How to Select Air Pollution Control Systems

Emission control equipment offers varied technologies, temperatures, and costs

By Charles M. Martinson

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Air pollution control regulations require the installation of emission control systems to destroy volatile organic compounds and/or hazardous air pollutants. Failure to install such systems can mean stiff non-compliance fines. While general guidelines regarding the destruction of air pollutants in process exhaust air streams are somewhat consistent within each industry, a company's individual requirements and desires can vary greatly. Developing an optimal design for each operation depends on many variables including the type and quantity of the air pollutant and the volume and temperature of the air being exhausted. Manufacturing growth expectations and even geographical location should also be considered. By understanding the efficient designs now available and taking into consideration selection issues, companies can be better prepared to specify and select a custom designed air pollution control system.

Destruction Technologies

The basic design concept of both thermal and catalytic oxidizers is to promote a chemical reaction of the air pollutant with oxygen at elevated temperatures. This reaction destroys the pollutant in the air stream by converting it to carbon dioxide, water, and heat. The rate of reaction is controlled by three interdependent and critical factors: time, temperature, and turbulence. What distinguishes one technology from another is the temperature at which the air pollutant is destroyed and the methods used to generate the heat used in the process.

Thermal Recuperative Oxidizer

Designed to operate at temperatures of 1,400&#176F to 1,500&#176F, thermal recuperative oxidizers use a tube-in-shell stainless steel heat exchanger as an air pre-heater. Oxidation is achieved as the process exhaust is passed through the heat exchanger, mixed, and held at elevated temperatures in the combustion chamber for a minimum of 0.5 seconds. Older thermal oxidizers only achieved from 40 percent to 60 percent thermal efficiency and up to 95 percent destruction efficiency. Modern thermal oxidizers are designed for up to 80 percent thermal efficiency and 99+ percent destruction efficiency.

Regenerative Thermal Oxidizer

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To achieve destruction, the air pollutant collected from the manufacturing process is directed by the air pollution control system's supply fan into the regenerative thermal oxidizer (RTO) inlet manifold and through one of the two energy recovery canisters by use of inlet control (switching) valves. The air pollutant passes from the valve assembly vertically upward through the first of the two heat exchanger canisters, where it adsorbs heat from the ceramic media and thus cools the media and preheats the air stream. The preheated air then enters the combustion chamber &#151 typically at a temperature very close to the temperature required for thermal oxidation &#151 where it is heated further to 1,500&#176F (if necessary) and held at this oxidation temperature for a period of time (minimum 0.5 seconds) sufficient to achieve a high destruction efficiency. Destruction of the air pollutant takes place within the combustion chamber, where auxiliary fuel is introduced if necessary.

The clean (hot) air then passes from the combustion chamber vertically downward through the second energy recovery canister. Heat generated during thermal oxidation of the air pollutant is then adsorbed by the ceramic media, thus cooling the air and preheating the media. Finally, the clean (cooled) air is routed to the atmosphere through an outlet control (switching) valve, exhaust manifold, and the air pollution control system's exhaust stack. To maximize the heat exchange, switching the valves alternates the airflow path between the canisters every three to five minutes, which continuously regenerates the heat stored within the ceramic media. Older RTOs achieved from 80 percent to 90 percent thermal efficiency and up to 95 percent destruction efficiency. Modern RTOs are designed for up to 97 percent thermal efficiency and 99+ percent destruction efficiency.

Catalytic Oxidizer

Catalytic oxidizers are designed to use an industrial grade catalyst to promote a chemical reaction (oxidation) at lower temperatures as compared to thermal oxidation, typically between 500&#176F and 650&#176F. Because of the lower operating temperatures, catalytic oxidation commonly requires less energy to operate. To minimize operating costs, catalytic oxidizers incorporate a high-efficiency counter-flow plate-type heat exchanger to preheat incoming exhaust fumes from the production process. Oxidation is achieved when the fumes are passed through a bed of industrial-grade catalyst manufactured of pure platinum group metals. Older catalytic oxidizers achieved only 50 percent to 70 percent thermal efficiency and up to 95 percent destruction efficiency. Modern recuperative catalytic oxidizers are designed for up to 80 percent thermal efficiency and 99+ percent destruction efficiency.

