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Talk to a Chemist

You may get valuable insights for successfully scaling up a process

By Tom Blackwood, Contributing Editor

Chemical engineering is the art of producing a material economically. That last word distinguishes us from chemists. Now don't get me wrong, chemists come up with innovations and sometimes can offer great ideas on how to improve a process. For instance, when it comes to crystallization, their ability to optimize the crystallization and make a product with few impurities gives us a clear goal and helps define what can be manufactured on a larger scale.

Unfortunately, the steps taken by the chemist may require more time, induce product changes and involve much more expensive equipment than the product's profit margin can justify for commercial production. Also, scale-up may result in a different physical or chemical form. We can't build a plant based

on hundreds of Buchner funnels and being close to the Hoover Dam to run a filtration process. However, working with the chemist to identify the physical properties and extrinsic conditions that control the various steps in the process can convert the laboratory findings into a meaningful process design. Dozens of examples cross my mind, but the following illustrates how talking to the chemist can result in a practical and economical design.

Our laboratory had developed a new chemical for use in a consumer product. The chemists could grow the product to as large as 500 micron — but this could take 20-30 hours. In about 6-8 hours, they could get to about 100 micron. We expected some attrition in the real world and the crystallizer would utilize the fine particles. How-

ever, our customer wouldn't tolerate the amount of dust created during drying and post-drying handling. (That firm was sensitive to having any dusty material handled by consumers.) Fortunately, we looked into this product's physical properties, such as clumping, flowability and agglomeration. During this evaluation, we discovered the material clumps easily. Normally, this would be taken as a negative for most final products but we turned it into an advantage. After a few more discussions and experiments by our chemists, we looked at four alternative routes:

1. Crystallize to 50 micron, filter and wash to remove impurities, and then extrude to 200 micron. Drying produced very little dust.
2. Feed the wet cake from the previous route into a granulating fluid-bed dryer to get a 100-micron particle with a slightly wider particle size distribution (PSD).
3. Dry the wet cake in a flash dryer and then spheronize the fine particles to about 100 micron in a tilted-pan dryer with water added back to agglomerate the particles.

PRODUCT FOCUS

FOOD-GRADE HOSES HANDLE HIGH-STATIC APPLICATIONS

Kuriyama of America's new line of Tigerflex Voltbuster food-grade material-handling hoses have been designed for high-static applications such as the transfer of powders, pellets and other granular materials.

The hose's design helps dissipate static charges to ground, helping prevent static build-up and reducing the potential for dangerous electrostatic discharges. They have been constructed with static dissipative plastic materials, allowing for the free flow of static to the hose's embedded grounding wire. The light-weight design of the hoses can help reduce injuries related to heavier metal hoses.

The "Volt Series" hose-tube construction includes abrasion-resistant food-grade polyurethane to ensure the purity of transferred materials. In addition, the grounding wire has been encapsulated in a rigid PVC helix on the exterior of the hose, eliminating the risk of contaminating the transferred materials. The VLT-SD Series is constructed the same, but has an FDA polyester fabric reinforcement to handle both suction and higher pressure discharge applications. New 2- and 8-in. ID sizes have been recently added to this product line.



4. Crystallize to 100 micron, filter, wash and dry as originally planned, but use the fines from downstream processing as seeds for the crystallizer. This reduced the crystallization time to less than 2 hours.

With these routes defined, we could evaluate the unit operations, which also allowed us to supply product samples to our customer, and price the project. This provided confidence that full-scale operations would meet the customer's long-term goals.

Always remember there's no universal formula for the best solids route like there is for liquid processes. Moreover, as the above example highlights, finding the most economical solution often depends upon evaluation of physical properties.

With solids processing, you must perform several crucial steps for the scale-up and design of any new process and before significantly modifying an established one.

The first is to establish the basic process route and evaluate alternatives as illustrated above. Next, you must define required product properties such as PSD, stickiness, flowability, dustiness and ease of solubility. Ignoring that latter point has caused grief many times when making a "minor" process change. Basic filtration and drying data often are overlooked as product properties; this can lead to a lot of extra work in assessing the various dryer choices. Obtaining single-particle drying kinetics and using models to evaluate a wide range of dryers can simplify the selection.

Another often-overlooked factor in the planning of experiments with solids is temperature sensitivity, especially for polymorphs. This is an area in which chemists shine because they have the tools to identify polymorphs and solvates. With molecular models available, they can propose and later validate these chemicals. ■

TOM BLACKWOOD is a *Chemical Processing* contributing editor. You can email him at TBlackwood@putman.net

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Surmount Sticky Situations

A properly designed fluid-bed dryer can handle sticky solids

By Tom Blackwood, Contributing Editor

“Don’t put them in a fluid bed.” I often hear this comment about sticky solids from plant operators and engineers because they’ve had many bad experiences with fluid beds. They end up spending countless hours cleaning out a plugged distributor, opening a discharge chute or banging on the vessel to get the solids to flow. They say the solids are too sticky to fluidize. Let’s face it: sticky solids need special attention. But first, we must identify the source of the stickiness.

