

ASH AND SLAG HANDLING

3.7. Analytics

3.7.33. Major barriers to effective solution of the coal ash handling problem

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ABSTRACT

The article presents a situation in the field of coal ash handling in Russia, U.S., India and EU member-states. The main barriers to efficient use of coal ash in Russia are considered. The examples of international projects on informing the world community on the coal ash handling problem are given. The question of specialists' training in this area is highlighted. The aftereffects of incomprehension and ignoring by the power companies' management the role of science and the system of education in solving the ecological and coal ash handling issues are considered. Basic directions of activity for effective solution of the coal ash handling problem are stated.

1. INTRODUCTION

Russia. In 2000 - 2005 the annual output of coal ash from thermal power plants and boiler-houses of the RAO "UES of Russia" varied from 22.4 to 25.0 million tons. In 2000 – 2002 the relative volume of coal ash processing according to the expert evaluation made from 12.4 to 14.5 %, and in 2005 the expert evaluation showed 17.9 % of the annual output. Since 2002 there is no sufficiently reliable data reported by TPPs relating to volumes of coal ash processing and disposal, and hence they are not given. Since 2008 there is no reliable data on coal consumption at thermal power plants and boiler-houses. Furthermore, there's no reliable data on beneficial applications of coal ash used for production of various commercial products.

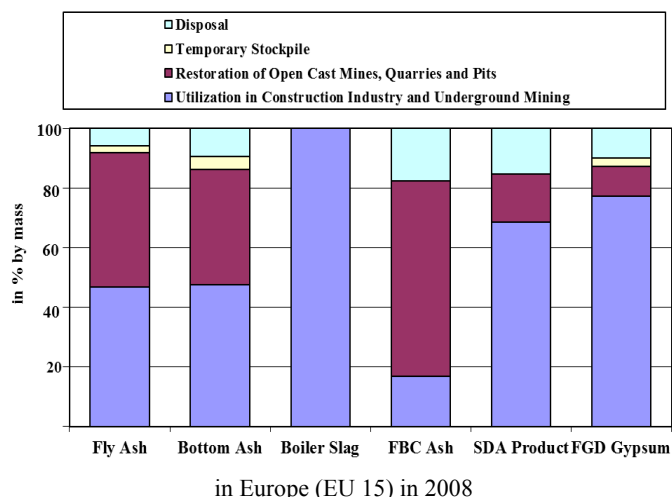
About 85 % of ash is transported by hydraulic ash removal systems in a form of a low-concentrated slurry to be placed at hydraulic ash disposal sites, being a major source of pollution while energy production. The total area of hydraulic ash disposal sites is about 24 hectares. Briefly ash handling systems can be characterized as economically not feasible and environmentally non-acceptable.

USA. From the report of ACAA in 2005 [1]: "Over 50 percent of the electricity generated in the United States comes from coal-fueled power plants. Coal represents 80 percent of America's fuel reserves, followed by natural gas (15 percent) and oil (5 percent). Twenty of the nation's 25 lowest cost electric generating stations are fueled by coal. In 2003, over 121 million metric tons of coal combustion products (CCPs) were produced and of this amount, approximately 38 percent (46,5 million tons) were used beneficially. The number of beneficial uses for CCPs continues to grow each year and by 2010, the industry and Department of Energy have set a goal of increasing utilization of all CCPs to 50 percent. The U.S. government has recognized and endorsed that the use of CCPs enhances the nation's sustainability and «green» objectives as well as offering growth of positive U.S. technology, business and research initiatives". According to the report of ACCA in 2008 [2]: beneficial use of CCPs made almost 43 percent of more than 131 million tons of CCPs produced in 2007.

