The Idea Book for Safe, Smooth Conveying by Volkmann

Our Engineering Team Selected These Nine Articles for Your Bulk Material Handling Success

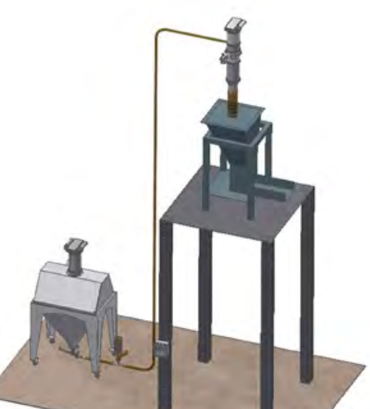
As featured in: POWDER & BULK SOLIDS

Dave Nichols

Conveying Considerations When Transferring Up and In

Selecting the ideal solution to move material from point A up and in to point B from a wide variety of conveying options available is often confounding.

Transferring powders and other bulk materials from floor level up and into a hopper, feeder, mixer, reactor, or other destination ranks among the most common material transfer applications. Yet selecting the ideal solution to move the material from point A up and in to point B from the wide variety of conveying options available often confounds even experienced powder handling professionals – especially those under pressure to place safety, throughput, automation, dust control, contamination prevention, ease of use, and cost all among the top priorities. Each conveying approach offers distinct capabilities and characteristics that either support its use for a given up and in application or disqualify its use as inefficient, ineffective, or even outright dangerous.



In this common up and in example, material is loaded into a bag dump station at floor level then automatically transferred vertically via a pneumatic vacuum conveyor set above a hopper for discharge into a feeder, mixer, reactor, or other destination. VOLKMANN USA

Conveyors Support Safety

In many food, chemical, pharmaceutical, and other manufacturing plants, the most common up and in type of installation still involves a worker carrying bagged powders, pellets, and other bulk materials up stairs onto a mezzanine, or up a ladder, then dumping the dry solids into a surge hopper, feeder, or directly into a tank, mixer, or reactor. Though simple and seemingly inexpensive, this manual approach invites serious health and safety risks proven to cause expensive workers' compensation claims and exposes the company to liability.

Hauling 50-lb bags of flour or sugar over the shoulder and up stairs creates a high risk of slips, trips, falls, back injuries, and a variety of other ergonomic concerns. Emptying the bag and loading the materials into the hopper or port by hand often exposes workers to contact with the material as a cloud of airborne dust and/or as a dusty layer blanketing his or her clothing. If ignitable powders and combustible dusts are involved, then a static discharge caused by the sliding action of emptying powders from bags becomes a real threat to trigger an explosion. Loading the material into an existing mixture or liquid also invites vapor exposure and may generate a hazardous splashing effect. Any conveying approach that automates this material transfer process naturally eliminates the numerous safety concerns that inherently plague manual handling approaches for a vastly safer work environment.

Conveyors Support Consistent Quality

In addition to protecting workers from exposure to the material, it may be equally important to protect the material from exposure to workers and to the workplace. Many materials are highly sensitive to contact with air or moisture and even short-term exposure during the up and in transfer process may compromise their material properties. For example,

A pneumatic vacuum conveyor transfers coffee beans up and into a hopper for grinding. Volkmann conveying systems use stainless steel as standard to excel in food, pharmaceutical, and other sanitary processes (Volkmann USA).

ascorbic acid (vitamin C) loses its antioxidant capabilities, pectin loses its gelling ability, some polymers begin curing prematurely, and powders such as corn starch, whey protein, lecithin, and dry milk clump very easily, which may adversely impact flowability and alter how the ingredients interact in the recipe.

Some applications call for metering or dosing materials into a process and this can pose an especially challenging task for workers emptying the materials from bags by hand. Loading minor and/or micro-ingredients into a mixer, for example, often requires attention to proper dispersal to ensure the targeted homogeneity is achieved. Erratic loading or imprecise manual measurements may leave key ingredients unmixed in a finished product that ultimately needs to be discarded as waste. The diversity of materials, recipes, production targets, and of the myriad up

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and in applications, along with the challenges of manual powder handling, have led to the development of a diverse range of conveying solutions to match the ideal conveyor to the application.

While worker safety and contamination control often factor into the decision to upgrade from a manual material transfer process to an automated conveying system, the primary driver justifying the investment is often throughput. As companies grow and need to scale, or as consumer demand for a niche, regional product takes off nationally, the manual method simply cannot deliver the increased production volume required. Consider the process engineer for a nutritional products manufacturer, for example, who needs to transfer large amounts of a protein powder from the discharge under a mixer or dryer up and in to the nearby hopper above a vertical form fill seal machine on a packaging line. Several different conveying methods may be suitable:

Watch exactly how a pneumatic vacuum conveying system automatically transfers seeds from floor level up and into a hopper for fast, efficient bag filling.

Belt Conveyor

The traditional belt conveyor can be used to transfer powders at up to 100 tn/hr, given a wide enough belt running at a high enough belt speed. It excels when transferring materials with a high bulk density such as cement, aluminum, and salt in mining operations. In this protein powder case, to raise it from the floor level under the mixer up to the hopper of the nearby filling machine, a belt conveyor would require a steep incline that would allow the powder to slide down and off of the belt. Or, to prevent this, a very long conveying length could be used to allow for a gentle incline, but this would require far too great a distance to suit this application.

Bucket Elevator

A bucket elevator excels in transferring bulk materials vertically and is, therefore, often specified to accommodate tight space constraints. It consists of a series of open buckets attached to a belt or chain that lifts the material up to the desired height and discharges at the top. Like open belt conveyors, bucket elevators expose the material being transferred to the open-air environment during the entire operation. This doesn't immediately disqualify its use for all food products, but the risk of contamination due to humidity, contact with air, workers, or chain lubricants, plus issues with pest control and product spillage suggest that it may not be ideal for a sanitary process. In this case when transferring a protein powder for human consumption, the process engineer needs to consider this lack of containment in the context of the required level of cleanliness and sanitation. Further, cleaning each, individual bucket for product changeovers poses a time-intensive challenge.

Flexible Screw Conveyor

If exposure to the open air needs to be avoided, how about an enclosed approach that reduces the risk of contamination? A flexible screw conveyor is one example of an enclosed material transfer approach. This bulk material handling system transfers the materials from a hopper at floor level up a rotating screw conveyor set inside a plastic tube to discharge at the top. This helps prevent exposure to contamination during transfer, though loading the material in the hopper is typically performed manually and may generate a dust cloud depending on the material. It can move materials horizontally or at an incline to navigate space constraints but often needs to be set at a particular angle near 45 degrees to achieve efficient transfer at any reasonably high throughput. The steeper the pitch, the more this type of conveyor struggles when transferring mixtures and/or materials with wide particle size distributions. Further, a given amount of the material must remain in the screw after the hopper has been emptied and material discharged. Though the product loss may be minimal, this creates an issue with cleanup and sanitation that needs to be avoided.

Tubular Drag Conveyor

What about a conveyor alternative that's enclosed for contamination control but can also handle transferring materials at a variety of angles including vertically, and even around corners, if necessary? A tubular drag conveyor offers an enclosed conveyor system that uses a continuous loop of cable or chain with attached discs set inside a tube. As the cable or chain moves, it pulls the discs, which carry the bulk materials up and into the destination.

A plant engineer watches as a pneumatic vacuum conveying system from Volkmann automatically transfers powder up and into a stick pack machine. Transferring finished products up and into filling and packaging lines automatically speeds production, prevents contamination, and promotes a clean, sanitary work environment (Volkmann USA).

This mechanical conveyor provides gentle transfer for sensitive products, it can accommodate several curves and bends, and can be used in sanitary operations. Though it checks several critical boxes in our pro-

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tein powder transfer system, as a mechanical approach, the tubular drag conveyor may struggle to reach the speed and throughput required.

Pneumatic Vacuum Conveyor

A pneumatic vacuum conveyor uses a vacuum pump to create negative pressure that draws powders, granules, pellets, and even small components from the pickup point up through enclosed tubing and into the discharge. As a sealed system, vacuum conveying provides containment to safeguard against product contamination, prevent worker exposure to and contact with the material in process, and eliminate the risk of nuisance dust in the work environment. Without any belts, chains, cables or other mechanical parts, this approach reduces friction to allow for high-speed material transfer and high throughput rates in a choice of dense phase or dilute phase. The material flows automatically and consistently as a continuous stream or with gentle pulses to protect particle integrity. Line downtime for mechanical wear part maintenance is also eliminated, along with any concern for product contact with lubricants, greases, or metal parts.

Vacuum conveyors that use flexible tubing can fit into compact spaces and effectively transfer materials up vertical inclines and through a number of curves and bends into the discharge. For the example case transferring protein powder from a mixer up and into a hopper, pneumatic vacuum conveying offers the high throughput, gentle conveying, and product containment required, and accommodates steep angles and vertical configurations that fit tight spaces. It excels in sanitary processes and vastly improves efficiency and worker safety versus manual methods. Any risk in transferring dangerous combustible dusts and ignitable powders is virtually eliminated.

In addition, off-the-shelf vacuum conveying systems suit a wide variety of applications with little to no customization. Workers with little technical expertise can typically manage the installation process and operate the system without outside engineering assistance.

Positive Pressure Pneumatic Conveying

Vacuum conveying's alter ego, positive pressure pneumatic conveying, uses compressed air to push materials through the piping or tubing from one point to another rather than draw it from the discharge end with a vacuum pump. This approach offers smooth, gentle, contained conveying in either dense phase or dilute phase comparable to vacuum conveying. It is often specified when materials need to be transferred long distances at high throughputs, when space allows for the large sending vessels, and when energy-efficiency is not a top priority. This air conveying approach would likely be deemed overengineered when considered for the protein powder installation.

Conveyor Return on Investment

From this review of conveying systems for transferring bulk materials up and in to process or packaging equipment, it is clear that several different approaches could be used to meet the application's requirements, though some are more efficient and effective than others. Thinking an automated approach is too costly, it is easy for many managers to overlook the hidden expenses involved with a labor-intensive, manual process. The disbursements of a single workers' compensation claim for a slip, trip, or fall in the US, for example, average $49,971, according to the National Safety Council. The cost of just one injury could easily exceed the investment needed to upgrade to nearly any of the conveying systems described, depending on the specific application. When also considering the immediate improvements in efficiency, productivity, and quality, and the cost savings in labor, automating the material transfer process is proven to deliver a return in a relatively short payback period. ■

Dave Nichols is vice president of sales and marketing for Volkmann USA. The company designs and manufactures pneumatic vacuum conveying systems, vibratory weigh feeders, and other process equipment. For more information, call 609-265-0101, email contact@volkmannusa.com, or visit www.volkmannusa.com.

