B. OLEKSIAK, M. KOZIOŁ, J. WIECZOREK, M. KRUPA, P. FOLĘGA

ISSN 0543-5846
METABK 54(1) 95-97 (2015)
UDC – UDK 669.3:66.082:622.66:662.8.05=111

STRENGTH OF BRIQUETTES MADE OF CU CONCENTRATE AND CARBON-BEARING MATERIALS

Received – Prispjelo: 2014-01-30
Accepted – Prihvaćeno: 2014-08-20
Preliminary Note – Prethodno priopćenje

In the present paper, results of the research on application of residual fine-grained, carbon-bearing materials as coke substitutes in the shaft process of copper matter smelting are discussed. The addition was introduced into the charge as a component of concentrate-made briquettes; then, its effects on properties of the obtained briquettes were analysed for their compressive and drop strengths. The results of investigations confirmed the potential use of proposed alternative fuels (as briquette components) in the process of copper matte smelting.

Keywords: copper concentrate, alternative fuel, briquette strength

INTRODUCTION

In many pyrometallurgical processes, a major component of the charge, in addition to metal-bearing materials, is coke or coke breeze. They are mainly energy carriers and reducers. For many years, extensive research on the use of cheaper substitutes for these materials in metallurgical systems has been conducted. It involves iron ore sintering, the blast-furnace process and non-ferrous metal smelting in shaft furnaces as well as the technology of processing of various secondary metallurgical materials [1-5]. As alternative fuels for metallurgical processes, fine-grained, metal-bearing materials from the process of coal-enrichment, coke waste and biomass are applied. Some of them have already been used for energy industry purposes. [6-8]. It should be noted, however, that alternative fuels must ensure a proper course of the specific technological process and should not compromise its thermal balance or cause extra consumption of fluxes and generation of larger slag amounts. In many metallurgical systems, physical properties of the fuel (coke, coke breeze) are of very high importance as they markedly affect e.g. gas permeability of the charge. It can be assumed that the above carbon-bearing materials and biomass are prospective fuels but in most cases, their application requires using charge materials in the form of granules, briquettes, pellets etc.

RESEARCH METHODOLOGY

For the investigations, sulphide copper concentrate from “KGHM Miedź”, containing 27,81 % mass Cu, was used. The residual carbon-bearing materials were: coal flotation concentrate, coke dust and anthracite dust. Their chemical compositions are presented in Table 1.

The briquetting process was conducted using a hydraulic press (max force 10Mg).

Table 1 **Chemical compositions of the investigated carbon-bearing materials**

Fuel type	Fractions of individual components / % mass			
	C	S	humidity	ash
Coal flotation concentrate	64,3	0,45	26,5	8,71
Coke dust	88,5	0,6	0,3	10,3
Anthracite dust	71,5	1,7	5,4	25,1

The binder was sulphite liquor. The resulting briquettes were of a cylindrical shape, 30 mm in diameter and 25 - 30 mm in height (Figure 1). The sulphite liquor content in the briquetting mix corresponded to the industrial values. In Table 2, compositions of the mixes used for the briquetting process are presented. The fraction of binder was 5,3 % mass in each case.

Figure 1 The obtained copper concentrate briquettes

B. Oleksiak, M. Kozioł, J. Wieczorek, M. Krupa, P. Folęga - Silesian University of Technology, Katowice, Poland

Table 2 **Compositions of the mixes used for the briquetting process**

Mix label	Concentrate fraction / %mass	Carbon-bearing material fraction / % mass		
		coal flotation concentrate	coke dust	anthracite dust
S	94,7	-	-	-
A-4	90,7	-	-	4,0
C-4	90,7	-	4,0	-
F-4	90,7	4,0	-	-
A-2	90,7	-	-	2,0
C-2	90,7	-	2,0	-
F-2	90,7	2,0	-	

The briquettes were tested for compressive strength and drop strength. The compressive strength test involved applying a load that caused fine grains to approach each other. The compressive strength is capacity of a material to withstand loads tending to destroy it. It can be measured by plotting the applied compression force that led to destruction of the material structure against the surface affected by the compression force [9-11]. It should be noted that the test results depend on many factors, such as the shape, size and weight of the briquette as well as on the speed of the compressive head. Sufficiently high forces lead to briquette crack providing it is brittle enough. Certain briquette types with bitumen, clay or plastic material additives show plastic properties that preclude precise determination of the destructive force during compression. It should be noted that comparison of compression forces is possible for samples of the same shapes and sizes [12]. The compressive strength depends on the direction of force acting on the material fibres or layers. In the case of fine-grained materials, it also depends on the material humidity and the temperature. For briquettes made of waste materials, the axial compressive strength values range widely from 0,5 MPa to 15 MPa and more [13]. The copper concentrate briquettes were tested for compressive strength using the INSTRON 4469 test machine at a compression speed of 2 mm/min.

