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Need your powder questions answered? We have an expert for that.

Q: I would like to know if there is an available table or data available for conveying densities (pneumatic conveying) of powder/solid fuels such as coal, biomass (rice husk), woodchips, etc. In designing pipe lay-out, blowers and feeder valves, this data is important.

A: There are numerous charts and tables available. The primary basis for selection of the type of conveyor is the Geldart Powder Classification Chart. This was published in *Powder Technology* in 1973 on page 285. It has been reproduced extensively. Because of its density and particle size, cement and coal are difficult to convey. In using the Geldart chart, remember that the density is the particle density not the bulk or structural density. This would be especially true for rice husk and wood chips or products that have internal voids.

Visit www.chemicalprocessing.com/experts/powder-handling/ to pose your own question or to review other Q&A.

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Get the Most from Your Flexible Screw Conveyor

Consider several key factors to achieve optimum performance and efficiency

By Mike Zeluff, Hapman

DUE TO their relatively low cost and uncomplicated construction, flexible screw conveyors are very popular with manufacturers. In these units, a screw (also called an auger), driven by an electric motor, rotates within a tubular housing. The screw is the only part that moves.

Despite the conveyors' simplicity and straightforward operation, many end-users overlook important factors that potentially could lead to poor performance, excessive power usage, severe wear and material degradation. To avoid such issues, it's essential to consider all system parameters when selecting conveyor options. Only then can you ensure a correct and successful installation that achieves maximum operational efficiency.

THE BASICS

A flexible screw conveyor has a helicoid screw that rotates inside a fixed tube. Screw conveyors typically range in diameter from $2\frac{1}{2}$ to 8 inches, and can be used for horizontal transports of up to 80 feet and inclines of up to 60°. An 8-in.-diameter unit can handle 1,800 ft^3/h at 360 rpm at a 45° angle.

The flexible screw is made from stainless steel and comes in a variety of configurations. As the screw rotates, it creates directional force that moves the product through the tube. At the same time, it creates centrifugal force that pushes the material against the tube's wall.

The characteristics of the material being conveyed are extremely important considerations when selecting any conveyor. Flexible screw conveyors can move many types of materials, such as powders, crystals, flakes, granules, pellets and irregular shapes. However, you still must assess how the material will affect the conveyor as well as how the conveyor might affect the material.

For example, certain materials, such as sugar or salt, have the potential to create friction within the flexible screw conveyor. This can cause crushing, heating or chipping of some particles during transport. Moreover, material friction can result in overtaxing of the conveyor's motor, increasing wear and eventually leading to failure if left unchecked. Or the actual material being conveyed could build up on the screw and make it stall.

TYPES OF SCREWS

Augers come in many designs, each addressing the challenges presented by different material characteristics. To get the best results possible from your flexible screw conveyor, you must select the auger type that best suits the material you need to convey. Here's a rundown on the basic types (Figure 1):

- *Flat wire.* These augers are the most common type used. Made of rectangular wire about $\frac{1}{4}$-in. thick, they can handle a wide variety of powders ranging in bulk density up to 60 lb/ft^3. The flat conveying surface applies a more positive forward directional force on the product being conveyed and

HELIX AUGER TYPES

Figure 1. Screws generally are available in four configurations: flat wire, beveled wire, square bar and round wire.

reduces the outward force against the tube wall.

- *Beveled or square bar.* This type of auger is designed specifically to convey difficult-to-handle or fragile material with minimal product degradation or damage. The beveled auger must be installed straight. It rotates at a much lower rpm, typically 360–450 rpm.
- *Heavy-duty square bar.* Usually $\frac{3}{8}$-, $\frac{1}{2}$- or even $\frac{3}{4}$-in. thick, wound into sections and welded as needed, these screws can cope with heavy and abrasive materials and suit large hoppers.
- *Round wire.* Made from a coiled round bar, these screws mainly are used for heavy or highly abrasive materials. The biggest benefits of this auger design are its strength and flexibility, which minimizes the load imposed on it by material weight or size or particle shape. The design creates high slippage and stronger outward forces on the conveyed product.
- *Centercore.* A small tube placed in the center of the screw extends the full length of this auger (Figure 2). By restricting the space available, the centercore reduces the amount of material that can enter the conveyor, which in turn decreases the load imposed upon the screw. Use a centercore when conveying very dense products or highly aerated or fluid product.

Table 1 summarizes the advantages and disadvantages of the various types of augers. Table 2 lists some of the materials each auger type suits.

ADVANTAGES AND LIMITATIONS

The flexible screw conveyor is the best choice for many batch processing applications. However, as with any type of conveyor, when selecting equipment you should consider advantages and limitations:

Advantages:

- well suited for horizontal and vertical conveying;
- easily transports many free- and non-free-flowing bulk materials;
- low cost;
- takes up very little floor space;
- easy to clean;

- allows for flexible installations (conveyors 4-in. and smaller can be curved within a specific bend radius, and inlet hopper angles also can be varied);
- causes low-to-moderate material degradation; and
- ensures a dust-tight system, with hopper options to ensure that product remains within the process.

Limitations:

- residual product left in the casing;
- height and length limits; and
- different screws may be required when conveying multiple products with the same conveyor.

CAPACITY CONSIDERATIONS

Many factors affect capacity and power requirements. The most common elements to consider are material particle size, bulk density and flowability, conveyor length, diameter and incline angle, auger rotational speed and helicoid pitch. Optimal operation will strongly depend upon the conveyed material, the rpm of the auger, and what size hopper is being used. If the conveyor is inclined, tests must be run to determine capacity and power required. Capacity decreases as you increase the incline. The power requirement rises with speed at any slope.

