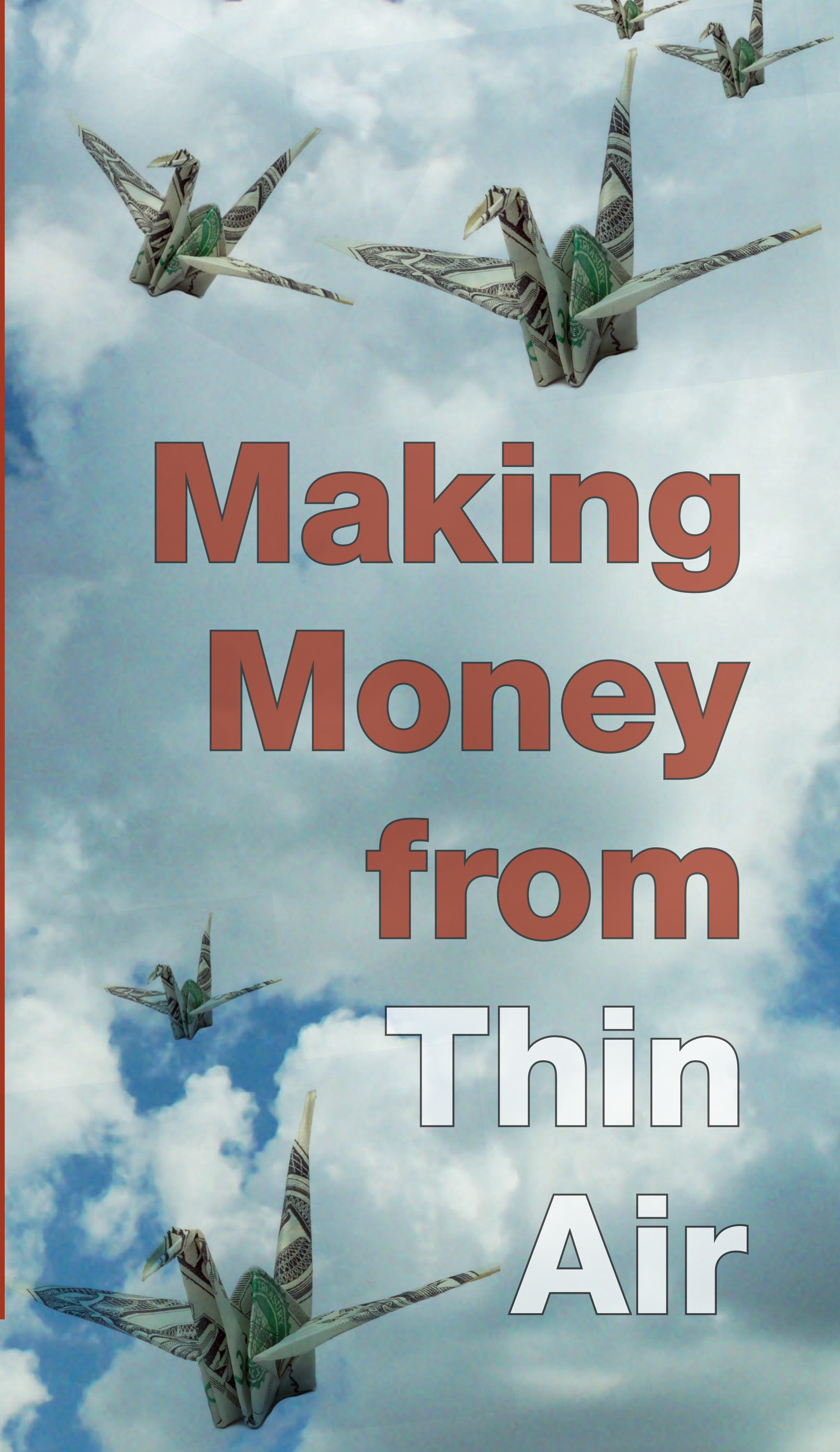
Christopher Schmelzer, Flow Aid Products Manager, Martin Engineering USA,
reveals how reducing the compressed air consumption of air cannon systems can lower energy costs and improve performance.

Making Money from Thin Air



Abstract

Advances in valve technology allow air cannons to operate with lower volumes of compressed air. Adoption of this technology results in an attractive return on investment based on reduced operating costs.

Air cannon application

Air cannons, also known as air blasters or just blasters, belong to a family of products known as flow aid devices. For over 30 years, air cannons have been widely used in industries such as cement manufacturing, electric power generation, coal, metal and non-metal mining, and pulp and paper manufacturing.

Applications for air cannons range from emptying stagnant bulk-material from storage vessels to cleaning high-temperature gas ducts. Air cannon systems have proven over time to be an effective solution to problems in material flow.

In the cement industry, air cannons have found a number of applications, including the elimination of build-ups and blockages in preheater towers at points such as the riser ducts, feed pipes, kiln inlets, and cyclones. They are also used extensively on clinker coolers and in material transfer chutes and storage bunkers.

