Particulate control options

Particulate emissions control has become an intrinsic part of cement plant operations. To address the changing needs of particulate control in cement kilns and emissions system performance, Babcock & Wilcox MEGTEC explains how a multifaceted approach can help achieve environmental compliance.

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Particulate emissions control is one of the most important requirements when manufacturing clinker. While electrostatic precipitators (ESPs) have been a very common means of control to date, several factors are now driving cement producers towards pulse jet fabric filters (PJFFs), as outlined below.

Tightening regulations

Increasingly stringent regulations are driving down particulate emissions to levels in the 20mg/Nm^3 range (0.08kg/t of clinker for most dry or semi-dry processes). The requirements become even more stringent when hazardous fuel sources are utilised. It is not uncommon to see specific emission limits on arsenic, cadmium and lead. Since these metals are enriched in the fine, sub-micrometre particulate fraction, collecting them at high control efficiencies presents a greater challenge to ESPs compared to PJFFs.

Often, regulators treat particulates as surrogates for trace metals and ratchet down the particulate emission requirements even further. It is not unusual, for example, for there to be emission requirements below 10mg/Nm^3 levels at cement kilns co-firing hazardous waste with conventional fuels, such as coal, oil or gas.

Integral equipment

An increasing focus is on higher availability of pollution control equipment. More and more, emissions control equipment is treated as an integral part of the plant's kiln system.

Exceeding the required emission limits is not as permissible as before. Even when some exemptions during start-up and shutdown are allowed, kiln operators are required to show considerable documentation to ensure best practices are being followed from start-up through full load and shutdown.

Pulse jet fabric filters for controlling particulate emissions in cement kilns

Risks of explosion

There are risks of ESP explosions, even from a single spark or arc when carbon monoxide (CO) concentrations exceed 0.5 per vent (largely during start-up) inside the ESP. To mitigate these risks, operators employ continuous, fast-acting CO monitoring and feedback control systems to the ESP. Such systems allow for the de-energising of the ESP in advance of developing potentially explosive situations. De-energising of the ESP results in the release of considerable amounts of particulate matter already held on the ESP collector plates. If the high CO situation lingers longer than desired, the continued particulate emissions from kiln gases can become objectionable. In several countries such peak emissions are being increasingly disallowed.

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The dry-process factor

The migration from wet- to dry-process technology has made the process of particulate collection more difficult for ESPs. The reduced flue gas moisture levels have increased the cement kiln exhaust particulate resistivities beyond the 10E10 ohm.cm range where optimum collection efficiencies can be achieved.

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Unless moisture is added and the flue gas temperature is reduced (not always possible), the higher dust resistivity of the particulate will limit the ability of the ESP to accept the needed corona power. The required residence time in the ESP may need to be increased by a factor of four in order to achieve the new, lower outlet emission requirements. Even if ESPs can achieve these requirements, however costly, the persistent issues related to peak particulate emissions from the ESP during its de-energising mode can remain objectionable.

The discussion that follows focusses on emissions from the kiln and on the choices available to the plant operator when considering a baghouse.

Modern particulate control approaches

The drive to find better options for reliable particulate control has led to the following approaches for existing cement kilns:

- addition of all new PJFFs
- converting an existing ESP with a PJFF
- partial replacement of ESP fields with a PJFF.

Addition of all new PJFFs

The footprint required to replace an ESP with a baghouse can be a deciding factor. The footprint for PJFFs is 30-40 per cent smaller than that of reverse gas fabric filters. A major advantage of replacing an ESP with a baghouse is the ability to complete the baghouse installation while the cement kiln is online. The downtime necessary to make the required tie-ins before start-up and commissioning will be relatively short compared to the other options.

