THE

POTASH PROCESSING

HANDBOOK

FROM THE FEECO

MATERIAL PROCESSING SERIES

FEECO INTERNATIONAL

TOMORROW'S PROCESSES, **TODAY.**

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PRODUCING A PREMIUM PRODUCT

Introduction

FEECO International was founded in 1951 as an engineering and equipment manufacturer. We quickly became known as the material experts, able to solve all sorts of material processing and handling problems, and now serve nearly every industry, from energy and agriculture, to mining and minerals.

As experts in the field of mineral processing, FEECO has been solving problems through feasibility testing and custom potash processing equipment since the 1950s. We've helped our customers process hundreds of materials into value-added products, eliminating handling and transportation problems, improving product characteristics, and creating marketable products.

Many of the world's top companies have come to rely on FEECO for the best in custom process equipment and solutions, some of which include:

PotashCorp Helping Nature Provide
bhpbilliton
Mosaic
RioTinto
Agrium
K+S
INTREPID POTASH

For further information on our potash processing capabilities, contact a FEECO expert today.

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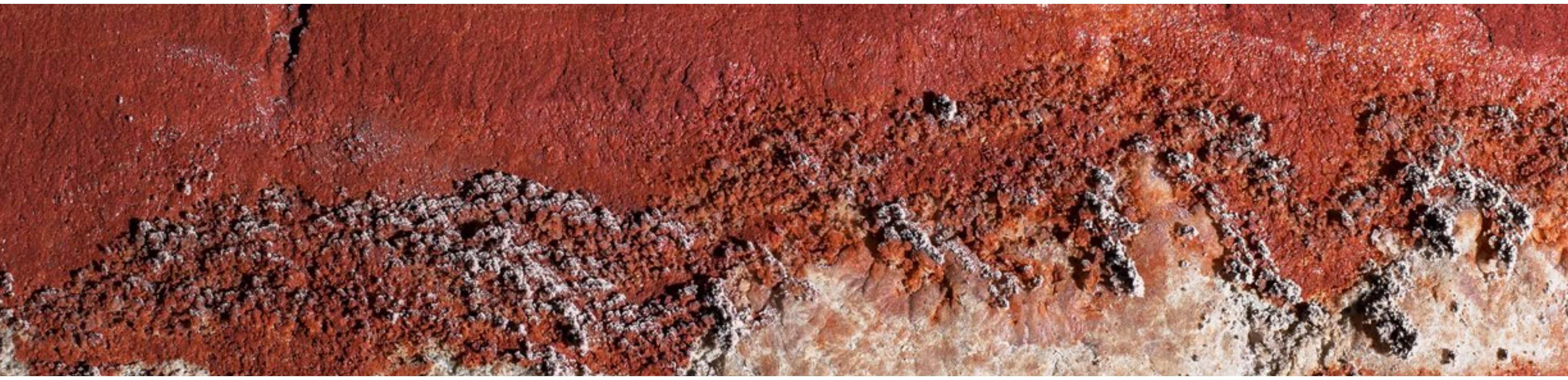
Find us on:

An Overview of
POTASH

Potash granules created in the FEECO Innovation Center



POTASH THEN AND NOW

The term *potash* generally refers to potassium chloride, although it is also loosely applied to a number of potassium compounds found in the agriculture industry.[1]

Utilized in a variety of products such as soaps, glass, and gunpowder, before it was mined for industrial use, early potash processing was a by-product of forest clearing, involving the burning of wood and leaching of the resultant ashes, garnering the name, *potash*. The discovery of deposits worldwide later opened the door to large-scale use of this versatile mineral.[2]

Today, the lion's share of mined potash goes to the agriculture industry, where, as one of the primary nutrients in plant growth, it has become a staple in modern fertilizer products.

Potash's role in meeting food security needs continues to grow; while the scientific community has long understood that potassium is a key contributor to overall plant health and quality, recent research has found that potassium plays an even more critical role than initially thought, particularly in terms of how plants tolerate stress.

The finding has prompted much excitement during a time when biotic and abiotic stresses on plants continue to escalate. Some experts anticipate that potassium will be especially important in drought tolerance—a growing concern amidst the uncertainties of climate change and dwindling water resource, making the potassium-bearing mineral ever more important.

This has pushed development of advanced processing techniques in the potash industry and has resulted in a wealth of options for processing this vital mineral, as well as exploration into unconventional sources of it.

Despite many advancements in both the potash and fertilizer industries, there is still a lot of groundwork to be done when it comes to processing potash into a refined product, particularly when working with non-traditional sources of the mineral; different deposits yield varying mineral combinations and present unique processing challenges. In addition, potash is generally a demanding material that requires an experienced hand to produce desired results.

The following takes a look at potash sources, processing techniques and equipment, the challenges presented by potash during processing, and how to combat these challenges.

AN EVOLVING INDUSTRY

Potassium's role in meeting global nutrition and food security needs cannot be understated. As the industry continues to adapt to meet the evolving demands of the global population, a few trends have come to the forefront. Here are some of the major trends that have been reshaping the potash industry in recent years.

SOP GAINING ON MOP

Historically, potash used in the fertilizer industry has been Muriate of Potash (MOP) or Potassium Chloride (KCl). Although MOP still accounts for the majority of potash fertilizer use, SOP is gaining ground.

Also known as potassium sulfate or sulfate of potash, SOP is stealing market share from MOP as an alternative offering advantages to some crops. The addition of sulfur, combined with a lower salinity and reduced chlorides, makes SOP an excellent fit for boosting yield and crop quality in high-value or chloride-sensitive applications, with experts predicting a healthy growth rate in market demand for the compound in the coming years.

SOP is also gaining interest for its use in organic farming, which continues to expand as a market. In contrast to MOP, SOP holds potential for organic certification when not manufactured via synthetic production.

GROWING INTEREST AROUND ALTERNATIVE SOURCES OF POTASH

Similar to the move to SOP, fertilizer producers are increasingly exploring alternative and specialty sources of potash.

Chris Kozicki, FEECO Process Sales Engineer, commented: "We still have a lot of traditional projects coming through the doors, but we have seen a significant uptick in specialty projects—even in just the past few years."

Some of the minerals being explored as alternative sources of the potassium nutrient include:

- Polyhalite
- Struvite
- Silicate rocks
- Langbeinite
- Leonite
- Granite dust
- Kelp Meal
- Wood Ash
- Green Sand
- Potassium nitrate

Feldspar is also being researched as an alternative source of potassium at MIT's Materials Research Laboratory.[3]

Kozicki notes that this exploration into alternative sources plays into the growing interest around specialty fertilizers and soil amendments brought on by the movement toward more sustainable nutrient management.

PREMIUM PRODUCTS MORE WIDELY ACCEPTED

Premium products are also becoming more widely accepted; while cost still remains a key factor in crop planning, the standard for products has been raised thanks to an ultra-competitive market.

Further, growers are more willing to spend a little extra on a product that adds value to their nutrient program. This might be through enhanced nutrient performance, the inclusion of a beneficial additive, or simply the selection of a higher-quality product to reduce dust and ensure application accuracy.

Two trends that seem especially dominant are wet granulation of potash and coating.

POTASH WET GRANULATION

Processing potash by wet granulation (also commonly referred to as pelletizing in this setting) continues to be investigated as an alternative to roll compaction.

Granules produced via wet granulation techniques provide several benefits to growers, including a significant reduction in dust, more accurate and predictable application, and faster nutrient delivery.

POTASH COATING

In addition to reducing attrition and improving product handling and storage, coating is also becoming a widely used approach to create a specialty product through the inclusion of a beneficial additive, whether to enhance the nutrition profile of the product or control release properties, among other things.

AUSTRALIA ENTERS THE MARKET

Australia has thrown its hat in the ring to bide for a spot as a global potash producer. The nation previously relied exclusively on imports of the nutrient, but with favorable market conditions, is looking to start up its own industry around domestic production, with several projects underway.

This comes not long after Saskatchewan took a hit to their competitive standing in the global market; in 2019, the province announced they were making changes to their tax structure—a move that would eliminate a popular tax credit, cutting into the industry's profit margins and adding to the uncertainty already in place from Bill C-69, legislation that aims to revamp the approval process for a range of development projects.

A DEEPER LOOK AT SOP

The growing market for potassium sulfate merits an in-depth look at this beneficial source of potash.

