The heat is on

Igor Makarenko, Solex Thermal Science, Canada, explores how vertical plate technology helps mitigate planned rate reductions.

Fertilizer production plant owners continue to search for ways to remain competitive. Improving product quality, creating new formulations, reducing operational costs and maximising market share are examples of some of the initiatives that producers are focused on when looking to get the most out of their operations.

One of the most important steps when working to maximise fertilizer production is maintaining consistent product quality throughout the year. Product quality becomes quite challenging for producers located in hot and/or humid climatic conditions where they struggle with product agglomerating not only in the plant's warehouses, but also during transportation to final users' locations. For proper storage and transport, fertilizers must be cooled to certain temperature so the final product temperature before packing, storage or shipping is within 10 to 20˚C of the ambient temperature. This prevents moisture migration from the air to the product that can lead to agglomeration or caking and result in facilities producing a lower-valued end product.

When ambient temperatures are high – particularly during summer months where, in many parts of the world, they can peak upward of 46 to 48˚C – current cooling equipment either does not exist, or is insufficient/restricted. The later is especially true in cases where fertilizers are cooled through direct-contact air coolers such as rotary drums or fluid bed coolers in granulation and prilling plants. A typical specific temperature for fertilizer in storage is in the range of 40 to 45˚C.

As a result, many plants are turning to inefficient practices such as bulk storage in which the product is left to sit to cool on the floors of warehouses for 3 to 4 days. This complicates plant logistics – for example, demurrage and warehouse management. Or worse yet, plants are forced to schedule planned rate reductions that lower throughputs and allow their limited cooling capacity to cool their product down to an acceptable temperature. By no longer operating at peak capacity, plant owners are effectively handcuffed from fully maximising the sale of their product in local and global markets.

In addition, the operation of both rotary and fluid bed cooling technologies require high volumes of air. This involves large-scale fans for air movement and scrubbers or baghouses to clean the air in order to meet ever more stringent emissions requirements. The load on these air-cleaning systems is often too much during the summer months when the ambient air is too hot and/or humid to effectively cool the fertilizer. In turn, this creates a bottleneck that results in planned production rate reductions and reliance on bulk storage practices.

Vertical plate technology, however, allows fertilizer plant operators to consistently cool their product prior to packing and storage independent of ambient temperatures. By doing so, production can send cooled product directly to the loadout, thereby eliminating the need for inefficient and crude warehouse cooling practices and avoiding planned production rate turndowns.

By minimising caking, plant operators are further able to avoid the product degradation that typically occurs when trying to reclaim fertilizer that has bonded together.

ABC's of fertilizers' critical relative humidity

To understand the importance of cooling – and, by extension, how caking occurs – means first understanding the behaviour of fertilizers. By nature, fertilizers are hygroscopic, meaning they attract and absorb moisture from the surrounding air. Moisture transfer between the product and air will cause the humidity of the surrounding air to increase, leading to condensation and product caking.

The humidity of the surrounding atmosphere and the temperature of fertilizer has an effect on the storage behaviour. Fertilizer can absorb moisture only when the relative humidity of the ambient air is, for a given temperature, above a specific value, called the critical relative humidity (CRH).

The CRH governs the relationship between dew point and product temperature. For example, when a fertilizer's CRH is lower than the ambient air's relative humidity, the product will absorb moisture from the air, which will cause caking. For prilled urea this value is 70% for a temperature of 30˚C and 66% for 42˚C. For granular urea, the CRH is considerably lower.[1]

Understanding the CRH of each fertilizer and customising cooling techniques prevents caking within the unit. To prevent this reaction, cooling the product to the required temperature for storage and transport is extremely important and will lead to a higher quality end product.

Vertical plate technology

Solex Thermal Science has developed a vertical plate solution to indirectly cool fertilizers and avoid the use of high-energy consumption air chillers and large fans. The technology focuses on a vertical tower that allows the fertilizer to slowly pass through proprietary heat transfer plates that are cooled by water or other liquid mediums.

One of its key strengths is that the design allows true counter-current flow of the cooling water inside the plates, which achieves greater thermal efficiency and, as a result, more effective cooling. The stainless-steel plates absorb the heat from the fertilizer and the product cools as, encouraged by gravity, it slowly moves through the tower.

The fertilizer is cooled by conduction as opposed to convection (air cooling). As a result, the product cools evenly and without the risk of condensation, excessive temperature changes and, ultimately, caking. Because the cooling water flows counter-currently inside the plates, it never touches the product and thereby avoids both product contamination and attrition.

