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Review

THE ISSUE OF BROWN COAL QUALITY ON THE BASIS OF PHYSICO-CHEMICAL PARAMETERS

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Coal is expected to remain the dominant fuel for electricity generation in the Slovak republic for a considerable time in the future. Mining of lignite and brown coal is necessary for security and stabilizes the electricity systems of this republic through the heat power Nováky (ENO). Coal combustion processes represent a significant potential for contamination of environmental components. The elemental composition of coal from the mine Cígeľ showed that coal contains variable amount of arsenic which was found due to the presence of sulfide minerals containing arsenic in the coal substance. Close monitoring of the coal quality and composition of coal ashes is therefore essential.

Key words: brown coal quality, sampling, arsenic.

Ocjena kvalitete mrkog ugljena na temelju fizikalno-kemijskih parametara. Očekuje se da će ugljen ostati dominantno gorivo za proizvodnju električne energije u Slovačkoj republici za dosta vremena u budućnosti. Rudarstvo lignita i mrkog ugljena je potrebno za sigurnost i stabilizira elektro-energetski sustav ove republike radom termoelektrane Novaki (ENO). Procesi izgaranja ugljena predstavljaju značajan potencijal za onečišćenje okoliša. Elementarni sastav ugljena iz rudnika Cígeľ pokazao je da ugljen sadrži promjenjivu količina arsena, koji je prisutan u sulfidnim mineralima kao bitnim tvarima od kojih se sastoji ugljen. Stoga, neophodno je strogo praćenje kvalitete ugljena kao i sastava pepela nastalog njegovim izgaranjem.

Ključne riječi: kvaliteta mrkog ugljena, uzorkovanje, arsen.

INTRODUCTION

Slovakia has more than 1 billion tons of geological reserves of coal. Deposits of brown coal occur in various geological levels of the Horna Nitra fold, the South-Slovakia basin, the Danube basin and the Viena basin. Lignite deposits are known in the Viena basin, marginal parts of the Danube basin, the Žiar fold of central Slovakia and the East-Slovakia basin.

Upper Badenian deposits of the Horna Nitra fold in central Slovakia are of major economic importance concerning the

amount of reserves and quality of brown coal. Deposits Nováky, Cígeľ and Handlová extend on the area about 70 km² and are made up by 2 to 11 m thick coal seams. Caloric value varies from 10,7 to 12,9 MJ per kg.

Domestic brown coal production covered 78 % of demand in the Slovak Republic in 2010; the rest of the amount was imported, almost wholly from the Czech Republic [1- 8].

Mining of lignite and brown coal in Slovakia in recent years has been closely linked mainly to electricity production and the heat power plant Nováky (ENO). The existence of power plant Nováky is necessary for security and stabilizes the electricity systems of Slovakia.

SAMPLING FOR THE DETERMINATION OF PHYSICOCHEMICAL PARAMETERS

Sampling of the lignite seams is determined according to STN 441303 - Sampling of lignite seams [2]. Samples of the extracted coal were taken from the pouring conveyor belt, which are transported to the coal washing, with automatic links to the collection and processing of the extracted coal. Sub-samples are taken every 20 minutes of actual running conveyor belt.

They are taken within 24 hours and the next day they are preparing for the laboratory samples. For samples of drill holes is laboratory samples used to determine the basic characteristics of qualitative chemical analysis of coal.

Samples for chemical analysis of groundwater wells are taken into PVC bags and immediately transferred to the laboratory, which provides crude and residual analysis of water, ash content of the analytical form and calorific value in analytical form. For these values were then calculated the water in its original ashes condition W^r , ashes in their original state A^r , ash in the dry A^d , combustible V^r , calorific value of combustible Q^{daf} , calorific value of fuel Q_s^r , fuel efficiency Q_i^r . In most samples from the notches in addition also provides

Because of coal combustion processes represent a significant potential for contamination of environmental components, monitoring of the coal quality and composition of coal ashes resulting from its combustion play an important role [10].

the density of the sulfur content of S^r [3]. Characteristic physicochemical parameters of the Slovak brown coal are shown in Table 1.

Samples of coal sales types are taken for the species:

- "Cube 1 +2" - stopped manually from the conveyor belt, which conveys this kind of coal to shipping containers. Samples were taken every 30 min. net running time of the technological line. Sub-samples were taken immediately after collection to separate adjusting device, which consists of a grinding-mill and a rotating sample divider. The divided sample falls directly into the tank sub-samples.
- "Washed walnut 1 and 2" - using a mechanical sampler with automatic control of slump vibrating feeder, which is the kind of coal sales types loaded into rail cars; the sampler operates in 12 min. intervals.
- "Steam coal" - using straight lines for the collection and processing coal. Sub-samples are taken every 15 min. net time running conveyor belt, from the fall to be sampled.