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As featured in: Processing

by Rafael Navarro

Understanding ignition sources to avoid explosions

Despite recent attention to combustible dust, many processors operate in dangerous conditions as standard procedure. To support workplace safety, know how to keep sparks from flying.

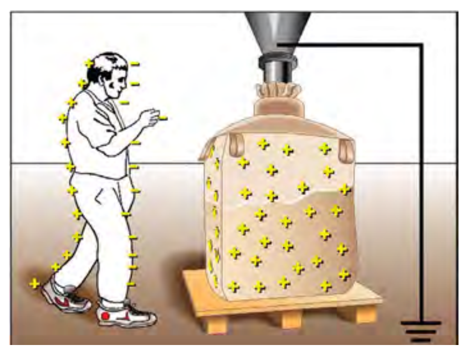
ATEX-certified pneumatic vacuum conveying systems permit safe material transfer in explosive environments. Volkmann VS Series model 250 is shown.

It may be alarming to learn that many workers are unknowingly doing their jobs in dangerous conditions and being protected from a potential explosion by not much more than luck. I received a call, for example, from a process engineer interested in upgrading an open powder transfer system to a contained pneumatic conveying system. The process involved manually pouring powders from bulk bags into an open vessel filled with ethanol and then conveying the mixture to another area downstream. It was surprising to find out the vapors were not being vented, removed or otherwise safely managed. Ethanol, by the way, is a highly flammable solvent with a flash point at just 55°F in its pure form and 97°F in 20% dilute solutions. Everyone understands how easily gasoline can catch fire or explode but ethanol actually carries greater flammability risk. It was also surprising to find out the workers emptying the bags into the vessel were largely unaware of the electrostatic charge that builds up when powders slide out of bulk bags, down chutes and against anything that causes particle separation. They were equally unaware of the risk posed by the ambient dust and vapor cloud billowing around the workspace.

An INEX pneumatic vacuum conveying system from Volkmann automatically transfers powders to a tablet press under an inert atmosphere. This system earned ATEX certification by eliminating the potential for ignition and avoiding explosions.

Consider that the open vessel created an explosive atmosphere with a mixture of combustible dust, air and vapors that would have been classified as a gas and dust EX zone and that the material discharged into an area with an explosive atmosphere that would have been classified as ATEX Zone 0 or 1 (Class I Div 1), and it becomes even more astounding the company escaped incident for so many years. Given the significant attention given to combustible dust safety and explosion prevention in recent years, one might think this happened 20 years ago, before the establishment of ATEX directives for explosion protection. But this happened last year, suggesting the issue of processing in explosive environments not only needs more attention but also needs constant reinforcement.

Yet, the presence of flammable vapors alone does not guarantee an imminent deflagration nor does the addition of air or combustible dust. A third element is required: ignition. Unfortunately, there are many potential sources of ignition in a plant environment. The ignition source that affects every type of processor and triggers a large portion of explosive incidents is called electrostatic discharge. When powders move and encounter particle separation, the particles often become charged, negatively or positively, while the conveyor, hopper, tank, drum, piping or other equipment also develops a corresponding charge. These situations invite disaster but are entirely invisible to the untrained eye. Since the human body is conductive, if an isolated worker shuffles his or her feet while unloading a bulk



Charged-IBC: Powder handling often creates charged particles on both workers and equipment that can trigger an explosive electrostatic charge. Proper grounding can continuously dissipate these charges and help avoid explosions.

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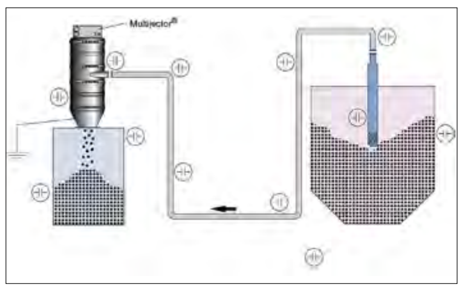
Did You Know? Pneumatic vacuum conveyors from Volkmann are automatically explosion-proof by design and ATEX-certified as proven suitable for hazardous locations.

bag or if charged dust particles on the worker's hands or clothing come in contact with the charged material or equipment, an electrical discharge such as a spark is likely to occur. This is often followed instantly by an explosion.

Since these electrostatic discharges are well understood, the preventative solution is as well. Each element in the process needs to be grounded to the earth to allow the electrostatic charge to be safely and continuously dissipated as it is generated. In a pneumatic vacuum conveying system, for example, all electrically conductive parts from the pick up location to the conveying pipes to the hopper, mixer, tablet press or other discharge location require proper grounding. Even each section of ductwork requires individual attention to grounding. When conveying hoses are used, specifying hoses with an internal grounded wire is not enough to ensure proper grounding. The grounding wire needs to be exposed and attached to a grounding port at the inlet to allow any charge to safely release. If a single clamp or connection becomes loose or misaligned after cleaning and maintenance, all of the careful grounding performed at installation may be nullified.

Filling a silo, discharging fines from a milling machine, and numerous other powder handling processes typically create these charged particles, and if continuous grounding is possible, then it allows them to dissipate safely. Where nonconductive materials such as coatings or cloth filter media interfere with the flow of electrical charges, engineered solutions are needed to allow safe grounding. Although our understanding of safe grounding dates as far back as Benjamin Franklin and his famous kite experiments, the knowledge is often taken for granted in the form of complacency. Remember that even lightning bolts from the sky pose an explosion risk that Franklin avoided with proper grounding via a lightning rod. But as Poor Richard might suggest, every processor operates on the verge of an accident.

Eliminating electrostatic charges as an ignition source in a processing plant boosts the level of safety by a large order of magnitude. However, other sources of ignition lurk in the plant that are less frequently charged in explosive incidents, but their impact is just as devastating. Sparks generated by mechanical action yield the same result as sparks generated by static electricity, for example. Consider a milling machine, mixer or lump breaker processing a fine powder when a steel nut or bolt comes loose. It travels downstream until entering a rotary valve and then comes to a grinding halt. Sparks fly as the metal churns against metal. An explosion ensues, regardless of the surety of the grounding. Vigilant preventative maintenance may prevent this situation. Specifying equipment with few fasteners and connections also helps reduce the risk.



Powder process equipment such as this pneumatic vacuum conveying system requires grounding at each individual section to ensure safe operation.

Or, consider the prevalence of open flames in industry. Wholesale bakeries use blow torches amid bulk bags of flour, corn starch and confectioners sugar. Welders join fine metal powders under intense heat with an open torch. Laboratory technicians often use ethanol to sterilize instruments, while nearby Bunsen burners heat their tests. All of these ignition sources have triggered explosions, and all of them were likely avoidable. Whether by open flame or by electrical heating equipment, nearly every processor applies heat to a material or ingredient at some point in the process.

Mixers, ovens, dryers, kilns and other heat transfer equipment with hot external surfaces not only pose a contact danger to workers but also pose additional ignition risk. If an exposed machinery surface is allowed to reach a high temperature in an atmosphere that contains flammable gases, vapors and/or dust, then an explosion may be triggered. The surface temperature, length of time in contact, and dispersion of the gases, vapors and/or dust relative to the size of the room affect the degree of risk. The surface temperature can be addressed with proper jacketing and by adjusting the placement of hot equipment out of the area. Or, the potentially dangerous atmosphere can be addressed by accounting for the flammable gases, vapors and/or dust, effectively eliminating the hot surface as an ignition risk. A growing selection of process equipment, for example, offers designed-in vapor management systems either to capture and safely vent flammable fumes generated in process or to establish an inert atmosphere that eliminates the potential for combustion. In powder handling, this is currently applied by the INEX pneumatic vacuum conveyors. This system uses nitrogen to create an inert atmosphere throughout the conveying process from pickup to discharge, continuously operating without risk of heat generation, electrical discharge or other concern for ignition.

While these are several of the most frequently encountered ignition sources, processors face innumerable hazards when operating with fine powders, solvents and other flammable materials. In fact, the National Electrical Code (NEC), also known as NFPA 70, lists additional ignition sources that are less prevalent in processing but can be equally dangerous. Electromagnetic waves, ultrasonic waves and high frequency radiation are among the others that may pose a greater risk in the future as plants become more and more automated. Given the range of ignition sources and the constant vigilance required to prevent their occurrence, it is vital to consider avoiding explosions entirely by preventing the necessary atmospheric conditions from arising in the first place as a philosophical directive. In cases where all manner of avoidance measures fall short of assuring the required level of explosion protection, a slate of constructive explosion protection systems and equipment are available to contain, sustain and suppress an explosive event. ■

Rafael Navarro is president of Volkmann USA. The company designs and manufactures ATEX-certified pneumatic vacuum conveying systems and other powder processing equipment and presents ATEX safety seminars for processors operating in explosive environments. For more information, call 609.265.0101 or email contact@volkmannusa.com.

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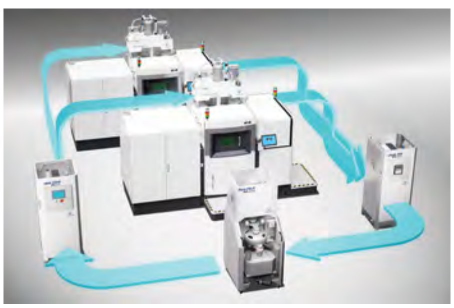
As featured in: FABRICATING & METALWORKING

Dave Nichols

Weighty Considerations Before Expanding into 3D Printing

Latest automated equipment helps metal fabricators tap growth potential of additive manufacturing.



In this closed-loop approach from Volkmann, loading metal powder into the printer, extracting excess powder, sieving and drying the powder, and storing it for reuse are automated in a contained system for safe, efficient 3d printing.

Metal fabricators poised for growth in the coming years, who may be considering investing in 3D printing equipment to tap into the projected $50 billion additive manufacturing industry, may be in for a surprise.

Expanding into 3D printing and efficiently integrating it into an existing operation isn't as simple as expanding the range of services with a new laser cutting machine, welding workstation or press brake. Metal additive manufacturing involves a completely different set of machinery and auxiliary equipment than traditional metalworking and comes with a completely different set of safety risks and physical infrastructure requirements that need to be considered.

Metal fabricators typically base their operations on working with bar stock, sheet metal, ingots, and other solid metals for subtractive processes that remove material such as machining, cutting and tapping. Additive manufacturing reverses the process by starting with fine metal powders and layering them into a solid part. Because most fabricators lack experience in handling, storing, and working with bulk powders, they may also lack an understanding of their inherent dangers.

Metallic powders such as cobalt, tungsten, aluminum, copper, Inconel, stainless steel, and others commonly used for 3D printing are toxic in varying degrees and milled to very fine particle sizes in a 20-to-45 micron range that must not be inhaled. These powders are also ignitable and labeled combustible in the forthcoming NFPA 660 Standard for Combustible Dusts and Particulate Solids Chapter 12 covering combustible metals. Failure to address these dangers in advance could result in serious worker injury and disease and/or a catastrophic explosion.

