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Project Summary

Kress Indirect Dry Cooling System: Bethlehem Steel's Coke Plant Demonstration at Sparrows Point, Maryland

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This report evaluates the Kress Indirect Dry Cooling (KIDC) process, an innovative system for handling and cooling coke produced from a slot-type by-product coke oven battery. The report is based on the test work and demonstration of the system at Bethlehem Steel Corporation's Sparrows Point facility in 1991, covering both environmental and operational impacts of the KIDC process. Areas covered in the report include opacity levels, quenching emissions, and the impact of the KIDC coke on blast furnace operations. Also evaluated were various performance characteristics of the KIDC system, including reliability, cycle time, coke cooling requirements, and costs. Unfortunately, the abbreviated test program, caused by the idling of coke production at Sparrows Point, limited the experience and data collected during the demonstration.

The data presented in this report have not been thoroughly audited, and the conclusions are not approved or endorsed by the Agency. Because of the sudden termination of the project and the associated quality assurance effort, it was not possible to perform the detailed laboratory and data audits that had been planned.

This Project Summary was developed by EPA's Air and Energy Engineering Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The Kress Indirect Dry Cooling (KIDC) process is an innovative method of capturing and cooling coke produced from a by-product coke battery. It offers the potential to reduce significantly the emissions from coke pushing and quenching operations. The KIDC demonstration was conducted at Bethlehem Steel Corporation's Sparrows Point, MD, facility using an existing 4-m by-product coke battery. During the demonstration, 321 KIDC pushes were performed. This report describes the KIDC process and provides an evaluation based on preliminary baseline and demonstration emission testing data.

The KIDC concept has been under development by the Kress Corporation since the early 1980s. On June 6, 1987, the first prototype testing started at National Steel Corporation's Granite City Division in Granite City, IL. During this testing, 27 pushes were successfully performed by the KIDC system. In December 1988, the first demonstration of the KIDC prototype occurred at Bethlehem's Sparrows Point plant with the successful demonstration of 12 pushes. Following this testing, Bethlehem signed a contract with the Kress Corporation to install a full scale demonstration system. The installation was to occur in two phases: Phase I was the installation and demonstration of the new technology on coke oven battery No. 11, and Phase II was to be an extension of the system to include controls on battery No. 12 if the demonstration on battery No. 11 was successful.

Start-up of the KIDC system began on June 7, 1991, on battery No. 11. This start-up testing of the system continued for about 3-1/2 months until the commencement of the performance demonstration early in October. This demonstration ended prematurely, however, with the idling of all coke production at Bethlehem's Sparrows Point facility in December. The results of the demonstration are reported based on KIDC pushes made during the limited 2-month demonstration. The results indicate that the technology has potential to reduce pushing and quenching emissions over many existing control technologies. A longer demonstration, however, would provide a better assessment of long-term operability of the KIDC system in the rigors of a coke oven environment.

Process Description

The KIDC System

The KIDC system is a patented process of the Kress Corporation for cooling coke after removal from a coke oven. It was designed to control emissions during both the pushing and quenching operations. The KIDC process confines the emissions completely during the push, unlike previous emission control technologies that typically rely on filtering or scrubbing the emissions after they have escaped. The conventional pushing technologies used for the baseline testing reported here utilized a water spay during the push (to reduce particulate emissions) or a Chemico control car.

The KIDC system completely eliminates the wet quenching process and relies instead on an indirect dry cooling process. The hot coke never comes into direct contact with the cooling water, thus eliminating the vigorous evolution of steam and consequent entrainment of particulate matter.

The KIDC carrier is impressively large, weighing about 400,000 lb (180,000 kg), with 8 ft (2.4 m) rubber tires. It carries and manipulates a 50 ft (15.2 m) long, 13 ft (4 m) high, and 3 ft (0.9 m) wide KIDC container (box). Its 24 or more hydraulic cylinders handle the intricate operations described below. These hydraulic cylinders have computer/electronic sensors for exact positioning and control. Auxiliary equipment includes 10 or more KIDC boxes, a support rail, a maintenance building, a quench station, and a fueling station. The support rail is used to balance the carrier's weight, counteract pushing forces, and maintain the carrier at a precise distance from the oven. Other functions of the KIDC carrier include door removal/replacement, door and jamb cleaning, and catching coke debris when the door is operated.