You can increase or decrease material flow rate by:

1. the type of auger used;
2. its rotational speed;
3. the configuration of the feed hopper and tube;
4. the material's flowability and overall characteristics; and
5. the conveyor's angle of incline.

A general rule of thumb is to set a flexible screw conveyor at no more than a 45° angle. Taking into account the material's characteristics, you may be able to convey material at angles greater than 45° without risking backflow; when conveying heavier materials, you may need to decrease the angle to less than 45° to prevent backflow.

Figure 2. By restricting the amount of material in the conveyor, this design alleviates load on the screw.

OPERATIONAL ISSUES

With the exception of initial charging and emptying, you never should operate a flexible screw conveyor empty for extended periods of time unless the particular unit is specifically designed for that. Running a conveyor without material in the hopper can lead to excessive fatigue on the system's components. To mitigate this potential problem, use sensors at the pickup point to automatically shut off the conveyor when material isn't present.

Dry operations occur when a conveyor has been running fully loaded or at a high fill percentage and then no longer gets material to convey. This typically happens in applications exhibiting increased slippage, visual material rollback and a steady decrease in output. A conveyor can be designed to run under these conditions by using the proper outer tube, screws and slower rpm levels.

During standard operation, a flexible screw conveyor with any type of auger will leave residual

material in the inlet tube once the hopper is empty. You can quickly extract this residual material by removing the end cleanout cap at the bottom of the conveyor and then reversing the rotation of the screw. Further cleaning can be performed with air, water or solvents with or without disassembly of the unit; if necessary, you can remove and thoroughly clean the outer tube and flexible screw.

An option that's ideal for applications where total evacuation of conveyed materials is essential is a high/low or tilt-style flexible screw conveyor. The high/low design allows the operator to lower the conveyor to a horizontal position to fully remove the screw (Figure 3). This greatly simplifies and enhances washdowns, cleanouts, auger changeovers and regular maintenance. Operators can clean and disassemble the conveyor safely on the floor in just minutes without using lifts or ladders.

MODES OF OPERATION

A flexible screw conveyor can handle batch, intermittent and continuous services.

Batch operation. This is the easiest of all duties. When only one material is batched, it's relatively easy to maximize batch output; product left in the

COMPARISON OF AUGER TYPES

TYPE	ADVANTAGES	DISADVANTAGES
Flat wire	Most efficient Lightweight and flexible Usable with many different powders	Uses tighter tolerances, which could jam larger particles
Beveled or square bar	Reduces buildup Can convey difficult-to-handle materials, such as titanium dioxide or zinc oxide	Less flexible No conveyor bends
Heavy-duty square bar	Good for heavy materials Good for abrasive materials Good when using large hoppers	No bends Requires more horsepower Heavier screw increases load
Round wire	Lower material degradation Lower power draw Less startup torque under load Conveys small granules well	Less efficient Less flexible Will not work on fluid powders
Centercore	Eliminates fall back Helps to elevate fluid materials Reduces the amount of residual in the conveyor	Can reduce output capacities Must be removed when cleaning is necessary

Table 1. Each screw type offers a distinct set of advantages and limitations.

MATERIALS CONVEYED WITH SPECIFIC AUGERS

TYPE OF SCREW	MATERIALS CONVEYED
Flat wire	Calcium carbonate, fumed silica, talc, flour, starch, seasonings
Beveled or square bar	Zinc oxide, titanium dioxide, iron oxide, carbon black, cocoa powders
Heavy-duty square bar	Sand, metal powder, steel shot, large salt particles, products denser than 90 lb/ft^3
Round wire	Salt, sugar, rice, coffee beans, corn, plastics regrind
Centercore	Zinc oxide, titanium dioxide, calcium carbonate, fumed silica, talc, salt, sugar, starch

Table 2. The various types of screws suit specific types of materials.

HIGH/LOW CONVEYOR

Figure 3. Author shows how tilt-down design makes screw removal easy.

conveyor casing will make the first batch somewhat underweight, but successive batches will be more repeatable. When dealing with multiple materials, always consider residual product in the conveyor because it may contain various ingredients that may not completely transfer from the system as desired. By first introducing a portion of the major ingredients, followed by the minor ingredients, and then dumping in the remaining portion of the major ingredients, you can minimize loss. This is just one method of batching when delivering an exact weight isn't critical.

Intermittent operation. In this type of service, the conveyor starts and stops in a repetitive fashion under full load. Because of this, some heavy materials may cause startup issues. To mitigate such problems, special modifications to the conveyor can increase its structural strength or reduce the amount of material during startup.

Continuous operation. Units expected to perform nonstop for extended intervals must be specifically designed for this type of operation and should be sized to run at an average speed range.

CHOOSE WISELY

Flexible screw conveyors are a cost-effective, dependable choice for conveying a wide range of materials. Their rugged simple design fosters reliable service, provides user-friendly operation and keeps maintenance low.

By first considering several important factors — material characteristics (e.g., whether heavy granules or light powder, wet and sticky or dry and aerated, abrasive or corrosive) and process criteria (e.g., whether continuous or batch operation, necessary incline and run length) — you can ensure selection of a flexible screw conveyor that suits your application and provides proper operation and optimal service.

