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Progress in Metalcasting: Conditioning Sand by Using Indirect Plate Heat Exchangers

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In various regions of the United States there are swings in seasonal temperatures that can cause 70-degree Fahrenheit changes to core sand temperature in foundries. Consistent temperature control of sand in the core process is a challenge. The problem is further magnified when the sand delivery system is running intermittently or disruptions occur in the foundry process that results in the over-cooling or over-heating of sand. Not having this control can result in productivity loss, core scrap and casting scrap and rework. There is no doubt that these temperature variations cause inefficiencies in the core making process and reduces the core quality impacting the bottom-line profitability of the foundry operations.

The integration of Solex heat exchanger technology helps foundries ensure the sand is delivered at an accurate and consistent temperature. The indirect heat exchanger is essentially a temperature-controlled sand conditioning system ensuring core sand temperature can be controlled (even with ambient temperature fluctuations) within 1-degree F. This drastically improves on many current conditioning technologies where sand temperatures that may vary by as much as 20 degrees F.

The Solex advanced heat exchanger design keeps the working fluid separate from the sand and conducts the heat indirectly through the sand bed. This results in a very accurate and consistent temperature of sand delivered to the sand mixing operation. In addition, this temperature is maintained even when the sand capacity is intermittent, running continuously or stopped for a long period of time.

It consumes less energy in operation since it is a gravity fed, vertical column heat exchanger with material flowing in a uniform mass through a bank of hollow steel plates. The plates are fully welded ensuring the heat transfer fluid (HTF) is kept separate from the sand. The HTF and product flows are counter-current to gain greater thermal efficiency. A vibratory feeder or mass flow cone feeder ensures the sand flows with a uniform velocity and residence time through the heat exchanger. The feeder can also deliver precise rate or batch control. Figure 1 shows the indirect plate heat exchanger design.

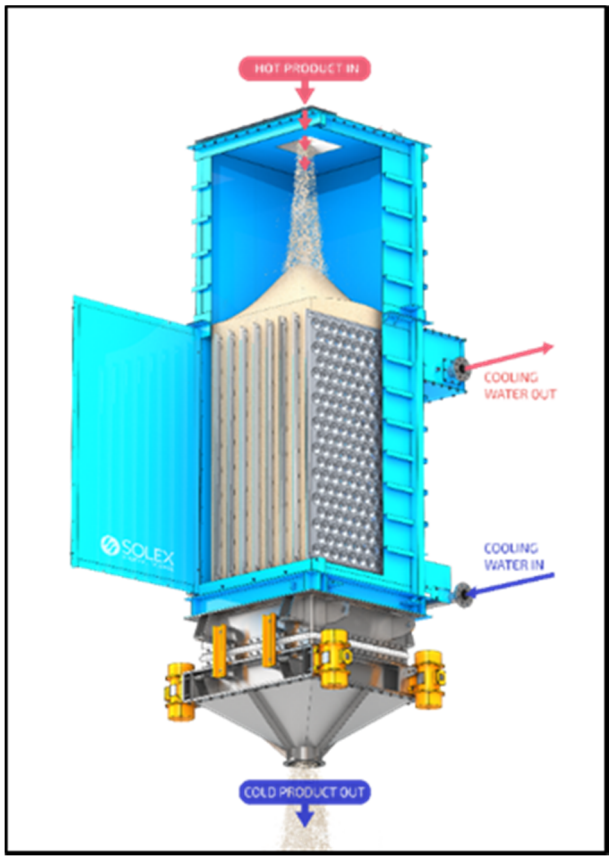

Figure 1: The Solex Indirect heat exchanger design

Indirect Heat Exchanger Advantages

To further prove the system performance, Solex provided a closed loop heating/cooling fluid temperature module (FM). In the cold months when core sand is below ideal process temperature the FM is heating water in the closed loop and

when the sand is above ideal temperature it is cooling the water. Figure 2 shows the process design.

