ANOTHER ONE BITES THE DUST

Igor Makarenko, Solex Thermal Science, Canada, examines how an integrated de-dusting solution for cooling processes helps reduce risk and produce a better fertilizer.

The fertilizer industry continues to invest billions of dollars in upgrades to make production processes more efficient and sustainable. This is in response to a continuing trend of farmers increasing their use of fertilizer for improved crop production yields due to soaring demand for food from the world's growing population.

According to the most recent State of the Industry report from The Fertilizer Institute, companies are collectively investing more than US$3.8 billion annually in new fertilizer facilities and infrastructure upgrades that meet increasingly aggressive environmental and sustainability goals.[1] Those efforts often include increasing production efficiencies while simultaneously reducing energy and water use, as well as greenhouse gases and other emissions that impact on the environment.

One of the most significant obstacles to improved efficiencies and sustainability, however, continues to be dust. Created by the breakdown of fertilizer product into fines within process equipment and during transport – through what is commonly known as attrition – the formation of fugitive dust varies between the types of fertilizers and production processes.

Most commonly, dust generation can be traced back to sub-optimal production techniques and the process of creating fertilizer crystals and/or granules that generally result in a lower crush strength of the particle. For example, agitation agglomeration produces more round pellets that are less likely to break down when in contact with each other than types of processes (e.g. compact granulation and drying within rotating and/or fluidised bed equipment) that produce a product with rougher edges. The rougher edges result in attrition in subsequent handling and processing steps.

Excessive dust can also be attributed to poor handling during transfer points along the production process such as drop chutes and impact points on conveyer enclosures that are not properly designed, installed and sealed – which, in turn, leads to product breakage and degradation.

Significant variations in temperature and humidity can also cause a further loss of granule integrity while fertilizer is in storage.

Impacts of dust

The impact of fugitive dust on equipment, safety and product quality is significant. Ultra-fine particles that are allowed to compile and accumulate throughout the production process can clog equipment and, over time, impact performance, thereby causing unplanned and costly downtime.

Product attrition, meanwhile, can lead to millions of dollars in annual losses, as well as the potential of contaminating other raw products elsewhere in the plant and nearby area.

A 2012 study published in the journal Environmental Technology looked at the effects of emissions from a phosphate plant along the east Mediterranean coast on local soil contamination.[2] It found that windy conditions spread fertilizer dust throughout the surrounding community, adversely impacting plant life and groundwater sources.

Safety concerns over dust has also led to regulations globally to protect employees and the community from respiratory issues. According to the US Environmental Protection Agency, respirable dust particles (under 10 μm) can make their way past the body's natural cleaning mechanisms and travel deep into the lungs where they are likely to be retained and cause long-term health issues.[3] Other health issues attributed to fertilizer dust include moderate to severe eye and skin irritation, burns to skin and mucus regions, nausea and vomiting, headaches, nervousness and uncontrolled muscle movement.

Fugitive dust can also be traced to the source of explosions. In 2001, 240 people were injured at a dust explosion at agricultural chemical plant in France.[4] As recently as 2017, three workers were critically injured during a dust-related explosion at a fertilizer storage facility in the US.[5] The deadliest industrial accident in US history occurred in 1947, when the cargo ship Grandcamp exploded while loading fertilizer.[6]

Stopping the spread

While fertilizer dust has traditionally been handled upstream by baghouses and screening equipment (e.g. typically vibrating), it can still find its way downstream in the production process. Therefore, the cooling stage of fertilizer production represents one of the last opportunities that producers have to remove these ultra-fine particles before conveyance, transport and storage.

Traditionally, nitrogen fertilizers have been cooled through direct-contact air coolers or fluid bed coolers in granulation and/or prilling plants. With these direct-cooling methods, however, ambient air is taken in using large horsepower fans, often cooled and blown across the product. The air is then cleaned and discharged to the environment.

Phosphate and potassium fertilizer production facilities employ similar technology for cooling.

