

A Discussion on Importance of Spinel Bricks in Steel Making Processes

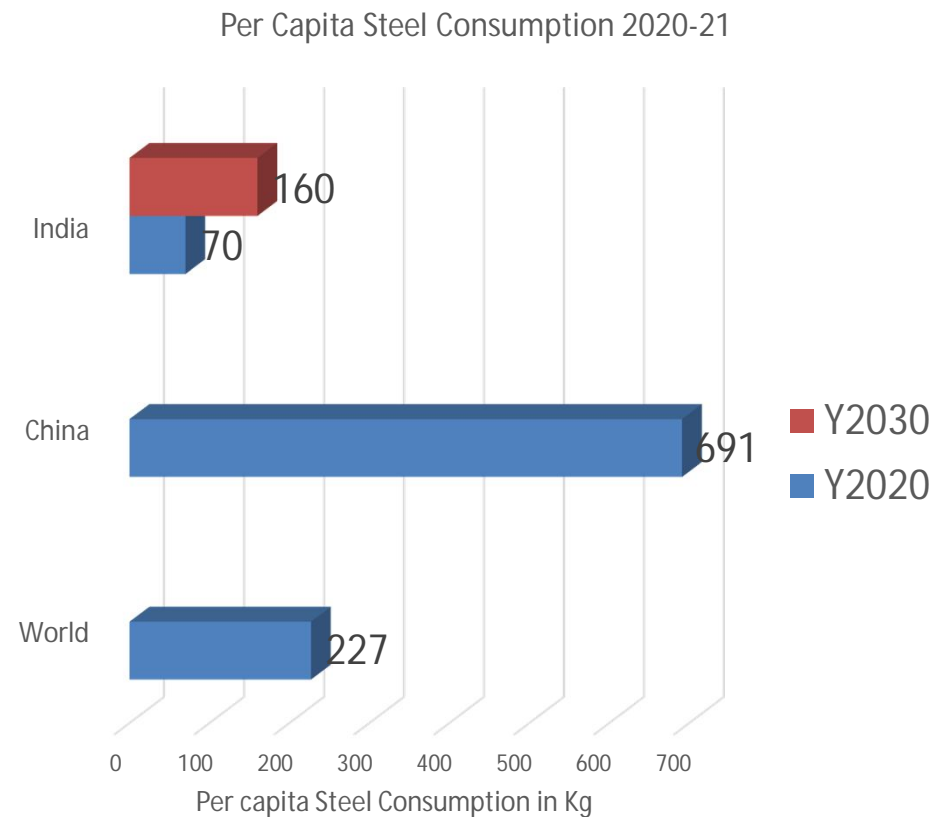
By

Deepak Mane (Head-Technical Services)

Maithan Ceramic Limited

Introduction:

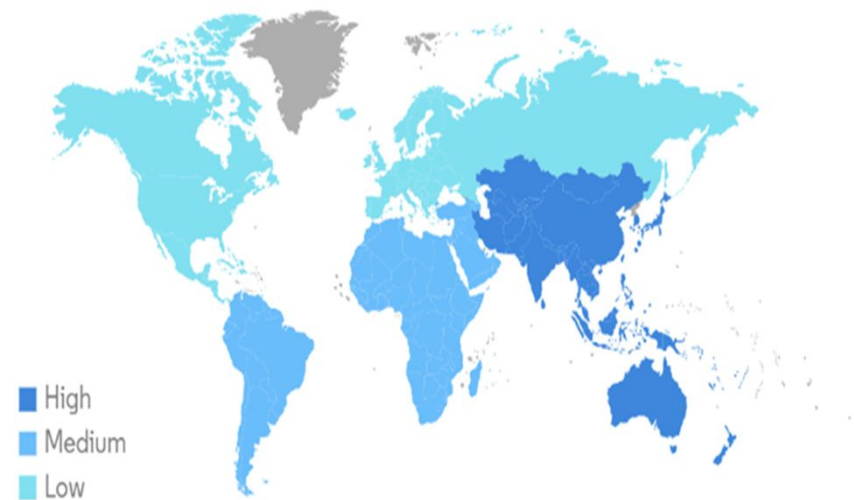
- India – 2nd largest steel producer.
- Annual production >110million tonnes. (118million tonnes in 2021)
- Production Capacity >150million tonnes.
- Ministry of Steel projection:
By 2030, Projected Annual production capacity >300million tonnes and production to reach 255million tonnes.
- Make In India Drive & the new steel policy by Govt. of India ensures domestic steel production and consumption.