The 3D printing process involves the following steps:

1. *Loading material to the printer from a container, IBC, supply hopper or other storage unit.*
2. *Unloading excess powder from the build box after printing.*
3. *Collecting and screening the excess powder to remove agglomerates.*
4. *Returning the screened material to storage for future reuse or directly to the printer for the next build.*

Each step creates opportunities for metal powder spillage, release, and toxic exposure to workers and to the plant environment. In addition to the risks to personnel, these exposures also risk contaminating the metal powder. Ambient moisture and humidity, dust, dirt, and particulates from nearby machining operations, and cross-contamination from other materials lead to serious consequences. These contaminants may cause poor flowability, corrosion, poor bonding between layers, and a variety of part defects from reduced strength and porosity to uneven surface finishes and otherwise weakened parts that may not meet quality specifications. Such parts become a costly waste of time and powder. Depending on the material, even exposure to oxygen can render the metal powder as unusable waste.

For low volume additive manufacturing using a single 3D printer, the new PowTReX basic from Volkmann automatically integrates metal powder transfer, extraction, and sieving to permit the recovery and reprocessing of excess material on a compact footprint.

Automation Creates Efficiency in 3D Printing

When metal additive manufacturing began in its infancy, the process often required transporting the metal powders from storage containers by forklift or by hand to the 3D printers where workers then handled the loading into the build box manually while suited up in full hazmat gear. After printing, the same workers

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The PowTReX, which stands for Powder Transfer, Recovery, and Extraction, from Volkmann, automatically extracts the excess metal powder from the build box via a pneumatic vacuum conveyor, sieves it to remove agglomerates, and transfers the material for reuse.

manually unloaded and collected the excess or unused material and brought it to a screener, then collected it in a container for storage, reuse or disposal. In addition to the alarming safety risks, this process can be termed highly inefficient and not at all likely to bring the cost per part down anywhere near the cost per part of a traditional fabrication process, given a comparable design. At a time when the metalworking industry continues to struggle with recruitment and retention, asking workers to spend their days in these conditions isn't likely to lead to success in hiring.

Now that the industry has begun to mature, a slate of automated metal powder handling solutions is available to address the safety risks, improve production efficiency, and protect the powder purity for consistent, high quality parts. These automated systems were developed in a research collaboration among BMW, GKN Additive, and Volkmann GmbH of Soest, Germany, and are available in North America via Volkmann USA. In devising the additive manufacturing equipment, Volkmann's engineers drew on the company's several decades of experience in designing and manufacturing automated powder processing equipment, such as pneumatic vacuum conveyors, bulk bag unloaders, vibrating feeders, and lump breakers for the safe, smooth transfer of hundreds of different chemicals, food ingredients, small components, and other bulk products and materials.

As an example, Volkmann's flagship system for fully automating the 3D printing process features a closed loop concept that integrates all of the steps involved in transforming powdered metal material into structurally strong, durable, printed parts into one safe, efficient, contained system. Material is transferred from storage into the printer (or into multiple printers) via a loader that consists of a pneumatic vacuum conveyor, patented vacuum pump, filter, and accessories installed onto or alongside any manufacturer's 3D printer. At the press of a button, the system automatically transfers the metal powder through fixed piping or flexible hose up to 25 meters away and up to five meters of vertical elevation to discharge into the build box.

After printing, a depowdering station automatically cleans excess powder from the part and from the build box. Entirely within a sealed chamber, a proprietary combination of compressed air or inert gas, gravity, and a vibratory action remove any material left on the part and inside the build box and frame. The station leaves the build box pristine and ready for the next job and discharges the part ready for any secondary finishing operations. The cleaning cycle may take 10-to-30 minutes, depending on the part.

Another system, for powder transfer, recovery and extraction automatically extracts the excess metal powder from the build box via a vacuum conveyor, then sieves it through an ultrasonic screener to remove any fused bits of metal agglomerates. Oversized particles are collected and separated from the process while on-spec material may be either returned to the printer for immediate reuse via another vacuum conveying tube or pipe or stored in a storage vessel.

The storage vessel serves as a buffer container to hold extracted powder after screening and/or while waiting for a printing cycle to finish. To ensure the moisture content of the powder meets the required specifications, a vacuum dryer automatically restores metal powders that have absorbed ambient moisture during storage or transport to the proper moisture content value. It may be integrated in multiple points in the process both upstream of the printer to address virgin material and downstream to address excess material extracted after printing.

This type of closed loop approach automatically streamlines the process versus manual handling, reduces the number of operators involved in the process, and minimizes the fixed costs of offering 3D printing at the outset. As a contained system, it eliminates the potential for material contamination due to exposure to the environment, eliminates dangerous contact between workers and toxic powders — along with the need for hazmat-style PPE — and eliminates concern for material spillage into the workplace. Manual handling of heavy storage containers is also eliminated along with the need for forklift traffic to manage powder transfer to the printers. Further, the Volkmann pneumatic vacuum conveyors and associated equipment are explosion-proof by design and ATEX-certified documenting protection from such a catastrophic event.

Watch Volkmann's automated metal powder handling, depowdering, and reprocessing systems in action at BMW and GKN Additive 3D printing facilities. Volkmann, BMW, and GKN worked together to develop several additive manufacturing advances as part of the IDAM research project.

Additive Manufacturing As a System, Not Just a Printer

Many additive manufacturers began the process of offering metal 3D printing with a focus on purchasing the ideal 3D printing machine to produce existing parts faster or to position the company for a future that seems to arrive more quickly every day.

While purchasing the appropriate printer is certainly critical, determining the appropriate powder handling system to keep the printer

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printing rather than sitting idle is equally critical to recouping the investment in the latest technology. Unfortunately, a number of AM managers have neglected to consider powder storage, transfer, and recycling early in the process and have struggled to create space in the facility for the 3D printing machinery and infrastructure, to keep the operation fully staffed, and to capture the promise of fast, efficient, low-cost production. Using a manual powder handling approach, for example, typically requires a separate room or area for printing to prevent the metal powder from contaminating other work in process or other metal material stocked in inventory.

When considering offering metal additive manufacturing in the range of metalworking services, it is useful to involve engineers with expertise in powder handling for 3D printing early in the process. This helps to avoid costly and potentially dangerous errors and ensures the new service may begin generating ROI as quickly as possible. ■

Dave Nichols is vice president of sales and marketing for Volkmann USA. For more information, call 609-265-0101, email contact@volkmannusa.com, or visit www.volkmannusa.com.

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As featured in:

BAKING BUSINESS.com
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by Lucas Cuni-Mertz

Meet the Expert: Volkmann's Dominick Fortuna

Dominick Fortuna's fascination with baking goes all the way back to making ciabatta bread with his grandmother and pizzelles, a traditional Italian cookie, with his aunt. But it wasn't the bread or cookies that caught his attention.

Dominick Fortuna

"I remember being much more interested in sifting the flour and figuring out how the oven worked," Mr. Fortuna said. "They never used a recipe; they just knew how to mix the ingredients and knead the dough just right, and everything we baked came out perfectly every time. I'm not sure how they'd feel about baking almost anything automatically at the press of a button today, but looking back at these early experiences with my family, it's clear that I was meant to be involved in engineering."

Mr. Fortuna attended New York-based Rensselaer Polytechnic Institute and graduated in 1992 with a bachelor's degree in mechanical engineering, taking a position at a small bulk material handling company soon after. He then served as project engineer and project manager with a global machinery manufacturer. Mr. Fortuna's role in the company eventually expanded, and he moved from his engineering position in the United States to a managerial role in Singapore and then Shanghai, where he received a master's degree in international business strategy from Rutgers University.

"As much as I naturally enjoyed designing and building machinery, I found taking on exceptionally large projects and putting together just the right team of experts to get them done especially rewarding," Mr. Fortuna said. "We would design and build entire plants from scratch, for example, from feasibility studies to engineering, machinery specification, manufacturing, installation, commissioning and maintenance services."

Mr. Fortuna continued to serve in engineering management over the next decade until he was recruited to serve as president of Volkmann's North America division. He jumped at the opportunity.

"I was already familiar with their pneumatic vacuum conveying systems and knew their technology was as good or better than any conveying system in the market," Mr. Fortuna explained.

As president, Mr. Fortuna gets to combine his passion for engineering and his managerial expertise.

"As an engineer, I enjoy when a well-designed concept becomes a reality in the plant. Seeing the equipment we discussed, designed, manufactured and installed out in the field operating as planned, and helping our customers gives me a great feeling of satisfaction. As a manager, I enjoy seeing our people grow in their positions as they take on new and bigger challenges."

How Can You Avoid Combustible Dust Explosions? What Are Some of the Most Common Combustible Dust Hazards?

For an explosion to occur, an ignitable fuel source, oxygen and an ignition source must all be present. In a bakery, grain dust, milk powder or sugar in the air, on surfaces and/or on the floor may provide the fuel source. The most common ignition source is an electrostatic charge. These charges can develop any time a worker manually empties a powder from a bag or bin into a mixer or hopper. Sparks and hot surfaces like ovens or other equipment can also ignite a dust cloud.

Keeping powders from escaping into the plant environment and keeping the plant clean at all times are key practices for avoiding explosions. Specific to conveying ingredients, open conveyors like belt conveyors and bucket elevators allow powders and other dust particles to collect on equipment and cloud the air. Besides the potential for contamination, this creates a constant combustible dust hazard that needs constant attention to cleaning.

Our conveying systems are fully contained so materials cannot spill out or enter the plant environment, which removes the fuel source from the equation. It also eliminates the ignition source so that an explosion or deflagration simply cannot happen.

What Are the Benefits of Using a Pneumatic Vacuum Conveying System?

Pneumatic vacuum conveying systems automatically and gently transfer powders, seeds, nuts, mixtures and other products and ingredients from one point in the process to another in a sealed, contained system. This safeguards the ingredients from contamination, safeguards workers from exposure to dust and promotes a hygienic workplace.

As an automated system, it eliminates manual bag handling along with its ergonomic issues and its explosive issues already covered.

Instead of a worker carrying heavy sacks up to a mixer inlet and emptying it in a cloud of dust, or using a lift truck to haul bulk bags through the bakery to the mixer (or other equipment), the bags can be automatically

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emptied from a bulk bag unloader directly into the conveying system and transferred into the mixer at the press of a button without exposing the ingredients to the plant environment and without anyone lifting anything.

Production moves faster with consistent product quality, workers are safer from dust and ergonomic hazards, and management gets some protection against staffing issues.

How Do Certain Ingredients Affect the Conveyor Needed?

