

## ASH AND SLAG HANDLING

## 3.7. Analytics

## 3.7.2. Challenges, opportunities and ways of solving the problem on ashes and slags from TPPs in Russia

V.Y. Putilov, I.V. Putilova

Moscow Power Engineering Institute (Technical University), Russia

## ABSTRACT

Brief estimation of ecological parameters of ash and slag removal systems of thermal power plants (TPPs) in Russia is resulted. Key deficiencies of traditional hydraulic ash and slag removal systems of TPPs are presented. Supervising documents on ash and slag from TPPs, developed by IACEE MPEI are brought. Basic barriers for using ash and slag from TPPs are observed as well as opportunities for raising a level of their beneficial use are resulted.

## 1. BRIEF CHARACTERISTICS OF ASH AND SLAG REMOVAL SYSTEMS IN RUSSIA

The annual output of ash and slag from TPPs and boiler-houses of the Russian Open JSC "UES of Russia" in 2000 - 2007 changed from 22,4 up to 26,5 million tonne. A relative volume of processing ash and slag from TPPs by an expert estimation in 2000 - 2005 made from 12,4 up to 17,9 % of their annual output. In tab. 1 data on annual volumes of ash and slag production,

processing and disposing of the unclaimed part at landfills of TPPs in Russia in 1990-2007 are given. There are no adequately reliable annual returns from TPPs on volumes of processing and landfilling ash and slag since 2002, and therefore they are not resulted. For 2005 such expert estimations are brought. As of March 1, 2009 there are also no reliable data on volumes of coal consumption and ash and slag production at TPPs in 2008.

About 85 % of ashes and slags are transported by hydraulic ash and slag removal (HASR) systems as a pulp of low concentration for landfilling them at the hydraulic ash and slag disposals (HASD) being one of the basic sources of environmental contamination at energy generation (fig.1). The total area of hydraulic ash and slag 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

Table 1. Volumes of producing, processing and landfilling of ashes and slags from TPPs in Russia in 1990–2007

Index	Years						
	1990	1995	2000	2002	2005	2006	2007
Coal consumption, million t of natural fuel/year	182,0	128,0	120,1	106,0	102,6	125,4	114,8
Average ash content, %	27,5	26,3	20,8	21,4	21,8	21,1	21,2
Ash production, million t/year	50,0	33,7	25,0	22,7	22,4	26,5	24,3
Ash processing, million t/year	4,5	1,9	3,1	3,3	4,0*		
Ash landfilling million t/year	45,5	31,8	21,9	19,4	18,4		
Relative volume of ash processing, % from the annual output	9,0	5,6	12,4	14,5	17,9		

\*- expert estimation

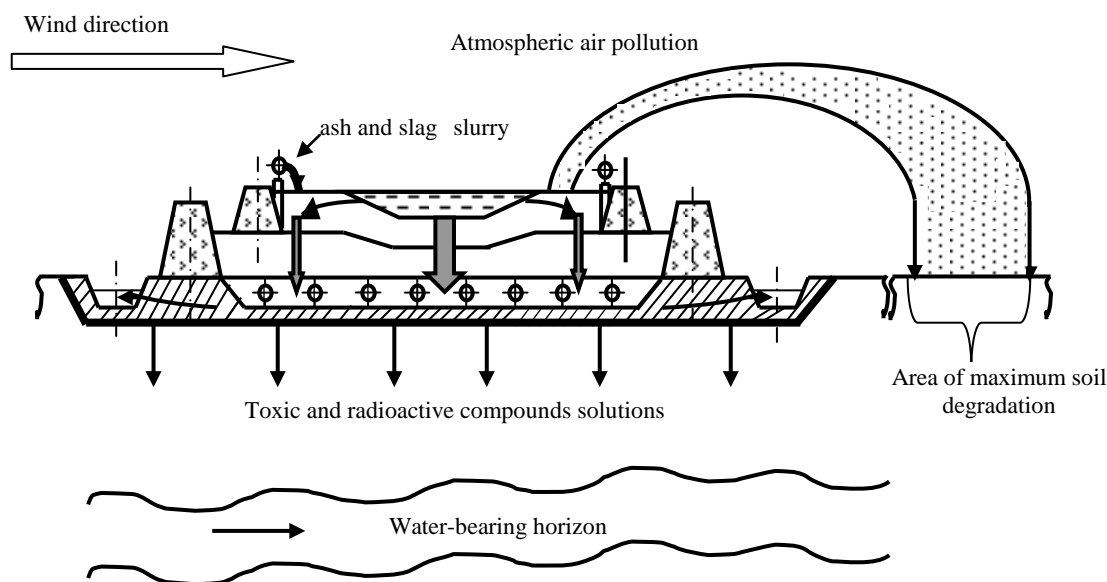


Fig.2. Influence of HASD of TPPs on environment

Analyzing technical, economic and ecological parameters of traditional HASR systems their following basic disadvantages have been found out:

