

SOME ASPECTS OF IMPLEMENTING ECOLOGICALLY SOUND ASH REMOVAL TECHNOLOGIES AT RECONSTRUCTION OF COAL-FIRED POWER PLANTS IN RUSSIA

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ABSTRACT

Brief estimation of ecological indices of ash removal systems of Russian Thermal Power Plants is given. Technical requirements for ecologically sound ash removal systems according to the state-of-the-art concepts of the admissible impact of power plants on environment are resulted. Block diagrams of the traditional and possible alternative ash disposal systems are shown. Some aspects of implementing ecologically sound ash removal technologies at reconstruction of coal-fired power plants in Russia are considered. An algorithm of decision making considering ash removal organization issues in the case of coal-fired power plants reconstruction is described.

1. BRIEF CHARACTERISTICS OF ASH REMOVAL SYSTEMS OF RUSSIAN TPPS

In 2000 - 2005 the annual production of ash at TPPs and boiler-houses of the Russian JSC "UES of Russia" changed from 22 to 25 million t. The relative volume of processing the ash of TPPs during this period made 12,4 ... 16,7 % of their annual production. In table 1 data on annual volumes of production and beneficial use (processing) of TPPs ash for 1990-2005 are resulted.

Table 1. Volumes of production, utilization and disposal of ashes from TPPs of the RF

Name/years	1990	1995	2000	2002	2005*
Coal consumption, million t natural fuel/year	182,0	128,0	120,1	106,0	107,8
Average ash content, %	27,5	26,3	20,8	21,4	22,2
Volumes of ash production, million t/year	50,0	33,7	25,0	22,7	23,9
Volume of ash processing, million t/year	4,5	1,9	3,1	3,3	4,0*
Volume of ash disposal, million t/year	45,5	31,8	21,9	19,4	19,9
Total relative volume of ash utilization, % from the annual output	9,0	5,6	12,4	14,5	16,7

*- expert estimation

About 85 % of ash is transported by hydraulic ash removal (HAR) systems in the form of a pulp of low concentration for landfilling it at the hydraulic ash disposals (HAD) being one of the basic sources of environmental contamination at energy generation. The total area of hydraulic ash disposals makes more than 20 thousand ha. The basic scheme of the traditional HAR system is presented in fig.1, and influence of hydraulic ash disposals on environment is shown in fig.2

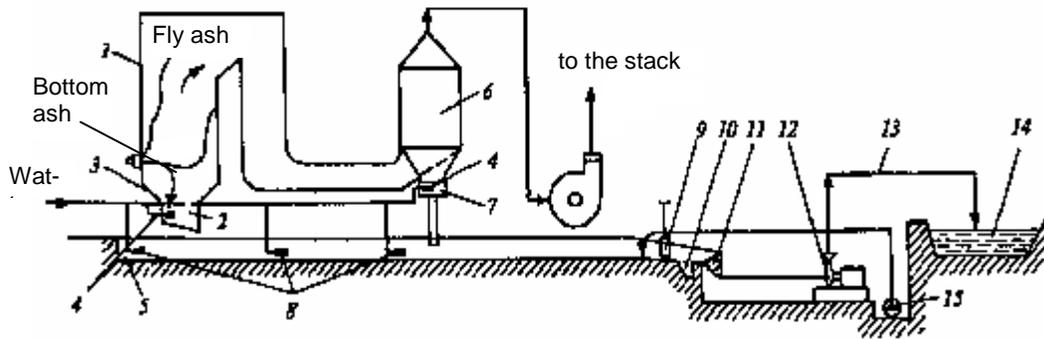


Fig.1. Basic scheme of traditional hydraulic ash disposal system
 1 – boiler; 2- bottom ash bath; 3 – furnace tap; 4 – flush nozzle; 5 – gravity canal; 6 – fly-ash collector; 7 – ash flushing device; 8 – driving nozzles; 9 – stop log; 10 – catch pit; 11 – bottom ash crusher; 12 – slurry pump; 13 – bottom ash pipeline to the disposal; 14 – ash disposal; 15 – drainage pump.

