Baghouse dust evacuation: Can your system handle surge-flow effects from offline filter cleaning?

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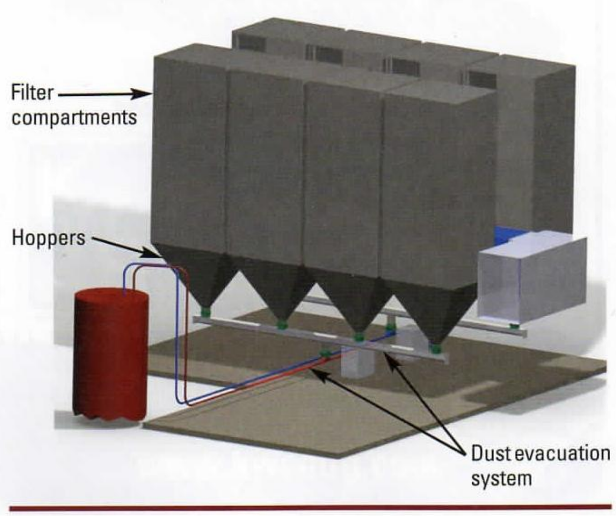
When choosing a baghouse, most of us think more about how well the unit will filter air than how quickly its dust hopper should be emptied. But when bag filters are cleaned offline by an on-demand cleaning system, a sudden surge flow of dust is released into the baghouse hopper. If this sudden flow isn't rapidly and completely evacuated, the accumulated dust can compact, bridge, and plug the hopper, leading to maintenance headaches and premature bag filter failure. This article covers factors to consider when designing your baghouse's dust evacuation system to remove the highest surge-flow volume your baghouse produces and keep the entire dust collection system operating smoothly.

In many bulk solids processing and handling operations, a baghouse equipped with several filter compartments, each containing several rows of bag filters, is used to clean dust from the process air. These multicompartment baghouses are commonly found in mining and minerals, cement, lime, and gypsum applications and in applications with high-temperature process air, such as power-generating plants, smelters, and foundries. An example is shown in Figure 1. In a multicompartment baghouse, each compartment is typically isolated for offline cleaning.

Figure 1

Typical multicompartment baghouse



The offline cleaning instantly releases a surge flow of dust from the filters that drops into the dust hopper below each compartment. This large volume of dust suddenly depositing in the hopper far exceeds the volume of dust entering the hopper during the baghouse's steady-state filtering operation (that is, while air and dust are entering the baghouse inlet and dust is depositing on the filters).

To avoid premature filter failure and hopper plugging, the collected dust must be evacuated rapidly. This requires designing an appropriate surge-flow capacity into the dust evacuation system downstream from the baghouse. Such a system generally includes equipment like rotary airlocks (or other valves) at each dust hopper discharge, pipes or chutes, and some type of transfer equipment such as screw conveyors, pneumatic conveyors, or a combination of various conveyors to move the dust to a storage silo or other location.

Designing an effective evacuation system starts with understanding the dust hopper's role in baghouse operation. The dust hopper has three primary functions:

1. To allow space for heavy and agglomerated dust particles to drop out of the air (or other gas).
2. To diffuse the baghouse's turbulent high-velocity inlet airstream into a uniform lower-velocity airflow inside the hopper.
3. To provide a discharge connection between the baghouse's filter compartments and the dust evacuation system.

The hopper is *not* intended to be a storage vessel, whether short- or long-term, and must remain virtually empty of dust.

Problems with inadequate dust evacuation

Dust remaining in the hopper can cause two problems: premature bag filter failure and hopper plugging.

Premature bag filter failure. When any dust remains in the hopper rather than discharges, the high-velocity inlet airstream entering the baghouse sweeps this dust back up into the filter compartment. Combined with the dust in the inlet airstream, this re-entrained dust greatly exceeds the inlet grain (or dust) loading the baghouse was designed to handle, causing disruptive eddy currents to circulate between the hopper and filter compartment. The extraordinarily heavy dust load in these eddy currents rapidly abrades the bag filters and prematurely plugs the media. (Be aware that while equipping the baghouse inlet and dust hopper with air diffusion baffles can promote uniform airflow and mitigate the problem, dust remaining in the hopper can still result in premature filter failure.)

