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Brad Pronschinske, Martin Engineering

CONTROLLING SILO CLOGS

Martin Engineering looks at how air cannons can control clogging in silos...

Cement plant silos were designed for the needs and environment of the time in which they were constructed. Over time, changes may occur, including shifts in production demands and business priorities, material volumes, cement compositions and moisture content. Changes can cause material to adhere to silo walls, resulting in unscheduled downtime. Low temperatures and changes in atmospheric pressure, especially if the silo is stagnant for long periods, can also contribute to drastic flow changes.

In the past, when material accumulation problems became a recurring issue, processors would usually limp along until the next scheduled shutdown. This approach could cost businesses hundreds of thousands of dollars per day in lost production. Once coarse material adheres, the build-up is generally fast and dense, eventually resulting in downtime to remove. Seeking ways to address it quickly without the proper tools or training can also be the moment when workplace safety degrades.

Air cannons are engineered to safely clear and prevent clogging, promote material flow and avoid costly downtime. To know if the technology will work well for a specific application, the first step is understanding how, where, when and why clogs happen in any given silo. The second step is removing any worker involvement in clearing the clog, aside from pushing a button to activate the cannon if it is not automated or controlled by logistical software.

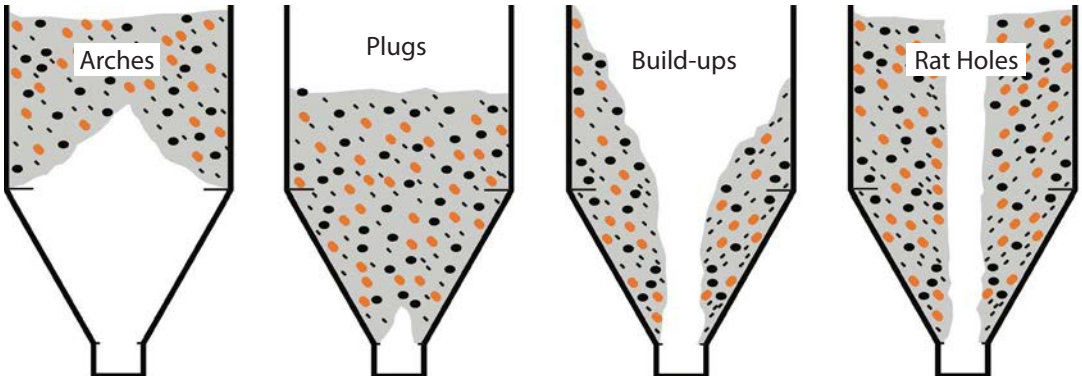
A series of air cannons can be programmed to deliver precisely timed discharges for maximum benefit.

Silo clogging and safety

Regardless of the cause, the types of clogs in a hopper can pose unique challenges for discharge, as well as very serious safety issues. There are several unsafe practices around silos that too often result in serious worker injuries or fatalities, mainly sudden discharge of adhered material and entrapment.

If left for too long, material build-ups can harden and take a silo out of commission for long periods. Poking or lancing from beneath the clog at the spout can result in a sudden surge of falling material, burying or crushing those below and seriously damaging the receiving belt. Beating the vessel walls with mallets or other objects to loosen adhered material is common. Operators who engage in this method find this worsens the situation over time as the divots and ripples left from hammer strikes provide additional places for material accumulations to start.

If a worker enters the vessel and stands on the volatile bridge, a sudden discharge could pull them into the cavity. Sometimes material build-up on the sides of the vessel reaches higher than the worker and falls from above, causing serious injury or burial.



Types of silo clogs.

Material churn

Silos are designed to hold a certain volume of a particular material, so awareness of the maximum load is important. Repeatedly filling and emptying them makes load requirements especially important in these cases, since capacity is reached repeatedly under differing conditions. When working with bulk solids, environments with high moisture and freezing conditions regularly experience clogging. Wide variations in the size and shape of the material can also affect the flow characteristics, leading to build-up and clogs.[1]

Types of silo clogs

Arches form when material consistency changes during loading or the top material contains more moisture. It can also just be caused by gravity. This is very dangerous, as material discharge has a long fall distance. The flat top surface can give workers a false sense of stable ground, so vessel entry is ill-advised. Air cannons placed at the upper point of where material begins to adhere will keep material flowing toward the discharge spout.

