CALGON CARBON CORPORATION

Case Study

Carbon Injection Proves Effective In Removing Dioxins

The technology, which is widely used in Europe, is beginning to take hold in the United States.

By Douglas R.Roeck and Alfred Sigg

During the past several years, there has been growing concern about emission of polychlorinated di-benzo-p-dioxins and polychlorinated di-benzofurans (PCDDs/PCDFs). Dioxins and related compounds are byproducts of combustion formed by recombining other organic constituents and chemical reactions in the combustion effluent-gas stream.

Generally, dioxins are formed in the cooler regions of the combustion system, where condensation onto fly-ash particles can occur. Certain metals can also act as catalysts and promote dioxin formation.

Much of the attention concerning PCDDs/PCDFs has focused on hazardous-waste combustion facilities. Actually, incinerators are a relatively minor contributor to the overall dioxin/furan environmental burden compared to medical and municipal waste combustors.

In Europe, carbon injection is widely used to effectively control dioxin emissions from hazardous-waste incinerators. The technology is beginning to take hold in the United States.

Waste Technologies Industries, a hazardous-waste incinerator in Ohio, recently completed extensive testing of the effectiveness of carbon-injection technology.

The System

Though the firm operates one of the country's newest hazardous waste rotary kilns in East Liverpool, Ohio, the basic system design isn't unique. It houses a well-engineered assembly of traditional unit operations coupled with combustion process design and control for minimizing formation of NO_x, CO, SO_2 and total hydrocarbons, as well as PCDDs/PCDFs. The incinerator train consists of a rotary kiln followed by a secondary combustion chamber and a waste-heat boiler.

Capable of handling drums, bulk solids, liquids and sludges, the system is permitted to feed up to 2,000 pounds per hour of chlorine. The flue-gas cleaning system (FGCS) is comprised of a spray dryer, a three-field electrostatic precipitator (ESP), and a four-stage wet scrubber that includes a quench section, two packed bed sections and a venturi scrubber section.

The enhanced carbon injection system (ECIS) is now an integral part of the FGCS. Pollutants such as HCl and SO_2 are controlled primarily by the wet scrubber portion of the FGCS, while particulate matter and heavy metals are effectively removed by the ESP and venturi scrubber and the activated-carbon injection system.

The system uses Calgon Carbon-type WPX, a powdered activated carbon produced from reactivated granular coal-based carbons. Once the powdered carbon is injected into the system and has adsorbed dioxins and other contaminants, it is removed along with particulates and other solids in the ESP. The material is then disposed of with other plant solid wastes in an off-site landfill.

Evaluating Carbon Injection

Three month after the initial trial burn, the firm began a program to evaluate using activated-carbon injection for controlling dioxin emissions. More than 60 stack sampling runs were conducted before and after the installation of the carbon-injection system to determine emission rates for PCDDs/PCDFs.

Data presented in the following charts are based on sampling runs conducted in accordance with the Environmental Protection Agency's Method 23. Emissions have been evaluated based on total homoloque groups (PCDDs/PCDFs or D/Fs) and on a total toxic equivalency (TEQ) basis using the 1989 EPA/international toxic equivalency factors. A comparison of average results before and after employment of carbon injection for total PCDDs/PCDFs and total TEQs is shown in **Table 1.**

The carbon-injection system is more than 95 percent effective in reducing total dioxin emissions. The ratio of total PCDDs/PCDFs to total TEQs from the control system changed, going from about 55 to 75 and indicating that the more toxic cogener groups are controlled more effectively than all groups combined. This is shown in the table for 2,3,7,8-TCDD and 2,3,7,8-TCDF where average efficiencies were 99.6 percent and 97.4 percent, respectively.

The extensive amount of emission data also permitted an in-depth analysis of potential correlations with other system operating parameters. With respect to both chlorine input to the system and kiln operating temperature, the data showed only a modest correlation with kiln outlet temperature (prior to installatlon to the ECIS).

Emission data, as a function of chlorine feed on a total D/F and total TEQ basis prior to ECIS installation, showed no discernible pattern. These data represent a small window of chlorine feed ranging from about 2,800 to 3,200 pounds per hour.

Similarly, emissions have been evaluated as a function of kiln-outlet temperature both before and after installation of the carbon system. Before the use of the carbon injection, emissions showed a tendency to increase with kiln-outlet temperature. After installation of the ECIS, no temperature correlation was seen, probably due to the fact that emission had been reduced to such a low level. The lack of distinct correlation with furnace operating conditions can be interpreted as further indication that dioxin and furan emissions are largely dependent on design and operating parameters associated with FGCS.

TABLE 1

Selected Emission Results Before and After Installation

Emission Parameters	Pre-Control Data	Post-Control Data	Relative Efficiency (*a*)
Total PCDDs/PCDFs	133	6.0	95.5%

ng/m³ @ 7% O_2			
Total TEQs ng/m³ @ 7% O_2	2.4	0.083	96.5%
Ratio of Total D/Fs: TEQs	54.9	75.0	N/A
2, 3, 7, 8 - TCDD, pg/train	107	0.4	99.6%
2, 3, 7, 8 - TCDF, pg/train	904	24	97.4%
1, 2, 3, 7, 8 - PeCDD, pg/train	483	10	97.9%
2, 3, 4, 7, 8 - PeCDD, pg/train	3,645	138	96.2%

(a) The efficiency based on average data prior to and after ECIS installation

Mercury-Emission Control

The use of carbon injection has also improved mercury-emission control. At the time of the original trial burn - at a feed rate of 2 pounds per hour - mercury removal was 7 percent. This low removal efficiency was partially due to excessive spiking of mercury into the scrubber neutralization system. Tests conducted with the carbon system in operation at a feed rate of only 0.12 pound per hour of mercury showed 97-percent removal efficiency.

Proven Effective

The use of carbon injection at the rotary-kiln incineration facility was shown to be more than 95 percent effective in removing dioxin emissions from the flue-gas stream. For 2,3,7,8-TCDD, emissions were reduced by more than 99 percent. Before using carbon injection, annual emissions (on a total TEQ basis) were equivalent to about 1.85 grams per year, assuming full-time operation. With the ECIS operating, emissions were equivalent to about 60 milligrams per year.

Dioxin emissions have been shown to be independent of chlorine feed to the incinerator, both before and after installing the ECIS. Without carbon injection, dioxin emissions were modestly dependent on kiln-outlet temperature. Since ECIS use, no such temperature dependence was seen.

Capital investment costs for carbon-injection technology average several hundred thousand dollars. The technology provides an attractive alternative to other processes used in Europe, such as fixed-bed or entrainment-process systems, which require a several-million-dollar investment.

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Douglas R.Roeck is manager of hazardous-waste incineration programs with ENSR Consulting and Engineering, Acton, Mass. Alfred Sigg is vice president and general manager of Waste Technologies Industries/VonRoll, East Liverpool, Ohio.

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