Introduction: contd.....2

- “Atmanirbhar Bharat” initiative is an inspiration & driving force to Indian refractory industry.
- It has revived growth of an Indian refractory industry and growing with rapid pace.
- Jharkhand government also conducive for refractory industry in state.
- As per ‘Fortune Business Insights’ refractory market research report, global refractory market size to reach USD42.30billion by 2027 & USD44.82billion by 2029 exhibiting CAGR 4.5% respectively. However, projection is that Asia refractory market will grow at more than 5% CAGR
- Expected strong growth in India.

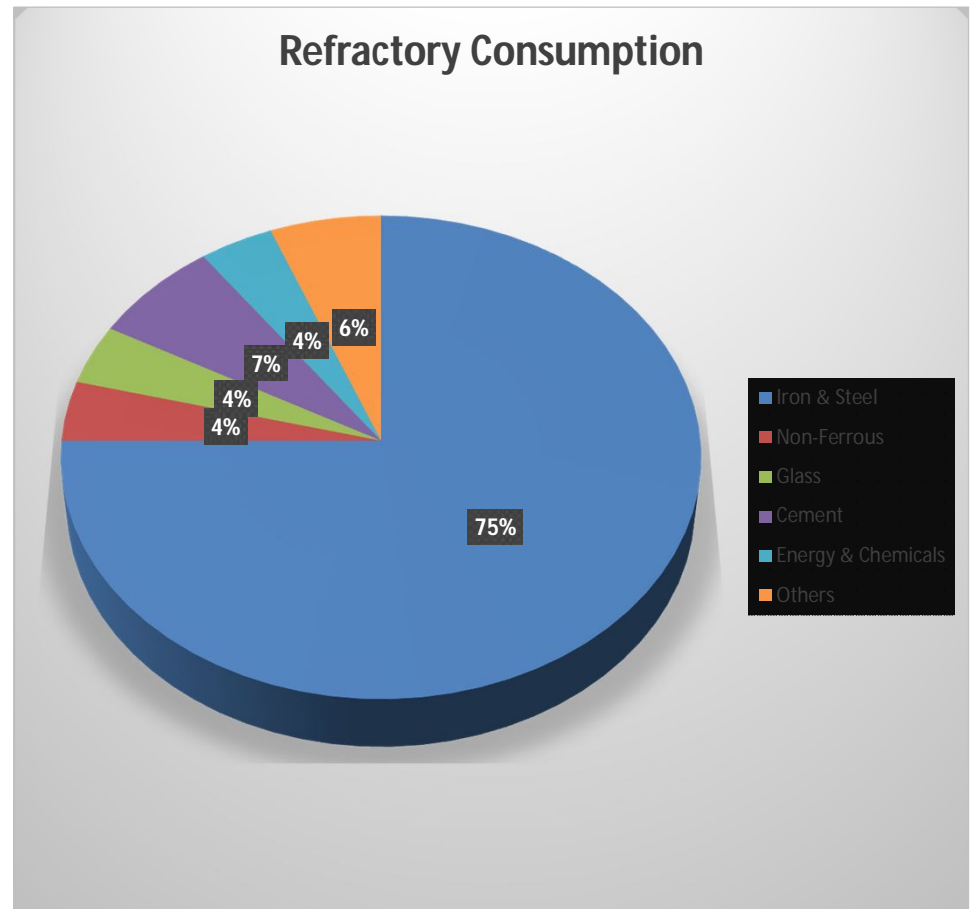
Refractories Market - Growth Rate by Region, 2022-2027



Source: Mordor Intelligence

Introduction: contd.....3

- Refractories play an important role and an integral part of many industries. Iron and Steel industry is the largest consumer of refractory.
- Technological advancements in steel making for ultra low carbon steel & higher productivity.
- Refractory industry has undergone many vital changes in terms of technological developments and raw material combinations.
- Spinel refractories emerged as carbon free refractories for steel ladles to meet process requirements of ultra low carbon steel grades.



Development – Spinel Refractories

- Refractories undergo erosion due to thermal/mechanical stresses & corrosion due to molten slag reactions.
- Carbon Containing refractories to improve
 - Slag corrosion resistance.
 - Thermal spalling resistance.
 - Thermal gradient/profile.
- Spinel refractories for IF, ULC and Electrical grade steel production.
 - Aiming no carbon pick up from refractory lining.
 - Spinel bricks for steel ladle (Metal zone & Bottom) linings.
 - Prolong ladle refractory lining campaign life.

