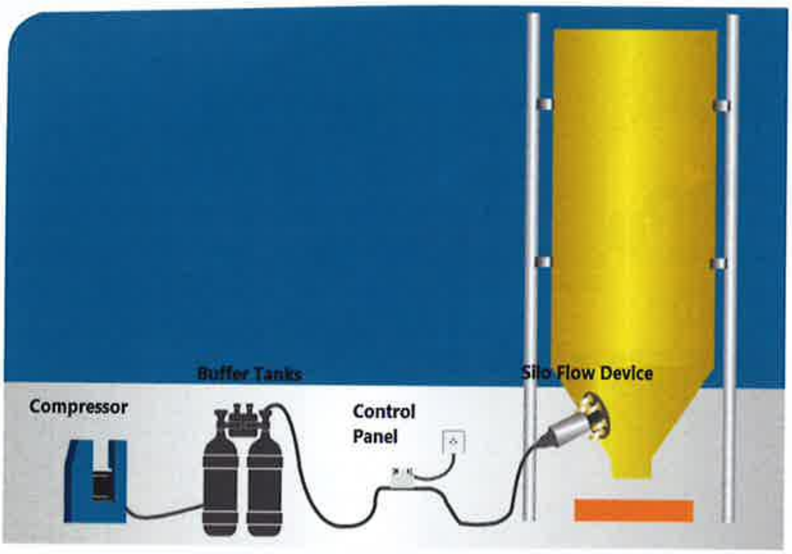
SOLUTIONS TO MATERIAL FLOW PROBLEMS

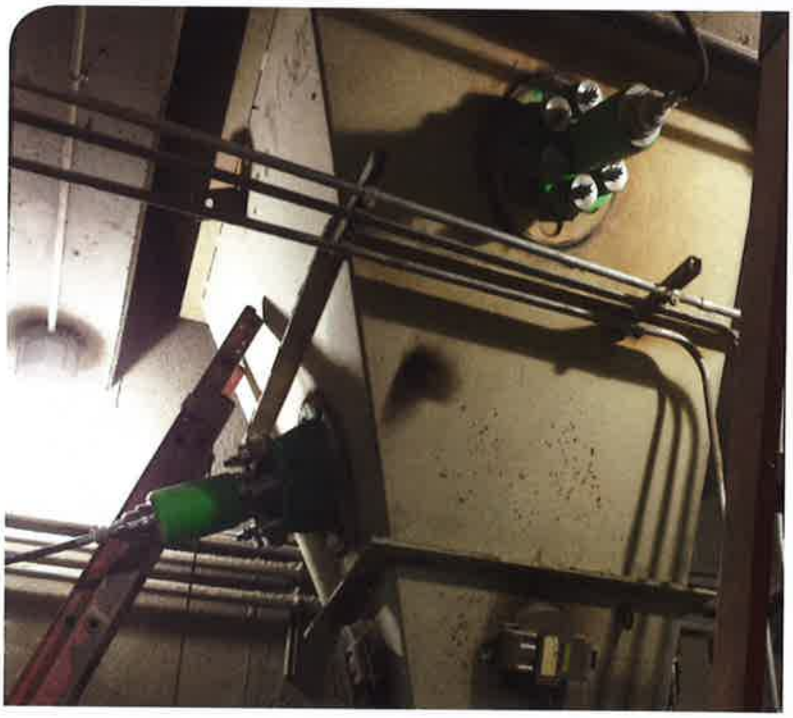
Arnon Fishman, Flow Industries, North America, uses case studies to explore different solutions to prevent buildup and stimulate material flow in storage vessels.

Introduction

The flow problems caused by material buildup in preheaters and coolers can easily cause production process interruption and loss of revenues. Removing these blockages can be both expensive and has the potential for high human risk. In response to this, Flow Industries has developed a solution. While Silo-Flow is used for elimination of blockages and accumulations in all types of silos, hoppers, bins and bunkers, Turbo-Flow is used for preventing material buildups in calciners, riser ducts, cyclones, feed shelves, chutes and coolers. The main feature of both systems is periodical high-pressure (up to 3000 PSI or 200 bar) cyclical and sudden air discharges.