The KIDC box, slightly wider and deeper than the coke charge, is positioned flush against the coke oven and receives the push. The KIDC process utilizes the conventional push-side apparatus. After the push is completed and the pusher ram is withdrawn, the KIDC box's guillotine door closes. The volatile organic compounds (VOCs) are controlled by a flare at the rear of the box, which is ignited during the push or start of travel. During the push, the KIDC carrier also cleans the cokeside door and door jamb, which should facilitate meeting the proposed National Emissions Standards for Hazardous Air Pollutants (NESHAP) regulations on door leaks. The jamb cleaner was, however, not operable during the demonstration. After the push, the box is transferred to the quenching station. During travel, VOCs also evolve and burn through small leaks at the guillotine door. The carrier runs cooling water on the outside of the box during the push and travel primarily to protect the box from overheating.

At the quench station, the carrier moves the box from the carrier into one of the nine cooling racks. Cooling water runs over the box to cool the coke. A recirculation fan, which derives power from a drive wheel in the quench rack, aids this cooling. During the first part of the quenching process, VOCs still evolve and burn at the guillotine door. After cooling, the carrier removes the box from the rack, carries it to the receiving station where the guillotine door is opened and the box is emptied by tilting.

Coke Oven Batteries

A typical by-product coke oven battery consists of 50 to 80 slot ovens. Each oven is charged from the top with coal specially blended for metallurgical coke production. This coal is pyrolyzed by heating the sidewalls of these narrow ovens to about 1150°C for 16 to 48 hours. The resulting product consists of elemental carbon and other non-volatile materials that were present in the initial coal blend. This product is essential to blast furnace operation where molten iron is produced.

The facilities on which the demonstration was carried out were Sparrows Point batteries No. 11 and 12: each is an underjet 4-m battery with 65 ovens. These batteries were constructed by Koppers and commissioned in 1955 and 1957, respectively. The condition of the batteries had, however, deteriorated significantly with age. At the time that testing began in 1991, 22 ovens were in service on battery No. 11 with coking times that ranged from 23 to 48 hours. In general, production on battery No. 11 was 18 ovens pushed per day. This production was scheduled during two shifts, 11 pm - 7 am and 11 am - 7 pm, because of the small number of ovens available and to balance gas flows in order to obtain a consistent coke oven operation.

Two conventional pushing emission controls were utilized on batteries No. 11 and 12: one was a Chemico scrubber car, and the other was a water spray car. These conventional controls established a baseline against which the KIDC performance was evaluated.

The Test Program

The test plan for the KIDC program consisted of (1) evaluating the operational impact of the KIDC system on the coke oven facilities and operations, and (2) evaluating the impact of the KIDC system on pushing emissions; quenching emissions; top, side, and door emissions; coke quality; blast furnace operations; and general area air quality.

The demonstration test program was scheduled for a 30-week period, which included a Performance Test lasting 4 weeks and an Operational Test lasting an additional 26 weeks. The test program was cut short, however, as a result of Bethlehem's decision to cease all coke oven production at Sparrows Point at the beginning of December 1991.

The baseline program was designed to provide an understanding of where the existing operation was with respect to a number of parameters that might change from the implementation of the KIDC system. Some of the baseline parameters measured and reported on included coal and coke quality; coke pushing, travel, and handling emissions; door emissions; quench and makeup water analysis; area monitoring of cokeside machinery; and evaluating the impact of coke quality changes on blast furnace performance.

Environmental Observations

EPA Method 9 was utilized to determine the maximum opacity during the push, and EPA Method 22 was utilized to determine the total duration of visible emissions. These methods were utilized for observation from the cokeside, the topside, and the pusherside of the battery during the pushing operation. In addition, the coke discharge and handling emissions were observed from both the conventional and KIDC systems. Readings were performed similarly for both the conventional pushing operation and the KIDC system. Cokeside observations for the KIDC system were, however, more specific so that emissions could be evaluated based on the different operations and areas from which emissions occur in the system.

Results indicated that cokeside visible emissions were reduced significantly with the KIDC system (see Table 1). These reductions were partially offset, however, by increases in emissions from the topside, pushside, and discharge (see Tables 2-4). These increases were minimal, however, when compared with the large reduction in cokeside emissions attained.

