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Options and Incentives to Rebuild or Replace VOC Oxidation Equipment

By ICAC



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Traditionally, environmental regulations have been the primary driver for the purchase of volatile organic compound (VOC) oxidation equipment. However, new techniques, technologies, and energy concerns are leading many companies to rebuild or replace existing oxidizers for economic reasons as well. Advantages include lower energy costs, improved VOC destruction efficiencies, and reduced emissions of other pollutants (e.g. NO_x, CO₂). The installed base of thermal oxidizers more than eight years old exceeds 5000 units. This creates substantial opportunities for companies to improve the performance of their oxidizers by rebuilding or replacing this equipment.

Multiple rebuild and replacement options are available for thermal and catalytic oxidizers. For example, a thermal oxidizer with no heat exchanger could be replaced with a thermal recuperative, catalytic recuperative or regenerative thermal oxidizer (RTO). These options will provide a reduction in energy usage. Additionally, technologies available today can have much higher VOC destruction capabilities. If a complete replacement is not practical or affordable, the existing equipment could be rebuilt to improve performance. Typical projects include installing a higher efficiency heat exchanger, adding variable frequency drives, improving flow distribution, integrating secondary heat recovery, etc. Similar projects could be undertaken for older catalytic oxidizers. Additional projects include the use of a lower temperature oxidation catalyst to reduce energy usage or replacement of the burner with a more efficient unit.

RTO technology, costs, and performance have improved immensely over the past 5 years. Older RTOs can be replaced with newer, more energy efficient and less space-consuming RTO units. One way to upgrade an existing RTO is by installing a higher efficiency, lower pressure drop media, or by converting an RTO to a regenerative catalytic oxidizer (RCO) for reduced energy consumption. In addition, improved valve technology can be retrofit to an existing RTO to provide higher VOC destruction.

In addition to lower energy usage, upgrade and replacement of existing units will provide better environmental protection by lowering NO_x and green house gas emissions. Further reductions of nitrogen oxide emissions is becoming more likely in order to address PM, regional haze and their associated health effects. Reducing emissions of green house gases is also receiving more attention and is becoming a reality in several states. California and Maine have passed regulations/bills targeting CO₂ emissions and considerable discussion on this topic is underway both domestically and internationally.

Although environmental drivers required the initial installation of VOC oxidation equipment, the predominant driver is currently economics. An upgrade or replacement project should involve a financial payback analysis to determine its financial viability. Financing packages can be put together allowing for the project costs to be covered through the reduced operating costs. In some cases, cost-sharing funds are available through utilities and other agencies for upgrading/replacing energy intensive equipment with energy efficient systems.

The following table illustrates some of the options that companies have recently taken or can take to rebuild or replace their VOC oxidation equipment. The table is arranged by the following four oxidizer-type categories and is followed by specific case studies. For further information on the ICAC member companies that provide these services, access ‘Their Products and Services’ from the ICAC home page.

- Any Oxidizer Type
- Regenerative Thermal Oxidizer
- Thermal Recuperative Oxidizer
- Catalytic Recuperative Oxidizer

If You Own...	And You Desire...	You May Want To Consider...	Limitations	Case Study Provided...
<i>Any Oxidizer</i>	Improved reliability	Add PLC/Modem package for remote troubleshooting		
<i>Any Oxidizer</i>	Increased capacity	Add concentrator system upstream of oxidizer.	Temperature rating of concentrators.	
<i>Any Oxidizer</i>	Reduced operating cost	Switch from inlet vane damper on system fan to VFD for pressure/flow control.		Yes (#1)
<i>Any Oxidizer</i>	Reduced operating cost	Heat recovery: Direct heat recovery or secondary heat exchanger project.		
<i>Any Oxidizer</i>	Reduced operating cost	Airflow reduction projects: recirculation, cascading, etc.		
<i>Any Oxidizer</i>	Reduce operating cost/ Extended life of original equipment	Retrofit/Replacement of heat exchanger to increase efficiency		Yes (#2)
<i>Any Oxidizer</i>	Increased burner efficiencies/Reduced operating cost	Burner upgrade		
<i>Any Oxidizer</i>	Utilize waste heat for customer's process	Heat recovery systems		
<i>Any Oxidizer</i>	Flow optimization	Computational Flow Modeling (CFD)		Yes (#3)
<i>Any Oxidizer</i>	Higher VOC Concentrations	Add hot-side by-pass		
<i>Regenerative Thermal Oxidizer</i>	Improved Destruction	Valve retrofit		