A mass flow discharge feeder controls the rate of flow through the heat exchanger. As gravity is the mechanism that slowly moves the product through the indirect cooler, the end result is a product with a stable and uniform final temperature.

The final, and perhaps most important, component to vertical plate technology is the complex thermal modelling calculations that guarantee precise discharge temperature control; this ensures that the product temperature to storage is optimal.

Ammonium nitrate and calcium ammonium nitrate create special challenges due to their phase changes and

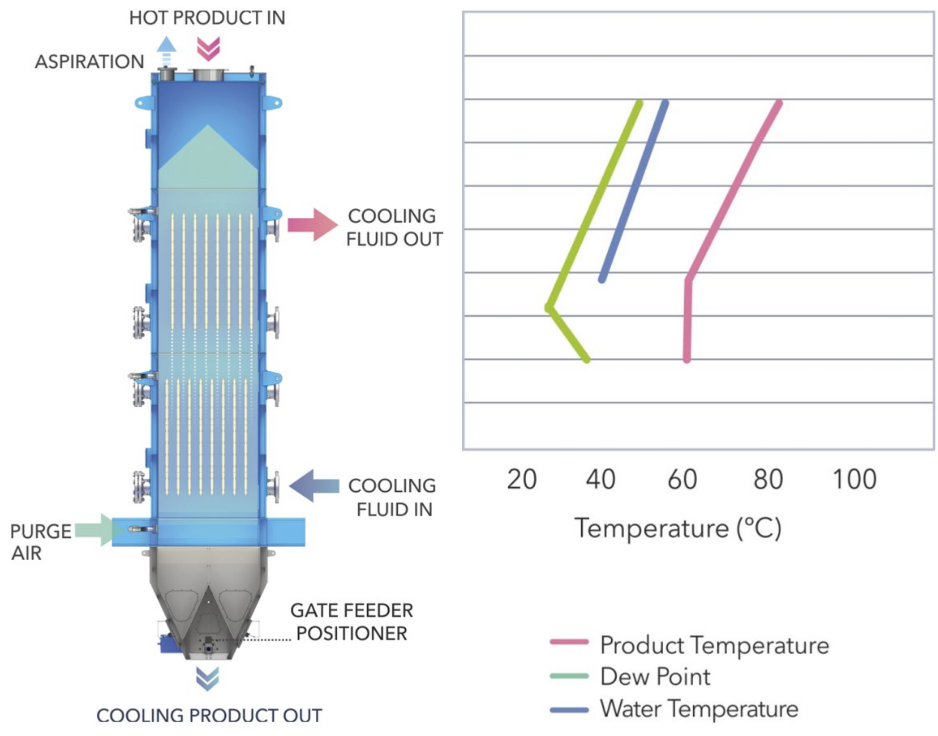

Figure 1. Understanding the CRH of each fertilizer and customising cooling techniques prevents caking within the unit. To prevent this reaction, cooling the product to the required temperature for storage/transport is important.

associated latent heat loads. Comprehensive thermal modelling allows for this complex phenomena, guaranteeing the final product discharge temperature and ensuring that all of the product has converted to the lower temperature phase.

More efficient cooling in action: a case study

For one of Russia's largest chemical companies, production constraints and product quality concerns due to inadequate cooling capacities were the reasons to seek out an alternative solution.

Novomoskovskiy Azot (NAK Azot), a subsidiary of EuroChem Mineral and Chemical Co., is the second largest ammonia producer and the largest nitrogen fertilizer producer in Russia, as well as a major exporter in the world market.

The company operates a granulated urea plant in Novomoskovsk, Russia, where it saw international demand for high-quality fertilizers growing at its very doorstep. And while the opportunity for the company's calcium ammonium nitrate product was significant, internally, the company needed to find a means to increase production while at the same time address product cooling practices that threatened quality.

NAK Azot's facility was cooling its calcium ammonium nitrate after granulation in three parallel fluid bed coolers. The coolers were designed to lower the post-granulation fertilizer temperature to between 65 and 75°C.

From there, the calcium ammonium nitrate moved into a rotary drum cooler for secondary cooling before being transported to bulk storage where it was held for 3 to 4 days until the temperature was reduced to its target range of between 35 and 40°C – a time-consuming process in which NAK Azot had to hold its product before being able to package and transport it.

