Part 3

ASH AND SLAG HANDLING

3.2. Ash and slag handling systems at TPPs

3.2.1. Brief characteristics of traditional ash and slag removal systems of the Russian TPPs

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Nowadays mechanical, hydraulic, pneumatic and combined ash and slag removal (ASR) systems are applied at TPPs [1]. Thus, each system, as a rule, includes the elements of other ones. A choice of ASR system type is defined after consideration of the following:

- technological features of power generation (bottom ash/slag type evacuated from the boiler furnace, method of flue gas cleaning, output of ash and slag and their properties, need for water and its availability in the sufficient amount);
- location of ash and slag landfills (ASLs), distance between ASLs and power plant sites and terrain for ash and slag transportation;
- requirements for reliability and profitability of ASR systems operation;
- nature protection legislation requirements relating to by-products (waste) handling;
- climate conditions, operation of ASR system and its separate units, etc.

Mechanical ASR systems aren't applied now at large TPPs. They are only used in small boiler-houses.

Hydraulic (wet) ASR systems are widely used at the Russian TPPs. In these systems ash and slag materials are more often conveyed together to the disposal site as ash-and-slag slurry. In case the pressure of dredging pumps set inside the main building or at the plant site is not sufficient, the dredging pump stations of the second, or maybe the third lifting are constructed along the ash pipeline routing between the power plant site and the ash and slag disposal. In direct-flow schemes of water supply at hydraulic ASR systems, characteristic for rather old and small TPPs, water after mechanical clarification in settling ponds is dumped into natural reservoirs. The raised content of toxic and radioactive substances in discharge waters leads to formation of the local polluted zones with adverse conditions for biota existence in reservoirs.

