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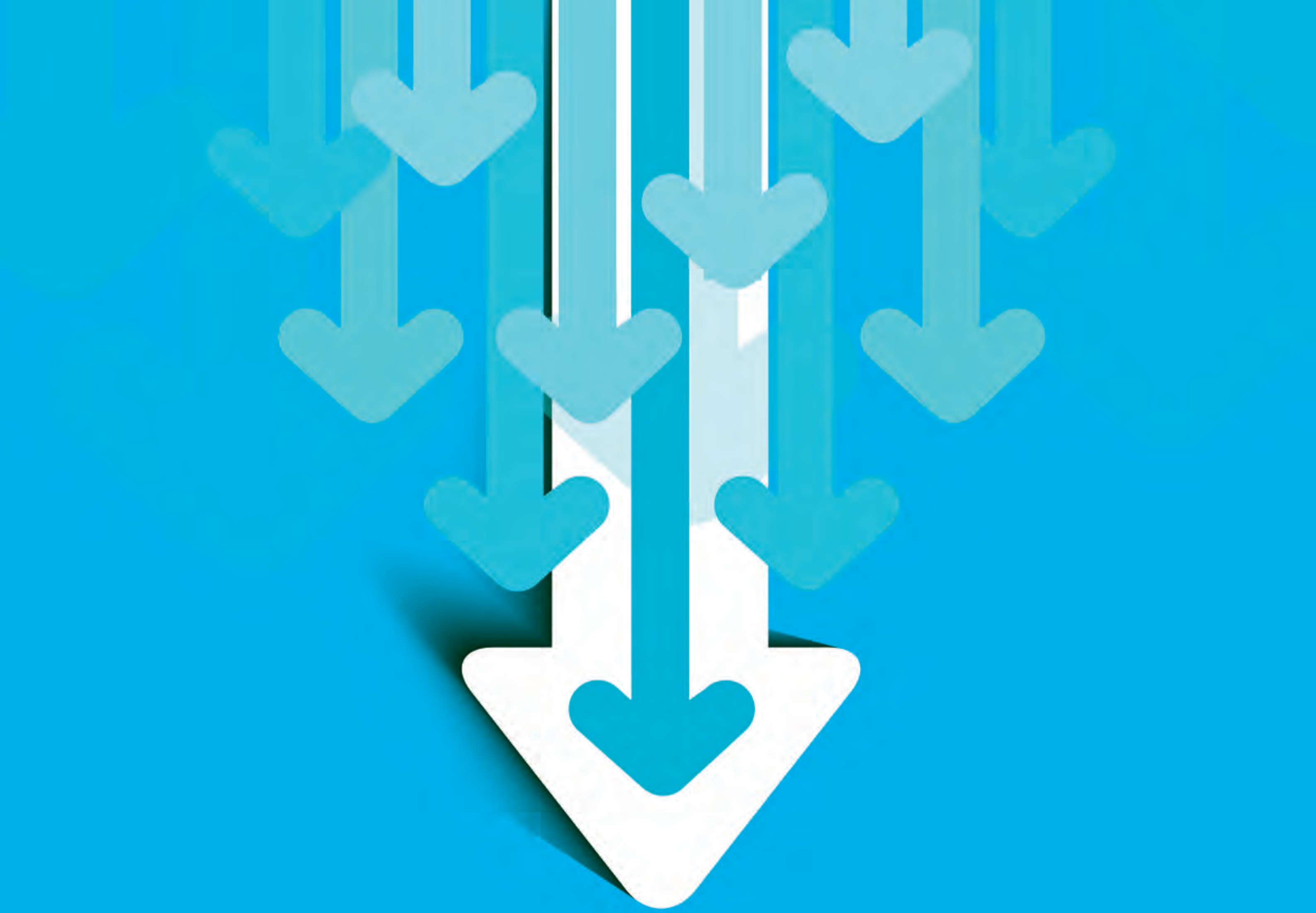

LOW-CARBON FERTILIZER COOLING

Igor Makarenko, Solex Thermal Science, Canada, explores how vertical plate technology at the cooling stage is helping fertilizer producers to reduce operational footprints.

Widespread sustainability commitments by producers and users in the fertilizer industry are creating trickle-down effects within the entire supply chain and giving technology partners opportunities to participate in innovation at all points along the production process.

The International Fertilizer Association (IFA) notes that the global fertilizer industry currently accounts for 2.5% of global greenhouse gas (GHG) emissions, with approximately 1% tied specifically to fertilizer production.[1] As such, there are calls to do better.