MIKE ZELUFF is a product manager for Hapman, Kalamazoo, Mich. E-mail him a mzeluff@hapman.com.

Cure Powder Measurement Headaches

3D technology can provide greater insight when measuring material in vessels

By Jenny Nielson Christensen, BinMaster Level Controls

POWDERS HAVE a tendency to create myriad material handling headaches, but with the advent of 3D non-contact technology, many of the hassles of level and volume measurement can be cured.

A relative newcomer to world of level measurement, the 3D sensor provides highly accurate level and volume measurement in challenging materials contained in bins, tanks, silos, domes and warehouses. The dust-penetrating, non-contact sensor sends pulses in a 90° beam angle, taking multiple measurements of the material surface and continually mapping it to detect changes in level to account for uneven surface topography. From the convenience of a PC or smartphone, the accompanying software reports the lowest and highest points detected and the average level based upon a weighted average of all measurements detected in the bin. The sensor also has the ability to accurately estimate the volume of material in the vessel. For the most advanced models, a colorful graphical representation indicates where high and low spots exist in the silo.

Now in existence almost five years, 3D technology is widely offered and is proven in thousands of installations, having been applied in a range of powders with bulk densities as low as 12 lb per cubic foot. As each 3D sensor installation is unique, a range of extensions and accessories have been developed to enhance the performance and reliability of the technology even when vessel conditions are not optimal. With operations demanding more accurate, real-time data about their inventory, new advancements continue to evolve for this non-contact volume measuring device.

BENEFITS OF 3D TECHNOLOGY

Advances and improvements in non-contact radar have made it a popular choice in many operations. However, there are attributes of 3D technology that enable it to perform differently and better than radar in vessels containing powders. Radar only measures a single point on the material surface and takes that one measurement within an extremely narrow

3D SENSOR EQUIPMENT

Figure 1. 3D sensors take multiple measurements of the material surface and continually map it to detect changes in level to account for uneven surface topography.

beam at the same location repeatedly. While that one measurement point may be very accurate, radar ignores the irregular topography that often occurs in powders such as cone up or down and buildup that may form in the bin as it is emptied and filled.

Conversely, 3D measures multiple points within a 90° beam angle to account for uneven material surface. This allows for mapping of the material surface, enabling multiple measurements to be used for calculating a true volume of material, versus a single level measurement point that may or may not accurately reflect the amount of material in the vessel. Knowing the volume of material increases the accuracy of inventory valuation for better financial management and purchasing efficiency. Additionally, 3D software has the capability to render a visual of the material topography that can be used to understand material behavior and manage filling or emptying points and for scheduling maintenance to remove buildup.

LEAVE THEM IN THE DUST

Dust can wreak havoc on the performance and accuracy of many level sensors, rendering them inaccurate and unreliable. In the case of radar, heavy dust may deflect the beam, preventing it from directly targeting the material surface and causing the measurement to be incorrect. Dependent on the stickiness of the material, radar may require frequent cleaning and preventive maintenance to continuously measure accurately. To address this, some radar devices are equipped with an air purge to periodically "dust off" the sensor.

The low-frequency, acoustics-based pulses used by a 3D sensor are able to penetrate excessively high levels of dust (Figure 2). With 3D sensors, the three-horn transducer is designed to resist dust buildup inside the horns. In most powder applications, annual minimal maintenance is all that's needed. Another important attribute of 3D sensors: three transducers (Figure 3) send pulses to the material surface, versus radar which only has one. This results in better accuracy and more reliable performance.

Level sensors live in some pretty unhealthy environments, many of which are characterized by extremely sticky dust. When dust is especially troublesome, a transducer with a Teflon coating resists buildup of dust on the device (Figure 4), ensuring the scanner performs optimally. The

DUST-PROOF

Figure 2. 3D sensors are proven to perform reliably in excessive dust.

THREE TRANSDUCERS

Figure 3. Using three transducers to continuously measure and map the material surface helps ensure accuracy.

DUST PROTECTION COATING

Figure 4. A Teflon-coated 3D sensor can be used in sticky, dusty materials to prevent blockage of the antenna.

ANGLED VIEW

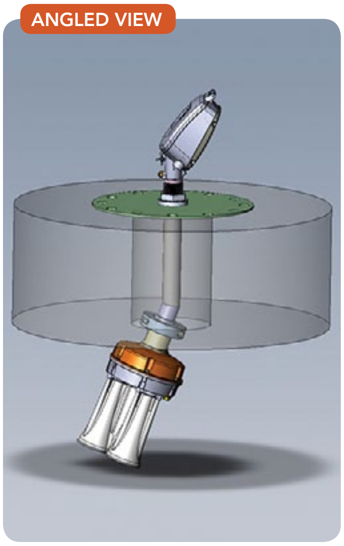

Figure 5. An angled neck extension provides improved coverage of the material surface when the 3D sensor can't be mounted in an optimal location.

NECK EXTENDER

Figure 6. A neck extension enables a 3D sensor to clear structures that may be present in the vessel.

Teflon-coated transducer prevents the antenna from becoming blocked, and the slick, self-cleaning surface requires minimal maintenance, reducing the need to for workers to climb silos, and thereby enhancing employee safety. Some common applications for the Teflon-coated transducer include soybean meal, flour, sugar, alumina powder, fly ash and other materials that are prone to cling to surfaces.

