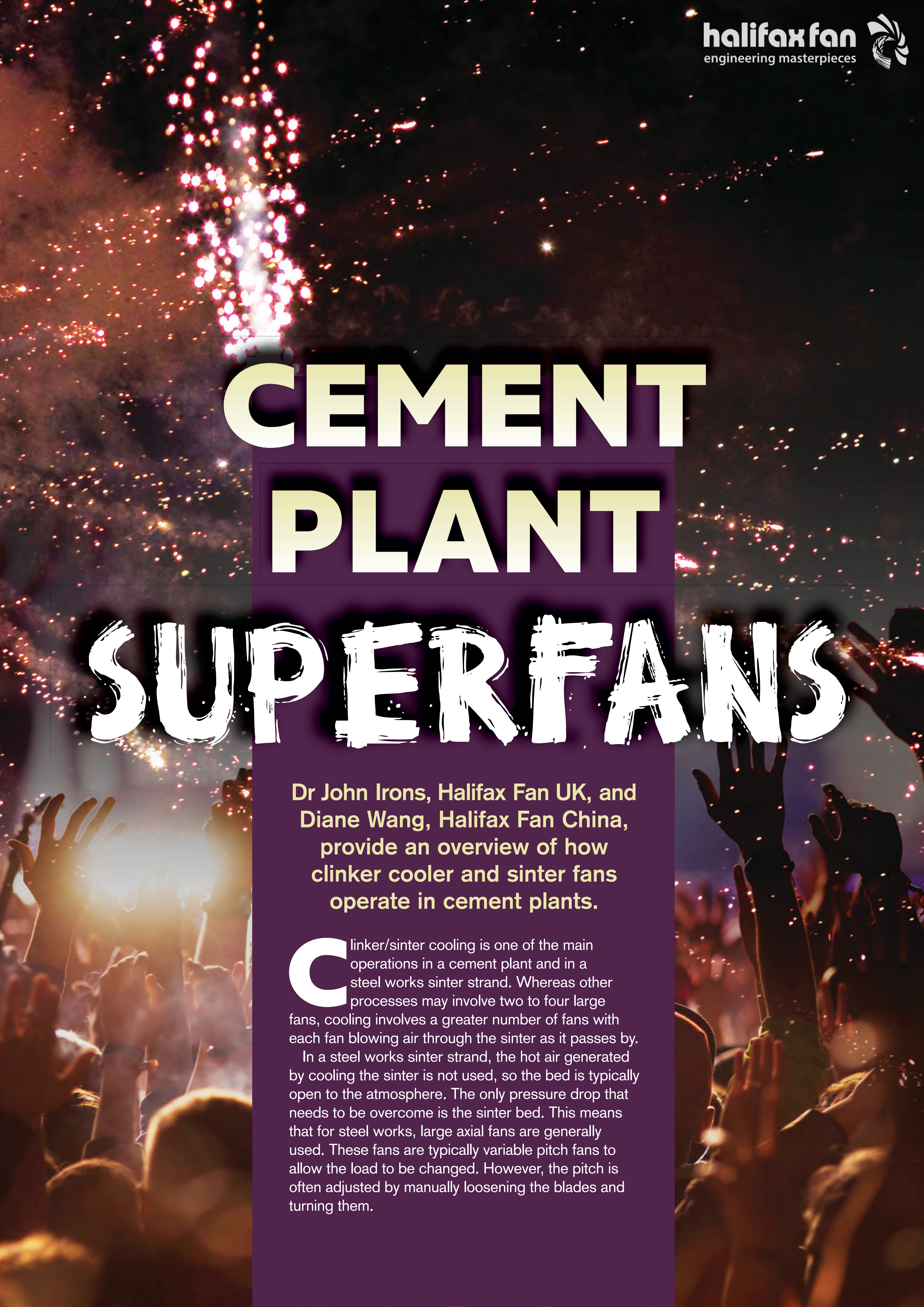


CEMENT PLANT SUPERFANS

Dr John Irons, Halifax Fan UK, and Diane Wang, Halifax Fan China, provide an overview of how clinker cooler and sinter fans operate in cement plants.

