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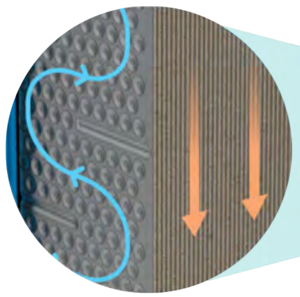
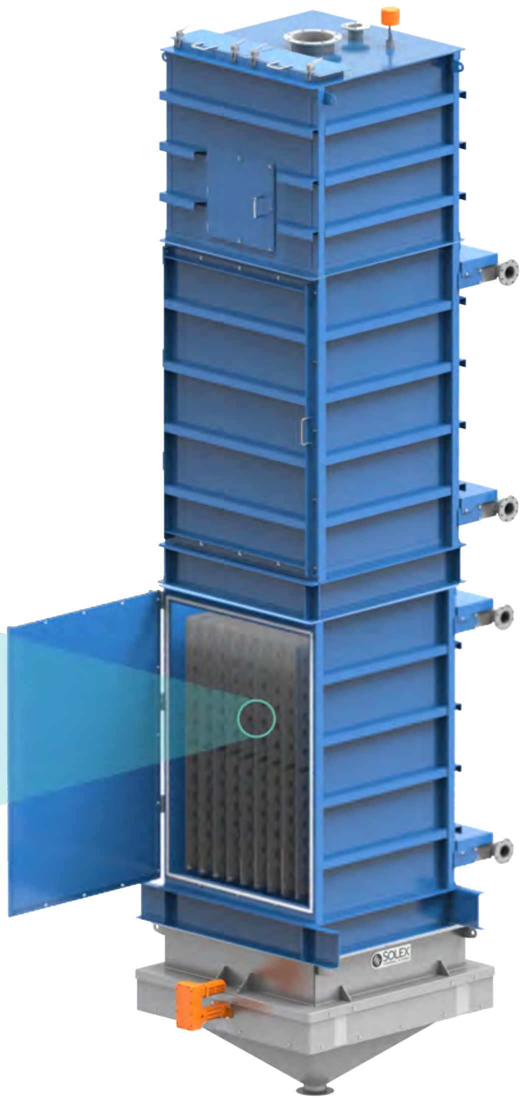
DECARBONIZING WOOD PELLET PRODUCTION VIA MOVING BED HEAT EXCHANGE TECHNOLOGY

Meeting net-zero objectives will require operators to increasingly leverage modern technologies and adopt innovative processes.

BY JILL CASKEY





In efforts to effectively tackle the climate crisis and reach net-zero emissions by 2050, operators across multiple industries have adopted highly deliberate strategies to decarbonize their processes.

Yet, as many have discovered, these endeavors have frequently encountered formidable barriers such as high capital costs, regulatory approvals and long implementation timelines. In the meantime, operators need access to low-cost, high-ROI, carbon-reducing solutions now.

The wood pellet industry is no exception. Raw material sourcing, transportation and waste management all heavily contribute to a carbon footprint that is no longer sustainable. The industry's conventional approach to wood pellet production has also been very energy-intensive and required extensive equipment to clean emissions before being released into the atmosphere.

While many efforts are already underway within the wood pellet industry to increase efficiencies at the manufacturing stage, meeting net-zero objectives will require operators to increasingly leverage modern technologies and adopt innovative processes.

Wood Pellet Process Traditional Technology

Before delving into decarbonization solutions, it is important to understand the wood pellet manufacturing process and technologies that are currently in use. Wood pellets are created by first removing moisture from incoming wood fiber. That fiber is then ground into dust and compressed into small pellets measuring between 6 and 8 millimeters in diameter and up to 40 millimeters in length.

During the process, the pellets are heated up so the lignin in the wood acts as an adhesive to keep the compressed particles together. Once discharged, the pellets range in temperature from 70 degrees Celsius (158 degrees Fahrenheit) to 100 C, making them too hot for storage and transport. The preferred option is to cool the pellets to approximately 3 C to 5 C above ambient temperatures.

Conventional counterflow air pellet coolers use chilled or ambient air to cool the pellets. The pellets enter a cooling bin, typically through a rotary valve, and are leveled off by a distributor. Cold air is then injected into an isolated bin under the bed of pellets, thereby indirectly cooling the product from the bottom up. A level sensor inside the bin determines when the pellets are discharged.