India. V. Kumar reported the following [3]: "Coal is pre dominating the energy scenario in India. Over the decades electricity generation in the country has remained coal dependant to the extent of 60-67 % as compared to global average of about 30 %. With Indian coal resources of about 300 billion tonne, and limited resources of other forms of energy, the dependence of power sector on coal is destined to continue for foreseeable future. Current annual generation of about 200 Mn. tonne fly ash from about 100 utility and 40 captive coal/lignite based thermal power plants of 120,000 MW (approx) capacity is projected to grow to around 1000 Mn. T/year by 2031-32 with expanding power sector. Commercialization and large scale utilization have started in 1991. In 1994 fly ash utilization rate made 1.0 million tonne till 100 million tonne in 2011. Hundreds of multiplier effects have come up, generating economic wealth more than US\$ 3 billion, employing more than 1 million people and saving more than 55 MnT CO₂ per annum". A task for 2025 is to provide 100 % ash utilization rate of the current ash output.

EU members. According to the ECOBA report [4]: "Coal is a major fuel for energy and steam production in European coal-fired power plants. The production in all the European member states is estimated to be about 100 million tonnes per annum starting from 2010 (56 56 million tonnes of CCPs were produced in EU15 in 2008). The rates of utilisation, temporary stockpile and disposal for the single CCPs are given in Fig. 1".

Fig.1. Utilisation, temporary stockpile and disposal of coal ash



Forecast of coal consumption by countries with a share of coal in electricity production more than 50%. T. Szczygielski, J. Hycnar reported as follows [5]: "The share of coal in electricity generation in 2006 was 93 % in South Africa, 80 % in Australia, 78 % in China, 71 % in Israel, 70 % in Kazakhstan, 69 % in India and Morocco, 59 % in the Czech, 58 % in Greece, 50 % in the USA and 47 % in Germany. In Poland, the share of coal is one of the highest in

the world, being respectively 64,9 % and 93 %. The biggest increase in the use of coal in economic development is found in China (growth of coal-based electricity production from 30 EJ in 2000 to 70...85 EJ in 2050), in India (increase in the consumption of coal for electricity generation from 310 m ton in 2005-2006 to 1.659m ton in 2031-2032) and the USA (increase by 20 % in the years 2006—2030)".

Such a growth of coal consumption will also result a sharp increase in the amount of generated CCPs that inevitably compel these countries to pay very close attention to the effective solution of the coal ash handling problem.

2. MAIN OBSTACLE TO THE EFFICIENT COAL ASH USE

2.1. Terms and their implications

According to the branch supervising document [6] 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 materials 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 wastes, results in the respective handling them as wastes, that evidently show statistic data on actual 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 sites 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 measures, 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 ponds 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 it means that 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 extraction of cenospheres from ash or groups of fractions with high concentration of 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 the man-made impact of coal-fired power plants and boiler-houses.

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 the authors together with the leading experts of power engineering organizations according to the plans of the most important R&D of the RAO "UES of Russia" has developed the following guidelines and technical documents:

- RD 34.27.109-96. Instructional guidelines for designing pneumatic ash disposal systems from boilers and plants of supply of dry ash to users and its discharge to the ash landfills / Vishnya B.L., Putilov V.Y. JSC "Uraltechenego", Yekaterinburg, 1997, 170 p.
- RD 34.02.103-98. Procedure for evaluating technical and economic indices of ash and slag removal systems of TPPs with regard to ecological requirements / Putilov V.Y., Avtonomov A.B., Borichev K.P., Orlov A.V., Malikova E.A., etc. NTF "Energoprogress", Moscow, 1998, 79 p.
- RD 153-34.1.-27.512-2001. Instructional guidelines for estimating erosion in pneumatic conveying pipelines of ash and slag removal systems and coal-pulverizing systems at TPPs / Putilov V.Y., Putilova I.V., Vishnya B.L., Borichev K.P., Malikova E.A. MPEI, M., 2001, 20 p.
- Technical proposals for improving reliability, efficiency and environmental characteristics of pneumatic ash removal systems from dry ash collectors at separate or joint pulverized combustion of coal of different grades / V.Y. Putilov, E.A. Malikova. - Moscow: MPEI(TU), 1999, 50 p. and modified:
- RD 153-34.1-10.341-2001. Wall material consumption rates for repair of airslide conveyors and pneumatic ash conveying devices / Putilov V.Y., Kobtsev S.V., Vishnya B.L. MPEI, M., 2001, 6 p.
- RD 153-34.1-10.342-2001. Steel tube consumption rates for repair of pneumatic ash pipelines of pneumatic conveying plants of TPP ash removal systems / Putilov V.Y., Kobtsev S.V., Vishnya B.L. - M.: MPEI(TU), 2001, 6 p.