Whether we're transferring wheat flour, confectioners' sugar, dried cherries, chocolate chips or a mixture like trail mix, we'd typically specify our Volkmann VS Series hygienic conveying system and adjust the size based on the requirements of the process. It's versatile and flexible and the same system can be used to transfer very fine ingredients to large chunks of chocolate breakup. Food processors commonly switch our conveyors from one ingredient to another between batches multiple times per day. The vacuum receiver, filter and other components disassemble without tools in minutes for cleaning.

How Much Does It Cost for a Wholesale Bakery to Begin Automating Production?

Automating an entire manual production line all at once can cost millions of dollars, depending on the scale of the production line. For a wholesale bakery working to increase production without relying on additional staff, it may make more sense to begin automating one step in the process at a time.

Starting with the mixer can instantly speed the process but at a cost of $300,000 or more. Starting with a pneumatic vacuum conveying system also speeds the process instantly but at an initial cost of only $30,000 for an entry-level system — more bang for the buck. Then other steps in the process may be automated as the budget allows.

But be careful. Eliminating a bottleneck in one area via automation, such as loading ingredients into a mixer, can create bottlenecks upstream or downstream as other equipment or workers try to keep pace with the automated system.

Watch how easily one worker can transfer nuts, grains, and other ingredients from bags into a mixer or other equipment using a Volkmann bag dump station and pneumatic vacuum conveyor.

How Does Volkmann Equipment Help Bakers Deal with Current Industry Challenges?

When our food industry customers recognize it's time to look at automation, they're usually already experiencing problems with throughput, staffing, product quality or something else that needs immediate attention. So we need to be able to specify the right solution and deliver it fast. Then we need to stay in touch with strong support. By design, our conveying systems assemble fast and are easy to install. ■

As featured in: POWDER & BULK SOLIDS

Dave Nichols

Material Costs Drive Heavy Demand for Automated Weighing and Feeding

As risks of overages and underages garner more attention, powder processors are automating weighing and feeding.

Pneumatic vacuum conveyors from Volkmann transfer multiple materials from multiple locations then companion vibratory weigh feeders weigh and dose them into a central tank. The entire process may be automated as shown or the weighing and feeding functions alone may be automated.

As the weight of ever-increasing costs becomes heavier and more difficult for companies to pass along to the consumer, tolerance for imprecise measurement of materials and other resources is no longer acceptable. In today's economy, accounting for every ounce of every component has become vitally important. Identifying sources of waste and adding automation in key areas such as weighing and feeding supports efficient processing, cuts costs, and assures quality production.

Material waste commonly occurs as spillage due to manual handling such as when receiving material from suppliers, during transfer from storage into a hopper, mixer, reactor, bag dumping station, or other equipment, and when weighing materials as batches. A food manufacturer recently eliminated the potential for these material losses by replacing manual handling with automation in several key places. A pneumatic vacuum conveying system automatically transfers ingredients from bulk carriers and railcars to storage silos. A bulk bag unloader automatically empties the ingredients directly into the conveying system for transfer either to storage or into the process. An integrated vibratory weigh feeder automatically measures the amount of each ingredient specified for each batch. Automation replaced the scooping, spilling, and dumping involved in weighing with an approach that yields consistently accurate, repeatable weighments and cuts the potential for material losses as waste.

Human Errors Lead to Overages in Weighing

Losses due to spillage in powder handling pale in comparison to the potential for losses at scale due to human errors that lead to overages in weighing. Consider a worker scooping powdered milk from a large bag into a small bin then weighing the small bin. As a process with an inherently high margin of error in repetitive, manual human application, the process depends highly on the skill, experience, and consistency of the worker to achieve an accurate measurement. Different workers on different shifts may load varying amounts of ingredients into the process. Workers commonly add slightly more material than is needed. Though it may or may not affect product quality depending on the processing window, this overage often adds up to significant losses over time.

For example: If this food manufacturer uses a manual hand scoop method for adding powdered ingredients to the mixer and the measurement accuracy is 5%, which means that for every 100 units of milk powder added, the actual amount added can allow an overage of up to 105 units. If the powdered milk costs $6.63 per pound and the recipe calls for 500 pounds per day then the company would be using up to 525 pounds each day, on average, for a cost of up to $3,480 per day.

Now the company upgrades to an automated weigh feeder with a measurement accuracy of 0.5%, 10 times more accurate than the manual method. This means that for every 100 units of milk powder added, the actual amount added can reach up to 100.5 units.

This vibratory weigh feeder from Volkmann features an optional, built-in load cell for weighing. It automatically weighs a preset amount of material and gently advances it either continuously or in precise doses.

With the more precise, automated weigh feeder, the company would be using up to 502.5 pounds each day, on average, for a cost of up to $3,332 per day. This yields a savings of $148 per day. Using an average of 25 working days per month, the cost savings total $44,400 in raw material costs alone that recur annually.

The same manual process that may lead to costly overweighments also may lead to

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underweighments. Using fewer materials than is called for in a recipe may, at a glance, seem less costly than using more, but delving deeper reveals that underweighments may be just as costly - and possibly more damaging.

Using the same example: The hand scoop method with the measurement accuracy of 5% means that for every 100 units of milk powder added, the actual amount added can also drop to as low as 95 units. If the processing window allows such wide variance without compromising product quality, then the recipe may be adjusted to use the lesser amount of milk powder as standard. But for most recipes, a 5% shortfall of an ingredient leaves reactions incomplete, causes nonuniformity in mixing, and leads to other problems such as clogs in the process equipment, excessive cleaning headaches, and an end product that fails to meet quality requirements. The cost to discard an entire batch as waste--which may

A pneumatic vacuum conveyor from Volkmann continuously discharges material to a companion vibratory weigh feeder for uninterrupted feeding. This system also may be configured for dosing as a loss-in-weight feeder.

exceed thousands upon thousands of dollars plus labor and lost time--renders any potential material savings earned by under weighing as painfully insignificant.

Now upgrade to the automated weigh feeding system with a measurement accuracy of 0.5% and the average weight on the low end drops to as low as only 99.5 units instead of 95 units. This ensures the recipe is followed precisely and consistently every time and that product quality is on-spec every time. Eliminating batch to batch inconsistencies and saving on material costs also creates a ripple effect through the entire process that improves overall efficiency and throughput yet cannot be fully quantified.

Automated Processes Can Still Generate Waste

Even automated processes with highly accurate weighing still typically generate waste. In years past, these waste streams were often landfilled without concern for the disposal costs or for environmental considerations. Today, as process equipment has advanced, along with the concern for sustainability in manufacturing, these waste streams are being reexamined as supplemental material sources and new revenue streams.

Instead of discarding off-spec product, for example, it is now not only possible but often viable to automatically collect it and return it upstream to the production process. Whether a batch or continuous process, the waste material may be collected in a hopper, conveyed to a lump breaker to return the material to a uniform particle size, then discharged into a vibratory weigh feeder for dosing or metering the material back into the process for mixing with virgin material. The weigh feeder may be adjusted to set the ideal ratio of reclaimed to virgin material as needed. This concept reduces material costs for uninterrupted, recurring savings. In other cases where off-spec material cannot be reused, it can often be repurposed. The fermentation waste generated during beer production contains proteins and fiber that can be dried, weighed, bagged, and sold to other companies as a nutritious flour or animal feed, for example. This diverts the waste from disposal and creates fresh, recurring revenue.

Watch how a Volkmann pneumatic conveying system automatically transfers seeds to our Vibrating Feeder Dosing System for continuous discharge.

Summary

Automating weighing, feeding, conveying, and other processes offers significant, tangible returns in reduced material costs, increased throughput, labor savings, and improvements in quality and consistency, often with a return on investment in as soon as a few months. Replacing even a single manual operation such as weighing with the latest automated equipment positively and quantifiably impacts the entire process without committing to the investment of a fully automated facility. ■

Dave Nichols is vice president of sales and marketing for Volkmann USA. The company designs and manufactures pneumatic vacuum conveying systems, vibratory weigh feeders, and other process equipment. For more information, call 609-265-0101, email contact@volkmannusa.com, or visit www.volkmannusa.com.

VOLKMANN
IDEAS AHEAD

As featured in:

POWDER & BULK SOLIDS

Dave Nichols

Explosion Avoidance: Safer than Containment and Suppression

Powder processing and combustible dust explosions occur far too often considering the vast base of knowledge and experience accumulated among process engineers, process equipment manufacturers, industrial safety professionals, and explosion protection system suppliers. An average of 31.8 combustible dust explosions happen every year in the US alone, according to the DustSafetyScience 2020 Combustible Dust Incident Report, mostly involving the food, wood, and metals industries. Many of these explosive incidents caused fatalities, serious injuries, and triggered financial losses in the millions. Few would argue that explosions need to be avoided. Yet for many companies, the standard procedure for managing explosion hazards calls for suppressing, containing, or venting explosions - after the explosions occur. These suppressed, contained, or vented explosions cause much less damage than if there were no suppression, containment, or venting systems in place, but doesn't it make more sense to prevent explosions from occurring in the first place? Avoiding an explosion at the conveying equipment design and specification stage eliminates the risk and liability entirely. To eliminate the risk of explosion hazards in pneumatic vacuum conveying systems, first consider the anatomy of such an explosion:

A plastics processor transfers polyethylene powder from storage to a twin screw extruder for mixing and compounding via an automated pneumatic vacuum conveyor, for example. As the material flows through the piping, an electrostatic charge builds up, the greater the conveying velocity, the greater the charge. Since the enclosed conveying system contains the material inside and prevents fine dust particles from escaping into the plant environment, the facility manager, despite paying attention to combustible dust safety, overlooks the danger posed by this electrostatic charge. Though the system was properly grounded at installation, a clamp connecting the conveyor discharge to the extruder infeed hopper was misaligned when returned to service following a routine maintenance check. This simple clamping issue blocks the electrostatic charge from safely dissipating the energy to the earth, resulting in a catastrophic explosion (Figure 1).

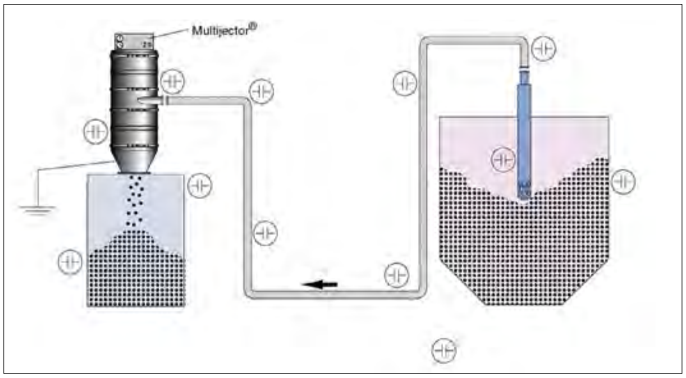

Figure 1: Electro-Charge-Diagram: Powder process equipment such as this pneumatic vacuum conveying system requires grounding at each individual section to dissipate the electrostatic charge generated during material flow.