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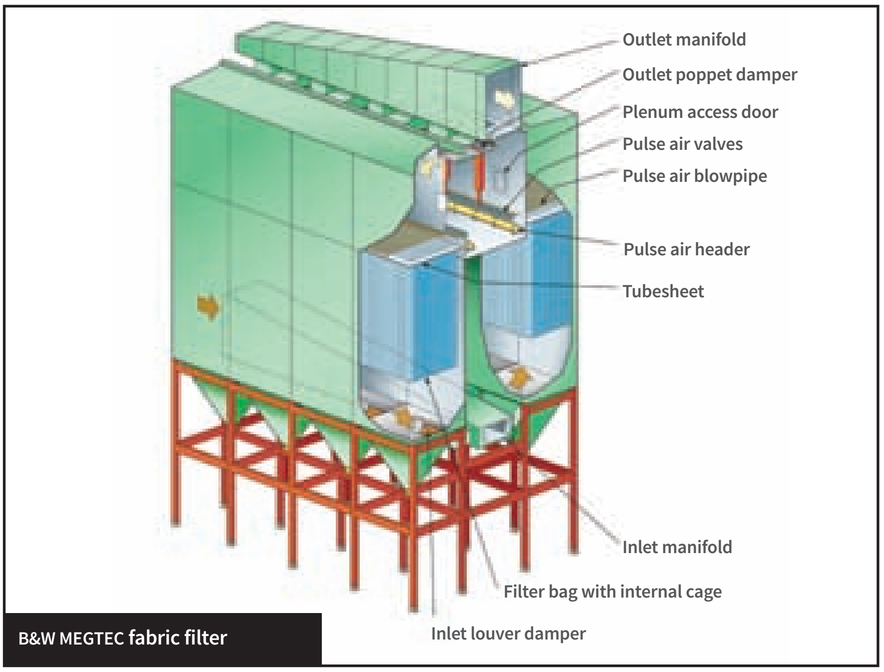

B&W MEGTEC fabric filter

Existing ESP plus new PJFF

The addition of a PJFF may necessitate the addition of gas conditioning to reduce the inlet temperature to the PJFF. If the plant operator wishes to utilise the existing ESP and follow it with a PJFF, it is possible to reduce both the capital and operating costs of the new PJFF. The relatively-low loadings entering the downstream PJFF allow for a more compact design.

For example, the gas-to-filter cloth (G/C) ratio can be increased by 30 per cent to 50 per cent if the PJFF sees a much lower inlet dust loading. Another advantage is that the ESP can be temporarily de-energised to manage high CO situations, and therefore let the baghouse temporarily handle peak dust loadings during these periods. However, it is important to design for adequate compressed air usage to effectively clean all the bags, and possibly at higher cleaning pressure, to deal with this temporary higher loading.

Complete conversion of existing ESP with a PJFF

If the existing ESP cross-section and height are adequate to install a conservatively-sized new baghouse, a proven approach is to remove the ESP internal collection

Figure 1: complete conversion of existing ESP with a pulse jet fabric filter

plates and discharge electrodes and install new outlet plenums with tube sheets, isolation dampers and a new outlet manifold. Since the ESP weights are generally considerably heavier than those of a baghouse, it is possible to retain the existing foundation, support structure, casing walls, hoppers and dust-handling equipment.

It is important to note that early verification is needed that existing ESP casing walls and hoppers are in good condition. In most cases, it is assumed and then confirmed that the existing casing walls and hoppers are in good condition and then verified, before converting the ESP to a PJFF.

Figure 1 demonstrates such an approach. It shows a large PJFF under construction, replacing the existing ESP at a power plant. The gas volume to be treated by this PJFF is large, exceeding 3MNm³/h. In this example, it was possible to fit the new PJFF with a conservatively sized 1m/min G/C ratio, because the existing ESP was large enough to accommodate a complete conversion.

Figure 2 shows it was possible to easily fit the 8m longer bags in a total of 10 compartments, each accessible through isolatable, man-safe dampers for maintenance and bag replacements, while staying within the structural load points of the existing ESP. The baghouse performed at particulate emission levels below 5mg/Nm³ with PPS felt. It should be noted, the fly ash was cohesive enough (accompanied by lower temperature and higher moisture) to allow for efficient cake-based "depth filtration" without the need for more expensive expanded PTFE membranes. As discussed later, the cement kiln application demands additional discussion.