Additionally, because the fertilizer going into bulk storage was at such as high temperature, it was also highly susceptible to drawing in moisture from the atmosphere and then caking as it went through its final stage of cooling. The caked product was reclaimed using two Kratzer-Crane scrapers, but this handling step further degraded the product and led to variable grain-size distribution and a high percentage of fines.

From the fluid beds to bulk storage, the entire process was both expensive and time-consuming. Furthermore, despite the high-cost inputs, NAK Azot was producing low-quality fertilizer.

To mitigate its caking problem and achieve better quality control, the company started by upgrading its rotary drum to allow for anti-caking additives to be injected into the hot fertilizer before sending it to bulk storage where the product had a layover for several days until it reached its acceptable temperature.

While this helped to reduce the amount and thickness of the caking, NAK Azot still needed a more efficient and reliable means to produce more fertilizer. Within its current facility, this meant increasing its cooling capacity.

The company therefore turned to vertical plate technology as its cooling solution, to not only eliminate caking but also dramatically enhance the overall fertilizer quality, production capacity and facility performance.

The switch has allowed NAK Azot to eliminate its reliance on bulk storage, thereby recouping the 3 to 4 day final cooling time. The fertilizer is fed directly into the vertical plate cooler directly from the fluid bed dryer at a temperature between 65 and 70°C, and is discharged at an optimum temperature of between 37 and 41°C. In addition, there is no breakage or degradation of the fertilizer granules during this cooling step.

Overall, the indirect cooling process allows the granules to keep their form, resist caking and hold their integrity during storage and transportation, as well as maintain overall product value.

The results with calcium ammonium nitrate also led to the company to choose vertical plate technology to cool its high-density ammonium nitrate. WF

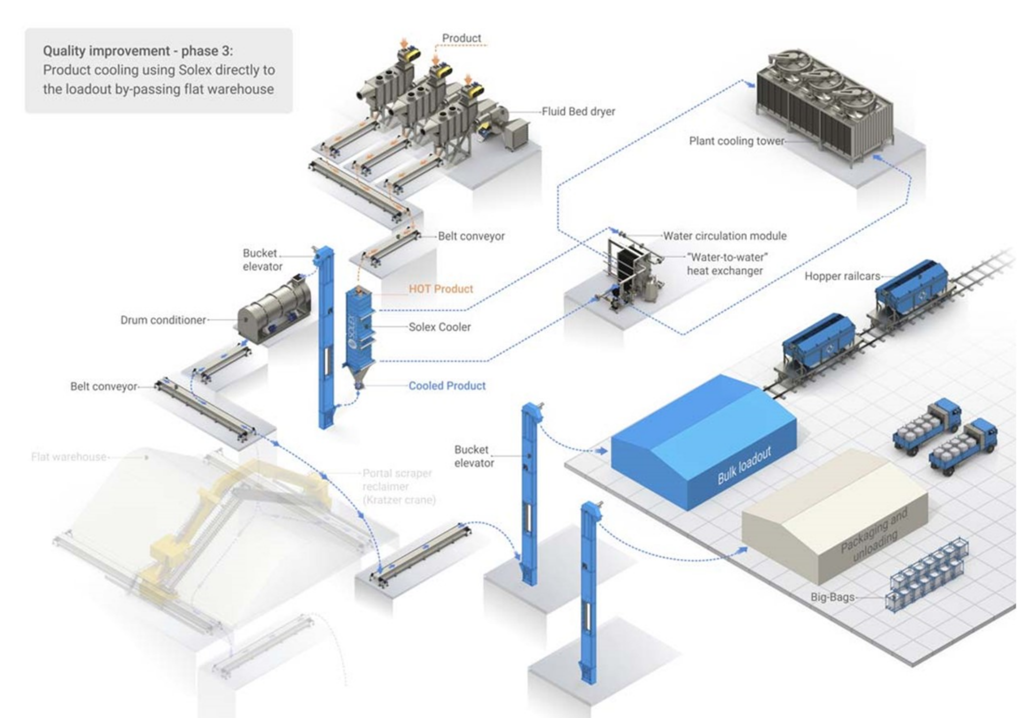

Figure 2. By turning to vertical plate technology as its cooling solution, NAK Azot was able to eliminate its reliance on bulk storage, thereby recouping the 3 to 4 day final cooling time.

Reference

1. ORPHANIDES, P., 'Urea Caking Problems, How to Avoid Them,' International Fertilizer Association Technical Conference, (2002).