Metalworking operations using water-soluble and oil-based metalworking fluids produce mist particles that should be contained or captured.

Chemtool

Mitigating Mist

There are several good ways to design and install a mist collection system. Choosing the right design depends on a shop's size and needs.

By Daniel Rousseau, Donaldson Co.

For more than 50 years, metalworking companies have been installing mist collectors on their machine tools to help provide clean air for their workers, reduce the adverse effects of exposure to metalworking fluids, comply with indoor air quality standards, reduce maintenance costs and improve part quality. Today, shops have several options when choosing mist collectors. This article examines why mist from metalworking fluids is a problem, the goals of mist collection and the types of collectors that shops can install.

What are Mist and Smoke?

While definitions vary, for the purposes of this article, mist is defined as a liquid particle 20µm or smaller, focusing primarily on applications that use oil-based and water-soluble lubricants, coolants and detergents. These applications include—but are not limited to—metalcutting, metalforming, grinding and part washing. For example, milling and turning operations using water-soluble metalworking fluids produce mist particles that range from 2µm to 20µm. The same operations using oil-based fluids produce mist particles that range from 0.5µm to 10µm.

Smoke is defined as a liquid particle that condenses from a vapor to a liquid and is typically 0.07µm to 1µm. It can also be described as thermally generated mist or oily smoke.

Smoke is generated by a process that heats up or compresses a liquid under high pressure and generates a vapor that condenses back to a liquid and forms what looks to be a cloud. Common applications that generate liquid smoke are cold heading, machining hard metals with straight oil, using lube oil reservoirs on large generators and heat treating.

Metalworking applications typically generate five different variations: mist, mist with "liquid" smoke, mist with "dry" smoke, mist with vapor and mist with dust.

Mist Problems

Numerous studies have shown that repeated exposure to mist and smoke from metalworking fluids through dermal contact, oral ingestion and inhalation is possibly carcinogenic. Other studies have proven these materials to be irritants to the eyes, nose and throat.

Government agencies and organizations such as the Occupational Safety and Health Administration, American National Standards Institute and American Conference of Governmental Industrial Hygienists have studied and developed recommendations and laws governing the maximum exposure to airborne concentrations (mist) of various oils,

greases and lubricants.

OSHA standards are enforceable by law. The OSHA standard for airborne concentration of metalworking fluids is less than 5.0 mg/m^3 of air over an 8-hour period. Since the late 1990s, organizations have petitioned OSHA to lower its 8-hour exposure standard for metalworking fluids to 1.0 mg/m^3, 0.5 mg/m^3 and 0.2 mg/m^3. Some companies have implemented their own more stringent requirements—down to 0.1 mg/m^3 of air over an 8-hour period.

Goals of Mist Collection

The objectives of mist collection are to prevent mist from becoming airborne, prevent workers from breathing mist-laden air and to eliminate or prevent haze. Mist collection experts agree that these goals can be best achieved by containing the mist within a metal or plexiglass machine tool enclosure and only capturing the lightest and smallest mist particles generated inside that enclosure that otherwise would drift out of the machine tool enclosure.

If this is done well, the finest and lightest mist particles that cause indoor air pollution are filtered out of the air by the mist collector. When mist collection is not done well, the following may occur:

1. Mist escapes through the machine tool access doors, chip conveyors and other openings in the machine tool.
2. Too much mist is pulled into the mist collector, limiting proper cooling and lubrication.
3. The mist collector is collecting so much mist that it cannot filter it fast enough, requiring frequent filter changes.

To avoid these problems, shops installing mist collectors must determine needed airflow for the application. There are several methods for determining airflow needs, which are discussed in detail in a technical reference guide published by Donaldson Co. (see Editor's Note on page 95 for information on obtaining a copy of the guide).

Other important considerations include sizing the unit based on airflow and combining mist sources from different fluids, which are discussed in the guide.

Types of Collectors

Once a shop has determined airflow needs and other considerations, it can choose among several mist collection alternatives.

- Machine-mounted mist collector.
- Single mist collector ducted to one machine (single ducted).
- Single mist collector for a machining center cell—typically three to four machining centers (cellular system).
- Central mist collector for up to 20 machining centers (central system).
- Ambient mist filtration.

Machine-mounted systems. This collector is the most popular and in many cases the most practical solution

(Figure 1). The top-mounted collector may be open on the bottom and directly connected to the machining center or connected by a short piece of flex hose or ducting.

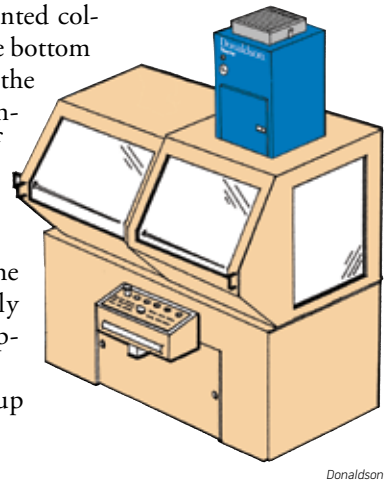

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Figure 1: Mist collector mounts on top of a machining center.