Figure 1. BIG BLASTER® XHV TORNADO (left) and HURRICANE Air Canons (two on right) installed on a cement plant's primary crusher.

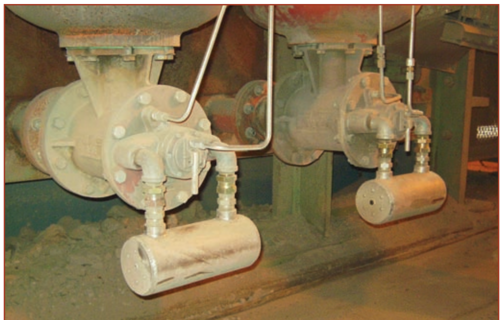


Figure 2. Piston Return Reservoirs installed on BIG BLASTER® XHV TORNADO Air Cannons.

The basics of air cannon operation

In its simplest form, an air cannon consists of a fast-acting, high-flow valve and a pressure vessel, or tank. Work is performed when compressed air (or other inert gas) in the tank is instantaneously released by the valve.

In a typical air cannon application, 700 l (25 $ft.^3$) of free air is compressed to 7 bar (100 psi) inside a 100 l (3.5 $ft.^3$) tank. The air cannon valve is designed so that the pressure of the air supply holds the valve closed, until a solenoid valve releases the holding pressure. When triggered, the fast-acting valve releases this tank volume in less than 300 milliseconds creating a high-magnitude force at the exit of the nozzle that is installed through the wall into the vessel or duct. This force is used to break down build-ups and blockages to improve material or gas flow through the vessel or duct. Different blast characteristics are achieved by varying the operating pressure, tank volume, valve design, and nozzle design.

The general rules of air cannon application are:

- More efficient valve designs deliver higher blast forces.
- Higher operating pressures deliver higher blast forces.
- Larger tanks deliver longer blast durations.
- Nozzles spread or direct the blast to suit the application.

The peak forces generated by an air cannon blast occur during the first few thousandths of a second after the valve is opened. In many applications, high-force output is required to perform the required task. Consequently, the useful energy is released during the initial moments, and the subsequent discharge of compressed air is wasted energy.

The cost of operating air cannon systems

Air cannon systems are most often connected to the plant air system, sharing this compressed air resource with other equipment and processes. In other operations, the air cannon system is supplied by a dedicated compressor. This may be because the plant has no plant air system, or because the air requirements of the air cannons exceed the existing plant air system's capacity. Blast forces vary directly with the air cannon's supply pressure; therefore, an air cannon system's performance suffers when the compressed air system cannot deliver the required pressure and volume.

Compressed air is a relatively expensive source of energy. While it is difficult to know the exact cost of compressed air used within a given plant, the US government estimate from 2000 calculates it at up to US$0.30/1000 $ft.^3$ of air (US Department of Energy Document DOE/GO-102000-0986, December 2000, Compressed Air Tip Sheet #1). Energy costs have gone up in the eight years since that estimate and in all likelihood will continue to rise. It therefore becomes increasingly valuable to find ways to reduce the compressed air consumption of air cannon systems.

For new system installations

Use air more efficiently with advanced valve technology

One way to minimise the use of compressed air is to select an air cannon that uses efficient valve technology. When supply pressures are equal, more efficient valves mounted on smaller tanks can deliver higher blast forces than less efficient valves mounted on larger tanks. This results in a compressed air saving equal to the difference in tank volumes. These compressed air savings are increased further when the operating pressure of the more efficient valve is reduced to the point where it will still deliver the same peak blast force as the less efficient valve.

A real-world example involves two of Martin Engineering's air cannon models: the BIG BLASTER® HURRICANE Air Cannon, which was brought to the market in 2007 and uses the company's newest valve design, produces roughly twice the blast force output while using about half the volume of compressed air; and the BIG BLASTER® XHV design, which was introduced over a decade ago. If the two designs were set to deliver the same blast force output, the BIG BLASTER® HURRICANE design would operate at roughly half the air pressure, further reducing the compressed air consumption to about one-quarter of that of the BIG BLASTER® XHV Air Cannon.

Selecting the air cannon system with the more advanced valve will cost a little more up front, but the air savings will more than pay back the difference over the life of the system.

To upgrade existing air cannon systems

Save air by closing the valve mid-blast

Air cannon systems that are currently in operation may also benefit from new air-saving technology. BIG BLASTER® XHV TORNADO Air Cannons can be equipped with a Piston Return Reservoir that will close the valve after approximately 50% of the volume has been discharged. The Piston Return Reservoir, also known as a "canister", is a pneumatic device that momentarily interrupts the exhaust of the air cannon's quick exhaust valve. This interruption allows the valve's pressure to equalise with the tank's pressure, enabling the return spring to close the piston while the tank is still half-pressurised. The air cannon's peak force is unaffected by this process, meaning that the same amount of work can be done using only half the compressed air.