Almost all fine solids, when wet, are sticky. Many others clump due to a variety of factors including stickiness (see: “Clamp Down on Clumping,” <http://goo.gl/bxhldn>). Only a few of those factors come into play in the operation of a fluid bed; the leading issue is the solvent, usually water. In my mind, melt-

ing of the particulate solids is the only legitimate excuse for plugging a fluid bed. So, what are the real causes of pluggage and how can you prevent them? The problem mainly arises on the fluidizing plate, screen or grid. The failure often stems from poor dispersion of the solids, lack of enough bed depth, low velocity through the grid and spacing the holes in the grid too far apart, as the following examples show:

- In one dryer project, a centrifuge had been placed above the dryer to eliminate the need for a screw feeder. Unfortunately, if the centrifuge was over-fed, slurry dropped onto the dryer grid. The grid had tuyeres designed for a catalytic cracker instead of a dryer. These were replaced with a more-robust design while retaining the tuyere spacing. The increase in veloc-

ity and horizontal gas flow tolerated the occasional centrifuge upsets, which were reduced by better instrumentation. The benefits of the new grid design didn't stop there. The dryer product had a more-uniform moisture content, partially due to the greater heat transfer to the solids. Later, thanks to the change in grid design, the plant was able to raise the capacity of the dryer.

- On a second project, the plant engineers were painfully aware of the stickiness of their product; it plugged up the centri-

fuge discharge on a regular basis. Also, the moisture content was higher than normally encountered in a fluid bed. The solution was to install a high-speed mill above the dryer even though the solids already were finer than the mill could produce. It dispersed the solids over the bed without attriting the particles. The fluid bed was split into zones, with the first very deep. This design allowed the particles to flash off the free moisture and eliminate the normally sticky surface. The deep bed required more pressure drop across the grid to ensure uniform distribu-

PRODUCT FOCUS

PARALLEL TUNNEL DIVERTER VALVE MINIMIZES CONTAMINATION

This precision machined valve is designed to prevent contamination and provide line switching for either dilute or dense phase conveying. The two-way PT45 valve operates as a 1-to-2-way diverting valve or a 2-to-1-way converging valve in a pneumatic conveying system for powdered or granular materials.

The PT45's actuator rotates the tunnel forward and backwards in the housing. This positions the tunnel to either the divert ports or the straight-through ports. Shaft bearings support the tunnel in the two end plates and between two thrust washers. The tunnel has position stops located in the housing for fine adjustment of both conveying positions. To prevent contamination, the tunnel rotates 45° port to port.

Two proximity switches mounted in the housing, sensing directly off of the tunnel, indicate tunnel position. A positive seal is made through the selected position between the tunnel bore and the housing interior by seal rings. During tunnel position changes, the seal rings act like a wiper to clean the surface of the tunnel.

It can operate at conveying line pressures up to 110 psi. The aluminum housing and tunnel are hard anodized for wear resistance.



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tion of the solids and to keep them off the grid. In addition, the higher pressure-drop requirement called for smaller grid holes that were spaced closer together to avoid hot spots.

- Another project involved a dryer suffering excessive entrainment after a recent product change presented a finer material to it. The corporate health and safety group had mandated a minimum velocity through the fluid bed of 3 ft/s for this product — due to frequent fires in the dryer when the velocity was below 3 ft/s, even though the solids could be fluidized easily at 1 ft/s. I replaced the grid with one that had the same pressure drop at 1 ft/s as the old one had at 3 ft/s. The lower velocity in the bed reduced the entrain-

ment while the higher velocity through the grid kept the solids from sticking to the grid and burning. It also improved the heat transfer and evaporation rate, enabling the dryer to maintain the same production rate despite the lower fluidization velocity.

