

Waste Plastic Injection as a Fuel In Blast Furnace Iron Making

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ABSTRACT

The establishment of technology for recycling waste plastics is a highly important issue for global environmental conservation and the society. Through this project pursued the effective use of waste plastics as a fuel and reducing agent injection into blast furnaces iron making, and conducted experiments to study the combustion and gasification behavior of waste plastics.

KEYWORDS: Waste plastic recycling in blast furnace, waste plastic use in blast furnace, Waste, waste plastic injection in BF

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I. INTRODUCTION

As an alternative reducing agent, plastics have been injected to blast furnaces aiming at mitigation of carbon dioxide emissions and attainment of sustainable development. Injected plastics may cause high temperature reactions gasification and combustion in lower part of blast furnace. It is well known that a part of injected plastics generates sunburnt char as a result of incomplete combustion. Unburnt char, consisting of fixed carbon and ash, are considered to be conveyed with gas flow. And then, it may be consumed completely by the direct reduction at the cohesive zone or it may be accumulated somewhere in coke packed bed.

waste plastics became clear, and research was carried out on various improvements. Moreover, in responding to recent trends of high productivity operation of the blast furnace and low reducing agent rate operation for reduction of CO₂ emissions, further improvement in waste plastics gasification efficiency is necessary.

Experiment is conducted to efficient utilization of waste plastic injection in Blast furnace and its effect on Blast furnace process and its output.

II. SELECTION OF MATERIAL

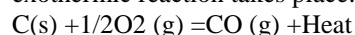
Selecting axillary fuel to blast furnace is a challenge to blast furnace operator since it required some special characteristics such as

- Carbon content in the material
- Ash content of the material
- Alkali content in the material
- Cost of the material
- Combustibility
- Environment effect on its usage

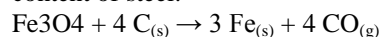
2.1 Carbon content in the material

Carbon content in the material is the key property since it's the element which acts main fuel in blast furnace process. Carbon is unstable at high temperature with presence of oxygen.

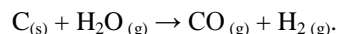
In blast furnace hot air passed through circumstance tuyler that air contact with Carbon from material exothermic reaction takes place.



At elevated temperatures carbon reacts with oxygen to form carbon oxides, and will reduce such metal oxides as iron oxide to the metal. This exothermic reaction is used in the iron and steel industry to control the carbon content of steel:



With sulfur to form carbon disulfide and with steam in the coal-gas reaction:



2.2 Ash content of the material

Material supposed to have minimum ash since it chance to react in hot metal and disturb its chemical property.

2.3 Alkali content of the material

Alkali such as K_2O , MnO , Na_2O and P_2O_5 are having high melting temperature and it may chance to form scaffolding and jam inside the blast furnace.

The material cost and material process cost to be low to achieve minimum cost of production.

2.4 Environment effect

Material should be an eco-friendly; these considerations are important but in recent years environmental factors have played an increasing role in the selection of materials and technologies. The inclusion of realistically complex environmental criteria in the design process necessitates the development of methodologies and tools to assist designers.

III. SELECTION OF WASTE PLASTICS

Waste plastics are being produced in ever increasing quantities due to the growth in the use of plastic products. The majority of this material is currently being landfilled or incinerated. Unfortunately, the synthetic polymers in the plastics do not readily degrade and leaching of toxic elements from the landfill can occur. Combustion of waste plastics can generate environmentally hazardous pollutants, such as dioxins/furans, as well as undesirable carbon dioxide. Consequently, cost effective ways of recycling the increasing amounts of generated waste plastics are required, preferably by turning them into marketable commodities.

