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Paper name: A case study - life enhancement of alumina spinel burnt bricks for slag dumping area of ladle metal zone

PRESENT AFFILIATION	**RND MANAGER AT DALMIA BHARAT REFRACTORIES LIMITED**
AREAS OF INTEREST	
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Experience	• **10 years**
Projects:	
Publication/ Patent	1.New generation Burnt Alumina-magnesia Spinel brick for Ladle Metal Zone - Avishek Mitra, K.B.Panda, Birendra Prasad, S.K.Hazra,Ingo Gruber in ICRJ 2019, Jamsedpur, India 2. Development of Burnt Alumina-magnesia-Spinel brick for Steel Ladle Lining - Avishek Mitra, S.K.Hazra, Birendra Prasad, Ingo Gruber, Shankha Chatterjee in UNITCER 2019, Yokohama, Japan 3. Effect of different additives on the grain growth of Magnesia Spinel brick - Avishek Mitra, Dr. PR Rauta, S.K.Hazra, Birendra Prasad in InTeC 2019, Thiruvananthapuram, India 4. Improvement of properties and performance of Rebonded Magnesia Chrome Bricks for RH Snorkel - Avishek Mitra, S.K.Hazra in UNITCER 2022, Chicago, USA 5. Variation of elastic properties of Magnesia Spinel bricks with varying percentage of spinel for Cement Rotary kiln - Avishek Mitra, PR Routa, S.K.Hazra in ICR 2022, Aachen, Germany 6. Development of creep resistant Magnesite checker brick for glass tank furnace regenerator - Avishek Mitra, SK Hazra, Glass International 2021 7. A Case Study - Life Enhancement of RH Snorkel through improved quality of Rebonded Magnesia Chrome Bricks - Avishek Mitra, K.B.Panda, Birendra Prasad, S.K.Hazra,Ingo Gruber in ICRJ 2022, Jamsedpur, India

REFIS 4.0 23-24 September Bokaro Steel City Jharkhand India 2022

A CASE STUDY - LIFE ENHANCEMENT OF ALUMINA SPINEL BURNT BRICKS FOR SLAG DUMPING AREA OF LADLE METAL ZONE

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Dalmia OCL

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- Trials
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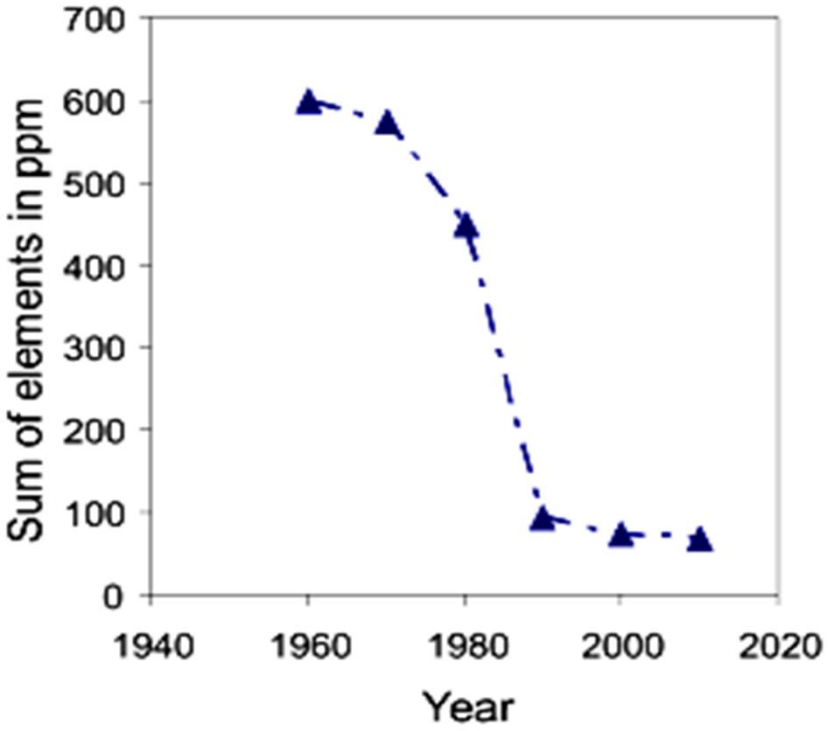
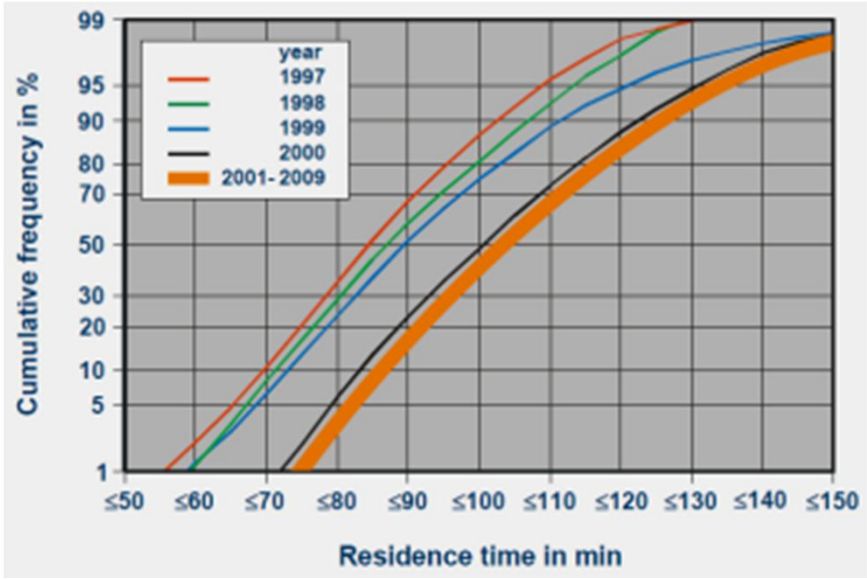
CURRENT CHALLENGES

