the caking, it is critical to indentify the cause (caking mechanism) before successful preventative measures can be taken. If crystal growth is the issue, then eliminating temperature swings in process equipment will limit the problem. Likewise, crystal bond size between particles can be controlled by the addition of surfactants to limit the size of crystals formed. The addition of a moisture barrier coating can limit surface area that may bind between particles. Each of these solutions addresses part of the caking mechanism and may be instrumental in preventing the root cause of clump formation.

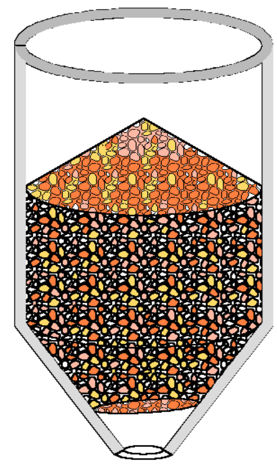
Mitigating caking due to other mechanisms can be approached in a similar manner.

Should you require additional information, or if we can assist you in resolving caking issues with your product, please contact us directly: Kerry Johanson at (352) 303-9123

Learning the Trade – Bulk Density as it relates to Packaging

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 Density. In characterizing bulk material, the bulk density is the weight of the particles divided by the combined volume of the particles and the interstitial voids surrounding the particles. It is a function of the stress level and strain history of the material. We measure density using uni-axial compression of a loosely packed bulk material. It is a function of the temperature, as well as moisture content and particle size, of the bulk material. It is used, along with the permeability characteristics of the bulk material, to determine the limiting rates of particulate materials. Bulk density values are also used to determine the ability of a given powder to store entrained air. Two distinct density values (representing the minimum and maximum bin densities in a processing system) are useful in characterizing the behavior of the bulk material. The first density value is the density of the hopper outlet (FDI, feed density index). It is the density at low solids contact pressures and describes the material leaving the process equipment. It is used to compute mass flow rates from volumetric flow rates. The second density value is the average density of the bulk material within the process equipment (BDI, bin density index). It is measured at higher solids contact pressures and is used to quantify the mass of material stored within the process equipment.



Schematic of material in storage bin for packaging

The ratio of the FDI and BDI is used to predict undesirable behavior of specific bulk materials. Pre-knowledge of such potential undesirable material behavior allows engineers and formulators to design for worst-case scenarios and ultimately saves company revenue by avoiding costly process down-time.

Variations in density (measured weight) of packaged products are often a first sign of problems, signally quality control personnel that the product is experiencing segregation somewhere in the production process. Measuring this critical material property, then, becomes a significant device in the design engineer or formulator toolbox.

PRACTICAL APPLICATIONS of ***Bulk Density***, FDI and BDI include, but are not limited to:

- Predicting flow rate from equipment
- Estimating de-aeration times
- Predicting segregation prevention
- Predicting of fluidized behavior
- Estimating process capacity
- Predicting equipment loads
- Determining packaging parameters
- Determining the cause of low-volume packages