The automotive, marine, machinery, road and agricultural heavy equipment, and other industry segments use wet painting methods. Whether they are solvent-based or water-based paints, both may require air pollution control equipment.

Reduce paint VOC emissions' costs with concentrators

Compress emissions, compress costs

By Jeff Kudronowicz and Kevin Summm

It is estimated that 60 percent of the global demand for architectural paints, coatings, and finishes is for water-based, or waterborne, formulas. In the U.S., use of the more environmentally friendly waterborne paint is even higher—between 80 and 85 percent. However, solvent-based paint still is used predominantly for product finishes on automobiles, machinery, and appliances for which a smooth surface finish or durability is crucial. Other special-purpose coatings, such as maintenance, traffic, and marine paints, still are manufactured with solvents as well.

Water-based paints are made to be less toxic by limiting the use of solvents, which are oil-based chemicals that emit volatile organic compounds (VOCs) and hazardous air pollutants (HAPs) during the application and drying processes. These known carcinogens also contribute to smog and ozone when released directly to the atmosphere. However, it is important to note that even water-based paints contain some solvents.

Manufacturers considering substituting water-based paints for solvent-based paints to avoid the need to use air pollution control equipment should consult their local regulatory authorities before making the switch. Depending on the facility's location (nonattainment or attainment area) and the potential emissions, manufacturers still could be required to install emission control equipment even if they are using water-based coatings.

Capture and Destroy

Using the proper abatement technology in paint, coating, and finishing applications can actually lower your cost of environmental compliance for airborne contaminants. Takeaways from emission treatment technologies and tactics used in paint booths can be applied to industrial coaters, curing ovens, and finishing lines as well.

Typical emission control projects focus on two primary areas: the capture mechanism and a destruction device. The overall efficiency of an emission control system is a function of both the removal and destruction efficiency of each device in the system.

Over the last 20 years, Environmental Protection Agency (EPA) regulations under the Clean Air Act have driven capture efficiencies toward 100 percent, which prevent emissions from ever entering the atmosphere. Properly designed hoods and enclosures protect employees and the community at large from potentially harmful exposure to fugitive emissions from paint overspray. However, increasing the capture efficiency increases the work load of destruction devices and could negatively affect the destruction capability.

Paint Booth Airflow

Whether you are painting large airplanes and trains or smaller vehicles, such as automobiles, paint booths generally require a large amount of airflow (see **lead image**). Even when recirculation is maximized within the paint booth, large operations can exhaust fumes in the tens of thousands of standard cubic feet per minute (SCFM). These emissions often are very low in concentration, partially because of the intermittent nature of painting operations but also because overspray is somewhat diluted. Most painting processes emit only about 50 to 200 parts per million (PPM), which is fairly low compared to other emission control applications.

Because of the low concentrations of emissions coming from paint booths, a regenerative thermal oxidizer has been the preferred technology to capture and destroy painting process emissions for many years. It is generally considered to be the most energy-efficient oxidizer technology because of its ability to capture heat from the purified exhaust air and preheat incoming, untreated airflow.

The oxidation process is an exothermic reaction in which heat and energy are released. If there is enough fuel value in the emissions, a regenerative thermal oxidizer will operate in a thermally self-sustaining way. This means that no additional fuel input is needed to generate the required treatment temperatures. This not only reduces the natural gas consumption and operating costs, but also reduces the subsequent greenhouse gas (GHG) emissions from the combustion device.

Even though regenerative thermal oxidizers are extremely efficient, they rely on a steady stream of emissions from the process to fuel combustion of incoming contaminants. The large airflow volumes and low concentrations that paint booths emit can result in a substantial need for supplemental fuel, generally in the form of natural gas.

> A concentrator can take exhaust streams at ambient temperatures and concentrate them so that the airflow sent to the oxidizer is reduced by a factor of eight to 20.

That corresponds to higher levels of carbon dioxide (CO_2) and nitrous oxides (NOX) emissions, creating secondary air pollution from the actual abatement device.

With carbon legislation looming, manufacturers should be very concerned with the GHG emissions generated by some pollution control systems, which could actually *add* to the cost of regulatory compliance.

Concentrators Reduce Airflow

Concentrator technology was originally designed as a dehumidification technology but has quickly evolved into an energy-saving add-on to thermal and catalytic oxidizers. As an air pollution control device, a concentrator can take exhaust streams at or near ambient temperatures and concentrate them so that the airflow actually sent to the oxidizer is reduced by a factor of eight to 20 (see **Figure 1**). This greatly reduced flow is typically rich in emissions and much less of an operating cost burden on the oxidizer system; in fact, it generally facilitates self-sustaining, fuel-free destruction.

How It Works. In operation, the high-volume, low-concentration airstream passes through a rotor concentrator wheel where the emissions are stripped from it and adsorbed onto the wheel (see **Figure 2**). The majority (about 90 percent of the total air volume) of this clean air can then be exhausted into

Figure 1

A concentrator can take exhaust streams at or near ambient temperatures and concentrate them so that the airflow actually sent to the oxidizer is reduced by a factor of eight to 20.

the atmosphere. The balance of the airstream (about 10 percent of the total air volume) is heated to an elevated temperature to be used as desorption air.

The concentrator wheel rotates continuously, transporting adsorbed VOCs and HAPs into a desorption section. In the desorption section, the organics are desorbed from the adsorptive media with the low-volume, heated airstream. This highly concentrated laden air is then processed by an oxidizer.

