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Influence of Addition of Briquettes with Dust Content into the Charge of Electric Induction Furnace on Cast Iron Quality

A. Pribulová [a]*, P. Futáš [a], D. Baricová[a]

[a] Department of Iron Metallurgy and Foundry, Faculty of Metallurgy, Technical university in Košice, Park Komenského 14, 040 01 Košice, Slovakia

*Corresponding author. E-mail address: alena.pribulova@tuke.sk

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Abstract

Foundry dust from blasting and grinding of castings contain a high amount of iron, ergo it is possible its recycling in foundry process. Dust was compacted by briquetting, two kinds of briquettes were prepared (A contained 95% magnetic part of dust from casting blasting +5% bentonite and B contained 95% mixture of dust from casting grinding and magnetic part of dust from casting blasting + 5% bentonite) and used as a part of charge into the electric induction furnace. It was found that addition of briquettes has had an influence of a chemical composition of cast iron above all on content of sulphur, phosphorus and silicon. It was not reflected in decrease in tensile strength and in microstructure. Yield of metal from briquettes was not lower then 70%.

Keywords: Environmental protection, Mechanical properties, Foundry dust, Briquettes, Electric induction furnace

1. Introduction

The Slovak foundries pay only very small attention to treatment of foundry dust into form which is not harmful and suitable for transport and which does not impair environment but first of all it enable its next metallurgical treatment. The dust that is collected in Slovak foundries is above lead up to dump and it has very negatively influence on environment on the ground water contamination.

Technology of dust wastes treatment in metallurgical processes with blowing in to the melting aggregate is not very wide–spread in Slovakia by reason of lack of technical installations. The most of dust wastes is impossible to treated directly in metallurgical aggregates and therefore it is needs to compact this material.

There are generally two methods of foundry dust treatment (when it is going to be re-use in furnace), the first is direct pneumatic injection back into furnace and the second is its compacting and introduction into furnace in a compacted form [1-6].

There are three technologies of fine ores, concentrates and wastes compaction [7]:

- Agglomeration, technology involving the fine ore and concentrates sintering with carburant materials at a high temperature.
- Granulation, or pelletization, consisting in pellets making, basing on the ability of moisturized particles of the grind ore, concentrate and dust waste to form pellets different in size and solidity, with subsequent pelleting in special equipment until acquisition of the required size and shape, and the final roasting.
- Briquetting, technology of lumps (briquettes) manufacturing with or without addition of binding agents, with subsequent mixture pressing into briquettes with given shape and size.

A number of materials can be converted into product of adequate strength without having to add a binding agent. Such materials include burnt lime, salts, sponge iron and magnesite.

Bonding in this case is achieved as a result of quite different phenomenally [8]:

- Van-der-Waals force,
- mechanical linkage,
- forging,
- plasticization under pressure.

According to [8] binders are categorized into seven groups:

- thermoplastic binders (e.g. pitch, bitumen, plastics, waxes, resins,
- mortar binders (e.g. lime mortar (set with or without CO_2), gypsum, cement
- glucouidic binders with water (e.g. starch, molasses, lingo-sulfonate),
- non – glucoidic organic solutions (e.g. bakelite, polymers),
- inorganic solutions (e.g. water glass, phosphoric acid,
- clayey binders (e.g. bentonite),
- fibrous binders (e.g. cellulose, fibers, paper).

Briquetting of fine materials with addition of binding agents is the most easy way to involve valuable fuel, ore and mineral raw material components into recycling. It also concerns a number of industrial wastes, the aggregate physical condition of which does not allow their direct recycling using engineering procedures and conventional equipment.

The main distinctive feature of briquetting technology is the possible of briquettes manufacturing out of charge mixtures, effective for use in basic types of metal working installations. Cold briquetting is the most economically profitable and environmentally friendly technology.

As the briquettes chemical composition and dimensions are determined prior to their fabrication, the important measure of quality of briquettes and of the whole manufacturing process is their mechanical strength.