In the drop strength test, 3 briquettes were dropped seven times onto a steel plate from a 2-metre height. After each drop, the amount of remaining briquette fraction (over 10 mm in diameter) was determined. The tested samples were both immediate and seasoned briquettes due to the fact that in the technological process, the manufactured briquettes must be sometimes stored for several days. This means that briquettes must show specific mechanical properties for a longer period.

STUDY RESULTS AND DISCUSSION

In Figure 2, examples of changes of compressive strengths in the case of immediate and seasoned (1-5 days) briquettes are presented. For all briquette batches, the strength was higher than 1 MPa and comparable to the values for briquettes made of copper concentrate only (as in the industrial setting). The data show that for all investigated mixes, no strength deterioration with the seasoning period elongation was observed, which means that the briquettes can be successfully stored before smelting, if required.

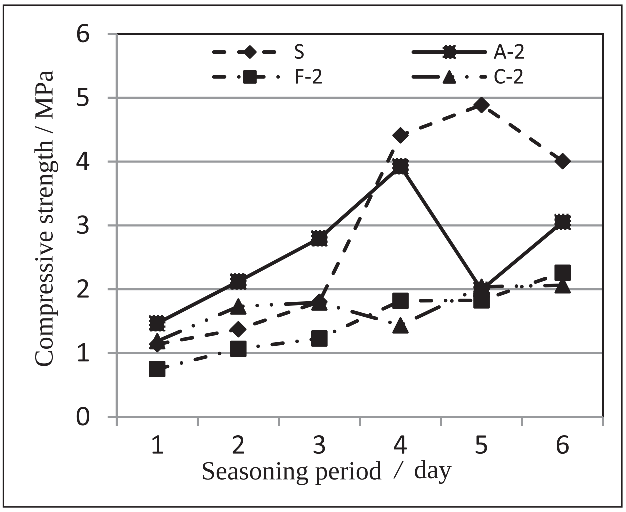

Figure 2 Compressive strength changes observed in the obtained briquettes.

Table 3 shows examples of drop strength test results for the obtained briquettes. The strength is presented as a fraction of briquettes of over 10 mm in diameter in

Table 3 **Drop strength test results for the obtained briquettes**

Type of the mix	Seasoning period / day					
	0	1	2	3	4	7
	Content of the fraction over 10 mm / %					
S	80,9	80,8	96,3	85,1	81,4	91,3
A-4	73,5	77,1	86,3	93,6	94,3	94,8
C-4	80,5	97,2	97,3	99,4	96,7	99,0
F-4	98,9	99,7	99,5	99,8	99,7	99,8
A-2	72,3	62,1	71,9	78,3	88,2	80,6
C-2	65,7	67,2	63,9	67,3	78,0	70,1
F-2	72,3	73,4	75,4	88,7	82,3	83,4

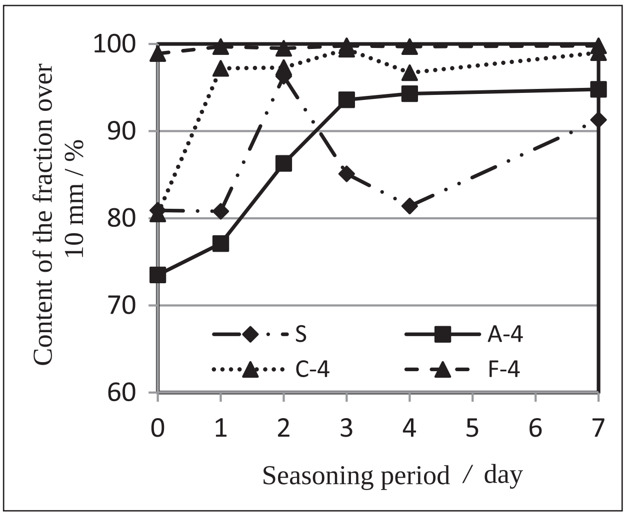

Figure 3 Drop strengths of selected briquettes versus the seasoning time.

relation to the total briquette bulk. A graphic interpretation of the results is presented in Figure 3. The Table 3 data refer to the strength after three drops as this value was assumed to illustrate briquette transport in the period from the immediate manufacturing completion to the shaft furnace charging (in the industrial setting).