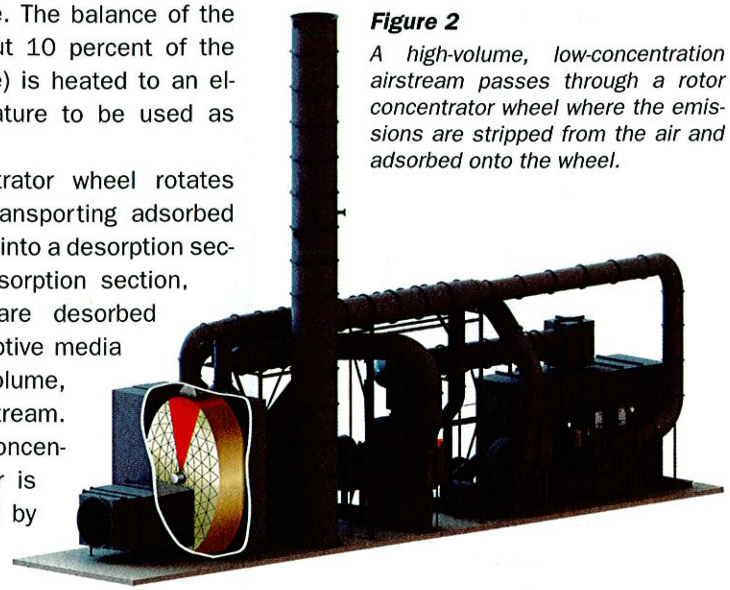

Figure 2

A high-volume, low-concentration airstream passes through a rotor concentrator wheel where the emissions are stripped from the air and adsorbed onto the wheel.

Specifying Oxidizers. Oxidizers are sized and specified for a given project based on the maximum amount of airflow being sent to the device. Reducing the air volume sent to an oxidizer can save manufacturers significant operating and capital equipment costs.

For example, 50,000 SCFM of paint booth exhaust can be routed through a concentrator system that will concentrate emissions into about 5,000 SCFM of contaminated air. Rather than using a large oxidizer to handle all 50,000 SCFM, an oxidizer for only the 5,000 SCFM is needed. The concentration in this 5,000-SCFM stream will be approximately 10 times higher than in the booth exhaust. Because the oxidation of these VOCs and HAPs releases heat that is needed in the oxidizer, much less supplemental fuel is consumed.

Operating a 50,000-SCFM regenerative thermal oxidizer under low loading conditions would result in high natural gas usage, larger operating costs, and significant release of GHGs. The concentrator system allows for much smaller oxidation equipment to control the same emissions.

So why doesn't every paint booth use a concentrator with a regenerative thermal oxidizer? Unfortunately, the concentrator technology is limited to 95 to 97.5 percent destruction rate efficiency, and most air permits are written around 97 to 99 percent destruction rate efficiencies. While the regenerative thermal oxidizer is capable of destruction efficiencies over 99 percent, the wheel within the concentrator has limitations.

Manufacturers interested in attaining the efficiency savings of a concentrator but whose permit requires higher destruction rate efficiencies than it can provide still have options. Most U.S. regulatory agencies will allow for a variance if the manufacturer can show the lower carbon footprint of the treatment device. They may be able to show this by running some simple calculations.

A comparison of the capital and operating costs of each design can indicate the relative cost per ton of additional control efficiency. This may dictate which destruction efficiencies would be acceptable by regulatory personnel, especially if a small decrease in VOC and HAP destruction would result in a large reduction of GHG emissions.

Using an example to compare the technology choices, assume a booth exhaust of 50,000 SCFM containing 50 PPM of VOCs and HAPs. If this is routed to either technology, the following capital and operational costs would result, where the regenerative thermal oxidizer cost is identified by an index of 100. This assumes continuous operation to arrive at the annual CO_2 emissions (see **Figure 3**).

A regenerative thermal oxidizer with a concentrator can operate with very little additional natural gas consumption. At higher concentration values, it even has sufficient "free energy" to provide the adsorption energy for the concentrator. A regenerative thermal oxidizer alone provides a slightly higher destruction rate efficiency, but the operating costs and carbon footprint are much greater.

If a relative value can be placed on each type of emission, such as a dollar cost per ton of emissions, then the appropriate control technology can be quickly determined by most regulatory agencies.

Concentrator technology provides for a unique way to significantly reduce the gas consumption and GHG emissions from a paint booth abatement device. However, this benefit comes somewhat at the expense of overall VOC and HAP removal rates. The tradeoff between VOC emissions and GHG emissions needs to be weighed to determine the most appropriate design basis.

Concentrator technology cannot be applied to all industrial process emissions. This technology has temperature limits of exhaust gases cooler than 100 F, with VOCs or HAPs that can be readily adsorbed and desorbed.

Each application must be considered carefully before the manufacturer uses this technology.

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Abatement Device	Control Efficiency (%)	Capital Cost (index)	Fuel Usage (million BTU/hr.)	Operational Cost ($7/million BTU/hr.)	CO_2 Emissions (Tons/ Year)	Uncontrolled VOCs & HAPs (Tons/Year)
Regenerative Thermal Oxidizer (RTO)	98-99+	100	3.8	$235,000	2,500	1.8-3.6
Concentrator/ RTO	95	100	0.5	$35,000	850	9
Concentrators/ RTO	97.50	115	0.9	$55,000	1,050	4.5

Figure 3

A regenerative thermal oxidizer with a concentrator can operate with very little additional natural gas consumption.