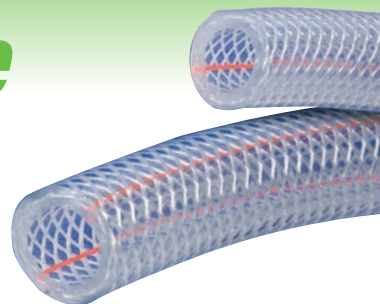
The secret to putting particulate solids into a fluid bed successfully (which means getting them out in one piece) is close attention to dispersion of the solids, good bed depth, and careful design of the fluidization grid. It's amazing how many other good things happen when you properly put sticky solids into a fluidized bed. ■

TOM BLACKWOOD is a *Chemical Processing* contributing editor. You can email him at TBlackwood@putman.net



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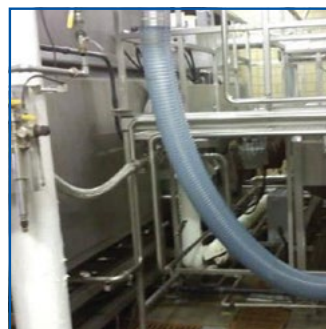


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Support Good Housekeeping Practices

Implement a proactive approach using industrial vacuum cleaners to prevent secondary dust explosions

By David Kennedy, Vac-U-Max

Since the U.S. Chemical Safety Board (CSB) released its 2006 Combustible Dust Hazard Study, the U.S. Occupational Safety and Health Administration (OSHA) has continued to amend its General Industry Housekeeping standards. Changes to the housekeeping requirements came as a result of employers' misinterpretation of housekeeping standards already included in the provision, and workplace accidents that occurred due to combustible dust explosions.

The General Industry Housekeeping standard applies to accumulations of dust that contribute to an explosion hazard. Provision 1910.22 aims to eliminate any doubt that employers are obligated to prevent combustible dust from accumulating in their workplaces.

Although OSHA's General Industry Housekeeping provision 1910.22 doesn't specifically address housekeeping and fugitive dust, other OSHA standards do address fugitive dust and suggest that operations "eliminate the use of compressed air jets to clean accumulated dust from the equipment or clothing and substitute a vacuum cleaning system" and "use a vacuum cleaning system to clean spills and dust accumulations. Avoid brooms and shovels."

However, there is still more regulation needed regarding the handling of fugitive dust for general industry, including food products, rubbers, metal, wood, pharmaceuticals, plastics, paint and coatings and synthetic organic chemicals.

FIRST DEFENSE: CONTROL FUGITIVE DUST

In nearly all industries, with the exception of the metals industry, the National Fire Protection Association (NFPA) recommends vacuum cleaning as the preferred first-defense method of controlling fugitive dust. NFPA 654 states that “vigorous sweeping or blowing down with steam or compressed air produces dust clouds.” Specifics on NFPA standards in relation to particular industries will be covered later.

Despite the recommendations of NFPA and OSHA standards, many companies still use air compressors and brooms to clean surrounding equipment and areas of dust and debris. This may be due to the misconception about industrial vacuum cleaners and sheer oversight when reviewing production processes. When a process has been in place for decades, it becomes somewhat transparent, and the standard reasoning that “if it ain’t broke, don’t fix it” often prevails.

The problem with using brooms and air compressors is that they just blow the dust around, resulting in small particles that settle onto elevated surfaces.

In an effort to bring a greater awareness to the severity of poor housekeeping methods, OSHA launched a National Emphasis Program (NEP) focusing on workplaces where combustible dust hazards are likely to be

found and lists different types of materials that can generate combustible dust.

Industries covered by the NEP include agriculture, food processing (including sugar), chemicals, textiles, forest products, metal processing, tire and rubber manufacturing, paper products, pharmaceuticals, recycling operations and coal handling and processing facilities.

These industries deal with a wide range of combustible dusts with differing properties, including metal dusts such as aluminum and magnesium, wood dust, coal and carbon dust, plastic dusts, biosolids, certain textile materials and organic dusts such as paper, soap, dried blood and sugar.

VITAL HOUSEKEEPING STANDARDS

While many technological advances have come about over the past 50 years to prevent dust explosions, good housekeeping is vital. OSHA notes that without the accumulation of significant amounts of combustible dust, catastrophic secondary explosions will not occur.

Even with OSHA’s increased enforcement, NFPA standards and the CSB’s push for tougher adherence, dust fires and explosions continue to happen” In 2012, the CSB estimated that a percentage of those explosions could have been prevented if there were standard housekeeping practices in place”



INDUSTRIAL VACUUM CLEANER INSTALLATION

Figure 1: Installing industrial vacuum cleaners can result in additional benefits in the areas of production, reclamation or wage savings.

After the Port Wentworth, Georgia-based Imperial Sugar refinery dust explosion in 2008, OSHA launched an intense campaign targeted at preventing additional mishaps and distributed a fact sheet, HazardAlert: Combustible Dust Explosions, that addresses secondary explosions.

It states that “due to poor housekeeping practices, an initial explosion may dislodge into the air the dust that is accumulated on the floors, beams, and other areas of a workplace. This dispersed dust, if ignited, may

cause one or more secondary explosions. These secondary dust explosions can be far more destructive than a primary explosion due to the increased quantity and concentration of dispersed combustible dust. Many deaths in past accidents, as well as other damage, have been caused by secondary explosions.”