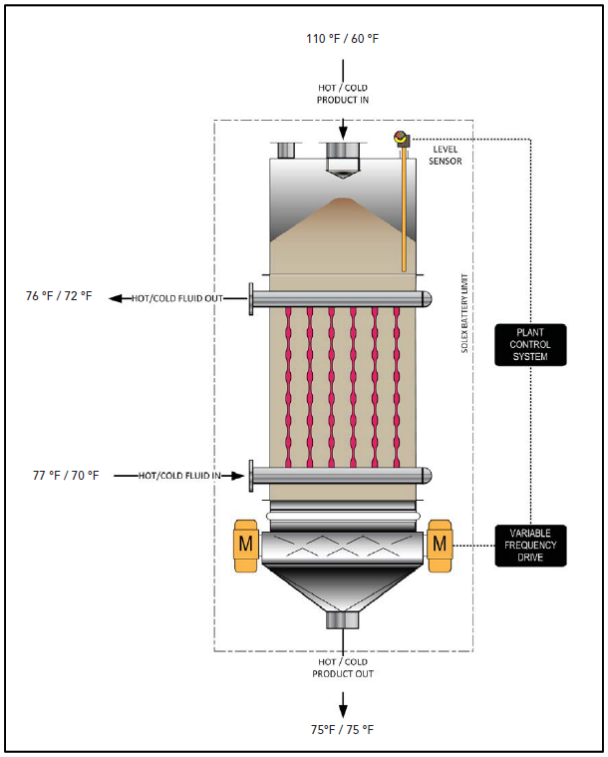

Figure 2: Process design

In the core process, sand is blended with a small amount of ingredients including chemical binders, catalyst, and dry additives in a high-speed mixer. The ingredients begin a chemical reaction hardening process when discharged from the mixer to the sand hopper. An important step in this process is to maintain consistent temperature of the sand before it is blended with the ingredients. If the sand is too hot or too cold the amount of ingredients added needs to be adjusted, which can create inconsistencies in casting quality, as well as wasting of raw materials.

An added advantage of the indirect plate heat exchanger design is that it will maintain consistent sand temperature even when the casting process is interrupted or shut down. Some foundries could shut down over the weekend. With the Solex system the TCM can maintain the sand temperature during the shutdown period and the process can restart without delay or casting quality issues caused by inconsistent sand temperatures.

Existing shell and tube technology struggle with providing even and consistent temperature as it is a challenge to get even flow-through.

In a sand-casting foundry, it is critical to maintain the consistency of AFS-GFN (American Foundry Association Grain Fineness Number). Fluidizing heaters can change the AFS GFN of the sand before going to mold. Great care needs to be taken when designing equipment to prevent and eliminate sand segregation. Indirect plate heat exchange technology offers this advantage since there is neither abrasion nor segregation occurring within the equipment.

Sand is an abrasive product so there is always concern of wear to process equipment. The Solex indirect plate heat exchanger equipment is designed to form a pile of material above the leading edge of the plates. This ensures no impingement between the product and the plates. The bed of sand can then slowly flow past the plates alleviating the chance for wear. In addition, for processes that undergo several fill/empty cycles per day, plate caps can be used to protect the plate leading edges.

Maintenance is almost zero with no moving parts, low energy input and thus no wear parts to replace. The HTF cooling water is enclosed by the plates and kept fully separate from the ambient air and core production sand product. This virtually eliminates any build-up of material that could interfere with efficient and reliable operation. Water contamination and downstream drain and pipe blockages are also eliminated.

The system maintains the highest obtainable efficiency using water indirectly as the heat transfer medium. Fluidized beds require blowers, ducting, and cleaning equipment.

The Solex heat exchanger has a compact design and footprint with easy access to heat exchange plates, with no moving parts or pinch points for safety.

Figure 3 shows an example of the positioning of the Solex heat exchanger in the sand conditioning process.