- formation of firm deposits in hydraulic ash pipelines resulting in its failure;
- frequent enough change of pressure ash pipelines due to their erosion and corrosion;
- unjustified high power inputs for external ash hydraulic transport due to practical uncontrollability of productivity of external hydraulic ash removal installations depending on mass of the transported ashes;
- 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 unloaded to users;
- large specific water discharge - up to 50 m<sup>3</sup> of water per 1 ash ton;
- additional expenses for air-conditioning of ashes at their unloading from landfills according to the technical requirements of users for their delivery;
- clearing the circulating water of HASR 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 landfills and pipelines of external ash removal;
- atmosphere pollution due to ash landfill dusting;
- underwater pollution by solutions of toxic and heavy metals compounds filtrated through a bed of an ash landfill;
- soil degradation in a zone of the ash landfill impact;
- frequent enough use of HASR 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. BASIC BARRIERS FOR BENEFICIAL USING OF ASH AND SLAG FROM TPPS

### 2.1. Terminology and consequences of its use

According to the branch supervising document «RD 34.27.109-96. Methodic directions on design of pneumatic ash disposal systems from boilers and plants of supply of dry ash to users and its discharge to the ash landfills» [1] ash and slag from TPPs have been firstly determined as follows.

**Fly ash** - particles of mineral residue of solid fuel including a certain amount of the unburnt organic part of fuel, taken out by flue gases from the furnace of the boiler.

**Bottom ash/boiler slag** – particles of mineral residue of solid fuel including a certain amount of the unburnt carbon, formed in the furnace of a pulverized boiler, falling from flue gas torch in the furnace of a boiler and coming from bottom ash/boiler slag evacuator with the size up to 40 mm or coming from furnace of FBC boiler through bottom ash/boiler slag coolers to bottom ash/boiler slag evacuators with the size up to 10 mm.

**Ash and slag materials (ASM)** – ash and slag with initial properties, ash and slag mixture and products of their conditioning.

However, unfortunately, most power engineers and other Russian ash and slag experts used to say before «ash and slag wastes» and now are saying the same instead of «ash and slag materials». It is a consequence of three main reasons:

- 1) in the federal legislation of Russia ashes and slags are abnormally referred to wastes;
- 2) ignoring of branch normative deeds;
- 3) wrong representation about true ash and slag value.

Authors of the paper consider that the most correct definition now is the following: «Ashes and slags from power generation are valuable mineral raw materials of a man-made nature». By the way, in recent years the leading world experts define them the same way or very closely. What will be ashes and slags depends on how do we handle them. If we process them, they will be valuable mineral raw material of a man-made nature. If we contaminate the environment more or less, landfilling them, ashes and slags will be wastes.

It should be noted, that definition of ash and slag as waste, results in the respective handling them as waste, that evidently show statistic data on natural and relative ash and slag processing volumes in Russia.

The concept "wastes" means, that ashes and slags are not to be used in economic purposes, but they are to be disposed at the fields for constant storage. Since their annual production makes hundreds million tonne worldwide, huge areas for construction of ash and slag landfills, located near large cities, are required. It is well-known, that ash and slag landfills of TPPs even at accomplishment of a necessary complex of nature protection measurements, make negative impact on environment more or less not only in a zone of their arrangement, but also far from them due to dusting and water pollution by filtrates of toxic and radioactive compositions. Hence, defining ash and slag as wastes at a legislative level, we prevent their processing and contribute in their disposing at ash and slag landfills and stimulate poisoning of environment by coal-fired power plants and by all these consciously making an ecological crime against ourselves and humanity as a whole.

If we are for the second definition in which ashes and slags are considered to be marketable products, and every product has its price. Hence, we start thinking what should be done for the most beneficial ash and slag application in manufacture of various products, both as substituents of natural raw materials, and as components in manufacture of other products having very few or even no analogs in environment. As an instance we can take cenospheres or rare-earth elements.

We assume that for representatives of regulating and executive bodies it's time to determine, whom do they support – destroyers or defenders of environment from man-made impact of coal-fired power plants.

