As thermal oxidizer technologies have been applied to a wider range of industrial applications, new challenges are continually uncovered that test their efficacy and durability.

BY JIM STONE

Selecting a control device for industrial organic gaseous emissions is an easier process today than it was when air pollution control regulations were first introduced. This is due in part to years of reliable service by a number of mature technologies. Facility owners and project consultants have a variety of options at their disposal to meet regulatory compliance with a minimal impact on everyday operations. The most widely used oxidizers employ a successful combination of residence time, conversion temperature, and turbulent mixing in the combustion chamber to eliminate gaseous emissions.

A cursory review of these technologies reveals that four main exhaust stream characteristics are key to selecting the right control device: pollutant type, pollutant concentration, airflow volume, and airflow temperature. It is vital to properly characterize, identify, and measure process conditions for the simple reason that lower airflow volumes result in a smaller oxidizer and thus lower the capital and operating cost investment. Another advantage to reduced oxidizer size is there are fewer secondary emissions from the oxidation process, meaning that less carbon monoxide, oxides of nitrogen, and carbon dioxide byproducts are produced from the conversion process. This may aid greatly in the permitting process for the control device.

Thermal and Catalytic Oxidation

All thermal oxidizers use heat to accelerate the oxidation process of combining organic pollutants with air. Thermal oxidizers use heat to break down harmful pollutants, while catalytic oxidizers use a catalyst to enhance the chemical reaction. Both methods are effective in reducing emissions, but the choice between the two depends on factors such as the nature of the pollutants and the required level of emission reduction.

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oxygen in an enclosed chamber. Temperatures in excess of 1,400 degrees F are typically sufficient to convert most organic pollutants to carbon dioxide and water vapor at a rate that is usually acceptable by permitting agencies—98 percent or better. Thermal oxidizers are typically steel enclosures that feature some sort of combustion chamber with a fuel source, most often a gas burner. The need for fuel from natural gas or some other source often dictates the use of heat recovery in some form.

Direct-fired thermal oxidizer (DFTO)

The direct fired version of the thermal oxidizer is a simple “flame in a box” that achieves volatile organic compound (VOC) conversion at a high rate. The lack of any preheat or heat recovery in these models means that the burner is sized to increase the chamber temperature from the inlet temperature to about 1,400 degrees F, which also means that these oxidizers can be copious consumers of natural gas. This consumption is mitigated by the caloric content of any incoming pollutants, so DFTOs are applicable to a wide variety of inlet VOC concentrations. Common practice generally restricts their usage to VOC-rich airstreams and air volumes of less than about 10,000 standard cubic feet per minute (SCFM). Anything outside of these parameters is typically more suitable for oxidizers with heat recovery.

Recuperative thermal oxidizer

These oxidizers differ from the direct-fired version by the use of a metal alloy heat exchanger, which transfers heat from the purified gases leaving the unit to the incoming polluted air stream. By raising the incoming process temperature, fuel consumption is reduced by a range of 50-70 percent compared to a similarly sized direct-fired oxidizer. Recuperative types are most effectively applied on airflows up to about 20,000 SCFM with higher incoming pollutant loads, and in cases where process heating can be achieved with the waste heat from the oxidizer.

Catalytic thermal oxidizers

These are similar to recuperatives, except that a catalyst bed is inserted in the unit that allows the VOC oxidation to take place at a lower combustion temperature—usually between 500 degrees F and 800 degrees F. Because of the lower temperatures involved, there are several benefits: Materials of construction are less expensive, fuel usage decreases, and there are lower amounts of secondary emissions from the combustion process such as carbon monoxide and oxides of nitrogen (NOx). What’s more, they can often be operated with electric coils as the supplemental heat source for startup and conversion temperature maintenance, eliminating the need for a gas burner.

Typical catalyst types are precious metal or base metal, and they do have a period of maximum efficacy before regeneration or even replacement is required. This window can be in the three- to four-year range, so catalyst cost needs to be figured into the life cycle equation. Finally, there are any number of halogens, metals, non-solvent resins, and other materials in exhaust streams that can contaminate and mask catalyst effectiveness, so proper application is vital.

