BLAST FURNACE (BF) - REFRACTORY LINING PATTERN

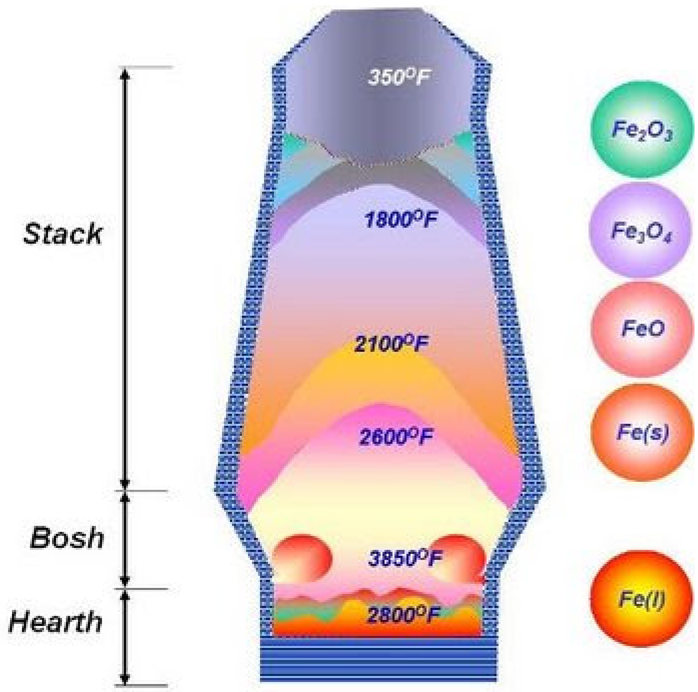

Fig: Blast Furnace Temperature Zones

Fig: Typical areas of a Blast Furnace

Blast Furnace - An Introduction

Blast Furnace is the focus of any integrated steel plant. Blast furnace is used to reduce the iron ore to iron. The charge, which consists of iron ore, coke and limestone etc. in the form of lumps and different ratios, is fed from the top. Air heated in the blast furnace stoves, is applied from the bottom of the furnace. The hot blast comes in contact with the descending charge in furnace and the iron ore gets reduced to iron due to reducing conditions on account of CO_2 and CO in the furnace. CO provides further heat and a very high temperature is developed because of which the iron gets melted which, along with the slag is collected in the hearth from where these are tapped separately from different tap holes.

Ironmaking technology in general made great strides particularly, during the past few decades and as a result of which many alternative ironmaking processes such as Finmet, Fastmet, Hismelt, Romelt, COREX, and FINEX etc. have emerged. Nevertheless, the classical *Blast Furnace*, which has been around the longest, continues to be the dominant method of ironmaking till now. Improvements in burden quality, burden distribution, casting technology, and computer assisted supervision were realized throughout the world. To a great extent these operational improvements made it possible to install very sophisticated refractory lining systems in blast furnaces. The application condition of different sections of a blast furnace is different due to the very nature of its geometry and also pyrometallurgical process occurring at different stages (see adjacent Blast Furnace figures). Therefore, the Blast Furnace Bottom, Hearth, Taphole, Tuyeres, Bosh, Belly, Stack, Cast house, Blast Furnace Stoves all require different quality of refractories depending on the respective application conditions.

Selection of appropriate refractory combination depends on in-depth knowledge of ironmaking system and the physical, mechanical and chemical properties of the proposed refractories. An improper understanding of the above factors often leads to a refractory failure which, subsequently, becomes a complex problem to solve. Refractory linings whether it is of a Blast Furnace or any other furnace, usually fail due to any number or combination of such factors. For the convenience of understanding, here we will discuss the types of refractory lining required in a blast furnace area wise as well as the trend in the refractory lining pattern that has been observed during the last few years.

Furnace Refractories

Now-a-days the campaign life of Blast Furnace is measured in terms of 10 - 15 yrs rather than 4 - 5 yrs while on the other hand, the trend is to replace smaller Blast Furnaces with large capacity Blast Furnaces, which are being subjected to even more stringent operating conditions. To achieve these goals, it is necessary to have a good combination of high grade refractories combined with highly efficient cooling systems and tight control on furnace operation to ensure high productivity without excessive wall working and with minimization of massive “slips” in the blast furnace which can cause excessive premature damage to the refractory linings. It is known that the bottom and a part of the hearth are corroded mainly by pig iron, slag and alkalies. Refractory bricks in these areas are subjected to high load and temperature. So it requires a refractory lining which should have high strength, lower creep in compression value and higher RUL and PCE values. Many furnaces still use low iron, dense 42-62% Alumina, Mullite refractory bricks, conventional Carbon blocks etc. in the bottom and lower hearth while the present trend is to replace it with super micro-pore Graphite bricks.

