Development of HAZ Castable for Copper Tuyeres of high productive Blast Furnaces

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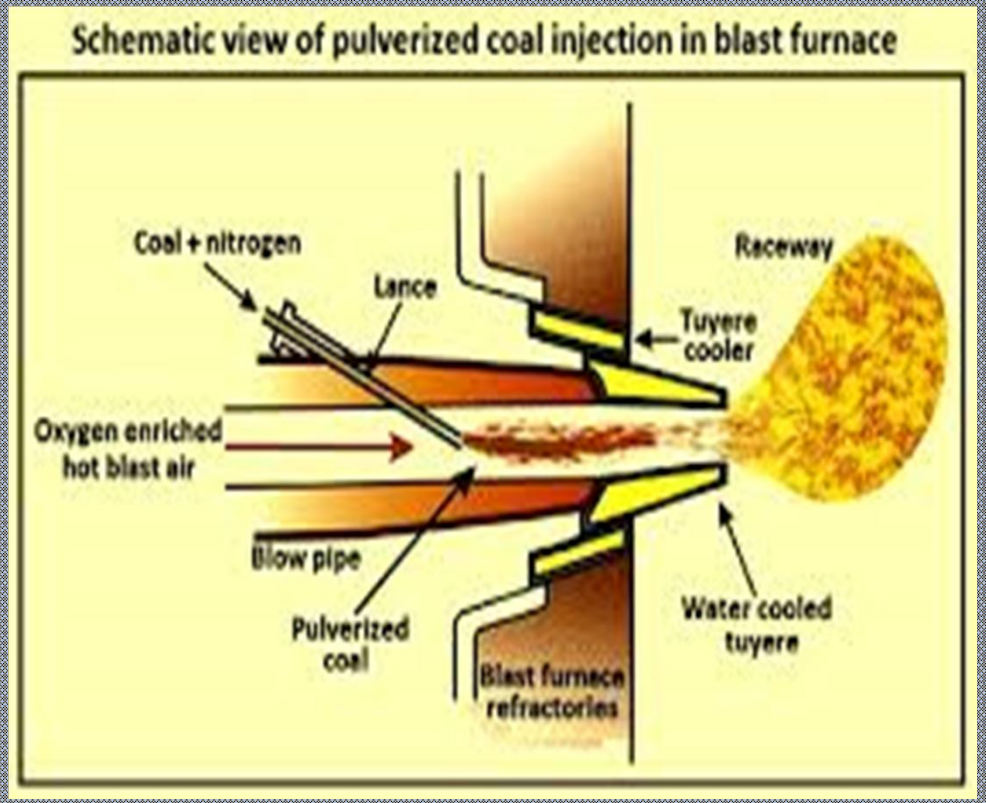
BF Tuyere

Hot Blast is injected to BF through Tuyere

- Special shaped nozzles
- Made of copper, located all around the BF
- Usually water cooled



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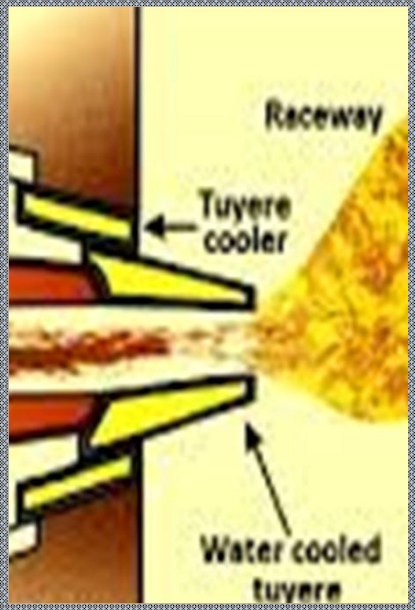
BF Tuyere

- Tuyere region is a dynamic and complex in nature
- It is exposed to harsh & turbulent operating environment at a very high temperature.
- Along with hot air from HBM, it also carries pulverized coal, coke etc.

To withstand such high temperature and abrasion, bore of tuyere is lined with high duty refractory materials

Types of Tuyere

- Single chamber
- Double chamber
- Multiple chamber
- Spiral chamber



Double chamber is the most widely used copper Tuyere

Study of Present practices

- To withstand such high temperature and abrasion, bore of tuyere is coated with refractory materials
- Considering operating conditions, the refractory material should have high volume stability, strength and abrasion resistance at elevated temperature

Study of Present practices

- All high productive BFs use Double chamber Tuyere.
- These Tuyere are prepared with HA castable and then cured, heated and sent to BF shop for installation.
- Cracks generation subsequently falling of castable observed during use.
  - Poor life of Tuyere is due to frequent erosion and poor spalling resistance of HA castable resulting leakage of high-pressure water, cooling the tuyere, into the BF causing furnace instability, increased fuel and material cost

Developmental jobs

- Considering operating condition of Tuyere, the refractory material should have very high volume stability, strength, abrasion and spalling resistance at elevated temperature

  Literature studies also confirm that

- Partially stabilized zirconia(PSZ) is having very high abrasion & spalling resistance, hardness and volume stability at elevated temperature because substructure of cubic and monoclinic ZrO_2 phases present in matrix of PSZ provides an effective stress-relieving mechanism during thermal shock.

