STUDIES OF OF PRE-BAKED INDUSTRIAL ELECTRODES

M. M. Coser, W. A. G. Oliveira, A. G. Cunha, K. M. B. Alves, E. J. Lourenço and F. G. Emmerich*
Departamento de Física, Universidade Federal do Espírito Santo, 29060-900 Vitória, ES, Brazil.
**Carboindustrial S.A., Rua Atalydes M. de Souza, 245, 29168-060 Serra, ES, Brazil*

Introduction

Pre-baked electrodes are widely used in the metallurgical industry for the production of alloys in electrical arc furnaces. The raw materials for fabrication of these electrodes consist basically of anthracite coals of several origins and a binder (pitch). The coals undergo a previous heat treatment for graphitization and after this stage they are mixed with the binder. The pasty mix is then compacted and shaped by extrusion, or molding by ramming or vibration, to form the green electrode block. Subsequent baking is performed at certain temperature levels in accordance with the requirements of the specific batch.

In the present work the materials were characterized before and after the thermal treatment of graphitization with measurements of true and apparent density, proximate analysis, hardgrove grindability index (HGI), Mössbauer Spectroscopy, electrical resistivity, BET surface area, dynamic elastic modulus, aiming a better undertanding of their properties and optimization of the final product.

Experimental

Four coals of different origins were analysed (A,B,C and D). Measurements of BET surface area were made with an automatic analyser Quantachome model Quantasorb, using N_2 adsorption at 77 K. The measurements of true density were based on the picnometer method, with helium as the displacement fluid, in a Quantachrome multipicnometer model MVP-1.

Mössbauer spectroscopy was performed in powder samples at room temperature with a radioactive source of Co^{57}, in the conventional transmission method.

Dynamic elastic modulus values of pre-baked electrodes were obtained, according to the norm ASTM C 747-74, with the measurement of the fundamental frequencies of samples in the form of bar with rectangular cross section, by inducing vibrations in the direction normal to the length of the sample. Accelerometers were employed as transducers and a FFT analyser model AD-3522 of A&D Company Limited was used for data collections.

Electrical resistivity was measured in green coals in a range of temperature of approximately 40 °C to 120 °C with a Keithley Electrometer model 617 and a Keithley nanovoltmeter model 197A. A small furnace with internal dimensions close to the sizes of the samples was built for an uniform and stable heating of the samples. The whole set was thermal isolated because the samples presented a great sensibility to external temperature fluctuations, as noted during the measurements at room temperature.

The resistivity of calcined anthracites and of the pre-baked electrode were determined with the same equipment, but only at room temperature. For these measurements the thermal treated coals were lapidated in the form of rectangular parallelepipeds with cross section perpendicular to the layers presented by the specimen.

Results and Discussion

The results of proximate analyses, BET surface area, HGI and true density of coals before and after graphitization are presented in Table 1. Significant changes in the BET surface area were observed after graphitization in the coals B, C and D; for these coals large variations have also occurred in the results of HGI test, an important parameter that is related to the grindability of materials. Since BET surface area and HGI are not usually employed in the characterisation of coals for the industrial production of pre-baked electrodes, the results indicate that they can become useful parameters in the analysis of the raw materials.

The electrical resistivity results as a function of temperature are shown in Table 2. After the heat treatment the materials presented an expressive decrease in the resistivity, as found in other anthracites [1], corresponding to 9 orders of magnitude for coals B and D and 6 and 3 orders of magnitude for coals A and C, respectively. This effect is related with a percolation transition characterized by an increase of the conducting phase of the materials [2].

The results of electrical resistivity of coals A and B (normally used in industrial scale), before graphitization, are shown in Figs. 1 and 2 as a function of temperature. We observe an initial increase of resistivity with the heating, followed by a substancial decrease after 45 °C.

According to Arikol e Özdogan [3], the initial increase of resistivity is due to a loss of moisture during heating.

The samples of pre-beaked electrodes prepared with A and B coals have shown similar results for dynamics modulus, of the order of 2 GPa, which are comparable to the static elasticity modulus, in the range of 1.6 GPa. In other studies, the behavior of the mechanical properties of pre-baked electrodes was found to be more dependent of the properties of solid raw materials (coals) than of the binder properties [4].

The Mossbauer spectra of the green materials do not present signal of sites of iron submitted to hyperfine magnetic fields, showing only doublet lines typical of electric quadrupole interactions, while those of the graphitized samples have absorption lines typical of iron nuclei in magnetic sites. The changes in the spectra can be related to the introduction of new chemical components in the graphitized samples, due to the fusion during the passage of the electric current of the metallic wall that contains the electrode.

Acknowledgements

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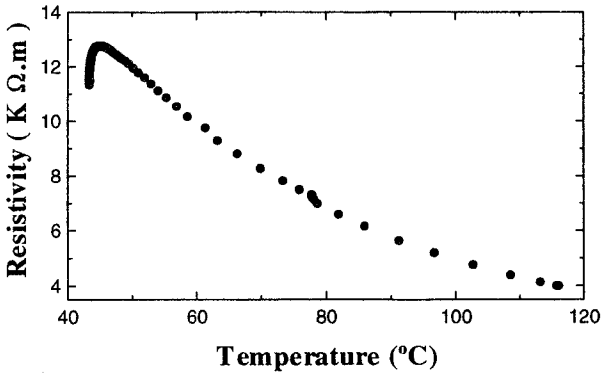

Fig. 1: Electrical resistivity of sample A as a function of the temperature.

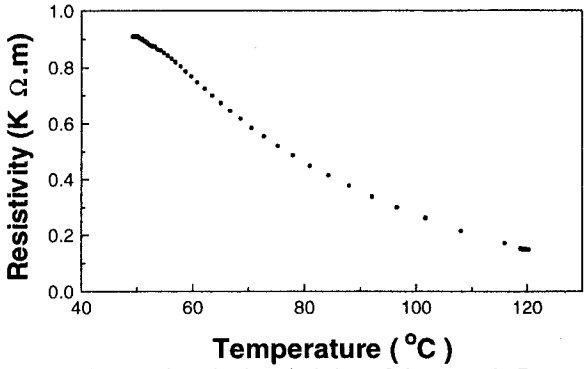

Fig. 2: Electrical resistivity of the sample B as a function of the temperature.

Table 1 - Analysis results in the coals before and after graphitization treatment. (NG: non graphitized; G: graphitized)

Coal	Ash (%)		Volatiles (%)		BET Surface Area (m^2/g)		HGI		True Density (g/cm^3)	
	NG	G	NG	G	NG	G	NG	G	NG	G
A	9.83	11.1	7.4	2.0	8.9	8.96	29.3	28.7	1.57	1.93
B	4.27	5.23	10.33	4.7	6.77	13.99	42.6	26.5	1.47	1.83
C	7.87	8.1	5.1	2.8	23.59	11.7	33.3	29.3	1.76	1.90
D	3.03	9.0	7.2	1.7	3.15	8.58	32.1	27.1	1.54	1.84

Table 2 - Electrical resistivity of the graphitizated raw materials.

Coal	Eletrical Resistivity (mΩ.m)
A	1.0 +/- 0.2
B	2.18 +/- 0.06
C	1.50 +/- 0.02
D	2.3 +/- 0.3

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