

Repair of Blast Furnace Hearth and Tuyere Using Shotcrete Technology

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The campaign of a Blast Furnace (BF) is mainly governed by the lifespan of the hearth. The hearth refractories are made up of the materials capable of withstanding high temperatures and also of not getting degraded while interacting with corrosive liquids under high ferrostatic load. Shotcrete is becoming popular in process industries now a days to repair the refractories due to its benefits compared to conventional installation methods. Shotcrete has been extensively used to repair the lining of Blast Furnace stack areas using robots and also using platforms. But for the first time in Indian Scenario, Shotcrete has been introduced for successful repair of the hearth of Blast Furnaces.

In this article, Calderys India shares their technical knowledge and experience of repairing the BF hearths using Shotcrete Technology in the Indian scenario.

Introduction

Hearth of a Blast Furnace is also known as its heart, because of the reason that the BF stack or any part can be repaired and BF can be put back into operation till the hearth is in good condition. The Modern BF hearth is composed of microporous Carbon refractories protected by a layer of Alumino-silicate and Alumina-carbon refractories.

In Indian scenario, for the repair of hearth refractories, the

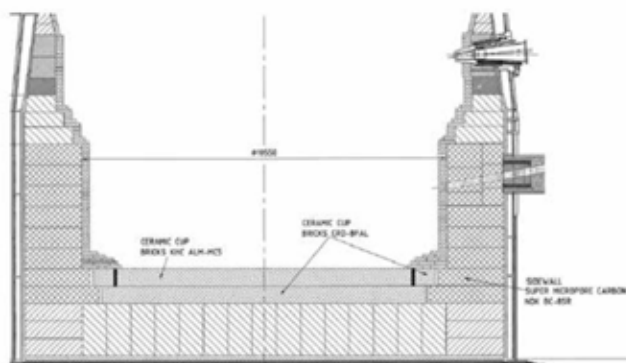


Figure 1: A typical hearth lining

only method available was to replace the old and worn out hearth lining with new lining blocks. No other method was available which can repair the lining in a shorter duration without going for a capital revamp which costs many folds extra to the BF operators.

Calderys India Refractories Limited, with its Global presence and expertise, have come up with a state-of-the-art solution for the repair of the BF hearth lining using Shotcrete Technology which ensures faster, safer and reliable installation of the refractories.

Factors affecting the lining in the Blast Furnace hearth

With a specific raw material and fuel, the wear of the hearth lining is mainly due to the following reasons:

- Penetration of hot metal into the carbon bricks
- Erosion resulting from the dissolution caused by carburisation
- Erosion by hot metal owing to the peripheral flow
- Chemical attack from alkali, zinc oxides, molten slags and iron
- Attack by oxide gases, e.g., CO₂, H₂O

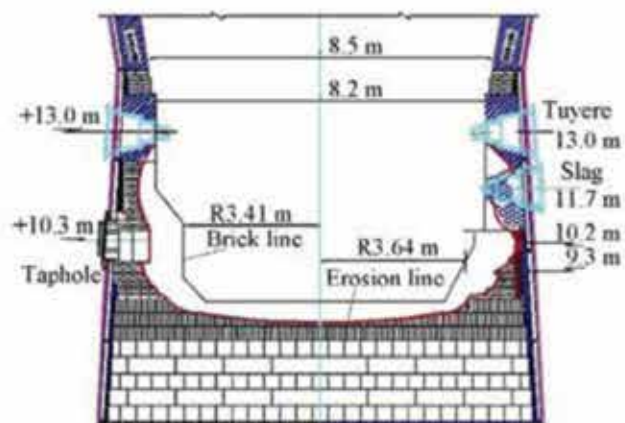


Figure 2: Erosion profile of a Blast Furnace Hearth

So, it's of utmost importance that the refractory materials which are to be used for hearth lining have to withstand all of the wear factors in order to give the BF a good service life.

Calderys' solution

Calderys India Refractories Limited has come up with a solution of Shotcrete installation of suitable refractory products on the worn-out hearth lining, thereby increasing the campaign life of the BF without going for capital revamp.

Shotcrete is a proven technique of installation of monolithic castable in a mechanised manner, which delivers an unmatched installation rate with the same quality of a cast product. The optimum installation speed with the Shotcrete technique is 7-8 Tonnes/Hr. with a rebound loss of as low as 2% when installed properly.

The Shotcrete process

Shotcrete involves the pumping of mixed castable material to a nozzle where the admix and compressed air is added at a certain dose, which enables the sprayed material setting on the target surface.