Developmental jobs

❖ Hence, it was decided to develop Zirconia containing HA Free Flow castable (HAZ) which is found to be suitable considering area of application and operating environment.

Developmental jobs

Experimental:

Raw materials used for development of HAZ based free flow castable are:

i) WTA, ii) PSZ, iii) Andalusite, iv) Sillimanite Sand, v) Calcined Alumina, vi) High Alumina Cement and vii) Additives

Developmental jobs

In the laboratory, trials were conducted using above raw materials & additives with different proportions to optimize the quantity of PSZ to get the desired properties of end product. The key properties like B.D, CCS, PLC, Hot MOR and spalling resistance of trial compositions of HAZ based free flow castable were studied in the laboratory to finalize the recipe. The test results of developed castable along with existing HAC-70 are mentioned in the following tables(I to V):

Developmental jobs

Table-I: B.D. of HAZ vs. HAC-70

Sample ID	Avg. B.D.(gm/cc)
After drying at 110°C/24 hrs.	
T-1(HAZ)	3.15
T-2(HAZ)	3.18
T-3(HAZ)	3.16
HAC-70	2.75
After firing at 1400°C/3 hrs.	
T-1	3.10
T-2	3.11
T-3	3.10
HAC-70	2.70

Developmental jobs

Table-II: CCS of HAZ & HAC-70

Sample ID	Avg. CCS (kg/cm2)
After drying at 110°C/24 hrs.	
T-1(HAZ)	771
T-2(HAZ)	770
T-3(HAZ)	775
HAC-70	711
After firing at 1400°C/3 hrs.	
T-1	1415
T-2	1410
T-3	1411
HAC-70	1200

Developmental jobs

Table-III: PLC of HAZ & HAC-70

Sample ID	Avg. PLC (%)
After firing at 1400°C/3 hrs.	
T-1(HAZ)	0.02
T-2(HAZ)	0.01
T-3(HAZ)	0.02
HAC-70	-0.11

Developmental jobs

Table-IV: HMOR of HAZ & HAC-70

Sample ID	Avg. HMOR (kg/cm2)
After firing at 1400°C/3 hrs.	
T-1(HAZ)	95
T-2(HAZ)	98
T-3(HAZ)	97
HAC-70	46

Developmental jobs

Table-V: Spalling resistance test of HAZ & HAC-70

Sample ID	Spalling resistance(Cycle)
Water Quenching at 1100°C.	
T-1(HAZ)	No crack after 40 cycles
T-2(HAZ)	No crack after 40 cycles
T-3(HAZ)	No crack after 40 cycles
HAC-70	Many major cracks developed after 15 cycles

Developmental jobs

It is evident from the above test results that all the key refractory properties of HAZ castable are superior than existing material w.r.t.

- Dry & fired B.D (15% higher)
- Green and Hot strength (9% & 18% higher)
- Volume stability (PLC is almost Nil for HAZ castable, -0.11 for LMC-70)
- Thermal spalling resistance under severe condition i.e. water quenching implies its sustainability under harsh operating environment

Plant Trial

Based on above lab studies, HAZ castable was manufactured with the developed composition and supplied to SGW, Kulti(producer of Copper Tuyeres for BFs) where tuyeres was casted with the developed HAZ castable taking necessary precautions like proper dry mixing, minimum water addition to attain the desired flowability and then maintaining proper drying, curing and heating schedule before taking into operation in BF#1 of BSL

It has been reported that the tuyeres coated with this developed castable achieved a life of 9 months which is 200% higher than refractory lining life of existing tuyere

Commercialization of developed castable

- Based on the plant scale trial at BSL with developed refractory material, it is now in regular use in all copper tuyerers of BFs of BSL.
- The material is now being applied in other high productive BFs of RSP, BSP and DSP.
- The material is being manufactured, tested at SRU IFICO unit on regular basis.

Conclusion

- This developed HAZ castable has doubled tuyere lining life and hence, BF availability has increased for production
- Decreasing leakage and formation of red spot has increased HBT from existing 900^{o}C to 1150^{o}C
- BF operating managers are highly satisfied with this developed product made by SRU IFICO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