Dual-ing RTOs Work Together

by Brian J. Cannon

The Clean Air Act and more recent Maximum Achievable Control Technology (MACT) air quality standards have caused most chemical, printing, paint finishing, composites, plastics and micro-electronics operations to consider evaluation of Regenerative Thermal Oxidizers (RTOs) for attaining cost-effective VOC and air toxics compliance. Many industrial plants continue to evaluate and install energy-efficient RTO systems, which can achieve self-sustaining operation — without auxiliary gas or propane input — at very low inlet concentrations of 3 percent lower explosive limit (LEL) or greater.

RTOs also have the ability to provide existing industrial facilities with significant reductions in natural gas and electrical energy usage when used to retrofit or replace outdated catalytic oxidizers, thermal recuperative oxidizers, afterburner fume incin-erators and carbon bed/filter systems. Even with very low exhaust temperatures due to their energy efficient design, many RTOs also can provide secondary heat/energy recovery for plant process cooling and heating, giving the oxidizer a deserving reputation as a versatile, flexible and energy efficient control technology choice for VOC compliance.

RTO history and evaluation

The regenerative heat transfer concept has been used for almost a century in the glass industry, employed for heat adsorption in glass checker furnaces and kilns to preserve, store and re-use the high temperature energy from the process. RTO systems were first commercially utilized for air pollution control in the mid-1970s, primarily for VOCs. But since the early '90s, the oxidizers have been applied to many other tasks due to substantial reductions in both capital and energy costs. One such capital cost reduction was made possible by a two-chamber or dual vessel design, which substantially reduced the number of heat transfer media beds, or vessels, required. Previous RTO designs generally used an odd number of chambers to house ceramic heat transfer media. The compact footprint and smaller size of dual chamber RTOs also reduced energy usage.

Skid mounted Retox RTO for halogenated chemical VOCs.

RTO simplicity and versatility

Schematic 1 illustrates a two-chamber RTO design in which the inlet hydrocarbon-laden gasses enter the oxidizer through a forced dart fan — induced draft designs are also available for process VOCs with condensable hydrocarbons to avoid fan plugging — and are directed through a pneumatic poppet valve flow control plenum. The VOC-laden process gases are then preheated as they are directed up through the bottom of bed no. 1, which is filled with turbulent ceramic heat transfer media. When the hydrocarbons reach the top of the first bed, they then enter the oxidizer combustion chamber, where VOCs are purified at oxidation temperatures of 1500 to 1600ºF to water vapor and carbon dioxide. The hot purified gases are then directed down through bed no. 2, where they preheat the second RTO ceramic stoneware media-filled bed before exiting the second poppet valve and enter the exhaust stack.

An integral PLC control system, which also monitors RTO combustion chamber and vessel temperatures, automatically switches the RTO flow direction (usually every three to seven minutes) to allow even preheating in the ceramic beds. Most poppet valve flow control designs available today are of a zero-leakage, metal-to-metal seating design, which provides most RTOs the ability to achieve 99 percent or higher VOC destruction efficiencies required by MACT standards. As an option, many RTO designs can also offer 100-percent VOC capture modules to ensure total treatment of all process VOCs in the RTO system.

Can RTOs be used for halogenated hydrocarbons?

Absolutely! A major advantage is the ability of the ceramic media to resist acid attack by halogenated and corrosive compounds at elevated oxidation temperatures. Of course, the RTO supplier needs to be notified if halogen, sulphur, particulate or chlorinated compounds are currently in the process stream, and at what quantities or they will be in the future.

However, if the process contains halogen or chlorinated compounds, the RTO may be an excellent oxidizer selection due the corrosion resistance of the ceramic primary heat exchangers compared to stainless, special alloy metallic tubular or plate heat exchangers, which can become very capital intensive for halogenated applications.

With such foresight and planning, the RTO housing and valve mechanisms, and any exposed internal metal components, may be designed and manufactured with corrosion-resistant alloys ranging from stainless steels to high nickel alloys or even titanium. Of great importance is defining the mode of operation of the RTO in a halogenated process environment — will the RTO see 24/7 continuous operation or will it be subjected to cyclical batch operations with frequent startup and cool-down cycles, which can cause the acids to go through the dew point and condense inside the oxidizer. Moderate to highly saturated halogenated applications will also require the addition of a scrubber system to neutralize any acids in the exhaust stream, so it is important for the RTO supplier to integrate the RTO/scrubber and control systems.

