Optimizing your dust collection system for process variables

Travis Haynam  |  Parker Hannifin Corp.

Making sense of the variables that impact dust collection system performance can be a challenging task. This article describes how some of the most common process variables can influence dust collection system performance and explains how to optimize the system design or operating parameters for your application.

Approaching a dust collection application generally involves gathering detailed information regarding the dust to be collected, the operating parameters, and the system design requirements. Variables such as contaminant particle size, dust load, operational duty cycle, and airstream conditions influence the system’s overall performance and must be accounted for to ensure effective dust collection.

The four fundamental design elements for a dust collection system are the hood, duct, dust collector, and air mover, as shown in Figure 1.

- Hoods are located at points in the manufacturing process where contaminant dust is generated and must be configured to adequately capture airborne dust and prevent the dust from escaping into the workspace.

- Ducts transport the captured dust from the hoods to the dust collector and must be designed to maintain adequate air velocity, temperature, and moisture levels to prevent the material from settling or building up in the ductwork.

- The dust collector separates the dust from the airstream typically using bag or cartridge filters and collects the dust for disposal or recycling back into the process depending on the application. The dust collector type, size, and configuration — including the filter media — must be selected to suit the material being collected and the process.

- The air mover establishes a vacuum in the system and must generate adequate airflow to transport the dust from its source to the dust collector.

Overlooking any of these fundamental design elements or incorrectly adapting components to your application can hinder your dust collection system’s performance. Optimizing your system for your material and process, however, can decrease emissions, extend filter life, reduce operating costs, and increase reliability.

Design considerations for common application variables

To optimize your dust collection system’s performance you must properly evaluate your dust’s characteristics and your application’s specific variables. The following sections discuss common application variables and how to address them when designing a dust collection system. To ensure that your system meets performance expectations, however, it’s important to consult a dust collection professional, who can accurately evaluate your specific process and determine the optimal design, configuration, and operating parameters for your application.

Material loading conditions. Material loading refers to the concentration of dust in the air and is typically expressed as mass per volume in units such as grains/ft³.

Figure 1
or mg/m³. Moderate loading for a cartridge dust collector is typically between 1 and 2 grains/ft³. For loading conditions that exceed this amount, you should consider the following:

• Increase the capture velocity at the hoods. Increasing the air velocity at the hoods will ensure that the system captures a high percentage of the airborne dust and prevents dust from escaping into the workspace.

• Use a more conservative air-to-media ratio when sizing the dust collector. Heavy material loading accelerates the rate at which dust accumulates on the filter media and increases the pressure drop (resistance to airflow) across the filters. Increased pressure drop reduces airflow and filter life. Lowering the air-to-media ratio provides more filter surface area to offset the increased dust load and allows the collector’s pulse-jet cleaning system to work more effectively.

• Use downtime cleaning. Downtime cleaning means that the pulse-jet cleaning system operates even when the dust collection system is not in use. This provides additional cleaning cycles that enable the filters to recover more effectively from a heavy dust load and maintain optimal pressure drop and design airflow.

• Consider installing a prefiltration device such as a cyclone (also called a centrifugal separator) or an air-distribution module. These devices reduce the dust concentration in the airstream passing through the filter media and allow the dust collector to operate more effectively. With a cyclone, as shown in Figure 2a, the dust collection airstream enters through a tangential inlet and loses velocity due to friction against the cyclone wall. This causes larger, high-mass dust particles to drop out of the airstream and fall into a collection hopper, while smaller, lighter dust particles remain in the airstream and continue on to the dust collector. An air-distribution module, as shown in Figure 2b, reduces particle momentum by expanding and changing the direction of the dust collection airstream, which causes some of the dust to drop out and reduces the amount of dust that reaches the filter media.

**Particle size distribution.** Particle size distribution is a mathematical representation of the size range and proportion of a material’s particles. This is typically presented by showing the mass of particles in each size range as a percentage of the total but can also be based on the particle count in each size range as a percentage of the total. Knowing your dust’s particle size distribution is essential for selecting filter media technology that’s capable of filtering the full particle size range and optimizing dust collection system performance. Based on your dust’s particle size distribution, you should consider the following:

• When collecting dust with a broad particle size distribution, use a cyclone collector, abrasive inlet, air distribution module, or drop-out box to separate larger, heavier particles from fines before the airstream reaches the dust collector filters.

![Figure 2](Examples of dust collection solutions for heavy loading conditions)

a. Cyclone prefilter

b. Air distribution module
• When collecting larger particles such as wood chips or stringy or curly contaminants, use cartridge filters with wide spacing between the pleats. This will allow the particles to release from the filter media more effectively during pulse-jet cleaning and reduce the chance of particles becoming lodged between the filter pleats.