The alert also references several NFPA standards that address the need for companies to use vacuum cleaners in housekeeping practices to prevent catastrophic explosions.

Addressing the need for to comply with housekeeping requirements, Edwin G. Foulke, Jr., then Assistant Secretary of OSHA noted “The fatalities and injuries at the Port Wentworth sugar refinery probably could have been prevented had Imperial Sugar complied with existing OSHA standards on housekeeping and other OSHA requirements.”

After the explosion, the company willfully refused to remedy similar conditions at its Gramercy, Louisiana plant, which has since closed, resulting in more than \$8.7 million of proposed penalties for both plants, the third highest proposed penalty in OSHA’s history.

The relative cost of even the most elaborate central vacuum system is minute compared to the loss of life that occurs from secondary explosions or the fines levied against a company that fails to proactively protect their workers.

Although the majority of companies aren't in willful violation of the standards, a lack of understanding of housekeeping standards and misconception of the relatively low cost of vacuum systems prevail in the industry. Often times, the addition of industrial vacuum cleaners to the housekeeping routine produces cost benefits in terms of increased production, reclamation or wage savings (Figure 1).

APPLYING HOUSEKEEPING STANDARDS

Although using vacuums isn't new to the many industries, some companies have tried in the past to use shop-type vacuums to clean up dust and debris and have found them inadequate under the rigorous demands in the processing industry.

In contrast to shop-type vacuums, industrial vacuums can suck up tons of material an hour. One such industrial vacuum is the air-operated vacuum cleaner, or air vac. Frank Pendleton co-founder of Vac-U-Max, Belleville, New Jersey, introduced it in 1959 to prevent dust explosions in textile mills.

The proper selection of an industrial vacuum cleaning system is based primarily on the application. In some cases small air- and electric-powered drum-style units will suffice, while others require central large electric- and diesel-powered units for multiple users and filtration systems capable of capturing particles that are invisible to the naked eye.

Some applications require customized vacuum cleaner installations. For other applications, compact, off-the-shelf vacuum systems are perfectly adequate when replacing crude or unnecessarily hazardous cleaning methods, such as the use of compressed-air hoses for blowing debris.

Often, users of industrial vacuum cleaning systems may assume they need a custom, one-of-a-kind solution when their application actually calls for a pre-engineered product. In other words, most applications require standard equipment with capabilities to best fit an application.

To prevent combustible dust explosions, companies can follow NFPA standards and guidelines when setting up a good housekeeping program. NFPA standards applicable to dust explosion hazards include 654, 61, 484, 664 and 655. Except for NFPA 61 and 664, which deal with combustible metals and food/agriculture products respectively, the fugitive dust control and housekeeping standards generally are the same for manufacturing, processing and handling of combustible particulate solids, wood processing and woodworking facilities, and also for sulfur.

In brief, the housekeeping standards call for establishing regular cleaning frequencies to minimize dust accumulation on walls, floors and horizontal surfaces such as equipment ledges, above suspended

ceilings and other concealed surfaces. The standards further state that vigorous sweeping or blowing down with steam or compressed air should take place only after the area or equipment has been vacuumed because of the creation of dust clouds by the other methods.

Standards also call for vacuum cleaners to be specified for use in Class II hazardous locations or for a fixed-pipe suction system with a remotely located exhauster and dust collector. When flammable gases are present, vacuum cleaners need to be listed for Class I and Class II hazardous locations.

NFPA 61 for food and agricultural processing plants has somewhat reduced precautions than the previously listed standards, and NFPA 484 for combustible metals requires that dust and particles be cleaned with non-conductive scoops or soft natural brushes or brooms before the dust is vacuumed. In addition, vacuums are suggested to pick up dust that is too small to be picked up with brushes. Blowing combustible metal dust with air compressors is not permitted.

For cleanup of truly explosive materials such as gunpowder, rocket propellant, sodium azide, aluminum powder and other materials that can explode if collected in dry form, a submerged recovery vacuum cleaner is available and designed specifically to pick up explosive powders safely.

The explosive or hazardous material is submerged under fluid to render it inert. The design includes not only a high-liquid-level safety shutoff, but also a low-liquid-safety shutoff to prevent vacuum operation if insufficient liquid is in the drum.

HOUSEKEEPING FOR FINE POWDERS AND CHEMICALS

Industrial vacuum cleaner experts can design systems for a company's particular needs. For instance, productivity suffered when a custom job shop fabricator faced potential flammability issues because it couldn't adequately sweep the fine powder coating residue from the floor, lights, booth walls and components of its shop and the shop-type vacuums it had been using posed a static electric shock to the workers. Not only did workers have to vacuum, but they also had to clean by hand using wet rags to prepare booths for the next powder coating job.