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, beside the standard fee rates for using nature resources. 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 wish to have an effective solution of the coal ash handling problem, the work on development of the holistic complex of normative and technical documents on coal ash handling 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 to effective solution of the coal ash handling problem in Russia is an absence of the clear federal policy that would encourage–inspire–force power engineers to ship coal ash for its processing instead of landfilling, 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 coal ash to estimate the need in coal ash as substituents of natural raw materials;
- study of sanitary and hygienic properties and commodity output produced using coal ash, as well as limitations on their use at commodity output manufacture;
- improvement of legal and normative documents on coal ash 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 coal ash relating to technological, legal and other issues in the field of effective coal ash handling 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 the inter branch ash and slag handling problem.

In addition to building the installations for discharge of coal ash 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 for encouragement of investments in creating such manufactures.

Especially, it is necessary to underline that coal ash supply to different customers allows to cut the cost price of electric and thermal energy generation according to the amount of coal ash supplied. That is a key factor resulting both in increase in 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 coal ash use

Public opinion about benefit and danger of coal ash use for commodity product manufacture can also have a positive or a negative influence on the coal ash handling problem solution.

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 a lack of information people have about actual properties of coal ash and products manufactured using coal ash. 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 coal ashes. 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 coal ash 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 coal ash is used without the required control by inspection bodies engaged in compliance of consumer properties of commodity output manufactured with using coal ash with technical, sanitary and hygienic norms. Such cases are possible due to the following main reasons:

- imperfection of legal and normative base in the field of coal ash 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 coal ash 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. Such cases become public very quickly, that leads to the fact that a relative volume of unfair ash processing compared to the total volume of their production on a national scale is negligibly small, but the enormous harm causes to the absolutely right idea of useful application of ash to improve the efficiency of energy production and to reduce the impact of ash removal systems on the environment.

One of the possible examples of informing the public on the best available state-of-the-art technologies on beneficial use of coal ash is creation of *Information Electronic Constantly Updated Open System "The Best Available and Perspective Nature Protection Technologies in the Russian Power Industry"* (OIS BAT, <http://osi.ecopower.ru>). The work on creation of the System in Russian and English was finished in 2011 according to the Program of MPEI development. A section "Ash and slag handling" is a part of the World-Wide Coal Combustion Products Network (<http://www.wccpn.org>).

Sources of information of OIS BAT are as follows:

- results of system researches on ecological problems in power engineering;
- state-of-the-art nature protection technologies in electric power engineering: Informational collection / Edited by V.Y. Putlov. M.: MPEI-Publishers, 2007 – 388 p.;

- Russian and foreign legal, normative and technical documents;
- proceedings of international scientific and technical workshops and conferences,
- reports of power companies relating to the nature protection activity;
- papers in printed and electronic Mass Media.

When creating OIS BAT the possibility for adjustment and placement of new materials in the relevant sections, as well as its addition with new sections or blocks with minimal financial and labor costs has been provided.

Content of all the sections and materials of OIS BAT is available in the public domain without any limitations. The main purpose of creating OIS BAT is reflection of results of systematic analysis of domestic and foreign experience to address the problem of ecology in power engineering as well as the problem of the coal ash handling at coal-fired thermal power plants and boiler-houses in the constantly updated system.

