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The influence of composition of coal briquettes on changes in volume of the heated coal charge

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ABSTRACT

Two coal blends of different composition made of lower, medium, and higher rank coals (further in the text LRC, MRC, and HRC appropriately) in the ratio of 70:20:10 and 20:70:10 were carbonized in a laboratory unit for coke-making with the use of X-raying. The carbonization of the blends was carried out with the briquettes having the same composition as the blend and with the briquettes made of HRC with 2 wt% of coal tar pitch (CTP), with 2 wt% of low density polyethylene (LDPE), and with 2 wt% of polypropylene (PP). Markers were introduced into the charges of the blends to enable measurements on X-ray pictures that are connected with volumetric changes. The same blends were pyrolyzed in thermobalance coupled with a TG/FT-IR interface.

It has been proven experimentally that the addition of briquettes to the coal charge having the same composition as the charge leads to an increase in volume of the charge near the heating wall. The introduction of the briquettes made of higher rank coal with addition of CTP, LDPE, and PP reduces the increase in volume of the two charges at the stage of coal grain swelling.

The briquettes made of the blend of HRC with LDPE are most exposed to gasification by decomposition products from blend 1; the composition of volatiles does not influence the gasification of the briquettes made of the blend of HRC with PP. The briquettes made of the blend of HRC with CTP substantially increase their thickness under the influence of a greater amount of volatile products.

1. Introduction

Briquetting of coal as a trend in thermochemical processing of low-caking coals began to develop widely in the middle of the 20th century [1]. Exploitation of resources of good-caking coals [2], a need to obtain a smokeless fuel (requirements connected to restrictions on emission of carbon and nitrogen oxides to the atmosphere) [3–8] along with restrictions on waste storage of different type [9,10] in recent years gave a fresh impetus to the research in this field.

The investigations carried out by different authors show that briquetting of coals can be made without a binder [11,12], a coal can be used as a binder for briquetting of lignite [13], a binder may be of petroleum or of coal origin [2,14–16], and synthetic materials modified by various chemical reagents can be used as a binder [17–19] or molasses in a blend with coal tar pitch after appropriate modification [20]. The authors of [16] suggest that the briquetting technology allows to obtain a coke very similar to the traditional metallurgical coke in regard to its properties. In this case, poor caking coals of bad quality and coal fines may be used for briquetting [14,21], lower rank coals [4,22] and higher rank coals [20,22,23], and the coke breeze [20,23]. The results presented in [17,18,20,24] give their authors all reasons to believe that the application of a binder modified by oxidizing additives enables the use of the obtained briquettes as substitutes for metallurgical coke omitting the carbonization stage.

However, at present the traditional coke-making technology is applied widely. This technology implies the use of coal briquettes with a greater density than the rest of the coal charge [1]. Without any doubt, partial briquetting of coal charge could bring economic effects because it leads to a higher coke yield. However, briquettes introduced into the coal charge can influence the flow of the process of traditional (conventional) coking, lead to decrease in quality of the obtained coke, and cause some unpredictable effects that are reflected in volumetric changes of the heated coal charge. Hence, this paper aims to study the behavior of briquettes having different composition in the heated charge of two coal blends along with the evaluation of its influence on volumetric changes in the charges of the blends in coking chamber.

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Table 1
Characteristics of the coals.

Coal	Volatile matter (wt.% daf)	Total moisture(wt.%)	Ash (wt.% db)	SI[a]	RI[b]	Dilatometry Audibert-Arnu					Plastometry Gieseler			
						T_I, °C	T_{II}, °C	T_{III}, °C	a, %	b, %	T_1, °C	T_{max}, °C	T_3, °C	F_{max}, ddpm
LRC	38.3	1.15	1.07	6.5	73	385	425	450	28	+66	398	437	463	485
MRC	23.32	0.49	7.01	5.5	75	400	435	455	27	+8	435	472	499	122
HRC	20.9	0.5	1.62	4.0	53	395	435	450	23	−7	449	477	495	10

[a] SI is Swelling Index.
[b] RI is Roga Index.

2. Experimental

2.1. Research material

2.1.1. Preparation of coal blends

The paper focuses on the analysis of carbonization behavior of the two coal blends made of three coals having different rank; the characteristics of these coals are presented in Table 1. Before making up the blends, the coals were ground to the size of grains less than 3 mm. Blend 1 contained LRC, MRC, and HRC in the ratio of 70:30:10, and blend 2 in the ratio of 30:70:10.

2.1.2. Preparation of coal briquettes

Samples taken from the prepared blends and ground up to the grain size of <0. of ground coal was taken from each of the samples to form briquettes and pressed into tablets of 1.2 cm in diameter and 0.7 cm high. The density of the obtained briquettes was about 1.3 g cm^{-3}.

A portion of HRC was also ground to the grain size of <0.2 mm. Less than a gram (0.98 g) was taken from the ground sample of this coal for each blend with 0.02 g of additives. A ground CTP with the softening temperature of 92 °C (the marking according to the Polish standard PN-C-97-067:1999) was used as an additive along with film scraps of LDPE about 0.5 1 mm in size and filings of PP. The size of the briquettes obtained from the blend of HRC with 2 wt% of CTP, with 2 wt% of LDPE, and with 2 wt% of PP was the same as the size of the briquettes from blends 1 and 2.

