"Surge Flow" Dust Volume Affects Dust Collector Evacuation Systems

Authors:

E. Lee Noddin, VP Technology

Mike Walters, PE

Coal Gen 2010 / Published May 2010
POWERENGINEERING / Published Oct 2011

History

Effective dust collection system performance relies on correct design of both the filtration and evacuation equipment. When a multi-compartment dust collector isolates a compartment for off line cleaning, a surge of dust instantly releases from the filter bags and flows to the hopper. A similar "surge flow" occurs when a single compartment collector cleans on demand/on line.

The sudden volume of dust depositing in the hopper far exceeds the steady state inlet load generated by the process. Ash/dust evacuation system designs must include the capacity to evacuate this "surge flow" from the hopper as rapidly and completely as possible. Overlooking this requirement causes dust to accumulate, compact, bridge and plug hoppers resulting in constant maintenance and premature bag failure.

This paper explains: why the "surge flow" volume capacity must be designed into the evacuation equipment; where to obtain the data for those calculations and; how this design keeps hoppers dust free at the maximum evacuation rate which minimizes system maintenance and extends filter bag life.

1.0 Importance of a Properly Sized Dust Evacuation System

The primary functions of a hopper are to:

1. Reduce inlet gas velocity to allow heavy & agglomerated dust drop out.
2. Diffuse the turbulent high velocity inlet gas stream into a uniform lower velocity flow. Proper design and use of inlet diffusion baffles also reduces filter bag abrasion and cage swing.
3. Provide a discharge connection between the filter bag chamber and the evacuation equipment.

The hopper is not intended to be a storage device, whether briefly or permanently and must remain relatively dust free. To retain any amount of dust invites two major operational problems.

Premature bag failure-Figure 1: When any amount of ash/dust remains in the hopper, high velocity inlet gas sweeps it back into the bag chamber. This re-entrained ash/dust, along with the

Figure 1: Re-entrained bag abrasion

incoming dust, greatly exceeds the initial design rates. Unless inlet and hopper designs employ adequate diffusion devices to encourage uniform flow, disruptive eddy currents will circulate between the hopper and bag chamber. Elevated levels of particulate in these eddy currents rapidly abrade filter bags and cause premature plugging from the extraordinarily heavy dust load.

Hopper flow interruption and bridging problems-Figure 2**:** Ash/dust released from filter bags during a cleaning cycle is highly aerated and freely flows down hopper walls. However, if flow is interrupted, for even a brief period, the ash/dust de-aerates and compacts causing the flow rate to reduce significantly. If the flow slows enough or ceases completely, the ash/dust can become cohesive and adhere to the hopper walls. Hopper corners are especially susceptible to accumulations that can lead to bridging, plugging and system failure.

During an off line cleaning event the "surge flow" volume of dust dropped could instantly fill the hopper several feet above the discharge. To minimize dust transfer problems, evacuation equipment must have the capacity to remove this huge volume of ash/dust as quickly as possible before it de-aerates.

Figure 2: Dust Bridge in Hopper

Pyramid hoppers are frequently found on dust collection systems of all sizes; however, their geometry does not encourage the free flow of particulate. This hopper configuration is prone to bridging/plugging if ash/dust is stored in the hopper for any amount of time-figure 2. The presence of moisture exaggerates this behavior.

Proper transport system designs must include the capacity to rapidly remove the "surge flow" volume of ash/dust from the hopper not just the lower steady state flow rate from the process. Failure to include this capacity overwhelms the transfer system resulting in plugged hoppers, pipes, screws, airlocks, pneumatic lines, hammer marks on hoppers, frequent use of vacuum trucks, emissions from transport equipment and premature filter bag failure.

2.0 Design Parameters that Influence a Properly Sized Evacuation System

Two key design parameters must be considered for correct sizing and selection of evacuation equipment:

Surge Flow Evacuation Rate: An ash/dust surge flow only occurs during an offline or on demand cleaning event. It is the highest volume of dust that can be dropped to the hopper in the shortest period of time. The surge flow evacuation rate is the rate required to completely remove the surge flow from the hopper before it de-aerates. Both factors are dependent on dust properties and cleaning system protocol. These must be evaluated in conjunction to determine correct evacuation system capacities.

Aerated Bulk Density: It is of upmost importance to use aerated bulk density for volumetric calculations. It is not uncommon for the aerated bulk density of ash/dust to be half that of its standard, de-aerated bulk density. Using the heavier density to determine transport capacities can lead to a severely undersized system plagued by constant maintenance problems.

The aerated bulk density of dust is rarely found in publications. However, these figures are of such importance that field samples should be taken to determine accurate values.

