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CHARACTERIZATION OF SOME BLAST FURNACE WASTE DUSTS

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This paper aims to evaluate through optical microscopy the morphology of some waste dusts, collected in the vicinity of blast furnaces in Romania. The amount of the textural components in blast furnace dusts mixtures has been quantified by microscopic techniques and expressed as optical type and size. Such characterization provides useful information in case of the dusts recycling, finding the source in case of an accidental pollution, as well as on the blast furnace efficiency.

Keywords: blast furnace, wastes, optical microscopy, dust bag, dust cyclone, sludge

1. Introduction

During the production of iron about 2 tons of waste are generated per ton of material obtained. During complex purification process of blast furnace gas (dry and wet dedusting) a significant amount of powdered wastes are released to the environment. Since removing these powder waste by landfills became increasingly less used due to the increased storage costs, their recovery and detailed scientifically investigation to determine potential pathways for their recycling, should be considered. The composition of these materials depends largely on the source of generation, usually containing several useful compounds as: iron, carbon, calcium, zinc, etc. that can be recovered and reused in an appropriate manner. Besides these, wastes may contain significant quantities of heavy metals, their storage by landfill or spread on soil being a serious environmental problem. The recovery and reuse of these solid wastes within the same production unit or by different industrial installation are essentially for protecting the environment and for conserving metals and mineral resources [1].

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Most of the materials as are sludges and dusts recovered from the steel industry are recycled in industrialized countries through sinter making. The recycling is generally controlled depending on the analysis of the waste material [2]. The variety of methods developed over time to reduce pollution and reuse the useful by-products, sometimes in the same generating industries, demonstrates once again the need for further evaluation of different types of waste by using more extensive way of investigation and characterization.

In the last three decades have been elaborated different methods of recovery and reuse of powdered wastes, by: sintering [3], size reduction [4], sludge leachability [5, 6, 7], pelleting by sintering of the furnace dust [8], iron oxides reduction [9], reduction melting in a rotary kiln [10], direct recovery of iron by fluidized bed [11], simultaneously injection of coal and blast furnace dust [12]. In Romania dust released from dust bag and cyclone enters the agglomeration circuit materials [13].

Pollution with metallurgical industrial wastes was largely investigated by studying their environmental risks a detailed scientific interest being aimed to recover and reuse them after physical-chemical and micro-morphological characterization [14] that was made either in Romania [1, 15, 16,]. A digital atlas [17] and monographies [18] of anthropogenic particles from different sources were elaborated to help identification of these particles under the microscope, giving the possibility to find the type and source of pollution.

In this study, we focus on pulverulent wastes, resulted from incomplete combustion of powder coal injected in the blast furnaces tuyere and, complex transformations of coke taking place in the blast furnace. The samples that contain mainly carbon, were analyzed in terms of physical-chemical methods, including microscopy, byassessing the specific grain structure and texture and the correlation with the origin of petrographic type of components from the powder wastes. Determination of petrographic composition of this type of samples represents a little investigated domain worldwide, revealing the original character of this study.

2. Experimental

The three sample sets used in the present study are technological solid dusts generated from blast furnace located on an industrial platform of Romania. The samples were taken from each of the points of interest, mainly after gas purification steps located on the rough and fine de-dusting flow at the outlet, respectively of dust bags, cyclone and sludge disposal.

During the 24 hours that coincided also with constant operation of the blast furnace, from each points of interest were collected 4 individual samples. From the individual samples have been made average samples of 2 kg each, considered as being representative for our research and the analyses performed. According to the standards in force, from the representative average samples were prepared samples for analysis by grinding, milling and sieving operations. For the physico-chemical analysis was used an amount of about 20g and for the microscopically analysis about 50g.