### 2.2. Holistic complex of legal and technical documents on ash and slag management and its

### **compliance with the state-of-the-art requirements**

Since 1996 our research group together with the leading experts of power engineering organizations according to the plans of the most important R&D works of RAO «UES of Russia» has developed the following guideline and technical documents:

- RD 34.27.109-96. Methodic directions on design of pneumatic ash disposal systems from boilers and plants of supply of dry ash to users and its discharge to the ash landfills.
- RD 34.02.103-98. Assessment method of technical and economic indices of ash and slag removal systems of TPPs with regard to ecological requirements.
- RD 153-34.1.-27.512-2001. Methodic directions on estimation of erosion in pneumatic conveying pipelines of ash and slag removal systems and coal-pulverizing systems at TPPs,
- “Technical proposals on increasing safety, economic and ecological indices of pneumatic ash removal systems from ESPs at separate and combined pulverized coal combustion of different coal types”, 1996. and modified:
- Norms of wall wear till repair of airslides and pneumatic devices for ash transport. RD 153-34.1-10.341-2001,
- Norms of steel tube wear till repair of pneumatic ash pipelines of pneumatic conveying installations of TPPs ash removal systems. RD 153-34.1-10.342-2001.

A peculiarity of these documents is that employees of TPPs and power companies can apply them in their practice without considering other sources of information, besides the norms on payment for nature resources use. In addition to the mentioned documents there exist other ones. However, unfortunately, it should be noted that for today we have the following situation:

- 1) no holistic complex of normative and technical documents on creation and operation of ash and slag removal systems meeting state-of-the-art requirements on reliable, economic and ecologic operation of power generating equipment.
- 2) not many experts use the developed documents.

It should be mentioned that in case we want effective solution of the problem on handling with ash and slag from power generation, the work on development of a holistic complex of normative and technical documents on handling with ash and slag from TPPs and its improvement should be constantly conducted for its duly modification in connection with the changing social understanding of ecological impact of power generation on environment, depletion of mineral natural resources, change in economic conditions of economic activity realization as well as a necessity to take into account other important factors of society development.

### **2.3. State policy in the field of ash and slag handling**

One of the most important barriers for effective solution of a problem on ash and slag handling in

Russia is an absence of the clear federal policy that would encourage–inspire–force power engineers to process ash and slag instead of landfilling them, and potential ash and slag users — to utilize these materials in different applications replacing nature raw materials.

State legislative and executive bodies of all levels should organize continuous coordinated system activity financing the following directions:

- continuous monitoring of existing and potential market of ash and slag from TPPs to estimate the need in ashes and slags as substituents of natural raw materials;
- study of sanitary and hygienic properties and commodity output produced using ashes and slags, as well as limitations on their use at manufacture of commodity output;
- improvement of legal and normative documents on ash and slag handling with the aim to develop a complex of documents of direct influence being compulsory for all state bodies of all levels all over Russia;
- information support of public, producers and users of ash and slag on technological, legal and other issues on effective handling with ash and slag considering the world experience.

It should be underlined the importance of effective interaction of legislative and executive bodies of all levels of the state management in solution of inter branch problem on ash and slag handling;

In addition to building of installations for discharge of ash and slag from TPPs to different users having initial properties, creation of manufactures on ash and slag beneficiation or production of intermediate products results in significant increase in a level of their beneficial use, however, there is no effective economic and legal mechanism of encouragement of investments in creating such manufactures.

Especially, it is necessary to underline that ash and slag supply to different customers allows to cut the cost price of electric and thermal energy generation according to the amount of ash and slag supply. That is a key factor resulting both in increase in of coal-fired TPP competitiveness, and it has also a positive influence on a price of electricity in the power market.

### **2.4. Public opinion about benefit and danger of ash and slag use**

Public opinion about benefit and danger of ash and slag use for commodity product manufacture can also have positive or negative influence on solution of problem on handling with ash and slag from power generation.

Different public representatives often have groundless concerns that materials manufactured with ash and slag are dangerous for the health of population. These concerns happen due to lack of information people have about actual properties of ash and slag and products manufactured using ash and slag. As an opposite example of a product manufactured with nature materials we can take radioactive properties of heavy granite concrete.

Its sanitary and hygienic properties with regard to radioactivity will be much worse than properties of the concrete manufactured using most of ashes and slags from power generating coals. These vague apprehensions can be dispelled by the most objective informing of all social classes about the results of investigations on sanitary and hygienic properties of commodity output manufactured using ash and slag conducted by corresponding health protection bodies. And this problem is to be solved by the state bodies through financing of carrying on investigations and creation of a system of public informing about the results of investigations.

