Tackling potash's carbon challenge

Waste heat recovery in the potash industry is now more feasible thanks to the availability or robust and reliable heat pipe heat exchangers (HPHEs). **Igor Makarenko**, Solex Thermal Science, explains how HPHE technology can help potash producers reduce their primary energy consumption and cut their CO_2 emissions.

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Air pre-heater: HPHEs can be used to recover thermal energy from particle-laden air discharged from direct-fired rotary and fluidised bed dryers.

Potash producers globally are facing mounting pressure to decarbonise their operations. Driven by environmental concerns, regulatory pressures, stakeholder expectations and market demand, the industry at large is being called upon to improve its energy profile and reduce greenhouse gas (GHG) emissions.

Some producers have already made significant inroads. The International Fertilizer Association (IFA), for example, recently recognised the success of a new sustainable mining management system at ICL Iberia's potash mining operation in Suria, Spain. This notably includes an aggressive GHG emissions management plan.

BHP, meanwhile, has announced an additional CAD 7.5-billion investment in its under-construction Jansen potash mine in Saskatchewan, Canada (*Fertilizer International* 517, p8). The extra finance will double planned production capacity while producing up to 50 percent less GHG emissions per tonne of product, in comparison to the emissions average for potash mines in the province.

Still, industry bodies such as Fertilizer Canada are urging all potash producers to make a step change in their carbon reduction efforts. Proposed solutions have ranged from energy co-generation and complete mine electrification to carbon capture and storage.

Yet these efforts face significant barriers – including high capital costs, regulatory approvals and long implementation timelines – while the potash industry needs access right now to low-cost carbon reduction measures with a high return on investment (ROI). This is particularly true for natural gas combustion, which is the single largest source of GHG emissions in traditional potash mining.

The combustion of natural gas generates nearly one-third of potash mining emissions, according to a recent University of Alberta study. In solution mining, there are typically two sources of emissions:

- Firstly, those from gas-fired boilers used to heat water before its pumped through the ore body to dissolve the potash.
- Secondly, those generated during later drying stages at processing plants.

Similarly, in conventional mining, large -scale emissions are also generated by the combustion of natural gas that provides the massive amount of heat required at the drying stage.

Heat pipe heat exchangers (HPHEs)

The adoption of heat pipe heat exchangers (HPHEs) has great potential in the potash industry (Figure 1). HPHEs have the ability to reclaim energy from process streams – that otherwise is typically wasted – offering the dual benefit of lower primary energy consumption and reduced GHG emissions.

While heat pipes have been around in some form or another since the 1830s, their use in heat exchangers first became commonplace during the mid 1940s. Today, HPHEs are generally used as industrial air-to-air heat recovery devices, with a variety of different designs available. They are typically found in industrial applications where plentiful (and otherwise wasted) heat can be recovered from exhaust gases.

The heat pipe itself is a hermetically-sealed hollow chamber containing a small amount of a functional fluid. The hollow chamber acts as a void and allows a phase change process to occur in the pipe.

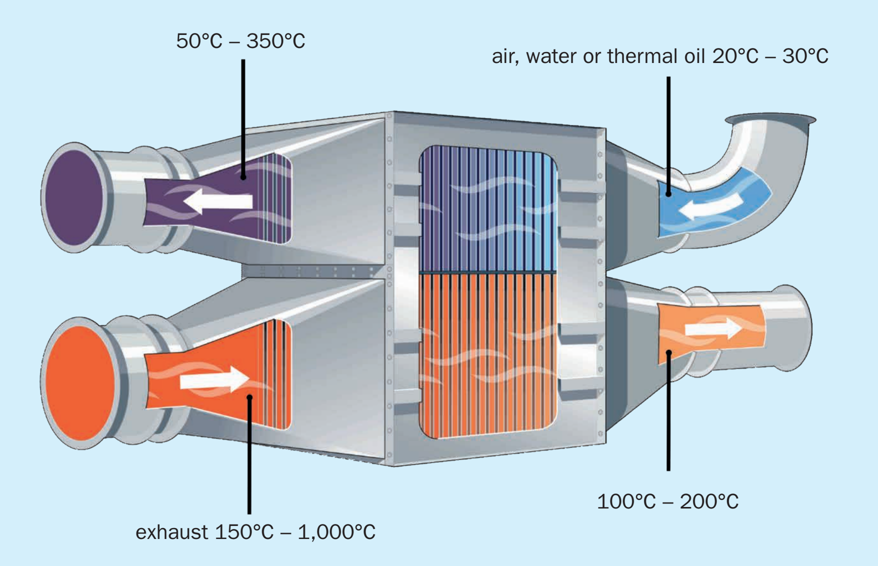
HPHEs recover thermal energy as follows:

- The latent heat of vaporisation of a functional fluid present in a series of pipes – as it changes phase from a liquid to a gas – is used to absorb the heat contained in hot exhaust gases or liquid.
- The vapour generated rises to the top of the pipes where they come into contact with cold air or a water coolant.
- This causes the vapour to condense and release its heat.
- This heat is then absorbed by the cold air or water.

In the potash industry, HPHEs can be used to recover thermal energy from particle-laden air that is discharged from direct-fired rotary and fluidised bed dryers. They achieve this by capturing heat from this so-called 'one-pass air' and then using this to pre-heat ambient air re-entering the dryers. A beneficial consequence of heat recovery is that it allows potash producers to curb their natural gas consumption during the drying of finished products. By lowering the temperature of the air entering scrubbers, the installation of HPHEs can also reduce scrubbing capacity requirements at potash operations.

Valuably, in solution mining, the energy recovered from exhaust streams by HPHEs during the drying stage can be used to pre-heat process water. This is pumped underground and through the ore body to dissolve the potash – generating the brine that goes on to supply the above-ground processing plant.

Fig 1: **HPHE schematic. HPHEs operate by extracting heat from 'one-pass air' at the potash drying stage. This can be used subsequently to pre-heat ambient air re-entering the dryers – or, in solution mining, pre-heat process water that is pumped through the ore body to dissolve the potash.**



Source: Solex

Benefits

HPHEs are well suited to waste heat recovery applications. In fact, their key advantages highlight the very reasons why other technologies have been less successful.

Potash processing generates exhaust gas as a by-product, as is common in most industries that process raw materials. The hot, corrosive and highly contaminated nature of these exhaust gases has made the use of traditional equipment such as shell and tube heat exchangers difficult.

In fact, many shell and tube heat exchangers fail within just six months, as noted in a recently published book on sustainable technologies[1]. Common types of failure include:

- Thermal stress cracking due to the differential expansion between the surface and casing.
- Corrosion due to cold-spot-induce condensation.
- Thin metal surfaces that lead to erosion and corrosion.

The risk of failure from contamination is also high in shell and tube heat exchangers, which can further disrupt manufacturing schedules.

The advantages of HPHE technology, in contrast, allow them to excel in industries where current heat exchangers are failing[1]. These include:

- The use of simple, robust industrial-grade equipment with built-in multiple redundancies.
- The pipes in HPHEs are free to expand and contract without applying stress on the casing.
- Isothermal operation eliminates cold spots and condensation.
- The risk of cross contamination is eliminated due to the separation between the exhaust flow and heat sink.
- The use of thicker walls (typically 2.5-3.5 millimetres) – because heat transfer is not affected by wall thickness – provides higher corrosion tolerance.

Furthermore, in the unlikely event that one heat pipe does fail, this doesn't significantly affect the overall performance of the HPHE unit and it can be easily replaced in the next maintenance cycle[1].

"The development of the HPHE technology eliminates the drawbacks observed with traditional technologies with a higher degree of flexibility and reliability," the book's authors conclude[1].

Conclusion

Potash production plays a pivotal and growing role in feeding the planet. Global food production will need to double by 2050, according to some projections, to properly feed an estimated population of 10 billion people.

The key challenge for the potash industry is how to become more sustainable while meeting growing demand for its products. Indeed, there is an increasing expectation that the whole of the fertilizer industry will need to adopt low-carbon technologies and processes, as the IFA urged in its recent 2023 *Sustainability Report*.

The recovery of waste heat is an attractive option for the potash industry, as it provides the opportunity to decrease primary energy consumption, while also reducing GHG emissions. Although highly challenging previously, reclaiming thermal energy from waste heat sources is now possible thanks to the availability of robust and reliable equipment such as HPHEs.

With decades of proven effectiveness and widespread use across various industries worldwide, HPHEs present a highly compelling approach to bolstering the decarbonisation efforts of the potash industry. ■

References

1. Malinauskaite, J., & Jouhara, H., 2023. *Sustainable Energy Technology, Business Models, and Policies*. Elsevier.