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Study of the Effect of Phase Composition on the Leaching of Basic Ash-Forming Elements

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ABSTRACT. The article discusses the study of the effect of phase composition on the leaching of the main ash-forming elements. Increasing the processing time from 0,5 to 3,0 hours in solution, the amount of silicon increases almost linearly. The processing time has practically no effect on the extraction of aluminum, since it is inactive in ash in the form of aluminosilicates.

KEYWORDS: Aluminum, silicon, alkali, degree, amorphous, macro element, microelement, iron, diffractogram.

I. INTRODUCTION

In recent years, research in all areas has been carried out at a very rapid pace. In particular, main factor affecting the leaching efficiency, in particular of microcomponents, is the phase composition of the compounds in the initial ash. X-ray phase analysis was performed on a Dron-3 apparatus. To irradiate the samples, a Mo K_{α} lamp was used, β filter, at a rotation speed of 2 g/min, sensitivity 2×10^3 . The interpretation of the obtained radiographs was carried out according to the standard method. The Bragg reflection angles and their relative intensity were determined. Then, the lattice parameters were calculated by the formula $\sin \theta_b = \lambda / 2d$ and compared with reference data.

II. SIGNIFICANCE OF THE SYSTEM

The article discusses the study of the effect of phase composition on the leaching of the main ash-forming elements. The study of literature survey is presented in section III, methodology is explained in section IV, section V covers the experimental results of the study, and section VI discusses the future study and conclusion.

III. METHODOLOGY

The diffraction pattern of fly ash (Fig. 1) shows the presence of four phases of the main ash-forming elements in the initial ash: amorphous phase (characteristic diffuse peaks); phase α - quartz (main peak 22 deg.); phase of aluminosilicates of the type sillimanite - $Al_2O_3 \times SiO_2$ or mullite - $3Al_2O_3 \times 2SiO_2$.

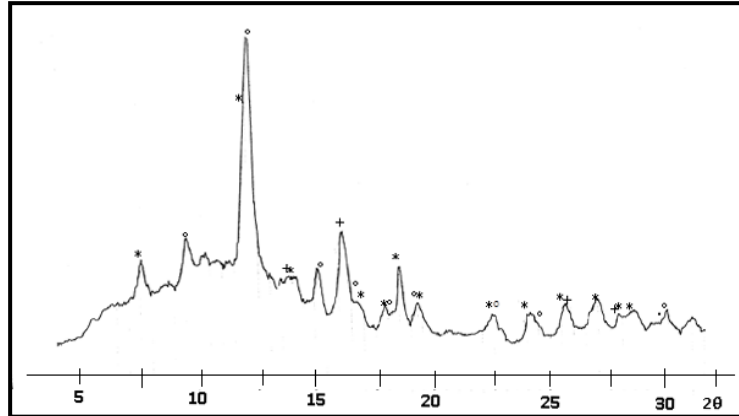


Figure 1. The diffraction pattern of coal fly ash: * mullite; ° α -quartz; + magnetite

This coincides with the literature data obtained by studying the phase composition of inorganic ash components for other coal deposits [1-3].

To study the composition of the amorphous component, the basic laws of the extraction of silicon and aluminum by hydro-alkali treatment were studied, since it allows the amorphous phase to be completely isolated from the ash. Based on the studies, the amorphous part was isolated under the following optimal conditions: $t = 85^{\circ}\text{C}$, $\tau = 2,5$ h, $C_{\text{alkali}} = 200$ g/l, S:L = 1:5. The degree of extraction of silicon under these conditions was 47% (in terms of SiO_2), and aluminum – 5,5% (or 10,5% in terms of Al_2O_3). Based on this, the composition of the amorphous part of the ash can be represented in the form of compound $9\text{SiO}_2 \times 2\text{Al}_2\text{O}_3$.

The diffractogram of the obtained residue (Fig. 2) shows the amplification of the α quartz signal and, at the same time, the absence of peaks of the amorphous phase. This confirms the assumption of the reactivity of the amorphous part of the ash and allows us to predict the effectiveness of hydro-alkaline processing of ash by the amount of the amorphous component.