In addition to both the air-cooling process and circulating

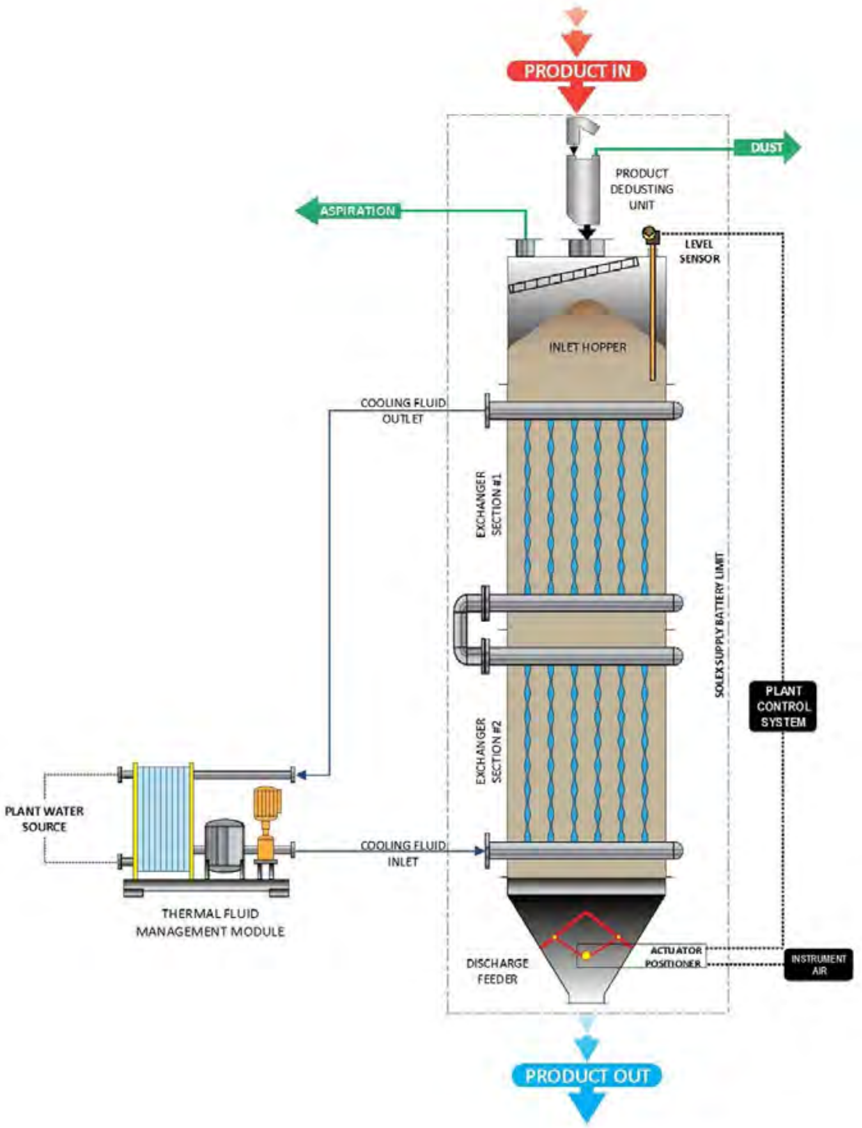

Figure 1. Situated before the inlet to the Solex cooler, an attached aspirator lifts the lighter fines into a selection chamber while allowing the heavier product to pass through the de-dusting steps and proceed down through the unit for cooling.

fans having high energy requirements, product degradation is highly correlated to these direct-contact cooling methods.

Vertical plate technology, though, prevents degradation from occurring and minimises emissions because of the low flow velocity (typically less than 0.3 m/min) and gentle handling of the fertilizer.

Using vertically stacked plates within a modular design to cool particles through conduction, the fertilizer flows slowly by gravity through banks of stainless-steel pillow plates with cooling water flowing counter-currently inside the plates. A mass-flow discharge feeder controls the rate of flow through the heat exchanger.