BENEFITS OF POTASSIUM SULFATE (SOP)

While muriate of potash serves as an excellent source of potassium and chloride, it is not appropriate in all settings. As many are discovering, SOP not only improves yield and crop quality, but it also presents a number of advantages:

REDUCED CHLORIDES

Chloride makes up a significant component of MOP. This may be preferable for some crops, but can be damaging to others that are sensitive to chlorides, such as some fruits, vegetables, and nuts. Many chloride-sensitive crops fall into the high-value category, so optimizing quality and yield are especially critical.

Additionally, if MOP is added to soils already rich in chlorides, toxicity can occur. When working with chloride-sensitive crops or chloride-rich soils, SOP provides an ideal alternative, as it is substantially lower in chlorides.

SOP granules produced in the FEECO Innovation Center

ADDED SULFUR

In addition to potassium, SOP also provides plant-available sulfur. Sulfur deficiencies have become increasingly common in recent years, making products that include the secondary nutrient increasingly desirable.

LOWER SALINITY

Potassium sulfate has a lower salt index than most potash fertilizers, making it the preferred choice when soil salinity is a concern.

ORGANIC CERTIFICATION

As mentioned, SOP offers the opportunity to be certified by the Organic Materials Review Institute (OMRI) for use in organic agriculture.

SOP PRODUCTION & EXTRACTION

Potassium sulfate (K_2SO_4) is not typically found as an existing compound in nature and therefore must be manufactured. There are two main approaches to obtaining SOP:

THE MANNHEIM PROCESS

Traditionally, SOP has been produced by the Mannheim process, in which KCl is reacted with sulfuric acid to yield K_2SO_4. Although this method does work, it produces the desired compound as a by-product; the primary product resulting from the process is HCl.

This process consists of first carrying out an exothermic reaction between potassium chloride (KCl) and sulfuric acid (H_2SO_4), and then an endothermic reaction between potassium chloride (KCl) and potassium bisulfate ($KHSO_4$) to produce HCl and K_2SO_4.[4]

The resulting K_2SO_4 is cooled in a rotary cooler and may be further finished into the desired product form.

While the Mannheim process is still in use, it has largely given way to an alternative method: extraction from natural complex salts.

Langbeinite pellets produced in the FEECO Innovation Center

COMPLEX SALT PROCESSING

Naturally existing complex salts can also provide a source of potassium sulfate. Here, potassium- and sulfate-bearing minerals are altered to remove by-products, leaving potassium sulfate behind. This process is highly complex and contributes to the often-high cost of SOP.

A high-level overview of the process could be described as ore preparation and flotation, conversion to and leaching of schoenite, and finally, moisture reduction in a rotary dryer. This process may differ depending on the complex salt being treated.

Langbeinite, in particular, is a well known source of SOP that has gained popularity in recent years. This nutrient-rich mineral compound ($K_2Mg_2(SO_4)_3$) can be modified to remove magnesium and obtain SOP, or it can be used as a potash fertilizer itself; in addition to potasssium and sulfur, langbeinite provides a source of the secondary nutrient magnesium. For this reason, it is also known as sulfate of potash-magnesia, or SOPM.

Kainite and carpathian polymineral ores are other common complex salts from which SOP is commonly derived.

Polyhalite, an evaporite mineral, is a similar source of SOP and magnesium. The mineral has been gaining interest in recent years, but is currently produced in only small quantities.

POTASH FERTILIZER PROCESSING

PELLETIZING | DRYING | COOLING | ROTARY VS. FLUID BED | GLAZING | COATING | HANDLING

FEECO Fertilizer Granulation Plant

PELLETIZING POTASH

While compaction granulation has long been the primary method used to process potash, pelletizing, or pelletization, is gaining popularity among fertilizer manufacturers looking for a premium, refined product that can quickly deliver nutrients. Pelletizing offers many benefits to the end product.

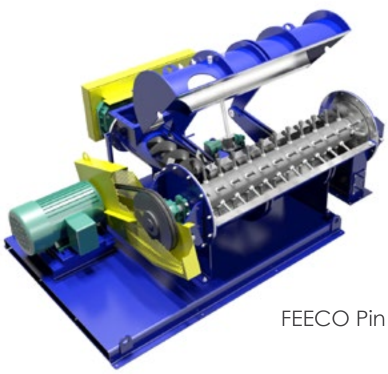
POTASH PELLETIZING PLANT OVERVIEW

The following is an overview of a typical potash pelletizing process. *See next page for diagram.*

PRECONDITIONING

1. First, finely crushed potash enters the pelletizing process through a raw material feed bin.

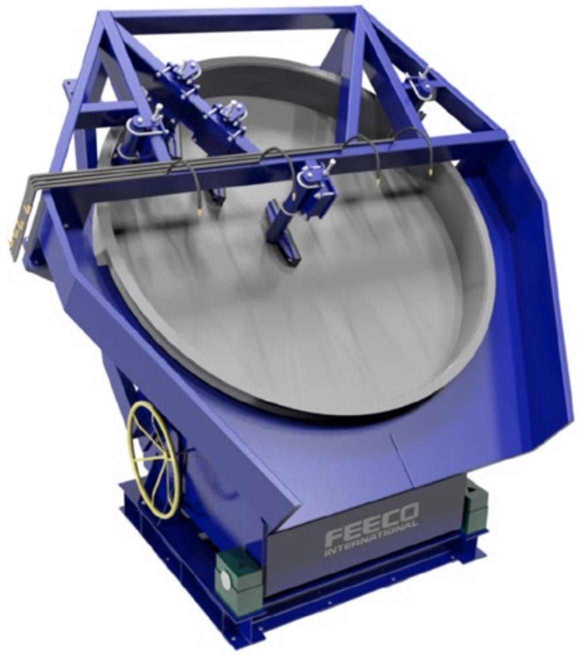
2. Next, the potash travels to the pin mixer. The intense spinning action of the mixer and the addition of a liquid binder work to pre-condition the material. This process reduces the air and water volume between potash particles as it creates densification within the material and begins to form seed pellets.



FEECO Pin Mixer

FEECO PIN MIXERS AT A GLANCE

SIZE	10" - 50" (254 - 1,270mm)
CAPACITY	200 lb/hr - 70 TPH
CUSTOMIZABLE?	Yes



FEECO Disc Pelletizer

PELLETIZING VIA TUMBLE GROWTH AGGLOMERATION

3. After preconditioning, the potash material is fed onto the disc pelletizer (also commonly called a pan granulator). Using tumble growth agglomeration or wet granulation, the potash material gradually rolls and builds against itself while rotating on the disc. Material is fed at a controlled rate and water is added to assist in binding the material. The result is a round, uniform pellet. Pellet size can be controlled using variables such as disc speed and angle. Once the potash pellets reach the desired size, they are discharged from the disc pelletizer.