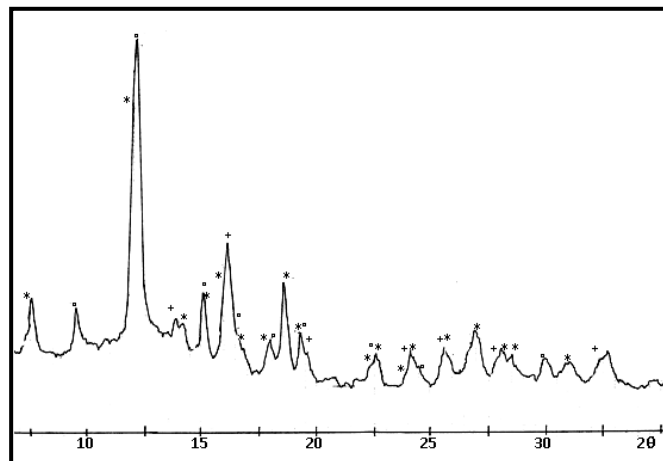


Figure 2. Diffraction pattern of coal fly ash after treatment with an alkaline solution: * mullite; ° α -quartz; + magnetite

Since the degree of leaching of macro- and microelements significantly depends on the temperature of the solution, we studied the reactivity of the macro- and microcomponents of fly ash at two solution temperatures - room temperature and the maximum possible value for aqueous solutions without the use of special equipment.

IV. EXPERIMENTAL RESULTS

The results obtained (Table 1) show that at room temperature, the degree of extraction of macro components in the solution does not exceed 0.5%, therefore, ash can be considered chemically passive. At elevated temperatures, the reactivity of macro- and micro components increases. The highest reactivity at elevated temperature (Table 3,9) is

shown by silicon ($\alpha = 49,4\%$) and gallium ($\alpha = 56,3\%$). A low degree of recovery is observed for aluminum ($\alpha = 5,5\%$) and vanadium ($\alpha = 5,7\%$). Under these conditions, iron is practically not extracted into the solution ($\alpha = 0,52\%$). High degrees of extraction of silicon and gallium require the study of the basic laws of this process.

Table 1
Dependence of the degree of extraction of macro- and microcomponents on temperature. Experimental conditions: $C_{alkali} = 200 \text{ g/l}$, $\tau = 2,0 \text{ h}$, $S:L = 1:5$.

t, °C	Al		Fe		SiO ₂		Ga		V	
	m, mg	α , %	m, mg	α , %	m, mg	α , %	m, mg	α , %	m, mg	α , %
20	2,66	0,11	0,28	0,03	0,014	0,11	0,046	5,3	0,12	4,3
80	133,1	5,5	4,89	0,52	6,08	49,4	0,48	56,3	0,16	5,7

By the method of x-ray phase analysis (Fig. 1), the presence of four phases of the main ash-forming elements in the ash was established:

- amorphous phase
- α - quartz
- aluminosilicate $2Al_2O_3 \times 3SiO_2$ (mullite)
- magnetite

The presence of a significant amount of an amorphous component allows the use of alkaline solutions for its effective removal. A similar treatment was carried out when obtaining aluminum from ash [2] or during the synthesis of zeolites of various grades from ash [2-5].

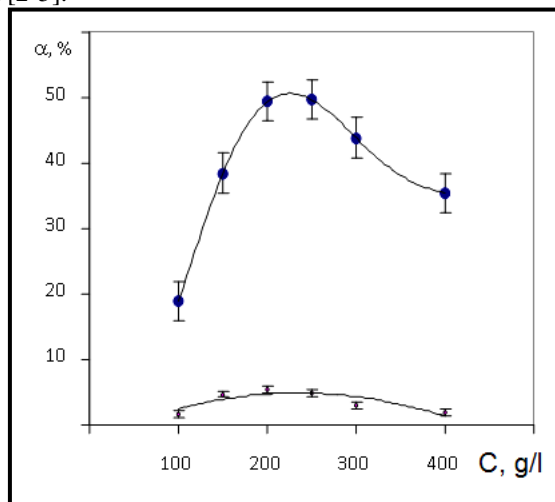


Figure 2. The dependence of the degree of extraction of silicon (1) and aluminum (2) on the concentration of alkali. Test conditions: $t = 85^\circ\text{C}$, $\tau = 2,0\text{h}$, $S:L = 1:5$.