CONCLUSIONS

Based on the investigations, it was concluded that:

– It is possible to use fine-grained, carbon-bearing materials as components of briquettes, obtained from copper concentrates, in the process of copper matte smelting in the shaft furnace.
– Introduction of a mix of alternative fuels into the briquetting process, in the amounts up to 4 %, enables production of briquettes that show technologically demanded compressive and drop strength properties.
– Humidity of the mix used for briquetting should not be higher than 10 %.

Acknowledgements

The study was conducted under the Research Project No. PST1/A5/21/2012, financed by the National Research and Development Centrethe – Poland.

REFERENCES

[1] R. Findorák, M. Fröhlichová, J. Legemza, The effect of charcoal addition on iron-ore sintering emision**,** Conference proceedings 13th Internat. Scientific Geoconference Science and Technologies in Geology, Exploration and Mining, Albena (Bulgaria), 2 (2013), 629-635.
[2] J. Legemza, M. Fröhlichová, R. Findorák, Thermodynamic study of utilization of charcoal in the iron-ore sintering process, Conference proceedings 13th International Scientific Geoconference Science and Technologies in Geology, Exploration and Mining, Albena (Bulgaria), 2 (2013), 649-656.
[3] M. Niesler, J. Stecko, L. Blacha, B. Oleksiek, Application of fine-grained coke breeze fractions in the process of iron sintering, Metalurgija, 53 (2014) 1, 37-40.
[4] J. Lipart, T. Matuła, M. Niesler, L. Blacha, J. Filipczyk, Wastes from the coal-enrichment process as alternative reducers for lead smelting from lead-acid accmulator scrap, Metalurgija, 52 (2013) 4, 493-496.
[5] J. Łabaj, M. Słowikowski, W. Żymła, J. Lipart, The research on reactivity of alternative carbon reducers, Metalurgija, 52 (2013) 1, 68-70.
[6] J. Hehlmann, W. Szeja, M. Jodkowski, P. Benducki, Research on Receiving Composite Energetic Biofuel Based on Biomass from Sewage Sludge Fermentation Process, Rocznik Ochrona Środowiska, 13 (2011) 1, 921-934.
[7] J. Tomeczek, S. Gil, The kinetics of coal chars hydrogasification, Fuel Processing Technology, Elsevier, 91 (2010) 11, 1564-1568.
[8] S. Gil, P. Mocek, W. Bialik, Changes in total active centres on particle surfaces during coal pyrolysis, gasification and combustion, Chemical and Process Engineering, 32 (2011) 2, 155-169.
[9] J. Myalski, J. Wieczorek, A. Płachta, Physical and Mechanical Properties of Composites with Aluminum Alloy Matrix Designed for Metal Forming, Solid State Phenomena, 212 (2013), 59-62.
[10] M. Koziol, Experimental study on the effect of stitch arrangement on mechanical performance of GFRP laminates manufactured on a basis of stitched preforms, Journal of Composite Materials, 46 (2012) 9, 1067-1078.
[11] M. Koziol, Effect of thread tension on mechanical performance of stitched glass fibre-reinforced polymer laminates – experimental study, Journal of Composite Materials, 47 (2013) 16, 1919-1930.
[12] G. Borowski, Wykorzystanie brykietowania do zagospodarowania odpadów, Monografia. Lubelskie Towarzystwo Naukowe, Lublin, 2011.
[13] G. Borowski, M. Miłczak, Badania przydatności brykietów z popiołów paleniskowych jako podbudowy drogowe, Postępy Nauki i Techniki, 4 (2010), 136-143.

Note: Nowak P. is responsible for English language, Katowice, Poland