LABORATORY EXPERIMENTS FOR DETERMINATION OF OPTIMAL CHARACTERISTICS OF ULTRAFINE FERROUS WASTE BRIQUETTES TO BE USED IN A CUPOLA FURNACE

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When determining briquettes' optimal structure, a pre modeling process is necessary for establishing the influence of parameter Φ form factor has on the mechanical strength. Nowadays practice takes into account granulometric fineness as the main parameter conferring resistance to briquettes. To this end the experiment will be preceded by an experimental mono factorial program where the only variable is Φ factor, and the response functions are mechanical strength, briquettes apparent density and volume. Experimental researches aimed at determining the optimal characteristics (porosity, reducibility) of ultra-fine iron waste briquettes in order to use them in a cupola furnaces.

Keywords: ultrafine ferrous waste, briquette, cupola furnace

1. Introduction

There are several particular bulk materials which were studied in order to analyze the particles shape.

There were chosen seven materials having as different as possible coefficients and there were used materials which normally would not be used for experiments but they had the role to create a wide field of values of the form factor in order to increase the degree of significance of correlation with mechanical strength. These materials were chosen as pure as possible and the wastes without any additions.

2. Paper content

There were chosen several bulk materials that have been studied with an optical microscope for the analysis of particles shape. There were chosen seven materials having as different as possible coefficients and there were used materials

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which normally would not be used for experiments but they had the role to create a wide field of values of the form factor in order to increase the degree of significance of correlation with mechanical strength. These materials were chosen as pure as possible and the wastes without any additions. In Fig. 1, 2, 3, materials having as different as possible shape coefficients are shown. The materials used were: skims, alumina, EAF dust, brazil ore, coke, chamotte, synthesis ferric oxide.[3]

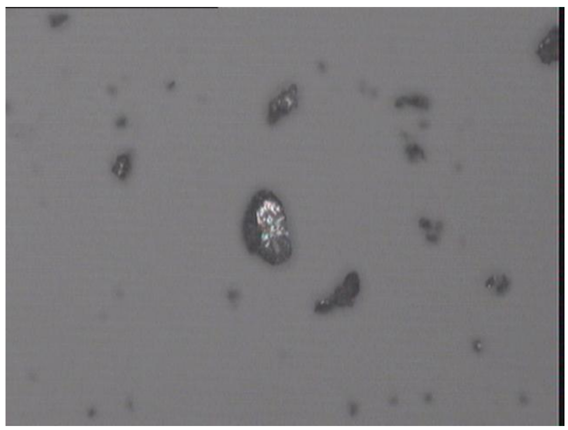

Fig. 1 Brazil iron ore (x 200) particles

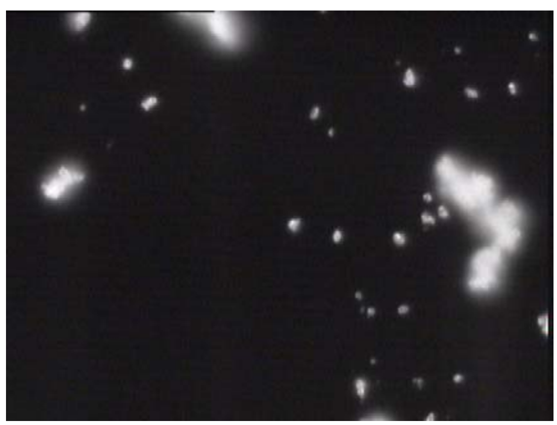

Fig. 2 Al_2S_3 synthesis of the alumina (x 750) particles

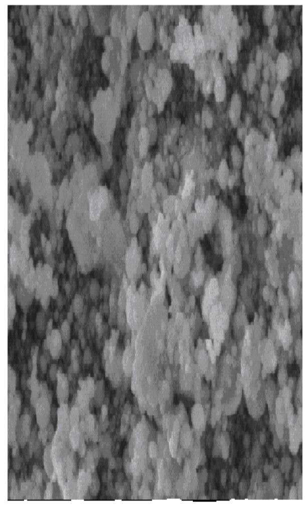

Fig. 3 Structure electrostatic dust particles from the development of steel in electric arc furnaces (x 30.000)

There were granulometric separated in a very narrow field between 1-35 μm after drying and sieving.

There were determined the bulk density values for each of them. Each was dosed in an amount of 80 grams, moistened with water at 10% humidity level. Two briquettes were pressed on a hydraulic press at a pressure of 50 tones, briquettes φ = 32 mm, resulting specific pressure to 6.25 ft/cm^2. The briquettes were dried at 130^0 C for five hours and then there were measured their height and compressive strength.

a. Experimental equipment

To determine the shape coefficient :optical microscope made by IOR, type MC - 5A with x 200 to 750, in reflected light and optical terminal strip with 100 gradations / 1 mm with Panasonic D5 CCD camera and PC interface MPEG video capture card - 4 resolution electronic image 550 LTV.

Granulometric separation was performed on a mechanical screening system for determining granulometric powders - RETSCH type AS200 Basic 35 μm horizontal sieve and vertical vibration 0.2 - 3 mm, 210 mm sieves diameter.