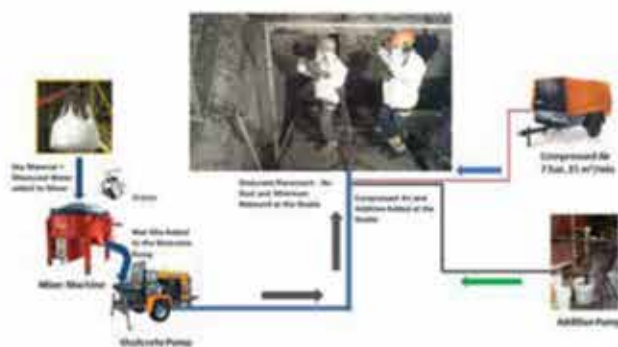


Figure 3: Shotcrete scheme

The benefits of Shotcrete compared to other installation methods are:

1. Faster installation -> Calderys' Shotcrete can be installed at a rate of 8 Tonnes/Hr. which is 2-3 times of Dry Gunning and 8-10 times of casting technique

2. Less rebound -> Calderys' Shotcrete material shows rebound loss of as low as < 2% whereas gunning methods show a rebound of 8-10% and sometimes more
3. No form work required for Shotcrete
4. Environmental friendly
5. Less manpower used compared to other installation techniques

BF hearth Shotcrete process

BF hearth repair is very critical to perform and requires a high level of technical skills both in terms of product selection and installation.

There are a few steps which are to be followed for the hearth repair using Shotcrete:

1. Shutting down the BF
2. Blowdown, tapping out the hot metal and taking salamander tapping
3. Cooling down the BF
4. Cleaning of the surface which is to be repaired
5. Closing down the salamander opening
6. Installing the Shotcrete material on the worn-out surface
7. Curing
8. Dry-out of the lining
9. Tuyeres installation and blowing in of the BF

The surface cleaning of the old lining is of utmost importance as it governs the adhesion of the newly installed lining with the old surface. In case of improper cleaning of the surface, the performance of the lining is doubtful.

Following are some of the pictures indicating the installation of shotcrete in BF hearth and tuyere area:



Figure 4: View of the old lining



Figure 5: Lining condition before Shotcrete



Figure 6: Preparation of the Shotcrete



Figure 7: Installation of Shotcrete



Figure 8: Lining condition after Shotcrete



Figure 9: Lining condition after Shotcrete

The material

With an enormous experience in BF Shotcreting, Calderys developed one special carbon containing Shotcrete material ACCSHOT BFHS2 (properties are reported in Annexure 2) for BF hearth repair. CIF corrosion test (1570-1590°C) shows minimum corrosion of this formulation. Being a monolithic repair, it would ensure jointless artificial skull to BF hearth, protecting it from corrosion. Moreover, the formulation ensures the corrosion resistance and spalling resistance required for the end application. Since installation by shotcreting, the repair is fast and virtually with no rebound.

Important properties of the material are given below:

PRODUCT	ACCSHOT BFHS2		
PRODUCT CLASS	REFRACTORY MONOLITHIC		
FIRE	CARBON CONTAINING SHOTCRETING PRODUCT		
NATURE OF BOND	HYDRAULIC		
INSTALLATION	VIBRATING, SPRAYCASTING		
GENERAL PROPERTIES			
MAX. SERVICE TEMPERATURE	1650 °C		
AVERAGE GRAN SIZE	8 mm		
SOLID REQUIRED FOR CASTING	82 - 10 %		
CHEMICAL ANALYSIS, %			
	RANGE	TYPICAL VALUE	TEST PROCEDURE
FeO ₂	882 - 912	883	ISO 12107 PART 2
TFeO ₂	1.20 - 1.30	0.30	ISO 12107 PART 2
CaO	0.75 - 1.15	0.90	ASTM C 672
PHYSICAL PROPERTIES			
	RANGE	TYPICAL VALUE	TEST PROCEDURE
Dry bulk density @ 20°C			
after drying @ 110 °C / 24 hrs	2.80 - 2.95	2.85	EN 1402-6
TCSC (g/cm ³)			
after drying @ 110 °C / 24 hrs	190 - 200	205	EN 1402-6
after heating @ 300 °C / 3 hrs	190 - 200	195	EN 1402-6
after heating @ 1200 °C / 3 hrs	270 - 300	300	EN 1402-6
% Water of hydration @ 20°C	0 - 5	0.5	ISO 1207 PART 11
THERMAL PROPERTIES			
	RANGE	TYPICAL VALUE	TEST PROCEDURE
PLC, %			
after heating @ 1200 °C / 3 hrs	(-0.30) to (+0.30)	+0.28	EN 1402-6
after heating @ 1400 °C / 3 hrs	(-0.80) to (+0.80)	-0.21	EN 1402-6