Table 1. Characteristic physicochemical parameters of the Slovak brown coal [4]**Tablica 1.** Karakteristični fizikalno-kemijski parametri slovačkog mrkog ugljena [4]

Item	Fuel	Slovak brown coal		
Symbol		assorted	boiler	average
Elemental fraction in the fuel		[wt. %]		
C^r	fraction of carbon	47.29	28.35	33.80
H^r	fraction of hydrogen	3.62	2.49	2.86
O^r	fraction of oxygen	14.36	12.42	13.52
N^r	fraction of nitrogen	0.78	0.45	0.54
S^r	fraction of combustible sulphur	1.37	1.76	1.78
Amount of combustibles "V^r" in the fuel		67.41	45.48	52.50
W^r	total humidity	24.26	36.04	32.00
S_v (Dm)	total dry matter	75.74	63.96	68.00
A^r	ash in the fuel	8.33	18.48	15.50
A^d	ash in dry matter	11.00	28.90	22.80
S_t^r	total S in the fuel	1.51	2.58	2.38
S_t^d	total S in dry matter	1.99	4.04	3.50
Q_i^r [MJ.kg ⁻¹]	fuel efficiency	15.27	10.76	12.04
Q^{daf} [MJ.kg ⁻¹]	calorific value of combustible	22.65	23.66	22.93
Q_s^r [MJ.kg ⁻¹]	calorific value of fuel	16.03	11.30	12.64

MONITORING OF THE COAL QUALITY IN THE MINE CÍGEL'

Brown coal is the raw material of Handlovska cage bearings in mining area - the mine Cígel'. Coal is primarily intended for combustion and heat and steam. Stocks in the mining area of Cígel' and Handlová are estimated at 5 to 15 years depending on

the amount of electricity produced in the heat power Nováky (ENO).

To assess the quality of coal supplies (Table 2) to power plants Nováky in site Zemianske Kostol'any, which is a major purchaser of coal is responsible for laboratory the mine Cígel'.

Table 2. The elemental composition of coal from the mine Cígel' [3]**Tablica 2.** Elementarni sastav ugljena iz rudnika Cígel' [3]

%	cube 1+2		walnut 1		walnut 2		small		mined coal	
	original	anhydrous	original	anhydrous	original	anhydrous	original	anhydrous	original	anhydrous
hydrogen	3,23	4,74	2,92	4,33	2,85	4,19	2,17	3,13	2,53	3,56
carbon	39,53	57,97	36,34	53,86	35,68	52,42	25,27	36,37	30,14	42,41
oxygen	15,07	22,09	14,46	21,43	14,06	20,66	11,39	16,38	12,56	17,66
nitrogen	0,51	0,75	0,47	0,69	0,46	0,68	0,36	0,52	0,41	0,58
sulphur organic	0,73	1,07	0,72	1,05	0,72	1,06	0,47	0,68	0,52	0,74
sulphur general	1,29	1,86	1,32	1,93	1,21	1,73	1,25	1,75	1,22	1,69
arsenic (g.t ⁻¹)	18,38	26,96	30,53	45,24	58,83	79,10	36,35	52,32	21,46	30,12

Chemical composition of ash is highly variable, depending on the type and quality of coal and combustion conditions. Distribution of chemical constituents is in the range of values SiO₂: 35 – 55 %, Al₂O₃: 20 – 30 %, Fe₂O₃: 3 – 30 %, CaO: 1 – 7 %, MgO: 1 – 4 %, SO₃: 0,2 – 3 %, K₂O + Na₂O: 1 – 8 %.

Toxic elements, which contain significant quantities of ash, in particular: As, B, Be, V and Cd. Ash may be inherently silico-alumina or silico-phosphate. Both types vary in content of active CaO, SiO₂ and Al₂O₃. The first has pozzolanic properties, the other may have an extra hydraulic properties.

Following the type of coal and combustion conditions ash and fly ash may include from 1 to 20 percentage by weight of unburned gas coal (expressed as loss on ignition in chemical analysis), approximately 35 to 65 percentage by weight of silica, 20 to 40 percentage by weight of oxides aluminum and iron together, 2 to 20 percentage by weight of calcium oxide (CaO containing higher percentages of fly ash as for burning lignite, mostly moving content around 3 % CaO, our case 4 to 7% of the ash of burning).

What is important is the content of alkali (Na, K), which ranges from 2 to 5 percentage by weight (expressed as oxides of sodium and potassium) and sulfur (expressed as sulfur trioxide - SO₃), or the content of sulphides (S⁻²) [5].

The elemental composition of coal from the mine Cígel' showed that coal contains variable amount of arsenic. It is due to the fact that substances in the coal field are examined prevalence of such minerals as pyrite – FeS₂, realgar - As₄S₄, arsenopyrite - FeAsS, orpiment - As₂S₃ [5]

Arsenic gets into the ash in coal combustion process. Coal combustion processes represent a significant potential for contamination of the environment. Upper Nitra Region, which is one of the most fuel-energy complexes of the Slovak republic - ENO Nováky, which is based on mining and burning brown coal with high arsenic, is strongly environmental laden area. Since 1953 (commencement of operations ENO) has been around the plants to a significant contamination of soils airborne ash, which are linked arsenic, depending on the weather conditions and topography [6- 9].

CONCLUSION

The issue of monitoring the quality of brown coal and combustion products plays an important role in the volatile data confirmed the content of arsenic in brown coal mines Cígel'.

In order to prevent events which took place in the year 1965, when the dam broke in the original pond Zemianske Kostol'any and the river Nitra missed about 2.5 million m³ ash materials, which also contain arsenic,

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since the 2007 significant attention is paid to monitoring the two ash electricity disposal site in the role of the Ministry of Environment of Slovak republic "Anthropogenic sediment nature of environmental burdens". The aim is to know the degree of contamination of alluvial soils and sediments arsenic in alluvial areas with ash and also assess the potential for possible mobilization of arsenic [7].

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