If You Own...	And You Desire...	You May Want To Consider...	Limitations	Case Study Provided...
<i>Regenerative Thermal Oxidizer</i>	Improved reliability	Retrofit for bakeout capability	Induced draft systems will probably need whole new system fan.	Yes (#4)
<i>Regenerative Thermal Oxidizer</i>	Reduced operating cost	Change to RCO	Payback not great in the US at this time.	Yes (#5)
<i>Regenerative Thermal Oxidizer</i>	Reduced operating cost	Add a fuel injection system		Yes (#6)
<i>Regenerative Thermal Oxidizer</i>	Increased capacity and thermal efficiency while lowering electrical costs	Media upgrade/retrofit		Yes (#7)
<i>Regenerative Thermal Oxidizer</i>	Increased capacity while reducing energy costs	Oxidizer tandemization controls		
<i>Thermal Recuperative Oxidizer</i>	Reduced operating cost	Convert system to catalytic	Catalyst poisons, loading limitations	
<i>Thermal Recuperative Oxidizer</i>	Extended life of original equipment	Refurbish recuperative thermal oxidizer		Yes (#8)
<i>Catalytic Recuperative Oxidizer</i>	Improved destruction	Additional catalyst capacity	May increase pressure drop, may reduce max capacity	
<i>Catalytic Recuperative Oxidizer</i>	Reduced operating cost	Catalyst change to reduce operating temperature.		
<i>Catalytic Recuperative Oxidizer</i>	Improve catalyst life	Add guard bed or self cleaning ceramic filter		
<i>Catalytic Recuperative Oxidizer</i>	Extended life of original equipment	Catalytic oxidizer rebuild		
<i>Catalytic Recuperative Oxidizer</i>	Increased capacity while reducing energy costs	Oxidizer tandemization controls		

#1 - Switch to Variable Frequency Drive (VFD)

Problem:

If you desire reduced operating cost on any oxidizer, you may want to consider switching from an inlet vane damper on the system fan to a VFD for pressure/flow control.

Situation:

A tier 1 automotive supplier located in northern Michigan has a 12,000 scfm RTO with a main fan inlet vane setup for airflow control. The customer paints automotive components, such as door handles and mirrors, in a paint booth. Following the paint booth the components are cured in an oven. The RTO treats a portion of the exhaust from the paint booth where the VOC's are emitted.

When the equipment was initially installed, an inlet vane damper was installed instead of a VFD to reduce the overall cost. Over the past 5 years, the 120v control motor was replaced four (4) times, and caused the unit to be down numerous times throughout the years. This caused the plant to suffer from production limitations until a replacement could be purchased and installed. In addition there were the costs of maintenance personal to oversee the unit and the costs to purchase new motors.

Solution:

To improve reliability the decision was reached to replace the inlet vane damper and motor with a VFD. As part of the installation, a spool section of ductwork was installed to replace the inlet vane damper.

Result:

Following the replacement, the unit has over 2000 hours of operation with no downtime or maintenance related interaction. It has been estimated that maintenance and control motor replacement costs to keep the inlet vane operational for the past 5 years was over \$20,000, more than the cost of a VFD. In addition to the maintenance savings, the customer is realizing a small improvement in electrical usage.

#2 - Heat Exchanger Replacement for Recuperative Thermal Oxidizer (RTO)

Problem:

A midwest manufacturer of tape products including duct, industrial, hospital wrap, and automotive harness tapes uses solvent-borne silicone adhesives in their process. In order to meet regulatory requirements for volatile organic compound (VOC) emissions, exhaust from their coating/laminating lines passes through a recuperative thermal oxidizer. Clean air from the oxidizer is then used to pre-heat the make-up air for the dryers on the process lines. After many years of service, major components in the oxidizer were beginning to fail and product quality was in jeopardy.

Situation:

The oxidizer, installed in 1980, included a shell and tube style heat exchanger. The original heat exchanger was replaced once in 1988. The tubes, tube sheets, and expansion joints of this replacement were bowing and cracking, necessitating a second replacement. In addition, the presence of silicone in the exhaust stream was a complicating factor.

Silicone, when heated to high temperatures, forms a powder that deposits on the heat exchanger tubes, blocking air flow and reducing heat transfer. These deposits periodically need to be cleaned to restore performance. Any new design needed to be robust enough to resist cracking over a long period of time and also allow for easy and quick removal of any silicone deposits.

Solution:

Recommendation was given for replacing the existing heat exchanger with a new "floating tube" unit. This design allows each tube in the exchanger to expand at its own rate, virtually eliminating tube and tube sheet stresses. Clean-out doors were added to the top of the exchanger and hoppers were added to the bottom to facilitate silicone removal without entering the oxidizer. Finally, control modifications were recommended to protect the heat exchanger during heat up and cool down.

Result:

The replacement heat exchanger was installed in March 2000. Since the heat exchanger was installed, the oxidizer has been running problem free. Heat exchanger performance is "like new" and cleaning is much easier.

