

# Energy and Chemical Balance in Blast Furnace

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**Abstract** - A detailed technical study of the plant measurement were conducted the detailed energy & material balance of entire pig-iron production process presented in the paper. This paper describes the estimation techniques for energy management of stove in pig iron plant. This observed parameter is then energy management to minimum fuel required for subsequent regenerative cycle the stove is regenerative type heat exchanger and uses the gas from blast furnace to stove to generate hot gas. This paper gives the energy management of combustion chamber to reduce the losses in pig-iron plant. That energy management improves the production capacity of the plant

**Key Words:** Non-contact thermometer, Fuel combustion, Reaction Balance, SCADA unit, 24 hour monitoring unit, Energy Requirement, Product Capacity....

## 1. INTRODUCTION

The purpose of a blast furnace is to chemically reduce and physically convert iron oxides into liquid iron called "hot metal". The blast furnace is a huge, steel stack lined with refractory brick, where iron ore, coke and limestone are dumped into the top, and preheated air is blown into the bottom. The raw materials require 6 to 8 hours to descend to the bottom of the furnace where they become the final product of liquid slag and liquid iron. These liquid products are drained from the furnace at regular intervals. The hot air that was blown into the bottom of the furnace ascends to the top in 6 to 8 seconds after going through numerous chemical reactions. Once a blast furnace is started it will continuously run for four to ten years with only short stops to perform planned maintenance.

### 1.1 The Path Process

Iron oxides can come to the blast furnace plant in the form of raw ore, pellets or sinter. The raw ore is removed from the earth and sized into pieces that range from 0.5 to 1.5 inches. This ore is either Hematite or Magnetite and the iron content ranges from 50% to 70%. This iron rich ore can be charged directly into a blast furnace without any further processing. Iron ore that contains a lower iron content must be processed or beneficiated to increase its iron content. Pellets are produced from this lower iron content ore. This ore is crushed and ground into a powder so the waste material called gangue can be removed. There mining iron-rich powder is rolled into balls and fired in a furnace to produce strong, marble-sized pellets that contain 60% to 65% iron. Sinter is produced from fine raw ore, small coke, sand-sized

limestone and numerous other steel plant waste materials that contain some iron. These fine materials are proportioned to obtain desired product chemistry then mixed together. This raw material mix is then placed on a sintering strand, which is similar to a steel conveyor belt, where it is ignited by gas fired furnace and fused by the heat from the coke fine into larger size pieces that are from 330 to 130mm. The iron ore, pellets and sinter then become the liquid iron produced in the blast furnace with any of their remaining impurities going to the liquid slag. [2]

## 2. Observation

The raw material for pig iron making are iron ore, coke & air. The material & energy balance of the blast furnace & stove.

### 2.1 Material balance across blast furnace:

Table -1: Input Material

Material	Quantity
Iron ore	23,750 kg/h
Coke	9,500 kg/h
Air	25,530 N cum/h = 32,927 kg /h
Total	66,177 kg /h

Table -2: Output Material

Material	Quantity
Iron melted	15,000 kg/h
Slag	4,000 kg/h
BF gas	36,000 N cum/h = 48,960 kg /h (Den : 1.36 kg/cum)
Total	67,960 kg /h

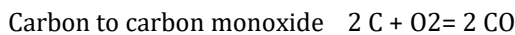
Table -3: Material Content Balance

Iron ore quantity	23, 750 kg/h
Fe <sub>2</sub> O <sub>3</sub> content in iron ore	19,287.3 kg/h (82 %)
479.1 kg of Fe <sub>2</sub> O <sub>3</sub> generates	352 kg of CO <sub>2</sub>

19,287.3 kg Fe <sub>2</sub> O <sub>3</sub> generates	14,170kg/h of CO <sub>2</sub>
BF GAS CONTAINS 29.72 % CO <sub>2</sub> BY WEIGHT,	
Weight of BF gas	48,960 kg/h
Weight of CO <sub>2</sub> in BF gas	14,552,73kg/h

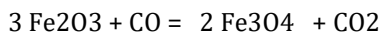
Heat of reactions involved in the Blast furnace worked out below [1]

