UDC 621.9

Part 3

ASH AND SLAG HANDLING

3.2. Ash and slag handling systems at TPPs

3.2.3. Bottom ash/slag removal

3.2.3.5. The Application of Air-cooled Dry Bottom Ash Handling Technology at Coal Fired Power Plant

Qian Yu, Beijing Guodian Futong Science and Technology Development Co., Ltd, Beijing, China

ABSTRACT

The environment protection requirements are more and more stringent in power plants of China, in order to reduce the polluting load from the power plant effluent, air-cooled dry bottom ash handling system, one of innovative and leading technology, was adopting for coal fired power plant. There is no any water using during the bottom ash processing. A series of operational and environmental problems was eliminated by the air-cooled dry bottom ash handling system. The dry solution of bottom ash avoids the problems and costs associated with waste water in ash handling, improving the performance and the efficiency of the boiler. It is an important contribution to the achievement of "zero waste water discharge" commitment of many utilities, as well as a drastic cost reduction comparing traditional wet system for bottom ash handling process in coal fired power plants.

1. THE EXISTING TECHNICAL PROBLEM OF TRADITIONAL WET BOTTOM ASH HANDLING SYSTEM IN COAL FIRED POWER PLANT

- High water consumption
- High power consumption (normally the slurry pumps and circulation pumps with high power)
- With possibility to cause the shut down of boiler
- The loss of unburned carbon (6…15 %) resulted in energy loss, all heat of bottom ash was completely lost in water
- Radiation heat loss in the area of boiler throat. Bottom ash drops into the water and the vapor produce the corrosion to the water tubes of boiler throat
- Components corrosion and wear down, high maintenance cost
- Potential dangerous to operator (Vapor explosion)
- Big space occupation, complicated system configuration
- Low ash comprehensive use value

Key elements of wet bottom ash handling systems are presented in Figs.1, 2.

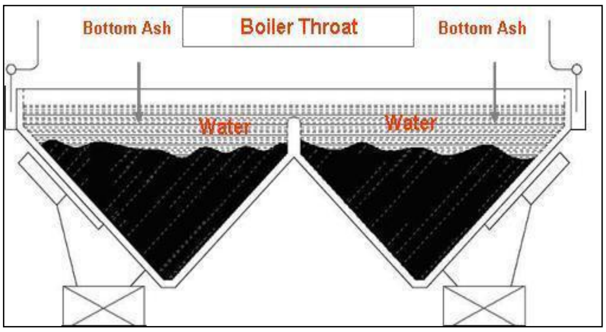

Fig. 1. Water Impounded Bottom Ash Sluice System.

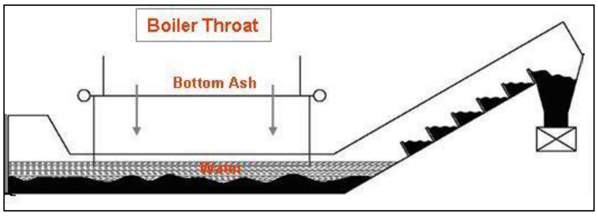

Fig. 2. Bottom Ash Submerged Scraper Chain Conveyor.

2. GENERAL DESCRIPTION OF DRY BOTTOM ASH HANDLING TECHNOLOGY

Steel belt dry bottom ash handling system is a unique technology for dry extraction, cooling and handling of bottom ash from coal fired boiler.

It is an innovative and novelty system comparing with traditional wet bottom ash handling system. The bottom ash was cooled by natural air, disposed and conveyed in a dry way. The performance was much improved than wet bottom ash handling system.

Steel belt dry bottom ash handling system has been widely used in green environmental friendly new power plants as well as for retrofit projects all over the world. Base on boiler type and capacity, general arrangement of whole power plant, available space, different configuration layout of dry bottom ash handling system will be adopted and fit to any kind of operation and site condition.