FEECO DISC PELLETIZERS AT A GLANCE

SIZE	24" - 25' (0.6 - 7.5m)
CAPACITY	100 lb/hr - 100 TPH
CUSTOMIZABLE?	Yes

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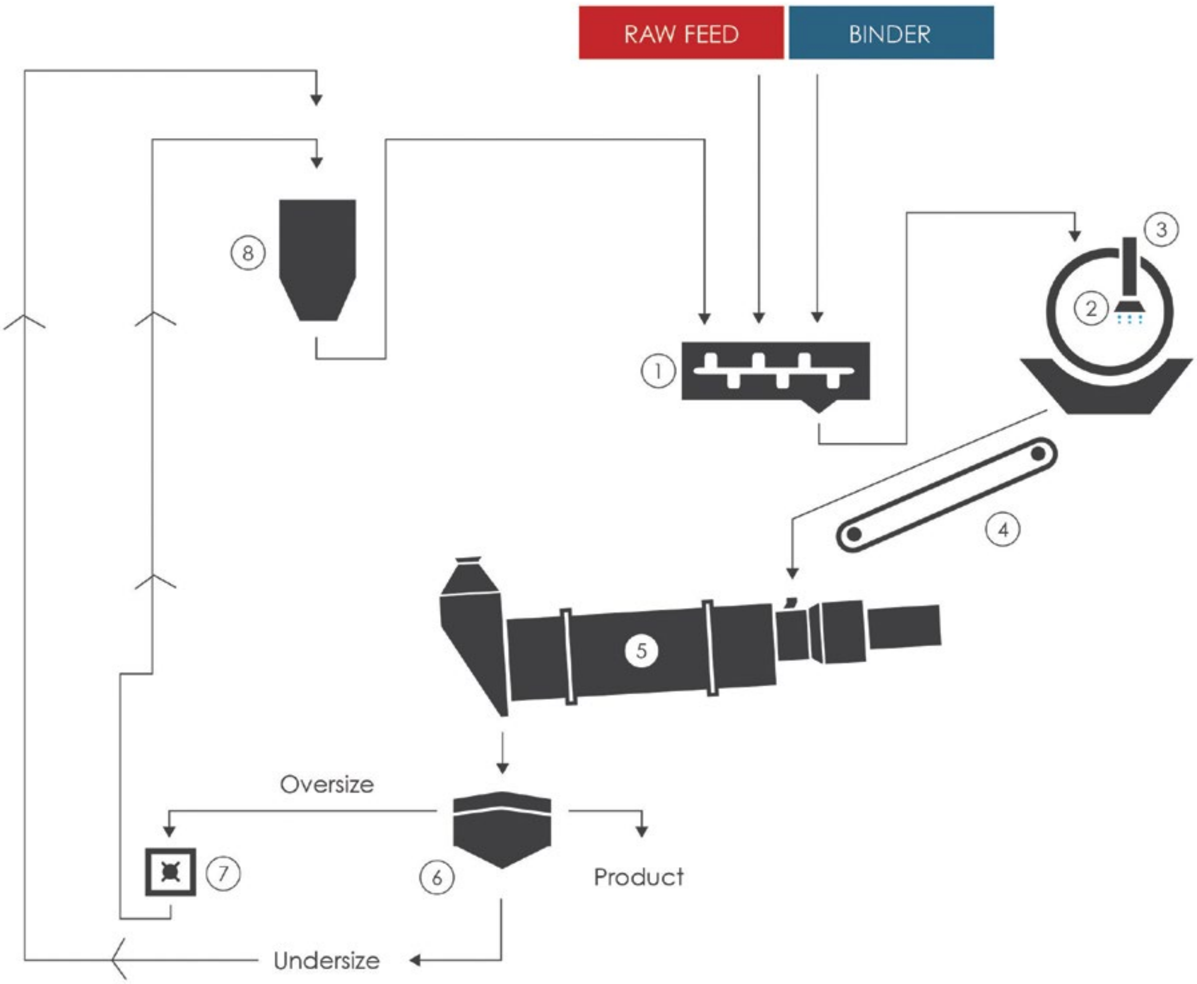
FLOW DIAGRAM OF TYPICAL POTASH PELLETIZING PROCESS



PRODUCT FINALIZATION

4. Because moisture is added during pelletizing, drying is necessary. This is commonly carried out using a rotary dryer or fluid bed dryer.

5. After drying, potash pellets are sometimes cooled. Cooling brings down the temperature of the material so it can move on to transport, packaging, or storage. It also aids in caking prevention.

6. Finally, the potash material is screened to ensure only optimally sized pellets exit the process. Both the larger pellets (overs) and smaller pellets (unders) are recycled back into the pelletizing process, while on-size potash pellets move on to bagging, storage, or transport.

DIAGRAM KEY:

1. Pin Mixer/Pug Mill
2. Disc Pelletizer
3. Liquid Spray System
4. Transfer Conveyor
5. Rotary Dryer
6. Vibrating Screen
7. Oversize Mill
8. Surge Hopper

ADVANTAGES TO POTASH PELLETIZING

Pelletized potash offers a host of advantages in terms of processing solutions and product benefits. Because the process is a non-pressure technique, the resulting product is an ideal solution for use as a fertilizer; the round, uniform pellet shape is less dense than that of more traditional compacted potash granules, allowing the pellet to deliver nutrients faster. Fixed formulations especially benefit from this quick breakdown ability. Moreover, the rounded shape of pelletized potash reduces the occurrence of potash fines due to attrition and is also very easy to handle and apply.

COMPACTION VS. PELLETIZATION

The choice between pelletizing and compaction is one that potash producers commonly face, with cost often being the deciding factor in determining which potash process to use. While the initial capital cost of potash pelletizing equipment is less than compaction equipment, the additional processing cost required in the pelletizing method has historically outweighed this initial cost benefit. However, there are advantages and disadvantages to each method that could ultimately dictate the process to be used.

Additionally, in certain occurrences, depending on the material's unique characteristics, pelletizing may be the only solution for processing. The primary considerations for both processes have been summarized in the following chart.

Pelletization	Compaction
Produces round, smooth pellets	Produces coarse granules
Less attrition	Significant attrition likely
Binder usually required	Typically no binder needed
Drying required	Typically no drying needed
Faster product breakdown	Delayed product breakdown
Lower capital investment	Reduced processing costs

DRYING

Drying is a vital aspect of processing potash into a usable form and creating a better end product.

BENEFITS OF DRYING POTASH

In general, the drying process accomplishes many benefits for potash, including:

REDUCED MOISTURE

The drying process reduces moisture in potash, diminishing material handling issues such as caking.

ROUND, POLISHED GRANULES

Rough granule edges can wear down other granules and produce a large amount of fines—a process known as attrition. Drying in a rotary dryer rounds and polishes granules, reducing the opportunity for attrition.

HARDENED GRANULE SURFACE

Potash drying flashes residual moisture off quickly, leaving a hardened, more robust potash product with a re-crystallized surface.

WHY DRY POTASH?

After potash is mined, it undergoes processing to extract potassium from minerals and create a final potassium product in a readily available form. Drying complements both the compaction granulation and pelletizing processes.

FEECO Rotary Dryer

COMPACTION GRANULATION AND DRYING

As previously discussed, compaction granulation is the most frequently used solution to agglomerate mined potash into a usable product.

Compaction is a dry process that requires a low-moisture feedstock, and in the case of potash, somewhat hot material. Drying is also commonly used to improve resistance to attrition. This is done by wetting and then drying the granules in a dryer—a process often called glazing. The goal is to fill cracks inside the particles and eliminate sharp granule edges, reducing dusting problems that would otherwise occur when the material is shipped and handled.

PELLETIZATION AND DRYING

Pelletizing is considered a wet process, because it requires a liquid binder to cause the potash to adhere to itself. Because the binder adds moisture, a drying phase is necessary.

MATERIAL CONSIDERATIONS IN DRYING

As with any material, there are a variety of material-specific factors that must be considered during the drying process, and potash is no exception. Common factors to consider when drying potash include:

AIR FLOW

Rotary dryers utilize a co-current air flow when drying potash, meaning the potash and air stream flow in the same direction, which proficiently dries the material. This maintains the integrity of the product, because the hottest gases come in contact with the wettest material. If a counter-current dryer were chosen, the hottest gases would come in contact with the driest material, which could discolor potash, cause attrition, and/or reduce the overall quality of the end product.

CORROSION

Because potash is a corrosive material, specialty materials such as alloys are often employed on processing equipment. For example, stainless steel is

FEECO Rotary Dryer

often used at the front end of equipment in order to counteract the product's eroding characteristics.

CLUMPING

Potash is also apt to clump during the drying process. For this reason, knocking systems can be added to a rotary dryer as a means of dislodging material that may have built up on the interior of the drum. A variety of knocking system design options are available and can be retro-fitted to an existing system.

Another solution used to avoid clumping is to employ a screw conveyor; the feed trajectory of a screw conveyor will "fling" or "throw" the potash into the dryer, breaking up clumps in the process.

FEECO ROTARY DRYERS AT A GLANCE

DIAMETER	3' - 15' (1 - 4.6m)
CAPACITY	1 TPH - 200 TPH+ (1 MTPH - 181 MTPH)
CUSTOMIZABLE?	Yes

Drying potash creates a multitude of benefits, resulting in an optimal final product with minimal moisture, clumping, and dusting issues.

COOLING

Cooling is also an important step in the potash manufacturing process. While a straightforward task, cooling is still a large undertaking that requires flexibility and expertise in order to finish with a better potash product overall.

FEECO Rotary Cooler

WHY USE A POTASH COOLER

Cooling provides a number of advantages that translate to an improved potash product. This includes:

INCREASED POTASH PROCESS EFFICIENCY

Adding a cooler to the manufacturing process offers facilities the ability to handle, bag, and store potash immediately, avoiding other time-consuming cooling methods.