Advantages

- Flexibility to move the machining center easily when manufacturing operations change.
- Ability to power up the collector only when the machining center is on. (Donaldson Co. recommends using a machine tool interlock with each machine for maximum energy savings and longest filter life.)
- Oil/coolant is returned to the machining center.
- No floor space required.
- Simple maintenance routines.
- Only one machine is without mist collection during any significant mist collector maintenance.

Disadvantages

- Each machine requires a motor starter.
- On collectors with a bottom inlet, the drain is typically not designed for continuous operations.
- Low ceilings, overhead cranes and electrical conduits may interfere with operation.
- Multiple machines require multiple collectors.
- High energy usage.

Ducted single machining center systems. A single mist collector for a single machine where the mist collector is mounted on the floor, hung from the ceiling or mounted to a beam is the second most common mist collector installation (Figure 2). It is typically used:

- when machine-mounting is not an option due to the size or weight of the mist collector,
- where top access to the machining center is required, and
- where tolerances are so critical that motor vibration from the collector may affect part quality.

These systems are typically mounted no more than 10' from the machining center and have minimal ducting.

Advantages

- Flexibility to easily move machining center when operations change.
- The collector is turned on only when machining center is on. (Donaldson Co. recommends a machine tool interlock with each machine.)

- Simple maintenance.
- Only one machine is without mist collection during mist collector maintenance.

Disadvantages

- Each machine requires a motor starter.
- Ducting must be installed properly to minimize leaks.
- Multiple machines require multiple collectors.
- High energy usage.

Ducted cellular systems. These systems use a single mist collector for a machining cell with two to four machining centers (Figure 3). Parts manufactured in a machining cell may move between machines or the same part may be manufactured in each machine. The machines typically use the same oil or coolant. In these instances, installing one mist collector for the machining cell may be more practical than using individual mist collectors.

Advantages

- Mist collector only operates when machining cell is operating. (Machine tool interlocks are recommended.)
- Energy usage is minimized by using fewer collectors and fewer fans to operate.
- Maintenance needs to be performed on only one mist collector, not multiple units, reducing maintenance time and filter and disposal costs.
- Collected mist can be easily returned to the coolant filtration system of one machine or the central coolant filtration system.
- When the machining cell is modified or no longer necessary, the mist collector can be moved elsewhere.

Disadvantages

- Ducting must be installed properly to minimize chance of leaks.
- Balancing the airflow between all machines so each machine has enough airflow requires expertise.

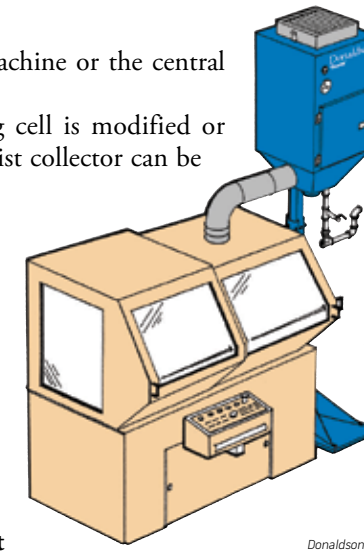

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Figure 2: Mist collector is connected by ducting to a single machining center.

Ducted central mist collection systems. These systems use a single mist collector ducted to up to 20 machine tools. These large systems were popular in the past, but are no longer common due to the disadvantages noted below.

Advantages

- Lowest-cost mist collector solution (one collector for many machines).
- Single fan and single motor starter quickens installation.
- Maintenance staff has to schedule filter changes on only

one unit.

Disadvantages

- Unit's fan is either on or off. This wastes energy for facilities that don't run all machines at once.
- Requires large amount of floor space.
- Installation cost may be higher due to more ducting and larger duct diameters.
- Ducting must be selected and installed properly to minimize chance of leaks.
- Duct diameter for main run is larger and can require extra floor space.
- Larger duct runs may require additional static pressure to work well, minimizing a central system's energy benefit.
- If shop is using more than one metalworking fluid, the collected mist cannot be reused, resulting in higher disposal costs.
- When the mist collector is down or maintenance is required, all or a large portion of the plant's mist collection system will be down.
- Balancing airflow between all machines is difficult.

