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The Power of Acoustic Horns in the Cement Industry

Environmental Services
8800 E. 63rd Street • Kansas City, MO 64133
800-821-2222 • 816-356-8400
www.ge-energy.com/airquality

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Introduction

Acoustic horns have long been used as an effective method for cleaning particulate buildup in baghouses, electrostatic precipitators, and other equipment associated with industrial dust collection. The many different designs and configurations of acoustic horns permit their use in many areas of material handling such as hoppers, fans, silos and ductwork.

Excessive buildup on forced air fans can be minimized or eliminated with the use of acoustic horns. Also the need for sledgehammering and rodding out hoppers can be eliminated by installing acoustic horn(s) in hoppers.

Within the cement industry there are a large number of applications whereby the use of acoustic cleaners would significantly:

- Reduce manual labor cleaning costs.
- Reduce downtime generally throughout the plant.
- Reduce the necessity to shut down dust collectors.
- Generally improve process productivity.

This paper will address the applications in the cement industry where acoustic energy is effective as well as discuss the theory of acoustic horns and acoustic cleaning.

How Acoustic Horns Work

Acoustic horns are air-operated devices that emit low frequency, high energy sound waves. The sound waves are produced by compressed air rapidly entering the sound generator (driver), causing the diaphragm to flex. As the pressure is equalized, the diaphragm impacts the pedestal, generating a sound wave that is then amplified by the horn bell. (See Fig. 1)

The length of the bell is one of the critical factors that determines the fundamental frequency of the horn. The longer the bell, the lower the frequency.

The sound waves generated by an acoustic horn create vibrations that can break apart and dislodge material deposits from surfaces. The vibrations are similar to those created by striking the surface with a mechanical impact. However, with acoustic energy (unlike a sledgehammer) there is no threat of structural damage. The vibrations are powerful enough to break apart heavy concentrations of particulate, but gentle enough to not hurt the surface. Once the material has been dislodged, gravity and/or gas flow removes it.

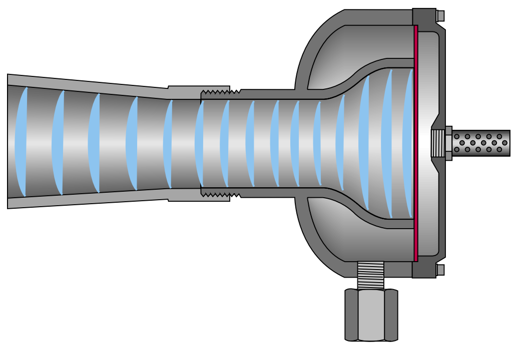

Fig. 1. Generation of sound waves.

The Role of Frequency and Decibels

Acoustic horns are rated by fundamental frequency and decibel level. Frequency is determined by the number of times a sound wave passes above and below a reference line in one second (cycles/second) and determines how large an area the horn will clean effectively. The decibel level is the height of a wave above and below the reference line and determines the power intensity of the horn. (See Fig. 2).

Although it is common practice to evaluate the performance of an acoustic horn based solely on these rating designations, it is important to understand how they work together to determine the cleaning effectiveness of an acoustic horn. Most acoustic horns available today produce more than one frequency (harmonics) when sounding. In general, the stated frequency of an acoustic horn should be its fundamental frequency. This is not necessarily the horn's lowest resonant frequency, it is the frequency at which the majority of the power is concentrated. As a result, it is important to know what percentage of an acoustic horn's output power (decibel) is at and/or near its rated fundamental frequency for accurate evaluation.

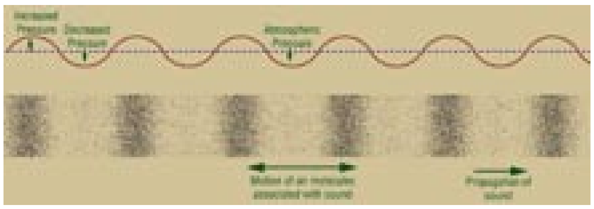

Fig. 2. Fundamental Frequency and Decibel

An important aspect of acoustic frequency is that the intensity (dB) level will be reduced by 3 dB after each complete sine wave (the higher the frequency, the lower the decibel level). This explains why a lower frequency acoustic horn will produce a higher total power output. Thus, the lower the frequency, the more effective a horn will be at dislodging dust.

Decibel levels are also critical for good acoustic performance. For example, increasing from 120 dB to 140 dB is only a 17% increase in decibel level. However, this modest decibel increase provides a 10-fold increase in total acoustic power. In most applications, the horns that provide the best performance are those with low frequency and high decibel levels.