KIDC Box Gas Sampling

During the demonstration test program, sampling and analysis of the gases contained within a KIDC box was performed by Keystone Environmental Resources, Inc., to provide both qualitative and quantitative analyses of the gases that are held in the KIDC box at the start and the end of the cooling cycle. A number of volatile and semi-volatile compounds were analyzed, including a library scan to identify the most prominent components. Three tests were performed during two cooling cycles. The samplings took place at 5 minutes and at 2 hours into the cooling cycle.

The results of these analyses show that VOC concentrations are extremely low for the gases held in the box. The semi-volatile compounds (SVOCs) investigated were polynuclear aromatic hydrocarbons (PAHs); phenols and cresols; and phthalates. Many of the targeted PAHs were found above the detection level but at very low levels. The analysis for phenols and cresols indicated the presence of two of the six targeted compounds. None of the targeted phthalate compounds were found above detection levels.

Area Monitoring

Area monitoring of the ambient air quality in the area of the coke oven bench of batteries No. 11 and 12 was performed. Samples were obtained in accordance with industrial hygiene methods. The constituents sampled for were total nuisance particulate and the benezene soluble fraction of total particulate matter (BSFTPM). This constituent is also sometimes referred to as benzene soluble organics (BSO). These samples were obtained over an 8-hour period in the area of the conventional coke oven door machine. This area was chosen because of its close proximity to the pushing operation. Each sample was converted to a time weighted average concentration (TWA). As a result of the limited operation of the KIDC system, no reliable comparison of ambient air quality could be made between the baseline and demonstration test periods.

Table 1. *Comparison of Visible Emission Observations for Pushing Emission Control Systems (Average Readings)*

Operation	Shenango Car	Chemico Car	KIDC
Pushing - Ave. Max. % Opacity	*69.5*	*67.6*	*NA*
Jamb Interface	*NA*	*NA*	*9.1*
Flare Stack			
Before Ignition	*NA*	*NA*	*20.4*
After Ignition and Travel	*NA*	*NA*	*12.2*
Travel - Ave. Max. % Opacity	*33.1*	*29.0*	*NA*
Cumulative Time of Emissions - sec.			
Pushing	*74.7*	*61.9*	*72.1*
Travel	*46.7*	*47.5*	*120.6*
*Relative Quantity of Emissions (Engineering Judgement)**	*Large*	*Large*	*Small*

NA - Not Applicable.
**Observation of videotapes will provide the reader with a better comparison of the relative magnitude of the quality of emissions released by the respective pushing emission control systems.*

Quenching Emissions

One of the environmental benefits of the KIDC system is the elimination of quench tower emissions. This testing program attempted to estimate the magnitude of the current quenching emissions from the operation of batteries No. 11 and 12 at Sparrows Point. A sampling program was undertaken to determine a number of the constituents in the quench water that might be evolved in the quenching process.

In general, it has been shown that one of the most reliable indicators of total particulate emissions is the amount of total dissolved solids (TDS) in the quench water. With the assistance of EPA, the specific design of the quench tower utilized for the battery 11 and 12 quenching operation was evaluated and their potential emissions were assessed.

Based on previous testing at other steel mills that appear to have similar physical design characteristics as Sparrows Point's battery 11 and 12 quenching operation, an equation was developed to provide a correlation between TDS and pounds of particulate emissions per ton of coal charged:

$$E = 1.31 + 0.000144Y$$

where

E = Particulate emissions (pounds per ton of coal charged)

Y = TDS (mg/L).

Coke Quality

A major objective of the KIDC test program was to determine the quality and yield of the coke produced by the KIDC system and to compare these results to the coke produced by the conventional wet quenched process during the same time period. Improvements were seen in reduced moisture levels and an increase in stability. Although data indicated a reduction in size, this is believed to have occurred from the specific coke handling characteristics of the system and not from the KIDC process itself. The effect of these changes on blast furnace performance was evaluated based on Bethlehem's Primary Facilities (BALWAX) model.

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The complete report consists of two volumes entitled "Kress Indirect Dry Cooling System: Bethlehem Steel's Coke Plant Demonstration at Sparrows Point, Maryland:"
"Volume 1. Technical Report and Appendices A-F," (Order No. PB93-191 302; Cost: $36.50, subject to change).
"Volume 2. Appendices G-N," (Order No. PB93-191 310; Cost: $44.50, subject to change).
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