Custom Design Extends Operating Range Of Regenerative Thermal Oxidizer

Regenerative thermal oxidizers (RTOs) offer an energy-efficient way to burn organic emissions. When the emissions contain high amounts of combustible vapors, however, the energy efficiency becomes a handicap. The heat of combustion from the vapors will produce more heat than required, causing overheating and reduced equipment life. Some plants with emissions that vary from high to low levels of organics are often forced to use thermal oxidizers that consume more energy than an RTO.

Chesapeake Finished Metals, Elk Ridge, MD, is an operator of a coil coating facility that produces a variety of products. Depending on the product being produced, the solvent loading in the exhaust from the coil coating ovens ranges from a low of about one-percent lower explosive limit (LEL) to as high as 25-percent LEL. The flow rate is also variable, ranging from 12,000 to 46,000 standard ft^3/min.

To comply with environmental regulations while controlling energy costs, Chesapeake had to use an RTO to destroy the solvent in the oven exhaust. The RTO initially worked well, so long as solvent loadings remained below 3–5 percent. At higher loadings, however, the heat of combustion generated by the solvents was more than required to preheat the exhaust from the coil coating lines.

Temperatures in the heat transfer beds and in the combustion section frequently exceeded the design parameters of the unit. Over time, the excess temperature caused serious structural weaknesses in the unit, reduced reliability and increased maintenance cost. The poor reliability, as well as leaks caused by the structural damage, threatened to reduce the unit's efficiency at destroying solvents to below the required environmental compliance levels. The company had to replace the RTO.

When replacement equipment was evaluated, catalytic and recuperative oxidizers were considered. While thermally efficient, catalytic oxidizers are designed for a relatively narrow range of solvent types and concentrations. Because it is a jobshop, Chesapeake required an oxidizer with greater flexibility.

Chesapeake Finished Metals uses a custom RTO to destroy solvent-laden emissions efficiently for a wide range of loadings.

Recuperative oxidizers were also evaluated and were found to be sufficiently flexible to handle a wide range of solvents and solvent loadings. The company found that at low loadings the thermal efficiency (70–80 percent) of a recuperative unit caused a major increase in energy costs.

Replacing the RTO

Chesapeake evaluated and selected a custom-designed* RTO to meet its needs for both flexibility and energy efficiency. The custom unit has five heat transfer beds and is similar in appearance to a conventional regenerative unit. There is one exception: A portion of the hot gas from the RTO combustion chamber, and a portion of the solvent-laden exhaust from the coil coating ovens can be bypassed around the heat transfer beds.

When the unit operates at low solvent loadings, the bypasses remain closed. Operating at its maximum thermal efficiency (about 85 percent), the RTO requires little or no auxiliary fuel, even at solvent loadings as low as two-percent LEL. At those levels, the solvent's heat of combustion is enough to maintain the combustion chamber sufficiently hot to oxidize at least 99 percent of the incoming solvent.

When the oven exhaust contains higher solvent loadings, the temperature in the combustion chamber and the oxidizer's exhaust stack are controlled by modulating flow through the bypasses. Using proprietary control algorithms, the system bypasses a portion of the exhaust from the RTO combustion chamber based on the final stack temperature, and bypasses a portion of the exhaust from the coil coating ovens based on the temperature in the combustion chamber. With these controls, high energy efficiency is maintained, solvent oxidation is virtually complete, and the unit does not overheat.

The RTO also has two mechanical features that further reduce operating costs and improve reliability:

- The valves that direct-flow to the heat transfer beds (three per bed, 15 total) are all operated by cams mounted on a single shaft. Driven by a 1.5 hp motor, the shaft makes one complete turn for each full cycle of oxidizer. By using a simple cam rather than multiple hydraulic valve actuators, maintenance on the high-temperature valves is virtually eliminated.

*Huntington Environmental Systems, Schaumburg, IL

How the RTO Works

An RTO consists of a combustion chamber and two or more heat transfer beds filled with ceramic packing. Solvent-laden emissions from the process are directed to the combustion chamber where they are heated with an auxiliary flame and oxidized. Hot gas leaving the combustion chamber flows through one of the heat transfer beds and releases its heat to the ceramic packing. When the packing is sufficiently hot, the hot gas leaving the combustion chamber is diverted to another heat transfer bed. Solvent-laden emissions from the process are then directed through the hot regeneration chamber where they are preheated before entering the combustion chamber. This preheating reduces, and can sometimes eliminate, the need for auxiliary fuel in the combustion chamber.

Each heat transfer bed alternates between capturing the heat contained in the gas leaving the combustion chamber, and releasing the heat to the gas entering the combustion chamber. In the case where an odd number (3, 5, 7, etc.) of heat recovery chambers is used, before a heat transfer bed switches from releasing heat to capturing heat, a small amount of solvent-free exhaust gas is used to purge the contents of the bed back into the combustion chamber to prevent un-oxidized solvent from entering the exhaust stack.

- The control valves that modulate the bypasses are electrically actuated, high-performance butterfly valves.

To further increase efficiency, the RTO exhaust is used to preheat the make-up air used on the coil coating ovens. Unlike conventional RTO systems that use an induced draft (ID) fan to pull gas through the unit, this custom RTO uses forced draft (FD) fans to operate at a positive pressure. Under positive pressure, the exhaust gas can be used in a heat exchanger to preheat the make-up air entering the ovens.

Since installation in late 1995, the RTO has required virtually no maintenance, according to its owners. The energy efficiency of the RTO, plus recovery of additional heat to preheat make-up air for the ovens, has resulted in significant savings for the company. The unit is also achieving more than 99-percent destruction of solvent emissions, well within the environmental requirements. Solvent loadings are ranging from one- to 25-percent LEL, without damage to the equipment. P&SF