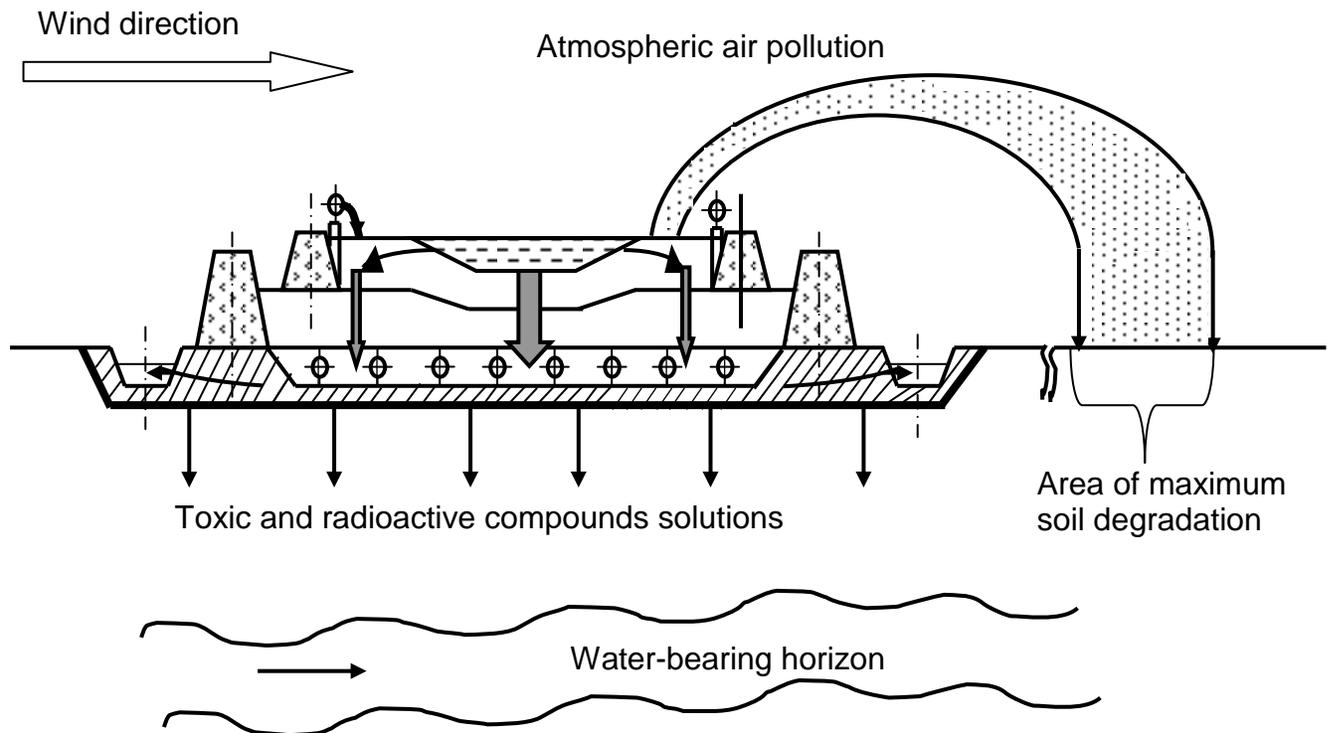


Fig.2. Influence of HAD of TPPs on environment

At the analysis of technical, economic and ecological parameters of traditional HAR systems their following basic disadvantages have been found out:

- formation of firm deposits in hydraulic ash pipelines resulting in its failure.
- need of frequent enough change of pressure ash pipelines due to their erosion wear and corrosion;
- unjustified high power inputs for external ash hydrotransport because of practical noncontrollability of productivity of external hydraulic ash removal installations depending on mass of the transported ashes;
- necessity of 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 ashes shipped to users;
- unjustified high power inputs for external ash hydrotransport because of practical noncontrollability of productivity of external hydraulic ash removal installations depending on mass of the transported ashes;
- need for large specific water discharge - up to 50 m³ of water for 1 ash ton;
- necessity of additional expenses for air-conditioning of ashes at their shipment from ash disposals according to the technical requirements of users for their delivery;
- worsening of consumer properties of ashes at their interacting with water;
- necessity of clearing the circulating water of HAR systems 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 disposals and pipelines of external ash removal;
- pollution of an atmospheric air due to ash disposal dusting;
- underwater pollution by solutions of toxic and heavy metals compounds filtrated through a bed of an ash disposal;
- soil degradation in a zone of the ash disposal impact;
- frequent enough use of HAR systems both directly and for sanitary piping of TPP industrial sewages, amount of which can be sometimes more then amount of water required for reliable transportation of the removed ashes.