Extended processing time for high purity steel.

Reduced Energy consumption.

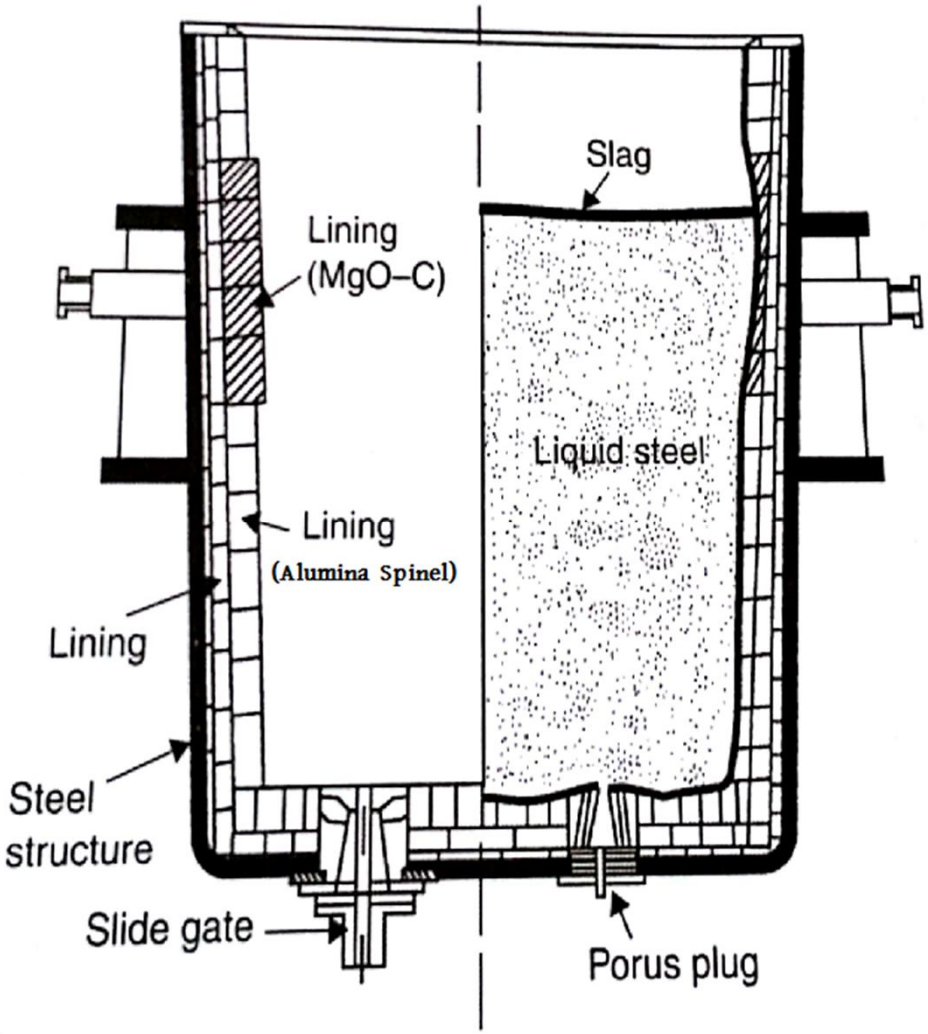
Zero failure for maximum productivity.





REQUIREMENT FOR REFRACTORY

- Thermal Stability
- Thermo-mechanical Stability
- Erosion resistance
- Corrosion/penetration resistance
- Potential for stress relaxation
- Thermodynamic Stability



CURRENT PRACTICES

Slag Zone	• **MgO-C (10-15%C)**
Side Wall and Bottom	• **MgO-C (5-10%C)** • **AMC** • **Burnt Alumina-Spinel Brick**
Impact Area	• **AMC** • **MgO-C (5-8%C)** • **Burnt Alumina-Spinel Brick**

ADVANTAGES OF ALUMINA SPINEL BRICKS

- Carbon-free
- Higher Service life
- Good Slag coating
- Low thermal conductivity