Every deflagration requires an ignitable fuel source, oxygen, and an ignition source. In this example, the polyethylene powder provides the ignitable fuel source and the electrostatic charge developed during powder transfer in the absence of proper grounding provides the ignition source. Many factors influence how and when each of these three components conspire to lead to an explosive event but all three must be present.

To help assess the risk, engineers designing pneumatic vacuum conveying systems use a measurement called minimum ignition energy (MIE). The MIE attempts to quantify the minimum amount of spark energy needed for a given powdered material to ignite, as measured in mJ. Grain dust--the fuel source culprit involved in many industrial explosions--often has an MIE of 55 mJ, powdered sugar 30 mJ, magnesium 20 mJ, polyethylene 10 mJ, and toner 1 mJ. The lower the MIE, the more sensitive the material and the greater the risk of an explosion. An MIE at 100 mJ or less typically demands equipment and staff are properly grounded and systems established to prevent fine particles from becoming suspended in the air. An MIE at 25 mJ or less demands additional consideration due to its high sensitivity to ignition.

Adding to the challenge, materials may yield different MIE results at different times. For example, even very slight changes in the particle size or shape, moisture content, concentration, humidity, and/or air pressure during testing may result in large variations in MIE. If a processing line is designed based on a bulk material with an MIE of 50 but a different supplier delivers the material with an MIE of 40 then trouble may follow. Further, two or more materials with relatively high MIE and low risk of ignition when mixed, reacted, crystallized, conveyed together, or otherwise processed, may measure a very different and far more sensitive MIE downstream than when in storage. These and other characteristics all need to be considered when assessing the risk and likelihood for the material to contribute to an explosion.

To safeguard against the potentially catastrophic consequences of an explosion, many companies invest handsomely in clever systems to suppress, contain, or vent the explosive energy in hopes of minimizing the damage to personnel, equipment, and to ongoing operations. Suppression systems use instrumentation that automatically senses when a deflagration has occurred. The explosive force is mechanically

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isolated within the vessel or space to keep it from expanding to interconnected equipment while a high pressure, chemical suppressant such as nitrogen instantly extinguishes the reaction. Containment systems focus on designing the process equipment to withstand the maximum pressure projected based on the material in process and other conditions. This may entail adding rupture disks or other relief devices to allow the explosion to occur without incurring catastrophic levels of damage. Similarly, venting features designed-in openings in vessels or other equipment that direct the explosive force to a safer location, such as outside the facility. Rupture panels, hinged doors, and other types of covers may keep the majority of the force contained in one place.

While the engineering behind these systems is both impressive and proven in operation, they share a potentially fatal flaw: they are all designed to operate after the fact – after an explosion occurs.

Preventing Explosions from Occurring

Even a suppressed, contained, or vented explosion typically triggers substantial line downtime to assess damage and affect repairs. Preventing explosions from occurring in the first place seems a far safer, less costly, and more desirable outcome. Recalling that an explosion requires an ignitable fuel source, oxygen, and a source of ignition, such as a spark, to occur, eliminating any one of the three requirements would achieve explosion-proof status. Given that transferring the ignitable powder likely keys the company's operation, eliminating the fuel source is impractical. Oxygen can be removed from the conveying system and replaced with an inert gas such as nitrogen, but this is often an excessive and unnecessary approach for transferring most materials. But eliminating the source of ignition from the equation is both possible and proven effective.

Figure 2: Volkmann-VS-Conveying: The latest pneumatic vacuum conveying systems like this ATEX-certified Volkmann VS Series model 250 eliminate the potential for an explosion rather than suppress, contain, or vent the explosion after the fact.

By operating entirely pneumatically without electricity, without rotating parts, without generating heat, and with proper electrostatic grounding, these conveying systems eliminate the source of ignition as a risk factor (Figure 2). This design earned the ATEX certification as suitable for safe installation in all dust explosion areas. According to the noted Dr. Martin Glor of Swiss Process Safety Consulting GmbH, for handling powders with low MIE, avoiding effective ignition sources typically should not be applied as the only protective measurement, "However, Volkmann vacuum conveyors, due to the avoidance of effective ignition sources, can be applied as a sole protective measurement."

Hundreds of these conveying systems worldwide transfer powders, granules, flakes, and other bulk materials as specified without incident.

As companies invest in workplace safety initiatives and divert resources to comply with the many regulatory requirements, guidelines, codes, and recommendations, savvy engineers are rethinking the logic of allowing explosions to occur by design and recognizing that avoiding explosions offers a more certain approach to safeguarding employees, minimizing risk, and keeping production moving. ■

Dave Nichols is vice president of sales and marketing for Volkmann USA. The company designs and manufactures ATEX-certified pneumatic vacuum conveying systems suitable for transferring ignitable dry powders down to 1 mJ MIE or lower and presents ATEX safety seminars for processors operating in explosive environments. For more information, call 609-265-0101 or visit www.volkmannusa.com.

VOLKMANN
IDEAS AHEAD

As featured in: Processing
SOLUTIONS FOR THE PROCESS INDUSTRIES

Dave Nichols

Evaluating conveying equipment for changeover compatibility

Many manufacturers tout how quickly and easily their equipment can be cleaned and adjusted for fast, easy changeovers. But after installation, the reality may be quite different. For frequent product changes, design for quick cleanability is key.

Health and dietary trends come and go faster than ever. Whether it is no carbs, gluten-free, fat-free, healthy fats or replacing prescription pills with organic foods as medicine, American consumers seem eager to chase the next wellness idea regardless of FDA approvals or peer-reviewed data. This can be a boon for food, nutrition and pharmaceutical companies that offer the right product mix at the right time. But these trends are typically short-lived and may leave gleaming new processing capacity idle as each hot health craze is superseded by the next.

This is a key reason why processing versatility has overtaken sheer speed among the most important factors in process equipment purchasing. Versatility enables manufacturers to quickly capitalize on the next trend, adjusting flavor profiles, adding functional ingredients and shifting resources to new product R&D without investing in expanded facilities or dedicated, new equipment.

Versatility as a business strategy also relies on frequent product changeovers, with myriad adjustments to one or more machines and a complete cleaning inside and outside to prevent cross-contamination. Though many manufacturers claim that their equipment cleans easily, after installation when performing an actual changeover, end users often realize that this is not the case. However, a situation like this may represent a failure to effectively communicate definitions of clean rather than a nefarious plot by the supplier to sell equipment.

Pneumatic vacuum conveying systems like the one shown in stainless steel from Volkmann are often used to transfer multiple materials and ingredients from different pickup points due to their designed-in cleanability for fast changeovers.

Defining Clean

Every process manufacturer needs to achieve a given level of cleanliness based on its own definition of clean. Even two competing process manufacturers producing similar products can view cleanliness differently. The definition is typically a balance of factors, such as the types of products in process, federal and local regulations, and the severity of consequences in the event of an oversight. A contract food processor transferring nuts into a mixer, for example, needs to be especially careful about the risk of cross-contamination when switching from peanuts to almonds due to the potential allergen risk. However, the risk when switching from a coarse salt to a fine-grain salt are far less severe. Changeovers in a validated pharmaceutical process demand a higher level of cleanliness, with written protocols documenting how this extreme state of hygiene is to be achieved. The chemical makeup of a drug simply cannot be compromised by the residue of another active ingredient left in a hopper, conveyor or discharge chute. And frequent swab tests with laboratory analysis are often required to verify cleanliness.

These examples carry different levels of risk and, therefore, do not typically require the same level of cleanliness during changeovers. In fact, when cleaning between batches of the same or very similar products, equipment needs only to be "visibly clean" per the FDA, since there is little risk of cross-contamination. It is not uncommon for process manufacturers to target several different levels of cleanliness in the same plant or on the same production line depending on the products in process.

Defining Inspectable

Regardless of the targeted level of cleanliness, the equipment needs to be inspectable to test and verify that the level has been achieved. The 3-A sanitary standards the USDA uses for dairy processing provide a much clearer definition of inspectable than other regulatory agencies provide. Inspectable means an item or area can be made available or exposed for close visual observation. Further, component parts are to be fully accessible for inspection or cleaning, demountable parts are to be readily demountable, there shall be no non-inspectable surfaces, and all manually cleaned product contact surfaces shall be easily accessible for inspection and cleaning without completely entering the vessel, which would create an OSHA confined space entry safety risk. When frequent changeovers become the standard and change-

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over speed becomes increasingly important, the USDA's keywords to focus on when evaluating different types of conveying systems are readily, easily and accessible.

Belt Conveyors

On the surface, belt conveyors seem quite accessible. Workers commonly clean soiled belts, remove any carryback material and vacuum up spillage from the plant floor in between batches or when changing products. But cleaning and inspecting under the belt often presents a serious challenge, with a potentially long shutdown and tedious work for a skilled mechanic or maintenance person if removal is required. Any overlooked food residue can quickly develop infectious bacteria that affects subsequent material. These conveyors also invite contamination risk from contact with lubricants, pests, humidity and other factors due to their open exposure to the plant environment.

Flexible Screw Conveyors

Enclosed conveying systems reduce the risk of exposure to the plant environment but also block or reduce access to the interior for cleaning and inspection. Flexible screw conveyors, for example, set a screw auger inside an enclosed pipe. As the screw rotates, material moves from a hopper at the bottom to a discharge at the top. In a frequent changeover situation, a screw conveyor often becomes a hindrance to speed and efficiency because it is difficult to access the interior. The conveyor must be detached from the hopper and discharge end, the screw removed — often using a hoist — then each flight cleaned, and the pipe interior cleaned with a long brush. Because the disassembly and inspectability are not readily or easily accessible, flexible screw conveyors are better for transferring powders in a process dedicated to a single product or material.

Bucket Elevators

The engineering behind a bucket elevator is very similar to that of a screw conveyor, but instead of enclosing the material in a pipe, the material is transferred in individual buckets while exposed to the plant environment. This is not ideal for sanitary processing. Depending on the layout, accessing each individual bucket for cleaning and inspection is not difficult, but it is time-consuming, labor-intensive and subject to the same spillage cleanup and other contamination risks as with an open belt conveyor. Even in semi-automated and clean-in-place (CIP) environments, the cumbersome nature of a bucket elevator often makes disassembly, cleaning and inspection a significant project. Bucket elevators are typically specified to move large volumes of powder when the targeted definition of clean is easily achievable using basic approaches to hygiene.

Pneumatic Vacuum Conveyors

Pneumatic vacuum conveying systems operate in a fully enclosed process that safeguards against contamination from exposure. Typically featuring a vacuum pump or pressurized sending vessel to generate the transfer action, a pneumatic vacuum conveyor creates a sealed, dust-tight system that automatically conveys powders, pellets and other bulk materials through hoses or piping from storage directly into a mixer, reactor or other vessel without worker involvement. Downstream, these air conveying systems can also be used to capture finished products, such as tablets from a tablet press or a mixture of dried fruits and nuts and convey them directly to storage or to filling and packaging.