2. MAIN PRINCIPLES OF CREATING ASH REMOVAL SYSTEMS OF TPPS

As a result of analysis of researching parameters of ash removal systems in Russia and trends of their development in the industrially developed countries of the world in view of more and more toughening requirements for ecological characteristics of various manufactures the main principles have been formulated. They are to be guided at creation of new and modernization of operating ash removal systems of TPPs.

1. The coal-fired TPP is not only a source of electric and thermal energy, but also a source of valuable mineral raw material of the technogenic origin in the form of ash.
2. Reliability, profitability and ecological compatibility are the basic requirements which ash removal systems should meet.
3. AR system is a unique technological complex within the limits of TPP simultaneously solving technological and nature protection problems on removal of ash from boilers, that can make profit while any other nature protection technologies cost money.

4. Use of ash at producing commodity output by internal and external users leads to raise of economic efficiency of electric and thermal energy generation and decrease of harmful impact of TPP on environment.
5. Separate removal of fly ash and bottom ash in connection with essential difference of their consumer properties promotes increase in volumes of their shipment for their using at commodity output production.
6. Collecting, transporting and shipment of the collected dry ashes for processing on fractions promotes decrease of costs and expenses at its shipment to users according to the contracts on delivery.
7. The realized in the ARS system opportunity of ash shipment for its processing in the volume up to 100 % of their current production allows to load them out under users' demand without any additional investments and time expenses or with the part of them.
8. Minimal technically achievable impact of AR systems on environment is possible at the maximum shipment of ash for its processing and landfilling of their unrequired part at the disposal using ecologically friendly ways.
9. The greatest possible application of technologies of landfilling the unrequired part of ashes at the disposals in the form of products of a pent-up demand or with initial properties allows not only to reduce harmful affecting of the landfill on environment, but also to ship ashes according to the demand of the users at the minimal expenses of means and time.
10. Opportunity of further technical improvement of equipment and configurations of separate units, installations and AR system as a whole is one of the parameters showing a quality of the project on AR systems.
11. Maximum mechanization and automation of technological processes without the unjustified application of hand work is one of parameters of technical perfection of the project on AR systems.

3. THE BASIC METHODOLOGICAL REGULATIONS

For practical implementation of the main principles for creating AR systems with optimum technical, economic and sound ecological indices it is necessary to be guided by the basic methodical regulations specified below.

1. Proceeding from that a TPP burning solid fuel is not only a source of energy, but also a source of valuable mineral raw material of a technogenic origin in the form of ashes, AR systems should meet the following primary goals:
 - reliable removal of coal ash in all range of operational loadings of boilers;
 - providing maximum discharge of ashes with initial and changed properties for use as substituents of natural raw material by manufacture of a commodity output at the factories of various branches of economy;
 - landfilling the unrequired ash part using ecologically sound ways.
2. Proceeding from that fly ash and bottom ash/boiler slag mixture has the least consumers' demand removal of fly ash and bottom ash/boiler slag should be separate unless there is a secured and long-term commodity market of all volume of the mixture.

3. For expansion of an opportunity of dry ash discharge to the existing and potential users in case of the difference of quality requirements of delivered materials in specifications on its delivery from ashes with initial properties, in units and installations of dry ashes discharge devices for discharging ash mixtures with different particles size from hoppers or silos should be provided. Such mixers are simple in design, and expenses for creation and costs on their maintenance are very small in a total cost of pneumatic ash removal system.
4. For meeting special users' requirements on ash delivery units (manufactures) for air-conditioning (superficial processing) of ash with initial properties, and also for essential changes of its properties (extraction of separate fractions, intermediate product production, etc.) can be created. In this case an expediency of creating special manufactures should be defined in compliance with change of technical and economic indices of the whole AR system in view of ecological requirements according to², instead of in compliance with the economic efficiency of the separately taken manufacture³.
5. The best known way of raising reliability of internal ash removal systems now is implementation of pneumotransport installations having in case of their qualified creation much greater operating flexibility in comparison with HAR systems. Besides, they have much wider control range of loadings on consumption of the conveyed ashes, and easier change of operating modes.
6. The most effective way of improving economic parameters of ash removal systems is the greatest possible selling of ash to users in the volume up to 100 % of its current production. Hence, one of the key issues is both permanent research of the existing and possible ash market and also its formation due to conducting a complex of provisions:
 - air-conditioning of ash properties;
 - creation of the own (being a property of TPPs) manufactures for commodity output production in the form of intermediate product and finished products;
 - creation of coproductions on share terms for processing of ash in a commodity output;
 - fixing of the reduced rates for all types of the consumed energy for the period of developing a technology of commodity output production using ash, etc.
7. From the world practice it is known, that use of ash from TPPs in the amount of 100 % occurs very seldom. Hence, the unrequired ash part should be landfilled. For maximum decrease of specific cost of ash removal by AR system as a whole and for minimal environmental pollution by ash disposals it is necessary to follow the regulations:
 - creating the new hydraulic ash disposals does not allow to achieve the objects in view;
 - the maximum part of the unrequired ash at ash disposals should be landfilled in a form of products of seasonal demand (storage less than one year to provide seasonal consumption by operating factories) or a pent-up demand (storage for the period before starting up the factories being under construction or design);

