CONTINUOUS FEEDING OF SHREDDED SCRAP USING "CLOSED DOOR PROCESS"[1]

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Abstract

The paper is based on the experience developed on a 43.5 t AC-EAF with a 45 MVA transformer, equipped with Supersonic oxygen lances. The “Closed Door Process” works with 60-65% DRI or HBI continuous feeding, with a high foamy slag (1.5 – 2m) which means no limitations in the power usage. It is possible to use more than 1.1 MVA/t in flat bath with high feeding rate of DRI (40 – 50 kg/min – MW) without significant damage to the furnace panels or refractory lining. It is also possible to feed shredded scrap continuously under the same conditions as DRI or HBI (Maximum power usage under flat bath conditions). Energy stored in foamy slag will be available to preheat cold shredded scrap when it passes through it, exchanging heat, maximizing material flow/min and minimizing “iceberg” formation. As a result, tap to tap decreases substantially under 40 minutes and electrode consumption goes around 1,2 kg/t. The process allows removing the slag with FeO content between 4 - 10%, so the metallic yield has been increased.

Key words: Shredded scrap; Foamy slag.

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INTRODUCTION

The Pisco Steelworks, Plant N°2 from Corporación Aceros Arequipa S.A. is located in the Pacific Coast of Perú.
The plant was built in a desert area in 1983.
The scrap yard includes a brand new 4000HP Shredded Machine, 1200t shear, two portal cranes and facilities for scrap torch cutting.
The meltshop includes one 43.5 t UHP AC furnace with a 45 MVA+10% transformer. The original capacity was 40 t.
One adapted ladle furnace: Formerly it worked as EAF.
A 4-strand 5m-radius billet caster.
The EAF has been revamped in October 2004 including a new hydraulic system, 1 coherent Oxygen lance, 2 double flow Post –Combustion Oxygen Lances, 1Oxi-Gas Burner and 2 manual consumable calorized pipe lances through the door.
Three carbon lances are located around the furnace.
Two pneumatic machines provide carbon injection.
Originally, the "Closed Door Process" was developed to melt low phosphorous DRI and run the furnace at maximum power during the flat bath period, charging one bucket with 60 – 65% DRI and/or HBI continuously fed.
28-30 heats/day -19hr – 2 buckets charge, are cast on an average, which corresponds to 38-41 minutes Tap to Tap time with 1.4 kg/t electrode consumption and 89% metallic yield.
Using 40-50% of shredded scrap. Capacity of the steel mill has been increased from 330,000 t/y to 400,000 t/y (20% additional out put).

THE "CLOSED DOOR PROCESS"

Before the flat bath period, the furnace door is closed, then a foamy slag is promoted up to 1.5-2.0 meters high (sometimes almost up to the roof) and DRI or HBI are fed continuously. Under these conditions the furnace runs at maximum power: Depending on the availability of power, 40 (Normal) to 45 MW are used with 0.90-0.94 Cos ϕ. If the electrical facilities allow, It is possible to use more power, thus further reduce the tap to tap time and others ratios.
We already have limitations with the short circuit power, the capacity of the primary transformer and the capacity of the EAF transformer. When 45 MW are available, 36 minutes tap to tap has been attained. Figure 1