The samples were prepared for laboratory analyses according to SR ISO 5069-1 and 2:1994. General physical-chemical characterization of the samples was focused to establish: dimensional distribution of particles (according to SR ISO 1953: 1999-Coals. Grain size analysis), moisture content (according to SR ISO 331:1994-Coals. Total moisture content), ash content (following SR ISO 1171: 1994-Coals. Ash content), volatile matters (according to SR ISO 602:1994-Coals. Volatile matters), bulk density (STAS 5630-73-Coke. Determination of bulk density). The equipments included: manual mortar, Retsch AS200 sieves shaker with different sizes of metal sieves with square mesh, Sartorius analytical balance to ensure accuracy in weighing 0.0002 g, heating laboratory oven with a precision of 1°C and horizontal electric muffle oven (1000°C) with an accuracy of ± 20°C.

In terms of qualitative petrographic analysis was used a binocular optical microscope Olympus BX51M with a transmission images camera model CCD-1300QB, reflected light (PL), gliceryn immersion and 500x magnification. Coal and coke particulate population were evaluated on two sizes <0.1 µm and >0.1 µm, their repartition being made using the ocular micrometer of a binocular optical microscope IOR MC1 and a point counter of Eltinor type.

The method of preparing coal samples and determining structural composition followed ISO 7404-2 and -5 (1994), respectively. To distinguish between the petrographic textures corresponding to the optical type and size (punctiform, mosaic, fiber, ribbon, domain), was used the method ASTM D 5061/1997, Microscopical determination of volume percent of textural components in metallurgical coke.

3. Results and discussion

Physical-chemical characteristics of the dusts collected in the area of blast furnace gas purification steps, are shown in table 1 and 2.

From the average granulometric analysis one may observe that the blast furnace is an issuing source of pulverulent wastes with a significant percentage of fine fractions of particles. Generally, the results from the physical characterisation showed that size distribution indicates that around 20% for dust bag and sludge and up to 65% of the cyclone dust particles have a median diameter under 200µm as presented in table 1.

Table 1

Size distribution of blast furnace dusts

Sample/origin	Grain size distribution (mm, %)						
	<0.08	0.08-0.2	0.2-0.8	0.8-1.25	1.25-2	2-5	>5
Dust bag	8.60	10.43	15.64	7.67	11.65	23.01	23.00
Dust cyclone	17.32	46.73	34.64	0.98	0.33	-	-
Sludge bin	7.78	10.20	20.28	15.56	32.53	13.65	-

Table 2

Physical-chemical analysis of blast furnace dusts

Sample origin	Sample no.	Proximate analysis, wt,%				Bulk Density (g/cm^3)
		Moisture (W^a)	Ash (A^{db})	Volatile Matter (V^{db})	Fixed Carbon (C_{fix})	
Dust bag	1	2.27	74,60	10.82	14,58	0.80
	2	1.53	73,50	11.80	14,70	1.00
	Average	1.90	74.05	11.31	14.64	0.90
Dust cyclone	1	0.59	71,02	0.82	28,16	1.15
	2	1.21	72,28	0.60	27,12	1.19
	Average	0.90	71.65	0.71	27.64	1.17
Sludge bin	1	2.65	78,58	4.72	16,70	0.62
	2	2.55	78,40	7.58	14,02	0.50
	Average	2.60	78.49	6.15	15.36	0.56

Table 3

Composition and type of powdered wastes, by microscopically analysis (%)

Sample/origin	Size <0.1 μm		Size > 0.1 μm		Total organic material	Mineral matter		Total mineral matter
	coal	coke	coal	coke		ferrous	other	
Dust bag	-	-	7.1	34.9	42.0	30.9	27.1	58.0
Dust cyclone	28.5	-	2.7	32.6	63.8	26.6	9.6	36.2
Sludge bin	-	-	0.6	1.2	1.8	69.4	28.8	98.2

Proximate analysis made on two paralel samples (table 2) shows a higher percentage of carbon in dust cyclone sample, but with a very low volatile matters which may lead to the conclusion that this powder waste can be recycled into the technological flow. Also, the content of ash and moisture is relatively the same for each of the analyzed samples.

The percents of organic and mineral components of residual solid dusts determined by optical methods led to differentiation between the samples and give valuable information for a possible recycling as shown in table 3. The particle size distribution of the technological dusts had its maximum of 28.5% for coal particle sizes of <0.1 μm and of 33-35% for coke particles sizes of >0.1 μm.

