Part 3

ASH AND SLAG HANDLING

3.3. Ash and slag properties

3.3.1. Properties of coal ash in Russia

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ABSTRACT

In the paper data on the basic coal ranks burnt at the Russian TTPs, boiler types, chemical and mineralogical composition of the produced ash and slag and volumes of their formation are resulted. The data on ash and slag landfilling and their beneficial use in various branches of economy: road construction, manufacture of concrete and cement are presented. In Russia about 85 % of ash and slag from TPPs are transported by hydraulic ash removal systems, and only about 15 % are disposed using pneumatic ash removal systems. However, a transfer from "wet" to "dry" ash and slag conveying systems for the purpose of using these products in a dry condition, is now planned. In the paper the Russian standard GOST 25818-91 on ash in concrete is resulted, and also the comparative analysis of GOST and the European standard EN 450 is made. The example of quality management of ash at the arrangement of the staged combustion system at pulverized coal combustion (PCC) boilers is also considered. In the paper technologies applied for using ash and slag from TPPs are reflected: pilot installations for brick manufacture from ash and slag, installations for ash and slag benefication.

INTRODUCTION

At the Russian Thermal Power Plants (TPPs) for combustion of all coal ranks, boilers of capacity from 200 to 1000 t/hour are basically applied. At TPPs with the power units of 500 MW for combustion of Ekibastuzsky coal, boilers of capacity of 1650 t/hour are introduced, and at the power units of 800 MW for combustion of Kansko-Achinsky coal, boilers of capacity of 2650 t/hour are applied.

In total more than 100 coal ranks are burnt in power boilers at the Russian TPPs, but the main coals are taken from the following fields:

Kuznetsky,

- Kansko-Achinsky,
- Ekibastuzsky.
- Berezovsky and Irsha-Borodinsky coals belong to Kansko-Achinsky coals.

PROPERTIES OF ASH AND SLAG FROM THE MAIN POWER COALS IN RUSSIA

The average chemical and mineralogical composition of ash and slag from the main power coals in Russia is resulted in tab. 1 [1].

The average particle size distribution, physical and mechanical properties of ash and slag from the main power coals of Russia are given in tab. 2 [1].

DATA ON COAL CONSUMPTION, PRODUCTION, PROCESSING AND LANDFILLING OF ASH AND SLAG

Data on the quantity of coal burnt at the Russian TPPs in tons of the natural fuel; volumes of production, processing and disposing of ash and slag at the landfills [2] are presented in tab. 3.

In Russia about 85 % of ash and slag from TPPs are transported by hydraulic ash removal systems, and only about 15 % are disposed using pneumatic ash removal systems [3]. However, a transfer from "wet" to "dry" ash and slag conveying systems for the purpose of using these products in a dry condition, is now planned.

From the total quantity of ash and slag that could be beneficially used about 1 … 1,2 million t/year is used for repair and expansion of wet disposals being under operation. The rest part of ash and slag from TPPs is applied in the industry of building materials for manufacture of cements, dry building mixes and products (brick, blocks, and etc.), in industrial and civil engineering at manufacture of concrete, in road building as additives in concrete and for soil replacement.

REQUIREMENTS FOR FLY ASH IN CONCRETE IN RUSSIA AND EU

In table 4 requirements for fly ash in concrete in Russia according to GOST 25818-91 and in EU according to EN450 are presented.

Table 1. The average chemical and mineralogical composition of ash and slag from the main types of power coals in Russia

