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Safer material flow in preheater towers

New cannon designs are more compact and have dramatically increased power and efficiency (all photos: ©Martin Engineering 2023).

Intense heat courses upward through the preheater, raising the temperature of the meal to ensure it doesn't cool the kiln when it arrives, *writes Brad Pronschinske, Global Air Cannon Product Manager, Martin Engineering*. Material fed into the preheater has a temperature as high as 200°F (93°C) but within seconds enters the kiln heated to 1,500°F (815°C)[1]. This saves on energy consumption, reduces the calcining time and promotes plant efficiency. However, no matter how many stages the preheater has, as the material flows through each stage, it can quickly adhere to the coarse refractory, build up and clog. This slows or stops the flow and leads to expensive downtime.

Many operators mitigate clogs by implementing regular cleaning schedules, assigning workers with water lances extended through access holes. A worker ascends the tower and dons a suit of high-heat personal protective equipment (PPE). Lancing the material with high-pressure water clears the blockage, and the workers restore proper flow. Unfortunately, this procedure is always done while the preheater is still in operation, causing a tremendous amount of heat and some molten material to blow back. The PPE, the heat and the safety issues make preheater cleaning one of the most unpleasant jobs in a cement plant.

"To improve safety and increase efficiency, virtually all cement plants in the USA have air cannons installed on the preheaters," said Mike Moody, USA Air Cannon Business Development Manager at Martin Engineering. "Over the years, we've worked to improve the technology to the point where both installation and maintenance can be performed safely without a shutdown or exposure to intense heat."

Preheater flow

Preheater towers, in some form, have been in operation since the 1920s. Today's designs can have as many as six stages in towers up to 12 stories (120ft/35m) tall. The mix flows down a chute to a splash box, proceeds to the airflow of the riser duct, where it gets heated and progresses to the next stage, and the procedure happens all over again.

One of the biggest contributors to material buildup is high heat and material velocity[2]. As material gets hotter, it gets stickier, clinging to the sides of the flow chutes and splash box, as well as in the riser duct. If left unchecked, clogs can form quickly, stopping the material flow, which leads to unscheduled downtime and lost production. Large buildups can even completely block the outlet of the cyclone.

Whenever operators open the access door, this lowers operating temps. Cold water also reduces temperature, and injecting water into the hot tower creates steam, which can result in a dangerous steam 'explosion'. A better alternative is a series of low-pressure air cannons — a technology originally developed and patented by Martin Engineering in the 1970s. Early cannon designs were engineered to use very high pressures — some as much as 34,474kPa (5,000PSI) — which were expensive to operate and introduced safety issues. But today's low-pressure 'air blasters' are fed by compressed air (or some other inert gas), which deliver a powerful surge through a specially designed high-heat nozzle to clear a specified area.

Air cannon nozzles are strategically positioned in the tower, riser duct or cyclone. As adhered material is dislodged, it returns to the flow, with the pressurized shot facilitating the flow and enhancing efficiency.

"In the past, operators were concerned with valve maintenance that required tank removal and nozzle replacement, which could only be performed during scheduled shutdowns that involved a system cooldown," said Moody. "Back then, most cement plants used their annual scheduled shutdown to maintain or clean nozzles. This often required the removal and replacement of refractory, where any disruption can lead to cracking. But over the last decade, these issues have been addressed by new technologies, including retractable nozzles that can be installed and serviced during production."

Many designers proactively include the mountings for air cannons in new designs, so that future retrofit can be done without vessel entry or extended downtime. New technology has even been developed for installing air cannons in high-temperature applications without a processing shut-down, allowing specially-trained technicians to mount the units on furnaces, preheaters, clinker coolers and in other high-temperature locations while production continues uninterrupted.