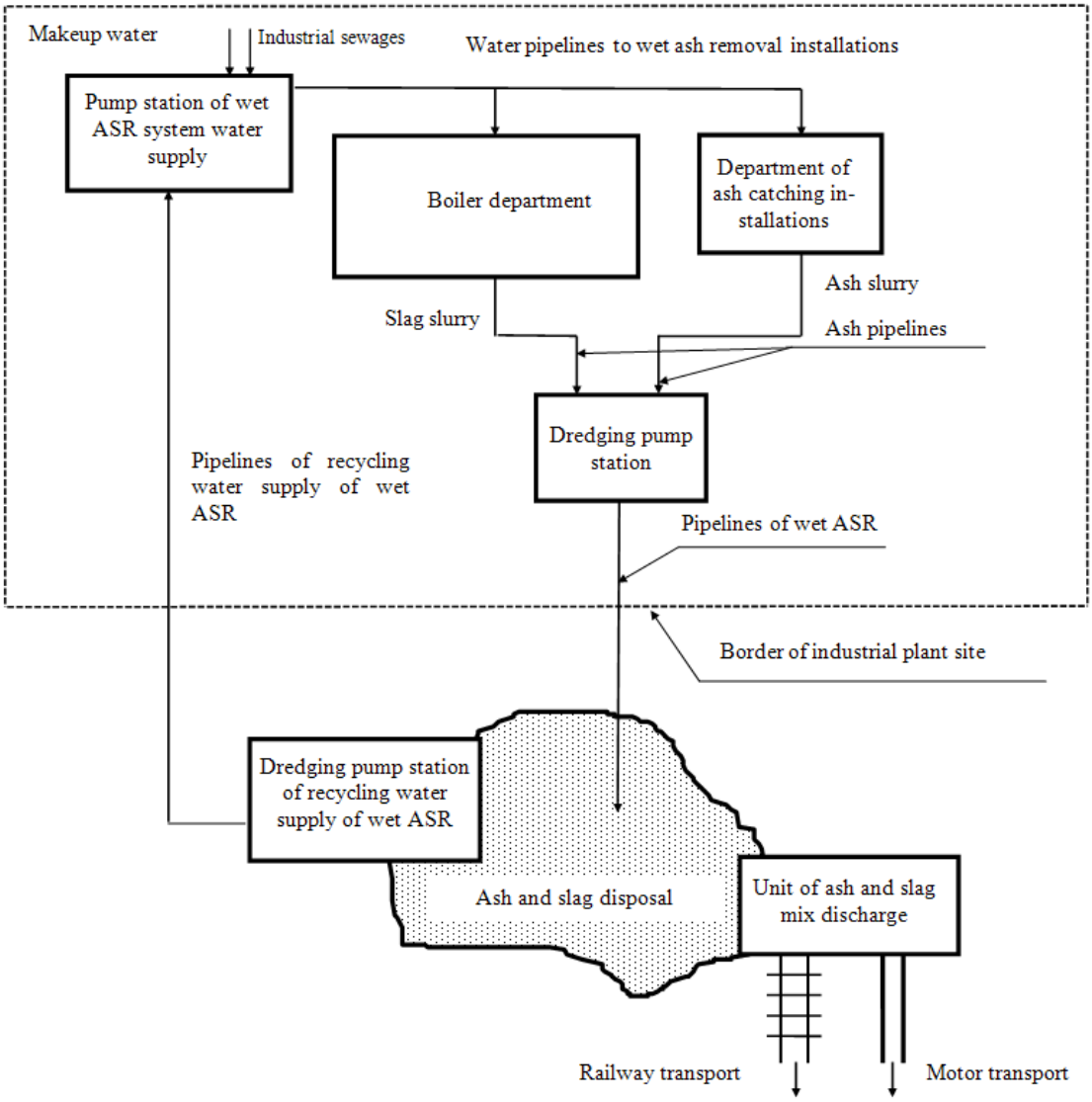

Fig. 1. Block diagram of traditional wet ASR system at TPPs at combined ash and slag conveying to the disposal site and discharge of ash and slag mix from the completed sections of disposal site to the motor and railway transport.

In recycling water supply schemes, after the clarifying pond water returns back to the TPP for its reusing. In such wet ash removal systems, the clarified water is pumped to the pumping station of recycling water supply, from which it is supplied in pipelines of the clarified water return to installations for evacuation of bottom ash/slag from the boiler throat and to the department of ash catching plants.

After that ash and slag slurry is fed to the dredging pump station, from which the pulp is transported in the external pipelines of wet ASR system to the ash and slag disposal. Thus, in recirculation water supply schemes of wet ASR systems, water is used in the closed cycle. At some TPPs ash and slag mix (ASM) is shipped from the completed sections of ash and slag disposals to cars and/or railway transport.

Block diagrams of ASR systems with recirculation water supply and shipment of ash and slag mix from the completed sections of disposal sites to cars and/or railway transport is presented in fig. 1. In this scheme additional dredging pump stations, constructed at insufficient head-capacity characteristics of dredging pumps, located at the power plant site, aren't shown.

In wet ASR systems at the Russian TPPs ash and slag is mainly conveyed together. Separate hydraulic conveying of ash and slag is applied when the corresponding requirements for consumer properties of these materials should be met, and according to these requirements ash and slag can't be mixed. In that case separate ash and slag disposal and discharge sites are constructed. Block diagram of wet ASR systems with separate removal, landfilling and discharge of ash and slag is presented in fig. 2. Slag discharge units in such schemes can be set both at the power plant site, and outside TPP. In this case equipment of slag discharge units includes installations for slag dewatering and pump station of the clarified water return.