LOCATION, LOCATION, LOCATION

Mounting the 3D sensor in an optimal location on the top of the bin is essential to getting the most accurate results. However, sometimes installation in the most desirable location isn't feasible or an existing opening is the only mounting option. The sensor must be able to "see" the contents of the bin in order to account for the entire material surface. To improve the 3D sensor's coverage of the material surface when it's not mounted in the best location, an angled neck extension allows the transducers to be pointed in a more desirable direction that results in better coverage of the material surface (Figure 5). The angled neck extension can be used in instances where existing holes are too close to the vessel wall for the scanner to optimally scan the material surface. It can support angles of either 10° or 20° and should be used only if mounting the scanner in the most desirable location isn't possible.

If the sensor is mounted on a vessel with a very steep roof or in a hard-to-access location, it may be preferable to put the head of the sensor in an accessible area separate from the transducer. The head body separation assembly allows the transducers to be installed inside the bin while allowing the head to be located in an easy-to-reach location. This optional assembly is available in three lengths: 3 ft (1 m), 8 ft (2.5 m) and 33 ft (10 m).

CLEARING OBSTRUCTIONS

It's not unusual for a permanent structure or other

DOME

Figure 7. 3D technology is proven to measure material accurately in large domes and silos.

MULTIPLE SENSORS

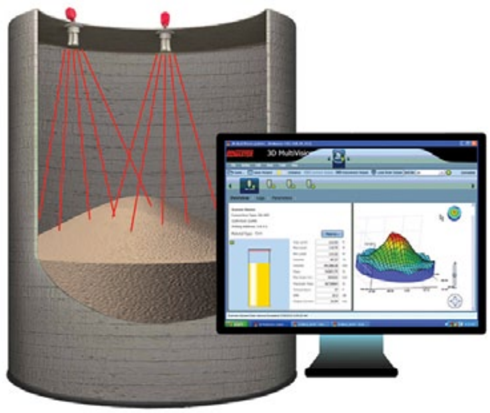

Figure 8. For very large vessels, multiple 3D sensors measure and map the material surface.

obstructions to be present in vessels, especially near the top of the vessel. The 3D sensor can see this structure, which impairs the accuracy of measurement results. Optional neck extensions (Figure 6) are used when it becomes necessary to lower the transducer assembly below obstructions such as beams or rafters that may interfere with the performance of the scanner. The neck extensions also are used when the scanner is mounted on a thick roof or on a raised socket. Neck extensions in 2-, 4-, 6- and 10-ft lengths allow the 3D sensor to be effectively installed without any degradation in performance, or the need for special structural alterations or adapters.

MULTIPLE SCANNERS DO DOUBLE DUTY

Very large silos, flat storage warehouses or domes (Figure 7) storing large quantities of powders, granules or other types of bulk solid materials are especially difficult to measure. Measuring a single point in these vessels and using that data to estimate inventory is risky, especially if the material doesn't flow freely and tends to want to clump or pile up.

For large vessels, multiple 3D sensors can be installed on the top of the vessel to measure and map the material within (Figure 8). With special software that combines multiple measurements from multiple devices, a true volume of material can be estimated and the contents can be visually mapped to show the location of the high and low spots. Devices such as radar or ultrasonic only measure a single point, making 3D sensors a more accurate and viable option for large vessels.

DOUBLE VISION

3D sensors come with standard PC software for configuration of the vessel and for viewing level measurement data, the estimated volume of material in the vessel, and optional 3D visualization of bin contents. If a site has multiple vessels, an advanced software program can be used to monitor multiple vessels from a single screen. Vessels can be identified by location and contents and can be sorted to view only the desired vessels. Alerts can be set to notify users when material reaches a predetermined level, such as a high- or low-level alert. Plant management, purchasing and financial personnel are able to access inventory data as needed to make better-informed decisions.

JENNY NIELSON CHRISTENSEN, MBA, is director of marketing for BinMaster Level Controls. She can be reached at jchristensen@binmaster.com.

Prevent Packed Powders

Determine a powder's compaction and flow behavior before problems occur

By Robert G. McGregor, Brookfield Engineering Laboratories, Inc.

DO NOT LEAVE POWDER IN THE BIN OVERNIGHT!!! That's the warning sign posted on the outlet hopper. Why is it there? The obvious reason is that the powder doesn't come out when operations start back up the following morning. Why won't the powder flow out of the hopper? "Time consolidation" is the answer. What happens during time consolidation? Powder particles under the influence of gravity slowly but surely pack closer together. If the degree of compaction is enough, then the increased inter-particle friction that results may prevent flow movement altogether when the hopper gate/valve is opened up.

Operators know from experience that powders, once placed in the bin, have a tendency to pack. The question is how rapidly this occurs and whether it can cause problems. Some powders may start to exhibit erratic flow behavior during a brief shutdown on the plant floor to fix a mechanical problem. The outage may be no more than 15 or 30 minutes, but that can be long enough for a highly cohesive powder to consolidate further to the point where it exhibits flow difficulty.

Plant managers know from experience the powders which can cause this type of problem. However, with changes in formulation and substitute ingredients coming on line with increasing frequency, there's a growing need to be able to predict and quantify the time consolidation phenomenon before it occurs in the hopper. Test instrumentation that measures the inter-particle friction is the solution. Generically known as "Shear Cells", these devices offer the technical approach for characterizing the time consolidation problem before it occurs.

Figure 1. Shear cell technology can easily test powders for time consolidation.

Figure 2: The shear cell containing the powder sample is placed in a powder flow tester.

