

SPRAY-COOLED™ EAF CONVERSION AT SDI COLUMBIA CITY PERFORMANCE & OUTLOOK

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Spray-Cooled™ EAF Conversion at SDI Columbia City: Performance & Outlook

Abstract

In 2016, SDI's Structural and Rail Division (SRD) in Columbia City, Indiana initiated a strategic upgrade to its electric arc furnace (EAF) operation. The facility transitioned from pressurized tubular water-cooled panels to a modern Spray-Cooled™ upper shell system. This enhancement aimed to address safety concerns, improve thermal performance, and lower maintenance demands. Over time, complementary technologies such as a Spray-Cooled™ roof, elbow, copper burner box, and the SYSTEMS Spray Safe Humidity Sensor were also introduced. This paper details the technical, economic, and operational benefits realized from these innovations.

Keywords: Electric Arc Furnace; Spray-Cooled™ Shell; Maintenance Optimization; Energy Efficiency; Leak Detection

Introduction

The SDI Columbia City steelmaking facility, part of the Structural and Rail Division, was commissioned in 2002. Originally designed with traditional tubular cooling panels, the plant operated two 120-ton AC EAFs producing a wide range of structural products, rail, and billets. Given the increasing maintenance costs and risk of leaks, the team evaluated new technologies for furnace cooling, leading to the adoption of Spray-Cooled™ systems starting in 2016.

Overview of this site:

- Greenfield May 2001
- Hot commissioning May 2002
- (2) 120 ton AC Furnaces
- (2) continuous casters - 13 shapes
- Demag EBT
- 120 MVA (run at +20%)
- 45 min ttt
- 6.7m (22ft) Shell ID
- Nominal capacity 2 million tpy



Overview of SDI Facility

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DEVELOPMENT

Technical Basis for Change

Conventional tubular panels posed safety and maintenance challenges, including high rupture leak volumes and frequent hose replacement. Spray-Cooled™ systems offered a safer alternative with reduced water pressure, better thermal performance, and easier installation. The evaluation matrix clearly favored Spray-Cooled™ sidewalls for long-term reliability and safety.

Design and Evaluation

The new Spray-Cooled™ shell, raised by 18 inches, was delivered pre-assembled and installed during a scheduled four-day outage. No significant changes to the existing water system were needed, making the transition straightforward.

Operators noted that this was the simplest portion of the facility's expansion project.

Figure 2

	Tubular	Spray-Cooled
Rupture Leak Volume	✗ High	✓ Low
Air Ingress	✗ High	✓ Low
Bump-outs for brick/burner	✗ No	✓ Yes
E-water required	✗ Yes	✓ No
Self Draining	✗ No	✓ Yes
Repairs	✗ Hot Side	✓ Cold Side
Maintenance	✗ Many Hoses	✓ Minimal Connections
Installation	✗ Multiple Pieces and Complex	✓ One Piece
Metal Pourback	✗ Higher Risk	✓ Lower Risk
Filter Required	✓ No	✗ Yes

EAF Evaluation Matrix

Installation Process

The newly designed Spray-Cooled™ shell was delivered fully assembled on a flatbed trailer and was offloaded directly by the overhead crane. It was immediately positioned onto the spare lower shell and prepared for integration. The installation, conducted during a scheduled four-day maintenance outage, required only the final connection of drain lines and process wiring. Special drainage funnels were incorporated to manage water runoff from the hot face and to facilitate in-service temperature monitoring. The shell featured design enhancements such as burner jacket bump-outs and additional refractory courses at the bosh level, and was ready for first heat operations in May 2017.

Figure 3



Shell Installation

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RESULTS AND PERFORMANCE

Maintenance and Cost Savings

Comparative analysis between 2014–2017 (tubular) and 2018 (Spray-Cooled™) revealed a reduction in panel and contractor costs from by 45%. The return on investment was achieved in under 1.5 years based on maintenance savings alone, excluding the additional gains from energy savings and productivity.

