Any operational strategies are available to limit a dust collector’s operating costs to an expected design level. This design level is determined by providing a target gas (typically air) volumetric rate against a system resistance that includes an allowable differential pressure range across the filtration media. These strategies include having properly configured equipment and components for the application and using some form of fan control. To reduce operating costs to an optimal range lower than the design operating values, you must ensure the appropriate fan control devices are in place and used properly.

Here are some strategies that can help you limit your dust collector’s operating costs to match your design level or reduce those costs when the filter media condition (differential pressure) is lower than the level specified as part of the fan specification.

**Calculating system losses**

A typical dust collection system incorporates filter media to separate the captured dust from the gas stream. When calculating the loss across the system, as shown in Figure 1, the static pressure losses (SP in inches water gauge) through the ductwork and equipment components at a design flow rate and known gas density are first determined. Then, a design “allocation” representing the allowable differential pressure for the dirty media condition (DP in inches water gauge) plus tubesheet loss is added to the “ductwork” loss to determine the required static pressure to overcome the losses in the system at the target air flows.

The result of the calculation of system loss is shown as point $O$ in Figure 1; the system loss is typically expressed as system static pressure to correlate with how fan static pressure performance is typically reported.

Once the losses across the system have been calculated, a fan can be selected for the application to provide a fan static pressure output to match the required system static pressure at the design flow and gas density (blue curve passing through point $O$ in Figure 1). Providing a flowrate at a specific resistance requires energy input from the motor. This input or demand is referred to as brake horsepower (BHP); for the example system, point $e$ on the BHP curve for the fan at the operating speed and gas density represents the required energy.

When the filter media is “clean,” the fan will move to the right on the fan curve toward point $M$ to provide higher rate of airflow, thereby increasing the energy draw of the fan motor (point $E$, maximum possible at the current configuration). Higher gas flow through the filter media can impact the performance of the filter media and the energy required to pulse-clean dust from the filter media, as well as cause a host of system performance issues. Therefore, controlling the system’s airflow to the design operating level is essential to optimum system performance and energy demand.

**Fan control and achievable energy savings**

All three forms of fan control — an outlet damper, an inlet damper, and speed control using a variable-frequency drive (VFD) — will limit a dust collection system’s airflow rate to design levels. However, reducing the fan energy demand at reduced fan static pressure conditions (low filter media differential pressure conditions) requires specific forms of fan control.

An outlet damper changes the static pressure loss in the system; the amount of additional system resistance depends on the position of the damper (percent closed). Using an outlet damper to control system airflow makes up the difference between the actual differential pressure across the filter media and the allowable range at a given system airflow level (or design allocation when operating at the design system airflow level). This has been shown in Figure 2. Moving the outlet damper toward the closed position moves the operating point on the fan static pressure curve from point $M$ toward point $O$ and the energy demand from point $E$ to point $e$. Therefore, you won’t realize energy savings beyond the design level at the
Proper fan control also involves using the appropriate reference signal for adjusting the fan performance to maintain the system design flow. For all three forms of fan control, a static pressure level at any point in the system corresponding to a balanced duct network is an appropriate reference signal. However, using an amperage reading on a fan motor as a reference signal is only appropriate with an outlet damper, since the other forms of fan control change the static pressure output of the fan, thereby leading to a lower energy demand at reduced static pressure requirements (typically differential pressure level). Note that the amperage reading across the leads of a motor are directly related to the BHP demand of the fan.

Furthermore, to minimize the fan energy demand for a multiple-branch dust collection system, regardless of flow control method, you must ensure that the system is balanced. An unbalanced system will naturally take on more airflow in the segments not associated with the duct network’s governing static pressure path, while the airflow in the segment associated with the governing path will be reduced. Note that the governing static pressure path is the airflow path through a duct network that results in the highest static pressure loss and is used to select the fan; all other air paths to the fan must be balanced to this path to provide the required flow in the individual air entry points.

Accordingly, you need a higher total system airflow to achieve the target flow in the segment associated with the governing path, resulting in a higher fan energy demand. Viewed from another perspective, an unbalanced system will have a different system loss characteristic from the balanced condition. So, for a target static pressure reading, an unbalanced system will have a higher airflow level than normal. The effect of the unbalanced system condition on system performance is shown in Figure 4.

**Maximizing filter cleaning energy savings**

For a pulse-jet dust collector, the common dust collector type for many powder and bulk industries, the cleaning system — which consists of blowpipes,
cleaning valves, compressed air manifold(s), and a compressed-air supply — must be configured and controlled to provide the required air volume to each row of filter elements to properly clean the filter media.

Using marginally sized cleaning system components (for example, a 1-inch pulse valve instead of a 1.5-inch valve or a 4-inch-diameter manifold instead of a 6-inch-diameter manifold) generally requires more frequent cleaning cycles to achieve the same result as a properly sized cleaning system.

Furthermore, using on-demand cleaning (based on differential pressure readings) in a pulse-jet dust collector typically requires less cleaning energy than when cleaning continuously. However, if the cleaning system isn’t configured properly for the application, you won’t receive the full benefits of the on-demand cleaning. Cleaning on demand may quickly approach the energy saving on continuous cleaning for significantly undersized or overtasked cleaning systems or process upset situations (excess moisture in airstream, higher grain loading due to excess system flow, etc.).

A cleaning system that once performed effectively may not achieve the desired results if the operating conditions in the dust collector change. This is typically caused by an increase in system airflow, whether intentional or unintentional, but is also possible with process changes. For example, it’s not unusual for a filter media upgrade from standard bag filters to pleated filter elements to require the cleaning system to be retrofitted when the system airflow has been increased, when you’re eliminating filter media rows, or both, in the dust collector.

The cleaning system has to be properly configured and controlled to maximize cleaning effectiveness, which minimizes the required cleaning energy. A pulse valve should be energized for a specific period of time (also known as on-time) to deliver the maximum flowrate at the pulsing pressure. Beyond a certain point, there’s no cleaning benefit and the additional time the valve is open only serves to drain the manifold. Also, the time between pulsing (also known as off-time) has to be sufficient to allow the manifold to refill and achieve the required pulse pressure.

I once reviewed an application where the expected benefits of lower differential pressure levels maintained with less cleaning energy weren’t being realized. The dust collector was retrofitted to include pleated filter elements and configured with a clean-on-demand controller. Upon inspecting the entire cleaning system, I discovered that the cleaning valves were energized for 500 milliseconds instead of the recommended range of 100 to 150 milliseconds. As a result, the compressed-air manifold on the collector only reached the required pulsing pressure when the collector wasn’t in operation and was rapidly drained soon after startup. Since the media was not being cleaned, the clean-on-demand controller was basically operating in continuous mode, thereby compounding the issue. After changing the setting, the filter media was recovered fairly quickly, and the clean-on-demand function worked properly.

For further reading
Find more information on this topic in articles listed under “Dust collection and dust control” in Powder and Bulk Engineering’s comprehensive article index in the December 2018 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.)
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