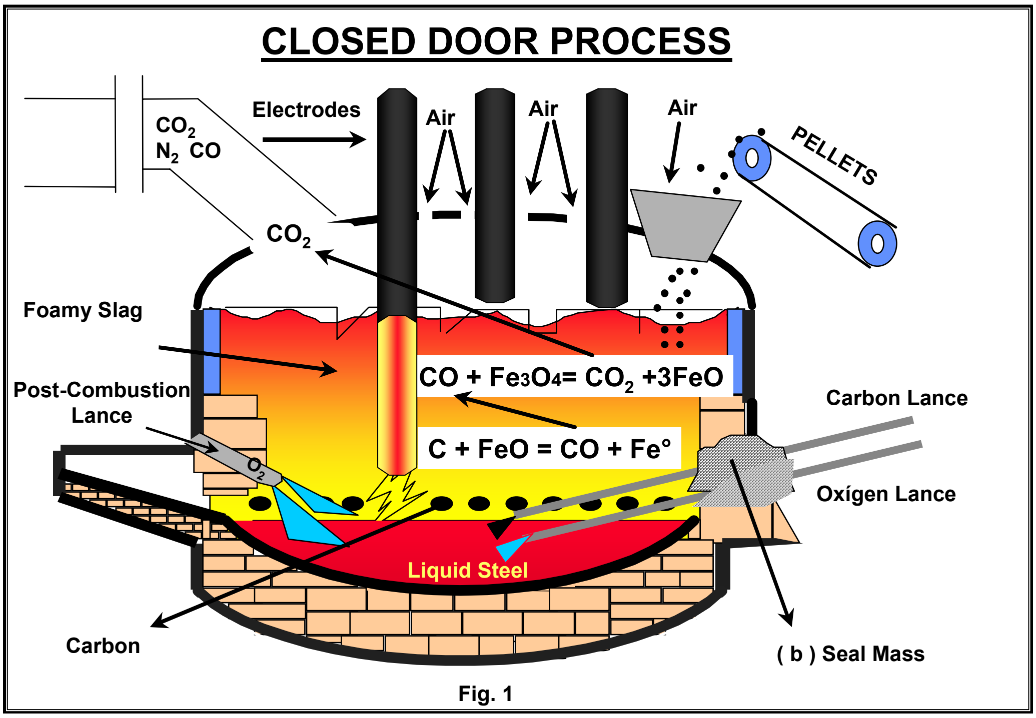

Figure 1. Closed door process.

In order to increase the residence time for hot gases, coherent and post combustion lances work submerged in the foamy slag. This will allow the heat to be transferred to and stored in the controlled foaming slag.(1)

This "hot" foamy slag will exchange heat with the continuous cold charge (DRI, HBI) that is slowly descending, passing through the hot reducing foamy slag.

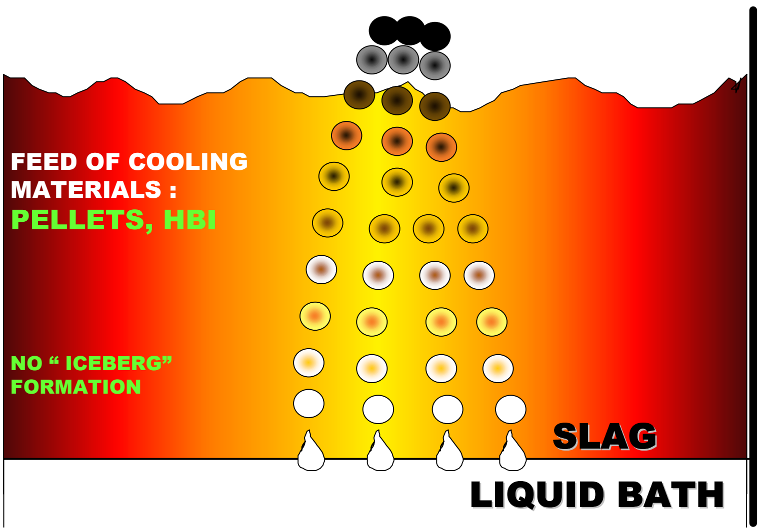

Figure 2. Feed of Cooling Materials

The pellets or HBI are preheated before they reach the liquid bath, then it is possible to increase the feeding rate without "iceberg" formation: 40-50 kg/min-MW.

The process increases the heat exchange mechanism from hot gases to the liquid bath by way of the foamy slag,