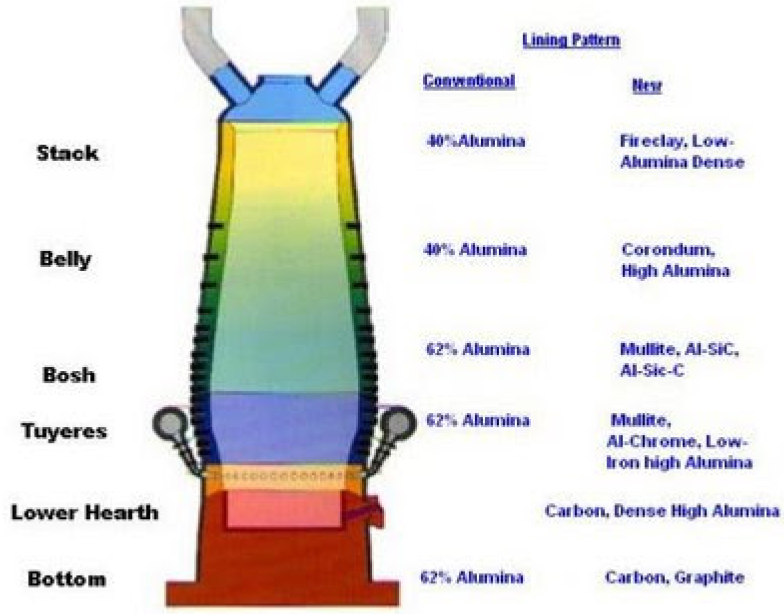

Fig: Conventional and New Refractory Lining along with Wear Mechanism

Research and data shows that **Blast Furnace hearth life** mainly depends on the following factors:

1. Operational Factors such as,

(a) High productivity leading to High heat loads

(b) High fluid velocity causing more erosion

(c) High coal injection means lower permeability

None of the above factors is under the control of furnace operator and hence, the only solution for this can be a robust refractory lining.

2. Refractory Lining System Design The entire refractory lining is also subjected to thermal stress which also plays a dominant role especially when the design is inadequate. The refractory lining system or design must take care of the following things -

(a) Optimize thermal resistance

(b) Provide expansion relief

(c) Prevent cracking

(d) Eliminate built-in barriers.

3. Refractory Properties

(a) High thermal conductivity

(b) Alkali resistance

(c) Low permeability

(d) Low thermal expansion

(e) Low elasticity.

The recent development of micro-porous carbon bricks and improvement in the quality of semi-graphite and graphite bricks has led to higher infiltration resistance to iron and slags, and thermal conductivity. The problem of brittle layer formation around 800^{O}C isotherm by alkali condensation and thermal stresses have been addressed to by using smaller blocks, optimum expansion allowances etc. The carbon refractories are covered by fireclay or mullite bricks to protect it against oxidation. The design of this '**Ceramic Cup**' is important, as the isotherms are altered depending on the quality and thickness of the cup material.

The stack bricks are particularly; exposed to high abrasion and erosion by charge material from top as well as high velocity fume and dust particles going out due to high blast pressure in a CO environment. Therefore, the application condition demands refractory materials which should have high strength, low permeability, high abrasion resistance and resistance to CO disintegration. Superduty fireclay refractory brick or dense alumina brick having Al_2O_3around 39 - 42% can impart these characteristics required for stack application. The tuyere and bosh are attacked by temperature change, abrasion and alkalies; and the belly and lower shaft by thermal shock, abrasion and carbon monoxide attack etc. In the critical areas of the furnace, i.e. tuyere, bosh, belly and lower stack, silicon carbide, SiC-Si_3N_4 and corundum refractories have replaced carbon and 62% Al_2O_3 or Mullite bricks – taking advantage of the high thermal conductivity of SiC in combination with the stave coolers. However due to the problem of water leakage around taphole and tuyere area many blast furnaces are lined with high alumina or Alumina-Chrome corundum refractories.

Hot Blast Stove Refractories

The hot blast system, incorporating either three or four hot blast stoves per blast furnace, is the other major refractory installation in the blast furnace complex. With today's large blast furnaces, the main trend in hot-blast stoves is toward high temperature and pressure ventilation with dome temperature around 1550^{O}C, blast temperatures of 1250 - 1400^{O}C, and furnace pressures of 3 - 5 kg/cm^2. Therefore, selection of refractories for hot blast stoves depends primarily on their creep resistance properties, bulk density, specific heat, thermal shock resistance, cold crushing strength, thermal expansion and dimensional accuracy. Blast furnace stoves are generally designed by high alumina bricks and checkers. Silica bricks have been introduced in high temperature stoves operating over 1300^{O}C and where the temperature is never allowed to drop below 600^{O}C as silica bricks display poor thermal shock resistance at such low temperatures. Alternatively silica checker bricks can be used can be used in high temperature zone, high alumina bricks in the middle temperature range and hard fired fireclay bricks and other high strength bricks at the bottom checker level.

Table: Blast Furnace Refractories

Area	Present	Trend
Stack	39-42% Al_2O_3	Super-duty fireclay
Belly	39-42% Al_2O_3	Corundum, SiC-Si_3N_4
Bosh	62% Al_2O_3, Mullite	SiC-Si_3N_4

Tuyere	62% Al_2O_3, Mullite	SiC self-bonded, Al-Chrome (Corundum)
Lower Hearth	42-62% Al_2O_3, Mullite, Conventional Carbon block	Carbon/Graphite block with super micro-pores
Taphole	Fireclay tar bonded, High Alumina / SiC tar bonded	Fireclay tar bonded, High Alumina / SiC tar bonded
Main Trough	Pitch / water bonded, Clay / Grog / Tar bonded ramming masses, Castables	Ultra low cement castables, SiC / Alumina mixes, Gunning repairing technique
Tilting Spout	High alumina / SiC ramming masses / Low Cement Castables	High alumina / SiC / Carbon / ULCC
Hot Blast Stove	42-82% Al_2O_3	70-82% Al_2O_3, 91% SiO_2checker bricks

Source : http://viewforyou.blogspot.in/2009/07/blast-furnace-bf-refractory-lining.html