Overview of advantages and testimonials

- Much Cleaner – hoses and connections inside
- Less areas for dust, scrap, and slag to build up
- Less downtime changing hoses and valves
- One-piece construction minimizes flame and fume emissions keeping workplace environment cleaner
- Integral EBT Sump – no fumes or heat between shell and EBT
- Equipment holds and retains slag better – more energy inside the furnace
- Equipment remains more dimensionally stable – less thermal cycling

Energy Savings

Upon startup in 2017, the newly installed Spray-Cooled™ system demonstrated immediate operational benefits, including improved slag retention and a reduction in overcharges. Energy consumption decreased by approximately 3–6%, and single-bucket charging performance improved by 5%.

Since the initial installation in 2017, further modifications have been implemented, such as increasing the sump opening, adding multiple access hatches, sealing the lance port, and changing the burner and box supplier. Adjustments to address thermal hotspots around the sump and slag door regions have also contributed to performance improvements. As a result, the upgraded shell has achieved operational life spans exceeding 25,000 heats before hot face replacement.

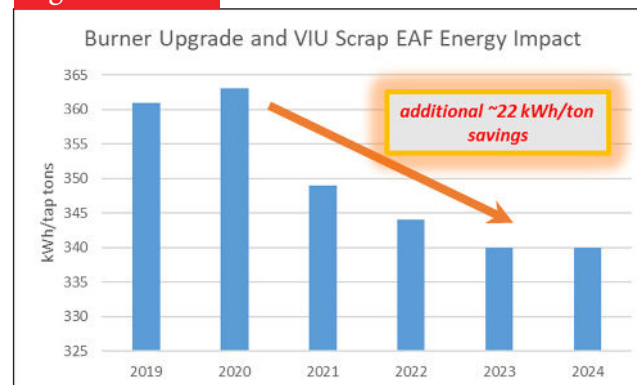
These modifications, along with enhanced burner design and more efficient scrap utilization, have contributed to an additional energy savings of approximately 22 kWh per ton.

Operator and maintenance feedback further validated the improvements: the system created a significantly cleaner working environment with fewer dust and slag accumulation zones, minimized downtime due to fewer hose and valve failures, and reduced air ingress. The one-piece construction and integral EBT sump design improved sealing and dimensional stability while maintaining heat and slag more effectively within the furnace.

Based on an energy savings of 20 kWh per ton, a production volume of 2 million tons per year, and an average electricity cost of \$0.06 per kWh, the resulting annual energy cost savings amount to approximately \$2.4 million.

- Improved slag retention and reduced overcharges.
- Enhanced operational reliability and safety.
- Reduction in energy consumption by 3-6%.
- Single bucket charge percentage improved by 5%.

Figure 4



Energy Savings

FUTURE INSTALLATIONS AND DEVELOPMENTS

Gravity Drained Spray-Cooled™ Roof

The success of the sidewall conversion has prompted SDI to extend spray cooling to the EAF roof, elbow, and burner box.

The roof transition was not part of the original Spray-Cooled™ upgrade project. However, operational experience with the existing tubular roof revealed several areas of slag buildup that have prompted further evaluation. The newly designed Spray-Cooled™ roof addresses these concerns through the integration of slag and tap drain boxes engineered for gravity drainage—eliminating the need for venturi pumps and reducing the risk of flooding in the melting area.

An integral component of the new roof design is the Spray-Cooled™ elbow, which is both supplied and drained through the roof itself, requiring no additional hosing. It is mechanically secured to the roof with a four-point pinning system, ensuring stability and ease of maintenance. This advanced roof system was first installed at Optimus Steel three years ago, where it has demonstrated reliable, consistent performance under production conditions. It is now scheduled for inclusion in SDI's next capital expenditure phase.

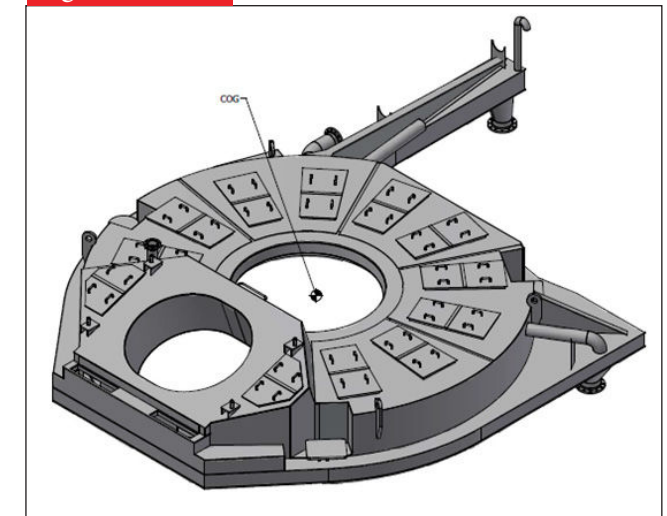
These innovations are designed with gravity drains and fewer hoses, further simplifying maintenance and reducing water use.

