TECHNICAL EVALUATION OF RECYCLING POWDER FROM EAF [1]

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Abstract
This contribution shows the development of a waste removed from the dusting system of an EAF, aiming for its reincorporating in the industrial process by briquettes as energy source, beyond giving an environment improvement. The methodology was based on two groups of experiments and analysis. Being one part for experimental agglomeration, preliminary development, and finally, the part of the heats carried through in the company for analysis of the process efficiency. According to the positive results, it was concluded that exists the real possibility of making the briquetting using the developed method, that the quality of the briquette under the physical point of view takes care of the company demand and that its effect in the FEA also does not present problems about the chemistry of the steel, improving the draining of the slag.
Key words: Reutilization; Dusting; Briquettes; Slag.

1 *Technical contribution to the 7th Japan-Brazil Symposium on Dust Processin-Energy-Environment in Metallurgical Industries and 1st International Seminar on Self-reducing and Cold Bold Agglomeration, September 8-10 2008, São Paulo City – São Paulo State – Brazil*
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1 INTRODUCTION

Along the years, the mentality on the aspects of technological and industrial development suffered a significant change. Concepts of the past had been replaced by new theories, these much more worried about the socio-environment aspects. Several were the factors that had contributed for this new paradigm, among them the great negative influence that some technological and industrial sectors had generated to the environment, as the particles concentration increase in the atmosphere, generation of wastes and inadequate destination for them. In this new search for the development, ally to the concern with the environment, it was born what was known as the sustainable development, that is, to produce and to generate profits, searching new technological methods, however having as partnership the new searches for not the negative influence on the ambient factors. In the current world, this became obligator in the negotiation time, because companies with an adequate ambient management, having its products certified as ambiently correct, possess priorities in the commercialization. Among some companies who had released in the front in this requirement, being the sponsor company of this project one of them, because such company possess an enormous concern with the environment causes, and saw in the wastes reutilization of its industrial process, a form to minimize expenses, to minimize environment damages and still to be able to eventually reduce part of the specific consumption of raw material.

2 OBJECTIVES

2.1 General Objective

Demonstrating through practical, that an environment management made by correct form, brings benefits for the companies and
Obtaining a sustainable development, for a waste generated into the EAF Verification of the possibility of agglomerating the material, aiming at its recycling and reincorporation in the industrial process.

2.2 Specific Objectives

- Reutilizing the residues generated in the industrial process in one of the plants of the company;
- Agglomerating the generated wastes;
- Producing briquettes with compatible mechanics resistance;
- Providing subsidies the correct management of industrial residues;
- Getting satisfactory results in the introduction of briquettes as additive in the arc electric furnace;
- Reducing expenses of the company, in view of the advantage of reutilizing the residues and doesn’t deposit them in sanitary landfills;
- Minimizing the environment damages, caused for the generation of these residues;

3 BACKGROUND

Having the company an innovative vision about environment management, intending to recycle its residues, the company presented to the professors of UFOP and PUC-Minas, a challenge of using of wastes generated in one of its plants. Table 1 shows the wastes and respective amount, beyond the amount and their final destination presented by the company.

Table 1 - Residues with their castes, their monthly amount and their final destination

Residue / Classification	Amount (t/month)	Destination
Filter / I	6	Recycling in FEA
Used in the Cement Industry/IIA	350	Use in the cement plants
Socket Filter Dust / IIA	250	Deposition in landfills

The generation of these residues meant a monthly reimbursement for the company in the order of R$373.200, 00. That is, an annual expense of more than R$4.000.000, 00, also generating problems about the environment. The cost of the first one is approximately R$7000,00, the second's is R$ 26 for ton (R$16 of transport to deposit it in a sanitary landfill, and R$10, symbolic cost; and the cost of the third disposal is of the order R$60 for ton).

4 METHODOLOGY

In the preliminary development, some samples of briquettes from the removed dust from the EAF process had been made, there were carried in a company located in the city of Timóteo-MG, that works in association with UFOP. A press was used to verify the possibility to agglomerate the material without any bond. The material I was agglomerated with 40% of material II (that contains bentonite). The material III was agglomerated with bigger difficulty. It is estimated that the force adopted in the empirical process was about 3000kgf. An estimated pressure of 120kgf for cm^2. After the production of briquettes, these ones in the initial phase had been carried in a steel plant with a capacity of 10 tons, to verify their dilution in high temperatures. These samples were charged into a ladle just after a 10t EAF from Semeato, in Vespasiano. It was observed that the material was diluted in less than 5 minutes in the bath. Figure 1 shows the material that was manufactured in Timóteo's company, and the bath carried through in Semeato.