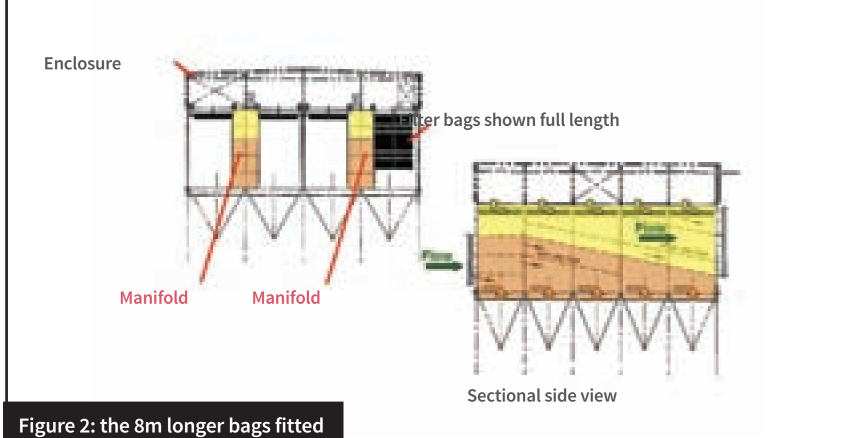

Figure 2: the 8m longer bags fitted in a total of 10 compartments

Partial conversion of existing ESP with a baghouse

A relatively-friendly environment for project execution will not be always available. If the cement plant has severe space constraints, it may be necessary to explore the opportunity for a partial conversion of the ESP to a PJFF.

Fundamental research supports the observation of lower pressure drop across the PJFF, even at higher G/C ratios, following an ESP. There are residual charged particles entering the PJFF from the ESP and the dust cake appears to be packed in a more organised manner due to charge polarisation effects, compared to uncharged particles. However, larger particles are collected in the first fields, which reduces load to the PJFF. This phenomenon is observed even though PJFFs now see a much finer particle size distribution from ESPs.

The 'packaging' of baghouse components inside the existing casing is both an engineering and process challenge, along with the project management challenges of completing work within the timeframe of the scheduled plant outage. In addition, there are several attractions that must be avoided to enhance project success. These include:

• Going too high in the G/C ratio simply because fewer bags can be fitted within the existing casing.
- G/C ratios higher than 1.3-1.5m/minute will present several challenges as described below.
- If local peak gas velocities within the baghouse cannot be controlled, an unusually more frequent rate of bag failures and persistent higher pressure drops can be expected. This can be especially true if you are forced to specify bags made of fibreglass to handle high kiln exhaust temperatures. Fibreglass media flex much less than felt, and therefore, are more prone to failures.

• Going to bag lengths more than 10m.
– It is tempting to reduce the G/C ratio within a given ESP casing by going to taller bags.
– As discussed above, if proper attention is not paid in the selection of filter media and the G/C ratio, keeping the bags clean can become more challenging. To manage dust build-up, the operator often triggers a more energetic and frequent pulsed jet cleaning cycle. As a result, bag failures will be invariably more frequent. To minimise the need for more aggressive cleaning and to increase bag life, it may be necessary to consider the more expensive expanded PTFE (ePTFE) surface treatment on fibreglass. Another major advantage of ePTFE is that it can ensure emission levels below 5mg/Nm³.

• Not adequately designing the baghouse for online replacement of bags.
– Due to the reasons noted above, the need for bag replacement must be anticipated. A very small number of bag failures can lead to permit violations. Cement production can also suffer due to mandated load reductions if in the quest for partial conversion of the ESP to PJFF, the operator is unable to maintain the baghouse for high availability of equipment at the required emissions limits.

• Not seeking an overall system solution for emissions control.
- Operating temperature of cement kiln exhaust gas can vary considerably from plant to plant, and during various levels of clinker production. In some cases, the kiln exhaust can exceed 260˚C, considered the maximum temperature for commercially available filter media in the kiln application. Therefore, it may be necessary to use an evaporative gas cooling system with high-performance dual-fluid nozzles for efficient water droplet evaporation, together with a responsive process control philosophy to maintain a consistently favourable kiln exhaust gas temperature entering the PJFF.

In applications where hazardous waste combustion can produce dioxins and furans (D/F), it will be necessary to rapidly cool the gas below 200°C through an evaporative gas cooling solution to control D/F within maximum permissible limits. ■