In other words, when equipped with a Piston Return Reservoir, the air cannon produces an initial blast of the same strength, but the duration of that blast (the aftershock) is reduced. Instead, some air is retained in the air cannon tank, minimising the overall air consumption without reducing the initial output force. Because the air cannon's main air tank never empties completely, the amount of air required to fill that tank after every discharge is reduced.

The performance of an air cannon system before and after the installation of the Piston Return Reservoir is shown in Figures 3 and 4.

Figure 3 shows the force and pressure curves of a typical air cannon blast. The blast force output reaches its peak in the moments just after the valve is opened and is reduced as the tank pressure approaches zero.

Figure 4 shows the force and pressure curves of an air cannon blast using the Piston Return Reservoir (canister). As the canister pressure approaches the tank pressure, the valve is closed with approximately 50% of the original pressure remaining in the tank. The peak force output has remained the same; but the addition of the Piston Return Reservoir has reduced the overall air consumption by 50%. This reduces the drain on the plant air system, and saves the plant money.

The return on investment derived from the compressed air savings by installing the Piston Return Reservoir on a typical BIG BLASTER® XHV TORNADO air cannon system is approximately 18 months. Plants operating standard BIG BLASTER® XHV air cannons can also take advantage of the air savings by upgrading their valves with a TORNADO Exhaust Valve and Canister combination.

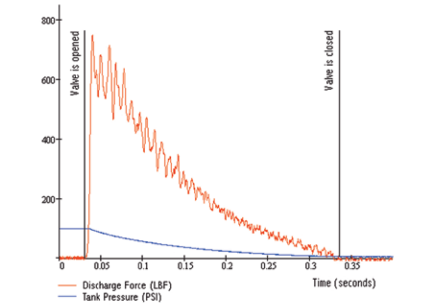


Figure 3. Force and pressure curves of a typical air cannon blast. The blast force output reaches its peak in the moments just after the valve is opened and is reduced as the tank pressure approaches zero.

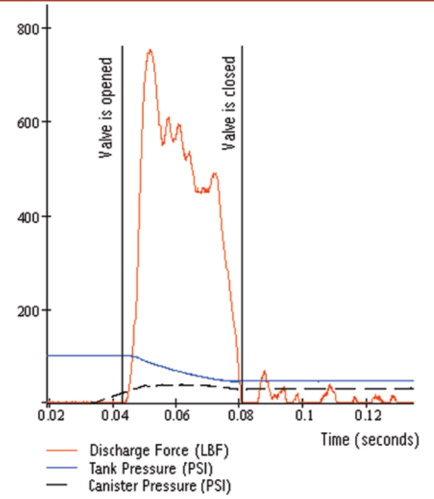


Figure 4. Force and pressure curves of an air cannon blast using the Piston Return Reservoir (canister). As the canister pressure approaches the tank pressure, the valve is closed with approximately 50% of the original pressure remaining in the tank. Closing the valve mid-blast does not affect the peak force output.

An upgrade case history

A midwestern US cement plant operated a system of four BB4-2030 BIG BLASTER® XHV TORNADO Air Cannons on its limestone quarry's primary crusher. This system, which had a fast cycle time of 30 seconds between firings, demanded 7 m^3 of free air per minute (250 cfm) at 6.5 bar (95 psi).

When operating conditions required additional cleaning capacity, four BIG BLASTER® HURRICANE Air Cannons were added to the crusher's system. However, the plant's compressed air system could not support the 35% increase in airflow demanded by the new air cannons, and the system's pressure was reduced to 4.5 bar (65 psi). The force output from the air cannon system was correspondingly reduced by 30%, negatively affecting the cleaning performance of the system. In short, the plant had added additional air cannons, but was suffering reduced performance of the entire air cannon system because of the added air consumption.

To overcome this challenge, Piston Return Reservoirs were added to each of the four original BB4-2030 BIG BLASTER® XHV TORNADO Air Cannons, cutting their compressed air demand by half. As a result, the operating pressure was raised back to 6.5 bar (95 psi), and the force output of air cannons was raised by 30%. This allowed the system to remove the tough material buildups and keep production running smoothly.

Conclusion

To reduce air costs, reduce air consumption

On new air cannon installations, the selection of an efficient valve such as the BIG BLASTER® HURRICANE Air Cannon Valve from Martin Engineering will provide effective material movement with reduced compressed air usage.

To reduce air consumption of the existing air cannon system, without reducing peak output force, the length of the blast can be minimised by installing a Piston Return Reservoir on BIG BLASTER® XHV TORNADO Air Cannons. Other models of air cannons can take advantage of air savings by upgrading with MARTIN® XHV TORNADO Valve and Canister technology.

The benefits of selecting efficient valve technology for new air cannon projects, and of upgrading existing air cannon systems include: reduced energy costs, improved air cannon performance and increased compressed air capacity for other processes within the plant.