DECARBONISATION ACCELERATION

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The fertilizer industry is playing an active role in pursuing a net zero future. In its 2023 Sustainability Report, the International Fertilizer Association (IFA) singled out continued efforts by its global membership of more than 450 members to contribute to the sustainability of the earth, and leave the ecosystems from which they draw natural resources as healthy as when they found them.

This has included many members taking cooperative efforts to accelerate the decarbonisation of their production processes – from reducing Scope 1, 2 and 3 emissions to water stewardship and more.

The IFA states in its report that, "the conclusions are clear – to reach the Paris Agreement's goal of limiting global warming to 1.5°C, the industry must transition to new technologies."

Much of this transition today is represented through IFA's Protect & Sustain Certification. Currently carried by producers, distributors, traders and transporters from more than 60 countries, it includes six evaluation areas ranging from sourcing and contractor management to manufacturing techniques. This is hoped to drive processes and technologies to do more – to help produce a better product at less expense to producers and the environment.

This is already being evidenced at many stages of the production process, notably the cooling stage where the combination of different technologies is unlocking many new sustainability-focused opportunities.

Fertilizer cooling

One of the more important process steps in fertilizer production is product cooling, which is required for proper storage and transport. Elevated fertilizer temperatures result in product caking during storage and transport, leading to breakage and a lower-valued end product.

Several different technologies have traditionally been used to handle the cooling responsibilities, each with their distinct advantages.

Rotary drums are a common method for cooling fertilizer given their ability to process different grades and operate with variable feed inlet conditions. In a typical rotary drum, material is first introduced at one end of the equipment, and then lifted and dropped numerous times. As the material moves through the drum, it is exposed to cooling air that flows countercurrent to the fertilizer flow.

Fluidised bed coolers are also commonly used to cool fertilizer. In this process, large volumes of air or gases are used to directly fluidise the material. The fluidisation air not only cools the fertilizer but also provides the motive force that enables the fertilizer to flow from the inlet to the outlet of the fluidised bed.

Fluidised beds and rotary drums are effective at cooling the fertilizer, but have the disadvantage of requiring large energy inputs, and high horsepower fans to ensure the job is completed. They also tend to create dust and fines due to mechanical abrasion of the particles during the cooling process, and require a significant equipment and operating cost investment for gas-cleaning systems. These are all challenges for fertilizer producers who are already face high energy costs at other stages of the production process.

Plate-based moving bed heat exchangers (MBHEs), designed to handle various fertilizer grades and sizes, offer fertilizer producers the opportunity to significantly improve the energy efficiency of their existing processes, improve the quality of the final product produced, and offer the added benefit of being able to recover and reuse waste heat that is generated from the cooling water.

MBHEs

In contrast to the direct-contact cooling methods used in rotary drums and fluid beds, plate-based MBHEs allow indirect heat transfer between solids and fluids. They accomplish this through the product entering the unit – in most cases at around 120°C or higher – and then allowing it to flow by gravity through banks of parallel vertical stainless-steel plates.

During this process, a heat transfer fluid passes through the plates to cool the material by conduction, typically to temperatures between 30°C and 70°C. The fluid is commonly circulated through the plates in a counter-flow for enhanced thermal efficiency.

A mass flow discharge feeder controls the rate of flow through the unit while providing uniform product drawdown. Gravity is the mechanism that slowly moves the product through the heat exchanger.

One of the keys to effectiveness of plate-based MBHEs is the complex thermal modelling calculations using proprietary material property data that guarantee precise discharge temperature control. This ensures the product temperature to storage and transport is optimal, which is key in industries like the fertilizer sector.

Energy upcycling

As different grades of fertilizer are cooled, plate-based MBHEs produce a hot working fluid – typically water or a glycol-water mixture of 70°C or higher. Currently, this energy is often wasted and sent to the cooling tower where all the energy is rejected to the ambient air. However, this energy can be used in other locations of the plant as useful thermal energy.

For example, the recovered heat can be used upstream in the production process to pre-heat air for combustion systems that are used to generate the needed heat to operate equipment such as a fluid bed or rotary drum dryer. This can materially reduce the amount of natural gas needed for drying, while also helping to reduce overall CO_2 emissions.

Alternatively, the recovered heat can be used to pre-heat air that is used to 'trim dry' the fertilizer in an MBHE. The trim drying stage occurs after the fertilizer has been largely dried in a rotary drum or fluid bed and some additional drying is needed. This is accomplished within the upper part of the MBHE, allowing producers to meet moisture targets more efficiently and improving product quality while cooling in the lower part of the unit.

Another opportunity to utilise otherwise wasted energy is to combine the units with industrial heat pumps. The technology is based on a basic thermodynamic cycle process that can be found in many aspects of our daily lives such as in air conditioners and refrigerators. It can bring a waste heat source to higher temperature levels where it can then be used. This allows users to 'upcycle' the energy from 'waste' to a 'heat source.' Because heat pumps are electrically driven, they also do not create any additional CO_2 emissions.

In a fertilizer cooling application, plate-based MBHEs can be used as a heat source for the heat pump. By using a heat pump, the temperature of the cooling water can be increased to the desired temperature levels where the plant can then use this thermal energy in the process. Temperatures between 110°C and 150°C are easily achievable, with the ability to reach around 180°C in some cases.

For example, depending on the process needs in the plant, the energy can be supplied as pressurised hot water or as saturated steam in the respective temperature and pressure range. The MBHE-heat pump combination can even be used to enhance the temperature and then preheat air for fluid bed or drum dryers similar to the process explained earlier.

By combining an MBHE and industrial heat pump, fertilizer producers can easily mitigate the wasteful practice of sending cooling water to the cooling tower and 'blowing' it to ambient, instead, upcycling the heat from that water to be used in that or another process.

Conclusion

Fertilizers will continue to play a crucial role in global food production systems. Yet, production and usage needs to be properly managed to ensure they align and complement the world's sustainability goals.

In its 2023 Sustainability Report, the IFA acknowledged that a key pathway to accelerating the sustainability transformation of the fertilizer industry is by accelerating innovation, including the adoption of new technologies and processes.

Plate-based MBHEs exemplify how these changes are already happening. For years, this technology has been vital in the fertilizer production process, offering a near-zero-emissions, low-energy solution that reduces the carbon and environmental footprint.

Recently, plate-based MBHEs have evolved to further contribute to producers' decarbonisation efforts. Introducing a waste heat recovery process after the cooling stage enables fertilizer producers to reduce natural gas consumption during drying. Additionally, energy upcycling through the combination of industrial heat pumps further provides producers with opportunities to put otherwise wasted heat to work and, at the same time, reduce their carbon footprint.

The collective pursuit of a sustainable future through technologies such as plate-based MBHEs will have a profound impact on the entire fertilizer production chain. By investing in versatile technological solutions, fertilizer producers can achieve their decarbonisation objectives while continuing to meet future food demands.