Regeneration game

*The use of regenerative thermal oxidizers is expanding into applications where they wouldn't have been considered years ago, says Mike Scholz**

As the first generation of oxidizer systems in the industry nears the end of their service life, many canmaking plants face repair or replacement of their existing air pollution control systems.

Like many others in the industry, a Silgan canmaking plant in the Midwest had been using a thermal recuperative oxidizer with direct heat recovery for control of emissions from its sheet coating lines. After more than a decade of service, the oxidizer needed repair so Silgan began looking for an effective, efficient solution.

Historically, thermal recuperative oxidizers with direct heat recovery have been a popular choice in canmaking facilities – especially those with oven zones operating above 350 deg F (177 deg C).

In the past, thermal recuperative oxidizers had a capital cost advantage over regenerative thermal oxidizers (RTOs) and boasted much more flexible volatile organic compounds (VOC) loading limitations. Their one drawback has always been in supplemental fuel usage. Thermal recuperative oxidizers top out at 70 percent internal heat recovery, whereas RTOs are able to achieve more than 95 percent.

For canmakers, this drawback was minimized with the use of additional heat recovery. Hot, purified air from the oxidizer is routed directly back to the oven zones and not lost to the atmosphere. This has reduced the operating cost 'penalty' of the thermal recuperative oxidizer and – in the past – has swung the balance toward specifying that system for VOC loads above ten percent lower explosive limit (LEL) almost exclusively.

So exclusively that, when hearing that Anguil Environmental Systems had recommended an RTO for its Midwest coating facility, Silgan responded almost incredulously: "They recommended what? This is clearly not an RTO application."

Given the technologies offered when Silgan made its initial selection of a thermal recuperative oxidizer, this was an understandable response. It also served as an ideal framework to study what has changed in oxidizer design over the past decade to reverse such a drastic initial response:

- Thermal recuperative oxidizers no longer have capital cost advantage
- With hot gas bypass and feed forward technology, RTOs are now specified in situations up to 25 percent LEL
- With fuel costs being unstable and still on the rise, every heat recovery percentage points counts
- New requirements for VOC capture plus destruction have marginalized direct heat recovery and increased the operating cost gap between thermal recups and RTOs.

Silgan's chose its new regenerative thermal oxidizer based on the capital cost advantage and operating cost savings

Silgan's existing thermal recuperative oxidizer was designed based on volume of airflow, organic vapor concentrations and desired destruction efficiency. During operation, VOC-laden air is drawn into the system fan and is discharged into a heat exchanger. The air is preheated through the tube side of the heat exchanger and then passes the burner, where the contaminated air is raised to the thermal oxidation temperature (1,200-1,800 deg F / 650-1,000 deg C). When the VOC-laden air is raised to the thermal oxidation temperature for the specified residence time (0.5-2.0 seconds), an exothermic reaction takes place. The VOCs in the air stream are converted to carbon dioxide and water vapor. The hot, purified air then passes on the shell side of the heat exchanger where the energy released by the reaction is used to preheat the incoming solvent laden air reducing the system's fuel consumption. Finally, the contaminant-free air is exhausted into the atmosphere.

A weakness in all thermal recuperative oxidizer designs is that the steel in the heat exchanger is exposed to high burner chamber temperatures (typically up to 1600 deg F / 871 deg C). The system at Silgan had a history of requiring ongoing maintenance in this area, which had been driving up cost and impacting throughput. The engineering team at Silgan needed to fix the aging system, replace it with an equivalent, or look for alternative equipment.

After evaluating several options, the RTO selection was based on the capital cost advantage and operating cost savings. It would be a custom-built abatement system designed specifically for this application with high loadings and concentrations. Anguil would design, manufacture and install a 40,000 scfm RTO with heat recovery, hot gas bypass and oven purge system.

Silgan's new RTO operates as follows: The solvent laden process gas enters the oxidizer through an inlet manifold. Flow control, poppet valves direct this gas into one of two energy recovery chambers where the process gas is preheated. The process gas and contaminants are progressively heated in the inlet ceramic bed as they move toward the combustion chamber.

The VOCs are oxidized in the combustion chamber, releasing thermal energy in ▸

the ceramic bed that is in the outlet flow direction from the combustion chamber. The outlet ceramic bed is heated and the gas is cooled so that the outlet gas temperature is only slightly higher than the process inlet temperature. Flow control, poppet valves routinely alternate the airflow direction into the ceramic beds to maximize energy recovery within the oxidizer. The VOC oxidation and high energy recovery within these oxidizers reduces the auxiliary fuel requirement and saves operating cost. For example, at 95 percent thermal energy recovery, the outlet temperature may be only 70 F deg F (40 F deg) higher than the inlet process gas temperature with an RTO. The oxidizer can reach self-sustaining operation with no auxiliary fuel usage at typical operating concentrations.

The process emissions at the Silgan facility as well as the temperature of the oven zones presented some challenges, as well as opportunities.

With process LEL levels as high as 14 percent there was a concern over high temperature in the RTO. A hot side bypass valve was provided to allow excess RTO reaction chamber heat to be vented directly into the exhaust or the back to the oven inlet manifold during periods when the inlet VOC loading provides more heat than is necessary to maintain the set point temperature. This primary heat recovery saves thousands of dollars in operating costs because the ovens require much less fuel to reach the desired temperature. With the Anguil design there is no loss of residence time at temperature, ensuring destruction and eliminating the concern of overheating the unit. VOC destruction efficiency is guaranteed whether the bypass is open or not.

Silgan is also investigating another energy reduction strategy by using a secondary heat exchanger to recover additional heat from the RTO exhaust stack. Initial estimates show that an extra 6.5 million btu/hr can be recovered by utilizing a heat exchanger in the oxidizer stack. Fresh air (at an average outdoor temperature of 46 deg F or 8 deg C) passes through a single pass 50 percent effective heat exchanger and is heated up to approximately 350 deg F (177 deg C). This recovered heat can be used for processes or comfort heat during the winter months, which could translate into significant savings.

The RTO is also equipped with a high temperature bake-out system, very similar to the self-cleaning option in an oven. This feature removes organic build-up on the cold face of the heat exchange media. In the bake-out mode, the RTO is taken off-line from the process. At a reduced airflow, the outlet temperature is allowed to reach an elevated temperature before the flow direction is switched. This hot air vaporizes organic particulate, essentially clearing the media bed of any obstruction. The flow direction is then switched and the opposite cold face is cleaned. Standard bake-out occurs at 650 deg F (343 deg C), stainless steel media supports and poppet valves were used on the Silgan system that allowed bake-out temperatures to reach 800 deg F (427 deg C), ensuring a more complete cleaning. Scheduled RTO bake-outs reduce the pressure drop across the heat recovery beds. Therefore, Anguil included the transmitters necessary to monitor media bed pressure drop and provide both continuous recording of this data as well as an indication to the operators when a bake-out is recommended.

Silgan's aging thermal recuperative oxidizer was replaced by Anguil Environmental Systems

Dan Gallo, Silgan's area manager of manufacturing, was pleased with the outcome. "We selected Anguil because of its technical excellence and commitment to service," he said. "Not only has the company been able to troubleshoot its own equipment, but Anguil has also provided operating solutions for oxidizers made by other manufacturers. We are pleased with their dedication to excellence and are happy to have Anguil as a business partner."

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