Controlling the flow

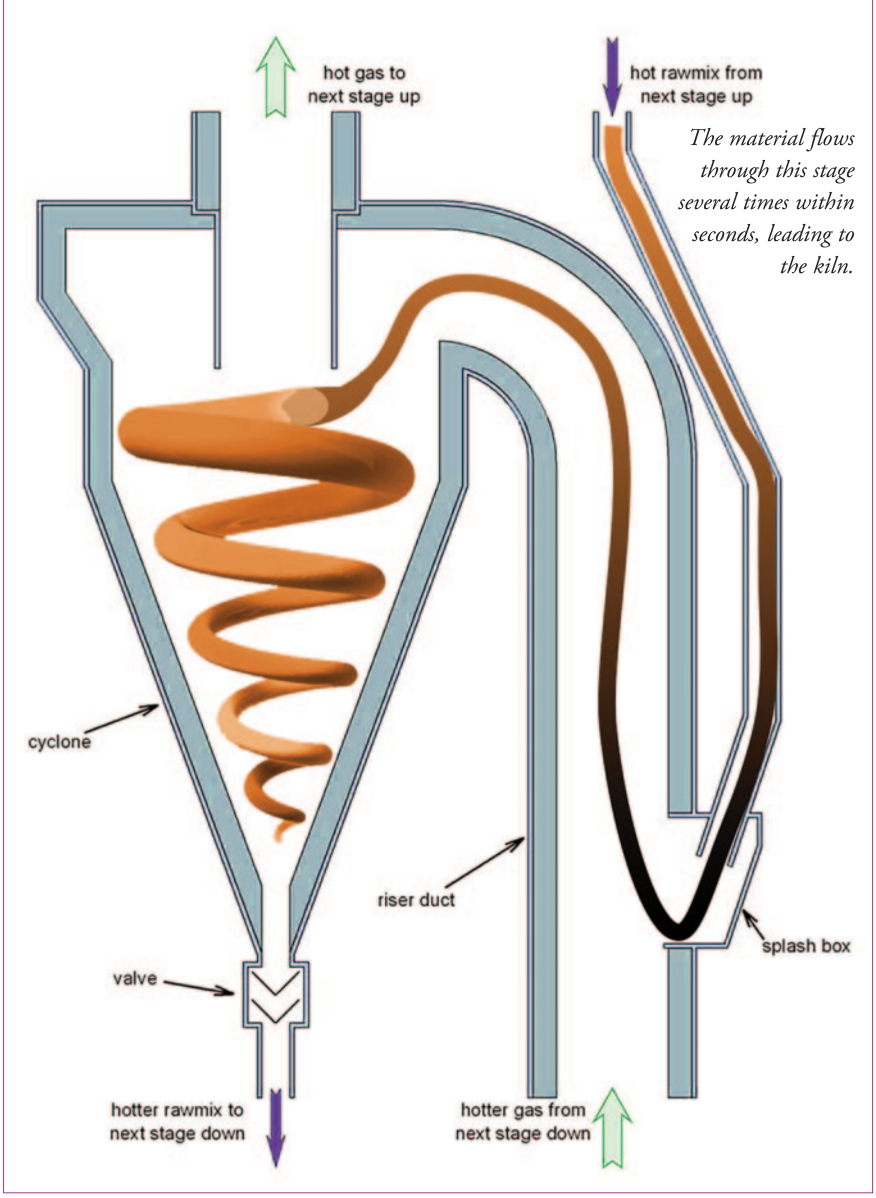
When employing flow aids such as air cannons, it's critical that the flow aid be properly sized and mounted. Nozzle location is critical, and the new designs allow nozzle installation from outside the structure, so they can be precisely located to deliver the necessary performance.

The best practice is to use flow aids as a preventive solution to be controlled by timers or sensors to avoid material buildup, rather than waiting until material accumulates and restricts the flow. Using flow aid devices in a preventive mode improves safety and saves energy, since flow aids can be programmed to run only as needed to control buildup and clogging.

How air cannons work

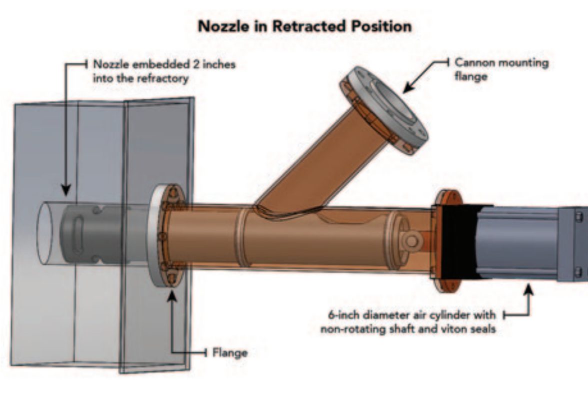
The basic components of the air cannon include an air reservoir, fast-acting valve with a trigger mechanism and a nozzle to distribute the air in the desired pattern to most effectively clear the accumulation.