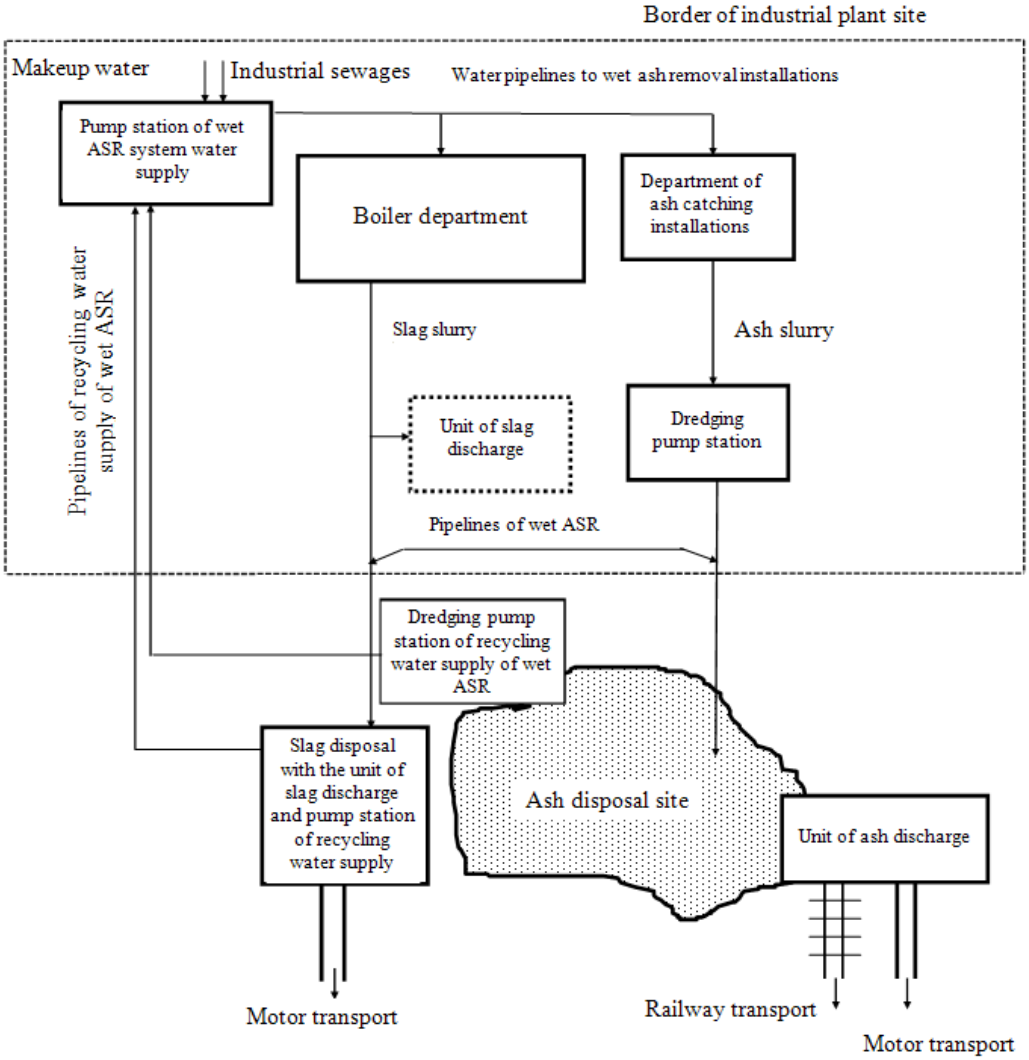

Fig. 2. Block diagram of wet ASR system with separate removal, landfilling and discharge of ash and slag.

Pneumohydraulic (combined) ASR systems are mostly introduced at large TPPs, where ash is collected in electrostatic precipitators. In 70-ties of the last century mainly at the Russian TPPs with power units, construction of installations of dry ash discharge (IDAD) started. Norms of technological designing at TPPs, equipped with dry ash collectors, provide pneumohydraulic ash removal inside the power plant: ash from ESPs is collected by pneumatic systems in the intermediate bunker, from which it is transported in pneumatic ash pipelines (PAP) to IDAD or in the absence of dry ash customers it is supplied by the channels of wet ASR systems to the pump station, from which ash and slag slurry is conveyed to the disposal site. Dry ash can be shipped to customers directly from intermediate bunkers or from the dry ash disposal site. By this, at disposal sites the units of ash and slag mix discharge can be also set. Block diagram of the combined ASR system with dry ash discharge from IDAD and ash and slag mix from disposal site is given in fig. 3.