- the part of ash meeting no seasonal or a pent-up demand on estimation, should be landfilled only by ecologically sound ways preferably in the form of products of superficial processing (gravel, crushed rock, etc.) with a minimal production cost or should be landfilled at dry ash disposals;
- decision-making on types, ways and technologies of landfilling of the unrequired ash part should be carried out on the basis of analysis of technical and economic indices of AR systems as a whole according to².

8. For achievement of the best project and average operation indices on reliability and profitability of technological units of internal and external pneumatic ash removal the preference should be given to the automated pneumotransport installations at other equal parameters.
9. For the best adaptability of AR systems of TPPs for expansion of the ash commodity market, change of specifications on ash delivery, toughening of the nature protection legislation and conditions of economic activities configurations of technological units (internal and external transport, devices and installations of ash discharge, manufactures for ash processing and ash disposals) should be provided with the opportunity of their change with minimal expenses.

In 1995-98 employees of MPEI developed main principles and methodic regulations on creating AR systems of TPPs with optimum technical, economic and sound ecological parameters due to means of the state budget and used them by development of the basic supervising documents of the Russian JSC "UES of Russia" on ash removal systems^{1,2}.

4. PERSPECTIVE ASH REMOVAL SYSTEMS OF TPPS

In fig.3 a perspective AR system by the example of Reftinskaya Power Plant is given. The annual ash production is about 4 million t and in the long term it can make 6 million t⁴. Nowadays ashes are removed using a traditional HAR system that is to be reconstructed. There have been developed several scripts of ash removal organization. A preliminary ecological and economic estimation of two basic of them has been carried on; they are the following:

- 1) the existing hydraulic ash removal system is remained and expanded,
- 2) a system with dry removal and disposal of the unrequired by consumers ash part is created.

In a basis of developing the alternative ash removal system the main principle - application of the best available technologies for evacuation of bottom ash from a boiler throat, transportation, shipment to users and landfilling of fly ash and bottom ash without any water as the carrying medium has been placed.

