EVALUATION OF THE MIXTURE OF MINERAL COAL AND TIRES FOR ITS INJECTION INTO THE BLAST FURNACE TUYERES[1]

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Abstract

This technical paper shows data of a project that is going to evaluate the results of combustion obtained when mixturing mineral coal and carcass of tires, both mixed in different proportions, in a way to identify which mixture of those materials will provide a better index of combustion, permitting an analyses of economic viability of the application of the methodology in blast furnaces. For the determination of the indices of combustion it's used an equipment developed in Escola de Minas-UFOP, which is similar to what occurs in the zone of combustion of the blast furnaces. The results indicated that a mixture of coal and tires can improve the combustion rate, this way the powder coal injection rate can be raised into the blast furnace.

Key words: Mineral coal; Tire; Injection; Blast furnace.

AVALIAÇÃO DO USO DE MISTURAS DE CARVÃO MINERAL E PNEUS PARA A SUA INJEÇÃO NAS VENTANEIRAS DE ALTOS-FORNOS

Resumo

A presente CT mostra dados de um projeto que visa avaliar os resultados de combustão obtidos quando se mistura carvão mineral e carcaça de pneus, ambos pulverizados, em diferentes proporções, de modo a se identificar qual mistura desses materiais proporcionará um melhor índice de combustão, e dessa forma seja analisada a viabilidade econômica da aplicação da metodologia em altos fornos. Para a determinação dos índices de combustão utiliza se um equipamento desenvolvido na Escola de Minas-UFOP, e que possui similaridade com o que ocorre na zona de combustão dos altos-fornos. Os resultados indicaram que a mistura de carvão mineral com pneus pode ser benéfica para a combustão, podendo inclusive possibilitar aumento da taxa de injeção praticada.

Palavras-chave: Carvão mineral; Pneu; Injeção; Alto-forno.

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1-INTRODUCTION

The injection of pulverized coal (usually called PCI) provides the reduction of the amount of grained reducer added by the top of the blast furnace and the use of coal and minerals of inferior quality, resulting in reduction of expenses in the steelmaking process and, furthermore, reduces the environmental impact and gives use to the thin generated. The not cokeable coal, generally used in the injection may have levels of ash up to 18%, that is, coal of low cost and wide availability. It should be noticed that the occurrence of not cokeable coal in the world is estimated in more than 70%.(1)

In the coke blast furnaces, the reduction of reducers loaded by the top it’s going to result in an increase of the life of coke plants because it requires a lower production. Besides, it is possible to inject fines that are collected by the dust removal equipment minimizing the amount of reject deposited in landfills.

The PCI is very interesting in terms of the thermal control of the blast furnace since it serves as a zone of thermal reserve more efficient than the dead man, because its modification will have immediate response, while the other can take over six hours. Reducing the quantity of fuel loaded from the top, implies a higher period of residence of ironcharge, reducing the reduction process in the shaft and thus reducing even more the fuel consumption. Another important factor is the increase of the levels of hydrogen obtained with the PCI, increase of reduction without consumption of carbon, higher availability of fuels (increase in the levels of hydrogen) are factors that provide an increase in the productivity of blast furnaces and a reduction of fuel rate.[2]

The main limiting factor of the quantity of coal being injected is the guarantee of total combustion in the bottom area of the blast furnace. From a certain rate of injection it is difficult to burn completely the material in the zone of combustion of the blast furnace, even making the enrichment of the air with oxygen, therefore, many studies are being done to achieve this goal.[2]

The carcasses of tires currently causes a major environmental problem, because they take a long time to be decomposed, in addition to releasing toxic substances in the environment. And as the consumption of tires has been increasing we need to give a utility to its residues.

According to ANIPI in Brazil (National Association of the Industries of Tires), in 2002, 42.3 million tires were produced in Brazil and it is estimated that approximately 30 million would be discarded in that year. In the world, it was about 2 billion tires, and only 20% of that amount would be recycled.

The resolution 258 from CONAMA (National Environment Council) ordered that both the manufacturing industry as those that use the tires to recycle in the year 2002 25% of production, 2003 50%, 100% in 2004 and from 2005 on the amount recycled should exceed that produced. The regulations apply to new tires of all kinds, from bicycles to the aircraft, manufactured in the country or imported. For the importers, it’s an obligation to prove the final destination of the products before they enter in Brazil.[3]

Through some experiments we were able to verify that the tire has a good combustibility, this feature is attracting the interest of ironmakers to use it as a source of fuel in blast furnaces, making it important to study the rate of combustion obtained when injected either pure pulverized tire or it mixed to other coals, also pulverized.[3]

This work has as main objective to determine an appropriate proportion of the mixture between tire and pulverized coal to be injected into blast furnaces in order to reduce costs in the steelmaking process, using lower-cost raw materials. Vary the sources of energy used in the reduction process, giving usefulness to these materials.

