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An owner's perspective

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Carbon neutral approach to feed

Animal feed processing has come under intense scrutiny in recent years with heightened concerns about food and environmental safety.

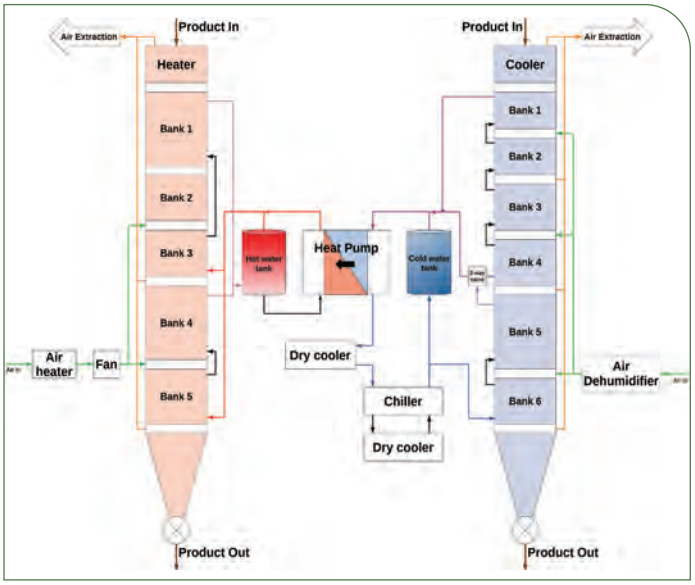
The primary ingredients of feed can be traced back to the oilseed industry where oil is removed from the seed and the remaining oilseed cake or meal act as the main protein source for animal feed. The cake and meal have historically been treated with formaldehyde and other chemical additives to modify the nutritional value while also acting as an antimicrobial that prevents the spread of viruses and bacteria such as salmonella and *E. coli*.

In the past several years, a rising number of jurisdictions worldwide have restricted or banned the use of chemicals such as formaldehyde, prompting operators to replace them with a variety of enzyme and heat treatments. These changes come with their own challenges.

Some methods create a reaction between the animal feed and the added reagent. Excessive heating, meanwhile, often leads to protein that is less digestible or a product that is not homogeneously heated. The heat treatment process is also energy intensive, resulting in significant operational costs and greenhouse gas emissions.

Dutch-based co-operative Royal Agrifirm saw an opportunity to create an efficient, safe and reliable method to treat the meal without chemicals while also increasing its nutritional value. Core to the process of producing this new-generation rumen by-pass protein was Agrifirm's Greenwave technology, a chemical-free process that heats the feed to around 130°C through radio frequency (RF) waves.

Agrifirm identified that to effectively reduce overall primary energy consumption in this production process, it still needed to pre-heat the product before using the RF technology – and then cool the product after the RF stage to an ambient temperature for safe handling and storage. Also essential was the ability to recover energy from the hot product at the cooling stage, and then 'upcycle' it for use back at the pre-heating stage.



Agrifirm partnered with Solex Thermal Science, a leader in solids, liquids and gas heat exchange with extensive experience in heating and cooling solid granular products in moving bed heat exchangers.

What is an MBHE?

A moving bed heat exchanger (MBHE) allows for the exchange of thermal energy between solids and liquids through thermal conduction. It is characterised by a rectangular casing that is equipped with vertically positioned stainless steel pillow plates. The solids move continuously as a bed of product, driven by gravity between the plates. Inside the plates, a liquid heat transfer media flows countercurrent from the bottom of the unit to the top, ensuring optimised heat transfer.

Given the product flow is driven by gravity and countercurrent to the liquid heat transfer media, the power consumption of an MBHE is low. It only requires power for the mechanical discharge (such as a rotary valve for both pre-heater and cooler) and the circulation pump for the heat transfer liquid.

Pilot testing

Agrifirm validated the thermodynamic design of the MBHE during several weeks of on-site pilot testing at its plant in 2021. The tests also focused on better understanding of how the solids would behave in the MBHE, particularly the flowability of the solids between the pillow plates. Flowability is primarily influenced by density and particle size distribution. Plate spacing that is too narrow could compromise the product flow by bridging and caking.

In addition, the pilot tests analysed how much moisture was released from the product in the void between the solids within the MBHE. This free moisture or relative humidity in the void leads to condensation, and needs to be controlled in both coolers and heaters. Condensation has the potential to create surface moisture on cold surfaces and/or particles, resulting in caking and bridging.

The pilot tests revealed that a small amount of pre-heated air in the heater was enough to decrease the dew point of the air in the void and mitigate condensation. In the cooler, dehumidified air ensured the dew point was below the cooling water temperature in the plates.

Implementation

The pilot tests confirmed the MBHE was suitable to be used in Agrifirm's process and the firm built and commissioned a full-scale plant in Oss, The Netherlands in 2023.

On-site, soyabean and rapeseed meals are stored in silos and conveyed to the pre-heater (MBHE) where they are pre-heated to about 70°C, after which the product is fed to the RF process where it receives the required thermal treatment to stabilise the product. The product is then conveyed from the RF equipment into the product cooler (MBHE) where it is cooled to around 30°C before it goes into storage.

To recover energy from the hot product, the pre-heater and the cooler are connected via a heat pump. Driven by electrical energy, the heat pump creates a temperature gain from the water rejected from the cooler, and then 'upcycles' it for use in the preheater.

As not all the energy in the cooling water can be used in the pre-heater, the system also includes a dry cooler and a chiller. The energy that cannot be used in the heat pump is rejected in the dry cooler. In case of high ambient temperatures, the dry cooler is assisted by a chiller to ensure the product can be cooled to the desired outlet temperature of around 30°C.

The first nine months of production have provided encouraging results, with performance optimisation being achieved and the product consistently meeting required standards, demonstrating that energy recovery from solids in MBHE can improve the energy efficiency of operations and reduce primary energy consumption.

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