The fabricator sought out Vac-U-Max for a system that could prevent static. To eliminate any shock, fire or explosion hazard associated with electric- or engine-driven units, a Venturi compressed-air-powered vacuum was installed. Antisparking vacuum inlets and grounding lugs, and static conductivity from end to end, including a static-conductive hose with internal ground wire and grounded end cuffs, help prevent static build up.



PULSE JET FILTER CLEANING SYSTEM

Figure 2: A pulse jet filter cleaning system increases color changes in the powder coating industry and ensures high vacuum efficiency while almost eliminating clogged filters.

To further reduce sparking danger, static-conductive filters were used, rated 99.9% efficient at 1 micron, which virtually eliminated any fine-particle discharge from the vacuum's exhaust back into the work area.

This helped to create healthful, productive breathing conditions in the workplace.

A pulse jet filter cleaning system on all the company's air vacs not only increased color changes in the powder coating industry but also ensured high vacuum efficiency while almost eliminating clogged or "blinded" filters (Figure 2). By simply pushing a button on the air vac, the operator can backwash the filter with compressed air instead of taking the vacuum apart to clean the filter by hand.

PRODUCTIVITY AND WORKER SAFETY

For many manufacturers and processors, industrial vacuum cleaners now are being completely integrated into production and process systems, and are becoming a key component of critical strategic issues that range from productivity to environmental safety and worker health. ■

DAVID KENNEDY is business development manager, VAC-U-MAX. He can be reached at davidkennedy@vac-u-max.net.



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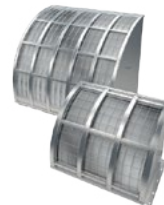
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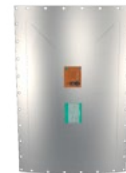
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Predicting Powder Flow Behavior Just Got Easier

New shear cell tests help to ensure product consistency

By Barry Ridley, Chris Freeman and Robert G. McGregor, Ametek Brookfield

Ask any plant manager if there is a way to know beforehand that a cohesive powder such as limestone, carbon black or cement will have discharge problems feeding from a bin. Most will say, there's a "definite possibility," but they may not know the level of difficulty or when interruptions are likely to occur.

Processing experience makes operations personnel naturally suspicious of potential processing problems. If they've had issues in the past, they may anticipate future stoppages. However, they need some type of powder measurement to provide a forewarning before the start of the production run.

Instruments typically used to assess powder characteristics — analyzers for particle size, particle shape, moisture content and electri-

cal charge — do not measure flow behavior. They are useful in explaining underlying reasons why a powder potentially will have flow difficulty, but they don't provide a useful indicator for flow behavior.

Traditional methods for evaluating powder flow — Flodex cup, angle of repose and tap test — are not truly relevant, either. Because they are inexpensive and quick to perform, they have endured the test of time for use in powder testing labs. However, they identify only physical properties that may correlate with flow behavior but do not assess flowability in and of itself.

FLOW FUNCTION TEST

Shear cells have become the instrument of choice in recent years. Figure 1 shows the



SHEAR CELL COMPONENTS

Figure 1: Annular shear cell components shown are a) trough with powder sample, b) vane lid and c) wall friction lid.

basic components of an annular shear cell. It requires a small powder sample volume (Figure 1a), uses a vane lid to compress the particles together (Figure 1b) and then shears them against one another to quantify the sliding friction for relative movement (Figure 1c). The test method is called “flow function,” and the resulting graphical information is referred to by the same name. This basic technical approach was established more than 50 years ago in the minerals industry.

WALL FRICTION TEST

A second test involves use of the wall friction lid (see Figure 1c again) to measure the resistance of powder sliding down the hopper wall before exiting the bin. This method, called the wall friction test, is also known as the “angle of wall friction curve” in graphical information.

The wall friction lid also is useful for testing powder compressibility, which quantifies how density increases from the initial “loose-fill” condition in the sample trough

to higher-density values as the lid pushed down on the sample and compaction pressure increases.

Improvements in instrument design have led to modern shear cells that are affordable and easy to use, run automatic tests quickly and provide analytical measurements for comparing powders. Figure 2 shows a typical shear cell that fits easily onto the workbench in a quality control (QC) or research and development (R&D) lab and can process a single sample in as little as 12 minutes. Rapid evaluation of flow properties using shear cells is a consequence of recent advancements in analytical data processing that makes this method practical for everyday use.

PUTTING THE TESTS TO WORK

Flow function. The flow function is the fundamental test used to evaluate flowability. Standard flow function tests measure the powder sample at five consolidation stresses and record the failure strength in each case. (Failure strength is the resistive force

or static friction between particles that must be overcome before relative movement can take place.)

