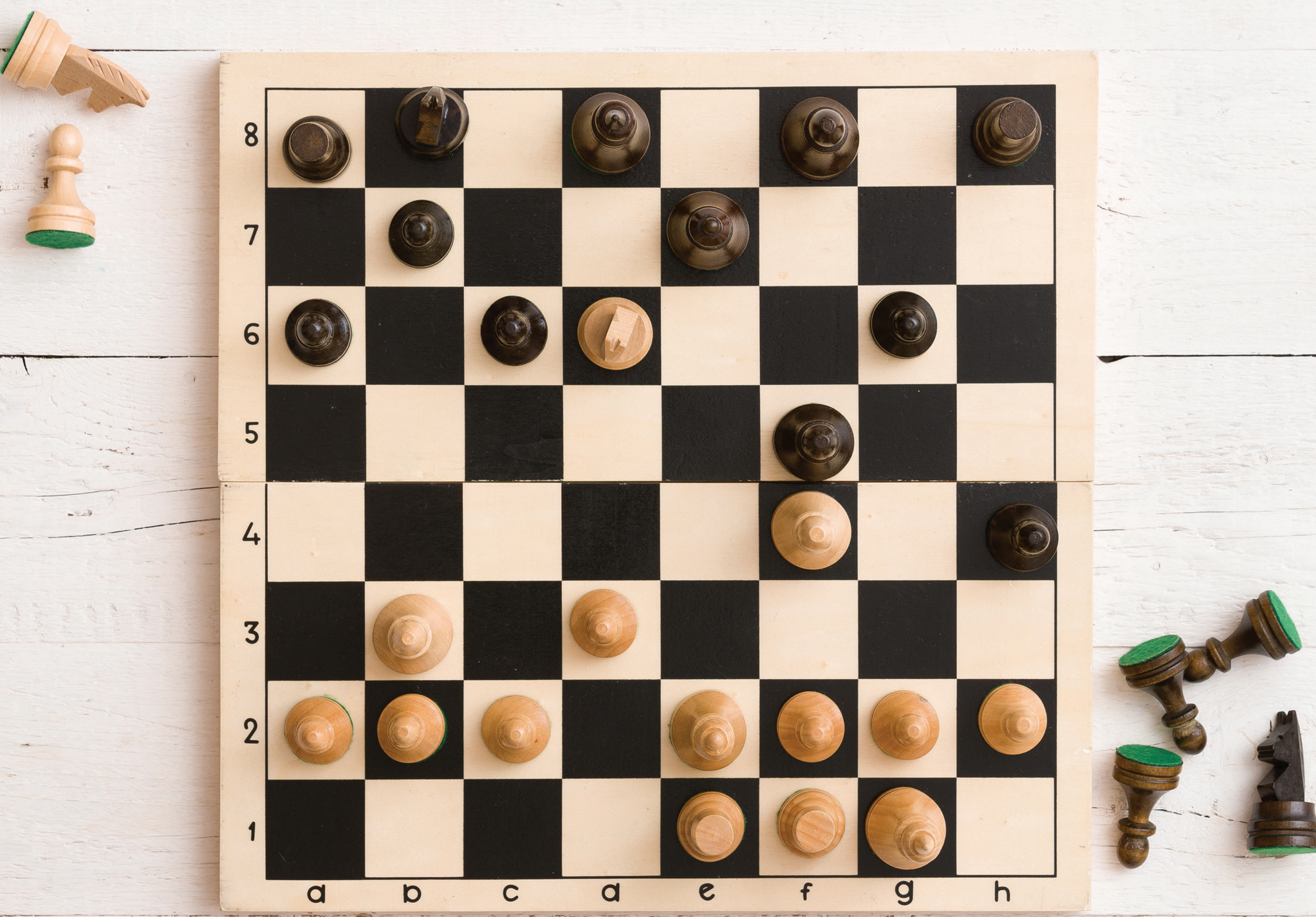
Playing the Long Game



Warren Chung, Solex Thermal Science, Canada, discusses maximising the longevity of fertilizer processing technologies through preventative maintenance.

As fertilizer producers look to meet rising global demand for their products, the need for reliable and cost-efficient operations become even more crucial. The critical process-based solutions that create the backbone to these operations are frequently subjected to significant stresses. These stresses can range from handling abrasive and/or corrosive substances to operating under extreme operating conditions that lead to increased wear.

With these challenges, it is essential to keep process equipment in peak working condition. Even minor disruptions can have significant impacts on product

Figure 1. Moving bed heat exchangers (MBHEs) combine the thermal efficiency of plate heat exchange design with the science of uniform mass flow to cool a full range of urea, nitrate- and phosphate-based products.