Hopper plugging. The surge-flow volume of dust released from the bag filters during cleaning is highly aerated and flows freely into the hopper and down its walls. However, if the dust's discharge from the hopper is interrupted, even briefly, the dust will deaerate and compact, greatly reducing its discharge rate. If the flow slows enough or stops, the dust can become cohesive and adhere to the hopper walls, eventually plugging the hopper. Because the volume of dust dropping into the hopper during cleaning can instantly fill the hopper to several feet above its discharge, it's critical that the evacuation system have enough capacity to quickly remove this huge volume of dust before it has a chance to deaerate.

One factor contributing to hopper plugging is the standard hopper geometry provided on many baghouses: an inverted pyramid with shallow wall angles. Unlike a hopper with steeply angled walls that promotes mass flow, a hopper with shallow pyramid geometry doesn't encourage the dust to flow freely toward the hopper discharge. If the accumulating dust is stored in the hopper for any length of time, it can bridge, as shown in Figure 2. Moisture can make the problem worse. The non-flowing dust can plug the hopper and eventually lead to the dust collection system's failure. [*Editor's note:* Hopper design is beyond this article's scope; for more information on this topic, see the later section "For further reading."]

To overcome these problems, the dust evacuation system at the hopper discharge must not only be able to remove the normal flow of dust into the hopper during steady-state filtering operation but have the capacity to rapidly remove the surge-flow volume of dust entering during cleaning. Otherwise, the dust can plug the hopper, not only causing premature filter failure, but overwhelming the valves, pipes, chutes, conveyors, and other equipment in the evacuation system. Trying to get this compacted dust to flow can result not only in hammer rash on the hopper and dust emissions from the evacuation equipment, but can require the frequent use of vacuum trucks to clean out the hopper and evacuation equipment.

Figure 2

Dust bridge in pyramid hopper with shallow wall angles

Understanding on-demand offline cleaning and surge-flow effects

In a multicompartment baghouse, the filters in one compartment are typically cleaned *on demand* while the compartment is offline. This on-demand cleaning cycle is started when the differential pressure across the entire baghouse (measured by sensors at the baghouse's main inlet and main outlet) exceeds a preset level, and the cycle is stopped when the differential pressure reduces to a preset level.

During steady-state filtering operation, a thick dust cake builds up on each bag filter and is retained on the media by the incoming airflow. Then − regardless of whether the baghouse uses pulse-jet, reverse-air, or shaker cleaning − airflow to the compartment is stopped to isolate it for cleaning, and a portion of the thick dust cake on each filter immediately releases and drops into the hopper. Next, the actual cleaning cycle starts: In a pulse-jet baghouse, a cleaning pulse drops the remaining dust cake from the filters into the hopper in 1 to 2 minutes, depending on the pulse frequency, compartment size, and number of filter rows pulsed at one time. But in reverse-air and shaker units, all filters in one compartment are simultaneously cleaned at one time, dropping the remaining dust cake in only 10 to 20 seconds into the hopper and producing a much larger surge-flow volume of dust.

[*Editor's note:* In a baghouse that uses timer-activated or on-demand *online filter cleaning*, the dust volume released during cleaning is lower than that released during offline cleaning, but the dust evacuation system must still be designed with the capacity to keep the hopper empty. Find tips for designing evacuation systems for these baghouses later in this article.]

What to consider when designing your dust evacuation system

To ensure that your dust evacuation system can quickly and completely remove the surge-flow dust volume entering the hopper during offline cleaning, you need to consider your dust's aerated bulk density, the baghouses surge-flow evacuation rate, and other factors. Your baghouse supplier − or, for a large-scale project, your engineering firm − can help you use this information to correctly select and size each piece of equipment in the dust evacuation system. As part of designing the evacuation system, it's always a good idea to use samples of your dust to test baghouses with various evacuation equipment.