3. WORKING PRINCIPLE

Steel belt dry bottom ash handling system mainly consists of mechanical seal, bottom ash hopper, pre-crushing bottom doors (Clinker crusher), steel belt conveyor, ash crusher, downstream conveying equipments, bottom ash silo and unloading accessories.

Steel belt dry bottom ash handling system (Fig.3) mainly consists of mechanical seal, bottom ash hopper, pre-crushing bottom doors (Clinker crusher), steel belt conveyor, ash crusher, downstream conveying equipments, bottom ash silo and unloading accessories.

The main components of dry bottom ash handling system is a super-steel-belt which running underneath boiler. It consists of high temperature and wearing resistance mesh and partially overlapped conveying pans. The super-steel belt is designed to withstand the arduous operating conditions under the boiler throat, characterized by high temperatures and shock impacts by large ash clinkers falling from the boiler. It was enclosed inside sealed case of the ash conveyor and can be expanded freely in any direction thanks to its special configuration.

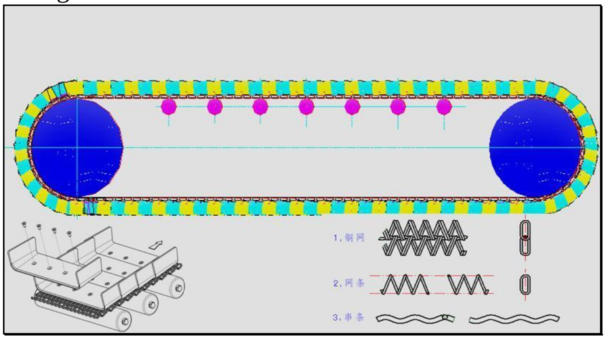

Fig. 3. The Configuration of Super-Steel Belt..

The force was transmitted to steel mesh through the friction between the driving pulley and steel mesh, while a hydraulic take-up device at tail pulley providing a constant tension. The steel belt is supported by the carrying idlers across the entire width in order to absorb and withstand the heavy ash lump impact. All bearings of the carrying and return idlers are fixed outside of conveyor case to prevent from the over heat as well as facilitate the maintenance works. There is no relative movement between belt conveying pans and transported bottom ash on it, so the wearing of steel belt can be negligible. Normally the average working life of a steel belt is more than 10 years.

The mechanical seal provides the tight connection between the boiler throat and bottom ash hopper and it can absorb the downward and lateral expansion of boiler.

Relative to the centerline of boiler, the bottom ash hopper was designed and built in eccentric way, which ensures that big ash clinkers do not fall directly from the boiler onto the steel belt, but have their first cushion on the sloped (refractory lined) hopper wall.

Under the bottom ash hopper, there are provided with pairs of pre-crushing bottom doors (Fig.4). With pre-crushing bottom doors, the bottom ash hopper can be closed completely. The bottom ash will be accumulated inside of ash hopper during the maintenance of downstream equipments (Fig.5). Moreover, the pre-crushing bottom doors will pre-crush the big ash clinkers into the size less than 300mm on the impact bars which will improve the cooling effect of big ash lumps during transportation on the steel belt. Meanwhile it can reduce the working load and wearing of ash crusher dramatically.

Fig. 4. The Pre-crushing Bottom Doors (Clinker Crusher).