**Reaction No 1:**



Heat liberated by formation of CO = -3,79,19,069.83 kJ/hr

**Reaction No 2:**

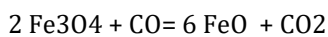


$\Delta HF + \Delta HF = \Delta HF + \Delta HF$

$[3 \times -198.5] + [-26.416] = [2 \times -266.9] + [-94.052] - 621.916 = -627.852$

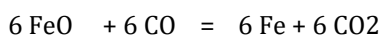
$\Delta HR = -627.852 - [-621.916] = 3 \text{ moles of } Fe_2O_3 = -24.87 \text{ kJ/hr}$

**Reaction No 3:**



$\Delta HR = 328.58 \text{ kJ/hr. [endothermic reaction]}$

**Reaction No 4:**



$\Delta HR = 75.77 \text{ kJ/hr.}$

**Net heat of reaction No 2, 3 & 4**

Iron ore quantity = 23,750 kg/h

Fe<sub>2</sub>O<sub>3</sub> content in iron ore (82 %) = 19,287.3 kg/h

Heat of reaction for 19,287.3 kg/h of Fe<sub>2</sub>O<sub>3</sub>

= 2,75,26,686.05 kJ/hr

Net heat of reaction in BF for input ore quantity of 23,750 kg/h.

**Table -4: Heat Reaction**

Reaction	Heat of reaction , kJ/hr
Formation of CO	-3,79,19,069.83
Reduction of Fe <sub>2</sub> O <sub>3</sub> by CO	+ 2,75,26,686.05
Total	1,03,92,381.15

**2.2 Energy Balance across Blast Furnace:**

Input Material & Energy:

**Table -5: Input Material & Energy**

Material	Quantity	Temp, entering °C	Heat in kJ/hr
Iron ore	23,750 kg/h	35	2,98,466.25
Coke	9,500 kg/h	35	1,19,386.5
Air	25,530 N cum/h = 32,927 kg/h	900	2,89,65,552.63
Total	66,177 kg/h		2,93,83,405.38

Heat generated in the reaction: 1,03,92,383.78 kJ/h

Output Material & Energy:

**Table- 6: Output Material & Energy**

Material	Quantity	Temp, leaving °C	Heat in kJ/hr
Iron melted	15,000 kg/h	1500	1,85,36,325
Slag	4,000 kg/h	1500	74,14,530
BF gas	36,000 N cum/h = 48,960 kg/h	45	4,92,224.256
Moisture in ore	750 kg/h ( 5 % )		16,96,545
Total	67,960 kg/h		2,81,39,624.26

HEAT DISSIPATED = (HEAT IN + HEAT GENERATED) - HEAT OUT

= (2,93,83,405.38 + 1,03,92,383.78) - 2,81,39,624.26

= 1,16,36,164.4 kJ/h.

Heat to be dissipated is dissipated by water circulated over the outer surface of the blast furnace.

### 3. SCOPE FOR ENERGY SAVING

Pulverized coal is injected into blast furnace through pipe by pulverized coal injection system. The type size of pulverized coal injected differs. By installing pulverized coal system, nearly 7 % of the coke can be replaced resulting in substantial cost reduction. Pulverized coal system is comprises equipment for coal receiving, crushing, bag filter, injection and instrumentation. Pulverized coal is economical coal, which substitute part of expensive coke.

The budgetary cost benefit analysis of the system is indicated below.

Annual coke consumption	= 1, 70,000 MT
Cost of coke	= Rs 26,000/MT
Cost of Coal (Indonesian)	= Rs 7000/MT
Difference in cost	= Rs 19,000/ MT

For annual coke consumption of 1, 70,000 MT and 7 % coal replacement

The savings	= 1, 70,000 MT x Rs 19,000 /MT x 0.07
	= Rs 22, 61, 00,000/ year
	= Rs 22 Core /year

The budgetary investment for the project would be to the tune of Rs 30 Crore.

### 4. CONCLUSION

Carbon dioxide present in blast furnace gas is generated by chemical reaction of carbon monoxide with iron ore. This was further confirmed by material balance of carbon as well. Material balance further indicates that optimum quantity of coke was being consumed. Energy balance of blast furnace matches with the actual readings. Coal injection in blast furnace is well proven technology to reduce operational cost.

### REFERENCES

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