Requirements in different zones - Steel Ladle refractory				
Property Description	Bottom	Bottom Impact	Metal Zone	Slag Zone
Hot Strength	+++	+++	+++	++
Erosion Resistance	++	++	++	+++
Corrosion Resistance	++	++	++	+++
Thermal Shock Resistance / Elasticity	++	++	+++	+++
Slag Penetration Resistance	++	++	++	+++

Development – Spinel Bricks

- Ultra low carbon i.e. 20-30ppm in IF grade steels and 50ppm in electrical grade steels.
- RH degassing to meet stringent requirements of gases removal like hydrogen and oxygen from steel.
- As an alternate solution to environmentally harmful chrome containing refractories.
- Volume stability during service.
- Better spalling resistance.
- Less slag penetration & better slag corrosion resistance.

Properties	Typical Value
Chemical Properties	
Al ₂ O ₃ (%)	94.36
Fe ₂ O ₃ (%)	0.21
SiO ₂ (%)	0.32
TiO ₂ (%)	0.02
MgO (%)	4.78
Na ₂ O+K ₂ O (%)	0.31
Physical Properties	
A.P. (%)	15.9
B.D. (g/cc)	3.10
CCS (kg/cm ²)	750
Other Properties	
Thermal Shock at 1350 °C (no of WQ cooling Cycles)	7
HMOR at 1400 °C (kg/cm ²)	95.8
PLC at 1600 °C/ 5hrs (%)	+ 0.06
RUL (t _a °C)	1720 (ND)

Advantages of Spinel bricks over conventional MgO-C bricks

- Ease of secondary refining of Ultra-low carbon Steel (IF grade steel) and No Carbon pick up in steel from refractory lining.
- To enhance MZ (Metal Zone) & Bottom lining life of ladles to increase ladle life and in succession, ladle turn-around.
- Reduced specific consumption of ladle refractories resulting in cost reduction. Also indirect savings like reduction in preheating & manpower expenses.
- Energy saving because of less heat loss due to heat radiation through ladle lining & shell. This is due to lower thermal conductivity of spinel bricks ($\approx 3 \text{ W/m.K}$) as compared to MgO-C bricks ($\approx 10 \text{ W/m.K}$).
- Spinel linings are more reliable in terms of safety as compared to conventional unfired products because any imperfection will be surfaced out during high temperature firing.
- Environment friendly refractories. Push to ecofriendly environment.
- Boost to refractories based on indigenous raw materials and reduce dependence on imported magnesia raw materials mainly sourced from China.
- Reduction in inventory and improved inventory management by having local sources & also optimization of working capital & other financial benefits.
- Spinel bricks material is recyclable by simple and hassle free processes.

Spinel Bricks – Application & results

- Alumina Spinel bricks used in ladles with heat size of 130 MT, 180 MT & 350 MT respectively. The lining pattern followed as per existing practice in the steel plant. Specific consumption is reduced & carbon pick from lining is within control limits.

Description →	Ladle Bricks Life MZ+BTM (Heats)		Specific Consumption for MZ+BTM (kg/TLS)		Carbon Pickup (ppm) during ladle refining	
	MgO-C	Spinel	MgO-C	Spinel	MgO-C	Spinel
Ladle Capacity – 130MT	140	195	0.95	0.60	NA	02-05 ppm
Ladle Capacity – 180MT	145	165	0.85	0.75	NA	02-05 ppm
Ladle Capacity – 350MT	90	110	NA	1.15	NA	NA

Spinel Bricks – Application & results

- Heat loss calculations are yet to be done. However, monitored shell temperatures throughout the campaign. Heat losses from the shell in Spinel working linings are less as compared to MgO-C working lining as shell temperature is always less by 20-30°C.

LADLE LIFE (Heats)		Shell Temperatures at Zone wise Refractory Lining Life					
		Bottom		Metal Zone		Slag Zone	
MZ	SZ	Impact	Non-Impact	Purging1	Purging2	Purging1	Purging2
0	0	121	119	119	122	144	154
0	0	129	115	125	133	145	146
1	1	146	138	169	157	194	201
11	11	174	169	171	158	191	171
22	22	194	180	180	168	190	205
35	35	217	195	187	181	202	204
40	40	207	185	176	186	199	206
45	45	215	196	197	202	225	218
80	36	228	202	209	218	228	220
95	49	235	211	227	221	256	264

Conclusions:

- Make in India – Product portfolio enrichment with superior quality new generation refractory products.
- Indigenously developed alumina-spinel bricks achieved performances higher than MgO-C bricks. Good future & more demand for spinel refractories in coming years.
 - No carbon pick up from working lining.
 - Less specific consumption of working lining refractory.
 - Cost effective solution for steel ladles (Metal zone & Bottom linings)
 - Energy savings as less heat losses in spinel bricks.
- In house developments with combinations of raw material sources yielded results. Hence reduced India's dependence on China raw materials.

THANK YOU!

MAITHAN CERAMIC LIMITED