Flameless Thermal Oxidation

Abstract

This case study covers flameless thermal oxidation for the destruction of volatile organic compounds (VOCs) in off-gas emissions. This technology is commercially available from Thermatrix, Inc. and it involves the oxidation of VOCs and chlorinated volatile organic compounds (CVOCs) to primarily carbon dioxide (CO_2), water (H_2O) and hydrogen chloride (HCL).

Flameless thermal oxidization differs from conventional incineration and oxidation methods in that it does not rely on the coupled phenomena of mixing and combustion provided by a flame. The Thermatrix flameless oxidizer consists of a hot bed of inert ceramic material. Mixing and combustion both occur within the ceramic matrix but in separate zones [3]. By separating the mixing and oxidation processes, unreacted VOC components and products of incomplete combustion are essentially eliminated [3]. This innovative technology results in extremely low NOx formation (typically < 2 ppmv) with virtually undetectable limits of CO [1].

Flameless thermal oxidizers successfully provide destruction and removal efficiencies (DREs) exceeding 99.99 for hydrocarbons and chlorinated volatile organic compounds (CVOCs) and can operate at low flow rates with low concentration of VOCs to high flow rates with high concentrations without affecting DRE [1]. Emissions amenable to treatment include: aromatics, olefins, paraffins, alcohols, ketones, and chlorinated organic compounds.

Process Description

A Thermatrix flameless thermal oxidizer (Figure 1) is a non-flame, packed-bed oxidizer that successfully provides destruction and removal efficiencies exceeding 99.99 for both hydrocarbons and chlorinated volatile organic compounds [1]. The unique feature of the oxidizer is its use of a hot bed of inert ceramic material. Mixing and combustion both occur within the ceramic matrix but in separate zones. By separating the mixing and oxidation processes, unreacted VOC components and products of incomplete combustion are essentially eliminated [3].

In operation, the VOC process gases (and any air necessary to support the oxidation reaction) enter the oxidizer and flow into the ceramic matrix. The ceramic matrix is preheated to temperatures typically between 1600-1850°F [1]. As process gases moves through the spaces between the ceramic elements, turbulence results thorough the mixing of oxygen and organics in a mixing zone. Turbulence is important in allowing the oxidation reaction to occur; oxygen molecules need to be thoroughly mixed with the organic compounds. As the gas proceeds through the ceramic matrix, heat is transfer between the gas and the bed material. The temperature of the gas increases until the oxidation temperature of the organics is attained. At these temperatures, the pollutant molecules spontaneously disassociate and recombine with available oxygen to form carbon dioxide and water vapor. The reactant must be held at this temperature for a finite period to complete oxidation. Once the organics oxidize in the reaction zone, heat

is released. A portion of the heat released from the oxidation reaction is absorbed by the ceramic elements to maintain the temperature of the reaction zone (Figure 1). The thermal mass of the ceramic matrix also allows the oxidizer to treat waste fumes from either continuous or batch processes [2].

Since the bed is composed of chemically inert material (that is not catalytic), the oxidizer can handle a wide variety of VOCs. Organic emissions amenable to treatment include aromatics, olefins, paraffins, ketones, alcohols and chlorinated solvents [2]. If chlorinated hydrocarbons are present in the VOC stream, a scrubber to remove acid gas from the thermal oxidizer exhaust may be needed [2].

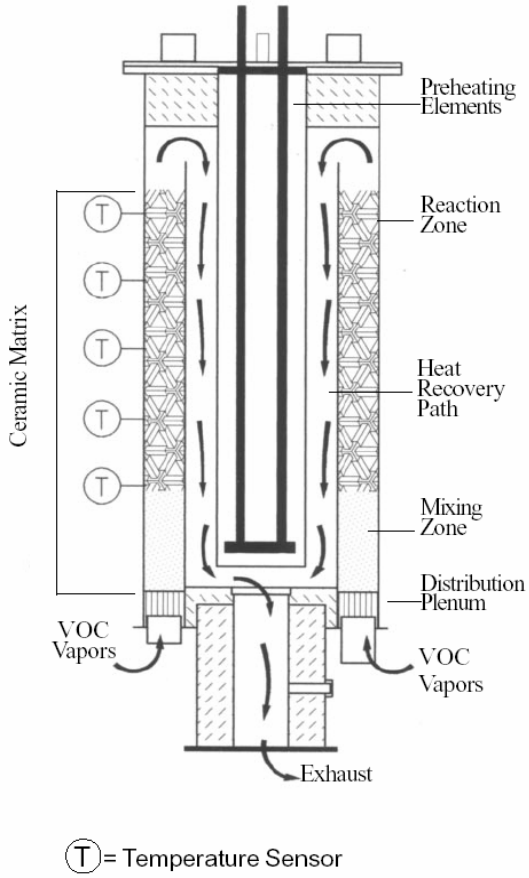

Figure 1: Thermatrix Flameless Thermal Oxidizer [2]

Literature Cited

1. "Flameless Thermal Oxidation," Innovative Technology Summary Report, prepared for the US Department of Energy, September 1995 (Historical), Tech ID 52 SCFA. http://www.em.doe.gov/plumesfa/intech/fto
2. "Thermatrix Flameless Thermal Oxidizer Technology: An Innovative Method for Treating VOC Vapors," Navy Environmental Leadership Program, NELP Fact Sheet No. 8, November 1996.
3. Thermatrix, Inc., http://www.thermatrix.com.