Access for cleaning and inspection is critical for smooth changeovers. The Volkmann VS vacuum conveyor shown earned a patent for quick disassembly without tools for access to the filter system inside.

With the ability to capture material from an open drum, bulk bag unloading station or silo, the same conveying system may be used to transfer different materials from various sources into a process multiple times per day, every day. This versatility also means that the system may need to be cleaned and inspected multiple times per day, every day, depending on the required standard of cleanliness.

Each connection linking the conveying hose to a feeder, discharge chute or other equipment may need to be disconnected, cleaned and returned to service. The vacuum pump may need to be disassembled to access and clean the internal air filter to prevent entrained fine powders from contaminating the next material. Hoses may need to be disconnected, cleaned, dried and returned to service.

But pneumatic conveying systems are not all created equal. The Volkmann Multijector vacuum pump, for example, earned a patent for easy access to the filter system without any tools for complete disassembly, filter replacement and cleaning either by hand or through a parts washer in less than 10 minutes. In fact, since an entry level worker can easily manage this part of the changeover process with minimal downtime, many companies that install these systems increase the frequency of product changeovers beyond the level anticipated because the headache factor and risk of cross-contamination have been virtually eliminated.

At a time when process manufacturers need to produce multiple products on the same process equipment with varying levels of staffing support, cleanability for frequent changeovers must be considered a vital asset in a conveying system. Speed of disassembly, ease of cleaning and access for inspection and verification are key factors. ■

Dave Nichols is vice president of sales and marketing for Volkmann USA. The company designs and manufactures ATEX-certified pneumatic vacuum conveying systems and other powder processing equipment and presents ATEX safety seminars for processors operating in explosive environments. For more information, go to www.volkmannusa.com, call 609-265-0101, or email contact@volkmannusa.com.

VOLKMANN
IDEAS AHEAD

As featured in: POWDER & BULK SOLIDS

by Nick Hayes

Additive Manufacturing Powder Handling: Time to Get Serious

As the growth of Additive Manufacturing (AM), or 3D Printing as it is commonly known, continues unabated, the techniques are being refined, the metallurgy of built components better understood, and productivity rates are accelerating. As a direct consequence, the need for the efficient and contained handling and processing of the metal powders that form the basis of the process has become increasingly critical. In short, unless the powders can be handled in volume and in a safe, contained way, the process will be limited to the highly specialized applications in aerospace and tooling.

In many of the current applications, two or three AM machines are typically in a room with the majority being fed with metal powder via small-volume containers. This may be acceptable when the number of AM machines is low and the build times take days. Yet, as AM machines inevitably increase in the production environment, and both the rates of manufacture and the size of printed components increase in turn, the effective supply of dense metal powders is an essential, rather than simply desirable requirement, if the technique is to reach its full productive potential. However, this effective transfer of metal powder must overcome two major factors: explosion risk and efficient transfer of dense metal powders.

The transfer of powders has long been a well-served area of engineering. From the days of an Archimedes spiral to today's advanced vacuum transfer systems, in food, chemical, and pharmaceutical industries the movement of powder within production environments is common. Nevertheless, while traditional machine shops are familiar with the requirements of bar stock and sheet metal, or even the use of casting techniques, few of them have experience in the safe and contained transfer of powders without the risk of explosion, let alone those with bulk densities as high as 650 lb/cu ft in a contained manner.

Here are the process requirements and challenges associated with AM:

- *Loading material to the printer from initial supply*
  - *Bulk IBC*
  - *Small containers*
- *Unloading surplus but unused powder from the build box and or the overflow collection and screening the product to remove agglomerates*
  - *Direct from the printer*
  - *From the overflow collection on the printer*
  - *From so-called unloading stations*
- *Returning material to the printer for use in the next build*
  - *After screening and collection*
  - *After blending with a percentage of virgin material*
  - *After drying, should the process be required, as may be the case in binder jet applications*
- *Achieving any of the above in either inert or non-inert conditions.*

Avoiding Explosion When Processing Metal Powders

One of the obvious challenges is to keep the area of the workplace clean, and to avoid the risk of operators inhaling fine metal powders, while avoiding the need for cumbersome protective clothing and breathing apparatus. How many of us would enjoy our work if it involves full PPE day in and day out? Certainly, subtractive manufacture does not require this. For this reason, contained vacuum transfer immediately affords the advantage when compared to mechanical or positive pressure, or so called "blower system" pneumatic conveying in that in the unlikely event of a leak, air leaks inward keeping the powder contained.

Contained vacuum conveying is a simple concept. It essentially consists of a vacuum pump, a filter system, and a means of controlling the volume of powder within the generated airstream at a given velocity. The vacuum pump itself provides a means where the pressure in a system is reduced at the discharge end, and in so doing, causes air (or gas) to pass from the higher pressure to the lower pressure. For a given velocity, known typically as the saltation velocity, the airstream is capable of carrying a given amount of powder with it, thus transferring the powder from one end to the other. Upon arrival at the destination, a means of separating the powder from the airstream is needed, and hence a filter system is included to accomplish this.

Fig 1: Operating principle of a vacuum conveyor

Vacuum pump (1) produces negative pressure in the separating container of the vacuum conveyor. Air is sucked through the intake opening (2) having been transferred from a product feeding station and material for transportation is moved. The vacuumed air passes through the filter system (3) inside the separating container depositing material and it

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accumulates there. In the case of fine dust, an additional cyclone insert [used in the separator (4)] allows for higher flow rates due to lower filter surface load. After the separator container is filled, the vacuum pump is switched off. The pressure in the separating container quickly reduces to atmospheric pressure. The valve in the discharge module (5) opens and the transferred material falls from the vacuum conveyor directly into the receiving vessel. When emptying, the filter is cleaned by a back-flow pulse of compressed air. In this case, any filter cake is reliably removed. In the case of heavily 'bridging' or adhesive material, one can add optional piston vibrators and fluidizing units to aid discharge. After emptying is complete, the discharge valve closes and the conveying process begins again.

Fig 2. Metal powders are also known to be explosive; some are even selfigniting in certain conditions.

Top: The essential elements required for ignition

Bottom: Swiss expert Dr. Glor demonstrating that "the long duration of the flame compared to a gas explosion makes dust explosions particularly dangerous" during a recent seminar at a leading vacuum conveyor company seminar in Soest, Germany.

This all sounds simple enough, but as many readers will appreciate, unlike liquids, powders are far from predictable and behave in different ways depending upon such factors as moisture content, particle shape, particle size distribution, bulk density, and flowability, all of which combine to increase the challenge. To further complicate the situation, metal powders and indeed many powders that we might consider to be handled every day, can also be hazardous from a potential explosion perspective. Fine sugar, coffee creamer, and potato starch are examples of products known to have exploded when presented with the three conditions shown in figure 2.

Eliminating any one of the three factors shown in the "fire or combustion triangle" will prevent any risk of explosion. Generally speaking, particles greater than 500 microns are not considered to have a high risk. However, with metal powders typically in the D50 area of 30 to 45 microns, we cannot eliminate that sector.

Under the ATEX certification system for explosion protection, 13 ignition sources are identified as follows:

1. *Chemical reaction*
2. *Hot surfaces*
3. *Mechanical sparks*
4. *Flames, hot gases*
5. *Electric units*
6. *Flash of lightning*
7. *Electric compensation currents*
8. *Ultrasonic*
9. *High frequency radiation*
10. *Electromagnetic waves*
11. *Adiabatic compression*
12. *Ionizing radiation*
13. *Electrostatic charges*

Of the 13 factors listed, only the last is of concern in an all-pneumatic vacuum conveyor system supplying or unloading metal powder from the AM machine. By ensuring that all components are grounded and that each part of the conveying circuit is static dissipating, the last factor can be eliminated (Note: the commonly referred to condensate filtration and control is not part of the metal powder handling covered in this article and remains the responsibility of the AM machine manufacturer).

Critically, the ATEX Certification for explosion-free operation is only achieved after a rigorous process of detail design submission, testing and documentation, culminating in the award of a standard. The award is underwritten by the testing agency and results in the ability to use the Ex symbol with the statement of the areas and conditions for which it is approved. Here is an example:

ATEX certified for assembly in zones 1, 2, 21, and 22. EC type approval certificate number TÜV 02 ATEX 7005 X. Special conditions apply for the safe use of the equipment. II 1 D c 80°C/II 2 D c 100°C - /II 2 GD c 100°C (T4)

The European standard of ATEX testing far exceeds the approach taken by the US NFPA as can be seen in the NFPA 484 standard for combustible metals which states: "NFPA codes, standards, recommended practices, and guides ("NFPA Standards"), of which the document contained herein is one, are developed through a consensus standards development process approved by the American National Standards Institute. This process brings together volunteers representing varied viewpoints and interests to achieve consensus on fire and other safety issues. While the NFPA administers the process and establishes rules to promote fairness in the development of consensus, it does not independently test, evaluate, or verify the accuracy of any information or the soundness of any judgments contained in NFPA Standards."

Addressing Concerns About Oxygen in Explosions

Currently there is some confusion in the marketplace concerning the need to address another of the elements of the fire triangle: the presence of oxygen. There is no question that eliminating oxygen is one way of avoiding an explosion risk. However, it is not essential for any powder with a Minimum Ignition Energy (MIE) level great than 1mJ as we have shown from the previous ATEX certification statement.

Some user risk analysis studies have resulted in companies forming the opinion that reducing the oxygen level to below 6% is desirable, and while doing so definitely applies a belt and braces approach to safety, it is not needed as long as the ATEX certification exists and the safeguards are followed.