Often installed in a series and precisely sequenced for maximum effect, the network can be timed to best suit

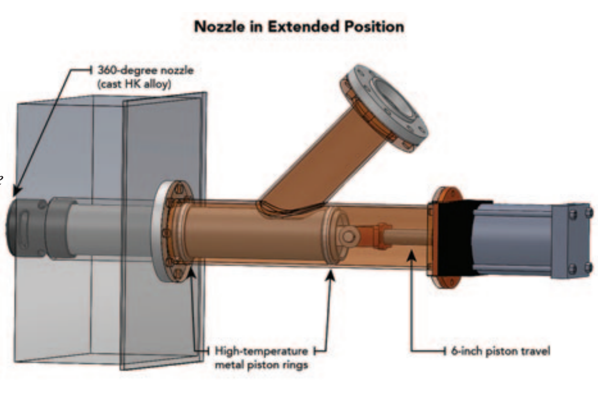


The material flows through this stage several times within seconds, leading to the kiln.

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



Retractable nozzles are only exposed to the material stream for the split second it takes to deliver the shot.



individual process conditions or material characteristics. The air blasts help break down material accumulations and clear blocked pathways, allowing solids and/or gases to resume normal flow. In order to customize the air cannon installation to the service environment, specific air blast characteristics can be achieved by manipulating the operating pressure, tank volume, valve design and nozzle shape.

Tanks and valves

To facilitate maintenance without a process shutdown, air reservoirs with volumes typically ranging from 35L up to 150L are now outfitted with a rear-facing valve that can be removed without dismounting the tank. Today's fast-acting valves can release the tank volume in a fraction of a second, creating a high-magnitude force at the exit nozzle that's installed through the wall of the vessel or duct. The new designs feature a hybrid valve concept that provides more force, uses less air and simplifies maintenance in challenging applications with limited budgets.

Positive-firing valves that respond to an air pressure surge delivered by a solenoid have also made air cannons safer. Unlike negative pressure-firing designs, a cannon equipped with this type of valve will not discharge accidentally in response to a drop in pressure, so an air supply failure or broken line cannot trigger it suddenly. The high-speed valve design is mounted on a smaller air reservoir, delivering higher discharge forces than less efficient valves on larger tanks. The new generation of valves produces about twice the blast force output of previous designs, saving energy by using about half the compressed air volume.

Nozzles and service

Another innovation has been the patented Y-shaped assembly that allows the nozzle to be maintained or replaced without removing the tank or disrupting the refractory. The system allows specially-trained technicians to mount the units on furnaces, preheaters, clinker coolers and in other high-temperature locations while production continues uninterrupted. It dramatically reduces downtime associated with traditional approaches to installation, service and replacement, which require that high-heat processes be halted to allow core drilling and mounting of the cannons.

"Avoiding unplanned shutdowns is key to a plant's profitability," said Moody. "Any shutdown other than scheduled maintenance is production time that can't be recovered," he continued. "Once that production time is lost, it can't be made up again. With the core drilling option and Y-pipe, installation and maintenance can be done during normal production."

The nozzle is the component that takes the stored energy in the form of compressed air and directs it to do work, so it has a dramatic effect on the performance of any air cannon. The application dictates the type of performance needed, including the shape of the air blast, length of the plume, etc. A primary goal in every application is to use the stored energy as efficiently as possible.

The new series of retractable air cannon nozzles has been developed specifically for high-temperature applications, extending into the material stream only during the firing cycle to protect the nozzles from extreme temperatures and abrasion. These 'smart' nozzles allow the cannon and nozzle to be installed independently, so the nozzle can be accessed for inspection or service during production, without stopping the process or removing the cannon. The new design solves two common industry problems: effectively dislodging accumulations in hard-to-reach areas without shutdown or manual labour, while significantly extending nozzle life. Further, the units can be serviced from outside the vessel without disturbing the refractory, reducing potential damage while minimizing service time and risk of injury.