HRC as the base of the briquettes and the additives was chosen not by chance. At present, due to reduction of natural reserves of middle rank coals, higher rank coals are mined to a greater extent, and this trend will increase in the future. CTP has been used for long as a plasticizing additive in the briquetting process [2,25]. According to the authors of Ref. [26], the addition of several percents of polyethylene will not reduce the quality of coke. Moreover, the addition of polyethylene and propylene will not substantially reduce the maximum fluidity of coals [26]. However, Vivero and co-authors [27] believe that the use of additives of this type will reduce the maximum fluidity of coals about twofold.

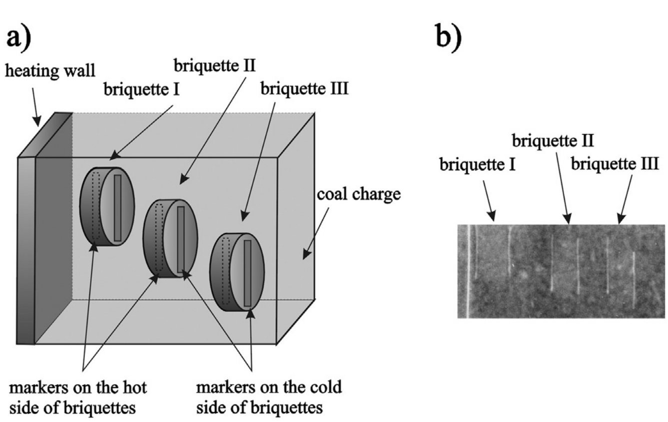

Fig. 1. The scheme of positions of briquettes in the charge (a) and the X-ray picture of the charge heated with briquettes (b).

2.2. Experimental methods

2.2.1. Carbonization test

The changes in volume of the heated charge in the coking chamber were determined in a laboratory unit with X-ray apparatus. The changes in volume of the charge were recorded on X-ray pictures according to the techniques presented in Ref. [28].

Heating of the coal charge in the chamber was one-sided. The coking chamber was equipped with a vertical heating wall. Heat was

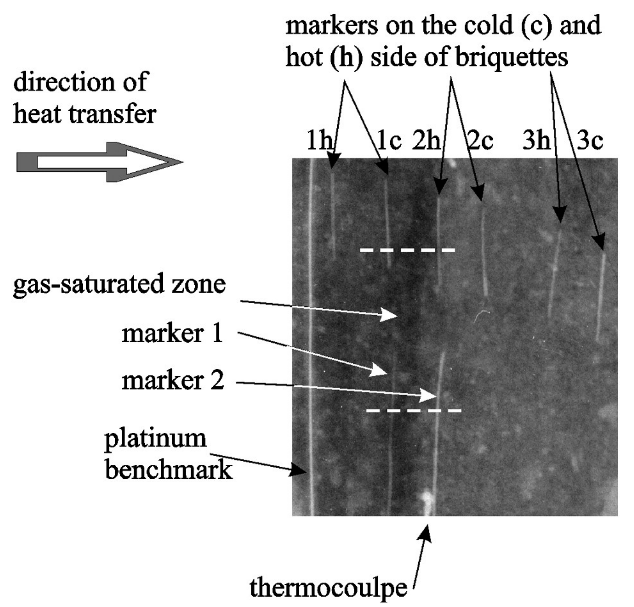

Fig. 2. The X-ray picture of the charge heated with markers and briquettes.

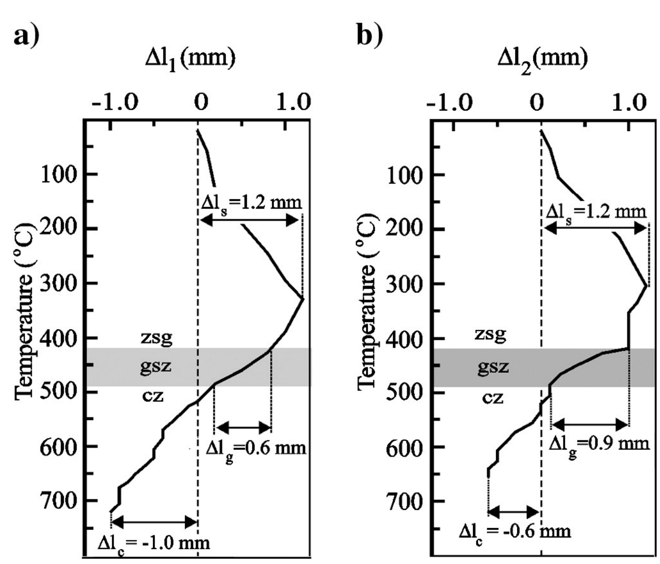

Fig. 3. The curves of displacement of markers 1 (a) and 2 (b) in the heated charge of blend 1.