The IFA and its members have already committed to playing a part in curbing GHG emissions so that global warming is limited to below 1.5˚C above pre-industrial levels, which is the goal of the 2015 Paris Agreement. In fact, the fertilizer industry has already made considerable strides in reducing its carbon footprint. Fertilizers Europe notes that the fertilizer industry in the EU has reduced its GHG emissions by 40% since 2005.[2]

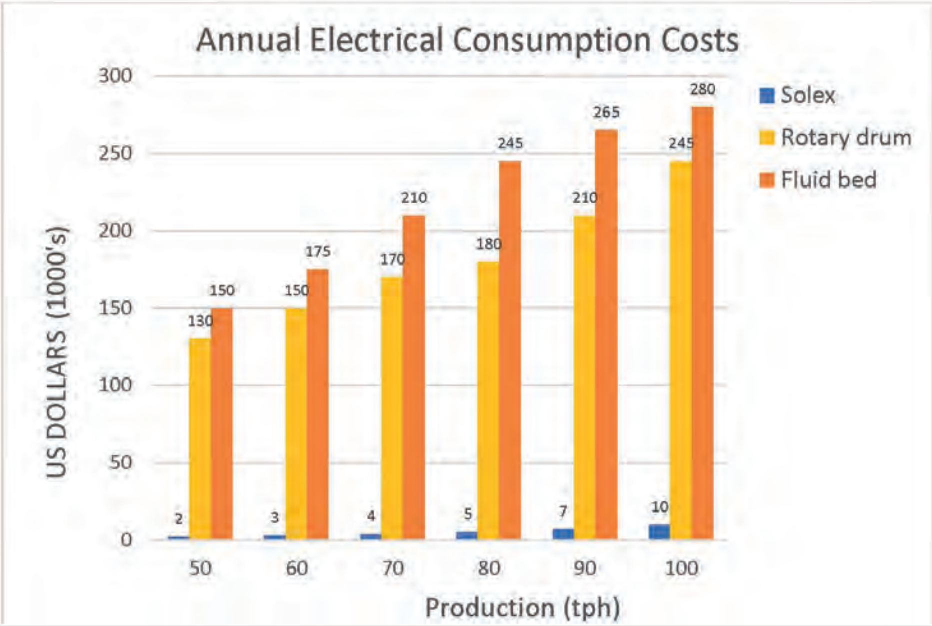

Figure 1. Annual electrical consumption cost comparisons between direct and indirect fertilizer cooling technology.

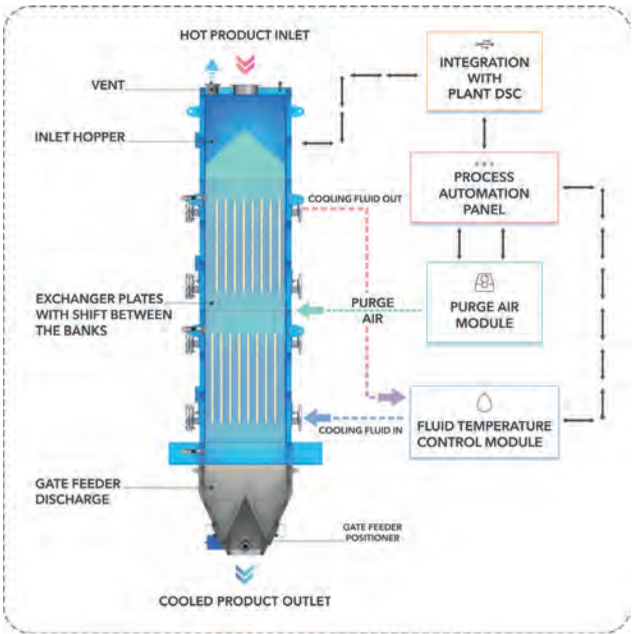

Figure 2. Vertical plate technology cools the product by conduction instead of convection (e.g. air cooling). Free-flowing particles enter the exchanger, slowly passing between a parallel series of heat exchanger plates that contain a counter-current flow of water or other heat transfer fluids.

Meanwhile, US-based The Fertilizer Institute (TFI) reports that GHG emissions produced by its member companies have decreased annually since reporting began in 2013, more recently by approximately 5% in 2019.[3] According to TFI, an estimated 29% of GHG emissions from US fertilizer manufacturers in 2019 were captured and not emitted.[4]

However, both TFI and Fertilizers Europe also highlight the need for adopting even further technological innovation in order to meet aggressive emission-reducing targets, from those pledged within the Paris Agreement to – more recently – the Fit for 55 climate package that will put the EU on track for a 55% reduction in carbon emissions by 2030, and net zero emissions by 2050.