Fuel	Material	Chemical composition, %										Loss on ignition
		CaO_{FREE}	SiO_2	Al_2O_3	Fe_2O_3	CaO_{total}	MgO	TiO_2	K_2O	Na_2O	SO_2	
bastuzsky coal	Fly ash from PCC boilers	–	63,0	27,0	6,0	0,8	0,5	1,2	0,6	0,3	0,6	2,2
	Bottom ash	–	50,0	25,0	11,0	1,0	0,6	1,2	0,5	0,3	3,5	3,1
	Bottom ash from CFBC boilers	5,0	54,0	26,4	6,0	7,7	0,5	1,0	0,6	0,3	3,5	6,0
	Fly ash from CFBC boilers	6,0	52,1	26,0	6,0	10,0	0,5	1,0	0,6	0,3	3,5	2,5
Kuznetsky coal	Fly ash from PCC boilers	0,4	62,4	22,0	6,5	4,0	1,5	0,9	2,0	1,2	0,5	8,0
	Bottom ash	–	60,0	20,0	9,0	5,0	1,5	0,7	2,0	0,8	1,0	24,0
	Boilers slag	–	–	–	–	–	–	–	–	–	–	–
Irsha-Borodinsky coal	Fly ash from PCC boilers	5,0	45,0	6,0	6,0	25,0	5,0	0,3	0,15	0,15	1,0	2,5
	Bottom ash	0,5	52,4	6,0	12,0	22,0	4,0	0,8	0,5	0,5	1,5	3,0
Berezovsky coal	Fly ash from PCC boilers	12,0	26,1	9,5	8,5	42,0	6,4	–	0,5	0,5	6,5	4,0
	Bottom ash	8,0	29,0	8,0	10,5	40,0	5,0	-	0,5	0,5	6,5	6,0
	Bottom ash from CFBC boilers	8,0	24,5	9,0	11,0	38,0	4,5	-	0,5	0,5	8,0	12,0
	Fly ash from CFBC boilers	8,0	24,5	9,0	11,0	38,0	4,5	-	0,5	0,5	8,0	7,0

Table 2 The average particle size distribution, aggregate density (ρ_a), bulk density at the maximum densification (ρ_b), dynamic natural angle of slope ($\propto_d$) and specific surface (S_{sp})

Fuel	Material	Particle size distribution, %										ρ_a, $\frac{g}{cm^3}$	$\rho_{b,}$ $\frac{g}{cm^3}$	$\propto_d$,°	S_{sp}, $\frac{cm^2}{g}$
		>10	10 –5	5 –2	2 –1	1– 0,5	0,5– 0,25	0,25– 0,125	0,125– 0,063	0,063– 0,04	<0,04				
Ekibastuzsky coal	Fly ash from PCC boilers	–	–	–	–	–	2,0	10,0	15,0	25,0	50,0	2,1	0,9	35	3600
	Bottom ash	10,0	5,0	9,0	7,0	5,0	15,0	24,0	15,0	6,0	3,0	2,15	0,85	40	–
	Bottom ash from CFBC boilers	–	5,0	20,0	16,0	22,0	18,0	18,0	–	–	–	2,1	0,9	40	–
	Fly ash from CFBC boilers	–	–	–	–	–	1,5	9,0	14,0	26,0	51,6	2,2	0,95	35	3800
Kuznetsky coal	Fly ash from PCC boilers	–	–	–	–	–	1,0	12,0	17,0	15,0	55,0	2,1	1,0	31	3200
	Bottom ash	16,0	10,0	8,0	5,0	3,0	10,0	20,0	14,0	10,0	4,0	2,15	0,8	40	–
	Boilers slag	26,0	30,0	36	7,0	0,7	0,3	–	–	–	–	2,5	0,7	45	–
Irsha-Borodinsky coal	Fly ash from PCC boilers	–	–	–	–	0,2	8,0	18,0	18,0	30,0	25,8	2,85	1,25	35	2900
	Bottom ash	–	11,0	15	33,0	24,0	9,0	6,0	1,5	0,5	–	2,9	1,2	45	–
Berezovsky coal	Fly ash from PCC boilers	–	–	–	–	–	3,0	12,0	20,0	30,0	35,0	3,0	1,3	40	4000
	Bottom ash	2,0	5,0	3,0	15,0	25,0	27,0	15,0	6,0	2,0	–	3,2	0,75	45	–
	Bottom ash from CFBC boilers	–	3,0	3,0	10,0	36,0	24,0	13,0	8,0	3,0	–	2,7	0,65	45	–
	Fly ash from CFBC boilers	–	–	–	–	–	3,0	3,0	1,0	43,0	50,0	2,44	0,5	56	8000

Table 3. Coal consumption at the TPPs of Russia, production, processing and landfilling of ash and slag