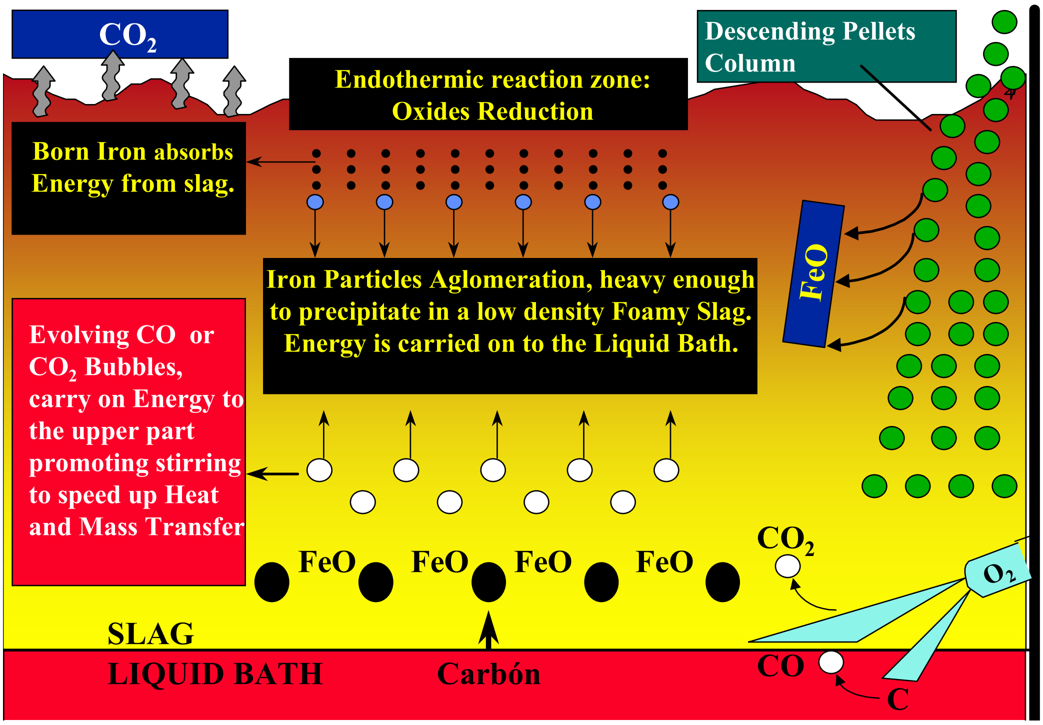

Figure 3. Endothermic Reaction Zones

This mechanism defines the following heat exchange cycle.

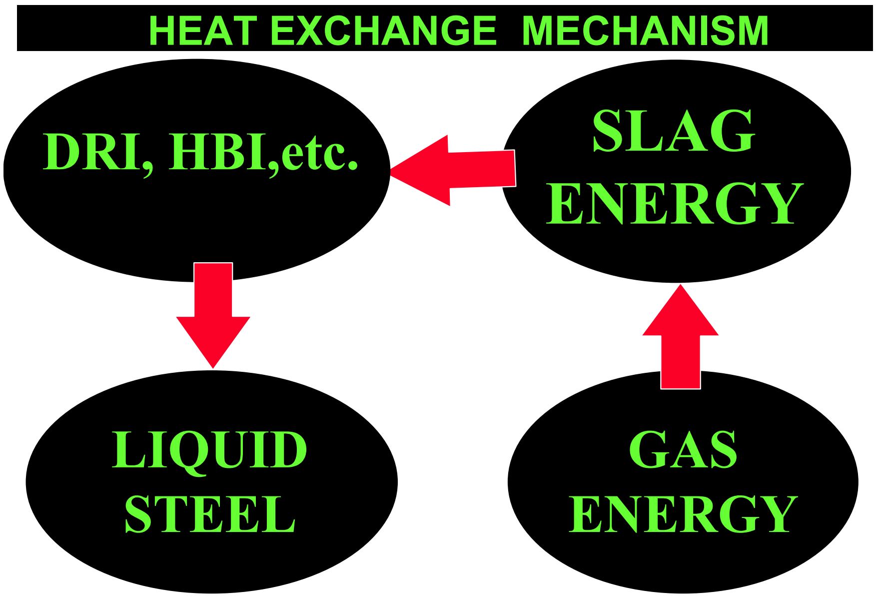

Figure 4. Heat Exchange Mechanism

Another important feature of the process, is the FeO content in the slag. We normally remove the slag with FeO content between 6-10% (when using low Phosphorous DRI or HBI), and then slag is killed with additional carbon before tapping.
This has a strong effect over the metallic yield, Table 1, the ferroalloys yield and the ladle dolomitic refractory lining, because the furnace is tapped with a tea spout type.