However, these concerns can be sometimes reasonable. This can take place in case ashes and slags are used without the required control by inspection bodies over compliance with technical, sanitary and hygienic norms on consumer properties of commodity output manufactured with ash and slag. Such cases are possible due to the following main reasons:

- imperfection of legal and normative base in the field of ash and slag handling;
- inactivity or wrong activity of representatives of the corresponding inspection bodies;
- transgression by ash and slag suppliers and processors of legislation in the field of ash and slag handling.

In similar cases a role of state legislative and executive bodies of all levels can't be overestimated. This can also be under careful attention of procuracy and Mass Media. Very soon such cases are being of a public domain. A result of it is that the relative volume of ash and slag careless processing into comparison with the total volume of their production in the country is negligible, but a proper idea on beneficial use of ash and slag aiming to increase in power generation efficiency and decrease in harmful impact of ash and slag removal systems on environment is strongly damaged.

One of the possible examples of informing the public on the best available state-of-the-art technologies on beneficial use of ash and slag from power generation is creation of the site on coal combustion by-products in Russia of an open access. The main goal of the site is conducting system investigations of domestic and foreign experience on solution of a problem on handling with ash and slag from TPPs burning solid fuel and boiler-houses as well as representation of investigation results on the constantly updated site.

The results of creation and update of the site:

- online acquaintance of any Russian or foreign user with constantly updated information on handling with ash and slag from TPPs and boiler-houses in Russia and in the countries worldwide;
- open information exchange on handling with ash and slag from TPPs and boiler-houses between Russian and foreign experts;
- unhindered access of students of educational institutions, listeners of programs on skill improvement and professional retraining, scholars and other groups of users interested in getting information on problems and ways of their solving in the field of handling with

ash and slag from TPPs and boiler-houses considering the world experience;

- creation of the objective image of Russia worldwide with regard to activity on environmental improvement in the area of coal-fired TPPs and boiler-houses influence by adequate informing of the world public on activity of the Russian power companies on reconstruction of existing and creation of new economically effective ash and slag removal systems with sound ecological indices and use of by-products from organic fuel burning as substituents of natural raw materials.

With regard to international projects on informing the world public on handling with ash and slag from power generation, the activity on creation of the Worldwide Coal Combustion Products Network (<http://www.wccpn.org>) initiated by the American Coal Ash Association (ACAA) needs to have an absolute approval.

## 2.5. Qualified experts in ash and slag handling

First of all, it is necessary to notice that there are no higher educational institutions in Russia and other countries all over the world, where experts on ash and slag handling are prepared. A paradoxical situation appears, when the problem exists, but there are no dedicated experts in educational institutions. People become experts in this field as a result of any casual events occurring in their life. As a rule, such experts have fragmentary, non-systemic knowledge which are insufficient for effective solution of a problem on handling with ash and slag from power generation.

This issue has been discussed by experts from different countries during the 1<sup>st</sup> International conference EUROCOALASH (Warsaw, October 6-8, 2008). As a result of discussing a problem on target preparation of experts in the field of ash and slag handling the following understanding of the current situation formed:

- 1) It is necessary to prosecute target preparation of the graduates in specialized secondary educational establishments and higher educational institutions.
- 2) In addition to the target preparation of graduates a system on professional skill improvement and professional retraining of experts it to be organized.

1). For practical solution of a problem on target preparation of graduates it is necessary to complete the following primary tasks:

- define a need of various economy branches of the state in such experts;
- develop Curricula of training of technicians, bachelors and engineers;
- select the interested basic educational institutions having training facilities and methodological framework which are to the maximum extent ready and meet the above-stated Curricula, where it is possible to arrange such a preparation of experts with minimum expenses;
- make the required changes in educational standards;

- create teaching materials for preparation of experts in the basic educational institutions selected in a corresponding order;
- start preparation of experts.

If we estimate a real time required to become the first experts it is possible to assume that it will occur in 8-10 years or even more after they start to make practical solutions on all the complex of problems. But time presses, though target preparation needs to be organized all the same.

2). Creation of systems on professional skill improvement and professional retraining of experts does not require so much time. There are two possible alternatives here: improvement of professional skill and professional retraining.

**Improvement of professional skill.** Development of teaching materials for improving of experts' skill, in our opinion, will take no more than a year. Improvement of professional skill of experts in Russia could be arranged in the Center of training and retraining of experts «Ecology in Power Engineering» of the Moscow Power Engineering Institute (CPPEE MPEI) involving authoritative Russian and foreign experts. We believe that in other countries of the world will be also educational institutions which could improve professional skill of experts. Duration of the program on professional skill improvement can be different, but by experience of training of experts according to different programs for continuing professional education in order to achieve a desirable efficiency it should be not less than 160 hours. In such a program execution and defense of the final work considering practical solution of any problem being sensitive for the organization in which the listener of the professional skill improvement program works, should be provided.