Ambient mist filtration. This system is designed to remove mist from general plant air without being connected to the mist source. Ambient systems are infrequently used as a primary mist filtration system, but are used in cases where source capture cannot be done effectively or done at all. Ambient mist filtration is occasionally used as a secondary system

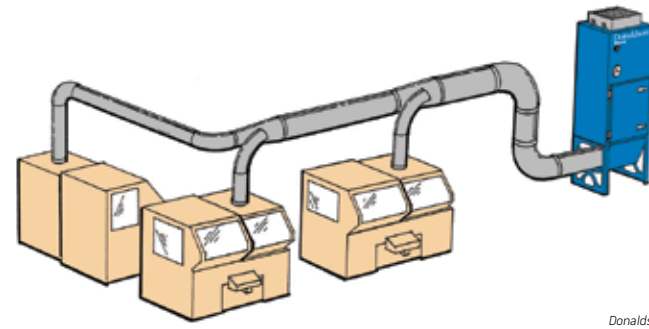

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Figure 3: A single mist collector supports several machining centers.

to provide exceptional air quality.

Advantages

- Can be used when there are several machines that have no enclosures or when 100 percent mist containment and capture cannot be achieved.
- Used after source capture units are installed on all machines to provide a high degree of air cleanliness.

Disadvantages

- Ambient systems have a maximum system efficiency of 70 percent (average efficiency during normal operations is 50 percent), which may not be efficient enough to meet local, state, federal or union requirements.
- Ambient systems require that specific airflow patterns

be managed for the entire plant—from ambient mist filtration systems, HVAC, personal fans and any other air moving device. If the airflow patterns don't work together or if the facility opens doors and windows to bring in fresh air, system efficiencies typically fall to less than 50 percent.

- To be captured by a system, mist must rise into the plant's airflow pattern. This means workers are still exposed to a high concentration of mist at the generation source.
- Airflow patterns from ambient units can stain building walls when mist is entrained in the discharge air.

There are five steps that can maximize the effectiveness of an ambient mist collection system installation.

1. What is the volume of the room that to be filtered? Measure the room's height, width and length to calculate the volume of air to be filtered and use this equation:

Total air volume of room = length × width × height

2. Is the volume of mist in the air light, medium or heavy? If the mist is light, allow 20 minutes per air exchange; if it is medium, 15 minutes; if it is heavy, 10 minutes.

3. Calculate the airflow required for the ambient system, dividing the volume of air to be filtered by the minutes per air change:

$$\text{Total cfm} = \frac{\text{Total air volume of room}}{\text{Minutes per air change}}$$

For example, consider a shop area 200'×100'×20' with medium-volume mist. The following equation calculates the amount of airflow required:

$$\text{Total cfm} = \frac{200' \times 100' \times 20'.}{\text{15 minutes per air change}} = 26{,}667 \text{ cfm}$$

4. Determine the type of mist collector to be used and the nominal airflow for that unit. Manufacturers of ambient air filtration systems can provide this information. To determine how many mist collectors will be required, divide the total airflow from the previous equation by the nominal airflow of the selected mist collectors as shown:

$$\text{No. of mist collectors} = \frac{\text{Total cfm}}{\text{cfm per mist collector}}$$

For example, it is common for a media/V-bag-style mist collector to operate at 3,000 cfm per collector. The number of collectors needed is determined by the following equation:

$$\text{No. of mist collectors} = \frac{26{,}667 \text{ cfm}}{3{,}000 \text{ cfm}} = 8.9 \text{ mist collectors}$$

Because you can't install and operate part of a mist collector, nine mist collectors, each operating at 3,000 cfm, are required to properly filter the mist in this example.

5. Lay out how the collectors will fit into the room so that the airflow pattern captures the mist. For maximum capture efficiency, position the mist collectors to develop an oval airflow pattern by pushing air from the exhaust of one unit to

the inlet of another. To create the oval airflow pattern:

- the distance from one unit's exhaust to the inlet of the next should be no less than 50' and no more than 100',
- the side-to-side distance between units should be no greater than 50',
- never place the exhaust of a mist collector closer than 20' from any corner, and
- the typical distance between the side of a unit to the wall is 10' to 20'.

In one example, calculations called for nine 3,000-cfm mist collectors, but when it came to locating the mist collectors, 10 were required to complete the airflow pattern. In this example, a figure eight airflow pattern was developed. If the manufacturer of the ambient systems offers 6,000-cfm mist collectors, two of these collectors could substitute for the four 3,000-cfm mist collectors in the middle of the figure eight. Lastly, the units that blow air directly towards the walls should use louvers to turn the exhaust so air is "bounced" off the walls towards the inlet of the next collector.

With the right information, a shop can purchase the right mist collector for its operation, knowing that the design will work well and provide years of useful service. Suppliers of mist collection systems can provide the guidelines a shop needs to choose the right system and work with the shop to build an optimal solution. CTE

Editor's Note: This article is adapted from "Mist Collection of Metalworking Fluids," a technical reference guide published by Donaldson Co. The full text includes sections on how shops can determine their mist collection needs, types of collector installations, how to install mist collectors, and selecting the right mist filter media and collector configurations. It is available from Donaldson by request. Send requests by e-mail to donaldsontorit@donaldson.com.

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