This traditional cooling method has the disadvantage of requiring large energy inputs (e.g., high horsepower fans) to get the job done—a challenge for pellet producers who are already facing high energy costs.

Moving Bed Heat Exchangers

Alternatives such as plate-based moving bed heat exchangers (MBHE) at the cooling step of production offer pellet producers the opportunity to improve the energy efficiency of their existing processes, with the added benefit of significantly improved heat transfer efficiency.

Plate-based MBHEs blend the thermal efficiency of plate heat exchange design with the science of uniform mass flow to cool pelletized bulk solids such as wood pellets. In an MBHE, the solids flow by gravity between a series of vertically oriented, hollow stainless-steel plates—typically made of SS304L for the wood pellet industry. The plates are cooled by a working fluid that flows through the plates' internal channels countercurrent to the product flow.

The cooling medium is often a cooling water source or chiller water. In some cases, brine, river water or seawater can be used by incorporating a closed-loop fluid temperature control module. The system can also operate as a stand-alone system via a dedicated closed-loop circuit using a dry cooler and chiller.

The MBHE has a discharge device at the bottom that controls the flow of product, usually by a variable frequency drive or pneumatic actuator, before it exits to the downstream conveyance system.

Typical Wood Pellet Cooling System

After the pelletizing process, the wood pellets enter the inlet hopper of the MBHE at temperatures typically around 70 C to 100 C. The bed of product, ranging from 1 to 200 metric tons per hour, then flows at a controlled speed through the heat exchanger bank(s)—usually 0.3 meters per minute—while cooling water at 20 C to 30 C flows countercurrently within the plates' internal channels. The number of heat exchanger banks required depends on the duty of the process conditions and necessary surface area to meet the cooling temperature target.

The flow of pellets is controlled by a sliding ladder feeder equipped with a pneumatic actuator positioner that ensures uniform mass flow and even product temperatures at the outlet. A level probe or transmitter in the inlet hopper maintains the proper level as it controls the instrumentation on the feeder.

The MBHE is static, with the only moving part being the feeder at the outlet. It is isolated from the rest of the installation to avoid any transmission of vibrations.

If the MBHE is installed in a hot, humid location, a small amount (less than 1,500 standard cubic feet per minute) of dehumidified purge air may be injected between the heat exchanger banks to prevent condensation from forming inside the column.

MBHEs can easily be retrofitted into existing processing facilities, as they have a small installation footprint (less than seven feet by seven feet) and can be used in conjunction with current equipment. As the heat exchanger banks are modular, additional banks can be added in the future when a plant considers increasing capacity.

How MBHEs Help Decarbonize

Reduce primary energy consumption: Water is a more effective cooling medium than air, absorbing up to 24 times as much heat, resulting in lower power requirements to circulate the much lower volume of cooling medium. While air coolers typically consume around 4 to 5 kilowatt hours per metric ton (kWh/mt) of pellets, an MBHE consumes, on average, just 0.4 kWh/mt of pellets.

Eliminates emissions: Because air is not being used as the heat transfer media, emissions are reduced to near zero. An MBHE will emit approximately 0.42 kilograms per 1 kWh, which is approximately eight times less than traditional cooling technologies.

Waste heat recovery: With advances in heat pump technology, it is now feasible to recover the heat extracted from wood pellet cooling rather than discharging it to the environment. The heat pump system extracts the thermal energy from the cooling water to a refrigerant via a plate-and-frame heat exchanger. Then, a small pump will move the refrigerant through a refrigerant cycle, resulting in an amplification of the heat. Typically, the heat amplification is three to four times the power input of the pump.

This heat is then extracted from the refrigerant—for example, to air using a finned-tube, air-to-liquid heat exchanger. This heated air can be sent to the dryer burner to displace a material amount of fossil fuel energy needed to produce the hot drying air. Alternatively, the recovered heat can be transferred to water, and the heated water can be used in other processes such as steam production.

Conclusion

The path to greener wood pellet production requires a comprehensive approach that involves making sure each stage aligns with broader sustainability goals. The cooling stage has always been an essential part of ensuring a quality finished product. Yet the technology employed at this stage must now do more.

Plate-based MBHEs provide wood pellet producers with an energy-efficient, near-zero emissions solution. By combining plate heat exchange design with uniform mass flow to indirectly cool pellets, the technology avoids having to rely on energy-intensive ancillary equipment to get the job done while virtually eliminating emissions and opening the door to additional waste heat recovery options.

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