REDUCED POTASH STORAGE ISSUES

Cooling potash before bagging prevents issues such as sticking, caking during storage, or condensation in cold climates.

ENHANCED POTASH GRANULE ROBUSTNESS

The process of cooling potash creates a more resilient final product that is less likely to wear down as granules come into contact with each other and also allows for direct loading into trucks and railcars.

FEECO ROTARY COOLERS AT A GLANCE

DIAMETER	3' - 15' (1 - 4.6m)
CAPACITY	1 TPH - 200 TPH+ (1 MTPH - 181 MTPH)
CUSTOMIZABLE?	Yes

ROTARY VS. FLUID BED DRYERS AND COOLERS

When selecting both dryers and coolers, potash producers are faced with the decision of choosing between rotary equipment and fluid bed equipment. Both types are standard in the industry, and with comparable costs, the choice between the two has historically been one of preference. However, the heavy-duty construction of rotary equipment is especially suitable for handling a challenging material.

In a rotary dryer, as the drum rotates, flights within the cylinder lift the potash and shower the material through the air stream. While not as gentle as the fluid bed type, the tumbling action benefits the material by further rounding and polishing the granules.

Fluid bed dryers and coolers work by suspending potash in a stream of air. This method provides gentle material handling, preventing erosion and wear between granules.

In general, both options handle material gently and avoid attrition, key qualities in industrial drying and cooling equipment. The advantages and disadvantages of each type should be carefully considered:

SPATIAL FOOTPRINT

In general, rotary equipment is much larger than fluid bed equipment. However, because of this greater size, rotary dryers and coolers are able to handle a higher material volume, making them an ideal choice for potash processing facilities running at high capacities.

Despite their larger footprint, rotary dryers and coolers have the advantage of requiring less air flow than their fluid bed counterparts, and therefore smaller dust collection systems and fans.

Fluid bed dryers and coolers are a modular, smaller equipment option. This makes fluid beds suitable for facilities with limited space or with a likely potential for operational growth.

OPERATIONAL CONSIDERATIONS

Rotary dryers and coolers require less supervision than their fluid bed counterparts. Rotary equipment is largely unaffected by fluctuations in feedstock or other processing conditions such as reduced feed, or lapses in energy. They offer a consistently reliable processing solution in settings where inconsistencies are to be expected.

Conversely, fluid bed dryers and coolers are highly sensitive to fluctuations in feedstock size or processing conditions, requiring a very consistent processing environment.

ENERGY CONSUMPTION

The choice between rotary and fluid bed equipment is also a matter of energy. Fluid beds work by fluidizing the material, which requires a high magnitude of air. For this reason, it is not always practical to run high-volume, heavy materials through a fluid bed, because of the extra energy required to fluidize the material. Additionally, because it takes a certain amount of energy to fluidize a material, energy is not reduced when running at reduced capacities.

Rotary dryers require less energy to dry material, and unlike fluid bed dryers, energy consumption is reduced when running at decreased capacities.

In terms of thermal efficiency, the two dryer types are comparable.

MAINTENANCE AND LIFESPAN

In terms of maintenance and lifespan, rotary and fluid bed equipment are comparable.

GLAZING

Potash is notoriously prone to attrition, the degradation of product resulting in fines. This is particularly true when potash has been processed into a granular fertilizer product via roll compaction; because granules produced in a roll compactor are jagged and irregular, granule edges are more likely to rub together and break down into dust during handling or transport.

While the generation of dust is problematic in itself, dust also leads to another major problem; caking is more likely to occur when dust is present, further degrading the product and presenting a new set of issues such as workplace hazards, flowability challenges, and more.

Glazing, also commonly referred to as polishing or conditioning, is a finishing step utilized in the production of potash fertilizers in order to reduce the potential for attrition to occur. Glazing essentially creates a hardened protective shell around each granule, lowering the potential for product degradation and ensuring product integrity is maintained throughout handling and transportation.

HOW THE GLAZING PROCESS WORKS

Glazing is carried out by spraying a small amount of water onto the surface of the granules while the material is hot. The addition of moisture to the hot material (this process is sometimes referred to as re-wetting or surface wetting) fills in surface cracks, dissolves, and simultaneously evaporates, creating a smooth, re-crystallized surface on granules that reduces product breakdown. Throughout this process, the material is continuing to tumble in the rotating drum. This tum-

Glazed potash granules

bling action evenly distributes the moisture throughout the bed of material and knocks off any loose edges, polishing the granules.

GLAZING EQUIPMENT

Depending on the product goals, one of a few approaches to glazing may offer the best solution:

Glazing in the Dryer

Glazing can be carried out as part of the drying (or cooling) process by incorporating a "bald section" or flightless area at the end of the rotary dryer or cooler. A spray system is added to this portion of the drum so that when the granules reach the bald section, they are sprayed with the water as they continue to tumble, eventually being discharged.

Glazing in a Separate Drum

Glazing may also be carried out in a separate rotary drum following the dryer or cooler. This approach is common when additional coating agents will be included, or when gentle product handling is necessary. A drum in this setting may also be referred to as a conditioning or polishing drum, or if coatings are used, a coating drum.

Rotary drums used for potash glazing are typically provided with internals for efficient bed turning and can be manufactured from special alloys, if required, to deter corrosion.

Glazing in a Pugmill Mixer

Pugmill mixers (also known as paddle mixers or pug mills) are also an option for glazing, and as with the separate rotary drum approach, would be incorporated into the process after drying or cooling.

The pugmill mixer uses dual counter-rotating shafts to impart a kneading motion onto the material. A spray system incorporated into the mixer cover distributes the water evenly across the moving bed.

While pugmill mixers offer a smaller footprint, they handle a lower throughput and are not as gentle on material as a rotary drum.

A Note on Polishing

It's important to note that some operations utilizing a "polishing drum" do so not as a means of glazing, but simply as a way to knock off loose edges and smooth granules. In this case, water would not be included.

Glazing provides a way to minimize attrition by filling in surface cracks and creating a hardened shell around each granule. The rotary drum offers a highly effective approach to gentle, uniform glazing.

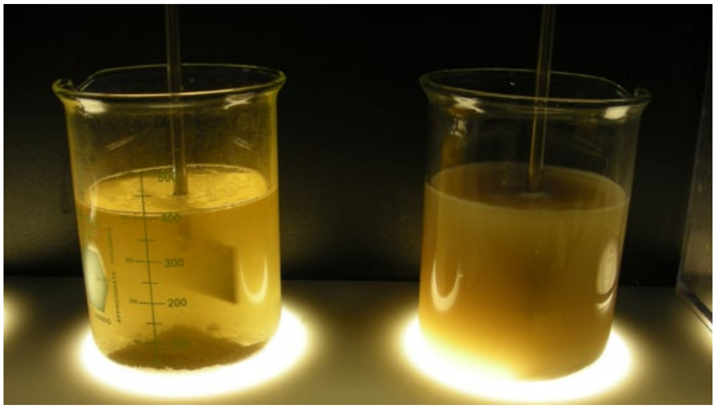
COATING

Potash is perhaps the most dusty material in the fertilizer industry. Because dust is a health and safety hazard, results in product loss, makes handling and application difficult, and increases the potential for caking, producers go to great lengths to prevent dust generation. This often involves an added coating step after potash is pelletized (preventing dust is so critical in fact, that potash will often be coated several times throughout its lifecycle prior to reaching the customer).

POTASH COATING EQUIPMENT

The coating drum is the preferred type of equipment for coating potash, as it offers the superior results essential to preventing dust generation in such a crucial application.

Unlike other coating methods, the coating drum provides uniform coating distribution – a vital aspect of dust prevention. Uniform coating is achieved as



A solubility test is conducted with coated (left) and uncoated (right) product in the FEECO Innovation Center

a result of a well-designed spray distribution system, combined with the tumbling action that occurs in the material bed of the coating drum; as material tumbles in the rotating bed, a spray bar distributes coating at predetermined points. The granule-to-granule contact then works to evenly distribute the coating throughout the bed. The result is a uniform coating on each and every granule.

The coating drum also aids in polishing and smoothing granules when applicable, knocking off loose edges and incorporating the resulting fines into the coating.