#3 - RTO Upgrade Using Computational Fluid Dynamic (CFD) Modeling

Problem:

A company using paint spray booth processes was having difficulties with a regenerative thermal oxidizer at a new manufacturing facility which jeopardized their manufacturing capabilities of a new product.

Situation:

Oven and spray booth exhaust from this manufacturing facility flows through a 60,000 scfm regenerative thermal oxidizer. Since its initial start-up the oxidizer was not able to meet its guaranteed performance relative to destruction of VOC's. The situation was further complicated by the bankruptcy of the original oxidizer manufacturer. The company was up against a compliance deadline and needed a solution to their problem.

Solution:

The company contacted the supplier to inspect the oxidizer and make recommendations to improve performance. Given the looming compliance deadline, advanced technologies would be required to evaluate and make changes to improve VOC destruction on this oxidizer.

By adding some instrumentation and performing a Computational Fluid Dynamics (CFD) analysis on the oxidizer, it was discovered that there was a substantial problem with flow distribution within this oxidizer. As a result, VOC's were passing through the system without being completely oxidized.

Based on this flow modeling, the supplier recommended modifications to the cold face plenums to improve flow distribution through the oxidizer.

Result:

Three days after completion of the flow modeling, the supplier was on site installing the recommended modifications. All work was completed over a weekend shutdown. As a result of the modification, VOC destruction was increased to the level required to meet the plants operating permit.

#4 - Regenerative Thermal Oxidizer (RTO) Retrofit for Bakeout Capability

Problem:

If you desire improved reliability and you own an RTO, you may want to consider a retrofit for Bakeout capability.

Situation:

A manufacturer of aluminum beverage cans in the southern US owned a RTO that processed exhaust gases from several inside bake and pin ovens. Freshly painted and coated beverage cans are continuously conveyed into ovens where the coatings are dried and cured. The VOC emissions from this drying process are ducted to the RTO where they are oxidized.

The temperature of the exhaust gas is close to the dew point of some VOC constituents. Under certain conditions condensation of the VOC emissions occurs. The build up of this material impacts the RTO operation in several ways, the condensation plugs the regenerating heat exchanger beds thereby reducing flow capacity of the RTO and it can also build up on the seats of RTO valves preventing correct closure and even prevent the valves from opening. The material has a very high BTU content and under certain conditions can provide fuel for uncontrollable fires. At this particular site an uncontrolled fire virtually destroyed the RTO.

Solution:

To reduce the impact of the condensation build up the RTO can be retrofitted to include bakeout capability. There are many ways to bakeout a RTO. In this instance an auxiliary inlet burner system was added. During the off-line bakeout this burner slowly increases the temperature of the inlet air, after sufficient time and temperature all of the organic material is oxidized and inorganic ash remains.

Result:

Following this retrofit, the plant now schedules regular off-line bakeouts thereby reducing condensation build up, increasing reliability and virtually eliminating the risk of catastrophic fire damage.

#5 - Replace Regenerative Thermal Oxidizer (RTO) with Regenerative Catalytic Oxidizer (RCO) to Reduce Operating Cost

Problem:

If you desire reduced operating cost and you own a RTO you may want to consider changing to a RCO.

Situation:

An Oriented Strand Board (OSB) manufacturer processing northern species wood owned an RTO that processed the exhaust from their press vent. During the manufacturing process, the previously oriented stands are glued together through a multiple opening press with steam heated platens. The press emissions occur when the press closes under high pressure and the glue and resin bonds with the strands forming the finished board. Once the press is open the VOC emissions from the cured glues and resins are released and treated by the RTO.

In the pressing operations the exhaust flow rates are high, typically over 100,000 scfm and the VOC emissions are relatively low, less than 100 lb/hr. With this high flow, low concentration exhaust stream even an RTO has high operating costs.

Solution:

To reduce the auxiliary fuel and electrical requirements necessary to destroy the pollutants a retrofit to a RCO was performed. This entailed the addition of a precious metal catalyst on top of the heat exchange media that was already present in the RTO. The addition of the catalyst on top of the heat exchange media required a shutdown of less than 24 hours.

Result:

Following the conversion to an RCO, the unit was restarted and the performance was monitored and analyzed. The VOC removal rate was not affected by the addition of the catalyst. Because of the lower operating temperature of the RCO, 800 °F compared to 1550 °F of the RTO, the fuel and electrical usage were reduced by approximately 45 percent and 12 percent respectively.

#6 - Add a Fuel Injection System

Problem:

If you are an RTO owner and wish to reduce operating cost you may want to consider adding a fuel injection system.