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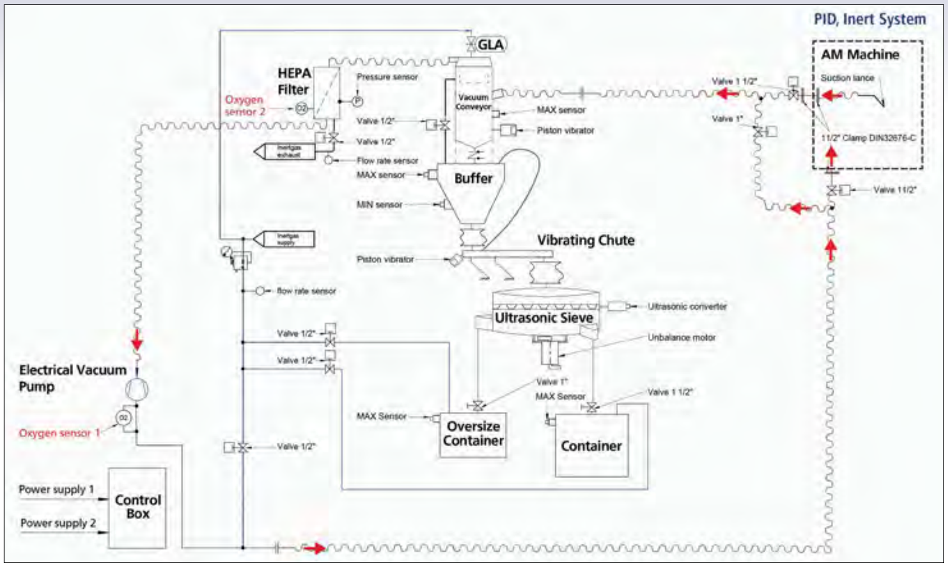

Fig 4. Example of a closed loop inert gas conveying and transfer system

There is a second requirement when conveying under inert conditions; namely, avoiding oxidation of the metal powder. This is an area for metallurgists to consider, but in either case, if inert transfer is needed, it is essential to use suppliers who have experience with such systems. Inert gas, typically nitrogen or argon, is expensive. In order to minimize the gas, the use of "so called" closed-loop systems have been employed. In these systems, the exhaust from the vacuum pump recirculates to become the conveying gas once more. Such systems require oxygen monitoring, the ability to purge the system and verify the O2 level, as well as controlling that level during the material transfer. An additional consideration, such as the increase in temperature and pressure that can occur during the recirculation until a steady state is reached, also needs to be addressed. Often this requires interface with the AM machine controls where permissive signals are needed to allow the process to take place.

Figure 4 above shows a basic closed-loop circuit for an unloading and screening station. Note that the container receiving the powder is inert and requires connection in such a way that the inert conditions are maintained when disconnected from the screener.

Efficient Metal Powder Handling

As outlined in the opening section of this article, the AM process requires several operations to ensure powder handling is efficient. It is also likely that additive manufacturers will have banks of machines using the same metal powder as the technique develops, as well as having some that are changing from material to material as the need demands. In the former case a conveying system that can both supply and unload three or four machines with powder, as shown in the graphic above, and in a contained, operator-friendly manner by using the same circuit, would be highly desirable.

In the case where one machine needs to be used with multiple, different powders, ease of cleaning between powder changes becomes the issue. How quickly can one change materials without the risk of cross-contamination? No-tools disassembly and quick-change filter systems are just two solutions to satisfy the obvious requirements.

Ever-increasing production requirements also demand a more efficient supply of raw material. Currently we see many of the metal powders being delivered in small volume hoppers or tubs. The simplest reason for this is the weight of the powder. Five liters of most material is a small volume, typically filling containers somewhat similar to the types of tubs in which protein powders are supplied. On the other hand, five liters of a dense nickel chrome alloy can weigh as much as 100 lb. As a result, manufacturers of these dense powders have taken to supplying multiple tubs on a pallet that require a fork lift to take them to the production machine. Worse still, they take a lot of shelf space in a warehouse or pre-use storage area.

Taking the Pharmaceutical Industry Approach

Suppliers of metal powders are now beginning to offer these powders in larger bulk quantities, delivering them within a hopper commonly known as an intermediate bulk container (IBC). For the heavier metals, 130 l is common. This solves the problem associated with the small containers, but requires a simple method of docking, dosing and possibly weighing the material as it is transferred to the printer using vacuum conveyors.

Powder handling equipment suppliers are now developing systems that will make increases in the production rate of additive

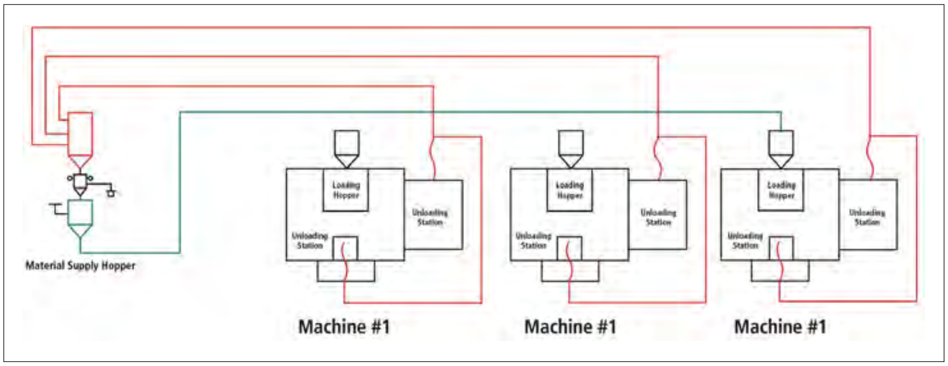

Fig. 5 Single conveyor system supplying multiple machines

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Fig 6: Recently displayed at FormNext is a 130-l IBC on a docking and weighing station along with a conveyor used for refilling the IBC with material that has been screened after passing through the printer build box.

manufactured components a practicality. Whether it is loading the printers, unloading them, screening the metal powder or returning previously used powders to the production process, it is clear that the handling and containment of powders in the production environment must develop if the technique is to become viable for the much larger general manufacturing market. Such systems must be capable of conveying dense, heavy metal powders in a contained, safe, and practical manner. ■

Nick Hayes is president, Volkmann Inc. Volkmann engineers and manufactures high-quality, high-performance vacuum conveyors, systems for additive manufacture, bag dump stations, unloaders, and equipment for the contained, gentle, and damage-free transport of metal powders, fine chemicals, granules, pellets, tablets, food particles, and small components for the pharmaceutical, nutraceutical, food, chemical, and additive manufacture industries. For more information, call 609-265-0101 or visit www.volkmannusa.com.

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Powder & Bulk Engineering

by Nick Hayes

The Challenges Of Handling Metal Powders For Additive Manufacture

As this new technology matures, additive manufacturing will create some serious safety and efficiency issues for those handling dense metal powders. Those issues are likely to become more prevalent as the industry moves from one of infancy to a more established manufacturing mode. This article discusses how metal powder vacuum transfer can help alleviate many of these problems.

The advent of additive manufacture (AM), or 3D printing as it's commonly known, has led to the requirement for safe handling of dense metal powders in an environment where there's typically little experience dealing with the difficulties associated with particulate material transport and containment.

Since the industrial revolution, metal component manufacturing has involved a combination of milling, turning, grinding, and fabricating techniques in a workshop environment where raw materials commonly arrive as bar stock, sheet forms, castings, blocks, or ingots. People involved in these traditional types of "subtractive" manufacturing (metal components are cut out of solid metal materials) using mills, lathes, and machining tools tend to have little knowledge or experience with the powder handling difficulties involved in additive manufacture. The issues are complicated by the need to carry out several different powder processing functions. Additive manufacture requires material loading, unloading, screening, and recovery in an inert or noninert atmosphere. These functions are different in terms of the conveying and handling needed. This article addresses some of these powder handling aspects that require careful thought and explains how vacuum transfer during the process can help ensure that the AM work place remains an efficient, clean, and safe area.

The AM Process

As the name implies, AM requires the ability to process metal powders by adding thin layers of powdered material, one on top of another, fusing each layer as it's applied, until the desired component is formed. Whether by laser fusion or use of a binder jet, these layers are spread in a method similar to a traditional laser-jet document printer. The process takes place in a build-box on an AM machine. A large proportion of the powder applied in each component layer does not become part of the actual component. This results in costly powder waste and requires that the unused material be recovered and reprocessed. These metal powders are heavy and potentially hazardous to handle.

Originally, loading and unloading AM machines was done manually, in small quantities, and by using smaller-sized containers. However, as AM production rates have grown, the need to efficiently deliver larger powder volumes both to and from the process has led to the need for material handling systems that offer a contained, safe, and user-friendly operation while also optimizing production efficiencies.

Investigating the available equipment options that can meet these requirements reveals that some have limiting factors. Flexible or rigid screw conveyors take up a large amount of floor space because of their need to convey at an angle. Transferring dense materials in a flexible screw conveyor isn't practical since the combination of the open auger and the need for material to act as the auger's bearing results in the auger's compression. Solutions such as aeromechanical conveyors, bucket elevators, and cleated belts aren't feasible, leaving pneumatic conveying and gravity discharge as the two best choices. Considering all the requirements of an AM environment, vacuum transfer can be a practical solution.

Consider All Powder Handling Requirements

The AM process involves several powder handling activities that should be considered before selecting equipment, including:

- *Loading new virgin material into the machine*
- *Unloading excess material from the build-box overspill*
- *Unloading unused material from the build-area around the finished component — either from within the machine or from an unloading station.*
- *Screening the excess and unused material*
- *Blending leftover and virgin materials*
- *Refilling the AM machine with blended and screened materials*

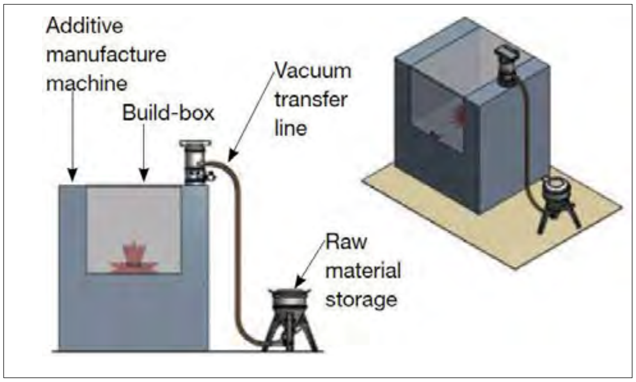

Figure 1. Load machine with material from storage.

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Loading virgin material. Supplying virgin metal powder to the machine, as shown in Figure 1, is much like that of loading tablet presses or capsule filling machines. The simplest option uses gravity and involves elevating bins (intermediate bulk containers) of material, as supplied by metal powder manufacturers, above the machine. The container is then connected to the feed hopper inlet and the material is discharged into the machine via gravity. This option sounds simple enough, except the method requires lifting the very heavy material containers, and, hence, requires sufficient space in the work area for a forklift to operate. Some sort of container support structure also is required on the machine to allow hopper docking. In many cases, the ability to do so and maintain inert conditions to prevent metal powder oxidation is added.

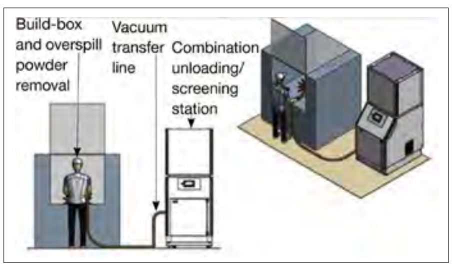

Figure 2.Transfer material from build-box to screener.

Unloading excess and unused material. Unloading overspill from the machine after a component is completed, as shown in Figure 2, necessitates some type of collection hopper supplied by the AM machine manufacturer, as well as a collection point for the overspill.

