CHEMICAL COMPOSITION OF ASH AND SLAGS OBTAINED FROM LIGNITE BURNING

Bogdan George RUJOI[1]

Acestă lucrare prezintă determinarea compoziției chimice a cenuşilor şi zgurilor colectate în urma arderii cărbunilor în termocentrale. Scopul ei este să scoată în evidență conținutul ridicat de compuşi minerali (macro şi microcomponenți) din aceste probe, în vederea valorificării acestor reziduuri de ardere în industria materialelor de constructii.

This paper presents the chemical composition determination of collected slag and ash samples obtained from coal burning in thermo power plants.Its purpose is to point out the existence of high mineral compounds content (macro and micro components) in these samples, in order to apply these burning residues in the building material industry.

Keywords: coal burning, fly ash, floating slag, laid down slag

1. Introduction

The main purpose of this paper is to bring a contribution to the valorification of ash and slag deposits existent in Romania. Ashes and slags can be used in the industry of building materials after the residual material and the water content from their composition are removed.[1,2,3]

For this study the average samples were: floating slag and laid down slag from the hydraulic capitation and ash cooling systems, and also fly ash from the cyclone collector [3,4,5].

2. Experimental

The granulometric analyses of ash and slags have been done using a Siemens jigger apparatus, while the thermo differential analyses with a MOM device [6].

[1] Chemist eng., Dept. of Chemical Organic Technology and Polymer Science, University POLITEHNICA of Bucharest, Romania, bogdangeorge84@yahoo.com

The amount of water (humidity) was determined by gravimetric methods, by measuring the initial and final sample masses after keeping them in a drying chamber till a constant mass was reached.

The metal content in ash and slags was determined by spectrographic emission analysis (UV-VIS). The chemical oxide composition was established according to literature methods [6], while the chemical compositions of the micro and macro components were determined using proximate analysis [7,8,9].

3. Results and discussion

The floating slag has a higher content of combustible material than that of the initial coal used for burning. This combustible material is given by low pyrogenated wooden pieces, similar in structure to xyloide particles. The xyloide-type particles in the floating slag are observed under the form of macroscopic components, having specific light colours with fine homogeneous dimensions. They are mainly obtained from burning processes [10,11,12].

Ash and slags generally contain important amounts of unburned material, as a result of partial and superficial burning of the coal.

Ash particles with different forms, aspects and dimensions were also found in the laid down slag (with a higher density than water), besides important quantities of unburned material.

The existence of floating slag indicates a high number of xyloide particles inlaid in the burning system, without their direct implication in this process or with a very small contribution to it. However, these particles participated on a small scale in the burning process but no energy transfer was recorded [3].

The chemical analysis results obtained for the collected ash and slags from thermal power stations by proximate analyses are presented in Table 1.

Table 1

Chemical characteristics of collected samples of ash and slag

No.	Sample	Humidity, %	Ash, %	Combustible Mass, %	Volatile Matter, %
1	Laid down slag	4.15	69.63	26.22	6.15
2	Floating slag	11.18	15.52	73.30	48.20
3	Fly ash	0.91	99.09	0.91	0.10

Laid down slag particles have an important percent of unburned material (26.22%), which indicates the existence of some difficulties in the burning of the xyloide particles in the hot points of the thermo power plant.

For a better characterization of the collected slags, the granulometric analyses were performed. The results are presented in Table 2.

Table 2

Granulometric analysis of collected slag samples

No	Sample	>$R_{4,0}$	$R_{1,5}$	$R_{1,0}$	$R_{0,75}$	$R_{0,5}$	$R_{0,25}$	<$R_{0,25}$	TOTAL	<$R_{0,75}$
1	Floating slag	19.30	55.60	8.25	5.24	4.50	3.90	3.21	100	11.61
2	Laid down slag	7.50	17.50	9.85	12.75	18.80	17.30	16.30	100	52.40

*R- Granulometric fraction

The existence of some small size particles (less than 0.75 mm) found in a proportion of 11.61 % in the floating slag, and 52.40 % in the laid down slag samples can be observed in Table 2**.**

The origin of these significant granulometric fractions can be correlated with the xyloidic nature of particles with small dimensions in the grinding system, as a result of incipient fusion traces. Therefore, characteristics of floating and laid down slag particles indicates a deficiency in the burning process of the particles, as shown also in [12].

In this respect, floating and laid down slag particles were analyzed in terms of their burning and melting conditions. Table 3 indicates the burning and melting points for these slags obtained through thermo differential analyses.

Table 3

Burning characteristics of collected slag samples

Sample	Combustible mass %	Burning point ^oC	Melting point ^oC
Floating slag	73.30	265	970
Laid down slag	26.22	440	1100

The low burning temperatures - even lower than that of coal particle [2] - show that these particles might have suffered a slight pyrogenation in their way towards the focus points in the burner, when they are approaching the tar leakage. This fact has contributed to the enhancement of their reactivity and, consequently, to the decrease of their burning point.

The analysis of the water absorption capacity of floating slag and laid down slag samples taken from the hydraulic system of the thermal power station, was performed by flooding the samples in water for 24 hours, followed by draining them on a travelling belt screen. Finally, the humidity of the treated floating and laid down slag samples was determined. The obtained results are presented in Table 4.