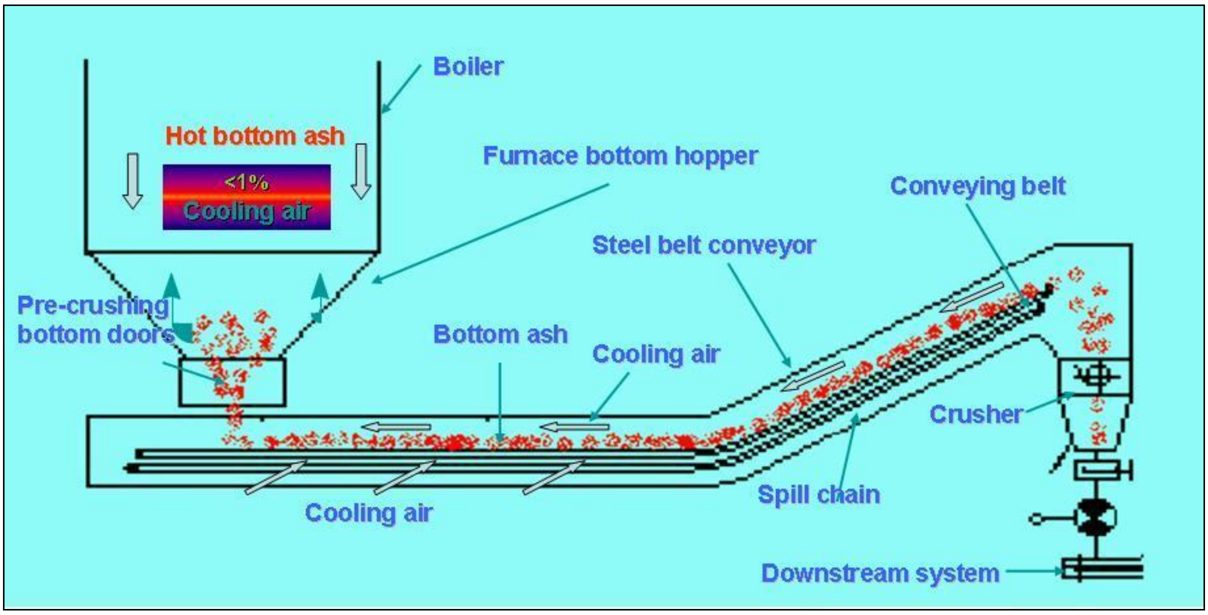

Fig. 5. The Working Process of Air-cooled Dry Bottom Ash Handling System.

The bottom ash generated (the bottom ash temperature is around 900°C) by the furnace drops on the super-steel-belt and was transported to ash crusher at very low speed (Speed range 0,4…4 m/min). Small amount of controlled ambient air (normally not over than 1% of boiler total combustion air) was sucked into conveyor thanks to the negative pressure in the furnace. While cooling down the bottom ash and steel belt, the air itself gets heated before enters into the boiler (up to 350°C in normal operation) and the heated air can be as the combustion air for boiler. Besides the cooling effect, the cooling air also provides oxygen for hot bottom ash. A significant burn-out of unburned carbon in the bottom ash takes place on the super-steel-belt and the heat was returned to furnace too. In traditional wet bottom ash handling system, all these heat was lost in the water. Tests and much experience have verified that the heated cooling air does not affect the combustion of boiler and not influence the NOx formation. Contrarily the considerable heat recovery will help to increase the boiler efficiency.

During heat exchange between the cooling air and hot bottom ash, the cooling air was heated up to 300~400 ºC and the hot bottom ash was cooled below 120 ºC. At lower layer of bottom ash conveyor, a cleaning chain is installed to avoid the accumulation of fine ash on the bottom floor of conveyor. The cleaning Chain consists of two lateral chains connected by scraper flights that sweep the accumulated dust over the extractor floor to the conveyor head section, where it is discharged into the ash crusher.

4.CONTROL SYSTEM

A. Steel belt air-cooled dry bottom ash handling system adopts automation program (PLC+CRT) and real-time data acquisition and processing, operation status supervision and process control (Fig.6).

