Balancing the Costs

Armin Möck, Lechler GmbH, Germany, explains why a spillback nozzle injection system can create energy cost savings.

Introduction

In the second half of the 20th century, nearly all dust emissions from cement, lime, steel, power and other plants were reduced by installing dust filtration systems. The most efficient and common way to separate the dust from the hot gas at that time was to use electrostatic precipitators (ESPs).

Many hundreds of ESPs have been built worldwide in recent decades. For high dust separation efficiency in the ESP, a certain level of gas humidity is essential. Gas conditioning towers (GCT) were introduced for this purpose, where water is injected and evaporated to cool down the gas and to increase humidity.

Today, most of the ESPs built in this period are still in existence worldwide, but some were replaced by baghouse filters. Today, the most popular method of cleaning gases is to use baghouse filters.

Nevertheless, all filter systems still need the GCT to cool down the hot gases from the cement kiln. Due to the high dust loads in the hot gas, it is essential that the injected water evaporates completely inside the GCT, which is a large vertical tube with a downwards gas flow. If the evaporation is not completed at the lower end of the GCT, build-ups of dust/mud will occur and will lead to the need for plant stoppages and/or high maintenance costs.

Due to the limited space available in cement plants and also the high price of steel, small GCTs are required throughout the market. A small GCT can only be achieved by producing a fine water spray that evaporates faster than large droplets. There are two main technologies on the market to generate a fine water spray:

- Spillback nozzles (also known as flowback nozzles, hydraulic nozzles): these are systems that generate fine droplet distribution with a high water pressure.
- Air atomising nozzles (otherwise called twin-fluid nozzle, bi-fluid nozzles): these systems use low pressurised water and compressed air as the main energy source to generate fine droplets.

Spillback systems (SB)

SB systems operate at 35 bar at nozzle level. The main operating features of this nozzle is a constant feed pressure and a backflow line to the tank, where the control

Figure 1. GCT.

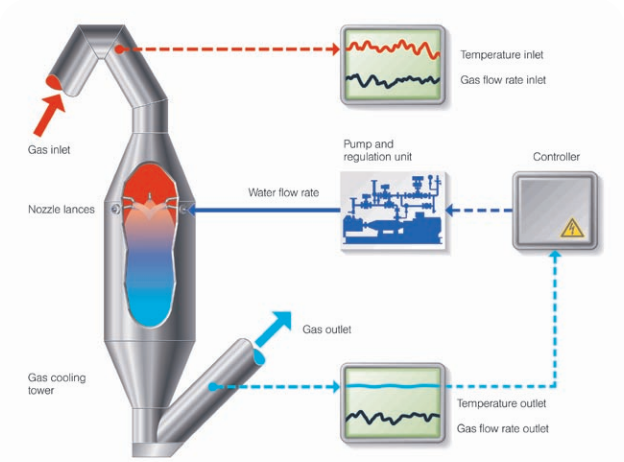

Figure 2. GCT principle.

valve is installed. In this way, the nozzle generates a fine water spray combined with a flow rate turn-down ratio of at least 10:1. The droplet size remains unchanged over the turn-down ratio.

GCTs can be equipped with single nozzle lances or, for larger diameters, with clusterhead lances to accomplish a sufficient coverage of the GCT cross-section. Today, 75 - 80% of GCTs worldwide are still equipped with the SB nozzles, which were the standard nozzles supplied by most filter OEM companies for many years.

The main disadvantage of wear caused by the high pressure no longer exists, since the use of wear resistant materials like tungsten carbide for the wear part is now common.

Air atomising system (AA)

AA-systems run at a much lower water pressure of approximately 5 - 6 bar. The fine water spray results from the intense internal mixing of the compressed air and the pre-atomised water.

The fine droplet spray exits the nozzle through several openings to generate a specific spray angle. The outstanding advantage of AA nozzles is the fact that the droplet size can be changed (even during operation) by varying the specific air consumption.

In the USA, AA-nozzles dominate the market because of the high presence of suppliers and low energy costs. In all other parts of the world, the SB nozzle is still the most used component for this application. The purpose of this article is to focus on a comparison of operating costs of these two systems.

Case study

In past decades, new investments in cement plants were mainly decided on a return-of-investment-period of one to two years. The attitude to focus only on the size of the GCT is limiting the view for the optimum solution.

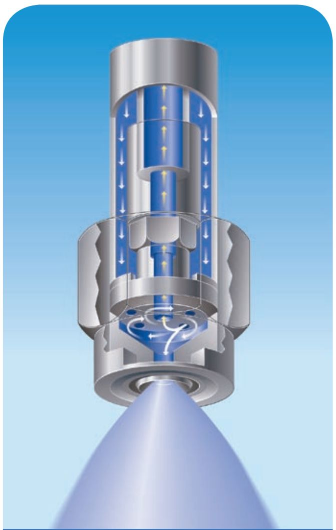

Figure 3. Spillback nozzle principle.

With the unexpected and rapid increase in the price of electric energy in recent years, the big cement producers are now comparing investment, maintenance and operating costs over a period of 10 - 12 years to find the most cost efficient technology.