Table 4

Maximum quantities of water in the collected slag samples from the hydraulic system in thermal power station

Sample	Maximum amount of water, %
Floating slag	53
Laid down slag	32

The values in Table 4 show high water absorption capacity, especially for the floating slag, which confirms the xyloidic-type structure of these materials and the appearance of pyrogenetic processes instead of burning process.

The chemical oxide composition of the collected ash and slags is given in Table 5. The oxide content is the smallest in the floating slag sample. The main elements are given as oxides. Among these oxide compounds, there is a relative high content of magnesium and calcium oxides which justifies the low melting points of this material. The laid down slag and the fly ash samples present a higher content in silicon and aluminium oxides than the floating slag. This feature accords to their higher melting points. All samples contain titanium dioxide, but its separation for recovery purpose is questionable, due to the high processing costs and due to a rather low content in valuable metal (less than 1%).[1]

Table 5

Oxide composition of the collected ash and slag samples

Sample	Oxide composition, %						
	C.L.*	SiO_2	Fe_2O_3	Al_2O_3	TiO_2	CaO	MgO
Floating slag	88.03	1.89	2.41	3.29	0.10	3.08	1.20
Laid down slag	31.10	35.83	6.02	19.10	0.47	5.18	2.30
Fly ash	7.48	46.07	8.83	23.14	0.70	10.78	3.00

* C.L. – calcination loss

The ash and slag samples were also investigated in terms of metal content and the obtained results are given in Table 6.

Table 6

Metal distribution (g/t) in floating, laid down slag and fly ash samples

Metal \ Sample	Floating slag	Laid down slag	Fly Ash
Chromium	45	50	90
Germanium	*UDL	*UDL	*UDL
Nickel	50	50	65
Bismuth	*UDL	*UDL	*UDL
Molybdenum	5	3	5
Vanadium	100	120	150
Beryllium	*UDL	*UDL	*UDL
Zinc	*UDL	*UDL	*UDL
Silver	1	1	<0.3
Cobalt	7	8	15
Copper	*UDL	*UDL	*UDL
Rubidium	7	20	*UDL
Cesium	*UDL	*UDL	*UDL
Boron	225	350	260
Barium	>1000	300	850
Lithium	30	25	100

*UDL = under the detection limit

The content in heavy metals, like Cr, Ni, Co, etc., in the samples is rather low as it can be noticed in Table 6. Their content was not affected by the burning process. Due to this low content in heavy metals these samples do not present any hazardous behaviour towards the environment and, consequently, they do not need to be removed by specific separation methods.

4. Conclusions

The research indicates the possibility of a complex valorisation of ash and slags as binder in the building material industry and also, in some cases, for rare metal recovery.

Floating slag material has a higher (73%) content of combustible material than the laid down slag (26%), and also a lower burning point than that of the laid down slag particles, due to the slight pyrogenation.

The low content of inorganic components from the floating slag, such as silicon oxide, aluminum trioxide, compared to magnesium and calcium oxides, justifies the low fusion point of ashes obtained from it.

The laid down slag represents mostly the sterile obtained from the burning process. However, in the floating slag there is a large amount of advanced pyrogenetic material and it could be also valorised by burning at over 400 ^{o}C.

The high amount of organic mass found in the floating slag and also in the laid down slag shows the existence of xyloide-type particles in the focus point.

R E F E R E N C E S

[1] *Barca F.*, Revista de Chimie, 1975, 26 (10), pp 853-858

[2] *Miu-Grigorescu M., Panaitescu C.,* Scientific Bulletin, Series B, **Vol. 69**, 4, 19, 2007

[3] *Miu-Grigorescu M., Panaitescu C., Charlotte Toma,* Scientific Bulletin, Series B, **Vol.70**, 1, 28, 2008

[4] *Voina I.N.,* Valorificarea cenuşilor de termocentrale, Ed. Tehnică Bucureşti. 1985

[5] ***, Combustion of lignite carbon under agitation, Fuel Processing Technology, **Vol. 86**, 8, 2005**,** pp 913-923

[6] ***, Analitical Methods for coal and coal products, Academic Press, 1978

[7] *Chiriac J., Barca F.,*Revista de chimie, **Vol. 60**, 4, 2009**,** p 432

[8] *Galetakis M., Pavloudakis F.,* International Journal of Coal Geology, 2009.

[9] *Gokcay C., Kolankaya N., Dilek F.,* Microbial solubilization of lignites, Fuel, **Vol. 80**, 10, 2001, pp 1421-1433

[10] *Panaitescu C.,* Petrografia cărbunilor , cocsurilor şi produselor carbonice, Ed. Enciclopedică, Bucureşti, 1991**,** pp 420

[11] *Panaitescu C., Predeanu G.,* Atlas Carbopetrografic, Ed. bilingva, 1999

[12] *Panaitescu C.,* Petrografia cărbunilor , cocsurilor şi produselor carbonice, Ed. Enciclopedică, Bucureşti, 1991**,** pp 420.