This was expected since coal and coke particles are released in significant amounts during rough purification of blast furnace gas. Mineral matter, mostly as iron oxides, had its maximum of 98% for the solid dusts evacuated into the sludge bin.

The optical micrographs in Fig.1 and Fig.2 show the structural type and optical appearance of the waste dusts. The mineral mater determined by point counting petrographically method in table 3 is consistent with the results given in table 2 showing the slightly correlation between the ash content and its composition.

In case of qualitative evaluation of the blast furnace dust samples, was used the criteria to distinguish between the petrographic textures representing the structural organization of the organic matter corresponding to different solid carbon particles, considering optical type and size (punctiform, mosaic, fiber, ribbon, domain), origin of the particles and the porosity development.

The size of the particles vary from coarse to very fine and differ also on the wastes sampling point. Depending on the emitting source they illustrate the presence of organic matter as coal (Fig.1 A) and coke particles which size where smaller to be observed by optical microscopy, but present in agregates (Fig.1 B). The coke particles are porous and have mainly anisotropic texture of punctiform, mosaic and flow type with unmelted coal or inertinite which are isotropically in dust bag samples (Fig.2 A,B). The mineral matter has different optical appearance in sludge: as infilling of the structured particles of coke (Fig.2 C), as ground matrix, embedding different fine and very fine particles of coal, coke and metal and calcite (Fig.2 D), and metallic clusters (possible hematite) (Fig.2 E) and magnetite spheres with skeletal structure of different sizes (Fig.2 F).

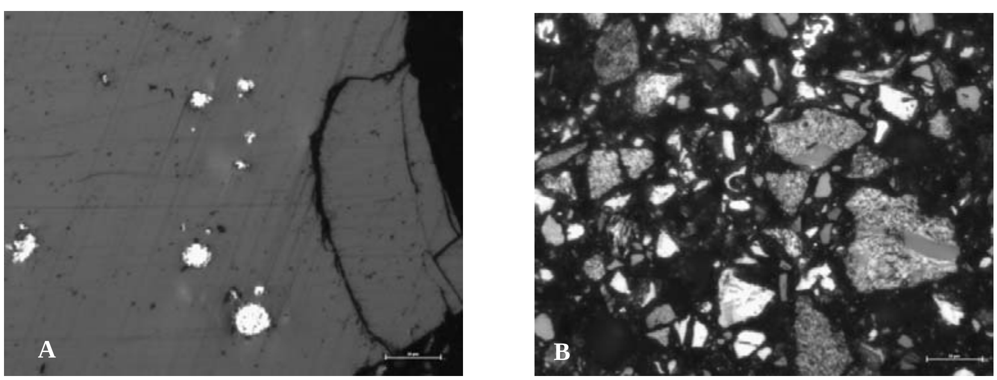

Fig.1. Photomicrographs of some petrographic constituents in blast furnace dust cyclone, reflected light, glycerin immersion, 500x. (A).Vitrinite coal particle, fissurated, with granular pyrite. (B). Agglomeration of small and very small particles of coal, coke, mineral matter and metal.

