H2 OH NO!

Igor Makarenko, Solex Thermal Science, Canada, examines how plant operators can overcome water scarcity or quality issues by installing a closed-loop system.

Water quality and scarcity have become a global concern, to the point that the UN has declared water scarcity as one of the greatest challenges of the 21st century.

An estimated 49 countries are currently considered 'water stressed' – nine of which experience water scarcity and 21 absolute water scarcity. By 2025, the UN expects two-thirds of the world's population will be living in water-stressed regions.

Water quality is similarly having 'severe' effects on many populated regions of the world. The UN notes pollution is getting worse in high-population areas such as Latin America, Africa and Asia. Pathogen and organic pollution have worsened in more than 50% of the world's rivers.

The fertilizer industry is experiencing these water issues first-hand, and in particular producers that are replacing traditional direct-contact air-cooling methods used in the manufacturing process with indirect fluid-focused solutions.

Quality water is at a premium in many areas of the world where fertilizer producers are operating, especially in the Middle East, India, Africa, China, Russia and parts of Europe.

Producers are looking for a solution that allows them to still manufacture a finished product with consistent quality, yet also reduce their reliance on continuous supplies of fresh water.

Vertically stacked-plate heat exchange technology, which is now being used in many plants around the world, relies on water to cool fertilizer instead of air. Yet economically sourcing a regular supply of quality water poses challenges.

If the water is available, it could have quality issues, the required volumes are not available or it is just too far away to bring to a cooling system from the producer's facility. Alternatively, the return temperature might be restricted.

If it is too dirty, it is risky to introduce into heat transfer equipment. If it is far away, operators need to build infrastructure to supply the water. The cost of that adds up when pipe bridges, insulation and, in some cases, heat tracing are all incorporated. Then, once the water returns to the plant circuit, it is much hotter, which puts an extra load on the cooling towers and increases operating costs.

If plant operators do have access to a water source and have the infrastructure in place, it may be the case that they do not want to assume the operating costs of treating that water prior to introducing it into the fertilizer cooling process.

In all of these cases, adopting a closed-loop system can offer a solution.

Opening the door to closed loops

A closed-loop system can be used when operators are faced with water scarcity or water source quality issues, such as water with a high chloride content. The system operates on a self-contained water circuit, with a plate exchanger isolating the heat exchange unit from the primary plant cooling water supply.

A tempered water module controls temperatures of cooling water before the water is brought into the plates of an indirect heat exchanger. This ensures the desired steady water temperature profile is maintained regardless of different operating conditions.

In a closed-loop system, the water module provides fertilizer plant operators with a robust gatekeeper that maintains the water temperature, circulating clean water before allowing it into the cooling exchanger.

If the plant water is too warm to meet process requirements, the water temperature control module may include a water chiller that can provide a boost to the cooling capacity when needed to help maintain the circulating water temperature.

A chiller is particularly useful in a closed-loop system when the water being discharged from the heat exchanger is too hot to reintroduce into the exchanger. In this situation, the output water is re-rooted to a chiller, where it is cooled to a regulated temperature before making its way back into the water module and eventually the exchanger.

Consequently, plant operators do not have to supply additional water or handle the heat load through their cooling towers. Processes continue to be maintained within the closed-loop system.

The combined system can also be optimised so the chiller will only operate during the summer months. During the rest of the year, the system operates solely with the existing dry cooler – which used to be servicing the chiller as a condenser – to save on energy costs.

Finally, the module includes a start-up heater to warm up the plates prior to plant start-up. This is important before filling the solids heat exchanger to prevent caking and flow issues. If cold water is injected into the plates before the solids are added, then it will form condensation on the plate surfaces and form product bridges (i.e. caking).

The cold plates, combined with humid air that exists in the void space between the solids, creates condensation on the plates that combines with dust to form scaling. This process can start anywhere in the heat exchanger, compounding vertically and disrupting mass flow along the way.