Parameter	Years									
	1990	1995	2000	2002	2005	2006	2007	2008[1]	2009[1]	2010[1]
Coal consumption, million tons of the natural fuel/year	182,0	128,0	120,1	106,0	116,5	126,2	118,5	118,7	123,0	125,3
Average ash content, %	27,5	26,3	20,8	21,4	21,0	21,1	21,1	21,2	21,2	21,2
Production of ash and slag, million t	50,0	33,7	25,0	22,7	24,5	26,6	25,0	25,2	26,1	26,6
Processing of ash and slag million t	4,5	1,9	3,1	3,3	4,0	4,2	4,4	4,6	4,8	5,0
Landfilling of ash and slag, million t	45,5	31,8	21,9	19,4	20,5	22,4	20,6	20,6	21,3	21,6
Relative volume of ash and slag processing, % of the annual output	9,0	5,6	12,4	14,5	16,3	15,8	17,6	18,3	18,4	18,8

Table 4. Requirements for fly ash in concrete in Russia and EU

Parameter	Type of coal	Index depending on the ash type according to GOST 25818-91, % by mass				Index according to EN450, % by mass
		I	II	III	IV	
1. CaO content						<1
- for acid ash	Any	<10				
- for alkaline ash, free	Lignite					
including CaO_{free}						
- for acid ash	Any	Not normed				
- for alkaline ash	Lignite	<5	<5	Not normed	<2	
2. MgO conent	Any	<5	<5	Not normed	<5	Not normed
3. SO_3 content						<3
- for acid ash	Any	<3	<5	<3	<3	
- for alkaline ash	Lignite	<5	<5	<6	<3	
4. Na_2O content						<1,5
- for acid ash	Any	<3	<3	<3	<3	
- for alkaline ash	Lignite	<1,5	<1,5	<3,5	<1,5	
5. Loss on ignition (L.O.I.)						<5
- for acid ash	Anthracite	<20	<25	<10	<10	
	Hard	<10	<15	<7	<5	
	Lignite	<3	<5	<5	<2	
- for alkaline ash	Lignite	<3	<5	<3	<3	
6. Specific surface, m^2/kg						Not normed
- for acid ash	Any	>250	>150	>250	>300	
- for alkaline ash	Lignite	>250	>200	>150	>300	
7. Sieve residue						
7.1. R_{45}	Any					<40
7.2. R_{80}						
- for acid ash	Any	<20	<30	<20	<15	
- for alkaline ash	Lignite	<20	<20	<30	<15	
8. Cl content	Any	Not normed				<0,1
9. Humidity	Any	<1,0				<1,5

ABOUT USING OF ASH AND SLAG FROM TPPS

Successful experience of ash and slag usage in territory of the former Soviet Union has been gained before its disorder. So, for example, near Ermakovskaya State District Power Plant (nowadays Aksusskaya Power Plant, Republic Kazakhstan) in the late seventies of the 21st century a factory consuming about 80 thousand tons of dry ash from Ekibastuzsky coal for manufacture of a high-quality brick has been put into operation. In the late eighties of the 21st

century a factory also manufacturing a high-quality brick has been started up and successfully worked in Chelyabinsk (Urals, Russia). Ash and slag mixture from the worked out wet disposal and dry ash from Chelyabinskaya Thermal Power Plant-2 were used as raw materials for brick manufacture. The main reasons of creating this factory are:

Impossibility of further disposing of ash and slag produced at the TPP at the wet landfill, being in a city, because of its design filling;

responsible position of administration of the Chelyabinsk Region and the power company solving the problem on decrease in a harmful influence of power generation on environment.

As a result of producing brick from ash and slag, production of factories manufacturing fired clay and lime brick turned out to have noncompetitive price and quality. Consequences of the competition with the ash brick appeared to be sad for these factories. Unfortunately, positive experience of using ash and slag from power generation for industrial production of a high-quality brick in scales of all Russia has not found wide application.

About ash and slag benefication. In the Kemerovo Region near Belovskaya State District Power Plant a factory for benefication of cenospheres from Kuznetsky coal is under construction. The initiator of this project is the Russian Division of the company Omega Minerals Group (Germany). Investors of the project are Omega Minerals Group and the Open JSC «Siberian coal energy company» (Open Society «SUEK). The factory will be put into operation at the end of 2010 – beginning of 2011.

Nowadays the pilot project on ash quality management at the staged coal combustion in power boilers together with application of pneumomechanical bottom ash removal technology and technology of the company Separation Technologies (STI) on separation of the unburnt carbon from fly ash is considered. This issue was considered in detail at the III International Scientific and Practical Workshop «Ashes from TPPs – removal, transport, processing, warehousing» held in Moscow on April, 22-23, 2010 [4].

RERERENCES

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