Modern Blast Furnace Top Gas Cleaning: Wet Separation
Improvements at U. S. Steel – Great Lakes Works B2 Blast Furnace

Authors

Jean-Luc Kuffer
Paul Wurth, Valparaiso, Ind., USA
jeanluc.kuffer@paulwurth.com

Jim Quick
U. S. Steel – Great Lakes Works, Ecorse, Mich., USA
jquick@uss.com

Christian Davidi
Paul Wurth, Essen, Germany
christian.davidi@paulwurth.com

U. S. Steel – Great Lakes decided to replace an outdated Venturi scrubber with a modern annular gap scrubber. The objective of the replacement was to improve gas quality and ensure safe and reliable operation of the B2 blast furnace during its next campaign. The new system was installed during the 2019 spring/summer furnace outage. This paper describes the scrubber technology, the project setup, as well as the concept of the erection and installation activities.

United States Steel Corporation, headquartered in Pittsburgh, Pa., USA, is an integrated steel producer with major production operations in the United States, Canada and Central Europe. It has an annual raw steelmaking capability of 27 million net tons. The company manufactures a wide range of value-added steel sheet and tubular products for the automotive, appliance, container, industrial machinery, construction, and oil and gas industries.

U. S. Steel’s integrated steel facilities include:

• Gary Works.
• Great Lakes Works.
• Mon Valley Works.
• Granite City Works.
• Fairfield Works.
• U. S. Steel Košice in the Slovak Republic.

U. S. Steel is also involved in several steel finishing joint ventures in the United States, Brazil, Canada and Mexico.

In 2018, United States Steel Corporation placed an order with Paul Wurth (PW) for the revamping of the gas cleaning system scrubber on B2 furnace in Ecorse, Mich., USA.

The existing scrubber was in operation since 2000 and had reached the end of its operational life due to heavy corrosion of the steel vessel.

U. S. Steel – Great Lakes Works wanted to achieve drier and cleaner blast furnace gas with the new scrubber, thereby resulting in more efficient and reliable operation of downstream equipment.

The existing double Venturi scrubber was replaced by the PW...
annular gap element (AGE) scrubber technology which was designed to achieve a dust content less than 5 mg/Nm³ with a blast furnace top pressure of 8 psig (0.552 bar,g).

The AGE design is much simpler and it replaces the two Venturis shown in the existing Fig. 1 design.

**Technology and Advantage**

AGE scrubber technology offers several advantages compared to the existing variable throat Venturi design. The main advantages of an AGE-type scrubber design are a much greater cleaning efficiency and better top pressure control. This technology also has a higher reliability and longer equipment lifetime.

Inside the outer conical casing, there is an internal movable cone that generates an annular gap where higher velocity is created with the dust particles of the BF gas and the injected water droplets. In the annular gap zone, the mixture between droplet and dust is optimized and the longer retention time in the annular gap ensures cleaning with minimized pressure loss and reduced water consumption.

In order to achieve optimum cleaning efficiency and minimum amount of wear, the distribution of the gas flow through the AGE has to be exactly symmetric. This means that both parts, the inner cone and outer cone, have to be precisely centered. If both parts are not centered, the width of the gap between the two cones will not be even around the circumference and the flow of the gas will not be distributed properly. However, the distribution of the injected water will not be changed due to the higher density. If this were to occur, the cleaning efficiency of the AGE would be reduced.

The AGE scrubber has been designed to have perfect alignment of the inner and outer cones. The guiding bearing for the movable inner cone is fixed to the outer cone so that perfect alignment is realized during assembly of the element at the workshop.
Revamping

In addition to the seven new spray arms (six in the upper section of the scrubber vessel and one above the AGE), the hydraulic system, water supply/discharge piping and automation system were renewed.

The complete system, including the vessel, was designed in such a manner that the existing old foundation could be reused.

All new structures, including platforms and walkways, could not interfere with the existing dust removal access lane from the dust catcher and nearby service road.

The complete revamping of the scrubber system was scheduled to take place within 30 days during the planned outage of the BF from 31 May until 27 June 2019.

In order to minimize the construction time, it was necessary to consider a high ratio of pre-fabrication and to choose a material that did not require an internal and external corrosion protective painting after installation, which may have added to the total construction time.