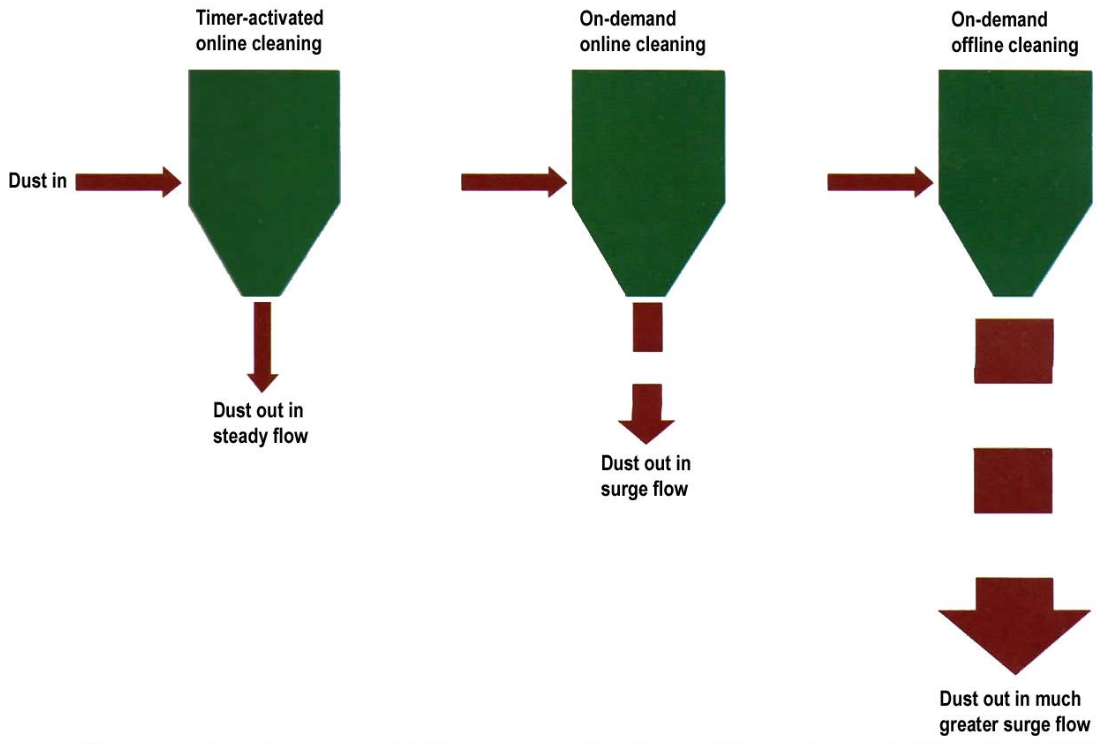
Aerated bulk density. Your dust's aerated bulk density is the bulk density of the dust in its aerated state, as it enters the hopper. You need to know the aerated bulk density to calculate the dust's maximum surge volume in your baghouse − that is, the highest volume of dust that can be dropped into the hopper in the shortest time period. The aerated bulk density is commonly half that of your dust's standard (deaerated) bulk density. Because aerated bulk density values for dusts are seldom found in published sources, it's best to take field samples of your dust and test its aerated bulk density.

Surge-flow evacuation rate. The surge-flow evacuation rate is the dust-transfer rate required to completely remove the maximum surge-flow dust volume from the hopper before the dust deaerates. Determining this rate is key to designing a dust evacuation system with enough capacity to quickly and completely remove dust from the hopper. The surge-flow evacuation rate for your baghouse depends not only on your dust's aerated bulk density, but the dust's other characteristics, such as particle size range, particle shape, particle surface area, chemistry, moisture content, and flow behavior. [*Editor's note:* See more about the influence of particle characteristics on designing for surge-flow effects in the accompanying sidebar, "Preventing surge-flow problems: Evacuating fly ash from powerplant baghouses."] The surge-flow evacuation rate also depends on your baghouse's cleaning method.

Other factors. You'll need some additional information to design the dust evacuation system, including the baghouse's inlet grain loading, the duration of online steadystate filtering operation, the differential pressure before and after cleaning, the cleaning activation pressure setpoint, and the filters' dust cake thickness. You must also consider the compartment locations, because the inlet duct on a multicompartment baghouse

Figure 3

Dust volumes released by various cleaning methods



rarely distributes dust equally to each compartment. Under normal operating conditions, the compartments farthest from dust source receive the highest dust loading so use their inlet grain loadings to establish the maximum surge-flow volume entering the hoppers. However, if you know that another compartment has a higher gram loading, use that compartment's loading to establish the peak surge-flow volume and size the evacuation system accordingly.

Evacuation system design tips for baghouses using online cleaning

A baghouse that uses online filter cleaning doesn't send as much dust into the hopper as suddenly as offline cleaning does, but it's still important to design the evacuation system to completely and quickly remove the dust from the hopper. See Figure 3 (previous page) for a comparison of dust volumes released during online and offline cleaning.

Timer-activated online cleaning. A single-compartment pulse-jet baghouse is often cleaned online during steadystate filtering operation. The pulse-jet cleaning is typically activated at regular intervals by a timer, with the result that dust falls at a relatively steady rate into the hopper.

Design tip: To keep the hopper empty, design the evacuation system so that it can remove dust from the hopper at a rate about twice that of the baghouse's inlet grain loading.