Horn Installation and Operation

Acoustic horns are easy to install. The majority of the installation cost regarding acoustic horns is in the plumbing. This involves running air lines to the horns and making electrical connections to the solenoid valves used to automate the acoustic horns.

Acoustic horns operate on standard plant air. Typically, an acoustic horn will sound for 10 seconds every 10 minutes. At a normal volume of 60 SCFM, this equates to an average air consumption of just one SCF per acoustic horn per minute.

One of the best aspects of an acoustic horn from a maintenance standpoint is that a horn has only one moving part, a titanium diaphragm (see Fig. 3). The diaphragm is housed in the sound driver and has a useful life of more than three years. When required, the diaphragm is easily replaced by removing the cover plate of the driver.

Acoustic Horns in the Cement Industry

Acoustic cleaning promotes material flow in the following areas of a cement operation:

- Pre-heaters
- Calciners
- Silos and hoppers
- Kiln area
- Cyclones
- Precipitators
- Baghouses
- Tankers
- Ships
- Bucket Elevators

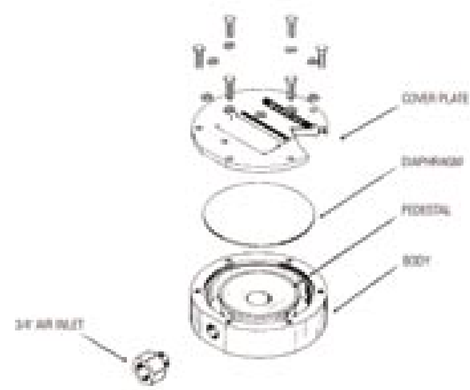

Fig. 3. Components of an acoustic horn driver.

Pre-heaters and Calciners - Acoustic cleaners can be employed to ensure trouble-free material flow and prevent blockages in the interconnecting ductwork and cyclones.

Silos and Hoppers - Blocked silos, bins and ductwork cause major plant shutdowns and loss of production in the cement industries. Manually unclogging these obstructions is dangerous, time consuming, and costly as it usually involves operators entering the silo or hopper to break up blockages.

Common types of clogging which occur in silos and hoppers include arching, ratholing, bridging, and sidewall buildup (see Fig. 4). Acoustic horns are particularly applicable within the aerated blending silos. The benefits include the following:

- Even material flow.
- Ensuring "first in - first out" principle.
- Providing a consistent blend of raw materials.

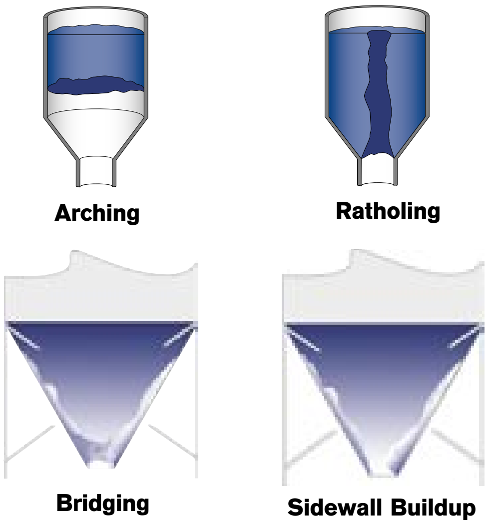

Fig. 4. Common types of material flow problems in silos and hoppers

Typical frequencies employed with acoustic horns are in the 75 to 360 Hz range, which do not cause any structural damage in steel or concrete structure.

Depending on the model of acoustic horn, the effective cleaning area ranges from 10 ft. to 45 ft. (1 m to 30 m). The low frequency, high-energy sound waves that are generated create pressure fluctuations within bridges or plugged materials. This resonance removes build-up from the surfaces to which they have become attached and bonded. The material falls away and is discharged normally, or is carried away pneumatically to the next part of the process.

Acoustic horns applied in silos and hoppers are both effective and efficient. When introduced into a process as an integral part, acoustic horns can eliminate plant and process stoppages caused by blockages. Unlike compressed air employed by air cannons, sound waves do not take the path of least resistance, they bounce around and can consequently clean the vessel's vertical walls and roof. Acoustic horns cause no structural damage and there are no fire or explosion risks involved. (See Fig. 5)

Utilizing an automatic cycling operation for the acoustic horn is one way of ensuring that particle buildup is eliminated. This can be achieved by using a timer connected to a normally closed solenoid valve. This timer should have "on" intervals of 0 to 30 seconds with a repeatable delay for optimum performance.