Coating drums can be integrated into a new fertilizer production line, or retrofitted into an existing facility.

The gentle action of the drum's tumbling bed is an ideal solution for achieving uniform results while still providing granule polishing.

HOW COATING DRUMS WORK

The coating drum consists of a sealed, rotating drum, through which material is continuously fed.

Set on a slight angle, gravity helps to move material through the drum according to a predetermined retention time. As material moves through the drum, a spray system disperses the coating agent onto the material bed. In some cases, tumbling flights may be used to promote greater bed turning for improved coating-to-granule exposure. Spray systems must be designed for optimal distribution of the coating agent, taking into account factors such as spray locations, nozzle type, bed depth, rotational speed, and more.

FEECO Coating Drum

Coating drums are typically smaller than a traditional granulation drum, but can range in size from 36" to 15' in diameter (1 – 4.6m) and can handle capacities between 500 lb/hr – 50 TPH.

Coating drums are highly diverse and can accommodate a wide array of both liquid and powder coating types, and are beneficial in any coating application.

ADVANTAGES OF A COATING DRUM

Producers can spend years developing the perfect coating formulation for their product, but the coating still needs to be expertly applied to achieve optimal performance. This is where coating drums offer significant advantages over conveyors—a common alternative approach to coating:

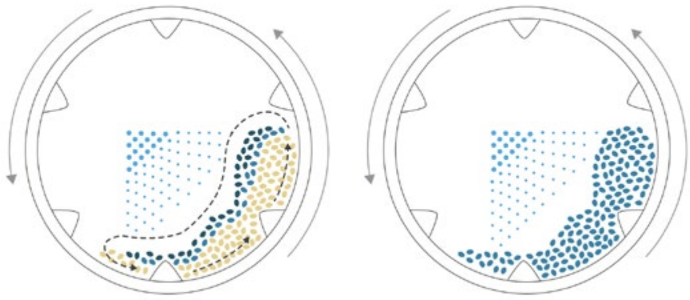
UNIFORM COATING DISTRIBUTION

When coating with a conveyor, material moves under the coating spray, but is stationary on the belt. This results in a liberal application to the top-most surface area of the material on the belt, while the granules underneath remain untouched. Similarly, if the feed rate of the coating is increased in an effort to improve coating distribution, the top layer will simply become more saturated with only a minimal improvement in distribution.

As material is stationary on the belt, coating with a conveyor results in uneven distribution of coating agent.

Conversely, coating drums tumble granules in a material "bed" as the drum rotates. This motion promotes greater granule-to-granule contact, which thoroughly distributes the coating throughout the bed. The result is a uniform distribution of coating on the entire surface area of each granule.

It's important to recognize that with any coating equipment, the product feed rate must be consistent to achieve uniform results. For example, if the feed rate of solids to a coating drum was reduced while



The tumbling action in a coating drum increases granule-to-granule transfer of the coating, resulting in an even distribution.

Coating drum test

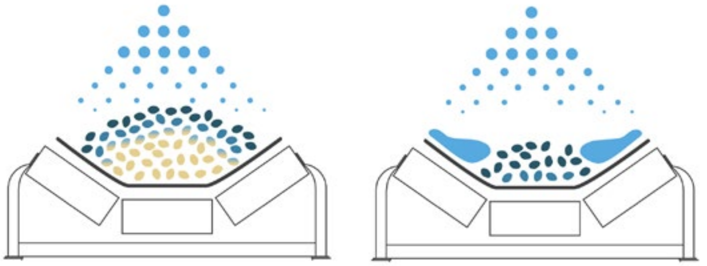
the amount of coating agent remained the same, the end product would have a higher quantity of coating than desired and could potentially change the final analysis, depending on the product.

INCREASED PRODUCTION & REDUCED MAINTENANCE

When using a conveyor to coat material, overspray is a common problem; since material typically lies in the center of the belt, coating may be inadvertently sprayed onto the adjacent belt surface as well. Overspray may also occur as a result of the coating agent spraying through the material, due to a high spray rate, or because material feed rate has been reduced, as shown at right.

This not only wastes coating agent, but depending on the coating, could cause a number of issues, from pooling to build up. In severe cases, it could require frequent shutdowns for cleaning.

Conversely, a drum contains the coating process to the drum's interior and when properly designed, prevents regular disruptions due to buildup, and mitigates the need for frequent cleaning to maintain operational uptime.



The tumbling action in a coating drum increases granule-to-granule transfer of the coating, resulting in an even distribution.

REDUCED COATING AGENT REQUIREMENT

As mentioned, uncontrolled overspray can result in a significant amount of wasted coating agent.

This problem is alleviated when using a coating drum, as the coating agent is used much more efficiently. This means that the same amount of coating agent provides better results, and in some cases, allows for a reduction in the amount of coating agent required.

TESTING THE COATING PROCESS

Achieving the perfect coating distribution often requires testing in a facility such as the FEECO Innovation Center.

This allows a number of variables to be tested and fine-tuned to reach optimal product coating. Data points may include:

- Rotational speed
- Coating feed rate
- Material feed rate
- Spray locations
- Tumbling flight design

The FEECO Innovation Center is capable of testing all of the variables above and more in order to gather the data necessary for the design of a commercial-scale coating drum.

AN INTRODUCTION TO POTASH HANDLING

Handling a demanding material such as potash requires dependable performance from each piece of equipment in a processing facility. The need for reliability holds especially true for bulk material handling equipment, which transports potash from one area of a processing facility to another, adding automation and flexibility to a system.

The following will give an overview of the handling equipment commonly employed when working with potash, as well as the various customizations available to combat the challenges potash can present.

COMMON HANDLING EQUIPMENT

Bucket Elevators are commonly utilized in potash processing facilities, with double chain, continuous-style bucket elevators being the most popular choice. Single chain options are also available, but a double chain is most often selected due to its increased capacity and height capability, which is often required in potash operations.

Bucket elevators transfer potash vertically, operate at low speeds, and are able to handle a high capacity of material. Bucket elevators are highly customizable, with a variety of options available to fit a facility's unique needs. This might include large access doors for ease of maintenance, various types of drive arrangements, service platforms, and more.

FEECO Bucket Elevator


FEECO Belt Conveyors

Belt Conveyors are also very commonly used in potash processing facilities. Belt conveyors consist of a continuously moving carrying surface (known as the belt) that rotates around two or more pulleys. As the belt rotates, material is transported to the desired location. Various conveyor options are available to assure proper load and transfer points are accomplished. There are also a variety of optional pieces of equipment (e.g. belt trippers, loading skirtboards, belt cleaner systems) to achieve the best material conveying solution for the job.

Potash processing facilities especially benefit from adding a belt tripper to a conveyor system. This complementary piece of equipment offers the flexibility to use more than one discharge location (fixed or movable) off of a conveyor system. When storing potash, this option is especially useful in creating a long, continuous pile.

EQUIPMENT CUSTOMIZATIONS

Depending on the manufacturer, there may be a variety of ways to customize material handling equipment in order to withstand the abrasive and corrosive aspects of potash. The customizations listed below are specific to FEECO.


FEECO Belt Conveyor

MATERIAL OF CONSTRUCTION

Various alloys may be used to defend against corrosion and other issues. *Example:* Bucket elevator boot sections may be constructed of stainless steel to prevent damage that could otherwise occur from regular use of a wash down system.


FEECO Belt Conveyors with weather covers

REINFORCING AREAS OF WEAR

High-wear areas are enhanced with heavy-duty construction, helping these vulnerable zones to better accommodate the abrasive material. *Example:* Transfer chutes and inlet loading areas (standard high-wear areas on a conveyor) are equipped with wear-resistant liners.

DUST BUILDUP PREVENTION

A buildup of potash fines can cause failure issues. As a result, protective measures are implemented in areas that would otherwise be damaged by dust buildup. *Example:* Auxiliary seals for bearings are often used in these areas.

COVER COMPOUNDS

Potash treated with a special solution may cause wear or service issues for certain equipment areas. To counteract this issue, special cover compounds are utilized. *Example:* Potash that is treated with amine solution adversely affects rubber components such as conveyor belts.

