Optimizing fertilizer production and quality

SOLEX
THERMAL SCIENCE

The importance of fertilizers to the world economy can hardly be overstated and the growth in fertilizer consumption since the 1960s has been impressive. By supplying crops with essential nutrients, fertilizers facilitate efficient use of land and water. In many developing countries the supply of fertilizer is as important as the supply of food itself, and regardless of market conditions, the need for high yields and increased crop production remains a priority. China leads the world in fertilizer consumption followed by India and the United States. In Canada, one of the world's smaller markets, farmers spend over $2 billion a year on fertilizers.

In line with growing environmental awareness and in order to optimize outcomes, the industry is working to reduce emissions, improve operational practices, and restructure existing plants to maximize production.

THE CHALLENGE

Within the fertilizer industry, an essential element of successful production is ensuring the product is stored and packaged at an appropriate temperature. Given the hygroscopic nature of fertilizer prills and granules, elevated temperatures can quickly translate into caking during storage, packaging and bulk transportation. When product quality is compromised by caking it results in breakage and handling difficulties which translate into a lower selling price and dissatisfied customers.

Two current market trends contribute to the importance of ensuring product is sufficiently cooled. One is the drive to increase production within existing facilities. This can result in product leaving the prill tower or cooler and arriving at the warehouse with an elevated temperature that consequently results in caking.

The second trend is the move to produce bigger prills and granules. The problem here is that bigger prills do not cool as much in the prill tower. Furthermore, there is a larger temperature gradient within the prill or granule itself. The outside cools quickly while the inside maintains both a higher temperature and a higher moisture content. In storage, heat transfer occurs between the surface and the core of the granules, until the overall product temperature reaches equilibrium. The same process occurs between the centre and outer layers of bulk product. As the heat from the centre is transferred to the surface, the increased surface temperature allows evaporated water in the surrounding air to migrate to the product causing caking to occur.

CONVENTIONAL RESPONSE

In order to ensure sufficient cooling and avoid caking, product temperature must be controlled either by installing an additional cooler in granulation plants or adding a cooler to prilling plants where the original design did not to include a cooler.

For example, the majority of urea prill plants do not have a separate cooler after the prill tower which, in the original design, was high enough and had sufficient air to cool the prills to an acceptable temperature for storage. This situation changes when plant capacity is increased – a common scenario given the development of innovative technologies for increasing plant production. What occurs is that the increased capacity reaches a bottleneck at the prill tower because the cooling capacity is essentially fixed by the height of the tower.

In order to deal with the increased capacity, a cooler is required. For many years, the standard choice of cooling technology in the fertilizer industry was the rotary drum or the fluid bed. When retrofitting an existing plant to facilitate increased production and larger prill and granule size, these options present a number of challenges. The conventional cooling technologies involve direct contact with high volumes of air which can impact product quality. They come with high installation and operating costs, and are often not suited to space restrictions within existing plants, particularly given the inclusion of expanded air handling and wet scrubbing systems that these technologies require.

INNOVATIVE TECHNOLOGY

In the early 1990s, faced with the high cost of retrofitting a fluid bed cooler for use in their plant near Calgary, an international fertilizer company developed a simple and elegant heat exchange technology that has come to be recognized within the fertilizer industry as one of the most significant technological developments of the last few years. Now in use in more than 60 fertilizer plants, the Solex Cooler offers improved product quality and stable temperatures at lower capital and operating costs.

The Solex Cooler has been successfully used to cool the full ranges of fertilizers from urea granules and prills to ammonium nitrate and CAN, NPKs, MAP, DAP, TSP and ammonium sulphate. Certain details are altered to allow for the differing properties of different products, but the principles of operation remain the same. For example, in urea prill plants, the Solex Cooler is installed after the prill tower.

The technology combines the science of mass flow with the thermal efficiency of plate heat exchange design. In the cooler, bulk solids pass in mass flow through vertical banks of stainless steel plates. Cooling water flows through the plates to cool the material by conduction. The water is circulated through the plates in counter-flow for enhanced thermal efficiency. The indirect plate heat exchanger design means air is not used in the cooling process, a feature that both increases product quality and reduces installation and operating costs. A mass flow discharge device controls the product flow rate through the exchanger. The product moves slowly by gravity through the unit to create sufficient residence time to achieve the required cooling. A level control system ensures the unit operates at its optimum configuration.

Lower Storage Temperature

Fertilizer producers need to be confident that material temperatures will meet their optimum storage requirements. As world leaders in the science of bulk solids heat exchange, Solex developed its own proprietary thermal software program to provide customers with accurate predictions of final product temperatures and guaranteed thermal performance.

The product is lab tested to evaluate thermal properties and flow characteristics. Then the modeling software, ThermaPro, performs detailed calculations based on material thermal properties and process requirements including the fertilizer's bulk density, specific heat, thermal conductivity, input temperature and flow rate. The results of this modeling accurately predict how long prills or granules need to stay in the cooler to reach the desired discharge temperature.

Based on the modeling program, the heat exchanger plates are positioned such that fertilizer flows through the cooler by gravity with a velocity that achieves the required residence time for sufficient and even cooling. The typical residence time is five to ten minutes. The uniform product flow combined with long residence times enables even temperature distribution in the product as it passes through the Solex Cooler, producing remarkably stable and uniform final product temperatures.

Improved Quality

While increasing production, it is important to ensure that product quality remains high. When compared with the conventional technology of the rotary drum and fluid bed coolers, the Solex Cooler offers advantages that contribute to improved product quality.