Regenerative thermal oxidizer (RTO)

RTOs are wonderfully adaptive oxidizers. An RTO maximizes heat recovery from combustion to pre-heat incoming pollutant-laden air, which reduces auxiliary fuel consumption. These units are characterized by multiple beds of ceramic heat exchange material capped by a combustion or conversion chamber where the VOCs are oxidized. Process exhaust air is switched from one bed to another—as one bed releases heat to the exhaust stream before the burner, another one absorbs the heat in the stream after the burner, which results in very high heat recovery (up to 97 percent). These units can be used for a variety of applications with the proper design—halogen destruction, batch or continuous operation, low VOC inlet loads, high air volumes, and more. They destroy VOCs at a very high rate (99+ percent). However, RTOs can be very large and heavy. While the current generation is very reliable, they do have more moving parts than any other type of oxidizer.

Vapor combustors

These control devices are similar to flares but are enclosed so that there is no visible flame. They handle varying emission flow rates and concentrations with a very high destruction efficiency of up to 99.99 percent. Vapor combustors can be used on both intermittent and continuous airstreams and are very low-maintenance devices with no heat recovery. Their application is generally limited to airstreams with very high pollutant levels. The high emission concentrations generally supply the fuel for conversion in most standard designs.

Adsorption

Emission concentrators

Pollutant concentration level in the exhaust stream is one of the most important
factors in selecting the proper control device, but the airflow volume itself is what determines how large the unit is. Therefore, it is an advantage to reduce the total air volume that actually has to be oxidized in a combustion chamber. By using a hybrid control system that combines solvent adsorption and thermal oxidation, it is possible to reduce the combusted exhaust by up to 20 times its original volume while enriching the concentration a similar ratio to reduce fuel usage.

Typical solvent emission concentrators operate using hydrophobic zeolites embedded on a slowly rotating wheel, adsorbing the pollutant-laden exhaust air continuously. At any one time, a small portion of the wheel containing the adsorbed VOCs moves through a heated regeneration, or desorption, zone where the VOCs are stripped from the wheel and conveyed to a small thermal oxidizer for final conversion of the VOCs. Such care puts the end user and oxidizer manufacturer on the same side of the profit equation, virtually ensuring a positive outcome for both parties and avoiding costly production shutdowns or regulatory fines associated with non-compliance.

**Special Issues**

As thermal oxidizer technologies have been applied to a wider range of industrial applications, new challenges are continually uncovered that test their efficacy and durability. In the past, only the most appropriate pollutant gas streams were treated by thermal oxidation. However, the oxidizers' ability to successfully reduce emissions, coupled with new uses of solvents and other VOCs in production processes, have required that they evolve to stay relevant in the air pollution control industry.

For example, the presence of halogens in a process exhaust stream presents a number of pitfalls for standard thermal oxidizer designs. When combusted, halogen compounds will form acids that will attack and corrode carbon steel shells, heat exchangers, and internal structures of thermal oxidizers. Thus, proper selection of corrosion-resistant alloy construction materials is the first line of defense against this phenomenon. Additionally, because organic acids will then be present in the otherwise purified exhaust air leaving the oxidizer, a means of neutralizing the acid will be necessary. Wet scrubbers are typically used with great success to first quench the oxidizer exhaust, then neutralize it with a caustic substrate.

Another challenge to the modern thermal oxidizer is the presence of silicone in the incoming pollutant air stream. When oxidized, silicones will form solid byproducts that can easily foul and obstruct the passages of both metal and ceramic heat exchangers found in today's oxidizer units. While it's not typically possible to avoid the byproduct formation, special attention must be made to the heat exchanger selection to ease cleaning and maintenance and to avoid costly downtime due to catastrophic plugging of the heat exchanger that restricts airflow passage. It is also advisable to design access doors to the thermal oxidizer—especially those adjoining combustion chambers and heat exchanger matrices—with proper care to allow for frequent and effective removal of accumulated solids.

Proper characterization of the pollutant airstream is paramount to guarantee that the right design strategies are then employed in selecting and building the thermal oxidizer. Such care puts the end user and oxidizer manufacturer on the same side of the profit equation, virtually ensuring a positive outcome for both parties and avoiding costly production shutdowns or regulatory fines associated with non-compliance. **EP**

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