Figure 10: Properties of BF Hearth Shotcrete Product

Case studies

Case 1: Calderys India Refractories was the pioneer to introduce BF hearth Shotcreting in MBF in India. ACCSHOT BFHS2 was used for hearth repair of one MBF, of capacity 350 m³. The furnace is 12 years old and produces approximately 1000 Tonnes of Hot Metals/day. Old lining (mullite bricks) was cleaned, as shown in Figure 7, before Shotcreting. The refractory surface is required to be exposed for better adherence of existing refractory with the repair mass. 80 Tonnes of ACCSHOT BFHS2

were installed on hearth side wall up to tuyere (Figure 8) by means of Manual Shotcreting. Installed refractory lining thickness was in the range of 250 to 450 mm. The appearance of the installed Shotcrete mass is shown in Figure 9.

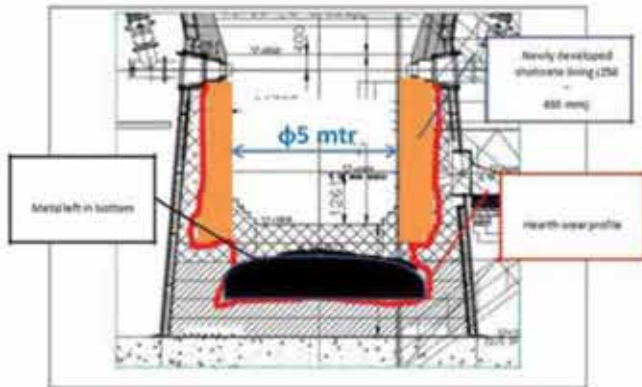


Figure 11: Schematic of the Shotcrete repair performed

Dry out of the hearth Shotcreted lining was done before furnace blow in. The furnace was operational for 6 months approx. and then it was taken for capital repair in which carbon blocks replacements were planned. After the opening of the furnace, it was observed that the Shotcrete lining was still present in the furnace with minimum erosion.

Case 2: A second repair was carried out in a furnace of size 550 m³. The furnace was non-operational for a few years and was to be started in a very short time period. The lining in the vicinity of tuyere area (approx. 1 mtr below and above) was not in good condition and for the successful operation of the BF, the lining must be repaired.

The Shotcrete installation was done by Calderys with a quantity of 55 Tonnes of ACCSHOT BF HS2 in a timeframe of 6 Hrs.

The lining was heated to 550°C using pilot burners before taking the Blast Furnace into operation.

The following pictures indicate some of the salient features of the repair:

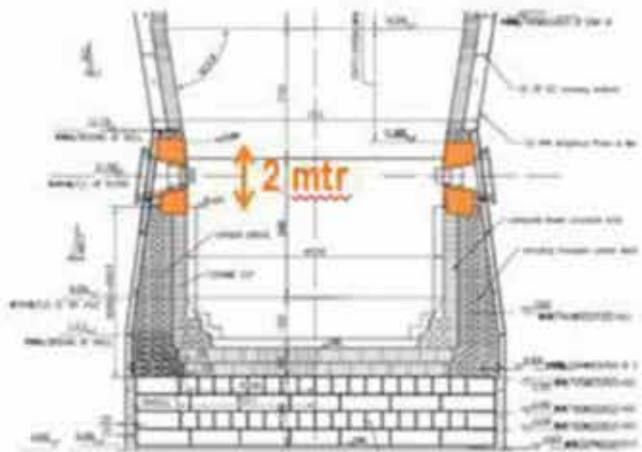


Figure 12: Schematic of the repair



Figure 13: Lining before Shotcrete



Figure 14: Preparation of the Shotcrete



Figure 15: Preparation of the Shotcrete

Conclusion

Refractory installation by Shotcreting has gained popularity among Indian refractory users due to its incomparable benefits, viz. faster rate of installation, lesser possibility of human error due to reduced manpower involvement, lower rebound, excellent service from the installed lining, etc. Calderys India over the years has gained enough experience in Shotcrete installation, through in-house developed products, virtually in all industry segments, including iron and steel. Calderys India has ensured that the product formulations are robust enough to withstand the Indian summer heat during installation and they are installed properly. Looking at process challenges, Calderys India Refractories have successfully developed Shotcrete products with special raw materials that can withstand the erosion and corrosion and ferrostatic pressure of the molten metal inside the hearth of the BF. Product rheology was adjusted as per Indian topical weather conditions and successfully established in the market since 2016. ■