Clinker/sinter cooling is one of the main operations in a cement plant and in a steel works sinter strand. Whereas other processes may involve two to four large fans, cooling involves a greater number of fans with each fan blowing air through the sinter as it passes by.

In a steel works sinter strand, the hot air generated by cooling the sinter is not used, so the bed is typically open to the atmosphere. The only pressure drop that needs to be overcome is the sinter bed. This means that for steel works, large axial fans are generally used. These fans are typically variable pitch fans to allow the load to be changed. However, the pitch is often adjusted by manually loosening the blades and turning them.

Cement clinker is much hotter than steel sinter when it exits the kiln, being up to 1450˚C. This is cooled down to about 150˚C. In addition, the clinker must be cooled rapidly to retain its quality. These aspects mean that air must be rapidly forced through the clinker. In addition to this, there has been a trend towards using high pressure grates to make the cooling flow relatively independent of the clinker bed. This also helps to keep the grate cool. The high temperature additionally means that heat recovery is required, its principal uses being pre-heated air in the kiln and in the pre-calciners. The result is that cement clinker cooling fans are typically centrifugal fans. The fans at the start of the process are higher pressure/lower flow and those at the end of the process are higher flow/lower pressure.

A pair of cooler fans ready to ship in the factory.

Clinker fan installed close to clinker cooler wall.

When obtaining new cooler fans, aspects such as higher efficiency, duct layout, bearing selection, noise and flow measurement should be considered to ensure that the new solution is better than the current solution.

A more efficient fan

Traditionally, fans were made by platers drawing out patterns on plates, cutting out the patterns and then welding the plates together. Blade angles would be measured and marked with the quality of the impeller, which was highly dependent on the skills of the plater. Today, fans are laser cut. The backplate has slots and tabs, ensuring that the blade angle is correct. A parallel topcone can also have slots and tabs, ensuring an accurate impeller construction.

The inlet eye of a centrifugal fan has a gap with the inlet cone. If this gap is incorrect, the leakage air can blow across the impeller, preventing the inlet air from filling the impeller. If the leakage air is in the optimum range and is guided up the topcone, it can help the air to fill the impeller. Optimum leakage air gives better performance than both too little and too much leakage air. Wider impellers can be more efficient because they have less of a leakage air effect. However they present two problems for cement production:

- They have a wider stall region and stronger stall, so do not have a large flow turndown.
- The pressure/volume characteristics of the fans are only suitable for the low-pressure end of the coolers.

Halifax Fan has focused its development of fans for the cement industry on medium width fans with a parallel topcone to ensure that the geometry is controlled during production, with slots and tabs on both the backplate and topcone. In order to ensure that the impeller is filled with air, the inlet eye is machined. These fans are the CSTC, MeSTC and MeNSTC. Using a combination of two pole, four pole and six pole selections, it is possible to cover the entire range with these designs.

Some cement plants avoid two pole fans for clinker coolers. This ignores the modern trend towards high pressure grate beds, which give a more stable load to the fans. Since narrower fans tend to be even less efficient, the concern is more correctly addressed by ensuring that the fan operates well below its peak pressure.

The benefits of improved fan manufacturing techniques and designs can be seen in Table 1, which gives selections obtained for a clinker cooler application. The average efficiency is 86.2%, much higher than the average efficiency of 75% or less typically measured with old fans.

Think about the ducting

The angle of the walls are important when it comes to duct expansion. Studies have shown that if the angle is close to 15° then the flow will separate from the wall. Once the flow has separated, there will be recirculating flow between the flow stream and the duct wall. This recirculating flow prevents the flow re-joining the wall, which results in flow maldistribution in the duct and, just as importantly, results in a large loss at the expansion.