PRODUCING A PREMIUM PRODUCT

MEETING PHYSICAL SPECIFICATIONS | PROCESSING CHALLENGES | PROCESS & PRODUCT DEVELOPMENT

Potash under a compression test in the FEECO Innovation Center

Potash pellets before and after agglomeration in the FEECO Innovation Center

MEETING PHYSICAL SPECS FOR POTASH FERTILIZERS

Fertilizer and soil amendment products have had a long evolution in terms of quality. At the start of modern agriculture, growers had few options – most of them not ideal. But advanced manufacturing methods, coupled with a greater understanding of nutrient and particle performance, has allowed producers to zero-in on precise product specifications to create a product that performs exactly as desired.

A product that is not produced to spec can cause a number of issues. This might include:

- Breaking down too quickly
- Breaking down too slowly
- Segregating during shipping or handling
- Producing excessive dust, yielding lost product and a hazardous work environment
- Caking during storage or transport, and subsequent difficulty of spreading and handling
- Inconsistent product on the consumer end
- Inconsistent flow properties
- Increased potential for nutrient runoff

As modern technology allows, however, the above issues are largely circumvented by using production techniques to reach precise particle characteristics. While these characteristics (and the combination thereof) often vary depending on the product, some of the most commonly targeted physical specifications are listed here, along with the production techniques used to influence them.

TARGETED PHYSICAL CHARACTERISTICS

PARTICLE SIZE

Particle size is a critical factor in the performance of fertilizer and soil amendment products and in most cases, is the first characteristic producers are looking to target. The particle size of a product influences two key parameters in performance:

Rate of nutrient/active ingredient delivery: In general, the larger the particle size, the longer the product will take to break down, with powders offering fastest nutrient delivery (though they also often become windblown). It's important to note that particle size is not singularly responsible for the rate of breakdown; many other factors come into play as well. Particle size can also influence the rate at which a fertilizer dissolves.

Segregation of particles: Segregation occurs when particles of varying sizes naturally group together according to size, forming a heterogeneous mixture, instead of remaining homogeneous. This often results in uneven application and unpredictable results.

PARTICLE SIZE DISTRIBUTION (PSD)

Particle size distribution is a measurement of the amount of material that falls into each of the various size ranges within a given sample. In addition to PSD, there are a number of other indicators used to define a sample's size qualities in more detail….

SGN (SIZE GUIDE NUMBER)

The size guide number of a material is a commonly used specification to describe particle size characteristics. SGN is the mean, or average, of the particle sizes that make up the product.

This number is calculated by multiplying the average particle size (in mm) by 100.

UI (UNIFORMITY INDEX)

The uniformity index of a product is a measurement of the relative difference in size between particles.

A UI between 40 – 60 is ideal for fertilizer (the larger the number, the greater the uniformity), as this will help to ensure that particles are uniform (mitigating potential segregation issues), but different enough within that uniformity that they will spread efficiently and maximize storage or packing space.

The UI of a product is calculated with the following equation:

$$\left(\frac{d_{95}}{d_{10}}\right) \times 100$$

d_{95} – size of sieve opening that retains 95% of sample (smaller granule diameter), i.e., the amount of particles at or above this specific diameter

d_{10} – size of sieve opening that retains 10% of sample (larger granule diameter) i.e., the amount of particles at or above this specific diameter

Example:

If d_{95} = 3.0mm and d_{10} = 6.0mm, then the equation is:

$$\frac{3}{6} = 0.5$$

$$0.5 \times 100 = \mathbf{50}$$

Since 50 falls within the ideal 40-60 UI range, this is an acceptable UI.

GSI (GRANULOMETRIC SPREAD INDEX)

Granulometric spread index is another size parameter producers are looking to control. This number quantifies how much variance exists between particles in a given sample. The lower the number, the more uniform the sample.

Potash sample created in the FEECO Innovation Center

GSI is calculated using the following equation:

$$\frac{(d_{84} - d_{16})}{2 \times d_{50}} \times 100$$

d_{84} and **d_{16}** = the diameter of mass fraction at the 84% and 16% percentile level, respectively

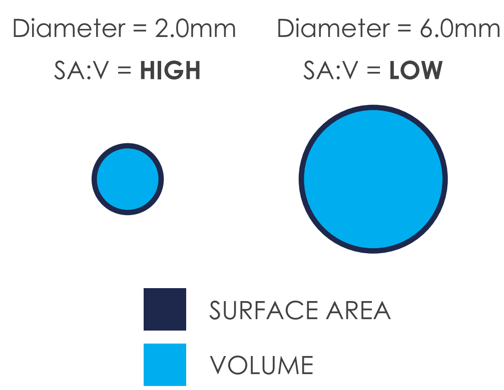
d_{50} = median diameter of the sample

SURFACE AREA TO VOLUME

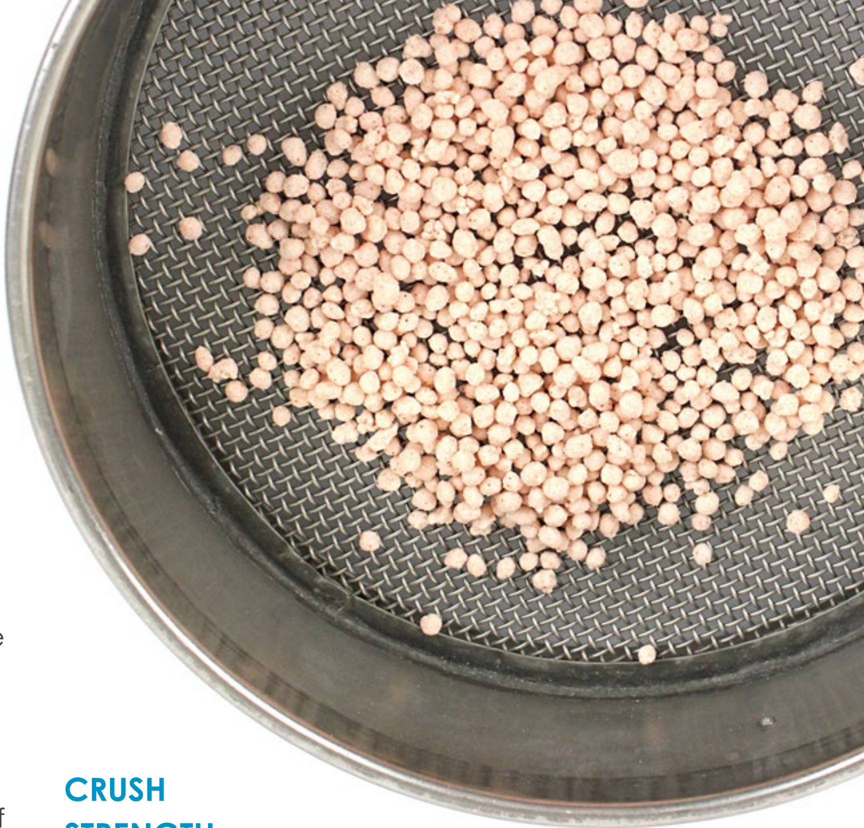
Also important in particle size is the surface-area-to-volume, or surface-to-volume ratio. This may be given as SA:V or SA/V.

This ratio illustrates the relationship between the total volume of the granule compared to its total amount of surface area. SA:V is important when working with fertilizers and soil amendments, because it influences the rate of active ingredient delivery.

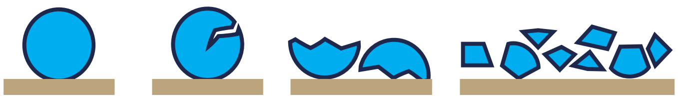
Particles with a high surface-area-to-volume ratio allow increased contact with the soil, which promotes faster product delivery.



Conversely, particles with a low surface-area-to-volume ratio will inherently take longer to break down and deliver the active ingredient. While in most cases producers are looking to promote faster delivery, the SA:V of a product can be used to control or delay delivery of the active ingredient when desired, such as when producing controlled-release or slow-release fertilizer products.



As can be seen in the illustration on the previous page, smaller particles have comparatively more surface area to volume than a larger particle.



Note how as the granule breaks down, there is an increasing amount of surface area exposed and the surface area to volume ratio increases.

FACTORS THAT INFLUENCE PARTICLE SIZE

Particle size is generally influenced by the method of production and the process parameters used in the production setting – most notably retention time in the granulation unit.

