ISSN 2176-3135

NEW CHARGE MATERIAL FOR BLAST FURNACE[1]

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Abstract
Self-reducing iron-carbon containing briquettes are perspective charge materials for Blast Furnaces (BF) making it possible to reduce considerably the coke consumption as well as the total emissions of the CO_2 within the technological network "Sintering-Ironmaking-Steelmaking". Such cylindrical shape (diameter 30mm, length 50-70mm) briquettes (Fe content 37-44%, C content 12-15 %) have been produced by the "Stiff-extrusion" technology at the industrial extrusion line with productivity of 20 tonnes/hour. The briquettes were made from disperse metallurgical wastes (BOF dust -48 %, BF dust -25 %, fine iron-ore -20%, Portland cement -7 %). They have been used as a main component of the BF charge (briquettes 60-62 %, iron ore 38-40 %) for the production of the foundry iron (Si content 0,9-2,5 %) in a small BF (working volume 45 m3). The coke rate was 565-710 kg/т, the blast temperature - 750-900 ^{o}C and slag volume - 275-380 kg/t.
Key words: Briquettes; Blast furnaces; Charge materials; Metallurgical wastes.

1 *Technical contribution to the 6th International Congresso on the Sicence and Technology of Ironmaking – ICSTI, 42nd International Meeting on Ironmaking and 13th International Symposium on Iron Ore, October 14th to 18th, 2012, Rio de Janeiro, RJ, Brazil.*
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ISSN 2176-3135

1 INTRODUCTION

In 1993 at the metallurgical plant of the Bethlehem Steel Corporation (USA) the industrial briquetting line started the production of the briquettes from the disperse metallurgical wastes based on the stiff-extrusion technology developed and realized on the equipment produced "J.C.Steele & Sons"[1]. Creation of the high-productivity equipment and of the stiff-extrusion technology at the market of the disperse substances agglomeration is the milestone event for the Blast Furnace production. The extrusion briquettes produced by this technology from the anthropogenic and/or natural iron-containing substances (brex) are the components of the Blast Furnace new generation charge. Design productivity of the first brex making line was almost 20 t/hour or 6000 t per month at average with the two shifts and 20 working days per month of operation. The brex were produced from the sludge and dust of the Basic Oxygen Furnace (BOF) and the sludge of the coke-making plant. The Portland cement and the lignin were used as the binder and plasticizer correspondingly. The brex were used in the Blast Furnace charge. Equipment costed to 275,000 USD, installed capacity of electrical equipment was 138 kW, binder and plasticizer costs – 8 USD/t of brex [1]. The line had been in a continuous operation since 1993 and till 1996 and had been stopped due to the cancellation and liquidation of the main production of the Steel mill itself.

2 DISCUSSION

Utilization of the new briquetting technology for Blast Furnaces has been renewed only at present time. In April 2011 the industrial line has been launched for the production of the brex with the design productivity of 20 t/hour at the small metallurgical plant belonging to the «Suraj Products Ltd» Company in Rourkela (India). The plant produces steelmaking and foundry hot metal by the small-scale Blast Furnaces and the sponge iron by the kilns. At present the brex are produced from the sludge bought from adjacent Steel-mill with the addition of some other oxides. Apart from sludge brex the washing brex made of the manganese fines are also being produced at the plant the share of these brex in the charge being 1 %. Briquetting unit includes: open air warehouse of the raw-materials, being delivered by automobiles; unit of the charge preparation (dosing, grinding, stockpiling, hopper feeding); mixing and briquetting unit; line of the transportation of the brex to the strengthening area; ready brex warehouse.

The main components of the brex are – steel-making and blast furnace sludge and dust. The binder and plasticizer are – Portland cement and the Bentonite respectively with their shares in the mix being 6% and 0,3-0,5 %. The volumetric dosing is applied for the charge components and is being implemented by the automatic loader, which creates the stockpile of the charge mix (but the cement), taking each single component from separate stockpiles located at the open air areas. Charge mix is also being fed to the hopper of the briquetting line by loader where from it goes through the homogenizing mixers to the extruder.

Due to the applied pressure during extrusion and the de-airing of the mix (90%) in the vacuum chamber the brex do have a dense structure at the die exit, high initial strength and a good plasticity. This helps to transport and to stockpile the brex for further strengthening without fines generation (Figure 1).

ISSN 2176-3135

Figure 1. Industrial brex production by Steele Extruder 25 at Suraj Products Ltd.

