METAL Finishing

Biofiltration for Abatement of VOC and HAP Emissions

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INTRODUCTION

Organic solvent emissions result in a variety of challenges for both formulators and applicators of paint and coatings. Workers and nearby residents can also be affected by health threats and unwanted odors from these industries. In addition, regulatory requirements affect product formulations, application methods, and even set production limits. Great progress has been made through pollution prevention efforts and incorporating new products and processes that emit less solvent. However, more cost-effective methods, such as biofiltration, are needed to control solvent emissions.

Basics

So, what is a biofilter? "Filter" suggests a physical mesh that removes particles from the air, but is misleading [1]. Biofiltration is actually an air treatment process based on concepts that are literally as old as dirt. Nature has provided bacteria and fungi that are capable of using almost any organic material as a food source. These microbes are plentiful in organic soils and decaying vegetable matter. Biofilters are a controlled environment where the organic solvents and odor compounds are brought in contact with the natural microorganisms that can use them as a food source. The end products of this degradation are carbon dioxide and water vapor. The concept, then, is to pass the contaminated airstream through garden mulch where the microbes will capture and eat the solvents and odors. (See Figure 1 in the printed version)

Traditional biofilters have successfully used these principles for decades, with more widespread use in Europe than the United States [2]. They have typically been very large, single-layer units that rely on a loose bed of organic media to control conditions for treatment. There have been significant limitations in handling high or variable concentrations of solvents, and the large footprints, some the size of football fields, have made them impractical for many developed industrial locations.

Engineered biofilters use a variety of advances to increase their efficiency of treatment and reduce their size from something like a parking lot to a parking space. First, the contaminated airstream is conditioned to maintain temperature and humidity levels ideal for the metabolism of the microbes. Second, the compost or organic media that supports the microbes is structured to increase the effective surface area and allow multiple layers. In brief, it is an engineered ecosystem where the microorganisms think they are in Miami on Spring Break with the buffet always open and consisting of the organic solvents and odors. As shown in Figure 2 (in the printed version), the contaminated airstream is conditioned through water contact in the biotrickling filter, followed by full treatment through the layers of the compost biofilter.

Competing Technologies and Costs

Painting processes typically result in a high volume airstream with a relatively low concentration of solvents. These air emissions can be extremely expensive to treat with incineration technologies because of the amount of natural gas required to maintain combustion temperatures. Thermal technologies also produce significant secondary contaminants like nitrogen oxides and greenhouse gases, as do the regenerative processes for activated carbon treatment systems. Biofilters, on the other hand, utilize the biological energy of the microbes to destroy the VOCs without creating secondary pollutants. The energy costs for engineered biofiltration are typically one-fourth to one-tenth the energy costs of thermal oxidation technologies. Additionally, the capital cost of biofilter systems are typically two-thirds to three-fourths that of competing technologies.

So, does this mean a biofilter is the answer for treating every source of organic emissions? No. There are some weaknesses. If the source has a very strong solvent content, economics would suggest adding a small amount of additional fuel and capturing the energy through an internal combustion engine or thermal oxidizer with heat recovery. If the source contains chlorinated solvents, metals, or strong biocides, the microbes may be stressed or killed, and a few organic chemicals simply are not easily biodegraded.

Also, since biofilters are a living biological system, it is harder to achieve certain removal efficiencies for regulatory compliance than for mechanical processes where you can simply turn a knob. The regulatory approach in the United States has pushed toward Best Available Control Technology (BACT), which tends to require a high level of treatment for the target pollutant with only limited consideration of the cost, in either money or environmental impacts. Engineered biofilters are currently achieving consistent removal efficiencies from 80 to greater than 95 percent, but this is less than the standards required in some regulations, permits, and jurisdictions. The result is that local permit requirements also may dictate what types of controls for organic emissions are acceptable.

Consequently, industrial biofilters are entering the market for situations with a little more regulatory flexibility. For example, paint manufacturers that are subject to the proposed USEPA Miscellaneous Organics NESHAP (MON MACT) must achieve 75 percent reduction in emissions. In the Los Angeles area, the SCAQMD Rule 1132 requires facilities with paint booths that emit more than 20 tons of VOC per year to reduce overall emissions by at least 65 percent in the next 2 years. A variety of sources may avoid additional permitting requirements or be able to expand their production capacity by implementing voluntary controls. Biofiltration is an energy-efficient technology for VOC control that can meet the demand of these and many other situations. Also, regulatory agencies are becoming more receptive to biofiltration, and are beginning to recognize the benefits of pollution avoidance and energy savings.