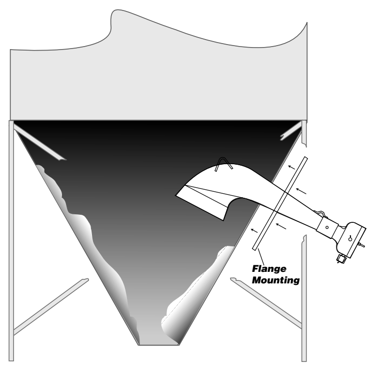

Fig. 5. Baghouse hoppers can be kept clean and free of blockage by using acoustic energy to dislodge dust.

Case Study
Cement Producer • Midlothian, TX
This cement producer was experiencing excessive moisture in their production process which resulted in a hard cake buildup on the main inlet wall of their finish mill baghouse hopper. Once every month over the period of an eight-hour shift, two employees would have to mechanically remove the buildup from the inlet wall.

A D-230 Powerwave® acoustic horn was installed near the main inlet of the hopper. Within 90 days of horn use, the company reported no buildup on the main inlet wall of the hopper.

The compressed air source required for the horn's operation was inadvertently turned off at one point following the first 90 days of operation. This brief interruption of the horn's service resulted in immediate buildup on the main inlet wall of the hopper. The customer reported that the return of buildup while the horn was not in use provided undisputed evidence of the horn's success.

Kiln Area - Acoustic horns can also be employed at the flame inlet area to prevent material buildup. A single acoustic horn can replace the multitude of air cannons typically found at the grate cooler infeed section. Remember, unlike air cannons, an acoustic horn actually prevents the occurrence of buildup and continually aids hot material flow, thus maximizing efficient cooling linked to even bed depth.

Cyclones - Cyclones present severe cleaning problems due to their inaccessible locations. By installing a suitably-sized acoustic horn, not only is particulate buildup eliminated, but continuous cleaning is also achieved.

Inducted draft fans - Blockages and material buildup causing fan imbalance can be eliminated by the installation of acoustic cleaners, especially on long dry kiln systems. The cost is soon repaid many times over by eliminating the need for costly kiln shutdown in order to clean and maintain these fans.

Precipitators - Precipitator cleaning involves the use of mechanical rapping systems. However, these can be expensive to maintain and cause damage to the plates, yet do nothing to prevent hopper pluggage and result in opacity spiking. Acoustic horns are now employed to replace rappers in many instances. (See Fig. 6) In addition to thoroughly cleaning the plates, frame and walls, they eliminate hopper pluggage. The benefits of acoustic cleaners in precipitators are as follows:

- Continual prevention of particle buildup
- Better overall cleaning
- No mechanical stress or damage
- Elimination of hopper pluggage
- Elimination of opacity spiking

Fig. 6. Powerwave® acoustic horns cleaned the internal components of this precipitator so well, the plant stopped using the conventional tumbling hammer.

Baghouse - Acoustic horns are used in baghouse applications to reduce differential pressure and extend filter bag life. (See Fig. 7) A high differential pressure drop across the baghouse is caused by airflow restrictions through the bag fabric. These flow restrictions, the result of small dust particles joining together, create a large mass disrupting airflow through

Fig. 7. Powerwave® acoustic horns can be chain-hung inside baghouses to provide effective cleaning of filters, without the abrasion and flexing.

the bags in both directions, thus preventing complete bag cleaning. Unlike reverse-air flows, acoustic energy does not take the path of least resistance. Powerwave® acoustic horns vibrate the bag and any accompanying particulate buildup, no matter where or how severe. Low frequency sound energy vibrates the bag surface where material adheres and also breaks the bond that binds agglomerates together. This enables the dust particulate to fall from the bag, and the reverse-air flow to penetrate the bag where it could not before. Consequently, the filtering airflow sees less resistance, allowing a lower pressure drop and more uniform air-to-cloth ratios along the bag. This will also help to eliminate premature bag failure cased by high airflow directed to the flex lines or where the least flow restrictions exist. (High airflow will cause premature bag failure in these zones due to their "sandblasting" effect.)

Case Study
Florida Crushed Stone

This cement plant in Florida has a 14-compartment, 933,000 acfm reverse air baghouse which vents a cement kiln, a raw mill, and a plant operated coal fired boiler. The ductwork from the various pickup points (cement kiln, raw mill, and coal fired boiler) did not have separate dampers to permit controlled airflow. In addition, the reverse air fan was not large enough to properly clean the filter bags effectively, which caused a lack of air in the overall system. With the various processes being starved of air, plant production was hindered.

