Control Air Quality with Effective Smoke Collection

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FILTRATION SOLUTIONS

WET MACHINING

Wet Machining: Control Air Quality with Effective Smoke Collection

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Wet machining processes can create mist droplets and "liquid smoke" that need to be collected for environmental, health, and safety reasons. Liquid smoke is the byproduct of wet machining that is the most difficult to capture because of its submicron particle size. This article will examine liquid smoke and methods of mist collection as a means of controlling air quality in the metalworking industry.

Smoke Defined

Smoke is typically thought of as the dark cloud coming off a burnt match, a roaring campfire, or melting metal. The smoke generated in wet machining is very different. For the purposes of this article, smoke is defined as a liquid droplet condensing from a vapor to a liquid state, ranging from 0.07 to 1.0 microns in size; a thermally generated mist; or an oily smoke.

This liquid smoke is generated by processes that heat and/or compress liquids under high pressure generating a vapor that may condense back into a cloud. Liquid smoke is typically found in metalworking applications such as cold heading, machining hard metal alloys with straight oil coolants, lube oil reservoirs on large generators, heat treating, and/or plastic forming.

Capturing Smoke

To properly capture liquid smoke, you need to understand the fundamental difference between smoke and mist. Mists are comprised of liquid droplets generally up to 20 microns in size. (For context, a human hair is about 40 microns in diameter.) Mists are created with oil-based and water-soluble lubricants or coolants. The more heat and/or pressure applied to these coolants from either the delivery head or the machining process, the smaller the mist droplets generated. If enough heat or pressure is applied to the coolant, the droplets that are generated can be so small that a liquid smoke can be created. At an average size of 0.7 microns, liquid smoke is almost 30 times smaller than an average mist droplet. As one might imagine, capturing this extremely small droplet requires a very efficient mist collector.

While liquid smoke can be captured, it is generally better to start by limiting the amount of smoke generated in your process. The first way to limit the amount of smoke in a process is to cool the process. As mentioned earlier, liquid smoke is often created by heat, so if the process is cooled prior to the mist collector, the smoke has a chance to condense back into a liquid. This can be accomplished by drawing cooler air into the process airstream. It is recommended the air be cooled to less than 105°F at least 15 feet prior to the collector. This ensures smoke is not condensing after the mist collector, which might otherwise give the appearance of poor efficiency.

Slowing the velocity of air in a system of ducts also may allow smoke to condense more fully prior to reaching the collectors. Velocities of 2,500 feet per minute often allow sufficient time for more complete condensation. Slowing the duct velocity any further can be challenging, as reducing the velocity too much can allow mists to collect and "pool" in the duct. A general practice is to always allow a slight slope in the ducts to help minimize mist pooling (½" incline of duct toward the collector is recommended).

If smoke is still exiting a collector even after the above modifications are in place, a focused effort on final filtration may be the best strategy. Consider the amount of smoke being emitted to determine your strategy. If the amount of smoke generated is considerable, a multi-stage mist collector may offer the best option. However, for lighter amounts of smoke, a typical strategy is to simply provide an after-filter following the primary filter.

After-Filters

Two types of after-filters are commonly used in wet machining applications: HEPA or 95% DOP filters. HEPA filters, by definition, offer 99.97% efficiency on materials 0.3 microns in size. A drawback to using a HEPA filter is its limited filtration holding capacity. A 95% DOP filter can achieve five times the life of a HEPA filter, however, it offers only 95% efficiency on 0.3-micron materials.

Experience has shown that 95% DOP filters are often acceptable, as most oily smokes average 0.7 microns. A 95% DOP filter may be 98% to 99% efficient at 0.7 microns. This level of efficiency may allow air quality from a mist collector to achieve federal, state, or local standards. Finally, a 95% DOP filter typically costs about the same as a HEPA filter despite its typically longer life. These attributes explain the distinct advantages of 95% DOP filters and why they have gained favor over the past several years.

If a wet machining process generates a significant amount of smoke, effectively capturing and removing the smoke prior to the after-filters becomes the best option for economic operation. To capture the smoke prior to an after-filter, one must understand the efficiencies of common mist collection equipment in the industry.

Mist Collectors

A common form of mist collection equipment is the centrifugal mist collector. Centrifugal mist collectors are generally small, relatively inexpensive, and often require minimal filter replacement. Many centrifugal mist collectors can even be fitted with an after-filter.

A typical centrifugal collector can offer roughly 98% efficiency on 1-micron materials. This efficiency decreases as the size of the materials decrease. Since the average size of oily smoke is 0.7 microns, the efficiency of a centrifugal collector may not meet the standards, and an after-filter would be considered a necessity. An additional downfall of centrifugal collectors is their limited airflow capacity. A typical centrifugal collector is limited to an airflow capacity of 1,000 CFM or less.

Figure 1: Donaldson Torit WSO Mist Collector capturing smoke.

Media filters are a new and more popular form of mist filtration (Figure 1) for finer mists. Media filter collectors typically consist of aluminum mesh screens for large heavy mists, followed by a series of polyester-based panels or cartridges. When a process generates a significant amount of smoke, a media filter can offer higher levels of filtration, and higher airflows than centrifugal collectors. As an example, a cross-flow fiber filter allows dirty air to flow in horizontally through the walls of the filter and enables collected mist to drain down the filter. This option can offer a filtration efficiency of 99.3% at 1.2-micron material with airflows up to 1,000 cfm @ 4" of external static pressure. These performance levels are difficult and expensive for centrifugal collectors to achieve. This collector design increases filter life and limits maintenance cost.

Conclusion

In summary, capturing liquid smoke can be very challenging. Yet, with an understanding of the process by which the smoke is generated, a filtration solution will generally be within reach. Maintaining proper duct velocity, sloping ducts, and lowering temperatures in the duct all help address the problem of filtering liquid smoke. And finally, an after-filter should be considered when dealing with this difficult material.

Choosing the proper filtration equipment for your wet machining process should offer you low operating cost for the system while helping clear the problem material from your airstream.

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