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KREBER

Home And Trim Dried

Barry Milln and Igor Makarenko, Solex Thermal Science, Canada, discuss how trim drying with vertical plate technology offers fertilizer operators an opportunity to produce a high-quality product, improve energy usage and minimise equipment maintenance.

Drying at fertilizer production facilities represents a vital stage of producing a high-quality product.

Traditional convection drying technologies, such as rotary drums and fluid beds, have commonly been called upon to shoulder the bulk of the drying load, a necessary process step during production. Yet, these incumbents sometimes sacrifice efficiency when pushed to reach target low moisture levels, becoming increasingly energy-intensive as the moisture content is lowered and production capacities ramp up. This can result in the potential for solid granules to enter the cooling stage that either have too much moisture or are too friable (e.g. incomplete formation of the particle).

In cases where producers want product moisture to be lower, they could benefit from having a final trim drying stage following a rotary drum or fluid bed dryer. This solution can involve using conduction drying technology – vertical plate-based moving bed heat exchangers (MBHE) – to create a high-grade final product.

This technology can also improve the overall energy efficiency of the drying process, with the added benefit of reducing the maintenance of downstream cooling equipment.

Background: Product characteristics and quality

All fertilizers are produced differently. Urea, NPK, monoammonium phosphate (MAP), diammonium phosphate (DAP) – the list goes on. They have different compositions and characteristics, they can be quick-release or slow-release, and they can come in different shapes and sizes, whether that be powdered, pelleted, prilled, or granulated.

Because each type of these fertilizers is different, so too is their behaviour during the drying step of the production process, whether that is because of the moisture content, void fraction, particle shape, particle size distribution, or amount of recycled product.

Why does this matter?

The properties of fertilizers, like any granular bulk solid, play a role in determining their flowability and thermal characteristics during the production process – and, in turn, the quality of the finished product. The quality of the finished product is important as it impacts the storage, handling, packaging, shipping and final field application steps.

The moisture content of fertilizer, in particular, is an important consideration at various stages of fertilizer production. Too much moisture can lead to a soft and sticky product. While too little can lead to cracking and dust formation, both extremes can compromise processing equipment and lead to a lower quality finished product.

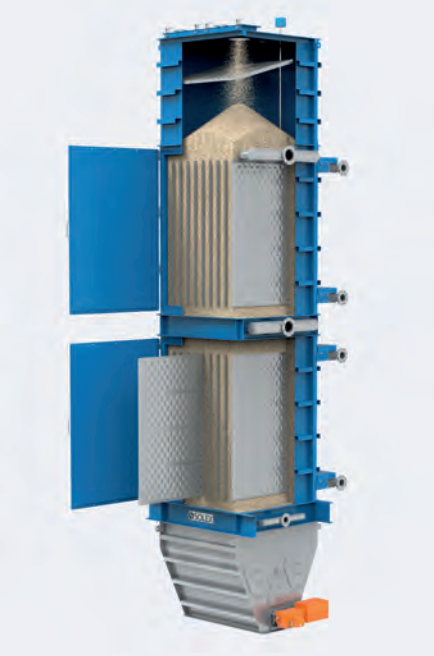

Figure 1. By adding a trim drying stage ahead of the existing plate-based MBHE, fertilizer producers can more efficiently create a better product.