B. To save the fault information automatically and meanwhile provides sound and light alarm

C. Self diagnose the failure and ensure the safety and stable operation of dry bottom ash handling system

D. Three operation modes: Automatic, Manual and Maintenance modes

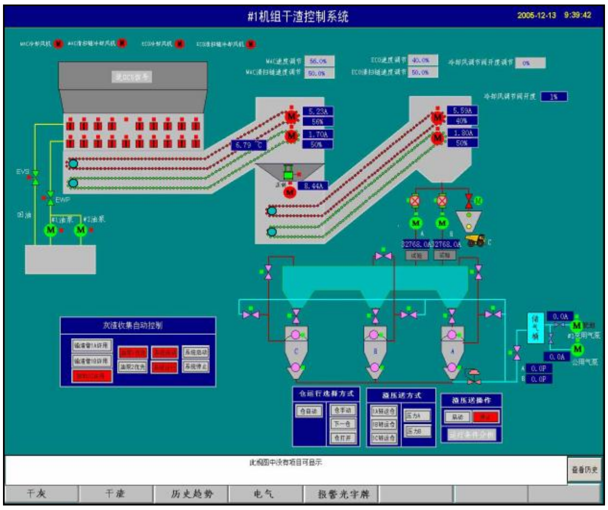

Fig. 6. The Supervision System of Air-cooled Dry Bottom Ash Handling System.

5. TECHNICAL ADVANTAGES, ECONOMIC CHARACTERISTICS AND SOCIAL BENEFIT

A. Technical Advantages

1). There is no water during bottom ash cooling and conveying processes, the seal between bottom ash hopper and boiler throat is mechanical one (no water type), thus has saved water resource dramatically and realized “zero-emission” of bottom ash system. And it eliminated all water-related problems (waste water production, fresh water consumption, equipments corrosion, risk of ice formation, hot water splashing etc.) from the source.

2). The existing heat in bottom ash, the heat generated by the burn-out of the unburned carbon as well as most of radiation heat at the boiler throat has been returned to the furnace, which has reduced heat loss of un-complete combustion and physical heat loss which facilitate increasing boiler efficiency.

3). Air-cooled dry bottom ash handling system has been simpler, with clean working environment and no ash water corrosion and wearing opposite to the wet system (Fig.7). It has improved the system dependability and has a very low maintenance and operation requirements.

4). The super-steel-belt runs at a very low speed and in a stable way. Its expected service life is at least 10 years. Reduced the maintenance cost extremely.

5). The amount of cooling air is less than 1% of total boiler combustion air without negative impact on the boiler combustion and NOx formation.

6). Bottom ash is handled in dry way and has much better opportunity for sales and comprehensive utilization.

7). The configuration of downstream system can be greatly customized.

B. Economic Characteristics

1). Cooling and conveying of bottom ash without water and the cost of water use are zero.

Fig. 7. The Corrosion of Traditional Wet Bottom Ash Handling System.

2). More than 10 years service life of the super-steel-belt, reducing the cost dramatically for operation, maintenance and overhauling.

3). The existing heat in bottom ash, the heat generated by the burn-out of the unburned carbon as well as most of radiation heat at the boiler throat has been returned to the furnace, increased boiler efficiency and reduced coal consumption.

4). Lower power consumption compared with the traditional wet ash handling system (30…70 % power saving), saving operation cost;

5). Flexible and user friendly design of the system, be more adaptable to the layout of whole power plant

6). Increase the value for comprehensive utilization of bottom ash, reduce environmental pollution

7). Reasonable cost, comprehensive investment equivalent to that of traditional wet bottom ash handling system

*C. **Social Benefit***

1). No waste water or other waste emission (Fig.8). Thereby reduced the impact of pollutant on the environment and saved pollution discharge fees, achieving benefits from environmental protection and to control pollutants production in the source.

2). To adopt air-cooled dry bottom ash handling system, many power plants are no longer with the expropriation of land for ash yard construction. In this way, a lot of valuable land resources have been saved, meanwhile dust emission problem surrounding ash yard has been solved.

3). Dry bottom ash can be used as a variety of building materials, such as insulation brick, filling material for expressway, cement additive etc. Comprehensive utilization of dry bottom ash saved land resources and reduced the impact and damage on geological structure, physiognomy and underground water resource.

Fig. 8. The Clean Working Environment of 4x600 MW Air-cooled Dry Bottom Ash Handling System.

.