Rotary Concentrator

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A rotary concentrator system is a hybrid air pollution control system designed to efficiently remove and destroy air pollutants from a process exhaust air stream. Application of this technology is limited to exhaust air steams at or near ambient temperature. The system requires a two-step process:

1. Removal of the air pollutant from the air stream using a hydrophobic zeolite rotating wheel.

2. Destruction of the concentrated air pollutant using an RTO.

In operation, air pollutants captured from the process via a ductwork collection system are passed through a high-efficiency filter because particulate can damage the concentrator wheel media. Once filtered, the polluted air passes through the rotating concentrator wheel, where the air pollutants are adsorbed onto the hydrophobic zeolite media. A slipstream of this air, approximately 10 percent, is routed through a cooling plenum while the remainder is routed directly to the common exhaust stack.

The rotor itself is fabricated from a corrugated mineral fiber substrate to which the manufacturer permanently bonds a proprietary mixture of hydrophobic zeolite and inorganic materials. The hydrophobic zeolite rotor is inorganic and completely inert. It has rigidity, physical integrity, and the ability to withstand thermal stress. In this application, the zeolite removes the air pollutant from the manufacturing process exhaust air stream as it passes through the rotor.

The concentrator wheel rotates at an approximate speed of two to eight revolutions per hour, continuously passing a sector of the wheel with adsorbed air pollutant through a desorbtion plenum for removal by a heated air stream, thus continuously returning a regenerated (or clean) sector back into the main housing for further adsorbtion. Desorbtion is automated as the slipstream of air that was routed through the cooling plenum is sent through a supplemental desorbtion heater, where it is elevated to desorbtion temperature and returned to the concentrator housing. This heated desorbtion air is directed back through the wheel via the desorbtion plenum, where the concentrated pollutants are removed. The highly concentrated air stream is then routed to the RTO for thermal destruction.

Secondary Recovery Units

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All modern emission control technologies incorporate the latest energy-saving design features. However, if an even greater level of efficiency is desired, secondary recovery units can be incorporated into a new air pollution control system or retrofitted to an existing system. While these energy-saving benefits are important to any company purchasing a new air pollution control system, they are absolutely vital when replacing older equipment. If a company is controlling emissions with an air pollution control system more than 8-10 years old, this less efficient equipment is costing money every single day.

Secondary recovery units capture the 250 to 1,500 degrees of heat energy (depending on the air pollution control system currently in use) that would normally be vented out the stack to the atmosphere. The unit can be designed for minimal pressure drop so that it does not affect the operation of the oxidizer while returning temperature-controlled fresh air for a variety of uses. This heated fresh air can be used for building comfort heating or process make-up air (ovens/dryers, kilns, curing zones, etc.) and, in some cases, can completely replace the need for natural gas fired burners in the manufacturing process.

Using the same idea of capturing heat from the exhaust stream, a hot water or thermal oil heat transfer coil can be installed in the air pollution control system's exhaust stack. Hot water can be used for building comfort heating or can be returned to the process for use (air preheat, condensation control, etc.) This coil could also be used as a preheat section to preheat cool water for a steam generator. Thermal oil is used as a main process heat source where direct flame heating is not desired. Adding a coil in the exhaust stream can reduce or even remove the heat load required from the thermal oil heating system. Depending on the stack temperature, the exhaust from the oxidizer could be routed directly to a low-pressure steam generator. If the plant uses steam for any reason (carbon bed regeneration, humidity control, etc.), this system could supplement steam production capacity whenever the oxidizer is running. In an ideal situation, the steam produced from the oxidizer exhaust would allow the main steam generator to function as a backup system.

Charles M. Martinson is president of the CMM Group, LLC, De Pere, WI. He has been involved in the design, fabrication, and installation of air pollution control systems for more than 20 years. The CMM Group manufactures custom-designed systems and provides emergency field service, preventive maintenance programs, engineering services, system retrofits and rebuilds, and turnkey installation. More information is available by sending an e-mail to info@thecmmgroup.com or calling 920-336-9800.