Typical fluid bed or rotary drum technology employs large volumes of air blown directly across the product and one drawback of this approach is that when air comes into direct contact with the product it introduces the risk of moisture content changes.

Unlike conventional technology, the Solex Cooler does not use air in the cooling process. This eliminates the risk of prills or granules absorbing moisture from saturated air. It also eliminates emissions, dust, fines and odors, as well as requiring significantly less energy than those technologies that use air.

In the Solex Cooler, a mass flow discharge feeder regulates flow rate and creates uniform product velocity through the cooler. The product moves slowly under gravity. The flow pattern is laminar and there is no mechanical handling and moving of the particles, rendering the cooler ideal for soft and friable grades. Tests have shown no measurable quantity of fines are created as the product flows through the cooler and the slow material movement avoids any product degradation and dust formation. This gentle product handling prevents product abrasion and degradation and produces a superior final product.

Lower Installation Cost

When analyzing the comparative cost of cooling technologies, it is essential to include the entire system. For example, with a fluid bed cooler, the air handling equipment required by the system includes fans, air chiller, air pre-heater, scrubber and ancillary equipment, and large diameter ducting to accommodate the high volume of air employed in the cooling process. As well as the cost involved, this equipment occupies a significant amount of space within a production facility and is often difficult to accommodate within an existing plant.

With the Solex Cooler, installed capital costs are reduced due to the elimination of air handling equipment. The cooling water pump and piping required are not of significant size or cost. No air conditioning unit is required to produce dry and cool air, and no additional or new wet scrubber system is needed.

The vertical configuration of the Solex cooler makes the design both compact and modular. The compact installation footprint makes this design easy to integrate into existing plants and ideal for de-bottlenecking, revamps and capacity increases. In addition, the modular design means additional heat exchanger plates can be stacked if increased thermal capacity is required in the future.

While many variables can impact on the final capital cost, several case studies have demonstrated that the installation cost of a Solex cooling system generally runs at least 30 percent lower than the cost of installing a fluid bed cooler.

Lower Operating Cost

The energy required to operate a fluid bed cooler and the ancillary equipment it entails is significant. Use of a fluid bed cooler typically requires two large horsepower fans: first, a forced draft fan is needed to supply air to the cooler; and second, an induced draft fan is required following the scrubber. Additional energy draws in a fluid bed system include the air chiller and air pre-heater.

On the other hand, the Solex Cooler has very low energy consumption. The cooler constitutes only a small additional load on the existing cooling water system. The cooling water pump, bucket elevator and purge air system all have low horsepower requirements. With thermally high efficiency and a large capacity of up to 150 tph in a single cooler, the Solex Cooler typically saves four to five kW.h/tonne compared to a fluid bed system, operating with as much as 90 percent lower energy costs.

Operating costs of the Solex cooler are further reduced by the ease of cleaning and maintaining the system. Large hinged doors on the back of the cooler give full access to the plate banks which are configured to enable easy access for inspection and cleaning. Cleaning is done by washing with water and drying with a counter-current of warm air. Typically the exchanger can be washed and dried in a four to eight hour period, easily fitting within a normal plant maintenance schedule. The

TYPICAL ELECTRICAL ENERGY REQUIREMENTS		
	Solex Cooling Technology	Fluid Bed Cooler
Electrical Fan Power	-	1000 kW
Electrical Pump Power	15 kW	-
Bucket Elevator Power	35 kW	-
Total Electrical Power Consumption	45 kW	1000 kW
Operating Hours/Year	8000 hrs	8000 hrs
Total Electrical Energy Cost/Year *	$18,000 US/Year	$400,000 US/Year
*Energy cost based on 0.05 $US/kWh)		

design makes it possible for single plates to be isolated or replaced if required. The simple system with few moving parts translates into minimal mechanical maintenance requirements.

AN IDEAL SOLUTION

Within the fertilizer industry, the drive to increase production capacity and the market trend towards producing bigger prills and granules has made it more challenging for plants to sufficiently cool their product. Nonetheless, adequate cooling remains key to maintaining product quality and preventing caking and subsequent problems with customer dissatisfaction.

The innovative technology of the Solex Cooler offers an attractive alternative to what has been the standard choices of rotary drum or fluid bed cooler. Recognized within the fertilizer industry as one of the most significant developments in recent years, the Solex Cooler guarantees final product temperatures and does so at much lower capital and operating costs than standard cooling technology. As world leaders in the science of bulk solids heat exchange, Solex combines the principles of mass flow of bulk solids with the science of indirect heat transfer. The Solex Cooler is supported by extensive testing and development and uses proprietary thermal modeling software to accurately predict temperatures resulting in a design that ensures remarkably stable and uniform final product temperatures.

Unlike other cooler choices, the Solex system does not require large volumes of air and instead allows gravity to do the work, greatly reducing power consumption as well as eliminating emissions, dust, and odors. In addition, the gentle product flow prevents product abrasion and degradation and produces a superior final product. Experience in more than sixty fertilizer plants around the world has demonstrated that, in comparison with conventional technology, the Solex Cooler generally costs 30 percent less to install and, given its high efficiency and low energy consumption, delivers operating costs that are as much as 90 percent lower. With vertical configuration and compact design, the Solex system is easy to integrate into existing plants. Taken together, these advantages make the Solex Cooler an ideal solution for the challenge of increasing capacity while turning out a high quality product.