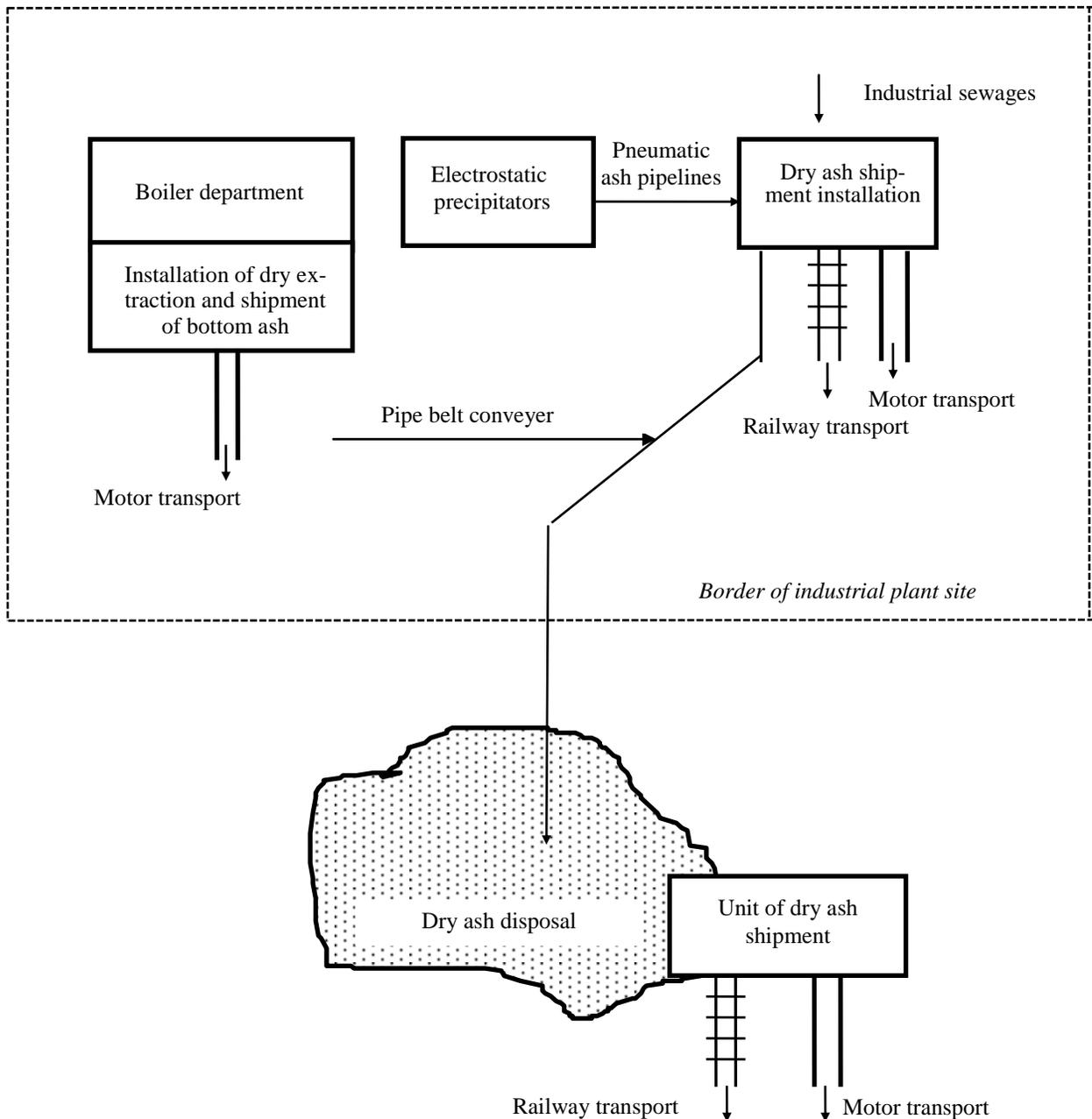


Fig. 3. A block diagram of a system of discharge, transportation and landfilling of the unrequired dry ash part at the ash disposal of Reftinskaya power plant

5. SOME ASPECTS OF IMPLEMENTING ECOLOGICALLY SOUND ASH REMOVAL TECHNOLOGIES AT CONSTRUCTION OF NEW AND REDESIGN OF OPERATING COAL-FIRED POWER PLANTS

Organization of close interacting of administration of the power companies with regional authorities on a problem of beneficial use of ashes is one of the main directions of activity for decreasing harmful environmental impact of coal-fired power plants, and also for reducing the cost price of electric and thermal energy generation. Such an effective

interacting will also promote more intelligent use of natural resources due to decrease of water consumption by power plants and replacement of nonmetallic materials with ashes/slugs by factories of other economy branches. It is necessary to note, that such a correct approach to the solution of the ash problem is formed for the present not in all heads of administration of the power companies and coal-fired power plants, and regions of Russia.

Normative and legal documents of a federal level on promoting beneficial use of ashes from TPPs are developed not systematically enough resulting in a very low level of replacement of natural materials with ashes and slags. First of all, it is necessary, in our opinion, to develop «Rules of certifying sanitary-and-hygienic properties of the commodity output made from ashes and slags, and ashes and slags as a commodity output». We suppose, that availability of such Rules would allow to avoid many misunderstandings and promote both essential growth of volumes of natural materials replacement with ashes/slugs, and also environmental protection in a zone of the TPP impact.

Underestimation of importance of the ash problem under development of projects for reconstructing coal-fired power plants by administration of the power companies leads to that at a stage of development of the feasibility report on TPP reconstruction not enough attention is often given to the problems of ash use. Many heads of the power companies have a wrong opinion, that somebody else should be engaged in the ash problem solution, but they are not power engineers, who have one aim - energy generation.

An algorithm of optimum solution of the ash problem is considered to be the following:

- The state through the matching legislative bodies provides financing researches on the ash and slag problem and a duly development of matching normative and legal documents, and through the bodies of control and nature protection supervision pursues a policy on promotion of intelligent use of natural resources and environmental protection;
- The power companies with the purpose of cutting power generation costs and environmental protection constantly finance researches of existing and potential commodity market of ashes and slags and organize operation of AR systems according to the main principles and methodical regulations on creating AR systems with optimum economic and sound ecological parameters.

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