System illustration with components labelled.



Silo Flow installed at Lehigh Leeds, Alabama.

Existing solutions

Air blasters or cannons have long been the standard technology in the cement industry to help stimulate material flow in storage vessels and reduce buildup in high temperature applications, such as preheaters and coolers. The air discharge is supposed to create a useful mechanical process for breaking down buildups and blockages, as long as the compressed gas expands inside the material. For an air cannon to be efficient, two conditions must be fulfilled. First, the maximum pressure amplitude of 100 psi must be sufficient to break down the blockage. In most cases, it is not enough, and to overcome the disadvantage of low power discharges, plants usually need to install a great number of cannons. Second, the vessel material should fully block the cannon nozzle so that it can build a pressure peak around the nozzle while the compressed air has no way to escape. Inside a fully confined space, the compressed gas would expand, exerting the potential energy of the compressed air to work on shifting the material, and hopefully breaking down the blockages. However, this is rarely the case. Bulk material usually has cracks, holes, zones of low density, etc. so a part of the air released by the cannon escapes, causing an immediate drop in pressure and making the entire process inefficient. The situation is even worse for high-temperature applications, such as riser ducts and so on, when air cannons face hard buildups and fail to cope with them almost everywhere.

One method to tackle hard buildups is to convert liquid carbon dioxide into a gas inside a tube that contains a bursting disc at one end. The rapid expansion of gas in the tube breaks the disc and creates a blast outside the tube. The method is mostly used to clean hard buildups in high-temperature facilities and creates only one blast per charge. Unfortunately it has the potential to damage the refractory.

Pneumatic solution

Silo-Flow technology was developed and is marketed worldwide by Flow Industries Ltd. The Silo-Flow™ devices (SFD) are pneumatic devices for the sudden multi-pulse release of compressed air, up to 3000 psi (200 bar), into the plant storage or process vessel, in accordance with the application requirements.

Operation

The system consists of an SFD, a control panel (CP), one or two high-pressure standard tanks and a dedicated high-pressure compressor. The compressor supplies air to the high-pressure tanks, which are connected to the SFD by high-pressure tubing through a normally closed CP valve, so that in standby mode the SFD is not under pressure. The SFD is attached to the vessel wall by a mounting socket, allowing insertion of the SFD nozzle into the vessel. Opening a CP valve and allowing compressed air from the cylinders to flow freely into the SFD can activate the system from the control room, either by stand-alone timer or manually. As soon as the compressed air reaches the SFD, it continuously creates powerful air pulses at the frequency of one pulse per three or four seconds, as long as the air supply is kept 'on'. Each such pulse results in a shock wave, followed by a high velocity air stream. The shock wave and air stream inside the plant vessel dislodge any blockage or buildups inside. The SFD is programmed to 'fire' at predetermined intervals depending on the application. In addition, the air pressure is fully controlled, from as low as 300 psi (20 bar) to as high as 3000 psi (200 bar).

Working principle

The SFD working principle is based on continuous firing, triggered by the incoming high-pressure gas. The pressure of the gas flowing into the device governs the firing power: the higher the gas pressure, the more explosive the firing pulse. In general, the SFD consists of two chambers separated by a piston. When air is fed into the device, the inlet chamber is filled more quickly and has a higher pressure than the pressurised chamber. This keeps the piston in a closed (charged) position. As gas continues to fill the SFD, the pressure in the pressurised chamber increases and becomes close to that of the inlet chamber. Because of the different piston surfaces exposed to the chambers, the piston is eventually forced towards the inlet chamber and opens the discharge ports, thereby releasing the energised compressed air stored in the pressurised chamber. This burst of air is directed into the storage or process vessel through release tunnels alongside the body of the SFD. When the compressed air reaches the vessel and atmospheric pressure inside, the sudden jump in pressure creates an instant shockwave and a strong turbulent air flow throughout the material inside.

Replacing natural gypsum with synthetic

The availability and low cost of synthetic gypsum has enabled cement producers to reduce the demand for mined gypsum. Synthetic gypsum,

Turbo Flow installed at Giant Cement South Carolina.