In granulation (or "tumble growth agglomeration") processes, various equipment configurations can be employed to obtain a product within a desired size range. If a pin mixer or pugmill mixer was used as the sole granulation device, the resulting granules would generally be smaller than those produced using the combination of a mixer and an additional device, such as an agglomerator or disc pelletizer.

In general, the longer the retention time, the larger the granules (up to the maximum size that the material characteristics allow for).

Moisture content also plays a role in the size of the granules, as up to a certain point, the more moisture that is added to a seed pellet or particle, the more tacky it will become and the more fines it is likely to pick up during processing.

CRUSH STRENGTH

Crush strength, or hardness, is another key specification in soil product performance. As the name suggests, this metric indicates how much pressure is required to break a granule. Crush strength is often used as a predictor for the amount of degradation due to handling that will occur with a product.

For example, a low crush strength can cause granules to break down too easily (for this reason, granules with a low crush strength may break down at the bottom of a super sac under the weight of the product).

Achieving the optimum crush strength for the product will help to ensure that it is capable of withstanding handling, bagging, storage, etc., but will still break down as needed under standard field conditions.

Crush strength is measured in the amount of pressure (lb. or kg.) it takes to crush a single granule. Crush strength for fertilizer and soil amendment products generally falls around 4-6 pound-force (LBF).

Potash pellets in a rotary dryer in the FEECO Innovation Center

FACTORS THAT INFLUENCE CRUSH STRENGTH

The crush strength of a product can be influenced by several factors – most notably, the binding agent.

During the granulation process, the liquid binding agent causes the particles to become tacky, allowing them to pick up additional fines as they tumble. The binder affects crush strength in two important ways:

Green Strength: The crush strength of the pellets in their wet state is referred to as "green strength." Reaching a suitable green strength is critical to maintaining pellet integrity throughout the process, as pellets must be able to withstand the various drop and transfer points that occur during processing. If an appropriate green strength is not achieved, pellets will break up during processing.

End Product Crush Strength: Upon drying, the binder enhances the bond between the particles to influence the end product's crush strength. The amount of binder, as well as the type of binder, will impact this value.

Binders are available by the hundreds, with some being better than others in the context of fertilizer.

Achieving a uniform distribution of the binder is also important. If binder and raw material feedstock are not properly combined into a homogeneous mixture, the finished product can vary in crush strength as a result of the uneven distribution.

Other factors that can be used to control crush strength include chemical makeup, agglomeration equipment/process to manufacture the granule, material preconditioning, and moisture content. The different components within a product can also sometimes react, producing a stronger bond.

Particle shape can also impact granule strength. Since the sphere is the strongest shape, spherical particles will generally hold their shape and be less prone to premature breakdown than jagged or irregular granules, which are more easily influenced by external pressures.

BULK DENSITY

Bulk density is also a critical characteristic when working with fertilizers and soil amendments. Bulk density is the relationship between weight and volume of a given bulk solid material.

The bulk density of a material has a substantial impact on end product performance and handling, with implications in packing, shipping, metering, and spreading.

Bulk density is measured as the weight of a material at a given volume. For this reason, if the bulk density of a material is known, along with one other variable, the missing variable (weight or volume) can be calculated.

There are several variations on the bulk density measurement. The two most common bulk density measurements are loose bulk density and packed bulk density:

LOOSE BULK DENSITY

The "bulk density" of a material generally refers to the material's loose bulk density. This measurement is simply the material's resting density after having been poured into a container, where void spaces exist between particles.

PACKED BULK DENSITY

Conversely, packed bulk density, or "tapped density" is a measurement of the material's bulk density after the container of material has been tapped until no further change occurs. Tapping causes the void spaces to become filled in by smaller particles (if applicable).

The difference between loose and packed bulk density is important to measure, because it can have several ramifications….

A material with a greater packed bulk density means that more material can fit in a smaller space. In some cases, this may be an advantage, such as when looking to maximize the allotted volume of a container. In other cases, it can be a disadvantage: material with a much greater packed bulk density may be packaged at loose density, but after transportation, appears significantly lower in volume. This can be especially troubling with consumer products: if a bag of product leaves the production facility full, but once on the shelf appears only half full, consumers may perceive the product as a lesser value.

FACTORS THAT INFLUENCE BULK DENSITY

A myriad of factors can influence the bulk density of a material, making it a complex specification to control in production. The most influential parameters are:

Moisture Content

In general, as the moisture content of a material increases, so too does the bulk density. This is because moisture adds weight. However, this is not the case with all materials; some materials, such as bentonite clay, will swell with added moisture, meaning that both weight and size of the particle are increasing.

Density of Each Individual Particle

Two particles of the same material and same size can have differing bulk densities. This is because a greater volume of material can be packed into the same size particle.

Potash pelletizing testing on a batch disc disc pelletizer in the FEECO Innovation Center

Production methods can greatly influence the density of particles. A pin mixer, for example, employs an intense spinning motion to create a homogeneous mixture of solid and liquid feed. This intense spinning action causes the particles to be more dense than if they were created in a disc pelletizer or granulation drum alone.

Particle Shape

Particle shape is another significant factor in the bulk density of a material, as it has a direct effect on the volume of void spaces between particles.

PARTICLE SHAPE

In addition to its influence on bulk density, particle shape is an important target characteristic in its own right as well. Fertilizers and soil amendments can be produced in a variety of shapes – from perfectly spherical, to jagged-edged angular granules and every variation in between.

Particle shape has a number of influences on the performance of a soil product:

- Packing ability
- Flowability
- Attrition/Amount of dust produced

ATTRITION

Attrition is the breakdown of particles into dust as a result of granule-to-granule or granule-to-equipment contact. Minimizing attrition is desirable in most cases to reduce product lost as dust, to avoid a hazardous work environment, and to mitigate other issues associated with dust.

Factors that Influence Attrition

Particle shape has a direct effect on the amount of attrition that occurs; angular granules are more likely to result in attrition than round granules, as a result of the jagged edges being knocked off. For this reason, round granules are typically considered to be a more premium product.

HYGROSCOPICITY

Hygroscopic materials are capable of exchanging moisture with the surrounding atmosphere. This can result in off-spec product that does not handle or perform as intended. Similarly, it can also foster the creation of crystal bridges between particles, causing caking to occur.

Hygroscopicity is generally controlled through the chemical composition of a product, as well as through surface treatments or coatings to inhibit the absorption of moisture.

SOLUBILITY

Similar to hygroscopicity, targeting a specific solubility, or rate of dissolving, contributes to the overall rate of breakdown as well. One way this can be controlled is through surface treatments and coatings.

PROCESSING CHALLENGES

As a key component in fruitful crop production (among other things), potash is produced extensively around the globe. However, potash's widespread use does not mean it is always easy to process; demanding material characteristics combined with unique processing requirements can present challenges during processing.

As mentioned, there are two primary methods by which potash is processed: tumble growth agglomeration (pelletizing) on a disc pelletizer, or through compaction granulation in a roll compactor. Each of these methods, combined with the characteristics of potash, presents its own unique challenges. The following list highlights some of the most common challenges experienced during potash processing when utilizing these two approaches.

MOISTURE LEVELS

Throughout the pelletizing process, achieving and maintaining ideal moisture levels is a critical consideration, affecting nearly all parts of the process, as well as the outcome. Moisture levels must be carefully monitored during conditioning, pelletizing, and drying.

Conditioning potash in a pin mixer prior to the disc pelletizer is a common practice in the pelletization method of processing potash. Here, two things are accomplished: raw material fines are vigorously mixed with a binder to create a homogeneous mixture, and raw material is brought up to the appropriate moisture level for optimum pellet formation. Too little or too much moisture in this stage will cause the material to be ill-prepared for pellet formation on the disc pelletizer.

Once the potash is fed onto the pelletizer, pellet formation begins. Here, additional binder is added to

Real-time moisture analysis in the FEECO Innovation Center increase tackiness and foster desired pellet growth. In this stage, moisture is also of crucial concern; too little or too much will not allow for desired pellet size or characteristics.

After the potash has been pelletized, the "green" (wet) pellets must be brought down to the moisture level required for the end product. It is here that the industrial drying system is employed. A dryer specifically designed around the material and process requirements will achieve the best results.

CLUMPING

Potash, due to its hygroscopic quality, is often prone to clumping, sticking, and caking issues. These issues may show up during drying, or storage. However, there are steps that can be taken to combat this.