Only a small amount of purge air is used in this process – specifically to maintain the dewpoint of the air in the void space between the particles to be below the temperature of the plates, thereby avoiding the condensation of moisture and, subsequently, caking. This indirect method of cooling fertilizer means there is little risk of product abrasion or attrition – and therefore, no dust formation or degradation of fertilizer quality.

De-dusting

While vertical plate technology can mitigate the generation of additional of fugitive dust during the cooling stage, it typically has not been able to remove it – meaning the dust that goes into these exchangers still comes out.

In response to the need for improved quality and reduced dust emissions, Solex Thermal Science has integrated a de-dusting solution into its fertilizer cooling units that involves adding a cascade aspirator to eliminate fertilizer dust from entering the cooling section of the indirect heat exchanger.

Situated before the inlet to the Solex cooler that distributes the fertilizer evenly across the unit, an attached aspirator features a series of specially designed and situated 'slides' – which range from four to six – that allow the product to slide gently back and forth downward by gravity. Ambient air is drawn upward through the product to lift the lighter particles out and into a selection chamber.

The upward flow of air in the aspirator provides an opposing gravitational force to the particles and reduces the rate of fall. The operating philosophy of the aspirator with the coolers is to have the acceleration of air slightly exceed the fertilizer's terminal velocity, thereby lifting the lighter fines (separation can be fine tuned to particles typically less than 0.1 mm) into the selection chamber while allowing the heavier product to pass through the de-dusting step and proceed down through the heat exchanger for cooling.

The dust-free fertilizer then passes through the vertical plates – again with calculated amounts of purge air inserted at strategic points to avoid caking within the exchanger.

The dust picked up by the aspirator sorts the particle based on the terminal velocity, with the heavier particles returned to the heat exchanger for cooling and the lighter ones filtered out to the air stream. The clean air is discharged to the environment.

The aspirator is designed to meet safety requirements through the incorporation of static-electricity reducing features.

The benefits

Removing fugitive dust during the cooling stage offers several advantages, including reducing the potential of caking between plates within vertical plate exchangers. When allowed to enter the plates, fugitive dust can spread as a result of the purge air, settling between contact points in small corners of the unit and forming bridges and/or stagnant pockets – the early formation of caking. This can then lead to costly shutdowns in order to mechanically clean the heat exchanger and remove stagnant material.

Left untreated and caking can affect flowability within the unit as the agglomeration continues to grow. Without cleaning and maintenance, the caking can build up over time, ultimately compromising uniform mass flow and even creating uneven and increased temperature profiles at the outlet.

As mentioned earlier, stopping fugitive dust during the cooling stage also mitigates the continuation of dust to conveying, transport and storage. Caking and clumping often result when stored fertilizers are exposed to humid air. As research has shown, there is a direct correlation between the particle size (e.g. surface area) of fertilizer and the susceptibility of adsorbing moisture from the environmental atmospheric air conditions – meaning fertilizer dust is more susceptible to this caking and clumping effect.

The highest theoretical cubic close packing of equal spheres has been noted as 74% of particles, leaving 26% volume for void (empty) area for air.[7] During storage, this void space will be filled with the surrounding air. If the humidity is high, any dust in the stored fertilizer product will cause caking

Accordingly, larger particles are less sensitive to pressure contact bonding because they have less contact points.[7] Therefore, it is critical to ensure the right size and consistent uniformity of fertilizer, in order to eliminate the risk of dust in the void spaces to avoid clumping and caking of fertilizer.

Conclusion

Fugitive dust poses numerous risks to fertilizer producers that can lead to a significant loss of product and product quality, costly maintenance, health risks and environmental hazards. Du-dusting techniques applied at the cooling stage in combination with vertical plate exchange technology can provide an opportunity to prevent these ultra-fine dust particles from further impacting later stages of the production process, while also improving cooling efficiency and overall plant sustainability.

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