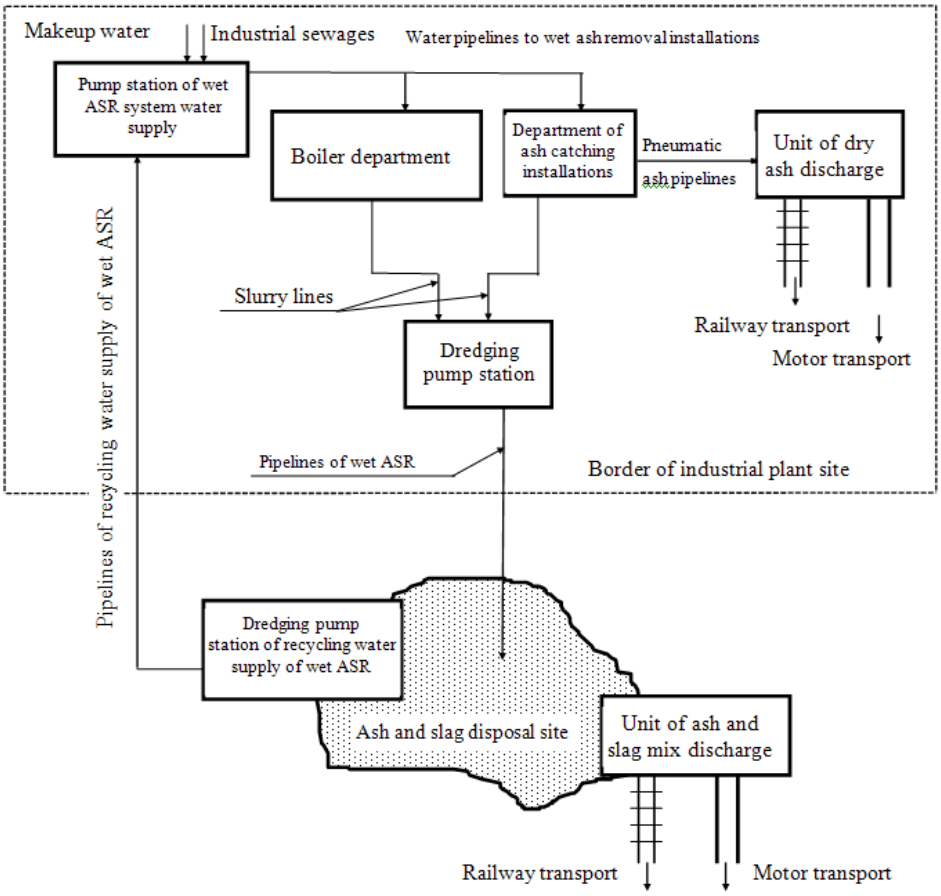

Fig. 3. Block diagram of the combined ash and slag removal system with shipment of ash to the customer from the unit of dry ash discharge and ash and slag mix from the disposal site.

Characteristic feature of any wet ASR system is ash and slag lagoon and use of water for external ash and slag conveying to the lagoon. Water use in wet ASR systems defines both their advantages, and disadvantages.

Wet ASR systems of different configurations are widely introduced because of the number of advantages they have:

- possibility of continuous removal of considerable part of ash and slag on long distances (to several tens kilometers);
- combination of cooling, granulation and slag transportation processes;
- possibility of full mechanization of all conveying and depositing processes;
- use of rather simple and reliable equipment;

However wet ash disposals pollute the environment significantly (fig. 4). In addition, combination of market conditions of economic activities and nature protection legislation becoming constantly tougher, forces to be more careful in ecological and economic estimation of wet ASR systems. As a whole, analyzing technical, economic and ecological indicators of wet ASR systems their following basic imperfections have been detected:

- formation of hard deposits in pipelines of wet ASR system which can result in its failure state;
- need for frequent enough replacement of pressure ash and slag pipelines because of their erosion and corrosion;
- unjustified high power inputs for external ash hydraulic transport because of practical noncontrollability of productivity of external hydraulic ash removal installations depending on mass of the transported ash and slag;
- need for significant investments and long enough period for modernizing technological configuration of ash removal system at change of the burnt coal ranks and/or technical requirements for consumer properties of ash and slag shipped to users;
- need for large specific water discharge – from 10 to 50 m^3 of water for 1 ash/slag ton;
- need for additional expenses for air-conditioning of ash and slag at their shipment from ash disposals according to the technical requirements of customers for their delivery;
- worsening of consumer properties of ash at its interacting with water;
- necessity of clearing circulating water of wet ASR system from the dissolved compounds in order to prevent formation of deposits in pipelines of the clarified water return;
- withdrawal from rational land use of large areas for ash and slag disposals and pipelines of external ash removal;
- atmospheric air pollution due to ash disposal dusting;
- underwater pollution by solutions of toxic and heavy metals compounds filtrated through a bed of the ash disposal;
- soil degradation in a zone of the ash disposal impact;
- frequent enough use of wet ASR system both directly and for sanitary piping of TPP industrial sewages, amount of which can be some times more than amount of water required for reliable transportation of the removed ash and slag.