Table 1. Closed Door Process Metallic Yield Improvement

CLOSED DOOR PROCESS METALLIC YIELD IMPROVEMENT BASIS: SLAG WEIGHT = 5 000 kg.				
	FORMER PROCESS SLAG		CLOSED DOOR PROCESS SLAG	
	20% FeO	10% Fe Particles	8% FeO	3% Fe Particles
FeO Weight	1000 kg.		400 kg.	
Fe Weight= % FeO x 56/72	778 kg.	500 kg.	311 kg.	150 kg.
Total Iron Weight	778 + 500 = 1278 kg.		311 + 150 = 461 kg.	
% Lost Yield	3,3 %		1.2 %	
YIELD INCREMENT:	89% + 2.1% = 91.1%			

The reduced slag enhances Desulphurization at tapping.

The binary basicity index is 1.2-1.5 with 9-12% MgO. This allows running the furnace with a low-density foamy slag, which is very important to keep the process under control.

MAIN ADVANTAGES OF THE CLOSED DOOR PROCESS

1. Possibility to use more than 1.1 MVA/t without significant refractory or panels damage.
2. Lower noise and less dust Figure 5.

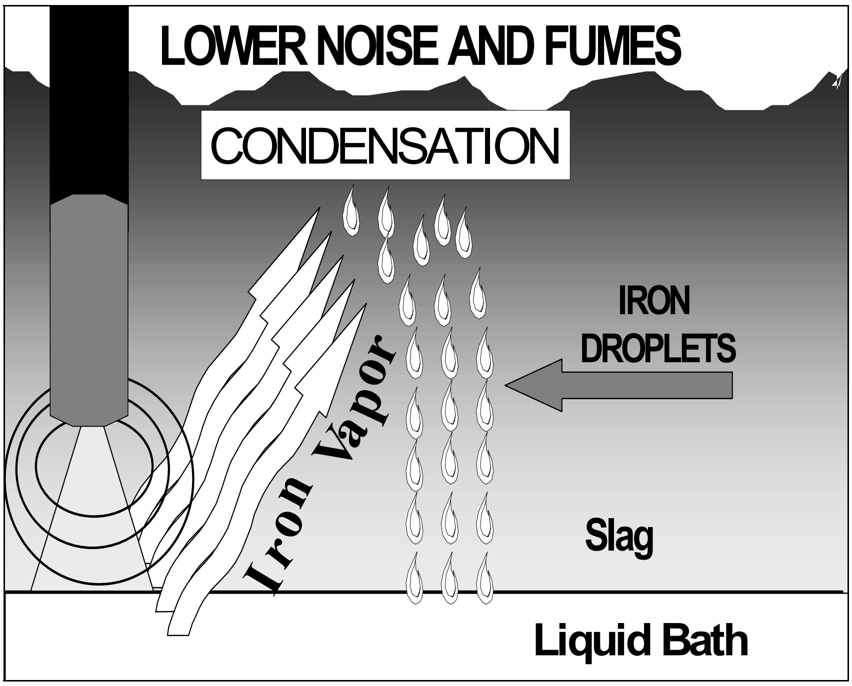

Figure 5. Lower Noise and Fumes

The arc is completely submerged in the foamy slag and noise is reduced drastically. Iron vapor generated in the arcing area will be condensed in the cold foamy slag so that Ferric oxide formation will be avoided when gases leave the foam, for instance Brown fumes will not form. We recover the iron units and the latent heat of iron vapor.