As shown in Table 1, the investment costs for AA-systems are higher than for SB-systems because of the additional investment for redundant compressors. Nowadays, the operating costs are the main parameter used to decide between the SB or AA system. The comparison made in this article is based on a case study at an existing cement plant in North America.

Table 1. Running cost evaluation

Energy costs		0.045 US$/kWh	
Time frame		10 years (7500 hpa)	
Mill operation		90%	
Direct operation		10%	
Spillback power consumption		**AA system power consumption**	
Mill operation	128 kW	Mill operation	447 kW
Direct operation	108 kW	Direct operation	652 kW
Running costs			
Spillback system		US$425 250 (total in 10 years)	
Twin-fluid system		US$1 577 813 (total in 10 years)	
Running cost difference		US$1 152 563	
New compressors		US$350 000 (estimate)	
Total cost difference		US$1 502 563	
Investment costs			
SB		AA	
110%		100%	
-		plus compressors	

Operating cost evaluation

At the customer's cement plant, the temperature after the 4-stage preheating tower is 370 - 450 °C. The raw mill runs for 90% of the time. Based on the high humidity of the raw material, the location of the raw mill downstream of the GCT (4.9 m dia., active height 28 m) and the capacity of the mill, the required temperature after the GCT at mill operation is 220 °C.

During direct operation (raw mill off), the GCT outlet temperature reached 170 - 180 °C. Tests to reduce the outlet temperature resulted in mud in the GCT dust hopper. The GCT is equipped with AA-nozzles, and the compressed air is supplied by a 350 hp (=260 kW) compressor that runs constantly, even

Figure 4. Spillback clusterhead lance.

during mill operation. A second identical back-up-compressor is also installed. Maintenance and running costs for the compressors are high, and the life cycle of the compressors is limited.

Facing lower emission limits for mercury in the near future, the outlet temperature after GCT has to be dropped to 130 °C. Simultaneously, clinker production will be increased from 3200 to 3800 tpd. This leads to an increased injected water quantity from 20 to 56 m^3/h.

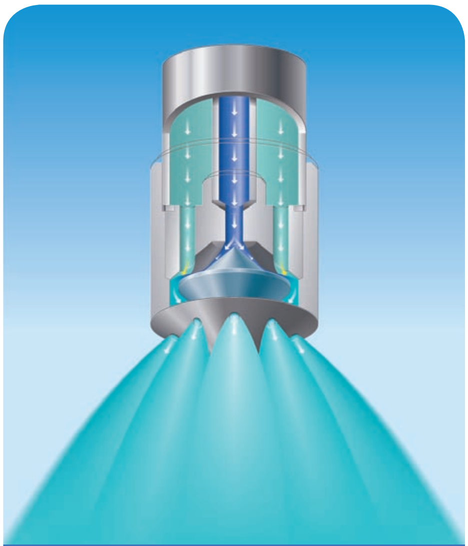

Figure 5. Air atomising spray nozzle principle.

This fact, plus the company's experience with the existing GCT and its limits, as well as the new gas quantities and the lower outlet temperature, forced the customer to improve the performance of the gas cooling process.

At first glance, the simplest solution would be to inject more water into the existing GCT. This is technically possible, but the relative water load per area (m^2/h water per m^2 GCT cross-section) would then be at the upper limit. Two parameters indicate a severely higher compressed air necessity:

- Finer water spray to overcome the known process limits regarding the wet bottom.
- A larger quantity of water required to cool down the increased gas quantity to a lower outlet temperature.

The investment costs for a water injection system that comprises nozzle lances, a pump and control skid, a PLC, and ring mains is comparable, and knowing the additional costs for larger compressors, the main focus was the comparison of the operating costs. The goal was to find out if the difference of the operating cost within a 10 year period between the SB and the AA injection systems and the cancellation of the compressors would be equal to purchasing a new and larger GCT.

The cement plant generated a flexible cost evaluation worksheet using Excel, with a nozzle supplier that offers both injection systems (the results of which are published in Table 1). The worksheet enables plant operators to enter variables such as:

- Energy costs.
- Number of years to focus on.
- Number of operating hours per year.
- Percentage of mill and direct operation.

It also allows individual local figures to be entered to get a realistic picture of the situation.

Based on the savings of US$1.15 million, plus the saving of the unnecessary investment in the compressors, it became clear that any investment in a new GCT would be paid off quickly and would save a lot more money over the years to come. Taking into account that the life cycle of a GCT and an injection system is at least 20 years, and the increase of costs for electrical energy are unpredictable for the coming decades, the real savings might even be higher.

Conclusion

It became clear in the above and specific comparison of the operating costs that the SB system is in favour. However, AA-nozzles are still the only possible solution for many projects where a finer water spray is needed, where the GCT exists and an extension is not possible (no space, foundation limits, etc.) or because the raw mill runs 98% of the time and the high compressed air consumption during 2% running time is acceptable.

Figure 6. Pump skid.

Only the long term comparison of all costs based on the individual parameters of each cement plant (% mill operation, raw material humidity, energy prices etc.) will give the cement companies a good position to decide for the best system.