Data from the test generates a flow curve such as seen in Figure 3. Industry has defined regions of flow behavior as indicated, ranging from “non-flowing” to “free flowing.” In short, the flow function offers a convenient tool to quantify the flow behavior of a given powder. Most important, it provides a quick way to compare powder batches and identify variations between formulations. To characterize a powder rapidly, certain pieces of information derived from the flow function may be used for benchmarking purposes:

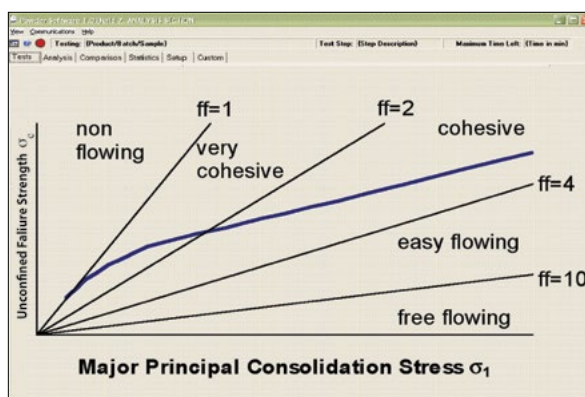
- *Flow index* is the slope of the line drawn from the data point associated with the fifth consolidation stress to the origin.
- *Arching dimension* is the minimum value required for the hopper opening to prevent bridging of the powder in “mass flow” behavior (powder flows downward uniformly toward the hopper opening).
- *Rathole diameter* is the stable annular ring of powder that can form in the bin during “core flow” (also known as “funnel flow”) behavior. The size of the ring may vary in diameter as a function of the powder height in the bin.

Wall friction. The wall friction test is performed in a similar fashion to the flow function test. Material of construction for the lid is identical to material constituting