Weighing was done on KERN digital weighing scale 4200 - 2 nm accurate to 2 decimal places.

b. Experimental results and discussions

Correlation values of bulk density, degree tamping and compressive strength are given in Fig. 4

- There is a direct relationship between the shape grains coefficient and tamping the same pressure degree - volume parameter indicating a decrease of material compressibility when increasing the value of the shape factor;
- As a volume reverse value, bulk density of the obtained briquettes decreases when increasing shape coefficient ;
- Mechanic strength is inversely proportional to Φ value and thus decreases when it increases. In conclusion, bulk materials with particles that tend to have a sphere shape as close as possible compact hardly and have a lower mechanical strength.

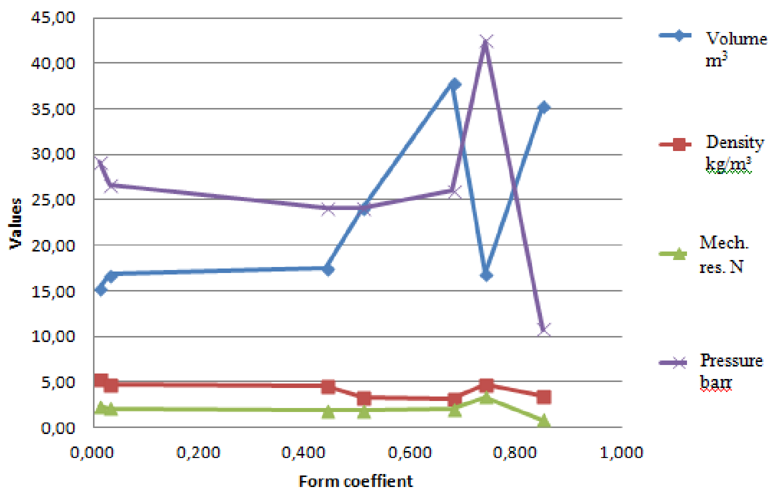

Fig. 4 Density and briquettes volume variation depending on grains shape coefficient

Experiments to determine the structural characteristics of briquettes[1,4]

Working method

There were chosen types of waste materials currently analyzed in order to process them: furnace powder, skims, slag and converter, ferric oxide. Reducing agent - coke

Materials that naturally result in larger dimensions of 1.2 m were ground into a fine mill and sieved on a sieve of 1.25 mm. The coke was ground and sieved on a sieve of 1.25 mm. There were made mixtures of ferrous wastes on following conditions:

- Firstly all materials were dried at 120^0 C for two hours;
- Ferrous wastes and coke were combined at least 20 % for coke dust provided that the molar / Fe ratio to vary within the limits of 0,14 to 0,2;

- The Ferrous waste mixture was performed under control so to produce a controlled coefficient of mixture with a general coefficient Φ= 0.2-0.3 and another lot with Φ 0,7-0,8. The mixture with Φ 0,2-0,3 have a high content of electrostatic powder CEA - 30 - 40 %, 10% ferric oxide ranging around 10 - 15%;
- Lot of briquettes with a shape Φ = 0,7 - 0,8 coefficient was achieved using 30 - 40 % skims, 10-15% brazil ore, 10% furnace dust and converter and 10 % ferric oxide and CEA electrostatic powder and the remaining coke dust. For each experiment there were formed batches of 1050 grams mixture to obtain 12 briquettes 80 grams each.

Each batch was stirred for 5 minutes and then they were humidified to 8% moisture briquettes as it was found that for some batches of the preliminary experiment water was excessive and it came out of some briquettes when pressing. Pressing was done at the size of Φ 40 mm at two pressure levels as it follows: 50-200ft/briquette according to the experiment matrix.

The briquettes were dried at 120^0 C for 5 hours.

There were used 10 to 12 pieces from each lot for the specific tests as shown in Fig. 5 :

- Determination of briquettes porosity;
- Determination of compressive strength;
- Determination of reducibility;

Reducibility is given by relation of oxygen mass loss taken up by reducing gases: *R = mf/(mi-mf)*100-%*, where: mf - mass of the sample after reduction – grams; mi - initial mass of the sample – grams

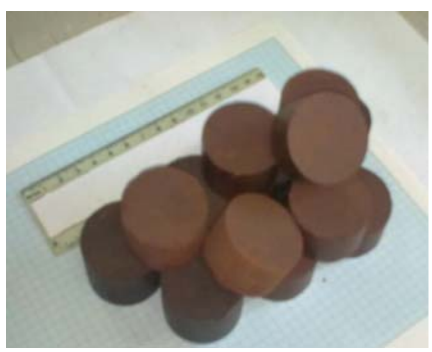

Fig. 5 Briquettes made from oxide powder waste with diameter Φ = 40 mm pressed at 15 ft/cm^2

Equipment used

Compared to equipment used at stage 1 there were used in addition:

- Drum laboratory mixing Φ = 200 mm, I = 300 mm with two chicanes width 20 mm longitudinal speed 30 rpm.