This has left no stone unturned as companies around the world look for more sustainable ways to produce fertilizer. For example, Nutrien has pledged to reduce its GHG emissions by 30%/t by 2030 through energy efficiency improvements, among several other initiatives. Similarly, CF Industries has set a target to cut its total CO_2 equivalent emissions by 25%/t of product by 2030, and achieve net zero carbon emissions by 2050.

This collective pursuit of improved sustainability is already having profound reverberations with technology partners, and is perhaps best illustrated by what is happening at the cooling stage.

Vertical plate technology – which cools fertilizer indirectly – has emerged as a more sustainable and standard solution when compared to direct contact alternatives. There are two main reasons as to why this is the case: reduced energy consumption and near zero emissions.

How it works

Before diving into sustainability specifically, it is important to understand how the technology works.

Vertical plate technology blends the thermal efficiency of plate heat exchange design with the science of uniform mass flow to cool the full range of fertilizers, including urea, ammonium nitrate and calcium ammonium nitrate (CAN), NPKs, monoammonium phosphate (MAP), diammonium phosphate (DAP) and ammonium sulfate.

The tower-like design cools the product by conduction instead of convection (e.g. air cooling). Free-flowing particles enter the exchanger at temperatures around 120˚C or higher, slowly passing between a parallel series of heat exchanger plates that contain a counter-current flow of water or other heat transfer fluids.

Heat transfers from the fertilizer to the heat transfer fluid via a steel plate wall. The product then cools to temperatures between 30˚C and 70˚C as, pulled by gravity, it slowly and uniformly moves downwards, controlled by a discharge device. While certain details change according to the differing properties of different products, the principles of operation remain the same.

Reduced energy consumption

Vertical plate technology can drastically cut energy consumption through the aforementioned stacked plate design that cools fertilizer particles through conduction instead of convection. Water is a much more effective cooling medium than air, as it absorbs up to 24 times as much heat, resulting in lower power requirements to circulate the much lower volume of cooling medium.

By comparison, direct contact air coolers or fluid bed coolers rely on ambient air that is first taken in using large fans, and then cooled and blown across the product before being cleaned and discharged to the environment.

Notably, only a small amount of purge air is used with vertical plate technology. Its purpose is to maintain the dewpoint of the air in the void space between the particles to remain below the temperature of the plates. This eliminates condensation and, subsequently, caking of fertilizer in the heat exchanger.

Figure 3. The tower-like design blends the thermal efficiency of plate heat exchange design with the science of uniform mass flow to cool the full range of fertilizers, including urea, ammonium nitrate, CAN, NPKs, MAP, DAP and ammonium sulfate.

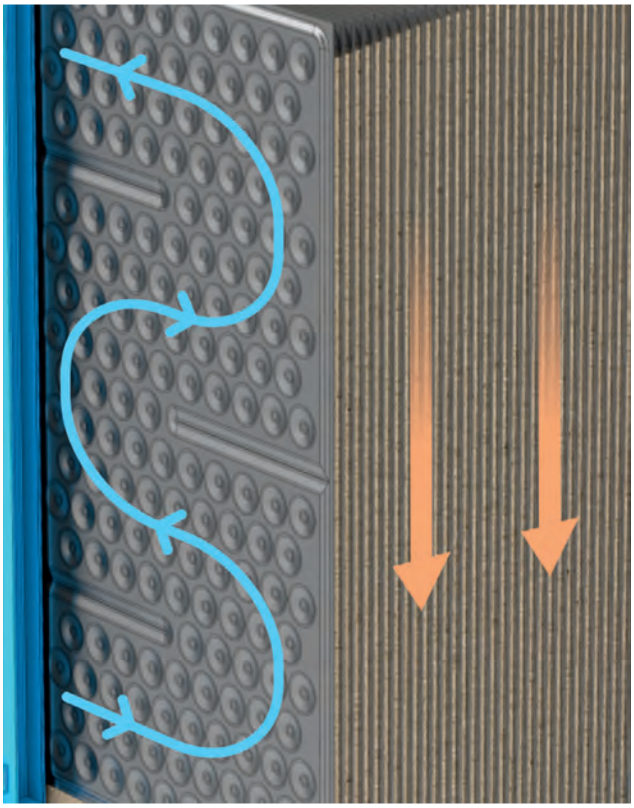

Figure 4. Fluids flow counter-currently through the plates, never coming into contact with the product and thereby preventing degradation from occurring and minimising emissions.