Case study – India cement plant

A cement facility in Northern India, producing 3.25 million tonnes a year, was experiencing clogging issues in the feed pipe of its preheater tower. Production demands prohibited managers from allocating system downtime to fully clear the duct. To mitigate clogs and avoid unscheduled stoppages, they implemented a manual cleaning schedule while the tower was in operation. The procedure used an air lance through an access hatch, which can result in extreme heat exposure, blowback, and potential contact with molten debris. This also pulled resources away from other essential tasks in the plant. The extra labour increased the cost of operation, so managers sought a solution that allowed them to address the problem without a shutdown.

Technicians from Martin Engineering India were invited to examine the issue, and they decided to install two air cannons at the clogging point. Buildup is common in preheater towers and can take up to ten days of downtime for cooling, cleaning and reheating. By using a Martin® Core Gate, holes were carefully drilled through the refractory during operation, then the air cannon assemblies were installed. Using 70L Martin Typhoon Air Cannons connected to the plant's compressed air system and jet nozzles designed for high-temperature environments, each unit delivers a powerful shot of air that dislodges adhered material. The cannons were set to fire automatically at predefined intervals.

The drilling and installation required just two hours. With the ability to service and maintain the valve and nozzle without removing the tank or assembly, a permanent solution was provided that significantly reduced maintenance labour, while improving safety. Moreover, dislodging adhered material before it accumulates means the problem area no longer requires manual cleaning. "We have never seen this done in a running cement plant," said an operator close to the project. "We are very happy with the performance." Managers are now working with Martin Engineering India to install a air cannon solutions in other parts of the tower and throughout the plant.


Preheater towers stand tall over the operations of the plant in India.

Conclusion

Flow through the preheater tower takes only seconds, but a clog can cause hours or days of downtime that can't be made up, resulting in significant losses (production time that can't be recovered). Prevention and maintenance can be a grueling task that leads to increased labor costs. Thanks to new air cannon technologies, the lost production, reduced revenue, workplace safety implications and employee morale issues can be effectively minimized.

"After calculating the costs saved by avoiding downtime, this technology pays for itself quickly," said Moody. "The savings are compounded by reduced maintenance, improved safety, lower labor costs and greater production efficiency." Given the current production volumes and costs, a typical manufacturing operation can avoid US$600,000 per day by preventing downtime and cleanout labour, not even including the potential safety implications and expenses. And air cannons aren't just an American phenomenon. They're a widely accepted flow aid technology worldwide, the only one that's so universally employed.

About the author

As Global Product Manager–Flow Aid Division, Bradley Pronschinske is responsible for the development and management of Martin Engineering's air cannon products and vibration systems. Pronschinske joined Martin Engineering in 1998 as a Product Specialist–Air Cannons, became Global Product Manager–Air Cannons in 2005 and continues in that role today. He holds many US and International patents on air cannon models with additional patents on nozzles for air cannon systems. Pronschinske received his BS in Electronics Engineering from Hamilton Technical College in Davenport, Iowa.

About Martin Engineering

Martin Engineering has been a global innovator in the bulk material handling industry for more than 75 years, developing new solutions to common problems and participating in industry organizations to improve safety and productivity. The company's series of *Foundations* books is an internationally recognized resource for safety, maintenance and operations training — with more than 22,000 print copies in circulation around the world. The 500+-page reference books are available in several languages and have been downloaded thousands of times as free PDFs from the Martin website. Martin Engineering products, sales, service and training are available from 17 factory-owned facilities worldwide, with wholly-owned business units in Australia, Brazil, China, Colombia, France, Germany, India, Indonesia, Italy, Malaysia, Mexico, Peru, Spain, South Africa, Turkey, the USA and UK. The firm employs more than 1,000 people, approximately 400 of whom hold advanced degrees.


Drilling for a new air cannon on an operating preheater by a trained specialist.