2 MATERIALS AND METHODS

The sample of coal used in the project was obtained from ArcelorMittal Monlevade, as well as its grain analysis, chemical and proximate, which data are presented in Tables 1, 2 and 3 below.

Table 1: Mineral Coal's Grain Analysis.

Grain Size (mm)	% Retained
50	0.32
40	1.38
30	4.62
25	3.05
10	10.22
5	8.18
3	10.59
1	23.43
0,5	14.61
<0,5	23.6
Average Size	6.68

Table 2: Mineral Coal's Proximate Analysis.

Parameter	Content (%)
Fixed Carbon	71.65
Volatile Material	12.19
Ash	7.63
Moisture	8.53

Table 3: Mineral Coal's Elemental Chemical Analysis

Component	Content (%)
Carbon	90.3
Hydrogen	4.11
Nitrogen	1.68
Sulfur	0.38
Oxigen	3.53

The mixture of coal and pulverized tire is burned in a lot of proportions to determine which one gives the best combustion rate.
The tire was prepared from a sample of about 50 kg from a company of asphalt located nearby Belo Horizonte, which has already added the material into asphalt. This technique has been applied in some Brazilian roads, mainly in the South. This material was taken to UFSCar and comminuted using a grinder to allow granulometry under 150 µm. These grinding experiments were already reported in paper presented at an international seminar in the U.S. [3]. The tire used was one of aliquots taken from this grinding, with 100% <100 # and 60% <200 #. The elemental analysis of this aliquot had showed 83% of carbon, 7% of ash and 6% of hydrogen.

Table 4 shows the proportions of reducer that were analyzed in the experiment:

Table 4: Proportion of analyzed mixtures.

% Pulverized Coal	% Pulverized tire
100	0
80	20
60	40
40	60
20	80
0	100

The methodology used starts with the identification of samples (proximate chemical analysis, chemical elementary, Grain size analysis) which are weighed on analytical balance to compose samples of varying quantities (50mg, 80mg, 140mg), simulating injection rates of 50, 80 and 140 kg / ton of hot metal simultaneously and, with the help of spatulas, put in a glass container with no moisture and then brought to the simulator where the burning happens. The PCI simulator can be seen in Figure 1.
The simulator has a pre-heating furnace for heat supply of the oxygen used in the blast, and an electric furnace capable of operating at temperatures above 1300 ° C, characterizing the combustion zone.
As stated earlier, the gas used in the process is the pure oxygen stored in cylinders each of 13m^3, which are attached to the simulator through hoses properly designed for this purpose. Through a glass funnel the mixture is introduced in the opening called "s" that after this procedure is closed so the material is not injected. The kilns are heated previously, at temperatures around 800°C for the pre-heating furnace and over 1200° C for the combustion furnace.