TEST FOR TIME CONSOLIDATION

Figure 1 shows the basic apparatus that holds the powder test sample. Volume requirement can range from 50 to 300cc, depending on the amount of powder that's available for testing and the range of consolidating stress that should be applied. The latter is determined by the height of the bin on the production floor and the fill level of the powder. At the start of a run when the bin is full, the consolidating stress on the powder in the hopper will be at its maximum due to the weight of all the powder above. As the bin reduces, the consolidating stress on the powder in the hopper goes down correspondingly.

The shear cell containing the powder sample is placed on the instrument shown in Figure 2. The vaned lid in Figure 3 comes down on top of the shear cell and applies a downward compressive force on the powder. Particles of powder fill the compartments in the vaned lid. The consolidating pressure in the shear cell causes the particles to move closer together, simulating what actually happens in the bin.

At each of several increasing consolidating stresses, the shear cell rotates through a very small angle while the vaned lid atop the sample applies a steady consolidation pressure. The vaned lid is physically attached to a spiral spring in the instrument that's connected to a torque sensor which measures the increasing inter-particle friction between the powder at the interface between the vaned lid and shear cell. The lid stops rotating with the cell when the measured torque exceeds the inter-particle friction. This torque value quantifies the amount of force needed to overcome the interparticle friction and is referred to as the "failure strength" of the powder.

The methodology for shear cell operation is to measure the powder's failure strength at specific consolidating stresses. Figure 4 shows a general illustration of the data from this type of test. "Flow Function" is the general term used to characterize the powder flow behavior. The x-axis is the consolidating stress while the y-axis is the powder failure strength. Industry has agreed to index different regions of

COMPRESSING POWDER

Figure 3: A vaned lid compresses the powder sample in the shear cell, causing powder particles to fill the compartments in the vaned lid.

FLOW BEHAVIOR

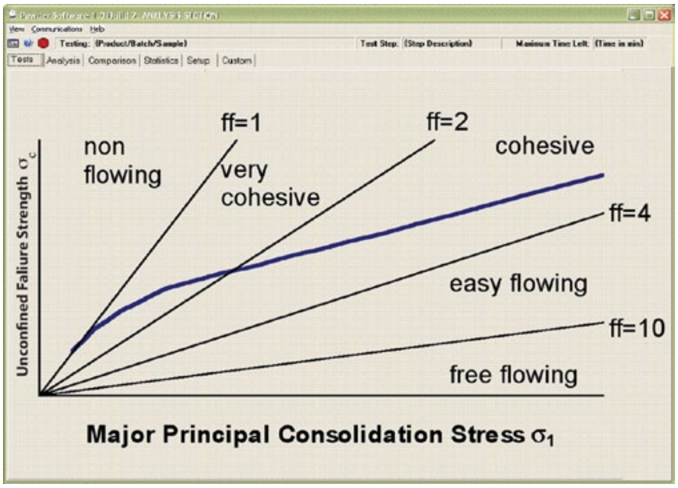

Figure 4: Flow Function curve characterizes the powder's flow behavior with free-flowing and non-flowing indices.

flow behavior, ranging from "free flowing" to "non-flowing." Rock salt and crystalline sugar might be an example of the former, while cement and cocoa could be examples of the latter.

Time consolidation uses this same methodology to evaluate what happens to the powder by repeating the failure strength measurement at each