Figure 2. MBHEs and common trouble areas such as the heat exchange plates should be regularly cleaned and inspected.

quality, operational efficiencies, safety and profitability. A true cost of downtime report issued in 2021 found that operators in industries such as fertilizer lose, on average, 23 production hours per month due to machinery failure, amounting to US$187 500/h or US$52 million/y per facility.[1]

Not surprisingly, many industrial organisations have decided to take control into their own hands, with more than two-thirds of respondents surveyed in the report saying they are making predictive maintenance a strategic objective.

Implementing a robust preventative maintenance programme, as well as ensuring installed solutions are operating at the conditions they were designed to, is not just a best practice but a necessity for fertilizer producers.

Take the final product cooling stage in the fertilizer production process as an example. It represents one of the last opportunities to get it right, whether that is optimising operational efficiencies, ensuring a high-quality final product or improving safety measures.

It is common to see highly engineered process solutions still operational decades later with minimal capital investment along the way. Yet this requires operators to execute disciplined operational practices and undertake regular preventative maintenance initiatives.

This article will focus on moving bed heat exchangers (MBHEs) where changing process conditions and, most commonly, improper maintenance practices are why the operational lifetime may be reduced prematurely.

How do they work?

MBHEs combine the thermal efficiency of plate heat exchange design with the science of uniform mass flow to cool a full range of urea, nitrate- and phosphate-based products. The compact tower-like design – which often has a physical footprint of approximately 2 m x 2 m – cools the fertilizer product by conduction instead of convection (e.g., air cooling).

Free-flowing material is top-fed to the exchanger and slowly passes through a vertical series of heat exchange plates by gravity. Each heat exchange plate contains a circulating heat transfer fluid. The plate spacing, plate sizing and number of plates are determined by the particle size and thermal loading requirements. The flow of solids is controlled by a discharge control device that is integral to the MBHE's performance.

While certain details change according to the properties of different products, the principles of operation remain the same.

How do operational disruptions occur?

The most frequent cause of operational disruption is using the MBHE outside the recommended operating ranges.

Take product blockages for example. An MBHE operates most effectively when uniformly sized product moves predictably through the heat exchanger. Yet, obstructions within heat exchange plate banks can occur when off-spec materials are introduced.

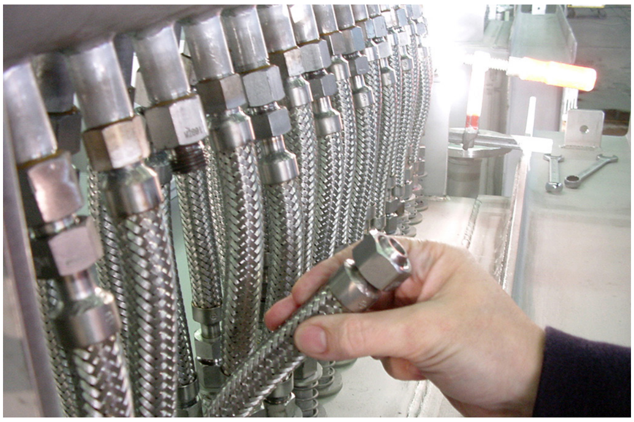


Figure 3. Operators should regularly inspect hoses to avoid leaking on threaded connections, corrosion and, ultimately, failure.

Figure 4. Obstructions at the top and/or within heat exchange plate banks can occur when off-spec particle size materials are introduced.

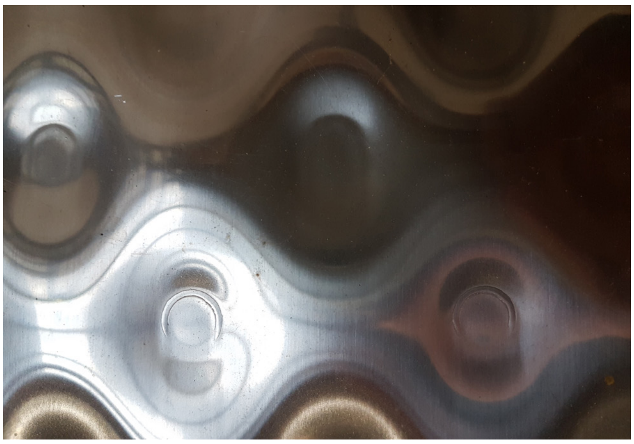


Figure 5. Heat exchanger plates that show fading or striations may be indicative of accelerated wear.

Blockages can:

- Divert product away from plates, lowering the effective heat transfer surface area within an MBHE.
- Create preferential flow scenarios that lead to increased flow velocities elsewhere. This can lead to outlet temperature inconsistencies, resulting in a product that does not meet process requirements due to insufficient residence time in the heat exchanger.

Another example is inadequate product level control – namely, the quantity of product in the heat exchanger is insufficient to achieve full coverage over the heat exchanger plates, resulting in exposure areas. Low product levels can increase product impact velocities on the edges of the top plates by five to 10 times when compared with plates that are fully submerged. This can dramatically increase the wear rate and eventually cause the plates to leak.