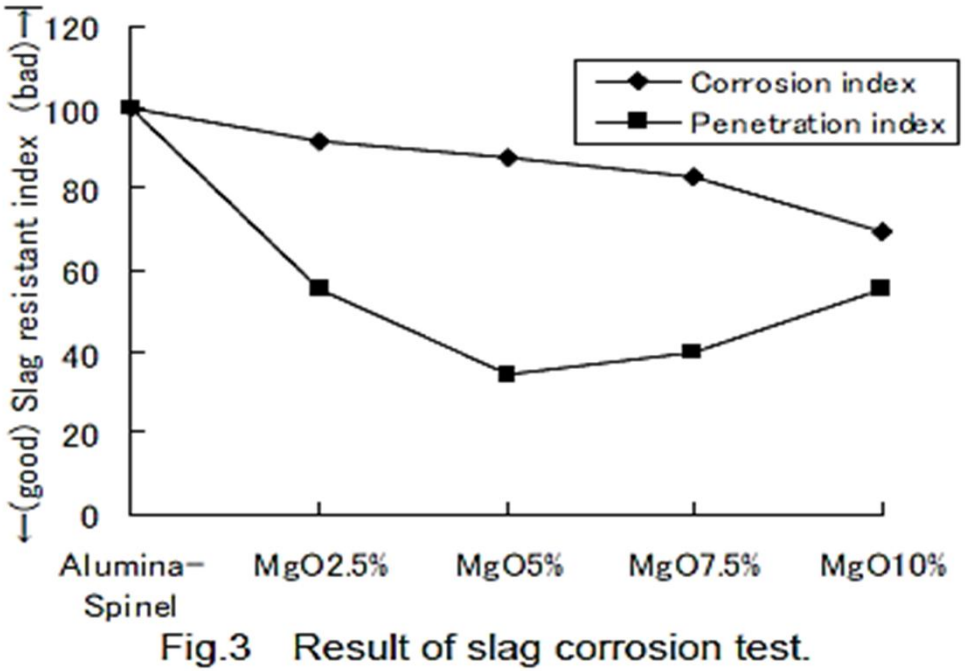
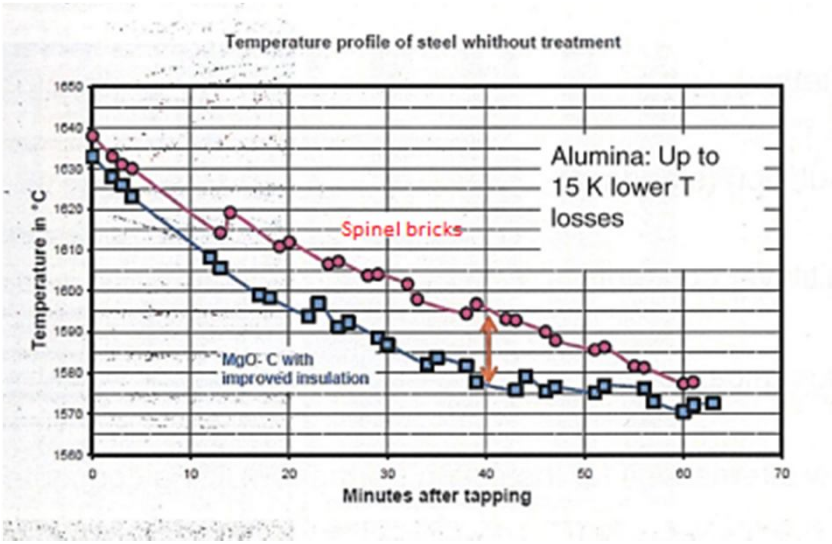


Fig.3 Result of slag corrosion test.

Good Slag Coating



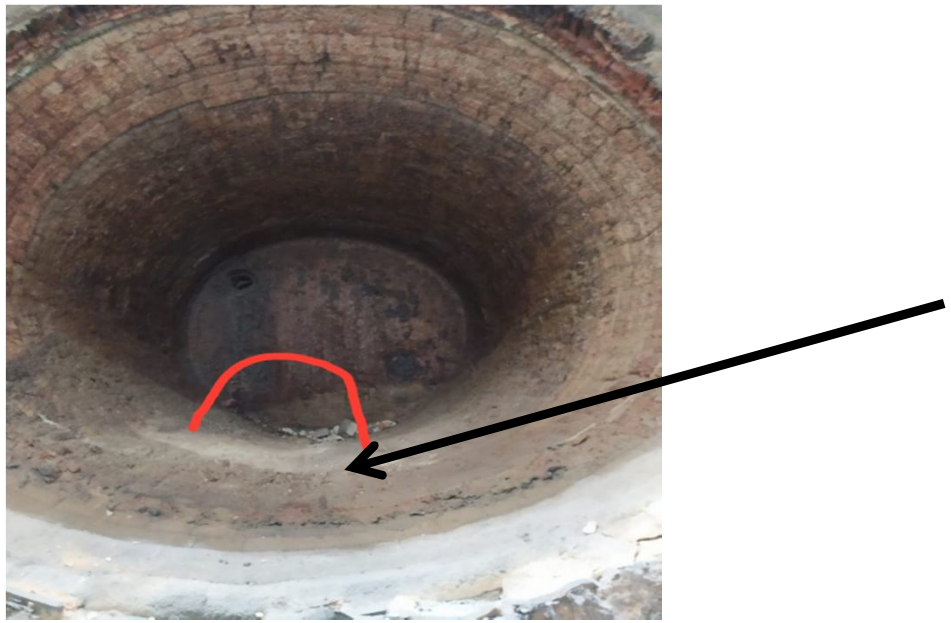
PROBLEM STATEMENT

In Plant A, Alumina Spinel bricks of standard recipe were being supplied in ladle metal zone for sometimes.