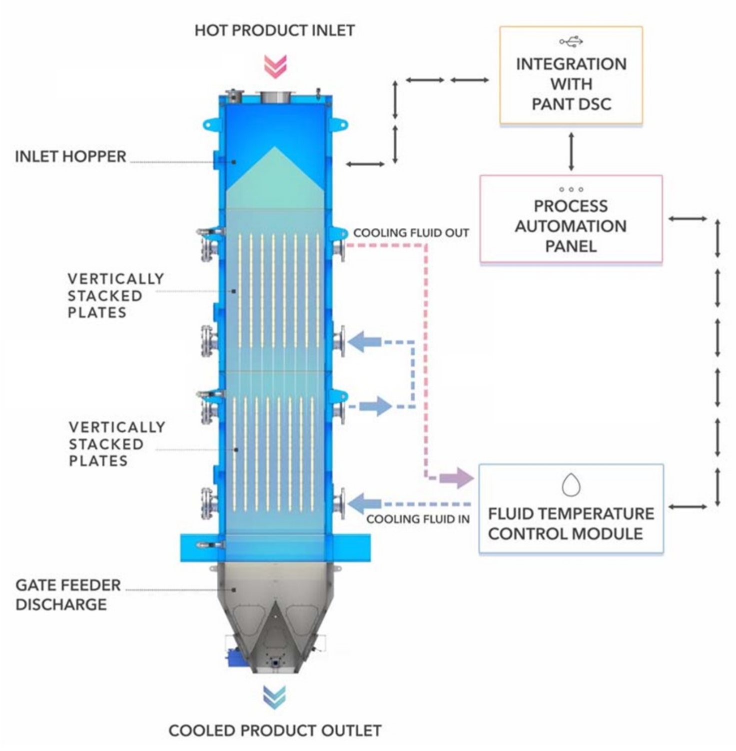

Figure 1. A closed-loop system operates on a secondary self-contained water circuit, with a plate exchanger isolating the heat exchange unit from the primary plant cooling water supply. A tempered water module controls cooling water temperatures before it is brought into the plates of the exchanger, ensuring the desired steady water temperature profile is maintained regardless of different operating conditions.

By pre-heating the plates in advance, the module can maintain the dew point as the product passes through the exchanger, and caking can be avoided.

Plant operators have ultimate control over water temperature, pressure and flow rates because the modules come with comprehensive control and instrumentation. This also removes the need to return warm water to cooling towers – which already tend to be over-loaded – and with that additional instrumentation with special controls, as well as water from their plant circuit.

Closed-loop systems also create stable and consistent product discharge temperatures and prevent moisture migration in the product stockpile. This ensures high product quality for longer-term storage and loading.

Clean water

An added benefit to closed-loop systems is that the water does not create 'surprises', such as organics entering the water stream. Because the water exists within a closed loop, it enters the plates clean each time.

Solex has worked with open-loop circuits where the water goes straight into the cooler and then back to the existing cooling tower, but this can lead to problems in the long-term.

For example, when open-loop circuits were used and cooling water was fed directly to the plates, over time organic content started to deposit inside the plates in the exchanger, leading to severely reduced performance, a cumbersome cleaning process and costly maintenance downturns.

Water with a higher concentrate of chlorides, or using seawater directly in the exchanger, can compromise the stainless steel plates.

The glycol alternative

In colder climates, plant operators may find it difficult to keep the cooling water from freezing when the system is not functioning due to various operating reasons. In such a situation, one option is to use a mono-ethylene glycol mixture – a viscous, colourless liquid that mitigates freezing and helps to keep the cooling system functioning.

Glycol is ideal for fertilizer plants in parts of the world where temperatures dip below 0˚C because it offers almost universal freeze protection. It also offers burst protection by depressing the water's freezing point.

The ambient conditions will dictate the amount of prescribed glycol that will be needed to efficiently and safely provide a correct cooling fluid solution to the customer.

Like water in a closed-loop system, glycol will circuit continuously without any losses, meaning no top-ups are required.

Preventing contamination

Solex has installed a number of vertical heat exchangers in fertilizer plants around the world over the past two decades – with the majority using closed-loop systems – as producers seek more efficient and economical ways to cool fertilizer prior to shipping and storage. Successful applications so far have included urea granules and prills, ammonium nitrate and NPK in climates that ranged from dry to humid.

The vertical configuration of the cooler makes the design both compact and modular. The compact installation footprint makes the design easy to integrate into existing plants and suitable 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.

The coolers also prevent product degradation or contamination from occurring. Slow and controlled movement of the fertilizer – whether in the form of granules, prills or fine crystals – through the exchanger prevents product abrasion and attrition so that there is no change in particle characteristics (dust formation) or quality.

While many variables can impact the final capital cost, several case studies have demonstrated that the installation cost of a cooling system manufactured by Solex generally runs at least 30% lower than the cost of installing a fluid bed cooler and up to a 90% reduction in operating costs.[1]

By using a closed-loop approach with fertilizer cooling systems, operators will only need to use existing plant water resources. This means they do not need to invest in costly infrastructure or ongoing, expensive and cumbersome water treatment processes. And by obtaining ultimate control over the cooling water temperature control process, operators are guaranteed final product temperature.

Footnote

1. Estimated operating power requirements for a fluid bed cooler at a typical 3600 tpd urea plant in the Gulf Coast, US, is 1040 kW, compared with 85 kW for a Solex cooler. Fluid bed cooler load is an average based on mean monthly day and night ambient conditions.