Humidity Sensor

This system allows moisture, relative humidity, to be measured in the channel in between the upper shell, hot face and the refractory brick. It's installed in a location where you would anticipate having some leakage or some hot face wear, and allows rapid detection of any moisture to prevent, of course, hydration of the lower shell refractory brick.

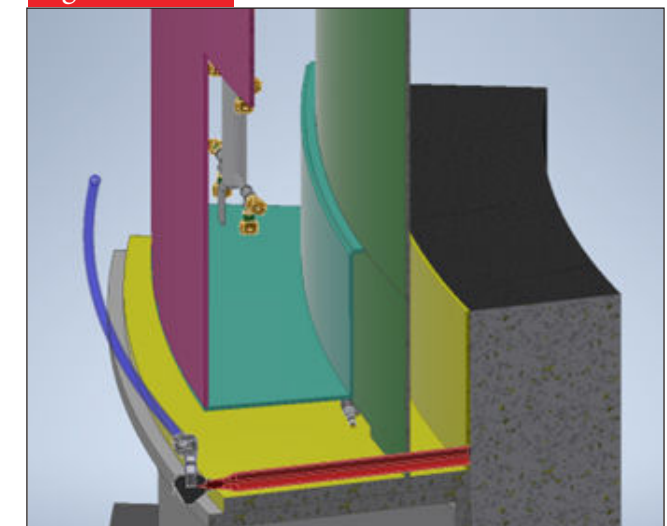
It is one the latest developments to cover all remaining question marks.

Figure 5



Gravity drain roof design

Figure 6



Humidity Sensor

Spray-Cooled™ Burner Box

The Spray-Cooled™ copper box presents an ideal solution for the burner injection zones. By eliminating the use of pressurized water circuits, it significantly reduces the risk of catastrophic leaks typically associated with cast copper burner blocks. The forged construction allows for approximately 50% less cooling water usage, while also making the unit lighter, more manageable, and easier to install and maintain.

Designed with System's modular "break-up" technology, the box retains more slag, thereby reducing heat extraction and enhancing thermal efficiency. The simplified supply and gravity return drainage system reduces the number of required hoses and piping connections, streamlining integration with the existing infrastructure.

Maintenance and repair are further simplified, as forged copper is easier to weld than cast copper. Additionally, the box is accessible from both the hot and cold face via a removable backing plate, allowing for straightforward inspection and servicing. Its modular, rebuildable design contributes to an extended service life and overall cost efficiency.

The initial installation took place at Nucor Hickman in June 2023, where the unit successfully completed over 10,000 heats. A full furnace trial is planned for late 2025. The Columbia City implementation, already delivered on-site, will utilize the same burner and carbon injector configurations as those currently operating with cast copper blocks. The system connects to the existing high-pressure supply line, with gravity-based return flow to the sidewall drain boxes—requiring no modifications to the sidewall itself.

- Far Safer – eliminating the largest failure risk, pressurized water leaks
- Requiring Less Cooling Water – ~50% less
- Easier to Handle – Lighter weight
- Requiring fewer hoses/piping – supply and drain from sidewall
- More Efficient – Less Heat Removed
- Easier to Repair – Easier to weld forged copper than cast and can access from both hot face and cold face sides
- Longer Lifetime – Rebuildable and Reusable

Figure 7



Spray Box (front and back view)

CONCLUSION

The Spray-Cooled™ conversion at SDI Columbia City represents a significant step forward in EAF safety, efficiency, and reliability. Ongoing improvements continue to refine the technology's impact on operational costs, energy consumption, and furnace life. These experiences make a compelling case for broader industry adoption of Spray-Cooled™ systems

Apart from the driving factor safety the total return on investment (ROI) was at the end less than 6 months.

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