3. Higher thermal efficiency.-

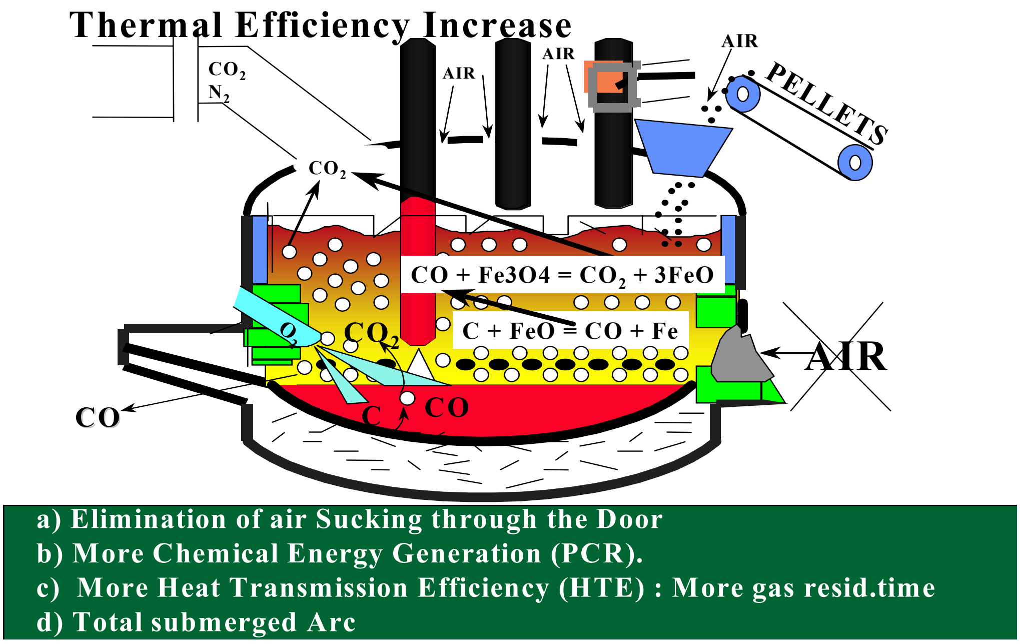

Figure 6. Thermal Efficiency Increase

4. Higher metallic yield
5. Can run at maximum power with longer arcs
6. Lower energy consumption
7. Lower electrode consumption
8. Shorter Tap to Tap
9. Higher DRI, HBI feeding ratio
10. Reduced harmonics (less transformer kWh loss and wear) (2)
11. Panels slag coating: more life
12. Longer ladle life
13. Higher ferroalloys yield
14. Improve arcs stability and reduces flicker
15. Improve Post-Combustion Systems efficiency in flat bath
16. Easier Desulphurization

CONTINUOUS FEEDING OF SHREDDED SCRAP USING “CLOSED DOOR PROCESS” AT ACEROS AREQUIPA EAF .

Taking advantage of the new shredder machine and some modifications on the continuous feeding system, 1 bucket charge is possible.
After first bucket melting and under flat bath conditions, furnace door is closed, foamy slag is raised and continuous feeding of DRI starts through the fifth hole, then shredded scrap is fed. This sequence allows born iron droplets “sweeping” from foamy slag, accelerating demetallization which is very important because as tap to

tap is shortened, slag demetallization becomes the bottle neck to attend high productivity keeping high metallic yield.
A typical period with total apparent power, active power and Cos ϕ values are shown in next figures.