➢It was was performing in all the areas but the issue was high erosion in the slag dumping zone.

➢Remnant refractory thickness of the area always found minimum irrespective of plant practise (around 10-20 mm).

➢Pocket repairing of Slag dumping area is almost a regular practice which is the main constraint to achieve higher life.



THOUGHT PROCESS

As the main reason for corrosion is the penetration of metal into the pores and high abrassion, we have taken the following step to reduce the pore diameter and increing the hot modulus of rapture.

By reducing the pore diameter, we can restrict the penetration into the refractory matrix and by increase the hot strengh, we can restrict the abrasion.

- **Adjustment of gradation based on "Modified Andreasen Equation"** - for perfect packing with less pore size

- **Addition of special additive** - for better high temprature properties and formation of finer phases in the intra-granular spaces adding to smaller pores

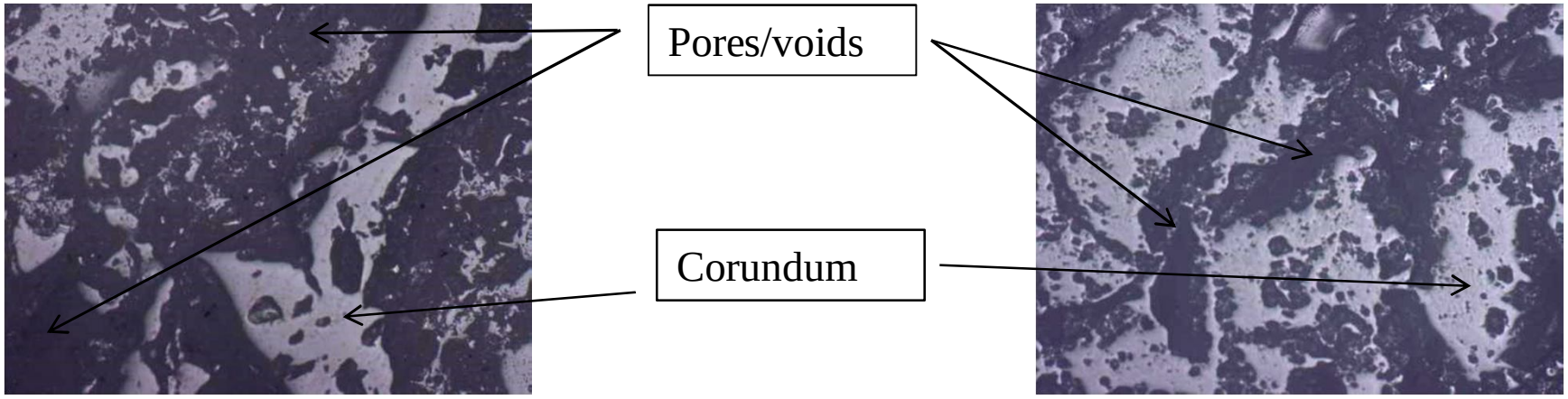
ANDREASEN EQUATION

The development of self-compacting mixes may hep to overcome porosity and permeability issues resulting from poor compaction.

$$\mathrm{CPFT}(\%) = 100\left(\frac{D^q - D_S^q}{D_L^q - D_S^q}\right)$$

where,
CPFT = Cumulative Percentage Finer Than
q = Distribution co-efficient
D_S = Minimum Particle Size
D_L = Larger Particle Diameter

Trials are done with different “q” values to find out the perfect packing density. For a “q” value, let 'x', the best packing density was obtained.



Microstructure with normal recipe

Microstructure with q value = x

DIFFERENT BATCHES

Component	RS	T1	T2	T3
Fused Alumina	Major	Major	Major	Major
Tabular Alumina	Major	Major	Major	Major
Spinel	Major	Major	Major	Major
Additive A		√		
Additive B			√	
Additive C				√