Situation:

An Oriented Strand Board (OSB) manufacture located in the North Central region of the U.S. processing primarily hemlock and other northern species of relatively “soft” woods owned an RTO system that processed the emissions from multiple rotary drum dryers. In the dryer, wood strands or wafers are dried with a large volume of direct-fired hot air. The product is also conveyed through the dryer with this air. Dryer air is heated by a burner fueled with both natural gas and sawdust. In the drying process, VOC’s such as pinenes and turpenes are released along with large volumes of water. The total volume of air utilized for dryer heating and conveying is sent to the RTO for oxidation. With relatively low VOC concentrations, supplementary fuel, (natural gas or propane in the winter), and electrical costs to operate large fans is a primary concern. An additional concern is the formation of NOx from the combustion of natural gas and propane at high temperatures in the RTO.

Solution:

To reduce the natural gas and electrical consumption of the RTO, a supplemental fuel injection system was added. This system consists of a sparger pipe located in the inlet air duct, a modulating gas control valve and a supplemental valve shut off train. In operation, after the RTO has been pre-heated to operating temperature and operating on-line with the process, the burners and combustion air blowers in the RTO combustion chamber are shut off. The natural gas required to maintain combustion temperature is then injected into the inlet air stream via the sparger pipe. The maximum volume of gas injection is limited to less than 25 percent of the Lower Explosive Limit (LEL) by sparger pipe sizing and flow control orifice plates. The direct injection of natural gas into the air stream results in lower overall fuel consumption because the cold outside air (combustion air) for the burners is no longer required. Electrical consumption is reduced because the volume of air handled by the fan is now lower (no supplemental combustion air) and the air temperature is also lower. NOx emissions from the RTO are also dramatically reduced because the combustion of the injected natural gas takes place at a temperature below the temperature required to produce combustion created NOx.

Result:

The addition of natural gas injection in this application lowered the natural gas consumption by approximately 30 percent with electrical cost savings of roughly 10 percent. The annual electrical and natural gas cost savings for this owner is averaging \$150,000 per year.

#7 - Media Upgrade for RTO

Problem:

When a Californian manufacturer of protective window films and optical films for commercial and industrial applications grew beyond its production capability, they had no choice but to upgrade the capacity of the existing regenerative thermal oxidizer (RTO).

Situation:

Exhaust from the company's production lines flowed through a seven-year-old 40,000 scfm RTO with a design thermal efficiency of 80 percent. The goal of this project was to increase the capacity of the oxidizer to 43,000 scfm while raising the thermal efficiency to 93 percent so that throughput capacity could be increased. Although the airflow capacity of the oxidizer needed to increase, the company did not want to increase the physical size of the oxidizer. In addition, the company wanted to reduce their energy consumption at the same time due to the energy-related problems recently experienced in California.

Solution:

Given these challenges, advanced technologies would be required to simultaneously reduce gas consumption and increase capacity. Industrial vacuum trucks were brought in to expedite the removal of the existing packed ceramic heat exchange media. Once the random heat exchange media was removed, the media support grid was modified to permit the installation of a structured type of ceramic media.

The timing for designing and completing the project was very tight as the upgrade was to begin within three weeks of receiving the order and needed to be completed in a three day weekend. In addition, the upgrades could have no detrimental impact on the performance of the oxidizer in terms of VOC destruction.

Result:

The company was able to expand the capacity of the existing equipment to improve production throughput while simultaneously reducing operating costs and maintaining the required VOC destruction rate efficiency.

The result was that gas consumption was reduced by 60 percent decreasing their operating costs, providing a payback on fuel savings of less than one year. The thermal efficiency of the oxidizer was increased from 80 percent to 93 percent and the pressure drop across the oxidizer was reduced. This permitted the capacity to be increased by 10 percent to 43,000 scfm, improving production throughput. In addition, independent stack testing results performed before and after the upgrade showed that the VOC destruction efficiency actually improved.

#8 - Extend Useful Life of a Regenerative Thermal Oxidizer (RTO)

Problem:

If you desire to extend the useful life of your recuperative thermal oxidizer and or improve the current thermal and destruction efficiencies you might want to consider refurbishing the oxidizer.

Situation:

A tier 1 seat supplier to one of the “big three” auto companies called an RTO supplier to perform an inspection and test the efficiency of their existing 12 year old recuperative oxidizer after the thermal efficiency had significantly dropped from it’s design point, and odor complaints had been received.

An inspection was performed and the VOC testing was completed to determine what was causing the decreased thermal efficiency and increased odor. The outcome of the inspection and testing revealed that the primary heat exchanger tubes had broken away from the end plate, bypassing VOCs and heat directly to the oxidizer outlet. This had drastically decreased the thermal efficiency and destruction efficiency of the unit.

Solution:

The oxidizer was taken apart and the end plate removed and replaced and sleeves were installed inside of the broken tubes and welded to the end plate. The oxidizer was put back together and started up.

Result:

Upon completion of the repair work, the destruction and thermal efficiencies were increased to acceptable levels for a fraction of the cost of a new oxidizer while extending the life of the existing recuperative oxidizer.