One way of the majority of waste plastics that are injected originate from packaging and container wastes. The wastes are highly heterogeneous, consisting of different types of plastics, as well as contaminants. Chlorine content is of concern due to its corrosive effects and consequently needs to be removed from the waste plastics

IV. SEGREGATION OF WASTE PLASTIC

PET (or Poly - ethylene terephthalate) is a polyester with high resistance to rupture, rigidity, good chemical resistance to abrasions well as to impact in the oriented form, it has low friction coefficient and minimum oxygen absorption

Those features give the material special properties that make it the best and most efficient plastic for the packaging industry, among other uses. According to the Brazilian Association of PET, the plastic consumption is increasing for decades, demonstrating their extensive use in various applications. The high consumption of these materials generates a large volume of waste that is often discarded inappropriately. Recycling is an alternative disposal of solid waste that reincorporates the feedstock in the production process, reducing its environmental impact, according Rolim (2000)²¹. As proposed by Gorni (2006)¹², it is possible to use plastic waste as an energy source, assigning the value of these materials for fuel reduction processes in iron and steel industries. This solution is interesting to recycle the materials of low or no marketing value, making it feasible to replace part of the charcoal, by waste plastics.

The plastic material injection in blast furnaces is a technique already in use in German and Japanese industries with government support. In those countries the technique demonstrated viability and is seen as an alternative for dealing with waste generation. Among the three possible ways to recycle PET (energetically, chemically or mechanically) this work focuses on energetic recycling of the plastic material. The process consists in converting the heat generated when plastic is burned into energy, which powers the furnace. Assis (2008)⁴ studied the PCI (Pulverized Coal Injection). The author affirms that the main aim of the technique is to substitute part of the grained reducer material, charged in the top of the blast furnace, for a lower-cost fuel injected directly through the tuyeres. Indirectly there are other derivative benefits, like the increase of productivity, higher operational stability of the reactor, due to the efficiency of its thermal control

The material must be submitted to some processes that adjusts it to the injection into the combustion zone (or "raceway zone"). Those processes consist in milling, to adequate grain size and drying, to eliminate moisture. After that, the coal fluidized through the addition of gases (generally air or nitrogen) is pneumatically transported through the ducts, and properly distributed through the tuyeres.

V. EXPERIMENT

For trial purpose injection of plastic carried in blast furnace the details follow.

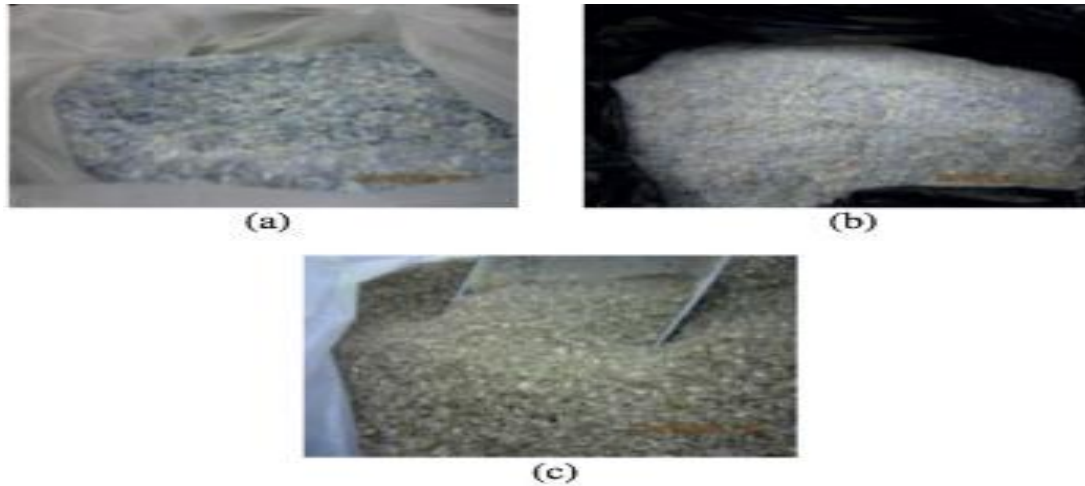


Fig-1 waste plastic granulates (a) PET, (b) polyethylene and (c) Polypropylene,

Chemical compound of injected plastic:

Polyethylene terephthalate

- Chemical formula = (C₁₀H₈O₄)_n
- C= 62.5%
- H=4.5%
- O=33.0%

Polyethylene

- Chemical formula=(C₂H₄)_n
- C=85.71
- H=14.28

Polypropylene

- Chemical formula=(C₃H₆)_n
- C=85.71
- H=14.28

Waste plastic physical parameter

Waste plastic size 0-7 mm
 Mean density (particles) 600 kg/m³

For experiment we used polyethylene terephthalate for injection in blast furnace, that chemical analysis

- C= 62.5%
- H=4.5%
- O=33.0%

Injection parameter

Parameter	unit	
Injection tank pressure	Kg/Cm ²	4.3
Injection pressure at lance	Kg/Cm ²	3.8
N ₂ flow	NM ³ /Hr	30
N ₂ pressure	Kg/Cm ²	6
BF hot blast pressure	KgCm ²	2.2-2.6
Injected quantity	Kg/hr	600

Table-1: Injection parameter

Blast furnace parameters before plastic injection

Blast parameter			Burden (charging) Details		
Parameter	value	Unit	Material	value	Unit
Blast Volume	80000	Nm ³ /hr	Iron ore	7400	Kg/charge
Cold blast pressure	2.45	Kg	Sinter	11100	Kg/charge

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Hot blast pressure	2.35	Kg		Coke	5300	Kg/charge
Top pressure	1.25	Kg		Dunite	30	Kg/charge
Tuyser velocity	225	M/sec		Quartzite	100	Kg/charge
Permeability	1.15			Nutcoke	275	Kg/charge
Steam	2	Tons		BF Output gas composition		
O2 enrichment	3	%		CO	21	%
O2 flow	2900	Nm3		CO2	22	%
Coal injection	6	Tons/hr		N2	54	%
Blast furnace output and specific consumption						
Pig Iron(Hot metal)	1000	Kg		Slag production	315	kg
Coke rate	485	Kg/thm		Fuel rate	575	Kg/Thm
Coal rate	100	Kg/thm		Hot metal temp	1485	°C
Nut coke rate	25	Kg/thm				

Hot metal and slag chemistry before Plastic injection

Hot metal.

Si%	Mn%	Su%	P%	Ti%	C%
0.65	0.16	0.035	0.025	0.5	4.4

Slag analysis

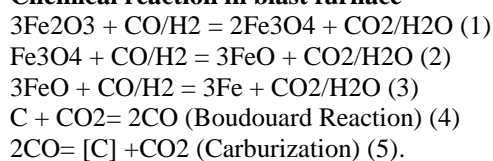
SiO2	Al2O3	FeO	CaO	MgO	S	Na2O	K2O	Na2O+K2O	Bas
32.80	19.45	0.18	35.83	9.31	1.06	0.24	0.32	0.56	1.09

Waste plastic injection experimental observation started in tuyere no 12. With adjusting the injection tank pressure total 600kg injected in one hour. The Blast furnace which having 16 tuyere in one tuyere injecting with plastic and remaining all are injecting with coal powder.

Combustion of waste plastic in blast furnace.

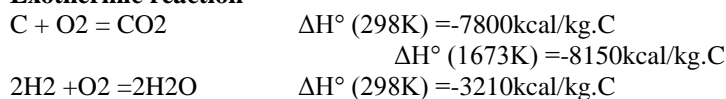
To examine the gasification and combustion behavior of plastics, plastic injection experiment has been conducted. In the hot model, plastic particle was heated up rapidly since tuyere zone have 2000 °C as same condition around blowpipe and tuyereofblast furnace observed through tuyere glass.

Chemical reaction in blast furnace

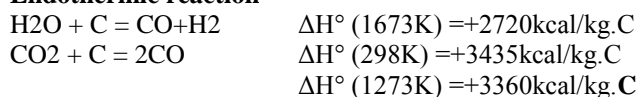


Chemical injection with plastic injection

Exothermic reaction



Endothermic reaction



Blast furnace parameter while plastic injection.

