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PRODUCTION OF FORMED COKE FROM NIGERIAN COALS

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Abstract

Nigeria is endowed with large deposits of high grade iron ore but reserves of suitable coking coals are extremely meager necessitating looking into the option of utilising lower rank coals. In this work, the properties of three Nigerian coals (Onyeama, Lafia-Obi and Garin Maiganga), are investigated to determine their suitability in developing formed coke for use as blast furnace coke. Parameters that were used include the shatter index, expressed as percentage stability and friability and micum index. The highest cummulative percentage stability and the lowest cummulative percentage friability was observed in Lafia-Obi with values of 67.54% and 32.46%, followed by Onyeama with 66.92% and 33.08% and then Garin Maiganga with 55.04% and 44.96% respectiely. Medium and low temperature carbonization of Onyeama and Lafia-Obi coal samples gave an improved and satisfactory percentage stability and friability for the semi-cokes. The percentage stability and friability are indicators of charge performance in the furnace and are within the range allowed for low shaft furnace except for Garin Maiganga whose stability index is low. The micum index (I_{20}), show that Lafia-Obi has the highest percentage of 31%, followed by Onyeama with 28%, and then Garin Maiganga with 23%. These show that Onyeama and Lafia-Obi semi-cokes have fair abrasive and impact resistance. Size consistency allows for good flow of gases through the charge. The results obtained indicate that Onyeama and Lafia-Obi semi-cokes have reasonable strength and hardness for use in the blast furnace.

Keywords: formed coke; coking coals; carbonization; Nigeria.

1. Introduction

The present global concern for new sources of energy has kindled a renewed interest in coal [1]. Scarcity of prime coking coals has led to extensive research on blend design, behaviour of blend and constituent coals of a given blend on carbonization [2-5]. Nigeria is blessed with a large coal deposit but most of them non coking [6]. If the indigenous Coal deposits can be explored and exploited, Nigerian economy can be diversified, leading to a smooth industrial and technological transformation from the present petroleum based economy [6]. Rank and type of coal are fundamental factors that determine suitability of coal for applications like coking, liquefaction etc. [7-8]. The non coking Nigerian coals may be blended to obtain blast furnace coke [3,9]. Coals carbonized at medium temperatures can yield semi-cokes suitable for metallurgical purposes [10].

The development of formed coke process is very vital to Nigerian economy and 100% Nigerian coal in form of formed coke may be used in the Ajaokuta blast furnace and other steel industries [9,11].

2. Materials and methods

2.1. Materials

Coal samples from Lafia–Obi and Onyeama (Enugu) were obtained from the National Metallurgical Development Cenre (NMDC), Jos, while sample from Garin Maiganga (Gombe) was collected from the mine site around Gombe, Gombe State. Samples collected were kept in an airtight polyethylene bags prior to analyses.

2.2. Methods

Shatter Index: 25kg weight of coal/coke samples were placed into a box of the shatter test machine, it was levelled and then dropped from a distance of 1.8 meter onto a steel plate.

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This process was repeated four times. After the last drop the materials were separated into sized portions using 50 mm, 38 mm, 25 mm and 13 mm square-hole screens for shatter indices. The results of the shatter index analysis for both the coal and the coke were recorded [12].

Coal Carbonization: 27.5kg weight of coal sample of about 50 mm particle size was taken in a rectangular mild steel retort. The retort was sealed with gas outlet at the top walls in the oven. Electrical heating element was provided in both the top walls on the front and rear walls. When the oven walls attained 100°C the retort was introduced into the oven and carbonization was carried out at 650°C for low temperature carbonization (LTC) and 850°C for medium temperature carbonization (MTC) respectively. When the gas evolution tapered off, the retort was taken out, cooled, cut open and the resultant coke tested. Shatter index test were used to determine the Stability and Friability index of the coke.

Micum Index: 25 Kg weight of coal sample of about 20mm particle size was placed in the micum drum; it was then rotated 500 times at the rate of 25 revolutions per minute. The samples were discharged and screened using 25 mm, 20 mm, 12.5 mm and 10 mm round holes screens [13]. The fractions were separated, weighed and the results expressed as:

I_{20} = % weight of sample above 20 mm size after rotation.