Four Powerwave® D-75 acoustic horns were mounted on the top of each baghouse compartment (above the bag caps), for a total of 56 acoustic horns. (See Fig. 8) With this location, the customer can troubleshoot and maintain the acoustic horns without taking the unit off-line. In fact, the customer was saved a full week of production time during the horn installation because the horns were installed on-line.

Since the D-75 acoustic horns were applied in 1999, the overall differential pressure has decreased from about 8.5 in. w.g. to 4.5 in. w.g., and the reverse air fan has been eliminated. Since the installation, production at the plant has exceeded original plant specs.

Fig. 8. Powerwave® acoustic horns mounted on the top of baghouse compartments.

<u>Bulk Tankers</u> - By placing a suitably-sized acoustic cleaner in one of the multi-top hatches during filling, the high-energy sound waves eliminate "peaking" and densify the load, thus providing the opportunity to gain up to 10% additional pay load.

<u>Ship Holds</u> - There has never been an acceptable, easy, or efficient method to clean the walls in ship holds which carry bulk cement. A properly designed acoustic cleaning system provides removal and rapid cleaning of these cells in a very effective manner. The special titanium diaphragm is flexed by the sound waves tuned to the selected frequency by a range of specially designed cast catenoidal shaped horns. Cleaning is rapid and total with the material falling into the floor for easy removal.

<u>Bucket Elevators</u> - Acoustic horns applied in bucket elevators provide more efficient pick-up and transfer of material by keeping the buckets, belt, and pulley clean. This ensures

that full loads can be picked up by the buckets and transferred to the next step in the process without interruptions due to buildup.

Conclusion

This discussion has highlighted a number of the primary applications of acoustic horns in the cement industry (see Fig. 9), but is by no means definitive. Acoustic horns are available in many shapes and styles for the various applications mentioned.

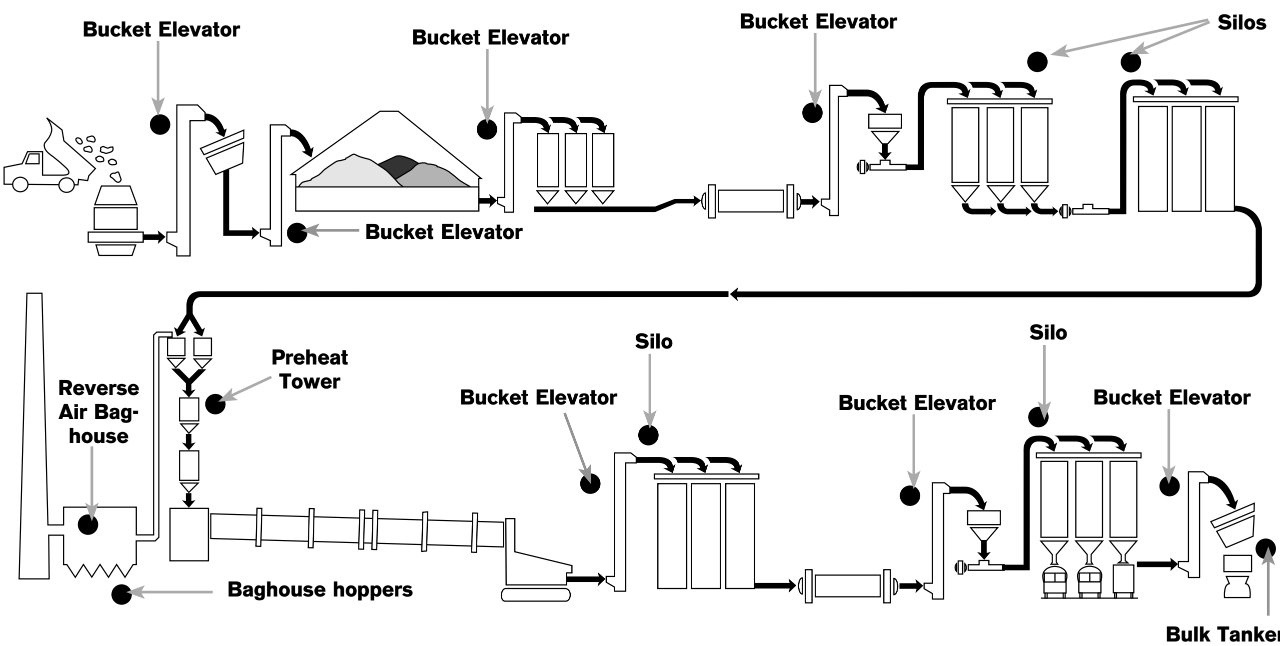

Fig. 9 Typical applications of acoustic horns in the cement process.