After the first trials, two matrices were developed and the used machine could apply a force of up to 20000kgf. In order to increase the compression pressure, a diameter of the order of 12mm was used, being able to reach pressures of up to 1000 kgf/cm^2. In the samples based on laboratory controlled conditions, a matrix for the beginning of the samples was developed. They had been used about 50kg of material (dust) gathered in the company during the month of March/2007. Figure 2 shows a sight of the first developed matrix and what happened with it after the first samples of briquettes produced.

Figure 1 – Material used in Semeato's steel pan (on right)


Figure 2 - Sight of the first developed matrix (deformation suffered after the first produced samples)

Figure 3 shows the detail of the pressure in the matrix, some instants before the pressure in the material.


Figure 3 - Detail of the system to pressurize the matrix to produce the briquette.

The material was initially weighed, mixed with a pre-selected bond and then it followed for the machine, where the briquette was produced. Figure 4 illustrates the dust handling.

Figure 4 - Dust handling, with mixing and weighting (it is seen on the side some briquettes produced in this phase)

The material was weighted and then it was constituted in three bodies of test, that later were submitted to the pressure in the traction machine. Figures 5 to 7 show the weighting and the ready small pots to feed the matrix and its feeding.

Figure 5 – Materials weighting

Figure 7 illustrates the matrix in the machine and a detail of the force controlled during a test. Then figure 8 illustrates the product of a sample. Due to not very favorable results (see in results), it had to occur certain changes, that is, new experiments would have to be made. The new material was produced from August until middle of November/ 2007, using two presses of PUC-Minas, in Belo Horizonte. The first one, that is usual for traction samples, and the another one, for pressing of mechanical tests. They had been used about 110kg of dust removed from the EAF system during this period. The figure 9 identifies the development of the briquette manufacture.

Figure 6 - Detail of the small pots containing the ready materials to be submitted to the compression test (weight % is how much of bonding agent was added into the powder)

Figure 7 - Detail of the ready matrix to be pressured and the control and register of the adopted load system

Figure 8 - Produced briquette

Figure 9 - Photo of the produced briquettes using PUC-Minas' presses

In this phase two parameters had been modified:
1) Type and amount of the bond, because the previous tests had shown a very weak physical quality of mechanical strength. So, it was opted to use inorganic bond cement with about 12% in the mixture. As the linking is hydraulical, then it was added about 10% of water to obtain a compatible strength. The produced briquette was placed in a humid chamber, to have its drying in controlled conditions. About 8 to 10 days had been to obtain an adequate resistance. The mixture conditions was: 190 of water, 150 of cement, 1350 of dust (12.7% dust).
2) Amount of dust to be briquetting. To increase the productivity, new matrices had been developed in order to increase the briquette weight, that became being of 100g each. That means more than three times the first trials. This was made in such a way to reduce the number of units for the samples to be used in the hot experiments in the company. It was foreseen the production of about 1000 briquettes for the industrial trials. The materials had been taken in bags of approximately 4kg, being that 3 heats had been made in EAF. The following data had been collected in the company: EAF possess maximum capacity of 6 tons. It usually produces 4,5 tons per heat. So, 14 heats per day. It produces special steel for manufacture of balls to be used in ball mills. The collected dust relates about the generation in 1 EAF + 2 Induction Furnaces (these with capacity of 6 t per h).
The addition was made in three sequential heats. The addition form is shown in the Figure 10.

Figure 10 – Addition way in EAF.

Heat 296 B
Addition on the load, about 20kg
Heat 297 B
Addition under the load, before power on the EAF, about 40kg
Heat 298 B
Addition under the load, 40kg.
Basically it was observed the resistance of briquette, so as the steel quality produced under the chemical point of view.

5 RESULTS

In the experimental agglomeration process (part I), it was gotten briquettes that had not been satisfactory, what characterized that the geometry of the test body should be modified for new assays, using one traction machine that could be monitored. The photos below of Figure 11 show the materials that had been agglomerated in this initial phase (Left: Waste I, Center: Waste II. Right: Waste III)

Figure 11 - Sight of the filter dust (Waste I) agglomerated in experimental phase

Still in the experimental phase, it is shown results below, contending the used load and the Figure 12, with a series of produced briquettes.
The data below mention the results of the preliminary development.