Blast parameter			Burden (charging) Details		
Parameter	value	Unit	Material	value	Unit
Blast Volume	80000	Nm3/hr	Iron ore	7400	Kg/charge
Cold blast pressure	2.44	Kg	Sinter	11100	Kg/charge

Hot blast pressure	2.33	Kg		Coke	5300	Kg/charge
Top pressure	1.25	Kg		Dunite	30	Kg/charge
Tuyser velocity	225	M/sec		Quartzite	100	Kg/charge
Permeability	1.10			Nutcoke	275	Kg/charge
Steam	2	Tons		BF Output gas composition		
O2 enrichment	3	%		CO	21	%
O2 flow	2900	Nm3		CO2	22	%
Coal injection	5.8	Tons/hr		N2	54	%
Blast furnace output and specific consumption						
Pig Iron(Hot metal)	1000	Kg		Slag production	315	kg
Coke rate	485	Kg/thm		Fuel rate	575	Kg/Thm
Coal rate	100	Kg/thm		Hot metal temp	1525	°C
Nut coke rate	25	Kg/thm		WP rate	10	Kg/Thm

Hot metal and slag chemistry after Plastic injection

Hot metal

Si%	Mn%	Su%	P%	Ti%	C%
0.85	0.18	0.025	0.012	0.70	4.43

Slag analysis

SiO2	Al2O3	FeO	CaO	MgO	S	Na2O	K2O	Na2O+K2O	Bas
33.35	18.45	0.55	36.35	9.35	1.06	0.24	0.32	0.56	1.09

VI. RESULT AND DISCUSSION

During blowing, O2 is used in gasification of the solid reducing agent, gradually consumed, and CO2 and H2O are formed as the reducing agent. The CO2 formation peak shows the combustion focus and indicates the position where gasification is most active. The formed CO2 and H2O react with coke and are converted to CO and H2. When the gasification behavior of the solid reducing agent is good, consumption of O2 is fast. A solid reducing agent with good gasification behavior is desirable. However, if gasification is too rapid, the combustion focus will be too close to the tuyere. This is not desirable, as it places a large thermal load on the tuyere.

When the gasification behavior of pulverized plastics is compared with that of pulverized coal, gasification of pulverized plastics with sizes of 0.075 mm and 1.2 mm is extremely fast, and substantially all O2 is consumed for gasification at a position 100 mm from the tuyere. On the other hand, with 2–4 mm pulverized plastics, O2 remains as far as 250 mm from the tuyere, showing that gasification is slow. Pulverized plastic with a size of 1–2 mm showed a tendency similar to that of pulverized coal. The CO2 concentration, which shows the combustion focus, showed the same tendency. Thus, the O2 consumption position shifts to the interior of the furnace as the size of the pulverized plastic increases, and the behavior of the pulverized plastic resembles that of the coke when a solid reducing agent is not injected.

Pulverized plastics with a particle size of 1.2 mm and smaller showed gasification behavior similar to that of pulverized coal. However, because 100% gasification is not achieved, char forms and is supplied to the furnace. Although part of this char is consumed by gasification by CO2, etc., the remainder accumulates in the furnace and becomes a factor causing deterioration of gas and liquid permeability. Therefore, the properties (particle size distribution, etc.) of the char formed from pulverized plastics and its CO2 reactivity were studied. The CO2 gasification rate of unburned char from pulverized plastics and pulverized coal both with 1.2 mm and under was measured using a thermos balance. Figure 4 shows the gasification rate at temperatures of 1 000°C to 1 200°C. Gasification behavior with CO2 was evaluated by heating 25 mg of char under an inert gas and supplying CO2 at 1.5 l/min after reaching the specified temperature. Unburned char from pulverized plastics displayed reactivity similar to that from pulverized coal.

VII. CONCLUSION

1. Fuel rate can be reduced by replacing with cheaper waste plastic. The replacement ratio depends up on quality of coke and furnace condition.
2. There is no direct relationship between waste plastic injection rate and production rate, but as there is a definite need for enriching the blast with oxygen above moderate waste plastic injection rates, production also rises correspondingly.

3. Apart from the coke strength ,which is a basic and important property of the coke for efficient and stable furnace operation, other parameters such as burden distribution, quality of raw materials and their softening points are very much important for smoother and economical operation.
4. Very fine size (1-2 mm) of plastic is required to achieve 100% gasification.

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