An AM machine's wiping action, which is similar to that of a silkscreen printing process, results in some material being "ploughed" to the end of the build-box area and into the collection hopper. Currently, these collection hoppers are typically small, but as AM production rates rise, so will overspill volumes, necessitating better metal powder collection and handling methods and larger hoppers. This leftover material also requires screening before it can be used for a future component build. A similar collection function involves collecting unused material surrounding the component. As much as 85 percent of the powder volume within the build box has to be recovered. To achieve this, the manufactured component and the nonfused or bound material must be removed and the latter screened for future use. Two common methods currently exist. The first involves simple suction of material and vacuum conveying it from within the build-box, while it remains on the machine. The second method involves removing the build-box on a platen-style station, similar to that used on a CNC milling machine, to an "unloading" station and the subsequent component and powder removal.

Screening, blending, and refilling. Figure 3 shows one option for returning the screened material to the AM machine — in

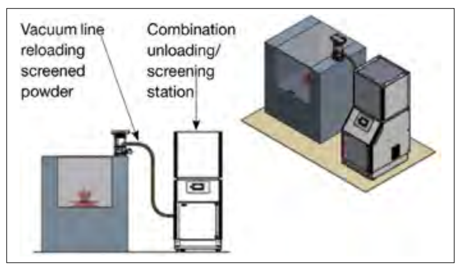

Figure 3. Load machine with material from screener.

this case from a combined unloading and screening station. The function is essentially the same as the initial AM machine loading but may involve the need to add a blending process prior to the AM machine, where the virgin and the already once-processed powder can be combined. These powder handling requirements exist for each AM machine, so as more machines are added to a plant, the requirements become more complex. Can the powder handing system handle a group of AM machines while still supporting the production rates? Is a separate powder handling room required to keep the production area free from these powder handling constraints? If a blending operation is needed, what type of blending should it be and where should the blender be located?

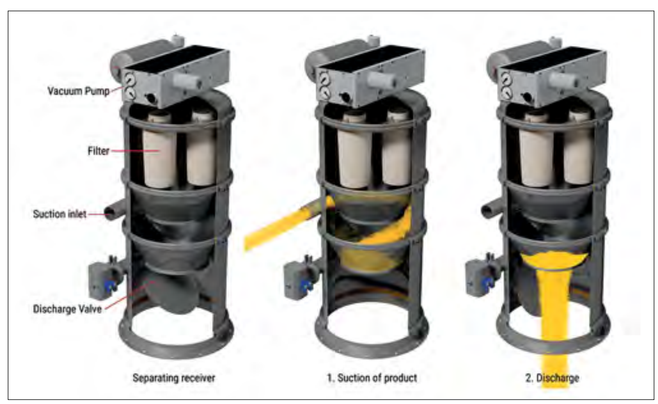

Figure 4. Design and sequesnce of a typical vacuum receiver.

Vacuum Conveying Solutions

Vacuum conveying, in one form or another, is a known technique for collecting powders and particulates. Industrial vacuum conveying systems exist to help meet AM dense metal powder safety and efficiency handling requirements, but not all systems are created equal. Many can't handle volume transfer of dense metal powders with bulk densities as high as 650 lb/ft3.

The vacuum transfer process is a simple concept. By using a vacuum pump, a vacuum receiver draws material and gas through a conveying line, achieving a lower pressure at the discharge end of the transfer line and generating air or gas flow from the supply point. By providing a filter system at the discharge point, powder is separated from the airstream and discharged into a receiving hopper. A typical vacuum receiver and its operating sequence is shown in Figure 4.

For dense metal powders, a conveying system design has several key requirements, including ease of cleaning, minimal material retention, and high-quality filtration down to the submicron particle range.

The type of vacuum transfer is particularly critical to successful conveying of dense metal powders. The choice is to either convey using high-velocity airflow, where the powder is conveyed in lean phase, or convey using low-velocity airflow dense phase transfer, which requires a high level of vacuum.

High-velocity airflow when conveying metal powders leads to abrasion and erosion in the conveying line, which can lead to potential contamination of the metal powder itself. As a result, the slower velocity dense-phase conveying option is preferred. To achieve dense-phase conveying, typical vacuum

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levels of between 15 and 22 inches mercury are needed for transfer. Systems using side-channel (regenerative) pumps or roots-type units aren't suited to this application.

Volkmann metal powder conveying systems for additive manufacturing automatically transfer powders to the 3D printers, then extract unused material from the build box, remove agglomerates, and transfer the material to storage or back to the 3D printer for immediate reuse.

Vacuum receivers have an advantage when conveying metal powders. The units are easily installed either directly on an AM machine or in conjunction with a surplus powder screening system for material collected during the build process. Vacuum units are inherently contained and in the case of AM, one must work with a system that is safe for the transfer of powders with minimum ignition energy (MIE) values as low as 1 millijoule. Furthermore, the potential exists to build a complete vacuum transfer system or loop allowing one main convey line to supply each AM machine's vacuum receiver with powder and to be serviced and filled by a bulk material supply system that typically can be located in a separate room. This layout or equipment setup is common in food processing facilities.

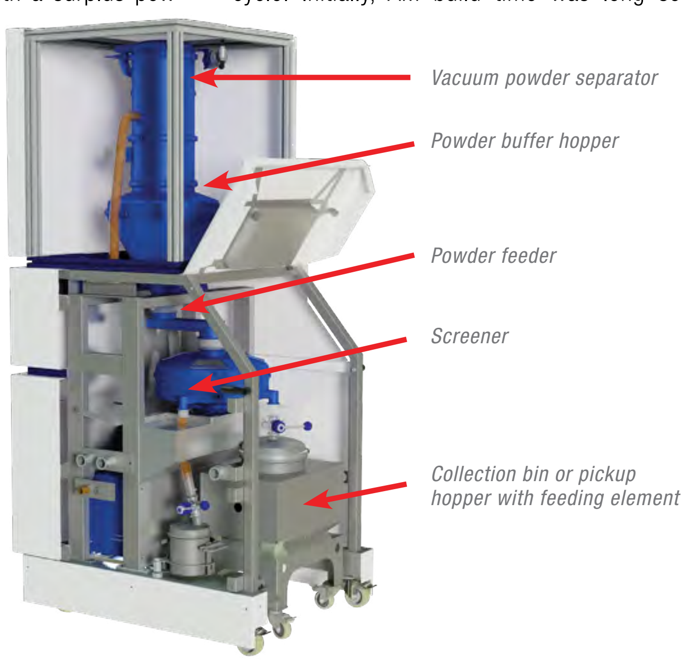

Figure 5. Unloading/screening, station.

Recovering powder from the AM machine for screening can be centralized with the option to either locate the process next to its associated machine or in a separate area, away from the AM production itself.

Here again, vacuum transfer shows its value since in vacuum systems controlling the feed to the conveyor with a metering valve isn't necessary. Material can be collected from the build-box, the unloading station, or the overspill area and transferred to a screener, where agglomerates are removed before collecting the powder in a bin or conveying the material back to the main powder supply point.

Combination unloading–screening stations can address the requirement to quickly unload an AM machine and begin the next component manufacturing cycle. Initially, AM build time was long so losing production time to unload wasn't particularly critical; however, with AM production rates increasing, unloading time needs to be minimized. In addition, the screening of fine powders can be difficult given the particle size range and the size of screen opening, typically in the 63 micron range, resulting in the process being slower than the vacuum transfer unloading rate.

This, in turn, leads to the incorporation of a buffer hopper system to allow rapid unloading where screening times are independent of the unloading, allowing the next AM process to begin without delay. An example of a self-contained unloader and screening station is shown in Figure 5.

Inert vs. Noninert Material Transfer

Further complications exist in that some metal powders can be transferred in a normal air atmosphere, whereas others require an inert gas of argon or nitrogen to control moisture and oxidation levels. Vacuum conveying techniques are well established for inert gas transfer applications for loading material into tanks or reactors containing volatiles. Adapting this type of experience and the techniques learned in these applications again points to the importance for AM users to involve knowledgeable powder handling equipment suppliers and experts from an early stage. Of particular importance is the use of closed-loop systems where inert gas use is minimized, oxygen content levels of between 2 and 4 percent are maintained, and steady state conditions can be achieved for safe metal powder handling.

Explosion and Other Risk Considerations

Metal powders used in the AM process are very fine, typically in the 20 to 45 micron range. They're not healthy for operators to inhale so require full OSHA-compliant personal protective equipment (PPE) clothing. Dense metal powder materials also are abrasive and potentially explosive. As a result, company safety officers who are new to the AM technique will apply risk analysis; however, plant personnel can be limited in their knowledge because they may not be familiar with handling bulk powders. These individuals, for example, may tend to specify electrical classifications such as Class II, Div. 1 or 2 for an

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explosion risk area rather than considering all 13 of the potential ignition sources that the ATEX code defines. The European ATEX standard, while not strictly applicable in the US, is possibly a complementary standard to use as a guide. It looks at the potential hazards in the process at the pickup point, within the conveying system during conveying, and at the discharge point. The standard applies zone ratings based on potential exposure of the material to an ignition source in sufficient quantity to cause an explosion.

In the US, NFPA 652 and NFPA 484 provide some guidance, although the section on AM is small, with much of the standard of the latter code dedicated to dust collection and vacuum cleaning activities that aren't the same. Undoubtedly, later revisions of the code will add recommendations.

Experienced Partners for Planning

Given all these factors that contribute to the safe and efficient handling of metal powders during AM, the situation behooves those new to the AM process to involve companies with wide experience of conveying powders, at an early stage in a facility's layout, thereby allowing the entire process to be considered from a practical powder handling perspective. This provides the ability to plan for future additional machines, with the ability to service multiple machines and, of prime concern, to do so safely in a contained system. Vacuum conveying becomes an obvious choice for handling dense metal powders in AM applications. Using this method allows handling these materials in a contained manner and in systems that are suitable for low MIE-value powders in either atmospheric or inert-gas transfer. Such systems are particularly suitable since they avoid the need for heavy lifting or the use of forklifts in the production area. As with many new technologies and techniques, the involvement of suppliers with experience can avoid considerable production- and employee-related problems as well as expensive mistakes, particularly in areas of safety and cost effectiveness. ■

Nick Hayes (contact@volkmannusa.com, www.volkmannusa.com), CMgr FCMI, and president of Volkmann Inc., is a mechanical engineer and a Fellow of the Chartered Management Institute. Originally trained at the Royal Aircraft Establishment in Farnborough, England, he has more than 40 years of experience in pneumatic conveying and bulk powder handling. In 2008, he joined Volkmann, establishing the North American division of the Volkmann Group, Volkmann Inc. Since that time, he has overseen the growth of the company from its US base in Bristol, PA.