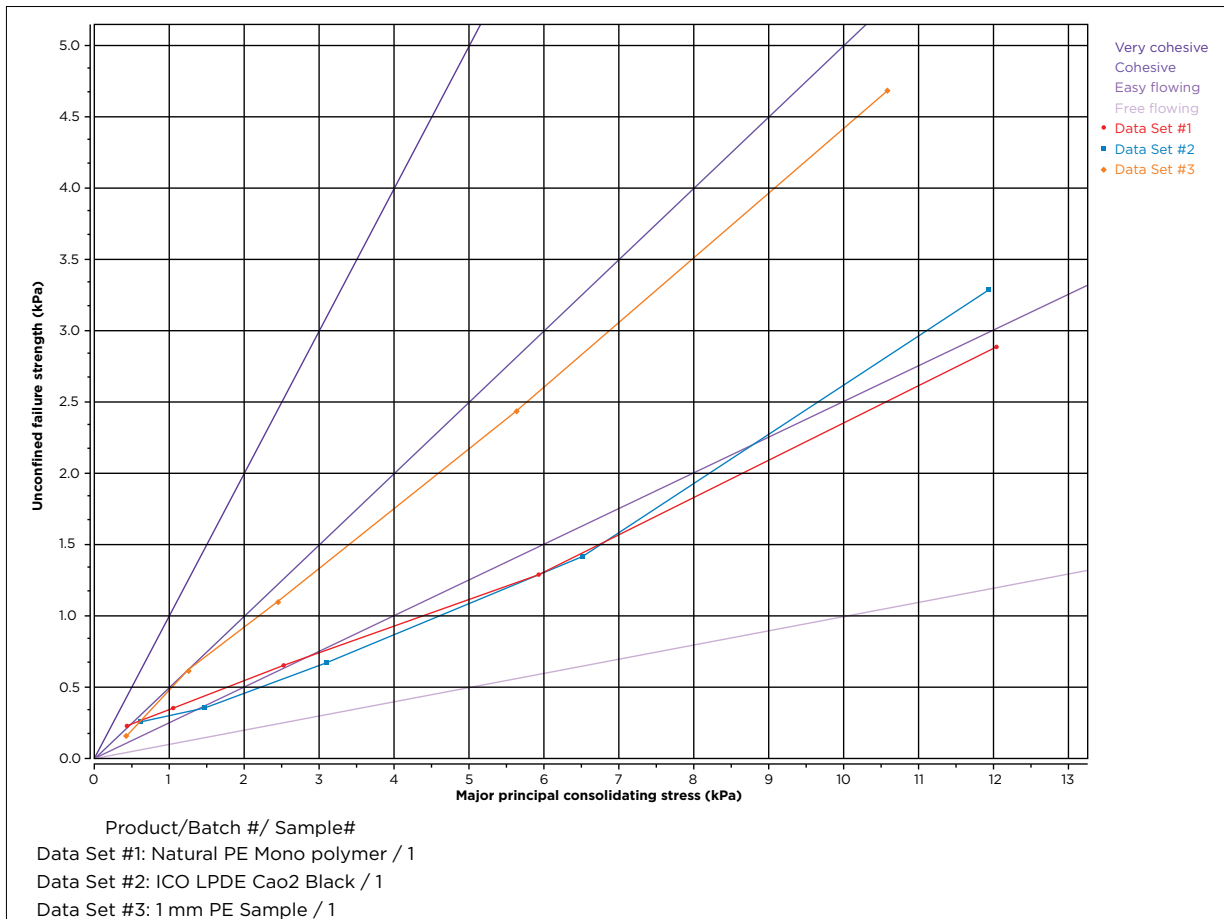
POWDER FLOW TESTER

Figure 2: The Brookfield powder flow tester is an example of an annular shear cell instrument.



FLOW FUNCTION GRAPH

Figure 3: This flow function graph shows failure strength (y-axis) vs. consolidation stress (x-axis) with defined regions for types of flow behavior.



POLYETHYLENE POWDER EXAMPLE

Figure 4: This chart shows flow functions for three polyethylene powders.

the hopper wall; possible choices include mild steel with 2B finish, stainless steel, and various plastic materials. Consolidating pressure is applied by the lid to the powder in the trough. The frictional resistance of the powder sliding against the lid a defined consolidation stress is measured. The process is repeated at increasing consolidating pressures.

Data resulting from the wall friction test gives two important pieces of information;

- *Compressibility ratio* is the change in

powder density from loose-fill condition before start of test to maximum density at highest consolidation stress.

- *Hopper half angle* required to achieve “mass flow” behavior can be calculated when wall friction and flow function data are combined. (For “very cohesive” powders, this angle may be too steep to be practical.)

Software used with shear cells automatically will compute these values. The person who operates the instrument needs instruction only in the proper method for filling

the trough with powder. The R&D scientist or engineer can use the test information to evaluate the effects of variations in formulation. Improvements in flow behavior are possible with selection of ingredients that have better flow capability.

Use of generic flow aids also may be considered. The operations personnel may decide that modifications to bin design (hopper opening and half angle) are needed to improve flow behavior. The QC department can run quick tests to qualify raw incoming materials used in the formulation. The final product after processing can be tested for compliance with established flow behavior limits for acceptability.

Consider the following example of three polyethylene powders for plastics processing. Figure 4 shows the flow functions for these materials. The natural PE monopolymer has the lowest flow function curve and is easy flowing at stresses above 4 kPa. The LPDE with calcium oxide is above the border line for easy flowing at all stresses tested and therefore is *slightly* cohesive. The PE sample with 1-mm particle size is cohesive

at all stresses and therefore will present the greatest challenge when processing.

ACHIEVING PRODUCT CONSISTENCY

Benchmarking powders for flowability has become possible with the regular use of measurements from the tests described above. QC now becomes the champion when using this new capability because visual observations and human judgment for acceptable product no longer are subjective. The powder processor is the ultimate winner because consistent product with predictable flow behavior will now ship to all customers. ■

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Understand Powder Flow Characteristics

A powder's variables and external factors will greatly impact blender size and type

By Adam Covitt, Federal Equipment Company

The goal of powder blending is a homogeneous, or uniform, consistent mix of materials. The key to selecting a blender that will blend powders together into uniform mixes, also called “bulk solids,” is the material's flow characteristics. Free-flowing powders are more likely to blend well together, but not all powders are free-flowing. Understanding the powder's flow characteristics will help determine the best type of blender for the product.

POWDER FLOW CHARACTERISTICS

Powders are the least predictable of all materials in terms of their ability to flow. Two sets of factors determine a powder's flow characteristics: the powder's variables and external factors. Powder variables include the product's bulk density, particle size, size

distribution, shape, surface texture, cohesiveness, surface coating, and electro-static charge, among others. External factors include vibration, temperature, humidity, spurious electrical charges, aeration, container surface effects (or wall friction) and storage time. Addressing only one set of variables or partially addressing both sets of variables will lead to flow and, eventually, blend uniformity problems on the production floor. The flow characteristics will help identify the proper type of blender and the powder's weight and density will help determine the size of the blender.

BLENDER SIZE

Blenders are volumetric, which means their sizes are usually measured in terms of their volume capacity such as cubic feet. Powders will not blend well (flow) if the blender

is too full or too empty. A safe range of effectiveness is 35-65% of the overall capacity. The product's flow characteristics will be the best indicator for the capacity range of each product mixed in the blender. As a rule of thumb, working capacity of a blender is usually determined as 50% of the total volume of the blender. For example, if a blender has an actual volume of 2 ft³, then the working capacity will be 1 ft³.