Main objectives of OIS BAT are as follows:

- online free acquaintance of any Russian or foreign user with all materials of the System;
- promotion to Russia the best world available technologies in the field of ecology in power engineering;
- provision of information environment for increasing the efficiency of using finances, physical and human resources while solving the issues of improving the ecological and economic indices at construction of new and modernization of operating electric power enterprises;
- improving the quality of preparation, professional development and professional retraining in the field of environmental protection of personnel, responsible for design, construction and operation of electric power enterprises;
- information exchange in the field of nature protection technologies and equipment between the experts all over the world;
- formation of a favorable image of Russia in the field of environmental protection in electric power sector in the countries worldwide relating to activity on improvement of the environmental quality in a zone of impact of coal-fired power plants and boiler-houses due to adequate informing the world community on activity of the Russian power companies on modernization of existing and creation of new economically efficient ash and slag removal systems having acceptable ecological indices and use of by-products from combustion of organic fuel, replacing the natural raw materials.

2.5. About international projects on informing the international community on the coal ash handling problem.

World-wide Coal Combustion Products Network (www.wccpn.org) was created on the initiative of the American Coal Ash Association (ACAA) in 1999 and is a result of effective cooperation on the non-state basis of authority world experts in coal combustion by-products handling, most part of which are ashes and slags from thermal power plants and boiler-houses. The authors of this paper are Russian members in the Coordinating Council and a Working Group on development of the World Wide Coal Combustion Products Network. Members of the Network are constantly interacting with each other and with other leading experts in the field of CCPs handling to discuss ways of resolving their

common problems, achieving the best results in research and implementing new technologies for the use of CCPs.

European Coal Combustion Products Association (ECOBA) was founded in 1990 by European energy producers to ensure efficient and high-quality use of CCPs. IACEE MEI actively cooperates with ECOBA and is its affiliate member since 2006. One of the main objectives of ECOBA is to promote information and documentation exchange on the coal ash handling problem between national and international organizations, including through participation in international scientific conferences and seminars presenting analytical reports on situation in the EU as a whole or its individual members.

2.6. Qualified experts in ash and slag handling

First of all, it should be noted that there are no higher educational institutions in Russia and other countries all over the world, where experts in coal ash handling are being prepared. A paradoxical situation appears, when the problem exists, but no dedicated experts are being prepared 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 the coal ash handling problem.

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

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

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.

Creation of systems of professional skill improvement and professional retraining of experts does not require 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 there will be also educational institutions which could improve professional skill of experts. Duration of the program of professional skill improvement can be different, but according to the experience of experts' training 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 MEI has a practical positive experience of training in all three forms of education, which, unfortunately, has not yet received widespread.

Graduate Courses. The 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 coal ash handling. At the same time along with studies a future master is involved in performance of works under contracts with power companies. During the part of study time the 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 the 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 the programs on professional retraining of experts from power enterprises, it was found out that many engineers have no required profile power engineering background. Therefore, duration of effective professional retraining of experts on coal ash 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.

2.7. 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 (perestroyka) 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 coal ash 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". We also have a positive experience of a long-term cooperation with power companies under programs of professional skill improvement and professional retraining of experts, but there are only few similar examples. We'll not list these organizations 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 of additional professional training. No orders from power industry — no scientific developments and no experts having required qualification and amount. Until the role of universities in addressing the coal ash problem is not recognized by the owners and top managers of energy companies, the work to improve the efficiency of energy production will result in reduction of a number of employees and cut of a fund of utility production staff, as makers of strategic decisions don't have greater imagination.

3. CONCLUSIONS

For effective addressing the coal ash handling problem it's needed to do the following:

- create a clear state policy, encouraging maximum coal ash processing instead of using natural raw materials to ensure economic sustainability and environmental soundness of the state as a whole ;
- create a coherent set of legal and regulatory documents of direct action relating to coal ash handling problem and its constant updating based on state funding of system research in the field of coal ash handling;
- improve the economic and legal mechanism of encouraging the investments in building manufactures for coal ash processing into commodity products;
- work out and improve the coherent set of legal and regulatory documents on creation and operation of ash and slag removal systems, meeting state-of-the-art requirements on reliable, economic and ecologic operation set for power generating equipment;
- establish a system for training, advanced training and retraining of specialists in the coal ash handling on the basis of specialized universities;
- encourage an effective interaction with international and national associations of the countries world-wide relating to the CCPs handling issues;
- provide funding of information support of 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.

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