Dry system improves ENEL bottom ash handling

Italy’s Ente Nazionale per l’Energia Elettrica (ENEL) installed an innovative conveyor belt system that continuously extracts hot bottom ash under tough operating conditions

By R. Tarli and M. Voltan, Ente Nazionale per l’Energia Elettrica

The Italian utility Ente Nazionale per l’Energia Elettrica (ENEL) is committed to improving operations without ignoring environmental issues. One example of this policy is the recent installation of dry bottom ash extraction technology at its Pietrafitta, Bastardo, Monfalcone and Fusina power plants.

The MAC (Magaldi Ash Conveyor) system, developed by Magaldi Industries and the Italian boiler manufacturer Ansaldo, continuously removes ash from beneath the boiler via a stainless steel conveyor belt. Because the system operates without water for cooling or conveying ash, it drastically reduces the amount of contaminated water the plant discharges to the environment.

The MAC system was first installed at ENEL’s Pietrafitta plant in 1986. Pietrafitta’s two 35-MW lignite boilers originally used a dry, refractory-lined hopper to collect bottom ash. It was replaced because the process was inefficient, labor intensive, and dangerous. Once every shift an operator was required to rake ash into the intake of the pneumatic system, sometimes exposing the operator to the hot boiler environment.

Bastardo plant project
ENEL accelerated its ash handling system retrofitting plans because local authorities began to regulate the amount of untreated water the company could discharge from its plants. The majority of this effluent is the water used in ash handling processes, either from the water-impounded bottom ash hoppers or the dewatering bins. The utility decided it could solve the discharge water issue and avoid future, more stringent water regulations by converting ash handling from a wet system to a dry one. It was under these circumstances that ENEL decided to install the MAC system on its Bastardo plant’s two 75-MW boilers.

Before ENEL approved the project, however, further testing was stipulated. The utility’s engineers needed some verification that the MAC unit’s metal conveyor belt could operate under sustained high radiant heat fluxes without a provision for cooling. ENEL also wanted to find out if controlling the amount of air entering the boiler through the MAC/boiler interface affected boiler performance and efficiency. At Pietrafitta, optimizing the interface (to control the amount of air entering the boiler) was not a critical design objective because of the fuel its boilers burned and its short remaining service life.

Ansaldo confirmed the belt’s physical characteristics while Magaldi tested the effects of controlled air entry into Pietrafitta’s boilers. After analysis, the data collected at Pietrafitta proved that air leaking into the boiler did not adversely affect its operation.

By 1990, Bastardo’s Unit 1 was outfitted with the revised MAC system design. Installation of the second unit followed approximately one year later. The system has accumulated more than 40,000 hours of operating experience without problems.

The system revealed
The MAC system relies on a metal conveyor belt to remove ash from beneath the boiler. The conveyor belt is manufactured as a net of stainless steel wire that is coiled in an oval shape. The wire mesh is covered with overlapping pan-like stainless steel plates. The complete belt is carried on support idlers (similar to a flat rubber belt) and driven by a friction drum. A tensioning device within the tail section automatically adjusts for the thermal expansion and contraction of the belt. Depending on conveyor size and application, the tensioning device can either be spring loaded or operated with thrust cylinders.

The belt’s design is well adapted to ash handling because of its mechanical resistance to high temperatures and its ability to withstand shock loading from large pieces of material striking the belt. The belt plates can expand freely in all directions without restrictions or distortion.

A shroud encloses the conveyor belt and seals it off from the surrounding environment. To keep the conveyor and its shroud cool, a controlled amount of ambient air is drawn into the extraction unit. The boiler’s negative pressure is used to draw air through specific points located along the shroud and at the discharge end of the unit. The amount of air used is roughly equal to 0.5-1.0% of the boiler’s total combustion air. (Therefore, the amount of combustion air required by the burners can be reduced by a similar amount.)

Before the MAC system was installed, engineers anticipated that a small gain in boiler efficiency might be realized because cooling air crossing the belt recovers some
of the energy normally lost in wet systems. Testing confirmed that this recovered energy comes from the heat content of the ash and radiant energy crossing the boiler throat.

Unexpected efficiency
Very little unburned material was found in the bottom ash. Ash analysis showed that uncombusted material dropped to 1.0%, down from an average of 5.0% found with the wet system. The smaller amount of unburned carbon meant that the boiler gained some efficiency, while producing ash in a state in which it could be reused (such as an additive in cement or concrete). The ash is then sold and most disposal costs are mitigated.

Because the MAC system resolved so many environmental and operational problems at Bastardo, ENEL decided to continue the program and explore the possibility of installing it on even larger boilers in the company's system.

New plant, new theory
During the company's review of candidate boilers, engineers theorized that increasing the size of the boiler would decrease the temperature profile inside the MAC unit. This theory was based on the fact that although cooling capability (i.e., the amount of air required to cool the unit) increases with boiler size, the energy that crosses the boiler throat also increases, but the relationship is not linear. Because an increase in boiler size negligibly affects the distance between the throat and flame, the result is a reduction in the energy flux (i.e., energy per square meter).

To verify this theory, ENEL chose to install the MAC system on its Monfalcone plant's two 160-MW units. As with the Bastardo plant, Monfalcone had a problem with effluent discharge. By 1992, both Monfalcone units were fitted with the MAC system.

At Monfalcone, bottom ash discharges off the end of the belt and falls into a crusher for sizing before it is conveyed pneumatically to a storage silo. ENEL mixes the bottom ash with flyash and then sells it to a cement plant.

Results compared
Before the second MAC unit was installed at Monfalcone, each unit's performance was compared to the other to confirm expected gains in thermal efficiency and measure the reduction of unburned carbon.

Test results proved that uncombusted carbon was reduced by as much as 75%.

Additional benefits included reduced auxiliary power consumption and reduced system and plant operating and maintenance costs. Dewatering bins and other water handling and processing systems were eliminated and an increase in the boiler's availability was noted as well.

Tests also indicated that NOx levels stayed constant, thus confirming that the air entering through the MAC unit did not modify combustion at the burners. During the summer of 1992, both boilers were modified to include NOx overfire air (OFA) ports. NOx emissions were reduced by 50% with no noticeable effect from the MAC system.

Furthermore, the volume of unburned material in the bottom ash remained at a very low level (the same level as before

OFA installation). When OFA is used in conjunction with a wet system, it usually increases the amount of unburned material.

With operating experience at Monfalcone proving that boiler size is not an issue and that its efficiency is not disrupted by the MAC system, ENEL plans to apply dry ash handling technology to even larger boilers. At present, ENEL's Fusina plant has just completed installation of two MAC units on 160-MW boilers. An additional order has been placed to retrofit its two 320-MW boilers, and 660-MW units also are being considered. ENEL also is developing a timetable to replace most of its current wet bottom ash systems with the MAC process.

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