On-demand online cleaning. While suitable for single- or multicompartment baghouses, on-demand online filter cleaning is generally used in a single-compartment pulsejet baghouse and is triggered by a differential pressure switch rather than a timer. The switch triggers pulse-jet cleaning to start when the differential pressure across the filters increases to a specified high setpoint and stops the cleaning when the differential pressure returns to an acceptable low setpoint. This extends the time between cleaning cycles, allowing a thicker filter cake to develop on the media. As a result, the dust volume entering the hopper during cleaning is much larger than that produced by timer-activated online cleaning. While this creates a surge-flow volume of dust, the volume is not as large as that produced by offline cleaning.

Design tip: Work with your baghouse supplier or engineering firm to design the dust evacuation system to handle on-demand online cleaning's surge-flow effects. As with designing the evacuation system for a baghouse using offline cleaning, consider the dust's aerated bulk density, other dust characteristics, and the surge-flow evacuation rate to determine what capacity your evacuation system must have.

Caution: Often, a plant will switch its baghouse cleaning system from timer-activated to on-demand online cleaning, but in such a case it's unlikely that the original dust evacuation system has the capacity to handle the new cleaning method's surge-flow dust volume. Before switching your baghouse from timer-activated to on-demand online cleaning, test the evacuation system to make sure that it can handle the higher dust volume and upgrade or replace the system if necessary.

Design aggressively

While it makes sense to focus on filtration efficiency when you select a baghouse, it's a mistake to overlook the dust evacuation system's role in bag filter life and overall dust collection performance. To ensure that your baghouse provides continuous trouble-free performance over the dust collection system's lifetime, design the evacuation system's capacity as aggressively as possible so that it can handle the highest surge-flow volume of dust from any filter compartment with ease. ***PBE***

For further reading

Find more information on baghouse operation in articles listed under "Dust collection and dust control" and on hopper design in articles listed under "Storage" in *Powder and Bulk Engineering*'s comprehensive article index (in the December 2010 issue and at PBE's Web site, www.powderbulk.com) and in books available on the Web site at the *PBE* Bookstore. You can also purchase copies of past *PBE* articles at www.powderbulk.com.

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Preventing surge-flow problems:

Evacuating fly ash from power-plant baghouses

Fly ash remaining after burning coal or biofuel in power-generating plants is one form of dust that presents unique challenges in evacuation system design. These challenges are based on differences in the particle characteristics of fly ashes generated by coals and biofuels from different sources.

To handle filter-cleaning surge-flow effects, the ash evacuation system for a power-plant baghouse must be designed to handle a specific fly ash generated by a particular fuel from a specific source. For instance, coals from different sources – such as Eastern coal from West Virginia and Powder River Basin coal from Wyoming – generate different volumes of fly ash and ashes that flow differently during transfer. The volume and flow behavior of fly ashes generated by different biofuels and by biofuels from various locations also differ and can present a range of handling problems. For instance, wood biofuels have variations in form (chips, bark, or ground wood), wood species, source, climate, and moisture level, and these combine to produce different ash characteristics and flow behaviors that challenge the evacuation system.

You can see variations in ash particle shape and size in the scanning electron microscope images of three different fly ashes in Figure A. The ash at left is from a biofuel blend of wood bark and tire chips, at center is from a biofuel of 100 percent green wood chips, and at right is from 100 percent coal. The smooth, spherical silica particles in the 100 percent coal ash promote flow. However, the irregular particle shape of the biofuel ashes reduces their flowability and increases their tendency to bridge in the baghouse hopper. These differences reinforce the importance of designing the evacuation system for each fly ash to handle its specific characteristics.

In an existing power plant, deciding whether to switch to a new fuel source should always involve identifying the new ash's characteristics and determining how they'll affect the ash evacuation system's performance. For instance, an evacuation system originally designed to move the coal ash in Figure A may not perform reliably with the biofuel ashes in that figure. Major factors to consider in determining how a new ash will affect the evacuation system's performance are the ash content (that is, its proportion of different components, such as silicon dioxide and calcium oxide), the volume of ash flowing to the dust collection and evacuation systems, the ash characteristics (including particle size range, particle shape, particle surface area, aerated bulk density, chemistry, moisture content, flow behavior, and others), and, especially, the evacuation system's surge-flow capacity during filter cleaning.
– M. Walters and E.L. Noddin

Figure A

Particle shapes of fly ashes generated by various fuels (at 1,000 times magnification)

Biofuel blend of wood bark and tire chips | 100 percent green wood chips | 100 percent coal