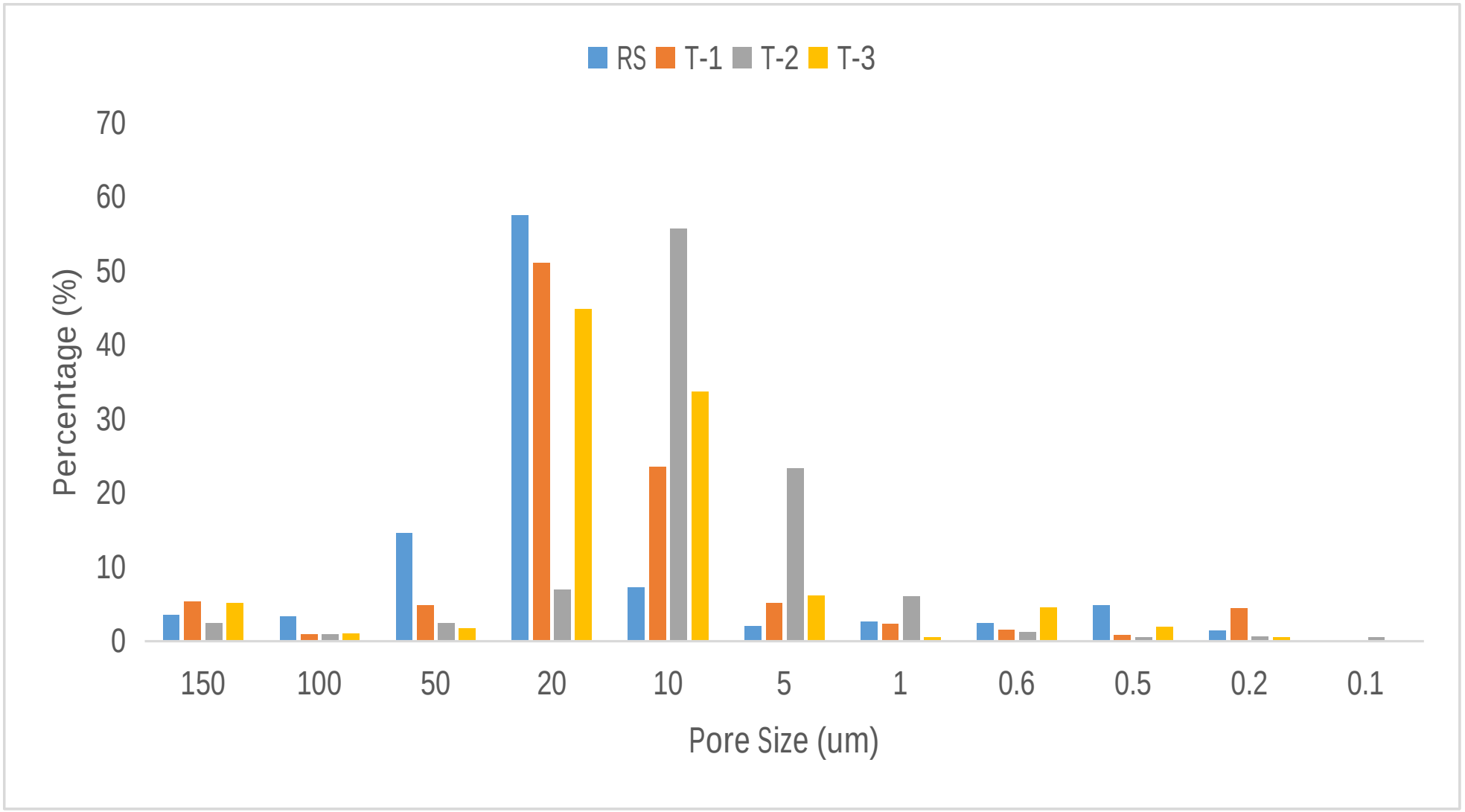
PROPERTIES

Sample	RS	T-1	T-2	T-3
AP (%)	17.6	16.8	15.4	18.3
BD (gm/cc)	3.11	3.16	3.25	3.09
CCS (kg/cm^2)	730	1077	1089	1074
HMOR (kg/cm^2)	61	83	127	53

Chemical	**RS**	**T-1**	**T-2**	**T-3**
MgO (%)	4.21	4.19	3.96	5.17
Al_2O_3 (%)	94.14	94.67	92.92	92.84

- T-1 and T-2 showed low porosity but the HMOR of T-2 is much higher than that of T-1.
- T-2 shows lowest porosity and highest HMOR in comparison with the other three batches.

PROPERTIES - PSD

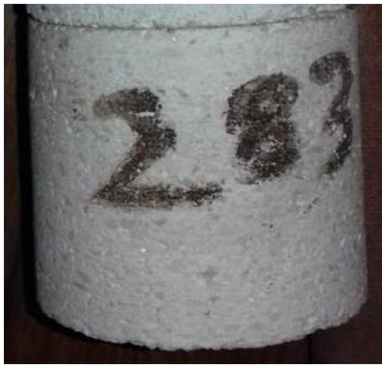


Pore size of RS is larger than all trials as it has a median pore diameter (50%) = 1.62 µm

Pore size of T-2 is lesser than all trials as it has a median pore diameter (50%) = 0.64 µm

PROPERTIES - THEAL SPALLING

Sample No	**RS**	**T-1**	**T-2**	**T-3**
Initial Crack development (cycles)	11	9	13	10
Thermal Spalling @ 950°Cto water (cycles)	36	32	39	28