Case Studies

Bio·Reaction Industries has developed a modular vapor-phase biofilter that is capable of treating both high concentrations of VOCs in low air volumes as well as higher airflows with typical VOC concentration of 2,000 ppm or less. Successful pilot studies and projects are in process for a variety of waste streams, including odors at sewage treatment and rendering facilities, gasoline vapors at petroleum remediation sites, methanol and formaldehyde at a wood products facility, and isopropanol at an integrated circuit manufacturing facility. Applications for the paint and coatings industry, discussed below, include: paint manufacturing facilities, paint booths, on-site recycling of aerosols cans, and solvent-laden solids such as rags, paint waste & still bottoms.

Paint Manufacturing Facility

A prominent paint formulator in Eugene, Oregon has been a development partner with Bio·Reaction Industries to pilot this technology for applications in paint manufacturing. This also enabled the manufacturer to be proactive in reducing facility emissions and odors prior to finalization of the MON MACT regulations. A pilot system started in December 2000 achieved greater than 60 percent removal [3], but the solvent concentrations were significantly higher than the system was designed for. In September 2001 the pilot was replaced with a modular unit currently treating 7500 cubic feet per minute with average VOC loadings of 200 to 1500 ppm. The system is consistently achieving more than 90 percent reduction in hazardous air pollutant (HAP) emissions, as shown in Figure 3 (in the printed version).

In fact, the facility is currently subject to Title V permitting due to HAP emissions of Toluene. 2002 will be their second year with toluene emissions below the Title V threshold. The local air authority is looking favorably at granting them synthetic minor status based on their enforceable commitment to continue voluntary treatment. This would let them drop out of Title V before the promulgation of the MON MACT, and no longer be subject to the requirements of either Title V or MACT, with significant savings in permitting and compliance costs. Additionally, a 25,000 cfm biofiltration system is being installed this winter at another paint manufacturing facility in California.

Industrial Paint Booths

A 10,000cfm biofilter was placed on one paint spray booth at a Tualatin, Oregon coater of metal and plastic components for the electronics and computer industry. Coatings with relatively high concentrations of VOCs are often necessary for this industry because of the "cosmetic" high quality that is required. This biofilter system, pictured in Figure 4(in the printed version), maintained greater than 80 percent removal of VOCs.

A major manufacturer of cabinets in California has purchased a system to allow increases in production at their current facility. Present permit limits for their coating operation effectively cap production for the entire facility. By voluntarily treating emissions, they will be able to increase production within the limits of their existing permit. This system will be operation in early 2003.

Aerosol Can Recycling

Partially used aerosol cans, when disposed of, are treated as a hazardous waste to prevent the release of these solvents into landfills. If an aerosol can is punctured to release the propellant pressure and drain the residual liquid contents into a receiving drum, it can then be recycled as scrap metal. Propellant gases and hazardous VOCs are released when the puncturing operation is performed, creating both an environmental problem and a potential health hazard for the workers in the facility. At the Portland Metro Household Hazardous Waste Facility (HHW), a BRI biofilter, over a three-year period, was used to capture off-gases from puncturing over 93,000 aerosol cans, resulting in a disposal cost savings of over $114,000. In this operation, the biofilter had a payback period of slightly less than one year.[4]

Solvent-Laden Waste Remediation

In many industrial processes, non-hazardous solid materials are contaminated with hazardous solvents and are thus classified as a hazardous waste. Examples include rags used in cleaning operations and paint sludges and wastes. Some jurisdictions allow these solids to be treated to drive off the volatile solvents, and the remaining dried solids may no longer be hazardous. A biofilter has been used, in conjunction with an attached drying chamber, for this process at a specialty coating company. Over a three month period 1111 pounds of potentially hazardous waste was dried to produce 804 pounds of dry solid waste, with the biofilter treating 307 pounds of lacquer thinner for a significant reduction in disposal costs.[5]

Conclusion

Biofiltration is a cost-effective and sustainable technology for VOC and odor control that holds significant promise for improved air quality for facilities involved in paint and coatings. Biofilters provide effective destruction of air pollutants with low energy demand and little secondary pollutant generation. Applications of this technology are increasing through a wider range of industries and an expanding list of airborne organics.

References:

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