Plugs are generally caused by compacted moist material that has been left for long periods. Strategically placed air cannons can help loosen material to get it flowing. Sometimes the contents have hardened to such a degree that a silo cleaning service is needed, which utilises the support of the air cannon system to resolve the issue faster, lowering the cost of the service.

Build-ups can be caused by several factors: weather, silo design, the way the silo is loaded, a horizontal grain of the metal on the side of the silo, the silica content of the material, and many other factors. Build-ups can be economically mitigated using strategically placed air cannons at common collection points to keep material flowing toward the discharge spout.

Ratholes often form over time and reduce the capacity of the silo. Since the material is flowing, they are often ignored by operators, but can severely impact production. The significant weight put on the thin walls of the silo and structural supports can pose a serious safety issue if buckling or a collapse occurs.

Some manufacturers have a refurbishing program that reduces costs through simply swapping and shipping.

Air cannons

Pioneered and patented by Martin Engineering, low-pressure air cannon technology has progressed exponentially over the 50 years since its conception. They use a plant's compressed air system to deliver a powerful discharge to dislodge material build-up. Mounted on a pipe assembly, the basic components include an air reservoir, a fast-acting valve with a trigger mechanism and a nozzle to distribute the air in the desired pattern to clear the accumulation most effectively.

The cannons are strategically positioned on the silo and when compressed air (or some other inert gas) in the tank is suddenly released by the valve, it is directed through an engineered nozzle toward a specific or general location depending on the design of the nozzle. The air blasts help break down material accumulations and clear blocked pathways, allowing solids and gases to resume normal flow.

Often installed in a series and precisely sequenced for maximum effect, the network can be timed to best suit individual process conditions or material characteristics. Specific air blast characteristics can be achieved by manipulating the operating pressure, tank volume, valve design and nozzle shape, to customise the air cannon installation to the service environment.

Valve replacement

The valve in an air cannon is considered a wear part, but it is common practice to refurbish them rather than replace them with new ones. Since clearances and fits are critical to proper operation, valves should be rebuilt and repaired by the manufacturer, or specifically trained plant maintenance personnel.

Martin Engineering created a program to supply factory-rebuilt air cannons. Customers can receive a standard pallet-sized container with six refurbished valves, so there's no need for users to rebuild worn-out components. The changeout can be accomplished in just 10 minutes, at less than half the cost of new valves. The used valves are shipped back to the company, where the units are rebuilt to as-new condition by factory-trained technicians. Customers save time and money, with no need to stock repair parts or provide the training and labour to rebuild.

Case study

TXI is a cement producer in Texas and California, as well as a major supplier of construction aggregate, ready-mix concrete and concrete products. At its plant in New Braunfels, Texas, it runs 100t/month of iron ore into the clinker feed from one line. In the past, when the iron ore came in wet, or it rained, the iron ore got very sticky, which then stuck to the inside of the silo. TXI would shut down for regular 24hr periods in order to manually airlance the resulting blockage, causing low feed rates.

Working with Martin Engineering, TXI developed a plan to install a series of air cannons in an ascending spiral on the cone section of the silo, keeping the material flowing at a constant feed rate. The four air cannons included blow pipes, air lines and control systems. The cannons are engineered to deliver the maximum discharge strength from high velocity output with half the air volume, for a highly effective discharge and reduced operating costs. Designed for simple maintenance, the complete valve assembly can be removed in one easy step, working from one side of the tank.

The air cannons eliminated the blockages. The timed discharge of the air cannons has successfully prevented the accumulation that impacted the process efficiency and required downtime for manual cleanout. Since the installation, TXI has not had to stop production, saving time and money. "The air cannons have been a success," said Sudhanva Bhat, Maintenance Manager at the plant.

New designs no longer require tank removal for valve replacement, saving time and manpower.

Silo flow

Air cannons are not new, but the technology has progressed to the point that the carbon footprint of the plant's compressed air system is considerably lower. Efficient silo flow is essential to plant production, so justifying the expense of installation and operation is easy once calculated against the cost of downtime and the importance of workplace safety.

References

1. Hafez, A., Liu, Q., Finkbeiner, T. et al. *'The effect of particle shape on discharge and clogging.'* Sci Rep 11, 3309 (2021). https://doi.org/10.1038/s41598-021-82744-w.