STARCH POWDER TEST

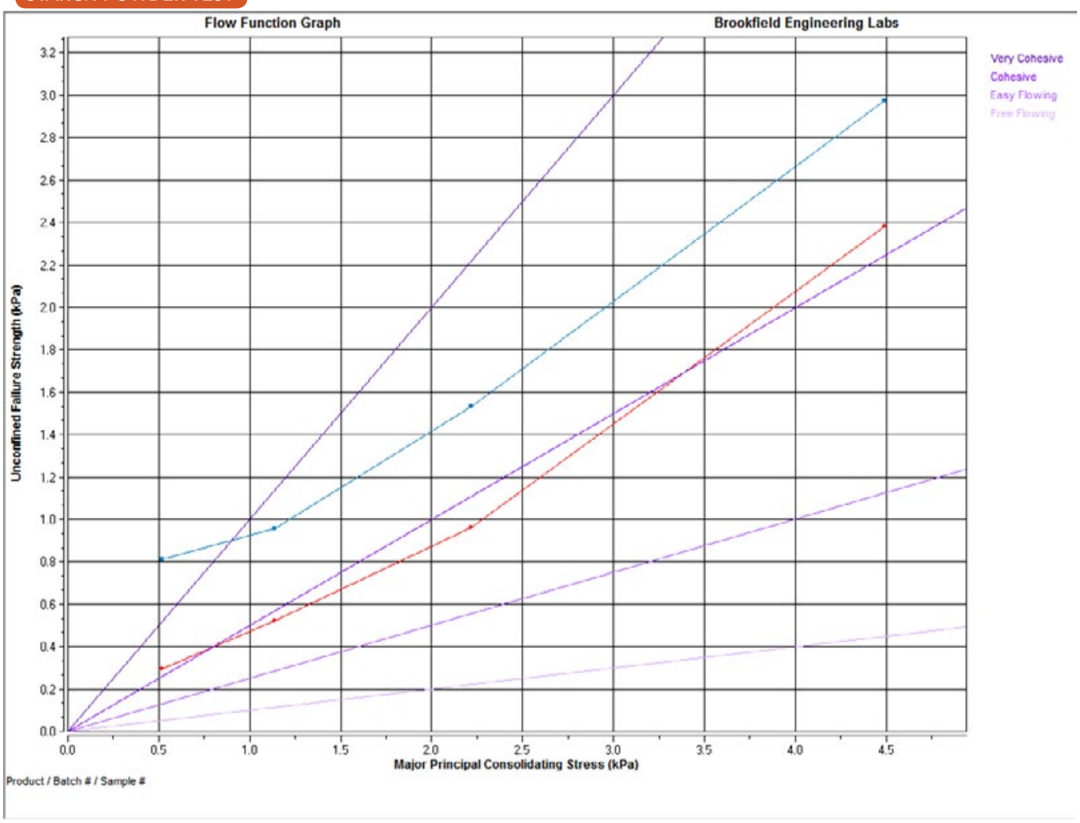

Figure 5: Results of a time consolidation test on starch powder indicate it shouldn't be left overnight in the bin.

consolidating stress after a defined time interval. Figure 5 shows the Flow Function data for a starch powder that has a 15-hour time interval for the time consolidation, which simulates an overnight situation. The flow function curve shifts upwards as a consequence of time consolidation. Note at low consolidating stress how the powder flow behavior shifts from "very cohesive" to "non-flowing." Therefore, this is an example of a powder that should not be left overnight in the bin.

SHEAR CELL ADVANCEMENTS

The value of shear cell technology for the plant operator is the ability to quantify flow behavior of powders against established references. This means that new formulations and incoming supply of the same powder from multiple vendors can be evaluated for acceptability before processing starts. Recent advances in ease-of-use and affordability for shear cell instrumentation provides processors with ready access to its capability. What had once upon a time been a science only for those trained in powder mechanics is now becoming a general purpose tool for plant operators in general.

ROBERT G. MCGREGOR is general manager, global marketing for Brookfield Engineering Laboratories, Inc. He can be reached at r_mcgregor@brookfieldengineering.com.

CAUTION
Think an explosion will never happen in your facility?
Dust and gas explosions are deadly and commercially devastating. Many facilities are at risk, but just don't know it. Fike is a global leader in the development and manufacture of reliable explosion protection solutions. And we offer a wide range of explosibility tests designed to assist you in identifying costly explosion hazards.
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Consider Pneumatic Vacuum Conveying

Be sure to examine vacuum receivers, pumps and filters when selecting this method of material transfer.

By Nick Hayes and Thomas Ramme, Volkmann

VARIOUS PRODUCTION steps in the process industries require a safe and maintenance-free method for transporting raw and auxiliary products as well as finished powders, granules and tablets. To handle such diversity efficiently and cost effectively, a vacuum conveying system should be flexible and have the ability to integrate easily into production processes such as loading mixers, unloading sacks or drums, filling bulk-bags or silos, and supplying product for filling or packaging machines.

The situation gets complicated for smart vacuum transfer when one considers the range of materials to be conveyed. Bridging powders; explosive, superfine dusts; hygroscopic, toxic and cohesive compounds with poor flow properties all require the same transfer as larger, particle-sized bulk materials with complex geometries. Compounding the issue are materials such as titanium dioxide, sodium azide, silicon dioxide and fine, activated carbon dusts — well known in industry for their difficult conveying characteristics based on their composition as well as explosion risks.

Therefore, dust-free conveying also is critical to the transfer solution. This article addresses how pneumatic vacuum conveying is best used and the key features to examine when selecting such a conveying system.

WHY TRANSFER VIA PNEUMATIC VACUUM

Pneumatic vacuum conveying is best used when material capacities range between 10 and 13,500 lbs/hr. and, under extraordinary circumstances, can reach up to 12 t/hr. Effective conveying distances can range from just a few feet to up to 300 horizontal feet and up to 150 vertical feet. Material pick-up can be accomplished automatically through feeding hoppers (e.g. tote bins) or manually by an operator with suction wands.

The volume of the bulk material receiver and the vacuum pump capacity dictate the conveying parameters. Assuming an average atmospheric pressure of approximately 1,013 mbar, a vacuum of -910 mbar could lift a closed water column approximately 30 vertical feet. However, because powders and bulk materials are always conveyed with a certain amount of feeding air, greater conveying heights are possible. Depending on the characteristics of the material being conveyed, heights of more than 150 ft have been realized. Achievable throughputs or capacities are strongly dependent upon the properties of the powder and bulk materials. Bulk density, adherent or bridging characteristics, particle size, surface shape, humidity and fat content, design of the pick-up point, feeding air supply, and of course, the total conveying distance, height and number of bends are crucial parameters of specific conveying tasks. For different products, alterations in throughput are common and can reach up to 4,500 lbs/hr, even with the same type of conveyor.