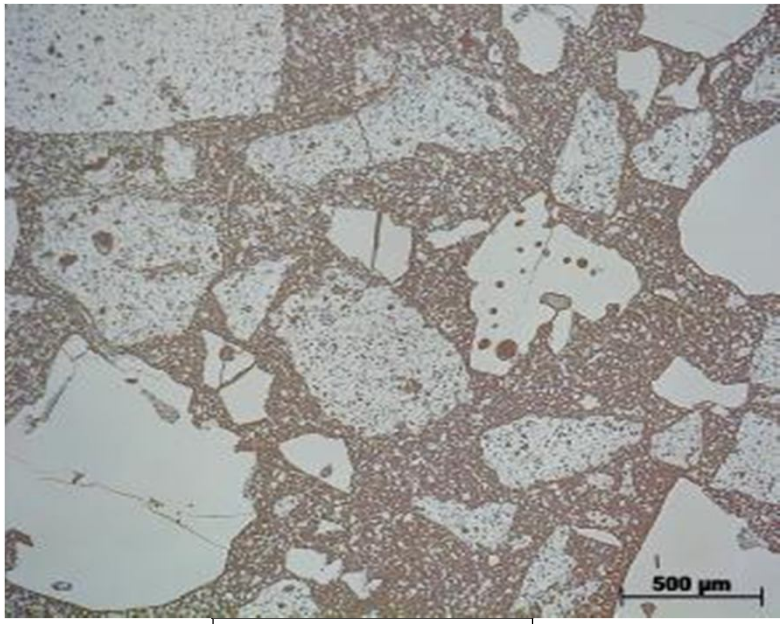
RS

T-1

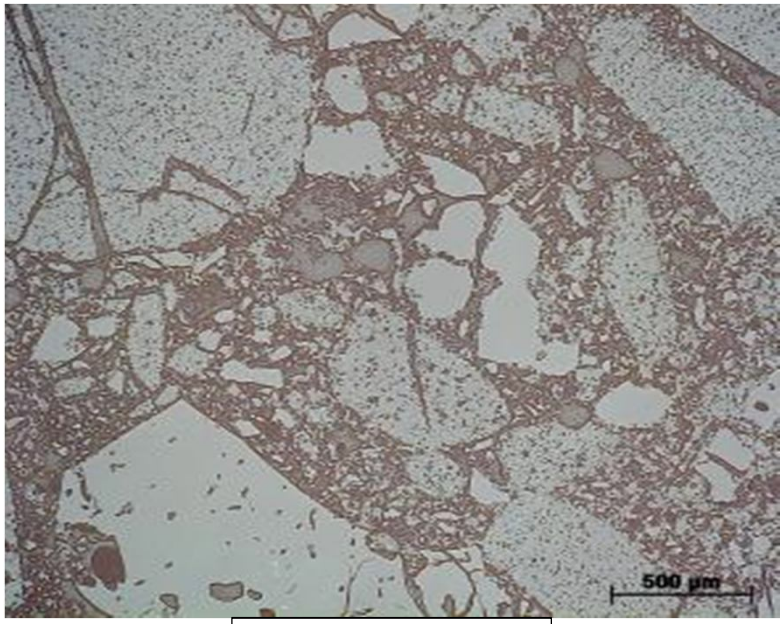
T-2

T-3

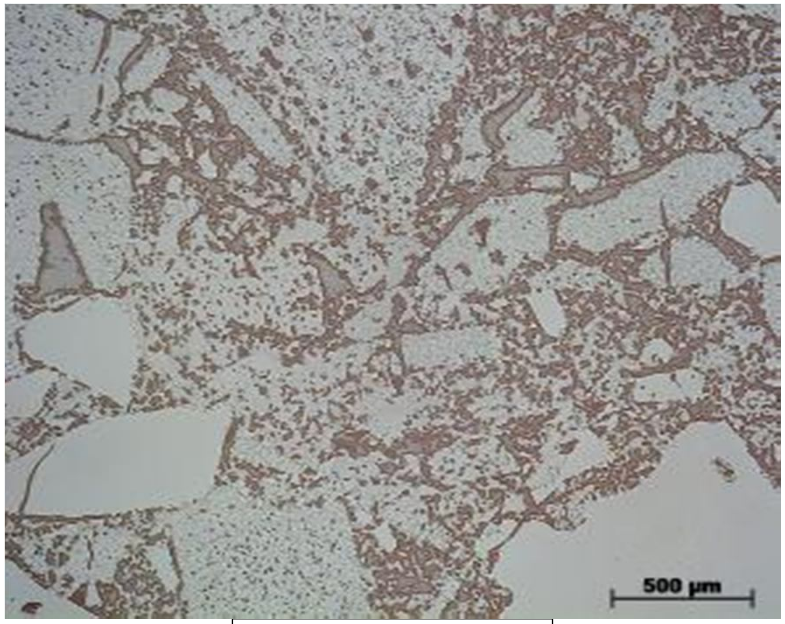
PROPERTIES - THERMAL SPALLING



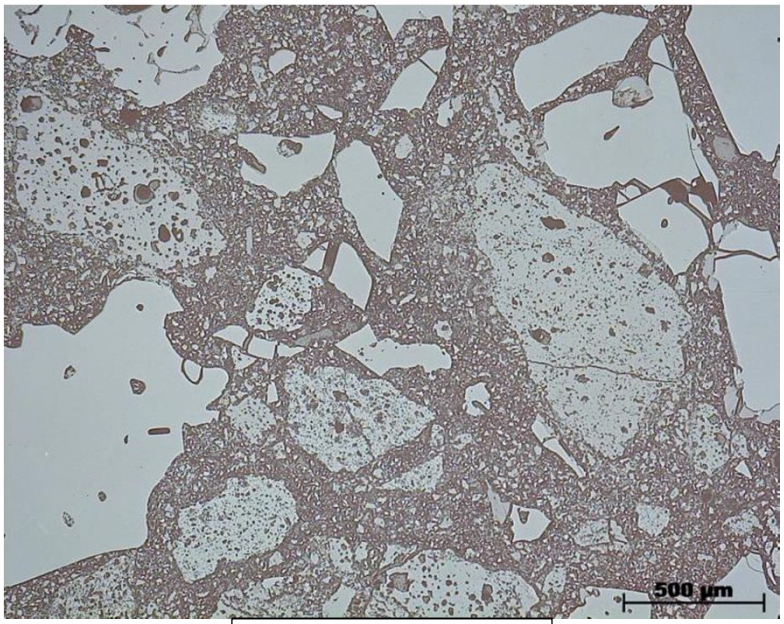
Microscopy of RS



Microscopy of T-1

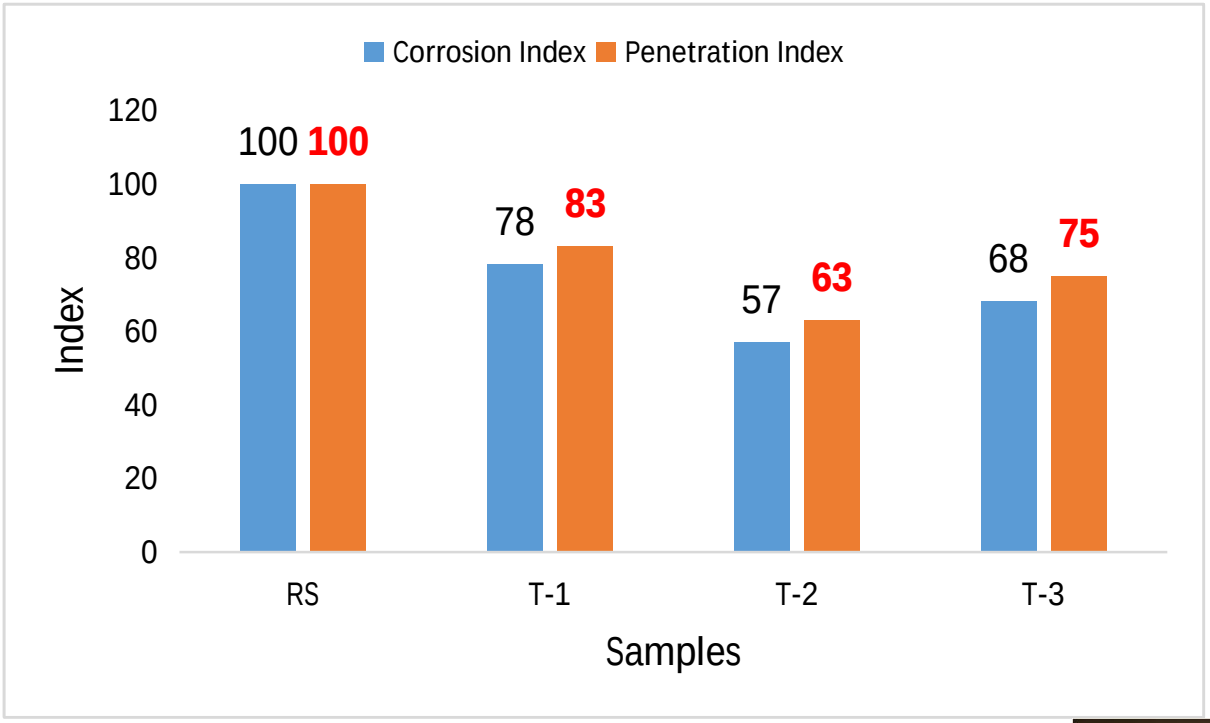


Microscopy of T-2



Microscopy of T-3

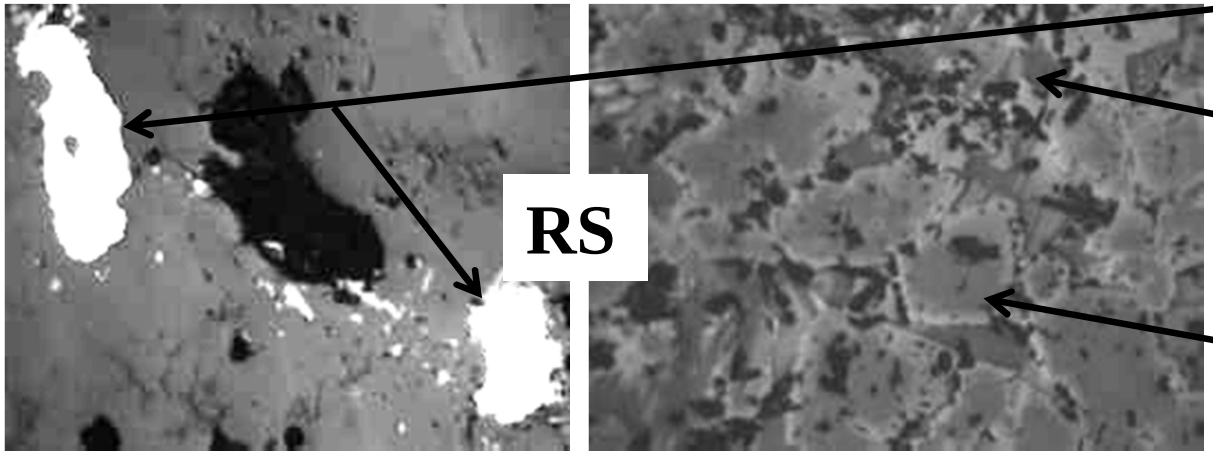
PROPERTIES - CORROSION RESISTANCE



T-2 is showing highest corrosion and penetration resistance

Minimum Corrosion

MICROSTRUCTURE AFTER SLAG CORROSION TEST



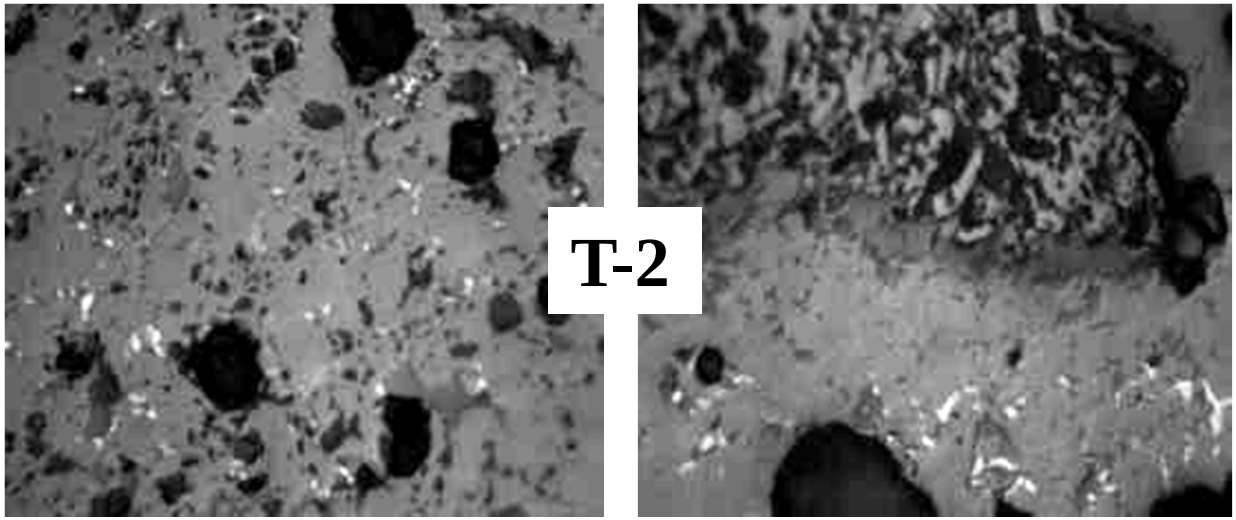
Slag penetration

Pores are filled up with low melting phases causing the structure to loosen up.

CaO & SiO_2 infiltration causes densification, thus generating internal stress

Infiltration of Fe_2O_3 & MnO from slag. The Fe^{2+} and Mn^{2+} settles into the cationic vacancies, thus deforming the spinel.