When the alkali concentration varies from 100 to 400 g/l, the greatest extraction of silicon and aluminum in solution is observed at concentrations of 200 - 250 g/l (Fig. 2). In this case, up to 50% silicon and up to 5,5% aluminum contained in the ash passes into the solution.

With an increase in processing time from 0,5 to 3,0 hours, the amount of silicon increases almost linearly in the solution. The processing time has practically no effect on the extraction of aluminum, since it is in the inactive form and in the form of aluminosilicates in the ash. The results are presented in Fig.3. For three hours, under these conditions, up to 65% of the main ash-forming elements can be extracted from fly ash.

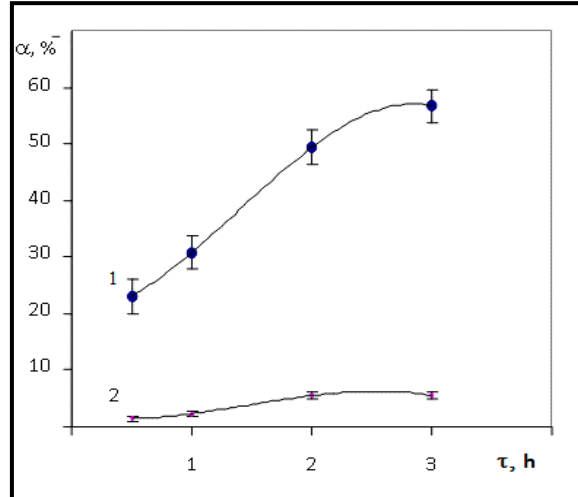


Figure 3. The dependence of the degree of extraction of silicon (1) and aluminum (2) from time to time. Test conditions: $t = 85^{\circ}\text{C}$, $C_{\text{alkali}} = 200 \text{ g/l}$, $S:L = 1:5$.

From the obtained results on the study of the influence of the ratios of solid and liquid phases on the process of silicon extraction (Fig. 4), it is seen that the optimal ratio is in the range $S:L = 1:4-6$. An increase in the amount of the liquid phase does not lead to any significant increase in the degree of extraction of elements, but it leads to an increase in alkali consumption.

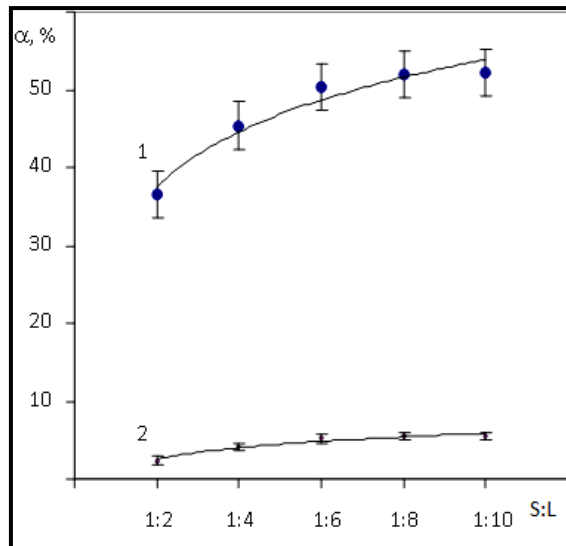


Figure 4. The dependence of the degree of extraction of silicon (1) and aluminum (2) on the ratio of solid and liquid phases. Test conditions: $t = 85^{\circ}\text{C}$, $C_{\text{alkali}} = 200 \text{ g/l}$, $S:L = 1:5$.

V. CONCLUSION AND FUTURE WORK

Thus, the optimal conditions for leaching silicon into a solution are: $t = 85 \pm 5^{\circ}\text{C}$, $\tau = 2 \text{ h}$, $C_{\text{alkali}} = 200-250 \text{ g/l}$, $S:L = 1:4-6$. Under these conditions, up to 65% of the main ash-forming elements pass into the solution.

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