I_{10} = % weight of sample passing through 10 mm screen after rotation

3. Results and discussion

Table 1 shows the results of shatter index analysis expressed as percentage stability and friability of the coal samples. The highest percentage size stability of 67.54% was observed for Lafia-Obi, followed by Onyeama with 66.92%, and then Garin Maiganga with 32.46%. The percentage friability of Lafia-Obi, Onyeama, and Garin Maiganga are 32.46%, 33.08% and 44.96% respectively. The shatter indices of Lafia-Obi and Onyeama falls within the limit specified for blast furnace coke [14].

Table 1 Percentage Size Stability of Onyeama, Lafia-Obi and Garin Maiganga Coal Samples

	Onyeama	Lafia-Obi	Garin Maiganga
%Size Stability	66.92	67.54	55.04
% Friability	33.08	32.46	44.96

Table 2 shows the cummulative shatter indices of the semi-coke at low and medium temperature carbonization. Onyeama semi-coke had 56% and 61.2% of the coke above + 1″ (25mm) size and 75.2% and 77.6 % above +½″ (13mm) for medium and low temperatures respectively. While Lafia-Obi coke gave 49.6% and 57.6% of the semi-coke above + 1″ (25mm) size with 74.8% and 82.8% above + ½″ (13mm) size for medium and low temperatures respectively. Garin Mai-ganga had 38.4 % and 48.8% above + 1″ (25mm) size while 72.8% and 69.6% were above + ½″ (13mm) sieve size.

Table 2 Shatter index value of semi coke for low and medium temperature carbonization.

% Cummulative Shatter Index	Onyeama		Lafia – Obi		Garin Maiganga	
	MTC	LTC	MTC	LTC	MTC	LTC
+1″ (25mm)	56.0	61.2	49.6	57.6	38.4	48.8
+½″ (13mm)	75.2	77.6	74.8	82.8	72.8	69.6

The semi-coke samples possess reasonable strength, +1″ shatter value being 61.2% for Onyeama and 57.6% for Lafia-Obi. Garin Maiganga was low with 48.8%. The semi–cokes obtained from Onyeama and Lafia-Obi has a reasonable strength, hardness and physical properties. Both Lafia-Obi and Onyeama are known to be higher in maturity than Garin Maiganga coal [15]. Increase in maturity leads to increase in hardness as a result of aromatization and decrease a corresponding decrease in moisture and volatile matter contents [16].

The physical properties of the semi-coke from Garin Maiganga (Gombe) indicate that they are less strong compared with those obtained from similar low rank coals. The result of micum index analysis of the carbonized coal at low temperature is shown on Table 3. This result revealed that Lafia-Obi has the highest value of 31% at I_{20} and lowest value of 12% at I_{10}, while Garin

Mai-ganga semi-coke had lowest value of 23% at I_{20} and highest value of 19.9% at I_{10} respectively.

Table 3 Micum index value of semi-coke at low temperature

	Moisture (%)	I_{25} (%)	I_{20} (%)	$I_{12.5}$ (%)	I_{10} (%)
Onyeama	1.8	15	28	21	12
Lafia-Obi	1.4	10.3	31	7.4	22
Garin Maiganga	3.0	7.7	23	19.9	19.9

The low hardness factor is due to high ash content [5]. For a good flow of gases through the charge, the coke particles size must be consistent. Large volume of fine particles tend to fill the void spaces in the charge and impede the flow of gases resulting in lower melting rate, increase in carbon pick-up by metal and higher Coke consumption [17].

4. Conclusion

The coals investigated are low rank, high moisture and high volatile non-coking types and results obtained show that development of "Formed coke" either from Straight run carbonization of Onyeama and Lafia-Obi coal or their blends are feasible.

The studies conducted revealed that Lafia-Obi coal has the highest stability index and the lowest friability, followed by Onyeama and then Garin mai-ganga.

The semi–cokes obtained from Onyeama and Lafia-Obi has a reasonable strength, hardness and physical properties.

The physical properties of the semi-coke from Garin Maiganga (Gombe) show that the cokes were of poor strength compared to those obtained from similar low rank coals. Shatter and micum value shows that the semi–coke had low resistance to impact and abrasion ability.

However, in spite of the moderate strength, it is believed that the semi-coke may be suitable for domestic and industrial purposes.

The quality of the coals can be improved through adequate preparation of coal prior to carbonization and coke samples before use as blast furnace coke.

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