**Professional retraining of experts.** This is the most effective direction of dedicated expert preparation. According to the Russian educational standard three basic modes are possible here:

- Graduate Courses;
- postgraduate study;
- professional retraining.

It should be noted that CPPEE MPEI has a practical experience in all three modes of study.

**Graduate Courses.** Training process under this form begins at the last (fourth) year of the bachelor's study on a speciality «Thermal Power Plants». A bachelor conducts the final work connected with ash and slag removal systems. Thus, professional retraining is combined with the basic education. During postgraduate studies there is a target preparation of the future expert in the field of ash and slag handling. At the same time along with studies a future master is involved in performance of works under contracts with power companies. During part of study time a student can also work for the power company which pays for his education. Total duration of preparation of such an expert makes three years (1 + 2 considering the last year of bachelor's study).

**Postgraduate study.** It is a form of preparation of highly skilled experts under system: «Bachelor's programme→Master's programme→Postgraduate studies». During postgraduate studies a future expert most of his time is involved in activity on performance of works under contracts with power companies. Total duration of professional retraining of such an expert makes six years (1 + 2 + 3 considering the last year of bachelor's studies).

**Professional retraining.** By experience of carrying out of programs on professional retraining of experts from power enterprises, it was found out that many engineers have no required profile power engineering education. Therefore duration of effective professional retraining of experts on ash and slag handling should make not less than 1000 classroom hours that is possible at on-site and correspondence training during two years with the training program duration of about 2000 hours. Total duration of separation of the trainee from manufacture makes four months during two years.

## 2.6. Misunderstanding and disregard of the role of science and educational system in solving the problems in power industry

One of the basic results of reorganisation (perestrojka) and postreorganization processes in the country is, unfortunately, misunderstanding and ignoring by the most part of so-called top-managers of power companies of a role of science and educational system in solving the problems in power industry as a whole and those on ash and slag handling in particular. An ideology of behaviour of such "heads" concerning science and educational system is built according to a very simple concept: «People of science should be happy that we listen to them free of charge». Many times Mr. Putilov wrote to the heads of WGCs, TGCs and other large power holdings offering them information and consulting cooperation on all the range of issues on power generation at TPPs, including ash and slag problem. No one responded, but they claim that MPEI graduates are not prepared so good on various specialities. We also have a positive experience of long- term cooperation with power companies under programs on professional skill improvement and professional retraining of experts, but there are only few similar examples. I'll not list these organisations not to draw attention to their heads. The problem is that quality preparation of experts at the modern level, especially, in market conditions, is only possible in case the society on behalf of the state or power companies makes an order for that. Products of high school activity are: scientific developments, graduates and experts trained under programs on additional professional training. No orders from power industry — no scientific developments and no experts having required qualification and amount. Until this is not realised by top-managers of power companies, activity on increase of power generation efficiency will result in decrease in the number of employees and cut of salary fund of the

personnel of power companies as they do not have any other ideas.

### **3. BASIC ACTIVITY DIRECTIONS ON EFFECTIVE SOLUTION OF ASH AND SLAG PROBLEM**

Basic activity directions on effective solution of ash and slag problem are the following:

- creation of clear state policy encouraging maximum ash and slag processing instead of using natural raw materials;
- creation of the holistic complex of legal and normative documents of direct influence on handling with ash and slag from power generation and as well as their continuous improvement;
- development of economic and legal mechanism of encouragement of investments in building manufactures for processing ash and slag from TPPs into commodity products;
- state financing of system investigations on handling with ash and slag from TPPs;
- working out and improvement of the holistic complex of normative and technical documents on crea-

tion and operation of ash and slag removal systems meeting state-of-the-art requirements on reliable, economic and ecologic operation for power generating equipment.;

- preparation of qualified experts on ash and slag handling;
- active interaction with international and national associations of other countries on CCP handling;
- informing all social classes on the best technologies on ash and slag handling implemented in different countries all over the world and potential danger of landfilling the unclaimed ash and slag part using ecologically unacceptable ways;

### **LITERATURE**

1. **Методические указания** по проектированию систем пневмоудаления золы от котлоагрегатов ТЭС, установок отпуска сухой золы потребителям и отгрузки ее на насыпные золоотвалы. РД 34.27.109-96. Вишня Б.Л., Путилов В.Я., Боричев К.П. Екатеринбург: Уралтехэнерго, 1996.