SiO_2 & CaO accelarates the reaction.

It makes the structure thermally unstable, low melting and less thermal shock resistance.



In Plant A developed Alumina Spinel bricks of formulation T-2 was sent and life achieved 198 with 3 repairs.

- During 1st repair at 55 heats, the erosion of Slag Dumping (SD) zone have been found to be improved with an SD area bricks LOT of 100 mm.
- During 2nd repair at 94 heats, erosion found in 3-4 bricks in SD area. The LOT of SD area bricks varied from 40-70 mm.
- During 3rd repair at 137 heats, only 5-6 bricks of SD zone was found eroded where as previously while using RS, all SD area bricks were being eroded. The LOT of SD area bricks varied from 40 - 60 mm.
- After the ladle was put down after 198 heats, the LOT in metal zone was 70-80mm while that of SD area is around 30-50 mm

CONCLUSION

From the above study the following conclusions can be drawn:

- It was found that formulation T-2 gave better results than the other composition.
- With addition of additive B, the HMOR increases by around 100% which is a very important property giving better corrosion resistance.
- The special additive also reduces the internal pore size of the brick. Moreover, at higher temperature, the sintering between grains are better which leads to less number of pores.
- It could be shown that addition of additive B along with high temperature firing not only improved the densification of the brick matrix but also lead to higher corrosion resistance against metal and slag.
- Same has also been proved at Plant A, where the life of slag dumping zone area bricks have increased significantly with bricks with recipe T-2.

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23-24 September

Bokaro Steel City Jharkhand India

2022

THANK YOU

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