• When collecting submicron dust particles (less than 1 micron), use filter media that’s capable of capturing particles in this difficult size range. Minimum efficiency rating value (MERV) is a useful tool to help ensure proper filter selection. The relationship between particle size distribution for many common dust contaminants and the filtration efficiency of different MERV ratings is shown in Figure 3.

• When collecting submicron dust particles, use a lower air-to-media ratio to ensure adequate airflow and filter cleaning. Conversely, when collecting dust with larger particles (greater than 5 microns), you can use a higher air-to-media ratio while still maintaining optimal pressure drop and filter performance.

Bulk density. Bulk density is the mass per unit volume of the collected dust. This is used to calculate the airstream velocity required to capture the dust at the hoods and transport the dust through the ducts. Dusts with higher bulk densities can also be abrasive to filter media, which can shorten filter life and reduce collection efficiency. Consider the following:

• Consult an expert or reference material for the proven capture and transport velocities for given applications, hood types, and dust characteristics. Industrial Ventilation: A Manual of Recommended Practice for Design published by the American Council of Governmental Industrial Hygienists (www.acgih.org) is a good source for this information as are regulatory agencies such as OSHA (www.osha.gov) or the National Fire Protection Association (www.nfpa.org). If you can’t find your specific process or contaminant, identify a material with a similar bulk density to use as a reference.

• For abrasive applications, configure the dust collector with a mechanical separator such as an expansion chamber (also called an extended dirty-air inlet plenum) or an abrasive inlet. An expansion chamber, as shown in Figure 4a, is a large open chamber just upstream from the dust collector filters. As the dust collection airstream enters the chamber, the expanded volume slows the velocity of the dust particles, reducing abrasion to the filter media. With an abrasive inlet, as shown in Figure 4b, the airstream velocity impacts a metal plate below the inlet, which slows the airstream velocity and reduces abrasion.
**Airstream moisture.** Moisture entering the dust collection airstream through the process, the dust, or the ambient air can pose significant challenges for a dust collection system. Cooling of the airstream can cause moisture vapor in the air to condense and form liquid droplets. These liquid droplets can react with the dust, making it agglomerative or corrosive, which can negatively impact certain filter media types. If moisture is present in your dust collection airstream or dust, consider the following design parameters:

- To reduce the potential for condensation, maintain a 50°F spread between the airstream’s dry bulb and wet bulb temperatures. Use worst-case ambient temperature and humidity conditions when making your calculations.

- Consider using a moisture-resistant, synthetic-based filter media such as spunbond polyester. For added filtration efficiency and improved filter cleaning properties, consider using filters that include an expanded polytetrafluoroethylene (ePTFE) membrane.

- For outdoor systems, insulate the dust collection system ducts and possibly the dust collector itself to prevent the airstream temperature from dropping below the dew point and causing condensation.

- A high-moisture airstream will be denser than a standard airstream, which must be corrected for when making the system airflow calculations. This is especially important for selecting the air mover because most published fan performance information is based on standard air conditions.

**Airstream temperature.** When collecting dust generated by high-temperature processes or materials, the resulting dust collection airstream temperature will also be increased. A high-temperature airstream has different physical properties than a standard-temperature airstream and may require different construction materials for the hoods, ducts, dust collector, and filters. If your process produces elevated temperatures, consider the following:

- Decrease the recommended air-to-media ratio by 10 to 20 percent. As temperature increases some filter media can soften or open up, which can allow more dust to pass through the media and lead to increased emissions. A lower air-to-media ratio will help to offset this effect.

- Ensure that the entire filter construction is suitable for high-temperature operation, including the filter media, gaskets, and any sealing compounds that may be used.

- As a general rule, if the airstream temperature is greater than 100°F, you should correct the airflow calculations to account for the reduced air density. These calculations include the capture velocity, transport velocity, and air-to-media ratio. Making the necessary adjustments will help ensure that the air mover will perform adequately under the dust collection system’s actual operating conditions.

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**For further reading**

Find more information on dust collection systems in articles listed under “Dust collection and dust control” in *Powder and Bulk Engineering*’s article index in the December 2017 issue or the Article Archive on *PBE*’s website, www.powderbulk.com. (All articles listed in the archive are available for free download to registered users.)

Travis Haynam is product manager at Parker Hannifin Corp. (travis.haynam@parker.com). He holds a BS in mechanical engineering and an MBA, both from the University of Cincinnati in Cincinnati, OH.

Parker Hannifin Corp.
Cleveland, OH
800-272-7537
www.parker.com

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