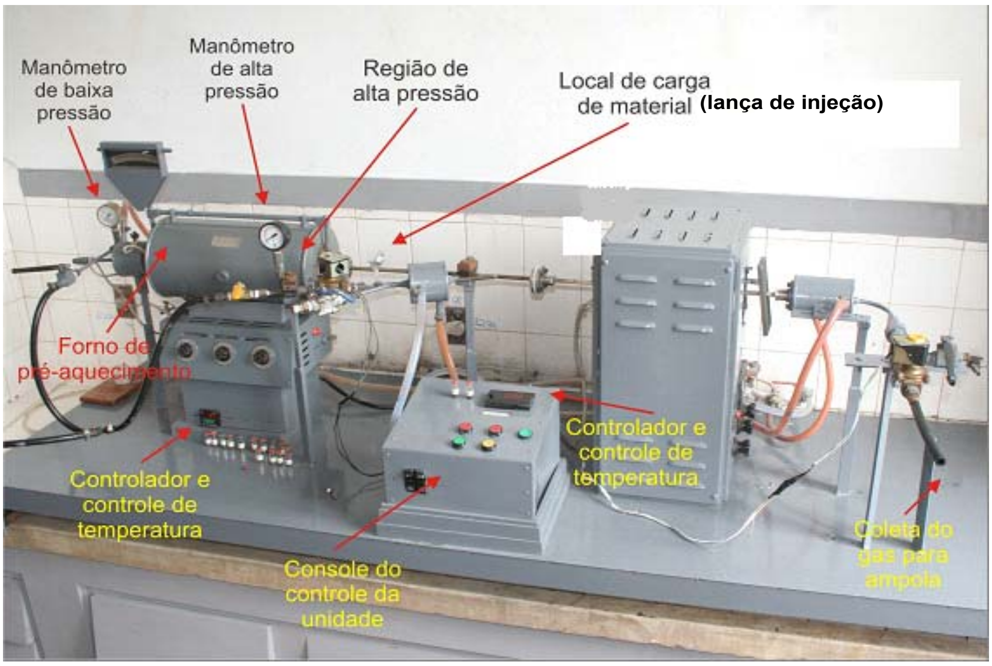

Figure 1 - Equipment used to simulate the injection of pulverized coal in blast furnace; available at the Iron and Steelmaking Laboratory at Escola de Minas [3].

Opening the valve of the cylinder, part of the gas goes to the pre-heating furnace where it is heated up to the blast temperature, similar to what occurs in the blast

furnace. The other part goes to the injection lance, to promote the drag of the pulverized material under the command of an electromagnetic valve. The material dragged enters into contact with the gas coming from the pre-heating furnace and go together to the combustion furnace where the burning of materials happens. The gases resulting from this process are collected in ampoules, and then follow for a gas analyzer which also consists of a set of ampoules, containing the appropriate solutions for analysis of each type of gas, CO, CO_2 and O_2.
The gas analyzer (ORSAT) showed in Figure 2 is a set of glass ampoules containing appropriate solutions needed for the analysis of gas. This system is interconnected by glass tubes through which the gas is forced to move thereby generating a solution separating the appropriate fractions of CO, CO_2 and O_2, the solutions used are copper chloride for CO, pirogalol for O_2 and potassium hydroxide for CO_2. Through a tube containing a saline solution and for the difference in level between it and the ampoules of solutions you can measure the percentage of each gas that composes the sample.
After analysis it is estimated the index of combustion using the formula:

$$TI = \{(\%CO + \%CO_2)*n_g/ [(m_a*\%C/1200000) – (k_1*n_g/100)]\}*100$$

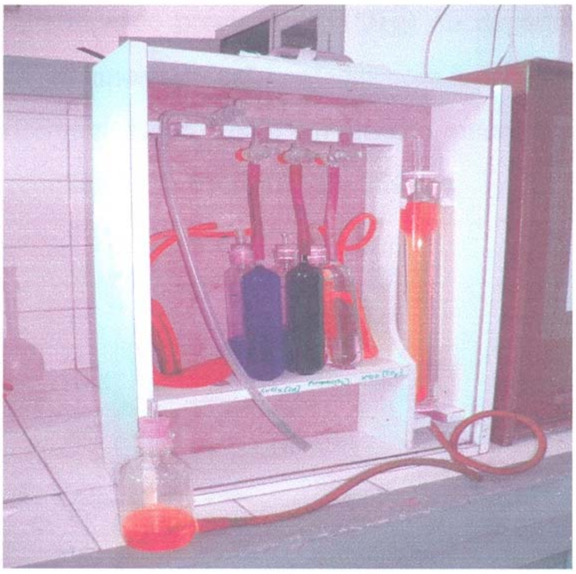

Figure 2 - Overview of gas analyzer ORSAT.[4]

observing that:
TI = combustion rate (%)
$\%CO, \%CO_2$ = percentages of the gases;
n_g = number of moles of the gas;
m_a = mass of the sample of carbon injected, in milligrams.
k_1 = constant determined for each material injected.

3 RESULTS AND DISCUSSIONS

Some tests were conducted to verify the indices of combustion obtained when mixing coal and tires pulverized. The simulations correspond to injections of 50, 80 and 140 kg / ton of pig iron.

Table 5 shows the combustion rate obtained through the mixture of coal and tire pulverized into the various proportions and rates of injection.

Table 5: Combustion rate Values

Injection rate		50 kg/ton	80 kg/ton	140 kg/ton
Mineral coal (%)	Tires (%)	Combustion rate (%)		
0	100	93,2	92,8	81,5
20	80	93,5	93,1	84,3
40	60	93,4	93,2	83,6
60	40	92,8	89,6	78,4
80	20	90,7	86,8	76,1
100	0	89	84,9	71,2

According to the results obtained, it can be verified that for the analyzed injection rates, the mixture that presents the best index of combustion correspond to 20% of mineral coal and 80% of tire. Besides, it's also verified a decrease in this index when the pulverized injection rate is raised. As shown in Figure 3. The guarantee of the injected material combustion is very important, because it influences the gas flow in the blast furnace. Additionally it is related with the pressure drop into the blast furnace.

