CLEARING THE AIR

The Use of Bio-Oxidation for Industrial Air Emissions Control

by Jim Boswell

The wood products industry began a rather arduous road to emissions control in the early 1990s with the first installation of a thermal oxidizer (an RTO) at a California MDF facility, for volatile organic compound (VOC) control. During the ensuing years virtually every panel board facility has had to control emissions of VOCs, and up until the last few years, always with some sort of thermal oxidizer—RTO, or a catalytic oxidizer.

The amount of natural gas that has been burned for VOC control during this time is conservatively in the billions of therms, possibly trillions. That's enough natural gas to heat hundreds of thousands of households during that period of time, not to mention the cost to the panel board industry for that natural gas.

Background

Interestingly, biofilters also were first applied to the US wood panel board industry in the early to mid-1990s. Three conventional bark and wood chip biofilters were installed on an oriented strand board press in the Midwest, a wet process hardboard mill in Michigan and in a particleboard mill in Georgia. All were and are relatively successful applications and continue in operation today. In Europe, several biofilter applications were applied to the panel wood industry in the late 1990s with modest success.

The primary issue with these 'conventional bark and wood chip' systems is that the beds must be replaced frequently, usually every 18 to 24 months because of channeling and compaction issues that cause operational problems, either loss of removal efficiency (channeling) or decrease in airflow (compaction). Biofilter system applications did not parallel the thermal oxidizer applications because of the generally mandated 90+% destruction efficiency (Dre) requirement specified in the first consent decrees associated with the US Environmental Protection Agency's regulatory pursuit of the wood products industry.

Emissions of VOCs from presses could have been controlled by biofiltration, but generally not at the Dre that was mandated, and the dryer exhausts were and are too hot to be treated in a biological system without adding significant amounts of dilution air. So, for roughly 12 years there was little or no progress on biofilter applications in the panel board industry because of the rather draconian requirement for 90+% Dre of the emissions stream. During that time period over 150 (estimated from conversations with thermal oxidizer suppliers) thermal oxidizers were installed in the industry at a capital cost of hundreds of millions of dollars and with ongoing natural gas costs of millions of dollars annually.

Current Status

With the promulgation of the Plywood and Composite Wood Product (PCWP) MACT rule there was a greater interest in utilizing biofilters, bioscrubbers, biotrickling filters, or simply some type of bio-oxidation system to provide emissions control for these largely water soluble HAP compounds. Historically, the three existing applications were already in operation and they achieved a more-than-adequate Dre for those constituents, specifically noted by existing data on formaldehyde and methanol removal. In addition, with the price of natural gas increasing through the late 1990s and into the new century an alternative to thermal oxidizers was being sought.

There were and still are two primary issues to be confronted when using biofilter systems. First, there is the issue of overall VOC/THC removal when compared to thermal oxidizers—bio-oxidation systems generally being less effective. Second, the exhaust gases from most wood dryers are simply too hot for processing in a bio-oxidation system. The organisms would literally be unable to grow or killed outright by the excessive heat.

Only press emissions or ideal press and dryer combined emissions could be reasonably treated in a biological air pollution control system without having to greatly oversize the unit with dilution air or adding heat exchangers, both driving up the capital costs so as to make them unacceptable. Many companies, already with thermal oxidizers on their dryers, carefully evaluated the capital costs of the two technologies and decided that bio-systems were the preferred choice for control of the press emissions and achieving compliance with the MACT standard.

Two companies, PPC and BioReaction Industries, supplied the PCWP industry with the majority of the biofilter units, approximately 20, while Tri-Mer installed three for MACT compliance. These units were brought on line in 2008 and most are in operation at this time (plant shut downs and operational curtailments have idled a few). All readily achieve compliance (or should) with the MACT regulation with substantial operating cost savings and huge reductions in green house gas (GHG) emissions when compared to thermal oxidizers.