Drying: Knocking systems can be added to rotary dryers as a method of breaking up lumps amongst the material itself, as well as dislodging any material that may be sticking to the interior of the drum.

Screw Conveyors: Another equipment-based solution to prevent clumps is the addition of a screw conveyor. The screw conveyor utilizes a feed trajectory that "flings" potash into the dryer. This motion efficiently conveys the material and breaks up lumps in the process.

Anti-Caking Additives: Anti-caking additives are applied to finished granules through the use of a pugmill mixer or coating drum. A variety of anti-caking additives are available, depending upon material characteristics and end product use.

CORROSION

Another potash processing challenge that manufacturers experience is corrosion. Since potash is a corrosive material, it can progressively destroy metal through chemical action. For certain equipment, special accommodations must be made in order to counteract the corrosive nature of potash. One example of this customization is the use of stainless steel or nickel alloys on areas of the equipment that come into contact with potash during processing.

Additionally, because potash is hygroscopic, dry potash can pull moisture from the air over time. If allowed to sit in equipment for extended periods of time, buildup is likely to result in corrosion. For this reason, seasonal operations should be especially careful, ensuring equipment is properly cleaned prior to off-season.

POTASH PROCESS & PRODUCT DEVELOPMENT

With the unique and varying challenges that potash can present, testing is often a key component in the success of a potash processing operation. Whether the goal is to design a new process, improve on an existing one, or even enhance product characteristics, testing offers the opportunity to confirm the viability of an intended process, as well as to work out process variables and other unknown data points. This can define a recipe for success, and reduce the opportunity for surprises after process scale-up.

Process engineers in the FEECO Innovation Center work with customers to develop customized testing programs around their unique project goals. Both methods of agglomeration can be tested, with continuous process loop testing available.

For all types of testing, depending on what information the customer already knows and is looking to gather, testing commonly starts at batch scale, with small samples of material being tested to gather initial data and determine feasibility of the intended goal. Once batch testing has been successful, continuous pilot-scale testing can be conducted. This is a much larger scale test, where the process is tested as a continuous process loop.

Potash producers are often targeting a set of parameters that will ensure their agglomerates perform as intended. During testing in the Innovation Center, a variety of particle characteristics can be measured and adjusted, including:

- Attrition
- Bulk Density
- Compression
- Crush Strength
- Flowability
- Green/Wet Strength
- Moisture Content
- Particle Size Analysis
- Physical Characteristics
- Solubility
- Temperature

BENEFITS TO TESTING WITH FEECO

Some of the many advantages to testing in the FEECO Innovation Center include:

MATERIAL EXPERIENCE:
FEECO has been a pioneer in material processing since the 1950s, and has extensive knowledge around hundreds of materials and processing methods, including potash and its many derivatives.

Customers gain a valuable familiarity with their material and its unique characteristics through testing in the Innovation Center.

COMPLETE PROCESS KNOWLEDGE:
FEECO has expertise in each aspect of potash processing, from agglomeration (pelletizing, compaction) to thermal processing (drying, cooling), allowing us to look at how the process will function as a whole, instead of each individual portion.

PROCESS SCALE-UP:
Once the process configuration has been defined, FEECO can aid in process scale-up, as well as manufacturing the equipment needed to get the job done.

AUTOMATION & DATA COLLECTION:
FEECO is a Rockwell Automation partner, providing integrated process control solutions for our customers, both as a service in the Innovation Center, and as part of a system purchase. This provides customers with state-of-the-art data collection and reporting capabilities.

The FEECO Innovation Center features a Rockwell Automation PLC/MCC system, which utilizes current technologies for optimizing testing operations. During the testing process, this provides for optimal process transparency; various data points can be monitored, trended, and adjusted in real-time, all from a single interface or mobile device. This includes everything from current (amps), feed rate, and flow rate, to horsepower, speed, and torque, and just about everything in between.

Historical data is also available for returning customers, allowing them to pick up exactly where they left off.

CONCLUSION

With widespread use and a well established and growing industry, potash requires an experienced hand to produce the desired results.

FEECO has been serving the potash and agriculture industry since 1951. We offer material testing, process and product development services, custom engineered equipment, and parts and service.

No matter what your potash processing needs, FEECO International has you covered.

ADDITIONAL RESOURCES

For further information or reading on potash, we have provided some additional resources below. Please note that the inclusion of any resource or company is not an endorsement and the views of that resource do not reflect those of FEECO International.

ASSOCIATIONS & PUBLICATIONS

Potash Development Association
www.pda.org.uk

International Potash Institute
www.ipipotash.org/en

International Plant Nutrition Institute
www.ipni.net/topic/potassium-k

PotashWorks Magazine
www.potashworks.com

BOOKS

Potash: Deposits, Processing, Properties and Uses
by D.E. Garrett
ISBN-13: 978-0412990717

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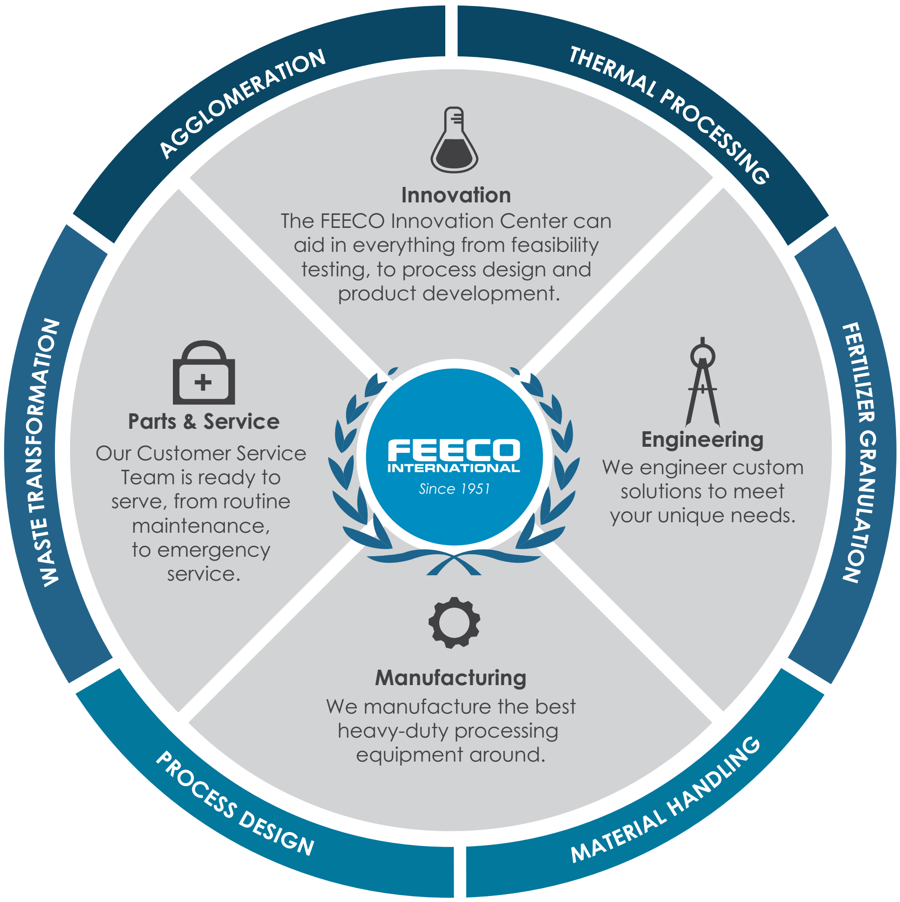
4. Fertilizer Manual. Kluwer, 1998.

ABOUT FEECO

FEECO International, Inc. was founded in 1951 as an engineering and equipment manufacturer. We are recognized globally as an expert in industry-leading process design, engineering capabilities (including everything from process development and sample generation, to feasibility studies and detailed plant engineering), custom equipment manufacturing, and parts and service. We serve a range of industries, including fertilizer and agriculture, mining and minerals, power/utility, paper, chemical processing, forest products, and more. As the leading manufacturer of processing and handling equipment in North America, no company in the world can move or enhance a concept from process development to production like FEECO International, Inc.

The choice to work with FEECO means a well-rounded commitment to quality. From initial feasibility testing, to engineering, manufacturing, and parts and service, we bring our passion for quality into everything we do.



For more information on processing potash, material testing,
or custom equipment, contact FEECO International today!

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