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THE POSSIBILITY OF USING IRON ORE CONCENTRATE AS A BINDER WHEN BRIQUETTING WASTE OF FERROALLOY PRODUCTION

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The paper presents the results of studying the use of iron ore concentrate as a component of the charge for briquetting finely dispersed dust generated during the production of ferrosilicon. Experiments were carried out on introducing iron ore concentrate into the mixture in the amount of 3 to 10 %. Liquid glass and water were used as a binder. It was shown that the use of 5-7 % by weight of iron ore concentrate with the iron and silicon content of about 65 % and 26 %, respectively, led to increasing strength and density of the briquette by an average of 20 % compared to the same characteristics of briquettes obtained without adding iron ore concentrate. It should be expected that improving such briquette characteristics as strength and density will provide higher safety of the product during transportation and loading and better conditions during deoxidation and alloying, which ultimately ensures an improved steel quality.

Keywords: ferroalloy production, finely dispersed dust, iron ore concentrate, briquetting, mechanical properties

INTRODUCTION

One of the main waste products of ferroalloy production is finely dispersed dust (FDD). This type of waste is generated both as a result of the technological process of ferroalloy production and as a result of cleaning ventilation systems, conveyors and other equipment.

FDD is an environmentally hazardous waste, because it has increased pyrophoricity due to its extremely developed specific surface area, increased ability to pollute the air and, in addition, it requires significant storage space.

Meanwhile, FDD is a valuable source of raw materials for the production of ferroalloys of the same grade, because it has almost the same chemical composition. There is a significant amount of studies in this area, the authors of which use various binders, technological additives, etc. [1-6].

The main problems that arise when briquetting FDD are as follows:

- low strength of the finished briquette, which limits the possibilities of transportation and loading;
- relatively low density of the finished briquette, which leads to its floating to the surface of the melt during the melting process, incomplete melting, segregation in the body of the ingot and ultimately to decreasing the quality of steel.

The first problem is solved by using various binders in the composition of the pressing mixture; the second one is in most cases solved by increasing the compaction pressure.

Increasing the compaction pressure brings the particles closer together which results in higher density. In the other words, there is an almost linear relationship between the physical compaction density and compaction pressure [7].

However, it should be noted that increasing the compaction pressure leads to greater wear of equipment and forming tools and reduces productivity. In addition, there is a certain limit on increasing pressure, after which the density of dispersed systems consisting of particles of an approximately equal size increases no longer. This circumstance is caused by the fact that, according to the theory of dense packing, even the tightest packing still contains a volume of voids equal approximately to 25 %.

At the same time, it is obvious that the use of particles of different sizes leads to the formation of a more dense structure: larger particles play the role of a "framework" of the compact, smaller ones fill the gaps between large particles.

It was suggested that the partial introduction of the iron ore concentrate (IOC) into the charge during FDD briquetting will contribute to the formation of a more dense structure (in the context of porosity); in addition, the iron ore concentrate itself has a fairly high physical density, which will also contribute to a higher density of the finished briquette. To test this assumption, the following experiments were carried out.

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Table 1 **Chemical composition of the main components of the charge**

Component	Si/SiO_2*	Fe	C	S	P/P_2O_5	Al/Al_2O_3	Mn/MnO	Cr	Zn
FDD	71,5	26,7	0,06	0,002	0,042	1,104	0,251	0,05	-
OPC	26,53	65,16	-	0,004	0,065	4,3	2,285	1,56	0,096

*Note: the lower index in all the columns belongs to the IOC

Table 2 **Fractional composition of the components**

Particle size	≤ 0,05 mm	0,05-0,2 mm	0,2-1,0 mm	1,0-3,0 mm	≥3,0 mm
FDD	12 %	14 %	52 %	12 %	10 %
IOC	53,4 %	29,6 %	7,5 %	4,2 %	5,3 %

EXPERIMENTAL

The component of the charge was FDD produced by ferrosilicon grade FS70, the iron ore concentrate from the Sayak deposit 1 (Kazakhstan), liquid glass and water. The chemical and fractional compositions of the main components of the charge are given in Tables 1 and 2.

The components of the charge in a given ratio (Table 3) were mixed in a mixer within 15 minutes until a homogeneous mass was achieved. Water and liquid glass in the amount of 10 % of each component were added above 100 %. After release, the mixture was treated with a water repellent. An aqueous solution of carbon dioxide was used as a water repellent. Then, using a press, samples with the diameter of 35 mm and the height of 10 mm were prepared using the prepared mixture; the compaction pressure was constant and amounted to 50 kN.

Table 3 **Composition of the charge for the production of experimental briquettes**

Sample No.	FDD amount/ %	IOC amount/%	Water/%	Liquid glass/%
1	100	-	10	10
2	97	3	10	10
3	95	5	10	10
4	93	7	10	10
5	90	10	10	10

Raw briquettes were dried at temperature of 40 ^{0}C within 2 hours. At the end of the drying process, the finished briquettes were tested for compressive strength and the density of the briquettes was determined.