In the case of harmful powders or potent pharmaceuticals, vacuum is the preferred choice

VACUUM CONVEYING SYSTEM

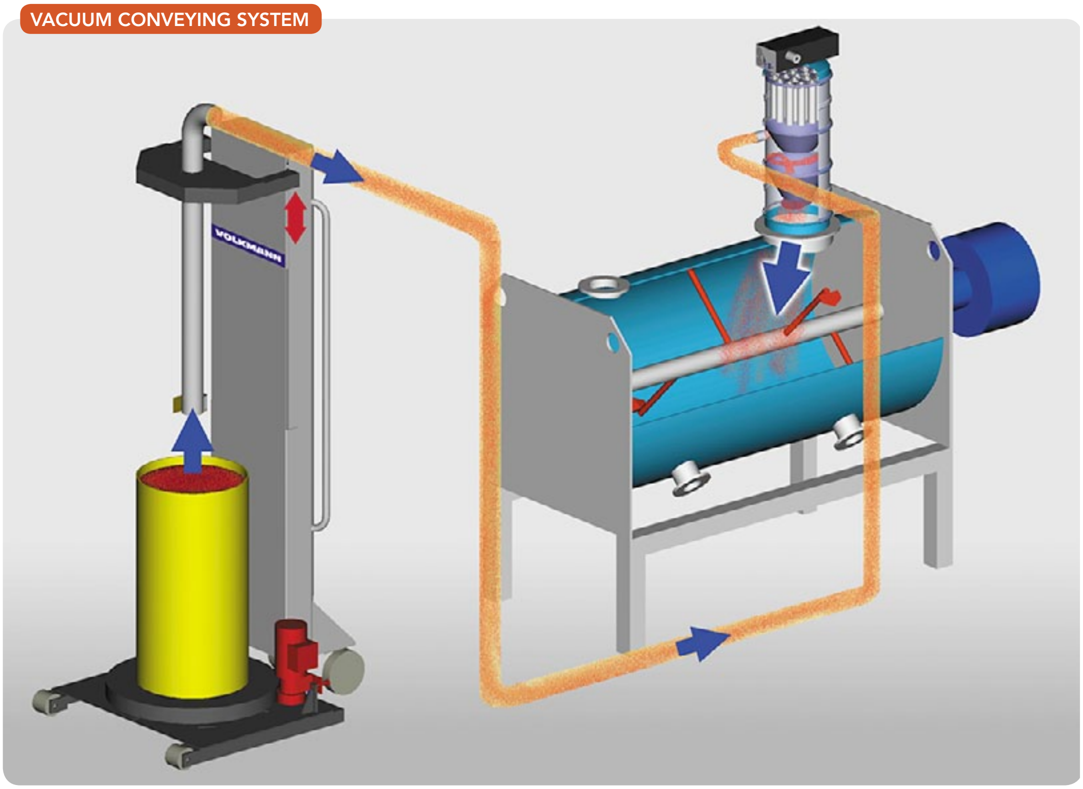

Figure 1: In a vacuum conveying system, material is drawn from the drum (left) by vacuum through a suction hose or pipe into the bulk material receiver (right).

in enclosed systems to achieve required containment levels. Volkmann offers a series of PPC Vacuum Conveyors currently used in production areas where an occupational exposure band (OEB) of 4 with occupational exposure limit's (OEL) from 1–10 pg/m^3 are monitored.

THE BULK MATERIAL RECEIVER

In vacuum conveying, material is drawn by vacuum through a suction hose or pipe into the bulk material receiver (Figure 1). Because many production processes require multiple powders or granulates to be conveyed with the same equipment, it's important to have a receiver with a simple assembly to allow quick and easy manual dismantling and cleaning to avoid cross contamination. The Volkmann VS and PPC series of vacuum conveyors feature a unique, stainless steel modular design with clamp rings allowing no-tools assembly and disassembly for cleaning and fast product changes. Alternatively, the vacuum conveyor can be designed to allow washing in place (WIP) or even cleaning in place (CIP). For example, manufacturers of paints and coatings use Volkmann systems to convey different dye powders (particle sizes 0.2 to 50 microns) or even toner, where major color changes from black to white are possible without difficulties.

All units offer stainless steel construction and fulfill the stringent hygiene demands of the pharmaceutical and food industry (Figure 2). Stainless steel construction is also very durable and robust, allowing up to 90 mbar absolute vacuum, while being lightweight and fully

mobile as needed. Volkmann conveyors feature stainless steel construction combined with design modularity permitting individual vacuum conveyor configurations to meet specific conveying tasks. Such customization might include modules with special suctions inlets or integrated cyclones which can be crucial for successful conveying.

A bulk material receiver equipped with a choice of powder process valves and optional fluidization and discharging aids will allow even bridging and sticky powders to be fed into the process. In most cases, the compact design allows the bulk material receiver to be mounted directly above the plant vessel or equipment which has to be loaded (Figure 3). A case in point would be a small vacuum conveying system for sugar. The complete conveyer could have a height of only 18 in, an 8-in. diameter and a total weight of only 14 lbs and be able to convey 1,100 lbs of sugar per hour into a mixer at a height of 14 ft. When space is limited, the small profile of these powder transfer systems plays an important role.

The optimum configuration for a vacuum conveyor to meet a specific application is often found by means of practical, one-to-one scale trials. Because modular, stainless steel systems are very easy to handle and integrate, trials can be performed in test laboratories or directly at the on-site process.

If the bulk-material receiver is combined with either stationary or mobile hoists, its ability to serve other applications increases. Therefore, it's no surprise that these pneumatic powder-transfer systems are replacing more and more conventional mechanical conveying methods like screws, augers, lifts, belts and bucket conveyors.

VACUUM PUMPS

In vacuum conveying, the driving force for powder transfer is pure vacuum. Therefore, choosing a pump with the proper function and size for the process at hand is just as important for a working conveyor as the optimum selection of the bulk material receiver configuration. Vacuum pumps

STAINLESS STEEL CONSTRUCTION

Figure 2: Stainless steel vacuum conveyors come in a variety of designs and sizes.

can be either electrical or air-driven, and specific models should be chosen based on the application. Criteria such as maintenance-free operation, small proportions and lightness, as well as easy adjustment and control are also important considerations.