The scrubber vessel and all internal parts were fabricated in high-grade stainless steel. The lower part of scrubber, which did not come into contact with the BF gas cleaning process, had a reduced diameter in order to fit onto the existing foundation anchor bolt circle. This section was fabricated in carbon steel and received different layers of a protective coating, which was applied in the workshop.

The scrubber vessel was delivered to the site in a single piece and was placed in a vertical orientation on a temporary pre-erection pad. The major advantage of this method was that all internal parts, such as the AGE, its supporting rod and water spray arms complete with nozzles, were installed in the vessel prior to the single main lift to its final position on the existing foundation.

With this pre-condition for erection, the scrubber vessel had to be engineered with sufficient trunnions in several areas to enable the vessel to be shipped horizontally and then lifted and rotated to the vertical position for final installation.

Pre-fabrication was also necessary for the gas mains, supporting structure, stair tower, maintenance platform, walkways and other platforms. All the steel
structures were pre-assembled complete with the water and utility piping and electrical cabling and lighting and lifted in two assemblies to their final position (Fig. 7).

This erection concept ensured the shortest erection time but required a large-capacity crane due to the distance between the pre-erection area and the final position of the equipment near the furnace.

The international setup of the project required extensive cooperation between PW in Valparaiso, Ind., and U. S. Steel – Great Lakes as well as resources from the PW gas cleaning competence center in Germany; Middough, U. S. Steel’s local engineering company for the balance of plant; and Songer Steel Services Inc., the construction company.

Regular meetings and teleconferencing between the various parties involved kept the project on schedule.
Prior to the start of fabrication of the scrubber vessel in North America, U. S. Steel announced a rescheduling of the outage, and it was necessary to deliver the scrubber vessel months earlier than originally planned. The difficulty of the new schedule was that the fabrication capacity in North America was not sufficient to ensure the reduced fabrication time. The closing of the St. Lawrence Seaway locks due to winter conditions and for maintenance affected the project schedule as well.

Global sourcing was required to find the right supplier to execute fabrication outside of North America. An order was placed with a Western European vendor to fabricate the whole scrubber vessel within 19 weeks and to ship the scrubber in one piece to the U.S. before the locks on the Great Lakes closed. The vessel landed on Zug Island prior to Christmas 2018.

The fabrication process followed ANSI standards and a successful execution of a pressure test of the vessel was performed before it left the manufacturer.

**Project Execution Timeline**

- Placing the order to Paul Wurth by U. S. Steel: 23 April 2018.
- Engineering and ordering the local parts: April–June 2018.
- Order placed in Germany: End of June 2018.
- Loading to riverboat in Germany: 12 November 2018.
- Arrival in Antwerp international port: 15 November 2018.
• Arrival in Detroit international port: 18 December 2018.
• Reloaded from ocean ship to barge same day.
• Barge landing on Zug Island: 19 December 2018.
• The (pre)-erection started in March 2019 and cold commissioning was finished on early August 2019.

Conclusion

Pre-assembly of the scrubber and stair tower, piping and electrical cabling reduced the construction time and therefore the scheduled downtime of the furnace.

Did You Know?

Not Just Your Morning Pick-Me-Up: Steel Researchers Use Coffee Grounds in Green Steel Breakthrough

Researchers at the University of New South Wales’ (UNSW) Centre for Sustainable Materials Research and Technology (SMaRT) have published findings that show various wastes, including coffee grounds, can be used in the manufacture of green steel.

Mining consumables supplier Molycop has shown through industrial trials of green steel polymer injection technology (PIT) that various wastes can be utilized in electric arc furnaces as alternative sources of coke and coal.

According to Steel Times International, waste plastic and coffee grounds are now joining the ranks of waste rubber tires as sources of carbon and hydrogen.

"Steelmakers have to meet the demands of quality requirements," said Veena Sahajwalla, UNSW SMaRT director and AIST member. "The metal that gets produced doesn’t have any memory of whether the parent material that went in was coal or coffee. It gives you the kind of productivity requirements that any commercial operator will want."

Sahajwalla added that eliminating coke completely would be ideal.

"If you have a combination of materials, you get a better outcome because you’re able to fine-tune and customize green steel and take the kinds of materials that do the best job," Sahajwalla said. "This is not a waste; it’s a really useful resource. It’s going to be an interesting shift toward valuing our waste resources and thinking about those innovative supply chains where recycling and manufacturing can be coupled together."