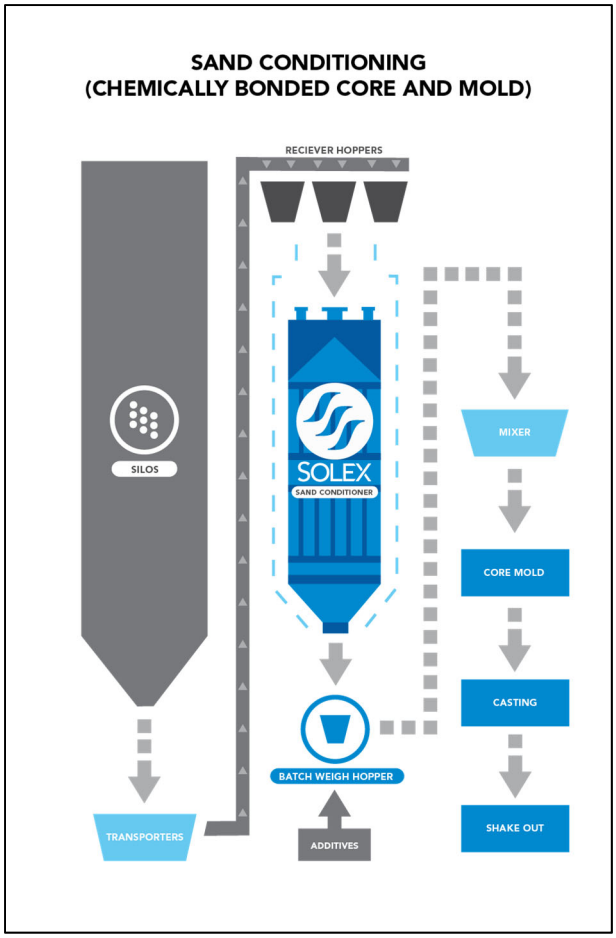

Figure 3: Core sand conditioning process

Other Challenges in Metal casting

Metal casters experience other challenges aside from consistent temperature control, which we have already discussed. Other notable challenges are inefficient binder usage and silica dusting.

Precise sand temperature control is vital to binder optimization. Lack of accurate sand temperature control results in excessive use of expensive binders to compensate. This is a costly and inefficient way to deal with sand control issues in the core-making step of the process.

The current use of fluid bed technology for sand temperature control introduces direct contact between the air heat transfer fluid and the sand product. This highly energetic, blowing air results in silica dusting that contributes to safety risks to personnel from the exposure of respirable crystalline silica. Indirect heat exchange technology reduces the risk of silicosis due to the gentle handling of sand fugitive silica. The silica dusting is reduced and ultimately contributes to a safer and healthier work environment.

The Right Partnership

The Solex heat exchanger proves to be a great value-added system. According to Waupaca Foundry Assistant Production Manager – Coremaking, Adam Kurszewski, the systems required zero maintenance. Foundries may also realize quality improvements and cost reductions through reduced core scrap and rework of cores. Casting scrap and salvage have also been reduced through the optimized use of binders.

Since the Solex sand conditioner installation was completed, Waupaca have reduced mold core scrap rates by 33% and additive costs have reduced by 10%.

Tom Wolfgram from MT Systems / Novis Works had the following to say about the Solex Heat Exchanger technology: “Solex has revolutionized sand control for core making”.

Today, Waupaca Foundry is one of only several known foundry users of the indirect plate heat exchanger technology in the world. Waupaca Foundry sought out an innovative solution to overcome consistent sand cooling challenges. They are at the forefront of core sand quality through temperature control and are reaping the benefits of exploratory efforts with Solex.