Heat exchanger plates can wear from the inside, too. When heat transfer fluid contains elevated chlorides content, the stainless-steel plate material may be subjected to chloride-induced corrosion or fouling, leading to fluid leakages into the product or reduced heat transfer effectiveness. This typically occurs in situations involving open-loop systems: for example, water direct from plant cooling towers. The longevity of the heat exchanger plates can be enhanced by incorporating a closed-loop water system that circulates clean/low chloride heat transfer fluid.

Diagnosing underperformance

Although it is the least likely scenario, the most obvious sign that an MBHE is underperforming is when the plates start leaking. A simple visual inspection of the exchanger's internal components can allow operators to quickly identify plate replacement candidates.

The observance of dents or gouges caused by foreign objects such as cleaning tools, as well as areas of the plates that looked 'over polished' or have localised striations may also be indicative of accelerated wear. Operators should pay special attention to the smoothness of plate dimple circular welds on the plates, as well as the condition of protective plate caps, where applicable. If either are smooth, that is an early indicator that the plates need to be more thoroughly inspected and, potentially, replaced. Other visual indicators from wear on the plates include:

- Discolouration.
- Less-pronounced laser welds.
- Deformed dimple shape.
- Apparent 'flat spot' in inflation profile.

Best practices

Operators should perform regular inspections and preventative maintenance to avoid MBHE leaks, ineffective performance and, in a worst-case scenario, accelerated wear.

First, the heat exchanger should operate within its design parameters. Altering the process conditions can affect the performance of MBHEs in different ways. For example, if product throughput increases but heat transfer fluid parameters such as flow rate and temperature remain constant, the product outlet temperature of the finished product will be deficient. In some cases, deficient product temperatures can lead to unwanted condensation within the exchanger during cooling and, subsequently, caking that results in obstructions.

In other cases, the product may change – as will key material properties including particle size, moisture content, specific heat capacity and thermal conductivity. This could lead to blockages, overheating, overcooling or, once again, condensation – which could result in caking within the MBHE.

Tightly controlling product flow rates within design conditions is essential to avoiding significant increases in material velocities. If operators do see these patterns, they should take note of the 'fast' areas. If there are signs of curved deformations, striations or areas of a plate that look over polished, operators should consult with the technology provider for further diagnose, repair or replace critical components.

Operators should also pay attention to draw-down and level control in the inlet section of an MBHE. Heat exchange plates should never be exposed, and unusual product flow patterns should be diagnosed and corrected. Operators should perform regular inspections of the inlet level sensor throughout the year.

The technology provider can offer added value by making additional assessment and evaluation recommendations. This may include undertaking ultrasonic measurements of the heat exchanger plate thicknesses that can indicate the technology's longevity. Hydrotesting pressure components may also be performed. This test could show bulged areas and provide a more definitive indication of future plate failure locations.

It is possible to isolate and remove a single heat exchange plate in an area of concern (high velocity) and perform many of the checks mentioned previously. However, it is important to replace or reinstall the plate prior to returning the MBHE to service.

A final best practice to enhance the longevity of MBHEs is to ensure upstream product preparation processes are working properly. This could include lump breakers, screens and air-cleaning systems.

Figure 6. A heat camera can be used to diagnose whether specific spots of the heat exchanger plates are heating up more than others, or indicate if there is poor flow of the heat transfer fluid within the plates.

Regular maintenance

As it relates to preventative maintenance, MBHEs should be regularly cleaned and common trouble areas inspected – notably the heat exchanger plates. These components are in constant contact with the product as it flows between channels and could wear over time. This is particularly applicable in environments where the quality of the heat transfer fluid is compromised and/or other process conditions change.

The frequency of cleaning should be determined based on an assessment of the need. Operators may need to periodically clean the internal surfaces of plates. For example, using water with a high carbonates content can lead to the formation of a thin layer of calcium carbonate on the inside the plates, decreasing the exchanger's thermal performance. This can be resolved by using a citric acid solution during the cleaning process. A plate supplier can assist with additional steps on how to internally clean the plates.

Operators should also regularly inspect door gaskets and nozzle seal assemblies. Over time, both components can dry, become brittle and lose their ability to form proper seals, leading to product leakage and/or introduction of air into the heat exchanger.

The same principles apply to hoses. Improperly maintained hoses can lead to fluid leaking on threaded connections, corrosion and, ultimately, failure.

Lastly, operators can benefit by having spare parts such as seal skirts, gaskets, hoses and various moving parts on the discharge device readily available to swiftly address unexpected issues. This helps minimise downtime and ensures continuity of operations. WF

Reference

1. https://assets.new.siemens.com/siemens/assets/api/uuid:3d606495-dbe0-43e4-80b1-d04e27ada920/dics-b10153-00-7600truecostofdowntime2022-144.pdf