6. THE COMPREHENSIVE COMPARISON BETWEEN TRADITIONAL WET BOTTOM ASH HANDLING SYSTEM AND DRY BOTTOM ASH HANDLING SYSTEM

Comparison item	Air cooling steel belt dry bottom ash handling system	SSCC system (Submerged scraper chain conveyor)
The adaptability for coking-oriented boiler	High adaptability, large ash clinkers are held up on the impact bars and do not drop on steel belt directly. The ash clinkers after crushed are easy o cool down and extracted by steel belt conveyor	Low adaptability, the large clinkers often resulted in shutdown of SSCC system or chin broken, blockage or damage etc.
Influence on boiler operation	The bottom ash is cooled by the ambient air and there is on water inside conveyor. 80-90 % heat is recovered resulting in increased boiler efficiency. High dependability and availability for boiler	The bottom ash is cooled by water. For coking-oriented coal, the large ash lumps drop into the water directly and generate extremely dangerous steam puff causing severe injuries to the personnel at site
System space occupation	Low	Higher
System characteristics	The configuration of dry bottom ash handling system is simper with nearly zero maintenance requirements (The only maintenance work is greasing bearing blocks periodically)	The system is more complicated. The presence of water leads to accelerated corrosion of equipment and boiler tubes as well as refractory lining material falling of bottom ash hopper. High maintenance costs due to corrosion and wear of all ash water handling equipment, particularly the chain, flights and sprockets
System dependability	High	Normal
Power consumption	Low	Higher
System water saving	Zero emission	Higher
Comprehensive investment (including civil works)	Low The investment return period is shorter (about 2-3 years) because of low O&M cost and few spare parts requirements as well as dry bottom ash better sales opportunity	Higher
Cost of operation and maintenance	Low	High
Bottom ash comprehensive utilization	The bottom ash is cooled and handled in a dry way which facilitates sales of bottom ash and utilization (used in cement and building material industry)	Due to the bottom ash was handled in a wet way it can only be used for road filling materials or as a waste product
Equipment working conditions	All equipment is working in a dry condition and that will reduce the wear rate	The chain, scraper flights and supporting wheels are working in ash/water which results in high erosion and corrosion
System working environment	The system is working in negative pressure and the working environment is very clean	Due to leakage of water and mud, the working environment is very dirty and needs to be washed down periodically

7. CONCLUSION

1). At present, there are more than 500 sets of air-cooled steel belt dry bottom ash handling system installed under 25—1000 MW units of coal fired power plants in the world. The first dry bottom ash handling system has been operated for around 26 years. The first air-cooled dry bottom ash handling system applied under 1000 MW boiler in the world has been successfully put into operation on the date September 24, 2009 (Fig.9).

Fig. 9. The first air-cooled dry bottom ash handling system applied under 2x1000 MW boiler in the world.

The successful operation of all these dry bottom ash handling system verified: Air-cooled dry bottom ash handling system is a mature and leading technology for treatment of bottom ash in coal-fired power plant. It can meet the requirement of high efficiency, stability, dependability and safety of boiler auxiliary equipment system.

2). Air-cooled dry bottom ash handling system is in line with the overall requirements of worldwide energy-saving and emission reduction and adapt to the characteristics of different boiler capacity, high bottom ash rate, complex variation of coal in power plant. Instead of traditional wet bottom ash handling system, Air-cooled dry bottom ash handling system is with remarkable economic and social benefit on water and electricity saving, bottom ash comprehensive utilization value improving and environment pollution reduction.

Thereby, air-cooled steel belt dry bottom ash handling system is an environment protection technology and should be widely used in all coal fired power plants (new or retrofit projects) in the world.

Qian Yu. The Application of Air-cooled Dry Bottom Ash Handling Technology at Coal Fired Power Plant // Proceedings of the IV scientific and practical worksop “Ashes from TPPs: removal, transport, processing, landfilling”, Moscow, April 19–20, 2012 — M.: MPEI-Publishers, 2012. P. 163 – 167.