During the transfers only the defragmentation of the brex into 2-3 pieces takes place with the creation of the brex with the length/diameter ration being 1,3-2,2 while this value after the die is in the range of 2,5-8,0. Simultaneously a small turning of the brex sharp borders takes place. For the strengthening the brex are being cured in the stock at the open place (figure 2).

Figure 2. The stock brex at the open place.

Chemical composition of the brex after curing: Fe_{total}-46-48 %; CaO 10-11%; SiO_2 7,2-7,7 %; Al_2O_3 -1,7-1,9 %; MgO 2,7-2,9 %; loi (hydrated water + carbon) 11-11,9 %, (CaO/SiO_2)=1,4.

During two shifts per day operation the briquetting unit produces 200 t of the brex. Melting of the 100-135t of the brex per day is being performed in the Blast Furnace with the volume 45m^3. The quality of the brex provides for the successful operation of the

ISSN 2176-3135

Blast Furnace with the brex share in the charge being as large as 80% (1444 kg/t of hot metal).

Blast Furnace is equipped by: skip hoist with the volume 0,5m^3, double-cone charging device, and hydraulic equipment for the notch servicing, stoves and by double-stage gas-cleaning system (dust collector + 7 modules of the bag house filters). The Furnace has 8 air tuyeres and one hot metal notch. Furnace is being cooled by external watering. Produced hot iron is immediately casted by the casting machine and the slag is granulated by the very simple scheme of the granulation next to the furnace. Hot metal and slag are shipped to the customers by automobiles. At the present time the Company is planning the blowing-in the second Blast Furnace with the volume of 25m^3.

Prior to the construction of the briquetting unit the hot metal had been produced based on the iron ore. The efficiency of the utilization of the brex can be seen after the comparison of the operation parameters of the Blast Furnace working on the iron ore and on the charge with 80% of the brex and 20 % of the iron ore (Table 1).

Table 1. Technical-economical parameters of the Blast Furnace operation

Parameters of the Blast Furnace operation	With iron ore	With brex
Iron ore consumption, kg/t	1500	372
Brex consumption, kg/t	-	1425
Lime consumption, kg/t	1500	
Dolomite consumption, kg/t	144	
Scrap consumption, kg/t	132	
Washing brex consumption, kg/t	-	19
Fe content in fluxed charge *,%	57.6	50.4
Coke rate, kg/t	680	530
Productivity, t/m^2 per day	1.9	1.62
Hot blast temperature, ºC	925	900
Tuyere pressure, kg/cm^2	0.5	0.34-0.38
Hot metal chemical composition, % - Si	1.0-1.8	1.0-1.5
- Mn	0.2	0.4-0,5
- C	3.8-4.0	3.75-3.90
- S	0.050-0.060	0.038-0.050
Slag composition, % - CaO	34.86	33.12
- SiO_2	31.98	30.23
- Al_2O_3	23.87	17.98
- MgO	9.46	9.48
- FeO	1.01	1.26

*Note: * - not accounted for CO_2 carbonates.*

One can see that the coke rate after using the charge with brex (80%) and the iron ore (20 %) decreased by 150 kg/t of hot metal (22%) as a result of the consumption of the carbon containing in the brex as well as due to the removal of the raw fluxes from the charge. Reduction in the productivity of the Blast Furnace by 15 % with this new charge with brex is mainly related with the decrease in Fe content in such charge - 7,2 % compared with the charge based on iron ore and the raw fluxes. The further growth of the brex share in the charge was restricted by the significant growth of the basicity of the slag due to the high basicity of the brex containing the BOF sludge.

During the mastering of this new Blast Furnace technology with the new charge component it happened necessary to decrease the stock level of the charge because of the difficulties related with the dry gas-cleaning. Gradual growth of the brex share in the charge resulted in the decrease of the top gas temperature and its moisture content

ISSN 2176-3135

growth. As the result the bag house filter became cluttered by the wet dust and their regeneration by the back pressure impulses was not successful. Lowering of the stock level resulted in the top gas increase and the cluttering stopped. This lowering didn't influence at all on the Blast Furnace operation parameters.

3 CONCLUSIONS

The equipment and the technology of the stiff-extrusion make it possible to produce the extrusion briquettes (brex) having high strength and reducibility. Metallurgical properties of the brex allow using them successfully in the Blast Furnace melting. Utilization of the sludge brex with the basicity 1,4 in the small-scale Blast Furnace at the level of 80% of the charge (1444 kg/t of hot metal) helped to reject entirely from the introduction of the lime and dolomite and to reduce the coke rate by 150 kg/t of hot metal.

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