By not relying on air during the fertilizer cooling process, the energy required with vertical plate technology is therefore significantly less than direct contact alternatives. The technology does not require the use of significant air handling equipment such as high horsepower fans – for example, fluid beds often require both a forced draft fan to supply air to the cooler and an exhaust fan to move air to the scrubber – nor does it use air chillers or air pre-heaters.

The unit itself constitutes only a small additional load on the existing cooling water system, while the cooling water module, bucket elevator and purge air fan all have low horsepower requirements.

As a result of its high thermal efficiency and ability to accommodate capacities of up to 150 tph and higher in a single cooler, vertical plate technology can save upwards of 4 – 5 kWh/t of fertilizer cooled compared to a fluid bed system.

For example, industry estimates peg power consumption of up to 1.7 MW for cooling 100 tph of fertilizer using either fluid beds or rotary coolers. This can be translated to annual electrical energy costs of approximately US$744 000.[5]

Vertical plate technology can reduce power consumption to just 170 kW for the same fertilizer capacity, resulting in energy savings of more than US$600 000/yr.

In a recent collaboration between Solex and a potassium chloride (KCl) producer, the plant needed a cooler to process 100 tph of crystalline potash product from 105˚C to 42˚C. Power consumption of the existing fluid bed system was unacceptably high at over 600 kWh.

The plant chose to install a Solex indirect cooling system with a total electrical consumption of 200 kWh, which was three times less than the alternative fluid bed system that was being considered.

In general, the lower operating costs of vertical plate technology result in a higher internal rate of return for the customer, which drives a quicker return on their investment. Solex estimates that installing indirect cooling equipment into a process can pay for itself in as little as 2 – 3 years.

Near zero emissions

Vertical plate heat exchange technology is also playing an important role in emissions management. Since 2003, the IFA has been benchmarking industrial emissions data from nitrogen, phosphate and potash fertilizer production sites located around the world. Data collected in 2020 from close to 300 production sites on more than 50 emissions to air, water and soil show a trend to decreasing emissions due to what it calls 'widespread adoption of environment mitigation techniques.'

Cooling fertilizer through conduction instead of convection offers the benefit of producing significantly lower emissions than direct contact alternatives. For example, fugitive dust has traditionally hampered fertilizer plant operators in their path towards improved sustainability. Created by the breakdown of fertilizer product into fines within process equipment and during transport – commonly known as attrition – the impact of fugitive dust on the operations and the environment around a fertilizer plant is substantial.

Permits for discharge stacks are becoming more difficult to acquire and, with ever tighter pollution controls, emissions must be cleaned and scrubbed before being dumped into the atmosphere, thus leading to high associated costs.

With vertical plate technology, emissions, dust and odours are not significant because air is not used as a cooling medium. Instead, fluids flow counter-currently through the plates, thereby never coming into contact with the product. The low flow velocity (typically less than 0.3 m/min.) and gentle handling of the fertilizer further prevents degradation and the occurence of dust, minimising subsequent emissions.

Comparatively, direct contact heat exchange solutions require air to be taken in, chilled, passed across the product and then disposed of through a stack. The large quantity of air required for direct cooling results in a large quantity of dust and emissions, and comes with the associated energy costs of operating the expanded air handling and wet scrubbing systems that these technologies require.

As such, vertical plate technology has been proven to offer a significantly lower carbon footprint than direct contact alternatives. Research by Solex shows that the indirect method of cooling fertilizer emits just 0.42 kg of CO_2 emissions per 1 kWh – an estimated eight times less than comparable cooling technologies.

Meanwhile, product attrition can lead to the potential for contaminating other raw products elsewhere in the plant and nearby area. A 2012 study looked at the effects of emissions from a phosphate plant on the east Mediterranean coast on local soil contamination, and found that wind conditions spread fertilizer dust throughout the surrounding community, adversely impacting plant life and groundwater sources.[6]

Conclusion

The path to producing a cleaner and greener fertilizer will continue to mean focusing on all stages of the manufacturing process and whether the technologies employed there support broader sustainable initiatives that are in play.

Fertilizer cooling has always been an essential part of ensuring a quality finished product. Yet the technology employed at this stage must now do more – namely, align with environmental, social and governance (ESG) principles that are likely to never disappear.

Vertical plate technology provides fertilizer producers with an energy-efficient, near zero emissions solution that has been successfully tested for more than 30 years. By combining plate heat exchange design with uniform mass flow to indirectly cool fertilizer, the technology avoids having to rely on energy-intensive fans, air chillers and pre-heaters, as well as scrubbers and/or ancillary equipment required to handle the emissions. Meanwhile, the low flow velocity and gentle handling of the fertilizer virtually eliminates all emissions, dust and odours. WF

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