Different methods are used to evaluate drop impact resistance, consisting briquettes drop onto a metal plate from 1.5 to 2 meters of height and estimation of formed breakage (size smaller than 5, 10, or 25 mm, depending on the briquettes sizes). Large briquettes (max .size about 100 mm) are dropped only 1 or 2 times and small briquettes (from 25 to 30 mm) are dropped 4 or 5 times, at least. But in all cases briquettes are considered to meet the drop resistance requirements if breakage amount does not exceed from 5 to 10 percentage (in some cases, even 15%). This means that large briquettes are not subject to multiple overloads and the process flowchart must comply with this requirement [7].

Main goal of the contribution was determine influence of briquettes addition, which were made from foundry dust, into the electric induction furnace on a cast iron quality .

2. Description of experiments

2.1. Materials used by experiments

Two kind of foundry dust were used by experiments. Both of them contained quite high content of iron. The first was a dust from castings blasting and the second was a dust from castings grinding. They originated by production of cast iron castings that were poured into the moulds with bentonite as a binder. Chemical composition both of dusts is given in Table 1.

Table 1.
Chemical composition of foundry dusts used by experiment

Dust	Fe, %	FeO, %	Fe_{metal}, %	Fe_2O_3, %	Si, %	C,%	Mn,%	P,%	S,%
Dust from castings grinding	83.78	2.16	80.42	2.40	6.97	3.07	0.34	0.13	0.101
Dust from castings blasting	58.64	21.27	39.32	-	SiO_2 24.71	5.67	0.37	0.09	0.155
Magnetic part of dust from castings blasting	74.34	26.58	49.37	-	5.15	3.31	0.36	0.06	0.156

The dust from castings grinding was taken from a dry dedusting. It was exhausted and collected with help of filters from final operations. It contained above all very fine-grained particles. More then 42% of all particles had a grain size lower then 0.063 mm. In this kind of dust were found metal particles from the grinded casting and a rest of SiO_2 from the sand mixture.

The dust from castings blasting originated from dry dedusting , it was exhausted, collected and them put into palettes. It contained the rest of metal from castings, blasting grit and particles of sand mixture. The dust was divided by using of magnetic separation on magnetic and non-magnetic part. 76% of magnetic part and 24% of non-magnetic part were obtained after magnetic separation. Table 1 shows the chemical composition of magnetic part of the dust, which contained 75% of iron and 50% was metal iron.

The magnetic part of dust from castings blasting was a main material that was used for briquettes preparation. Water glass and bentonite were used as binders in a different ratio.

One kind of briquettes was made from mixture of boths mentioned kinds of dust with addition of bentonite.

The best results (the best compression strength and the best drop impact resistance) were achieved by briquettes with 5% of bentonite. A compression strength of briquettes made from magnetic part of the dust with 5% of bentonite was 1.83 MPa and for briquettes from mixture of both dusts with 5% of bentonite it was 2 MPa. Both of kinds of briquettes had a very good impact resistance (decrease of weight after 3rd drop was 1.9 %).

Requirements of foundries are that the briquettes which shall be used as a part of charge into the electric induction furnace have to have a minimum of additives which could increase the slag quantity and they have to by made without next thermal treatment.

By experiments next briquettes were used:

Briquettes A – 95% magnetic part of dust from castings blasting + 5 bentonite (water – 100 ml per 1 kg of mixture).

Briquettes B – 95% mixture of both kinds of dust + 5% bentonite (water – 100 ml per 1 kg of mixture).

Briquettes were made without next thermal treating. They were used as a part of charge into the electric induction furnace (their addition was 2, 5 and 8% of weight of the charge. The first charge into the electric induction furnace contained only from cast iron scrap and from FeSi. Next charges contained cast iron scrap, briquettes and FeSi how it shows Table 2.

After melting metal was poured into the ladle and then the sample for chemical analyse and bar for compression strength were casted.

From the bars the testing samples for examination of compression strength by standard STN 420330 were made.