Ducting is usually sized for flow, with 20 m/s being a typical maximum. There is also a desire to have ducting with an aspect ratio of two or less. The traditional approach to clinker cooler fans was to use narrower width fans, especially for the fans at the start of the clinker cooler. Often little consideration was given to expansion losses, which would result in a rapid expansion from the narrow fan to the main duct.

More efficient fans can have wider casings. If no consideration is given to the ducting, this can result in the new fan having a contraction fitted to the discharge followed by the original rapid expansion. Table 2 gives losses calculated for a fan installation that was problematic.

Losses of 10% and 34% are very high. The higher loss was from a simple duct with a very rapid expansion, so could be easily fixed with a quick payback.

Getting the bearings right

The simplest fan design has the impeller mounted off the motor and, in many applications, this is possible even for relatively large fans – up to 1.5 m impeller diameter. However, cooler fans tend to have a separate bearing/shaft unit. The two types of bearing units used are bearing cartridges and separate bearing housings, and plummer block bearings.

With bearing cartridges, both bearings are in the same housing. With modern CMM measurement and CNC machining, it is relatively easy to ensure that both bearing recesses in the housing are concentric with each other, ensuring a long operational life. If the bearings are grease lubricated, the cavity between the bearings acts as a store for used grease. Halifax Fan has experience of fans running for 20 years with the original bearing unit and the cavity still being nowhere near full. The bearing types used for bearing cartridges are typically deep groove ball bearings (DGBB) and roller bearings (RB).

With plummer block bearings, and even with a machined pedestal, the concentricity between the bearings is not as good as with a bearing cartridge. This means that self-aligning bearings must be used. The self-aligning bearings used are spherical roller bearings (SRB) and self-aligning ball bearings (SABB). These are double roller and double ball bearings, so typically have a higher load-carrying capacity than deep groove ball bearings and roller bearings. However, a higher load-carrying capacity is not always good. If the bearing is too lightly loaded it can cause excessive skidding. The main problems with excessive skidding are vibration and reduced bearing life.

The risk of skidding is higher with taperlock bearing fittings as these make the bearings at least one size larger. For overhung fans, the bearing most at risk of being too lightly loaded is the fan drive-end bearing.

For bearing cartridges, the space in the middle can act as an oil reservoir. These are available with both oil and grease lubrication. Plummer blocks require a housing with an oil reservoir, so are not as readily available with oil lubrication. Although oil lubrication allows lighter bearing loading, with simple seals, oil has a tendency to leak. This means that specialist seals are now usually used with oil lubricated bearings. The oil leakage issue is an environmental issue. This means that even for larger fans, companies are moving away from oil lubrication, especially in the environments in which cooler fans are used. Halifax Fan is currently working with a customer to change sinter cooling axial fans from oil lubrication to grease lubrication. In addition to this, having reviewed the bearing loads, the bearing size has been reduced to improve the bearing load and extend the bearing life.

The right sound

Legislation in most countries has 85 dBA as the target level. In Europe it is 80 dBA. Many older plants have had fans installed with limited consideration to the noise. When fans are being replaced, there is an opportunity to survey the current installation and to assess what is required from new fans. This survey would be able to account for local and global effects:

← Local effects: Against a wall, the noise has 50% less propagation area, giving a 3 dB increase in

Table 1. Table showing the benefits of improved fan manufacturing techniques and design.