Multiple-stage ejector pumps are frequently used in vacuum conveying. Volkmann offers a patented Multijector pump (Figure 4) functioning under Venturi principles. Generally speaking, compressed air isn't the most economical source of energy; however, the Multijector pump offers efficient conversion ensuring cost-effective performance. It is five times more efficient than conventional single-stage ejectors and because they offer cyclic, non-continuous operation, they compare in energy usage with electrical pumps forced to run continuously by design. Their air flow above vacuum performance is actually comparable to an electric positive displacement pump rather than a conventional, limited single-stage ejector.

Multijector pumps operate by creating large volumes of suction air flow (e.g. for dilute phase conveying) and are also able to generate extremely high levels of vacuum of up to -910 mbar (used for dense phase and plug flow conveying).

COMPACT DESIGN

Figure 3: This vacuum conveyor (front, right) allows the bulk material receiver to be mounted directly above and feeds powders into the process vessel beneath.

The amount and pressure of the compressed air supply also are easily adjusted to allow application-specific control of conveying a variety of powders and other bulk materials. They build up and break the vacuum rapidly, thereby providing intermittent conveying, filling and discharging the bulk material receiver in cycles. Energy costs are minimized as the pump consumes no energy during the discharging cycle. The range of available pump sizes in combination with the range of receivers, enables further energy optimization in relation to individual conveying applications.

In addition, pumps with no revolving parts require no lubrication or maintenance, and generate no heat. On the contrary, a cooling effect is measurable on the surrounding air. Noise levels are low, typically less than a comparable electrical pump due to the lack of moving mechanics, even with generated air flows from 1–450 scfm.

If a Multijector vacuum pump is combined with a Volkmann bulk material receiver, the complete conveying system works pneumatically and allows operation in explosive zones without difficulties. These vacuum conveying systems are ATEX certified for all relevant powder and gas EX zones.

FILTER SYSTEMS

In all vacuum conveying systems, solids are drawn into the bulk material receiver before

being fed into the production process. To avoid contamination of the environment and potential explosions during this material transfer, a dust-tight operation is optimal. In actuality, the physical principle of vacuum is the first step in avoiding contamination of the environment. Where a leakage in a positive pressure conveying system will inevitably lead to dust emissions, a vacuum system just draws in air in the face of a leak. Special filters within receivers can safeguard the environment further by ensuring dust-tight operation, providing filtration capabilities for even superfine dusts like toner powder (particle sizes down to 0.2 um). For this reason, a fabricator of carbon black and soot changed his positive pressure system to that of vacuum conveying, dramatically increasing plant cleanliness.

For best operation, filtration systems should be largely maintenance-free, and easy-to-clean when product changes occur. Volkmann offers filter choices to suit the application. For chemical or lacquer applications, the intermittent conveying provides effective filter cleaning through back-blowing air shocks. This avoids gradual blocking of the filter. In food and pharmaceutical industry applications, solid filters constructed out of polymers or stainless steel are also offered. This ensures wear-resistant operation and permits wet cleaning with warm water or steam when needed.

Filtration of the conveying air also is critical during vacuum transport. Reducing the material's velocity with an increased diameter in the receiver can achieve this. The majority of the loose powder drops out of suspension and is collected in the bottom of the receiver above the discharge valve. Additional collection of the fines takes place with tangential suction modules with internal cyclones. Residual fines are held in the receiver at the filter unit, just below the Multijector vacuum pump.

Depending on the application, filter lifetimes of two years or more are not uncommon. If standard filter cleaning isn't sufficient for exceptionally adherent materials, it's possible to vibrate the filter unit and the bulk material receiver to remove the material.

MULTIPLE STAGE NOZZLE ARRANGEMENT

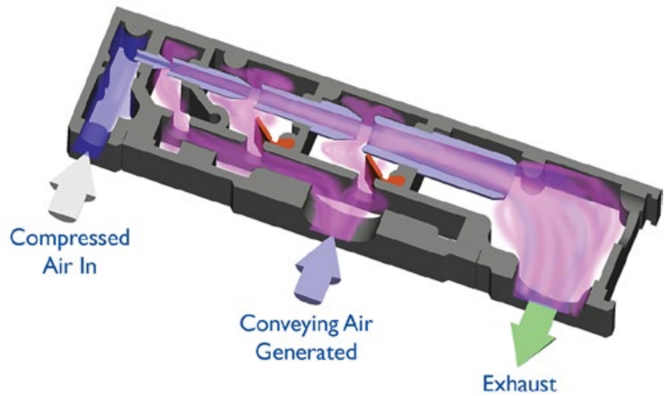

Figure 4: Multiple stage ejector pumps like the Multijector for Volkmann are frequently used in vacuum conveying.

OPTIMIZING VACUUM CONVEYING

By using the appropriate vacuum receivers, pumps and filters, complex transport and feeding devices are possible. For example, multiple product feed locations can be supplied with various receivers having a single control and one central vacuum pump. All product sources — bulk bags, sacks, silos — can be connected to all possible destinations — mixers, reactors, sieves — by means of pipes or hoses and respective diverter valves. It's equally possible to pick up the materials with only one conveyor on multiple charging locations.

The range and variety of vacuum conveying systems allow successful adaptation to nearly all process requirements.

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