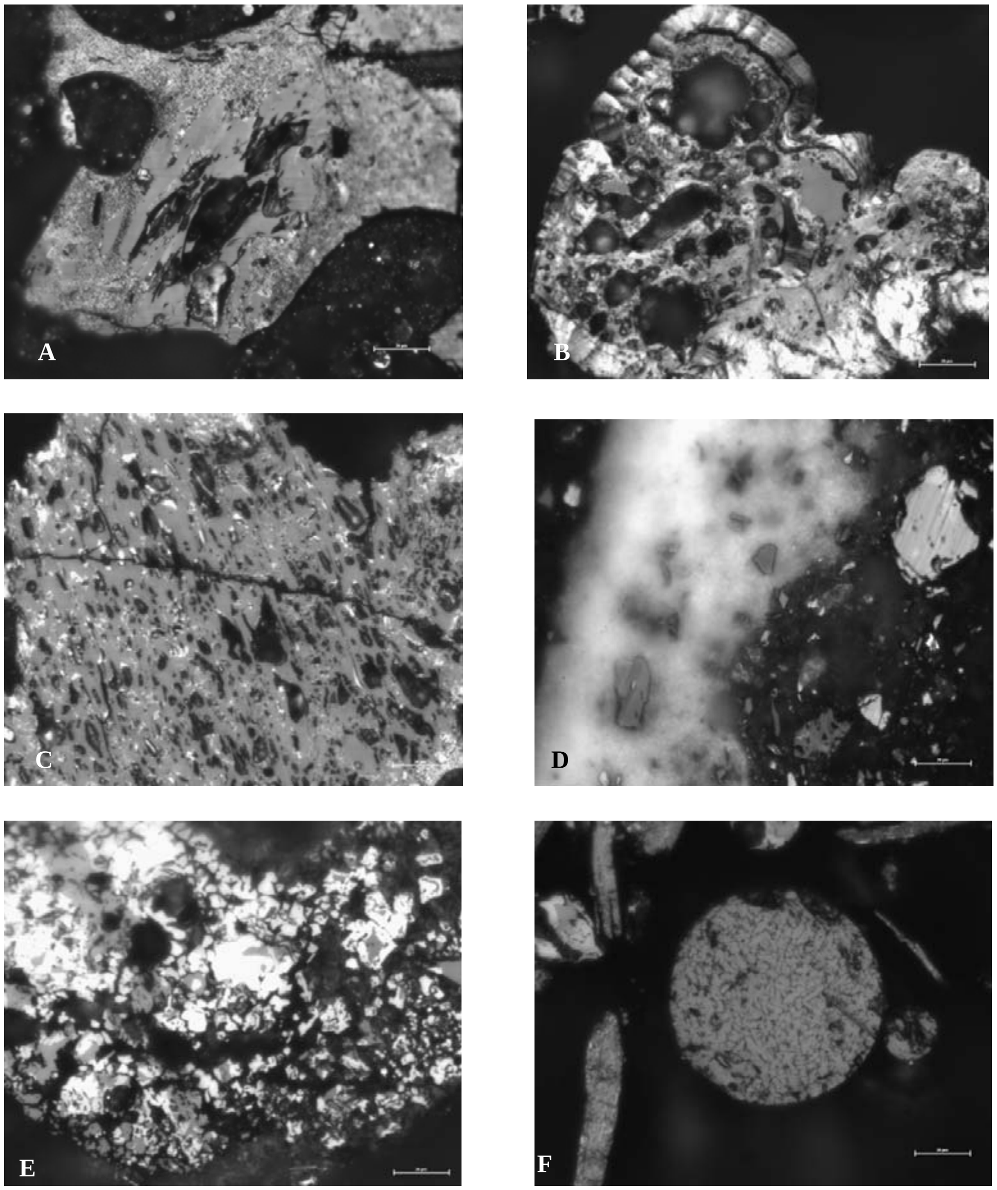

Fig.2. Photomicrographs of some petrographic constituents in blast furnace technological wastes, reflected light, glycerin immersion, 500x. (A). Coke particle with mosaic anisotropic texture and degassing pores at the edge and an isotropic porous inertinite (centre) in dust bag. The inertinite degassing pores were probably created during CO_2 reactions in the blast furnace. (B). Highly degassed anisotropic coke matrix of mosaic, flow type and domain at the edge of the particle, in sludge. (C). Inertinite coke with the porosity partially filled with bright metal. (D). Coarse calcite particle, in ground matrix, in sludge. (E). Metallic clusters (possible hematite), in sludge. (F). Spheres of magnetite with skeletal structure of different sizes, in sludge.

4. Conclusions

The paper shows the evaluation by optical microscopy the morphology of a mixture of solid waste particles from the dedusting flow of the blast furnace gas.

The evaluation of the petrographical characteristics of powdered wastes was carried out by assessing the specific grain structure and texture and the correlation with the origin of petrographic type of components from the powder wastes.

Determination of petrographic composition of organic-mineral constituents of the dust samples, can be applied in case of identifying a possible pollution source or recycling the blast furnace dusts.

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