Achieving Better Sand-Temperature Control with Indirect Heat Transfer

Waupaca Foundry leverages the advantages of heat-exchange technology to reduce scrap/salvage rates and offset sand-additive costs.

Jamie Zachary

The Solex cooler at Plant 3 in Wisconsin helped Waupaca Foundry to reduce mold core scrap rates by 33% and offset additive costs by 10%.

Following the successful installation at Waupaca's Plant 3, seven additional units were added at different locations, including four recently in Indiana, shown here.

In foundry operations, consistent sand-temperature control during coremaking is essential to maintaining process costs, product bench life, and overall quality. Yet that temperature consistency also can be the most difficult to achieve.

In most regions of the United States, swings in seasonal temperatures can cause upward of 70°F changes to coreroom incoming sand temperature. Those temperature variations are further magnified when the sand-delivery system is running intermittently, or disruptions occur in the foundry process that results in sand over-cooling or over-heating.

In some cases, the installed process equipment and corresponding control system is just not capable of providing the required temperature control. Not having this control can result in productivity loss, core scrap, and casting scrap and rework.

"The foundry industry, traditionally, has never had very good temperature control for foundry sand," said Mark Hoffman, Process Engineer/Project Manager with MT Systems Inc., an Ohio-based company that has deep roots in the foundry industry as a system integrator, project manager and metalcasting equipment provider.

"The traditional way to heat foundry sand has been through calciner rod heaters, and when cooling, fluidized beds with cooling coils. Yet the coils are always running either way hotter or way cooler than what you want your outlet temperature to be in order to adjust the sand temperature in a short amount of time.

"The problem is almost every foundry application is a start/stop run. You are not running sand at a continuous rate. And when you stop/start, you overheat the sand on the next run because the sand just sits there and gets hot. Or it gets too cold. So, you're always left chasing your tail. People, for years, have never been happy with traditional heaters or coolers."

Over the past six years, the pursuit of more consistent sand temperature control in the coremaking process has been cited as the driving force behind the increased adoption of indirect vertical plate technology by one of the world's largest independent iron foundries.

The capacity of the Solex coolers is typically designed to be 15 to 30 minutes of supply.

Before entering the heat exchanger, the sand is transported via pressurized air to a receiver hopper that then feds into the Solex inlet hopper.

When Waupaca Foundry, which operates three foundries in Waupaca, WI, started planning a new production line for Plant 3 in 2014, all options were on the table, recalled Adam Kurszewski, Plant 2/3 Assistant Production Manager – Coremaking.

Prior to 2014, Waupaca Foundry relied on those previously mentioned, traditional methods for cooling sand, before casting in the form of shell and tube exchangers. Yet, Kurszewski noted those units were unable to handle increased capacity demands, in addition to requiring ongoing maintenance and struggling in producing consistent sand temperatures.

"In this case, it was a brownfield development that saw the installation of a new line for our core room, including all the components. It made sense also to look for better options to handle both increased throughput and offer more accurate sand-temperature control. There were multiple reasons to pursue new technology," he said.

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Waupaca Foundry and its project partner MT Systems engaged Solex Thermal Science, a global leader in bulk solids heat exchange, to address its core-sand temperature control. The Canadian company specializes in the applications of indirect vertical plate technology and has more than 600 projects active in more than 50 countries.

"Our units keep the working fluid separate from the sand and conduct the heat indirectly through the sand bed. This results in a very accurate and consistent temperature of sand delivered to the sand mixing operation," explained Scott Harris, Regional Director, Americas for Solex Thermal Science, emphasizing that the sand particles flow uniformly by gravity between the hollow stainless-steel plates with the working fluid flowing counter-current to the sand within those plates.

Temperature control — Harris likens the indirect heat exchanger to a temperature-controlled sand-conditioning system that ensures core-sand temperature can be focused within 1°F – even with ambient temperature fluctuations. This drastically improves on the incumbent technology where sand temperatures could vary by as much as 20°F.

"In the Waupaca case, what we found we really liked about these heat exchangers is you set the temperature for what you're trying to have as an output sand temperature, and it matches your water temperature – plus or minus a couple of degrees," Hoffman said. "You don't fight it. You don't overcompensate or under-compensate.

"There's no response necessary to incoming sand temperature. If the incoming sand temperature changes from 80°F today to 60°F tomorrow, as long as we've properly adjusted the ranges of temperature of that sand coming in, the unit just takes care of everything. It offers the necessary retention time to handle that temperature fluctuation, so you don't have to guess an operating setpoint to try to get the

The sand discharge flow rate is managed by a vibratory feeder controlled by the MT Systems control.

temperature you need."

Installation considerations — Before entering the heat exchanger, the sand is transported via pressurized air to a receiver hopper, which feeds into the Solex inlet hopper. The hopper design may vary according to the selection of an air or bucket feed, restricted height, and enhanced inlet capacity that removes the need for a separate receiver hopper. For the Waupaca installation, pneumatic transporters deliver sand to a hopper mounted above the Solex exchanger.

A sufficient volume of sand is required before the heat-exchanger plates in order to keep a constant feed of sand to the heat exchanger, in the event of a supply disruption. The capacity is typically designed to be 15 to 30 minutes of supply, depending on the foundry's plant operational strategy.

In the Waupaca case, the heat-exchanger casing is mounted below the heat exchanger bank using standard support brackets. Mid-bank supports are another option for suspending the heat exchanger from a foundry upper floor.

The sand-discharge flow rate is managed by a vibratory feeder regulated by the MT Systems control, which meters out sand into the batch weigh hopper before it goes to the mixer. Knife gate feeders also are available.

Working fluid supply and controls are required to heat or cool the sand depending on the target temperature and desired flow rate of sand. Fluid modules and chiller and/or boiler systems can be added, depending on the facility auxiliary system resources available. In the Waupaca case, both hot and cold plant water is available.

In the Waupaca case, the heat exchanger casing is mounted by standard support brackets below the heat exchanger bank.

System controls to maintain fluid temperatures in heating or cooling modes under all operating conditions also are integrated into the facility control schemes. Separate heat-exchanger fluid controls are an alternative option.

QC and cost advantages — With the new exchangers, Waupaca has realized several important and significant quality improvements and cost reductions thanks to reduced core scrap and rework of cores. Casting scrap and salvage also have been minimized thanks to the optimized use of sand binders.

Kurszewski noted that since completing the Solex sand-conditioner installation, Waupaca Foundry has reduced mold/core scrap rates by 33% and offset sand-additive costs by 10%.

"This is meaningful," Hoffman explained. "You have to remember that when making a chemically bonded core or mold, sand is mixed with a small blend of ingredients that includes chemical binders – and, in some cases, also may include catalyst and dry additives. The ingredients in many of the chemically bonded systems begin a chemical-reaction hardening process before being discharged from the mixer to the sand hopper."

He added that sand temperature plays a significant role in how quickly or slow that hardening process takes place: This is the bench life of the mixed sand prior to blowing a core.

"If the sand is too hot or too cold, the amount of ingredients (catalyst in the case of the warm-box process) added needs to be adjusted, which can create inconsistencies in casting quality, as well as wasting of raw materials. Yet, if you combine a more accurate recipe with better temperature control, you're going to have a more refined process and reduced scrap."

Following the successful operation of the three Solex coolers at Waupaca's Plant 3, three additional units were commissioned for Plant 3, one additional unit for Plant 1 also in Wisconsin, as well as four more at Waupaca Foundry's Plant 5 in Tell City, IN.

This is second of a two-part series. Also see:

The Time is Right for Indirect Heat Transfer, FM&T August 2020

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