As an example, a 120,000 acfm biofilter unit, at two-thirds the capital cost (compared to a similar RTO), will save the owner over $900,000 annually in natural gas costs required to fire the thermal system. Electricity costs are also less because of the temperature and volume difference in the air stream that is drawn through the two units. An operating cost evaluation and a GHG comparison are provided nearby.

Bio-oxidation systems work by providing an environment for bacteria and fungi to grow and proliferate into massive biofilm and water-borne cultures that utilize the gas phase hydrocarbons (and organic particulate) as food for metabolism and growth. These systems work best at warm temperatures, 80°F to 100°F (27°C to 37°C), and relative humidity of 98 to 100 percent.

These systems are particularly suited for emission streams with relatively low concentrations of contaminates in high volumes of air. Systems rely on a humidification chamber to temper and saturate the airstream with moisture, a fixed substrate to support the biofilm and often a sump for added treatment and recirculation of water for redistribution of nutrients and organisms across all areas of the bio-oxidation system. These systems are also here for the long term, typically lasting 20 or more years with periodic maintenance and eventual bed replacement required.

Water soluble compounds, like the alcohol, methanol and the aldehyde, formaldehyde are readily absorbed into the water contained within the system (spray, sump and surface film). Therefore, these hydrophilic compounds are readily available at the microbial surface where they are assimilated and broken down for energy, maintenance and growth, producing carbon dioxide and water vapor.

Hydrophobic compounds can also be treated effectively in a bio-oxidation system; however these compounds, such as pinenes, are not readily *ab*sorbed but may be *ad*sorbed or collected on the surface of the microbial biomass for decomposition and absorption of constituents.

Generally, systems that are to treat air emissions with predominantly water soluble constituents can be smaller (shorter air mass retention time in the unit) than bio-oxidation systems treating air emission streams containing predominantly hydrophobic compounds. Retention times vary according to the constituents and the concentrations of compounds to be treated.

Systems must be sized to provide adequate time for decomposition of compounds and also be large enough to accommodate the growth that will occur with the specific hourly load of organic materials (e.g. food).

For a primarily water soluble constituent air emissions stream (HAP control) the system would need to have a relatively short retention time and be sized for the air volume to be treated. A similar airflow application, but designed to treat pinenes to 75 percent Dre, would need a much longer retention time to degrade those terpenes, and therefore need to be almost twice the volume for the 120,000 acfm airflow.

Temperature is also a factor in getting the highest removal for hydrophobic compounds like terpenes, and a system would need to operate in the 85°F to 100°F (29.5°C - 37°C) range to do best. Systems biodegrading water soluble compounds like formaldehyde and methanol can operate at temperatures around 65°F (18°C) and above, and achieve >90% destruction efficiency.

Since these are what are termed mesophilic biological systems, the biomass of bacteria and fungi that they contain can biodegrade VOC and HAP compounds throughout a wide temperature range. The rate of VOC and HAP biodegradation increases geometrically as the temperature increases up to approximately 110°F (43°C).

Conclusion

With the added emphasis on greenhouse gas emission reductions, the increasingly significant role that NOx is calculated to play in ground level ozone formation, and the cost and supply issues with natural gas and fuels in general, it seems that bio-oxidation systems are destined to play a much larger role in air emissions control in the future. Just this past year a bio-oxidation system was judged best available control technology for control of VOC emissions from a panel board press.

This precedent-setting pronouncement provides the impetus for industry to propose using bio-oxidation systems where appropriate to supplant conventional thermal oxidizers throughout the US.

Replacing a conventional RTO with a bio-oxidation system will reduce greenhouse gas emissions by 5,000 to 6,000 tons per year (CO2 reduction), save thousands of cubic feet of natural gas annually to heat homes and businesses, and reduce NOx emissions by as much as 45 tons annually. The energy savings to individual companies can also be very significant, potentially leading to reduced consumer costs for products.

Bio-oxidation systems do not fit every application but can supply an alternative control mechanism for a significant number of new and existing air emissions sources.

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