Installation considerations

Most sand conditioner projects are upgrades to existing systems and these system retrofits bring on unique challenges to the ease of installation that

require flexible designs. Since the Solex heat exchanger is gravity fed, sand enters the unit at the top via a duct opening in the inlet hopper. Sand is transported via pressurized air to the receiver hopper above the heat exchanger which feeds the Solex inlet hopper. Sufficient capacity is required before the heat exchanger plates to keep a constant feed of sand to the heat exchanger in the event of a supply disruption. This capacity is typically designed to be 15 to 30 minutes of supply depending on the foundry plant operation strategy. Solex have designed several inlet hopper options that provide for air or bucket feed, restricted height, and enhanced inlet capacity that removes the need for a separate receiver hopper.

Mounting of the heat exchanger casing is provided by standard support brackets below the heat exchanger bank. Mid-bank supports for suspending the heat exchanger from a foundry upper floor are now available should this arrangement prove easier.

Sand discharge flow rates are managed by a vibratory feedercontrolled by the MT Systems control which meters out sand into the batch weigh hopper before it goes to the mixer. Simple knife gate feeders are also available if they make sense for the system.

Fluid supply and control are required to heat or cool the sand depending on the sand target temperature and the variable flow of sand. Fluid modules and chiller and/or boiler systems are added depending on the facility auxiliary system resources available. In the Waupaca case, hot and cold plant water is used. System controls to maintain fluid temperatures in heating or cooling modes under all operating conditions are typically integrated into the facility control schemes but separate heat exchanger fluid controls can be provided as an option.

Figure 4: Solex conditioner installation

Acknowledgment

The authors gratefully acknowledge the contributions of Adam Kurszewski of Waupaca Foundry Mark Hoffman of MT Systems / Novis Works.

About Waupaca Foundry, Inc.

Waupaca Foundry, Inc., North America's leading supplier of iron castings to the automotive, commercial vehicle, agriculture, construction, and industrial markets, produces gray iron castings, ductile iron castings, HNM™ series high-strength ductile iron, and austempered ductile iron castings

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using state of-the-art processes and technology. The manufacturer also specializes in precision machining and assembly. Waupaca Foundry is headquartered in Waupaca, Wisconsin and operates seven iron foundries located in Waupaca, Wisconsin, Marinette, Wisconsin, Tell City, Indiana, Etowah, Tennessee, and Lawrenceville, Pennsylvania. The company operates two machining and assembly plants in Effingham, Illinois, and Waupaca, Wisconsin. Waupaca employs approximately 4,500 people. For more information, visit www.waupacafoundry.com.

***About MT Systems, Inc**.*

MT Systems, Inc. was established in early 1985 as a metalcasting equipment company. Since that time, the company has experienced steady growth by adding experienced electrical and mechanical engineers and expanding into other industries. We have developed a strong system integration team for your process system needs and expanded our process improvement product offerings to include Engineering Services, Foundry Products, Industrial Products, System Integration and Project Management/Turn Key Projects. Throughout this growth, our core business philosophy has been to develop long term relationships with our customers by providing customized, state of the art, system design and equipment. Our customer list includes many well-known companies from various industries who have chosen our products and services on multiple occasions. We are a three-time General Motors Global Supplier of the Year Award Winner. MT Systems is located and headquartered in Canton, Ohio. For more information, visit www.mt-systems.com.

About Solex Thermal Science, Inc.

Headquartered in Calgary, AB, Canada, Solex Thermal Science is the global leader in the development, design and manufacturing of high efficiency, indirect heat exchangers. Specializing in the heating, cooling and drying of bulk solids, our technology has been applied to the processing of sand (foundry sand and proppants), fertilizer, sugar, oilseeds, grains, plastics and many other bulk solid products. Using proven and proprietary thermal modeling software, each heat exchanger is custom designed to meet the unique thermal performance requirements of our customers. With over 25 years of experience, and more than 1000 heat exchangers installed in 50 countries worldwide, we provide best in class service from inception to completion, with technical and sales support available globally in multiple languages. Your partner in innovation, learn more at www.solexthermal.com.