Compressive strength was determined using an Instron machine. The density was determined by the pycnometric method [8].

Table 4 shows the chemical composition of the experimental briquettes and the composition of FS70 according to SS 1415-93.

It is seen from the data in Table 4 that all the test samples, with the exception of sample 5, correspond to the composition of FS70 in terms of the main elements content. However, in sample 4 the sulfur content is higher than in the SS and is 0,04 and 0,02, respectively. In principle, such briquettes can be used for steel deoxidation, because briquettes usually only partially replace standard ferroalloys in the charge for deoxidation. However, the fact of increased sulfur content must be taken into account when calculating the introduced deoxidizer or alloy.

The density and compressive strength were also determined on the experimental briquettes; the results of analysis are given in Table 5. The results were compared both with the briquette obtained without the addition of the IOC and with a conditioned ferroalloy.

Based on the data in Tables 4 and 5, a diagram was constructed (Figure 1) that illustrated the relationship between the IOC content in the charge, strength, density and sulfur content. For convenience, all the data are given to the same scale, i.e. the density value is presented as x*10; the sulfur content is presented as x*1000. This presentation of the data does not change the relationship between the corresponding parameters and allows presenting all the data on one diagram on the same scale.

Figure 1 shows that the use of liquid crystals as part of the charge for briquetting ferroalloy production waste has a positive effect on the strength and density of the briquette. However, the use of the IOC over 10 % leads to an increased sulfur content in the finished briquette, which is undesirable.

Increasing the briquette density when using the IOC can be explained by filling the gaps between the FDD

Table 4 **Chemical composition of experimental briquettes**

Grade	Si	Fe	C	S	P	Al	Mn	Cr
FS 70	68,0-74,0	26-28	0,1	0,02	0,04	2	0,4	0,4
1	71, 15	26,1	0.12	0,023	0,035	1,87	0,35	0,35
2	69,99	26,8	0.12	0,024	0,38	1,92	0,39	0,37
3	69,99	27,05	0,15	0,028	0,04	1,99	0,39	0,37
4	68,8	28,1	0,15	0,03	0,04	2,03	0,42	0,42
5	67,4	29,35	0,16	0,045	0,045	2,07	0,51	0,42

Table 5 **The results of analysis**

Sample	Compressive strength/MPa	Density/g/cm^3
FS70	35 [9]	5,0 [10]
1	27	3,4
2	27,5	3,9
3	32,6	4,6
4	34,2	4,8
5	39,1	4,9

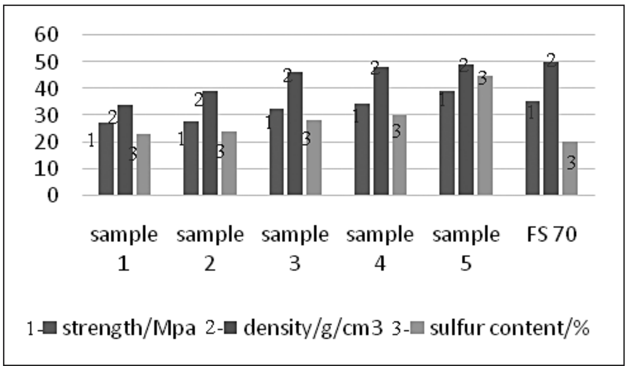

Figure 1 Relationship between strength, density, sulfur content in experimental briquettes and the IOC content in the charge

particles, because the IOC has a higher dispersion than FDD. However, there can be another option, when the IOC with a lower dispersion (for example, an agglomeration concentrate) will play the role of a "framework". The use of iron ore concentrate as a component of the charge for FDD briquetting helps achieving two goals: increasing the density of the briquette and preserving the chemical composition, because any iron ore concentrate necessarily contains iron in sufficient quantities and silicon in the waste rock.

The use of liquid crystals when briquetting dust of the other ferroalloys production (for example, ferromanganese) requires additional studies, because the introduction of liquid crystals into the composition of the charge when briquetting dust, for example, the IOC, can lead to significant changing the composition of the briquette and does not comply with the SS for this ferroalloy.

CONCLUSION

Thus, the studies carried out show the possibility of using the iron ore concentrate as a component of the charge when briquetting finely dispersed dust generated during the production of ferrosilicon. The use of 5-7 % by weight of the iron ore concentrate with the iron and silicon content of about 65 % and 26 %, respectively, leads to increasing strength and density of the briquette by an average of 20 %. Improving such briquette characteristics as strength and density ensures better safety of the product during transportation, i.e. increasing its usability, and provides better conditions for deoxidation and alloying, which ultimately leads to increasing the quality of steel.

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Note: Responsible for the English language is Natalya Drak, Karaganda, Kazakhstan