- Installation for determining water absorption capacity used to determine the total porosity of briquettes. The amount of water absorbed is measured on the graduated tube and turn into cm^3 by relationship:

Q water = 0.2 * L (cm) - cm^3

The amount of absorbed water is the total pore volume in cm^3 for each type of briquette. In table 1 porosity determinations are presented for each type of briquettes ranging from 1 to 16.

The equipment used were :

- Electric furnace chamber 12 dm^3 and SiMo resistant, maximum operating temperature of 1500^0 C. The furnace is designed for heat treatment operations and has an area of 5.15 dm^3. It can provide a heating rate of 20^0 C / minute up to 1100^0 C

- Reaction chamber for O_2 in N_2 at 500^0 C retention of copper scrap it has the function of purifying nitrogen used to protect low oxidation iron, the existing oxygen traces to 0,5 %.

As the sample is cooled in the nitrogen environment for three hours, the O_2 brought is enough to iron re-oxidation. N_2 used for protection and cooling is passed through a span of cooper mass heated to 500^0 C where the oxidation reaction occurs with the 50%. The amount of O_2 carried with N2 to an experiment is 1.54 g for which 12.32 g Cu are required. The span cartridge was calculated for 10 experiments and a safety reserve of 30 % and it weighs 160 g.

- Bottle of N_2 and H_2 and O_2 at 220 atm. Using O_2 in experiments is motivated by the need to ensure stability of ferric oxide in oxidizing atmosphere at temperatures above 450^0 C where it usually begins to break down. Presence of O2 raises the temperature of first stage decomposition to Fe_3O_4 above the temperature required for the experiment;

- Reduction in room alumina tube Φ 70 mm, length 160 mm, wall thickness of 5 mm with a capacity of 1000 cm^3. Removable wall is made of with 80 % MgO refractory concrete and heat treated at 1200^0 C. Through it there are placed two quartz glass tubes Φ_{ext} = 8 mm and Φ_{int} = 6 mm for the entrance and evacuation of reactive and protection gases.

Fig. 6 Assembly for reducing ferric oxide dust plant to obtain powders for sintering and nano-sized dimensions

Obtained results

Porosity parameter for the 15 types of briquettes has the following measured values presented in table 1 Y_1 column. Table 1 presents X_{1-4} variation limits parameter for each experiment according to experimental matrix and the testing response results functions Y_1 - porosity, Y_2 - strength and Y_3 – reducibility [2].

Table 1

Variation limits parameter

Experiment Number	X_1	X_2	X_3	X_4	Y_1	Y_2	Y_3
1	0.7	1.2	10	10	**1.64**	**44.22**	**44.5**
2	0.1	1.2	10	10	**1.25**	**58.63**	**39**
3	0.7	0.2	10	10	**1.41**	**36.92**	**69**
4	0.7	1.2	3	10	**1.39**	**26.34**	**55.2**
5	0.7	1.2	10	2	**2.51**	**19.68**	**73.6**
6	0.1	0.2	10	10	**1.33**	**71.56**	**56.9**
7	0.7	0.2	3	10	**1.37**	**42.21**	**49.63**
8	0.7	1.2	3	2	**2.26**	**22.16**	**63.28**
9	0.7	0.2	10	2	**2.39**	**28.64**	**71.56**
10	0.1	1.2	3	10	**1.44**	**54.29**	**33.69**
11	0.1	0.2	3	10	**1.35**	**69.56**	**45.98**
12	0.7	0.2	3	2	**2.89**	**39.51**	**68.63**
13	0.1	1.2	3	2	**2.91**	**32.59**	**59.36**
14	0.1	0.2	10	2	**3.15**	**48.63**	**74.23**
15	0.1	0.2	3	10	**1.28**	**53.67**	**48.65**
16	0.1	0.2	3	2	**2.87**	**39.79**	**58.74**

Calculation of response function is given by :

$$Y_1 = 1.97 + 0.59\ x\ 1- 0.81\ x\ 2 – 2.33\ x\ 4 + 0.43\ x1\ x2 \quad 3.39\ x1\ x4$$

The mechanical strength is defined by the following equation :

$$Y_2 = 43.3 + 16.9\ x\ 1 - 2.963x2 + 32.27\ x\ 4 + 10.91\ x\ 1x\ 4 -1.15\ x\ 2x\ 4 \text{ - tf/cm}^2$$

Reducibility is defined as a response function that indicated only a simple relationship according to briquettes pressing force, the response function being:

$$Y_3 = 57.5 + 17.1\ x1 + 23.331x2 - \%$$

4. Conclusions

By analyzing the data obtained from the experimental researches we can draw the following conclusions:

1. Briquettes porosity is a function directly correlated with the pressing force, specific internal porosity of the material and shape factor. It is find out that, although briquettes which were compressed to a smaller volume absorbed a specific amount of water expressed in the gr. water/ grams material unit higher than briquettes with greater volume.

2. Mechanical strength is directly dependent on the decrease of the form Φ coefficient and the pressing force.

3. Reducibility function is directly dependent on many factors, and for this matter the function coefficients are significant for porosity parameter only. This indicates the importance of carrying out gases diffusion resulting from direct reduction.

R E F E R E N C E S

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