Fan	Pole speed	Total efficiency (%)
K11	2	86.2
K12	2	83.7
K21	4	87.2
K31	4	87.2
K41	4	86.2
K51	6	86.6
K61	6	86.3
K71	6	85.9
K81	6	86.5
K91	6	86.5

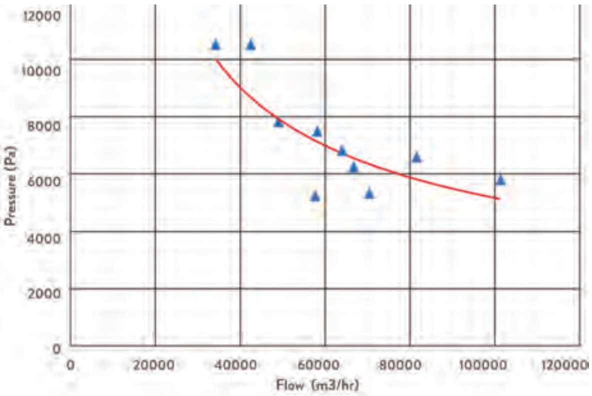
Table 2. Losses calculated for a problematic fan installation.

Fan pressure rise (Pa)	Expansion (Pa)	Losses (%)
10 104	259	2.6
6970	781	11.2
8783	2954	33.6

sound pressure. Against a corner the increase is 6 dB.

- Global effects: The relative size of the fan compared to the area and the sound absorption of the area affects noise levels. Ducting, other fans and walls prevent noise propagation.

Sinter fans are normally installed outside, surrounded by other sinter fans, ducting and sheet metal walls. There may also be a roof. This can result in significantly higher sound levels than the free-field predictions, with increases of 10 dB being possible. For example, a predicted free field sound pressure level of 85 dBA can give over 95 dBA on site.



Fan duties for clinker cooling.

Table 3. Table showing the benefits of sound survey carried out to rank sound sources.

	Sound power (dBA)	
	37 Hz	**50 Hz**
Inlet duct	102.2	108.8
Fan case	103.7	110.1
Motor	106.1	110.4
Discharge duct	107.5	113.1

Group of cooler fans installed and anti-vibration mounts with new foundations.

The sound survey should aim at deriving free-field sound pressure requirements or breakout sound power requirements. This is because a fan manufacturer will have only limited knowledge of the installation, so will quote one or both of these values only. Free-field is the sound pressure that would be measured if the machine was run in a large open field.

With cooler fans, there is not only casing break-out noise to consider. There can be significant inlet sound and duct breakout noise. The cooler chamber can also radiate noise from the fans. Reducing breakout noise usually means increasing the thickness and/or lagging. Unfortunately, situations do arise where the duct treatment does not match the fan treatment and the ducting becomes the major noise source. The end user can note what is being done with the fan and design the ducting accordingly.

A recent enquiry was made regarding two exhaust fans on a process. The fans were supplied unlagged with unlagged ducting. The question was asked as to what could be done to reduce the fan noise that was at 100 dBA. In order to assess the benefits of sound treatment, a near field sound survey was carried out to rank the sound sources. The results are given in Table 3.

From the source ranking it can be seen that the biggest sound contributor is the discharge duct, but that both ducts, the fan casing and the motor need treating to meet 85 dBA. This survey highlights the importance of considering more than just the fan when assessing noise levels in an area.

Cooler fans are often fitted with an inlet silencer and lagging/cladding to reduce the noise. Smaller fans usually have a round inlet silencer. Larger fans would have a baffle type silencer. The baffle type silencers can be quite large and it may not be possible to fit one in the available space. Therefore, the design of the silencer and other options need to be considered. In addition to a silencer, treatment of reflecting surfaces whether inside or outside the fan can be used to reduce the silencer requirements. By carrying out a detailed review of a cooler fan application, Halifax Fan was able to reduce the inlet silencer height substantially to fit within the available headroom. ■

About the author

Dr John Irons has had over 25 years of fan design and development experience, having joined Halifax Fan in 2015 as the Chief Engineer from Howden Group Technology. He has extensive experience of fan design, including noise, vibration and fluid dynamics.

Diane Wang joined Halifax Fan China in 2007 and has worked closely with customers to drive product development through providing solutions to customer needs. She is now the Manager of the Shanghai office, with a key focus on serving the cement industry. Last year Diane received her MBA from the University of Liège, Belgium.