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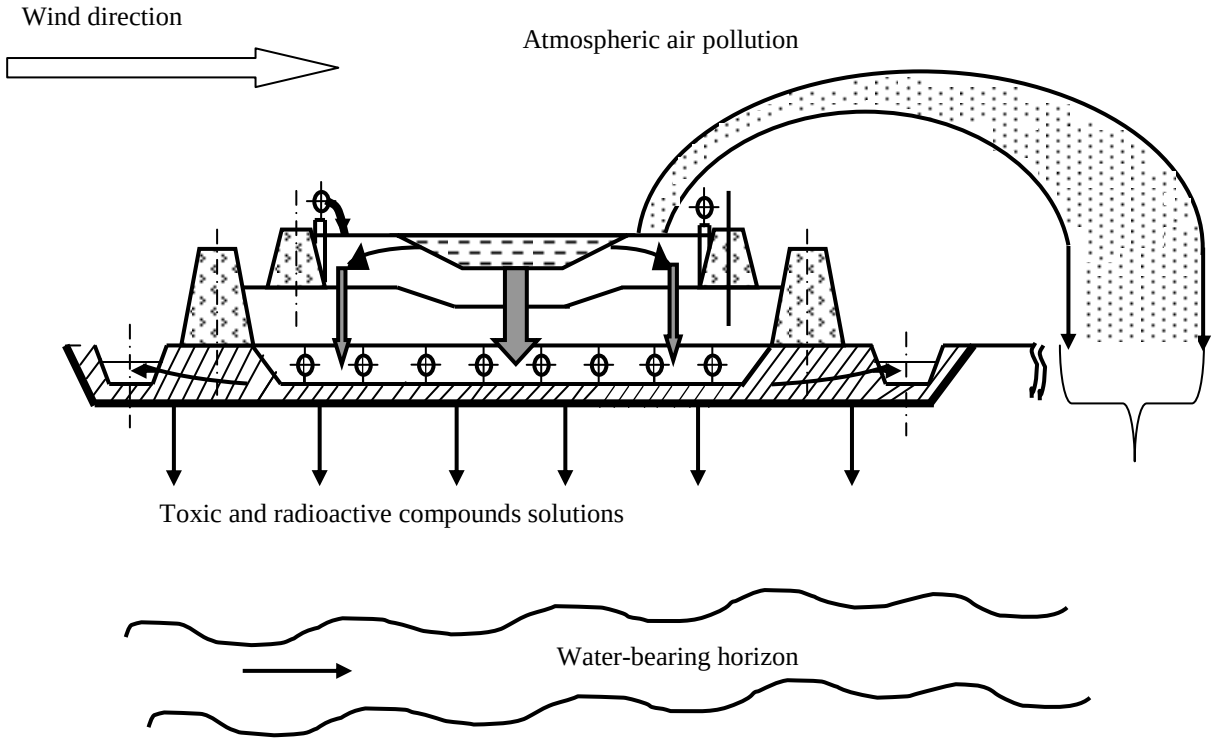

Fig.2. Influence of wet ASR of TPPs on environment

In comparison with wet ASR systems, pneumatic ones have a number of essential advantages:

- the reached level of reliability of the modern pneumatic systems isn't lower, and in case of high calcium ash conveying is higher than of wet ASR systems;
- possibility of wide range capacity regulation in installations of external pneumatic ash conveying;
- technological flexibility and adaptability in short terms to the changing specifications on delivery of ash to the customers without high investments;
- constant consumer properties of ash at its collection, transportation, time storage and shipment;
- possibility of dry ash shipment on particle size groups depending on the customer's demand.

Pneumatic ash removal systems have the following basic disadvantages:

- impossibility of ash conveying on distance more than 3 km without intermediate pump stations;
- erosion of pneumatic conveying equipment.

It is necessary to notice that technical issues on creation of installations of internal and external transport, and also shipment of dry ash to customers are thoroughly worked out and there is a corresponding normative and technical document of RAO "UES of Russia" [2]. Concerning estimation of technical and economic indicators of wet ASR systems taking into account ecological requirements there is also a normative and technical document of RAO "UES of Russia" [3]. Experience of creation and operation of dry ash and slag disposal sites at the Russian TPPs is also gained. One of the key factors having both technological and psychological value for the Russian power operators, preventing from the wide introduction of ecologically and economically more comprehensible pneumatic systems instead of wet ASR systems at TPPs, was a need for water usage for bottom ash evacuation from a boiler throat. It turned out so that since water was inevitably used for removal of bottom ash/slag from the boiler, there was no need for creation of pneumatic ash removal systems. Nevertheless, the world experience testifies that since 80-ties of the last century at TPPs of the industrially developed countries for bottom ash removal dry technologies are applied with no use of water for bottom ash cooling and transportation [4].