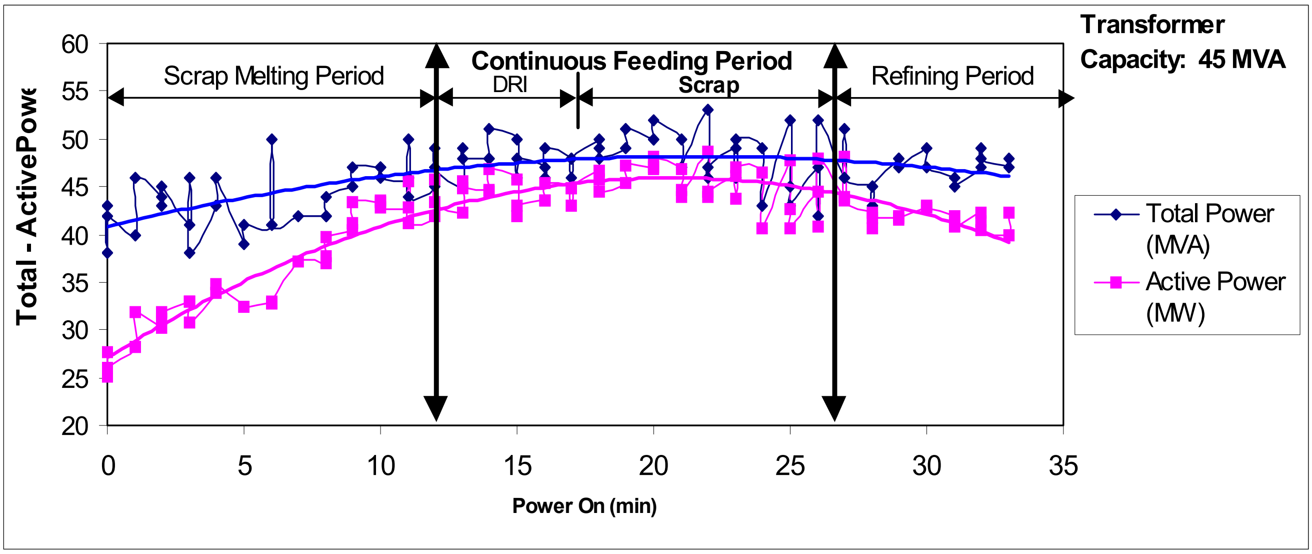

Figure 7. Typical Active and Total Power behavior during feeding period.