Advantages of flameless RTO operation

Some dual chamber RTO oxidizer systems can also provide flameless operation without generating any harmful NOx byproducts caused by continual burner operation. Nitrogen oxides are generated at very high flame temperatures in the 2800 to 3350ºF range.

Flameless operation RTO designs using the burner only for the initial cold (or subsequent warm startups after a weekend of shutdown) have been utilized with success since 1988. This was quite an important accomplishment in the stringent

Rooftop/platform mounted Retox RTO for web offset printing.

South Coast Air Quality Management District in California, where byproducts of combustion such as NOx are measured and regulated.

Many burner-fired RTOs can produce 15 to 35 ppm or more of NOx byproducts in similar applications. Actual levels may vary according to the burner type, setup, etc. If an industrial facility does exceed its allowable limit, a de-NOx system must be added or else NOx credits must be acquired under RECLAIM rules; both of these are expensive options.

In addition to low or no NOx production, flameless RTO operations can save up to 45 percent of oxidizer natural gas consumption by directly introducing supplemental natural gas upstream of the RTO inlet. This allows the full heating value of the natural gas to be realized in the combustion process as opposed to use of burners, which require combustion air blowers that take outside ambient air to mix with the natural gas, causing larger volumes of natural gas to be consumed. RTOs that require 100 percent burner operation with continual burner/combustion air blower operation can also require an additional 10 to 15 percent usage of its fan's electrical consumption, which generated added cost.

Can RTO oxidizers operate fuel-free?

The major advantage of an RTO is its high primary heat recovery that regenerates liberated BTUs in compact ceramic chambers. These can act as a heat sink to store BTUs to preheat incoming VOC-laden gases. Most RTOs include a nominal 95 percent thermally efficient primary heat exchanger ceramic media, but some RTO designs have as little as 85 or 90 percent primary heat recovery. This lowers the system pressure drop while raising the self-sustaining fuel-free level at which the RTO operates. While it is usually not cost-effective, RTO systems can be designed with up to 97 or 98 percent primary efficiency. This lowers the fuel-free self-sustaining inlet loading levels of the system, while raising the RTO system pressure drop and fan motor KW electrical requirements to high levels.

LEL solvent levels are compared in **Table 1** for RTOs with 85, 90 and 95 percent primary heat recovery, as compared to conventional recuperative thermal oxidizers with 0, 65 and 80 percent effectiveness. Recuperative thermal oxidizers generally have a maximum primary heat recovery effectiveness of 75 to 80 percent airside effectiveness with metallic shell and tube, or plate-type heat exchangers. This in turn causes the recuperated type oxidizers to require significantly higher levels of supplemental natural gas or propane fuel to operate on today's low inlet solvent and BTU process emissions sources.

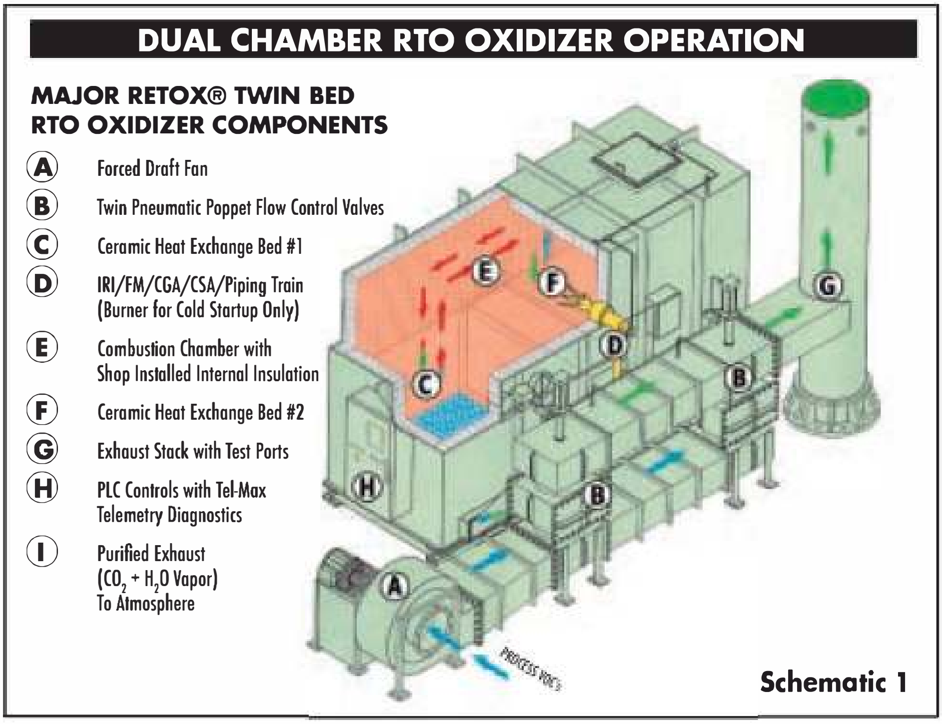
Secondary heat recovery options with energy rebates