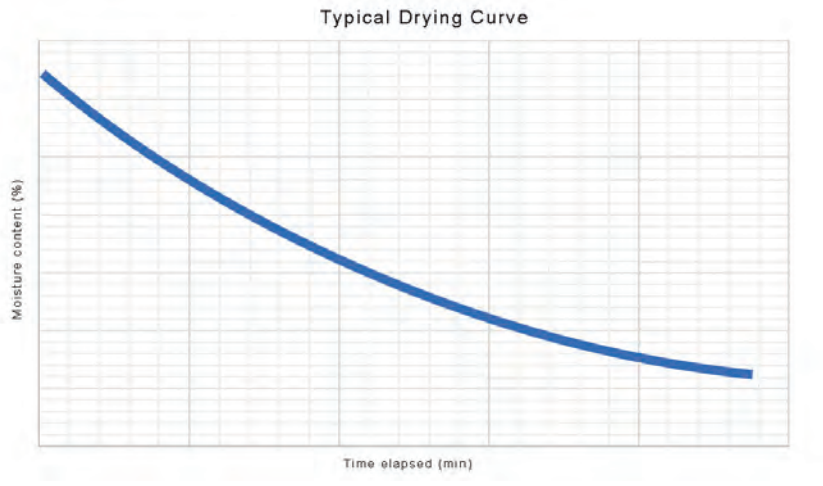

Figure 2. A typical drying curve illustrates how, at the later stages of drying, it becomes an exponential relationship between the driving force and the vapour pressure, which is what drives the moisture out of the product.

Before addressing where the moisture originates during the production process and what technologies are being used to remove it, it is necessary to acknowledge the proverbial elephant in the room: the inherent hygroscopic nature of fertilizers. All fertilizers will start absorbing moisture at a specific humidity or at a certain water vapour pressure.

The critical relative humidity (CRH) defines the relationship between dew point (e.g. when water first starts to condense) and product temperature. For example, if the CRH is lower than the relative humidity of the surrounding air, then the fertilizer will absorb moisture from the air. This leads to the formation of crystal bonds or mobile liquid bridges between the granules, commonly known as caking, which is highly undesirable.

The fertilizers with which caking is of significant concern are NPKs, urea, and MAP/DAP products, as well as fertilizer salts such as potash. These are often referred to as complex high-maintenance fertilizers.

To illustrate the challenge of working with hygroscopic fertilizers, consider a situation where air is entering at the fertilizer temperature of 75°C and a relative humidity of 35%. It will contain approximately 96 g of water per kilogram of dry air. As it is cooled – to 40°C, for example – the air will only be able to hold 49 g of water per kilogram of dry air at 100% relative humidity. This means 47 g of water per kilogram of dry air will condense out of the air as it is cooled together with the fertilizer. If not managed, this leads to product caking during storage, packaging and bulk transportation.

Therefore, it is important to reduce the moisture content of fertilizers to the required level before the product enters the cooling stage, and then subsequently cool it to an ideal temperature for conditioning/coating, storage, packaging and transport.

What is currently being done to address product moisture?

Large-scale plants typically use either prilled towers, rotary drums, drum granulator-dryers, pan granulators, or tower-spray granulation technology during the production of fertilizer types such as urea, NPK, DAP, and MAP. During this process, the raw material (melt) is dosed at a certain chemical specification and viscosity, and then processed until it reaches the desired particle size and static strength.

Exiting the above-mentioned processes, the product will have anywhere from 20% to 30% moisture content. It is then fed into drying equipment – typically a rotary drum dryer or fluid bed (static or moving). Both methods of drying involve passing a heated gas (typically air) through the product until it reaches the target moisture content – typically less than 2%, but ideally between 0.2% and 0.8%. Some operators will even want that moisture content to be closer to 0.1% before the fertilizer enters the cooling stage.

While rotary drums or fluid beds do a decent job of taking the bulk of the moisture out, the rate and efficiency of drying reduces

as drying progresses. At this stage of drying, it becomes an exponential relationship between the driving force and the vapour pressure, which is what drives the moisture out of the product as well as its retention time.

Both rotary drums and fluid beds require a 'brute-force' approach to drive the moisture out of the particles at the bottom of the drying curve. That is to say, lots of hot air is needed, which in turn increases the amounts of energy per unit mass of moisture removed.

Trim drying

A potentially more efficient and effective solution at the later drying stages consists of an additional trim drying phase after the rotary drum or fluid bed and before the cooler; a combination of an MBHE that uses vertical plate technology and very small amounts of hot air that allow for efficient moisture removal.

Conveyed from the rotary drum or fluid bed into the top of the MBHE, the product enters into an inlet hopper where it slowly and uniformly moves by gravity through drying banks. In these banks, the fertilizer is kept warm by indirect conduction of heat from the heat exchanger plates to give it the necessary residence time to form, and for the last amounts of moisture to be removed. Drying air supply and extraction manifolds are included in the drying bank configuration.