3.0 Surge flow volume methodology for on line, on demand & off line on demand cleaning.

On line cleaning: Most single compartment pulse jet dust collectors are cleaned on-line while gas and dust/ash are entering the collector and depositing on the filter bags. These systems commonly use timer activated cleaning which drops a relatively steady rate of dust to the hopper. Field experience with this collector and cleaning method has proven that an evacuation rate of twice the incoming rate is a reliable estimate for maintaining clean hoppers

On demand on line cleaning: On demand pulsing is started and stopped by a high/low differential pressure switch. Time between cleaning is extended, developing a thicker cake on the bags. It is unlikely the original discharge equipment was designed to evacuate the higher dust volume. Caution is advised before converting from timer to on demand activation. Tests should be conducted to verify that capacity exists to quickly purge the higher dust volume. Without this "surge flow" evacuation capacity, the negative effects of de-aeration, hopper bridging and associated problems can occur. Also, the inconsistent flow surges generated by this cleaning method could have negative effects on product quality and downstream processes.

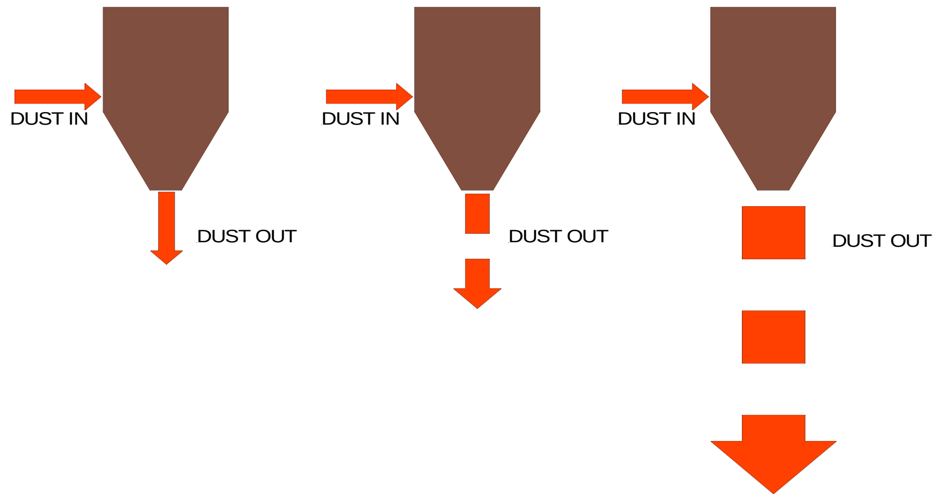

Figure 3: From Left - Online Cleaning - On Demand On Line Cleaning - On Demand Offline Cleaning

On Demand Off line cleaning: Multi-compartment systems are normally cleaned on demand off line. During the cleaning event, isolation alone allows a thick layer of cake, (accumulated over time and retained on the bag by gas flow), to release and drop immediately into the hopper whether the cleaning system is pulse jet, shaker, or reverse air. Pulse cleaning then drops the remaining cake in 1-2 minutes (depending on pulse frequency, compartment size and rows pulsed) whereas shaker and reverse air systems take only 10-20 seconds because all bags in the compartment clean simultaneously.

Regardless of the cleaning method, the rapid increase in ash/dust volume released during off line cleaning far exceeds the steady rate dropped to the hopper during the on line filtering cycle. This higher instantaneous "surge flow" volume must be considered when determining the evacuation equipment capacities required to keep the hoppers empty.

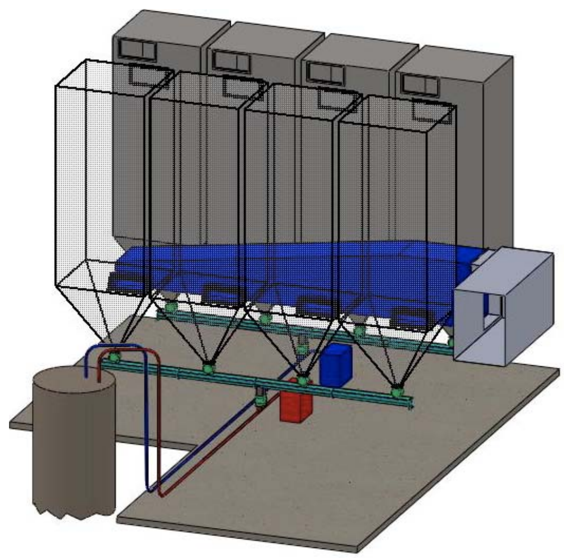

Figure 4: Large Multi-Compartment dust collector

Factors that determine accurate surge volume calculations are inlet grain loading, on line filtering duration, cleaning activation pressure point, pulse cleaning pressure, volume & duration, pressure differential before & after cleaning, module location (inlet loading is not uniform) and cake thickness. Calculations using this data determine the maximum surge flow volume of dust/ash released during a cleaning event and the transport equipment capacities necessary to completely purge the hopper as quickly as possible prior to going back on line.