These results may also be examined in Figure 4, which shows the combustion rate versus the injection rate and the proportions between coal and tires. In this chart it is clear the reduction of the percentage of material burned when the injection rate is 140 kg / t of pig iron and when the percentages of coal in the mixture are higher than 20%. It should be noticed that any mixture of fuels that were tested present a index of combustion higher than those obtained by only one fuel, being clearer when the rate of injection was 140 kg / t of pig iron. This can be explained by the mechanism presented and discussed by Assis.[4]

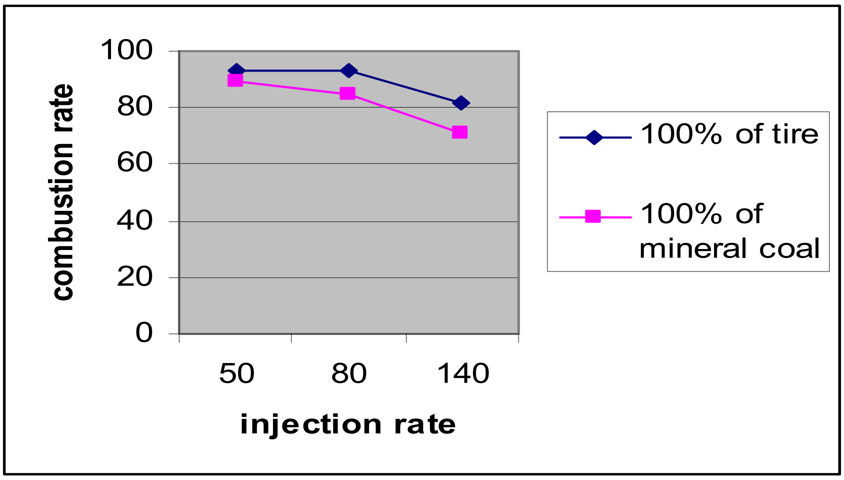

Figure 3 - Effect of the injection rate on the combustion rate of tires and coal [Injection rate; Combustion rate]

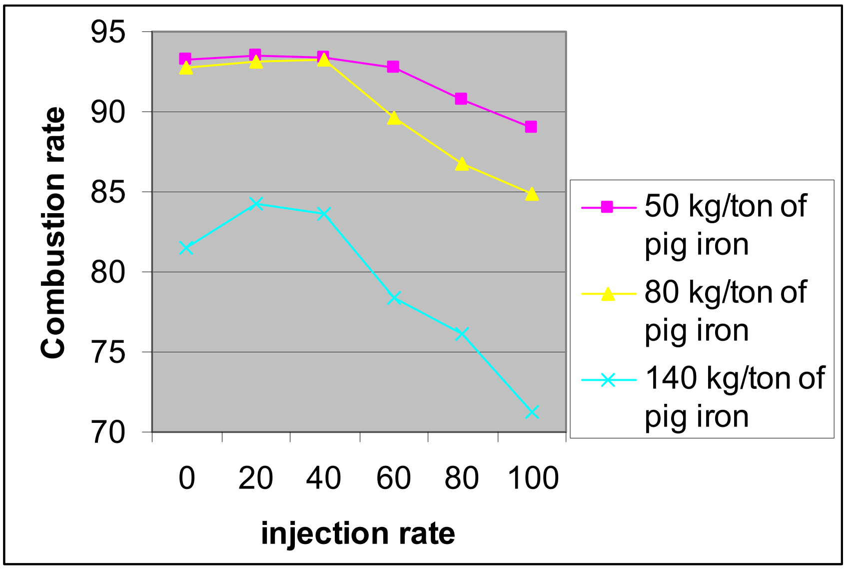

Figure 4 - Influence of the injection rate and the proportions between pulverized coal and tire on the combustion rate [combustion rate; % of coal in the simulated mixtures]

4 CONCLUSIONS

The results of laboratory equipment at Escola de Minas -UFOP suggests:
- The rate of combustion decreases with increasing rate of injection of pulverized material from 80 till140 kg / t hot metal.
- For the combustion rates between 50 and 80 kg / t hot metal, it can not be seen significant variation in the combustion rate when one has mixtures of up to 40% in the mixture of coal (coal + tires). However values for over 40% of coal, even above 50 kg / t hot metal there variations in the rate of combustion, and that these variations become larger when it reaches 100% of coal.
- The coal used always had lower rates of combustion, for higher rate of coal any injection rates, compared only with the use of tires as an agent of injection

The best results were obtained from trials where the percentages of tires are 80% mixture of coal and tires.

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