The forming stage is important, as the hardness or strength of fertilizer controls how it reacts to handling, transportation, storage and application. The optimal hardness is typically determined by a crushing test, or the resistance of granules to deform or fracture under pressure. The static strength varies for different types of fertilizers – from 2 to 2.2 MPa for urea to 3 to 4 MPa for granular NPK.

A mass flow discharge feeder at the bottom of the MBHE controls the rate of flow, ensuring uniform product drawdown. Gravity, again, is the mechanism that slowly moves the product through the heat exchanger.

One of the primary advantages to trim drying with plate-based heat exchanger technology is the ability to reach the required product quality. Fertilizer operators are not in the business of selling dust. Yet the potential of dust formation increases if fertilizer does not have the necessary residence time to form as it transitions to the final solid granular product.

If exposed to high amounts of hot air for too long, then fertilizer can be over-dried, resulting in cracking and degradation with the subsequent formation of dust. Alternatively, if passed from the drying to cooling stage too quickly, fertilizer with too much moisture content can lead to caking, where large agglomerations are formed and equipment requires frequent cleaning, which leads to process downtime.

Trim drying with MBHEs that use vertical plate technology can provide fertilizer with the necessary residence time required. And because the residence time needed to dry the last few percentages of moisture can take considerably longer relative to the rest of the upstream drying cycle, plate-based technology can be more efficient and effective than rotary drums or fluid beds, due to its ability to provide intimate contact between the product and the heat transfer area.

A secondary benefit to trim drying with plate-based technology is a more efficient use of energy. Water, which is often the primary heat transfer fluid used in plate-based MBHEs, is a more effective heat transfer medium than air.

As for the hot air that would be used, it would be nominal – upwards of 20 times less than that of a typical rotary drum or fluid bed for the same mass throughput. This is due in part to the maximum fluidisation velocity of the much dryer particles at that stage of the drying process.

Other energy benefits to running a fluid system include the low horsepower requirements of ancillary equipment such as a cooling fluid circulation module, bucket elevator (if required by layout) and purge air system, as well as not requiring significant air-cleaning equipment.

In comparison, rotary drums and fluid beds rely on heating ambient air, with large fans blowing that air through the product. The air must be cleaned before being discharged to the environment, thereby requiring large horsepower fans, an induced fan to supply air to the cooler and an exhaust fan.

A final benefit to trim drying fertilizer is it can result in lower maintenance at the cooling stage. By maintaining the dewpoint of the air in the void space between the fertilizer particles below the temperature of the water-cooled plates, this eliminates the possibility of condensation and therefore caking on the plates, which reduces cleaning intervals.

Considerations

Trim drying in an MBHE that uses vertical plate technology is most appropriate for fertilizer grades with a clean (e.g. after screen) particle size of between 2 to 5 mm – typically NPK and urea. Both possess good flow properties that allow them to easily pass between the heat exchanger plates.

Drying fertilizer products that are not completely formed in a MBHE is not recommended because the air distribution will not be ideal, which makes the drying process less effective with the risk of severe caking.

Some completely formed crystalline products also have their own nuances such as 'wearing their moisture' on the metal surfaces. This makes them prone to salt bridging. Therefore, without the proper operating conditions, this would quickly turn the fertilizer into a solid 'cookie' inside a plate-based MBHE.

Conclusion

With ongoing regulatory changes, fertilizer producers are coming under intense scrutiny to offer products that adhere to increasingly higher quality control standards. At the same time, the world's population is growing, sparking calls from the global agricultural sector for increased fertilizer production over the years to come. With the right technologies in place, fertilizer producers can accomplish both.

For its part, trim drying with MBHEs that use vertical plate technology provides an affordable, low-energy solution that meets calls for a high-quality finished product. Complementing existing equipment, the solution is simple in its operation, effective in allowing granules to reach the required quality without the development of dust, and efficient in removing remaining moisture.

By investing in a right-sized drying solution, fertilizer producers have an opportunity to meet future demands while preserving the integrity of their production models more effectively. WF