Table 2.
Composition of individual charges into the electric induction furnace

No. of charge	Cast iron, kg	Briquettes, kg	FeSi, kg
0	10	0	0.08
A1	9.8	0.2	0.08
A2	9.5	0.5	0.08
A3	9.2	0.8	0.08
B1	9.8	0.2	0.08
B2	9.5	0.5	0.08
B3	9.2	0.8	0.08

Table 3.
Chemical composition of melts with and without briquettes and achieved tensile strengths

No. of melt	C, %	Si, %	Mn, %	P,%	S, %	Cr, %	R_m, MPa
0	3.03	2.03	0.43	0.12	0.047	0.20	250
A1	3.05	2.42	0.36	0.16	0.054	0.19	241.5
A2	2.99	2.22	0.31	0.19	0.061	0.18	294
A3	3.01	2.26	0.33	0.18	0.063	0.18	332.5
B1	3.02	2.26	0.30	0.22	0.059	0.18	274.5
B2	3.01	2.15	0.30	0.21	0.064	0.18	286
B3	3.03	2.24	0.36	0.16	0.060	0.17	307

3. Description of achieved results

Tab.3 shows the chemical composition of melts without briquettes and with briquettes in the charge and achieved compression strengths. Weight of metal and slag and yield of metal from briquettes are given in Table 4.

Carbon content in the sample without briquettes was 3.03%. The content of carbon in another samples was in the range 2.99 – 3.03%. Content of manganese without briquettes was 0.43% and in all samples with briquettes it was in interval 0.3 – 0.36%. It is lower than in melt without briquettes. It could be caused the lower manganese content in both kinds of dusts. Coin content of silicon, phosphorus and sulphur in melt without briquettes was lower than in melts by using of briquettes. Expressively rise in content of silicon and sulphur is caused higher silicon and sulphur content in the dust (specially the sulphur content in dusts was 0.101% and 0.156%. Content of phosphorus was higher in all melts with briquettes and even though content of phosphorus in dust was lower.

Tensile strength of sample 0 (without briquettes) was 250 MPa . Only sample A1 had lower tensile strength , in all another samples it was higher and results of tensile strength show that higher content of briquettes in the charge accorded to higher compression strength.

From Table 4 results that quantity of slag rises in proportion to quantity of briquettes in the charge. Metal yield from briquettes in all melts was more then 70%.

Table 4
Quantity of slag and metal and yield of metal from briquettes from individual melts.

No. of melt	Weight of slag, kg	Weight of metal, kg	Yield of metal from briquettes, %
0	0.1	9.90	-
A1	0.125	9.81	54
A2	0,230	9.76	71
A3	0,285	9.71	74.25
B1	0,105	9.85	74
B2	0.165	9.83	85
B3	0.285	9.71	75.15

4. Conclusions

Foundry dust from castings blasting and castings grinding contain high amount of iron and their recycling in the foundry can reduce the costs in foundry. These kinds of dusts can be recycled in melting furnaces. Two options of re-using the dust into the furnace are possible: direct pneumatic injection back into furnace or compacting of dust (by briquetting for example) and introduction of briquettes into furnace.

This article deals with possibilities of re-use of mentioned foundry dusts in the form of briquettes into the charge of electric induction furnace.

Two kinds of briquettes were used as a part of charge: briquettes consisted of magnetic part of dust from castings blasting with 5% bentonite and briquettes from mixture of dust from castings grinding and already mentioned dust from blasting.

From experiments follow the next results:

- Addition of briquettes didn´t influence carbon and chromium content in metal but reduced content of manganese. Silicon content was higher in the melts with briquettes because the dusts contained higher amount of SiO_2.
- Briquettes had a very significant influence on sulphur. Their use in the charge increased the percentage of sulphur in some cases about 40%.
- Content of phosphorus was problematically too, it was higher in samples with briquettes but its content in dusts was lower or only slightly higher then in melt without briquettes.
- Addition of briquettes didn´t have any negatively influence on tensile strength, the values of this mechanical property were higher in samples with briquettes addition.
- Yield of metal from briquettes was higher then 70%.

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