Turbo Flow results at Buzzi Unicem, Italy.

however, is a cohesive material and has much worse flowing properties than natural gypsum, causing severe flow and operational problems throughout the industry, independent of the gypsum bin design or cover. These flow problems significantly impact productivity, thus preventing the cement manufacturers from replacing natural gypsum with the synthetic alternative.

Like many other cement plants, the Lehigh plant in Alabama tried to replace natural gypsum with synthetic, but experienced severe problems with the flow of the synthetic gypsum in its feeder bins, even though there had been no problem with the flow of natural gypsum. Despite the installed air cannons (several per bin), the gypsum bins would severely clog with the synthetic gypsum, so the plant continued to use natural gypsum, cutting into its profitability. The Plant Engineer was frustrated with the continuous failure to replace it with the synthetic gypsum. When he heard of Silo-Flow™ technology that assured continuous and stable material flow, he decided to try it at the plant.

The plant had the device fire for 25 sec (5 'shots') every 20 min at about half its maximum power (1500 psi). After several trials with various mixtures of synthetic and natural gypsum, they moved to 100% synthetic gypsum. The SFD maintained continuous material flow of 100% synthetic gypsum at all times. The plant benefitted from considerable savings with the move to 100% synthetic gypsum and paid back the investment in less than a year.

Adding water to the mix

Turbo-Flow™ uses the same SFD mechanism, while injecting a small portion of water into the gas blast. The Turbo-Flow™ system creates repeated high impact combined air-water spray that covers a large wall area. Once the air and water supply are switched on, the TFD pulses automatically at a rate of one pulse every 3 – 4 seconds. Typically, the system is activated for 30 – 90 seconds every 30 – 90 minutes. The frequency and pressure depend on the severity of the buildup. Typically each pulse will consume 0.5 – 1.0 litres of water and 200 – 300 litres of air. The air-water spray has a dual action. The first is the sheer impact of the combined air-water mass that hits the wall at a high force, generated by the high-pressure air stored in the TFD and its high-speed release. The secondary action is that of the water droplets 'exploding' into gas on impact with the extreme temperature inside the vessel. This additional energy is released right at the target zone and magnifies the impact. Both actions are less extreme than water-jets, but they are delivered repeatedly and effectively. The TFD can be mounted on any existing or specifically built 6 in. (for TFD-6 model) or 4 in. (for TFD-4 model) pipe and flange. For best results, its internal pipe connects to a heavy duty nozzle that is built into the refractory and points towards the adjacent perpendicular wall. The nozzle may be the same as that used with low-pressure air-cannons.

Solving the kiln feed shelf buildup problems

Buzzi Unicem, as well as many other plants, had experienced severe buildup problems with its preheater feed shelf. These buildups affected process efficiency, raised maintenance expenses, and caused costly process interruptions. As air cannons are known for their inability to cope with hard buildups and Cardox introduced a potential threat of damaging the refractory and safety of personnel, the plant searched for an efficient and safe method to prevent such buildups. The Turbo-Flow™ system was chosen. In order to compare the system efficiency, it was installed on one side of the feed shelf, with an air cannon installed on the other side, and both were activated for a number of months. At the end of the trial, the surface across from the Turbo-Flow™ Device was completely clean, while the surface in front of the air cannon was covered with buildup. The plant installed an additional Turbo-Flow™ Device to replace the air cannon.

Solving snowmen in the cooler

Giant Cement in Harleyville, South Carolina, was experiencing severe buildup (snowman) in its cooler. The plant performed several techniques to try to eliminate the problem, requiring the direct exposure of the operators to the hot materials. The Turbo-Flow™ system was installed at the beginning of March 2015 and the snowman was quickly eliminated when the system was operated. The application can be operated from the control room and can be programmed to work in a fully automated mode. The plant achieved a safer solution that is easy to use and a fast return on the initial investment.

Conclusion

Flow Industries' Silo-Flow and Turbo-Flow technologies could provide a safe, cost effective and environmentally clean solution for the blockage and buildup prevention and cleaning process.