While blenders are generally sized according to volume, powders are usually measured according to density. Such measurements are either grams per cubic centimeter (gr/cc) or pounds per cubic foot (lbs/ ft³). Additionally, the request for blended materials usually comes in terms of a specific weight of material such as 15 kilograms (kg) without reference to volume or density. Powders can be very light ("fluffy") or very dense which leads to different volumes of product at the same weight (think of a pound of feathers versus a pound of lead).

The proper blender size for the product is one that will have a working capacity within the effective range to achieve a uniform blend. The simple way to calculate the proper size versus the product density is to weigh a quart or liter of powder. 16 quarts or 15 liters of a product is equal to 1 ft³ at a density of 35 lbs/ ft³. Blenders sizes based on 35lbs/ ft³ at working capacity: 1 ft³ = 15kg; 2 ft³ = 30kg; 3 ft³ = 45kg; 5 ft³ =

75kg; 10 ft³ = 150kg; 20 ft³ = 300kg; 30 ft³ = 450kg; and 50 ft³ = 750kg. Size is not the only factor to consider, the type of blender is important as well.*

BLENDER TYPES

Twin-shell (or "V" blenders), double cone blenders and bin (or tote) blenders are all considered "random" style blenders. These types of blenders also are referred to as "open shell blenders." They randomly mix powders that are already free flowing through the blender's tumbling action. If the products are dense, an intensifier bar can be added which will force the powders to move inside the shell of the blender. Liquids may be added to the bulk solids mixture with a liquids bar. Intensifier bars can be overused which can result in particle break down for dry and friable powders or it can pack powders that are wet or cohesive (sticky).

Ribbon and paddle blenders are excellent ways to mix powders slowly and gently. In a ribbon blender, a double-helix agitator will move materials towards the center of a trough with the outer blade while the inner blades move the materials towards the outside of the trough. Paddles are an alternate design that can be used for small batches relative to the working capacity of the blender and with friable materials.

High shear mixers are generally used for products which are considered immiscible,

where the products do not generally form a homogeneous blend. The mixer operates by moving one phase into a continuous phase. The phases, or ingredients, can be solids, liquids or gases. The ingredients are moved with a rotor, or impeller, across other rotors or stators to produce a mechanical force called shear which forces the products to mix. Plow-style mixers are common high shear mixers that can be used for particle size reduction and to produce granules.

These are only a few, common-types of blenders available. Many additional types of mixers can be used for powder blending including planetary mixers, Nauta-style mixers and single and double-arm mixers — choices among many others which can be evaluated applying the same analysis of

weight, capacity and flow characteristics. Powder flow characteristics and the weight of the product can be used to determine the proper type and size of the blender needed for the product. Analyzing the weight of the product can be used to estimate the working capacity required which determines the overall size of the blender needed. The flow characteristics will also determine whether the product can be blended in a random type blender, a ribbon or paddle blender, high shear mixer or some other type of blender. ■

**Special thanks to Mike Tousey at Techceuticals, LLC for providing the technical information described in this article.*

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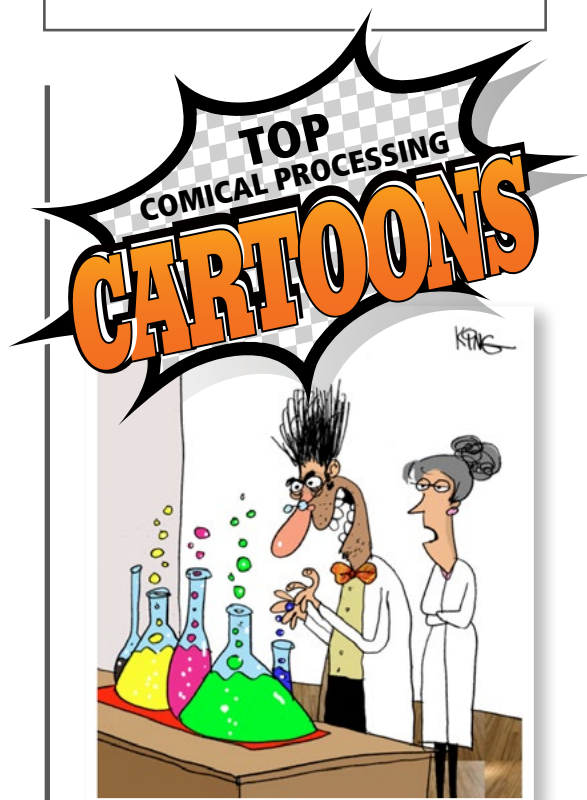
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