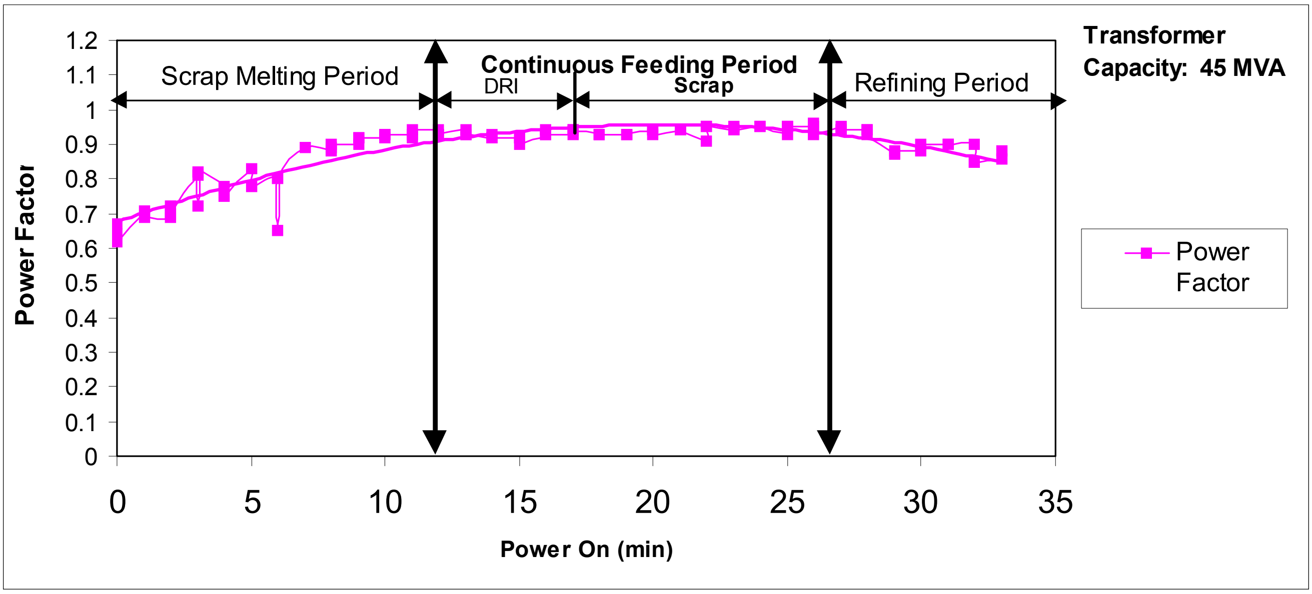

Figure 8. Power factor behavior during feeding period

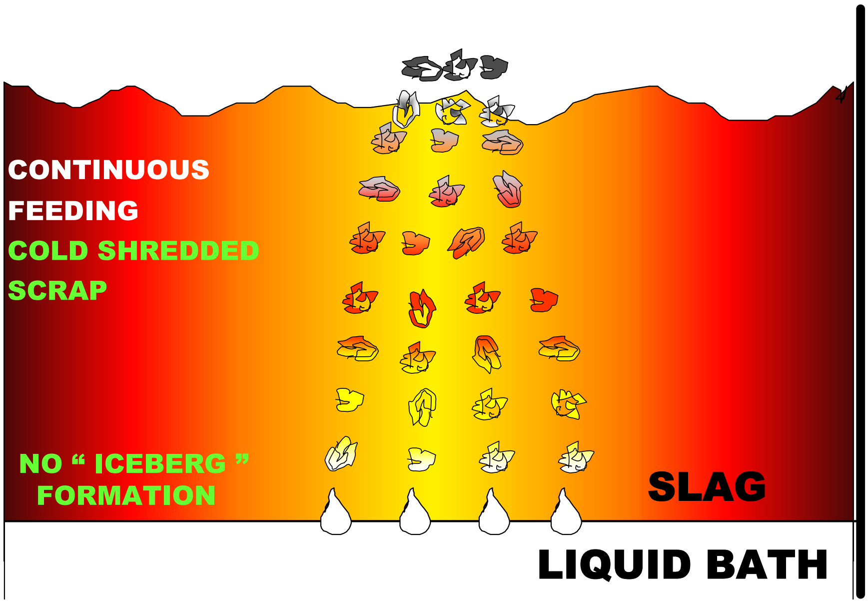

Figure 9. Continuous Feeding of Shredded Scrap using Closed Door Process

METALLIC YIELD

When using high Carbon DRI (2%), the process requires additional quantities of Iron Oxides (Millscale, Iron ore, etc.) in order to keep the slag foaming, otherwise, it will deflates because of lacking of CO or CO2 generation.
When using continuous feeding of Shredded Scrap, metallic yield increases because of less slag generation and fast melting of scrap pieces with no option to oxidation inside the foamy slag. Yield is about 90-91%

ENERGY CONSUMPTION: KWH/t

Energy consumption decreases because shredded scrap preheats while submerged and going down through the hot foamy slag.
Continuous feeding allows one bucket charge, avoiding thermal losses by furnace opening.
No scrap oxidation during melting means no energy requirements for oxides reduction if recovery of oxidized iron units is wanted. Reduction reaction energy requirements for FeO is around 1Mwh/tFeO.
Energy consumption is in between 380 – 400kwh/t

ELECTRODE CONSUMPTION: Kg/t

Lower energy consumption, use of stable longer arcs with 0.90-0.94 Cos ϕ and no air leakage through the door give 1-1.2 kg/t

TAP TO TAP TIME: minutes

High energy flow per minute, use of chemical energy by way of submerged coherent oxygen lances, shredded scrap preheating inside the foamy slag, increase of specific feeding rate – kg/min-Mw and avoiding second bucket charge give Tap to Tap time of 32–34 minutes

PRODUCTIVITY: t/h

Continuous feeding of clean shredded scrap, 4 coherent oxygen lances, a 45MVA + 10% transformer and the "Closed Door Process" make possible increasing productivity from 61t/h to 73t/h, which represents 20% increment.

CONSTRAINTS

- Difficulty to melt high phosphorous materials, because of phosphorous reversion.
- Overflows through the delta.
- Transformer overloading and electrode tip cracks.
- Difficulty to measure real slag height.
- Very conductive slag: Electrode raising will occur. Risk of damage to roof panels and delta.
- Blowback risk when FeO in slag is out of control.

CONCLUSION

- The Closed Door Process has allowed us to use power over 1.1 MVA/t of charge during flat bath period, without significant damage to panels and hot spots.
- The specific feeding Rate of pellets or HBI has been increased from 28-32 kg/min-MW to 40-50 kg/min-MW.
- The Metallic Yield, calculated over the total charge is in between 90 – 91%.
- When charging low phosphorous materials, the furnace and ladle campaigns are increased greatly.
- Using of long arc operation, electrode consumption and productivity have been optimized.
- The Process becomes more efficient if more energy is absorbed inside the foamy slag. Foamy Slag will be cool down if more reduction reactions take place, so that more heat will be transferred from hot gases.
- Post combustion becomes efficient because the foamy slag stores the generated heat and delivers it to the endothermic reactions, otherwise slag becomes overheated and heat exchange decreases.
- The capacity of our revamped Meltshop has been increased from 330,000 t/y to 400,000 t/y using 40–50% shredded scrap – 2 buckets charge, which represent a 20% increase.
- Continuous feeding of shredded scrap, using "Closed Door Process" is able to increase capacity from 400,000t/y to 480,000t/y which means 20% additional.

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