Body of Test	Preliminary Results	
% Mo (starch maize)	d (g/cm^3)	Load (t)
3	2,32	7
5	2,35	7
8	2,33	7/9/10
12	2,32	10

Test: April/2007

Figure 12 - Results and conditions of the samples and products gotten for a determined bond percentage

All the briquettes produced in this experimental phase were sent to the company at the end of the month of April for test directly in the EAF.
The results of the first phase (experimental phase) indicated the need to continue the research, using inorganic bond, then better mechanical resistance was obtained. The mechanical resistance of briquettes produced without bonds was extremely low, hindering its use in EAF or in the Induction Furnace.

After the accomplishment of right corrections in the parameters previously spoken in the methodology, better results were obtained. These obtained results from the second part of the project, that is related to the heats in the company (part II). The heats happened normally, being that in the first heat, there was not slag emptying (new covering). From the second heat, there was slag emptying, being that, according to the turn operator, there was improvement of the slag drainage (little effort to remove mechanically from the furnace). The Table 2 presents some data originated in the company.

Table 2 - Referring data to the heats with the company dust briquettes

Heat	Chemical Analysis (C, Cr)		Heat Temperature (^{0}C)	Tap-to-tap Time (min)	Briquette Amount (kg)	Specific Amount (kg/t Steel)
296 B	2,41	18,83	1653	105	20	4,4
297 B	2,48	17,30	1642	115	40	8,9
298 B	2,43	17,91	1654	110	40	8,9

It must be observed that the briquette presented enough resistance for not crumble when loaded in the FEA. In some carried tests, the briquettes had resisted to fall of about 1m, breaking itself in lesser pieces, however without generating fine materials. The samples had demonstrated the real possibility of making the briquetting using the developed method.

The quality of the briquette under the physical point of view took care of the company demand. Its effect in FEA also did not present problems about the steel chemistry, improving the slag drainage.

6 DISCUSSIONS

With all the raised bibliographical revision and the developed experiments, we can obtain the following considerations about the project:

1. producing the briquette with the maximum of 7% humidity. It is suggested a drying of it, with duration of about 5 to 7 days (cure).
2. bagging the briquette in bags of paper (10kg), airly-tight closed and with good resistance to small falls.
3. using, at least, 12% of binding agent, to prevent losses in the transport and handling.
4. preventing to bag the briquette with less than 5 days of cure (preventing humidity in the paper bags).
5. it is possible the agglomeration of the drained dust from the industrial process, in EAF;
6. the briquette presents good mechanical resistance (50kgf) and a density average of 1.255 g/dm^3;
7. It is recommended a single load of 30kg of briquette for heat (max 50 kg), that means ca. of 10 kg / t Steel;
8. It is expected a reduction in the pellets amount charged due to the fact that the briquette contains Fe in it.
9. increase of the Cr and Mn percentage in the steel; the briquette had a certain amount of Cr and Mn.
10. reduction in the silicon on the steel (this is the biggest advantage because it is possible to reduce the load of pellets).

An important example is that, for a load of 5 ton, for a 0,4% silicon reduction, should be loaded about 200kg of pellet. This means that it is possible to reduce the consumption of pellets of 40kg/t steel. This will generate an additional profit of 8 USD for ton of Steel. The addition of 50kg of dust for ton of steel implies in a cost of 12USD. Therefore, considering the previous profit, the value of the briquette would be in the direction to increase in 4 USD for t /steel. What it would imply in environment and social profits, that is, an efficient process and in accordance with the concept of Sustainable Development, based in development, but with responsibility.

7 CONCLUSIONS

Therefore, this study demonstrates by practical form:
- that the residues reutilization is good not only for the industry, as well as for all the society,
- it will culminate in a lesser number of waste deposited in landfills, thus diminishing the threaten to the environment.
- it was proved that this procedure of briquettes production of materials derived from the dusting system, is efficient as fuel to heat FEA'S and to minimize socio-environment damages.
- It was added till 10 kg of briquette/t Steel without any remarkable change in the Steel quality.
- It is expected a decrease on Si content of Steel, then permitting a reduction on the Iron Oxide charge of EAF.

Acknowledgments

The authors are thankful to Escola de Minas-UFOP, REDEMAT, PUC-MG, to Semeato, Solvi, to the company for the work support and financial. They extend gratefulness to CNPq, that assists in the research projects of the professor Paulo Assis, as well as they thanks FAPEMIG for the support to the students and the professor for financing the participation in the event.

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