With energy costs for natural gas, propane and electricity on the increase, many end users are seriously evaluating the addition of secondary energy recovery systems to enable them to squeeze every BTU out of their process air emissions and RTO systems. While most RTOs have high exhaust stack temperatures — typically 90 to 110°F higher than the inlet temperature to the RTO at 95 percent primary heat recovery — there are many processes such as printing, web converting, coil coating and process oven exhaust where secondary energy recovery may be very feasible. This is due to operation from 0 to 25 percent LEL inlet levels, which allow for hot gas bypass usage with the secondary heat recovery system. Popular oxidizer secondary energy recovery options include:

Comparative of Thermal Oxidizer Heat Recovery Fuel-Free Levels

Oxidizer Primary Heat Recovery Efficiency %	Thermal Oxidation & Heat Exchanger Type	Fuel Free/Self Sustaining LEL Levels
95%	Regenerative-ceramic media	3% LEL
90%	Regenerative-ceramic media	6% LEL
85%	Regenerative-ceramic media	9% LEL
80%	Recuperative-metallic HX *	12% LEL
65%	Recuperative-metallic HX *	21% LEL
0%	Afterburner without HX *	>50% LEL

Table 1 **Denotes recuperative oxidizers and afterburners requiring continuous burner low fire/pilot operation at maximum heat recovery.*



Schematic 1

- Hot water coils/modules for the RTO stack
- Adsorption chillers for plant and process cooling
- Secondary heated air for plant/process preheating
- Steam boilers or coils for plant heating
- Direct process recirculation back to ovens and dryers

Various state, regional and local utilities often offer energy incentives on both new and retrofit installation of RTOs via rebates or credits on gas, propane, electricity, etc. To illustrate how such a program could benefit industry, a California we printer recently upgraded and scrapped two older catalytic and recuperative thermal oxidizers with minimal primary heat recovery. They were replaced by one central 25,000 scfm, dual-chamber RTO, which had a customized secondary adsorption chilling system. It was powered by using the RTO stack exhaust — approximately 420ºF — to heat water used to drive the chiller system.

The turnkey adsorption energy system's project manager, Gary Ramus of Advantage Energy Group, noted that annual energy savings from the RTO was over $156,000 in natural gas and $204,500 for electricity. "In addition," he said, "the local electric and gas utilities were contacted prior to the start of the project with substantial energy incentives approved for the printer that were equivalent to the above direct energy savings."

The printer was able to realize the savings and energy incentives due to some thorough analysis of the plant's energy and air emissions control needs and upfront planning. In the process, the printer substantially lowered its plant energy bill while further reducing VOC air emissions and eliminating NOx emissions that the older incinerators generated. In addition, Ramus' company found that at any given time, investment tax and energy credits could become available from local, state and/or federal sources.

Parameters to evaluate for a successful RTO project

To assure a successful VOC and air emissions abatement project, it is very important for the plant environmental engineering staff and RTO supplier to work closely together on a VOC control project to define the current and future process operating conditions. This will help minimize current and future oxidizer energy usage and system capital cost.

It is always important to ask suppliers for RTO and abatement equipment references on similar applications.

25,000 SCPM Retox RTO with secondary adsorption chiller.

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