Historically, inlet ducts on multi compartment systems rarely distribute ash/dust equally to each cell. Under normal operating conditions the back compartment(s) receive the highest load. These cells should be used to establish peak surge flow parameters. However, if other compartment(s) are known to receive a heavier load, use those parameters for transport capacity calculations.

"Surge Flow" Considerations at Power plants: Dust collection systems for the power generating industry are designed to collect and transfer specific types of ash from specific fuels from specific sources. Like fuels from different sources such as Eastern coal vs. PRB coal can present changes in ash volume and behavior during transfer. Not unlike coal, ash from a variety of bio-fuels and locations present similar variations in conveying behavior and often more difficulties. Variations in wood species, source, climate, chips, bark, ground wood wet/dry, method of transport, construction debris, etc. all present different ash components, behavior and demands on the evacuation system.

Alternate fuels should always be evaluated in conjunction with a detailed assessment of the new ash components and their affect on the performance of the ash removal system. Factors to consider are ash content, ash volume to the dust collection and evacuation systems, chemistry, moisture, particle size range, surface area, geometry/shape, flow characteristics, agglomerative nature, aerated bulk density, equipment "surge flow" capacity, and other factors. Unless variations in "surge flow" volume are included in the original design or later modifications, ash evacuation systems can be subject to continuous maintenance problems.

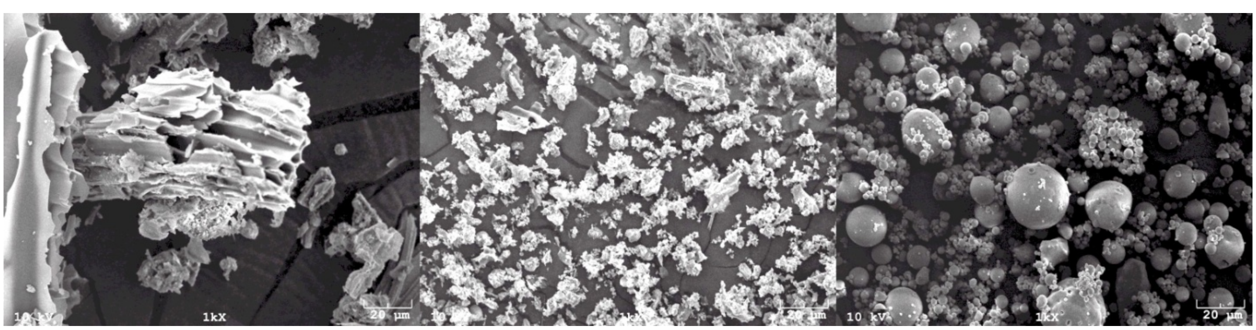

Figure 5: Left to Right - Bark/tire chips – 100% Green wood chips – 100% Coal

The 1000X photos in figure 5, taken from three different fuels, show the variations in fly ash geometry and size. The silica spheres from 100% coal ash contribute positively to the flow ability of this ash. However, the coarse geometry of the other ash varieties restricts their flow ability, causing them to easily bridge. An evacuation system originally designed for coal ash may not perform reliably with the biomass fuel ash shown here.

Boilers, dust collection systems and ash conveying equipment are normally designed to burn particular fuel/fuels and meet specific filtration and evacuation requirements of the ash generated by those fuels. Whenever a new fuel is being evaluated, it is wise to consider its affects on all system components and operating parameters. This applies especially to "surge flow volumes" of the ash evacuation system.

Applying the same level of importance to evacuation as filtration insures a properly functioning dust collection system.

4.0 Conclusion

The importance of dust collector evacuation systems is often overlooked. Proper design is vitally important to overall dust collection system performance including filter bag life. Maintenance is minimized when the ash/dust surge flow volume dropped to the hopper is completely evacuated in the shortest time possible. This helps avoid bridging, plugging, premature filter bag failure, accelerated equipment wear and total system dysfunction.

When equipment capacity calculations incorporate the most aggressive design possible to evacuate the highest "surge flow" volume from any compartment in the collector, the designer can be confident that the evacuation system will provide continuous trouble free performance during the entire life of the dust collection system.

AEES
Albarrie Environmental Engineering Services
Dust Collection System Specialists
E. Lee Noddin VP Technology
Mike Walters PE