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Paper name: Design of the State-of-Art Technology of RH Snorkel and its Performance

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Publication / Patent	**NA**

Design of the State-of-Art Technology of RH Snorkel and its Performance

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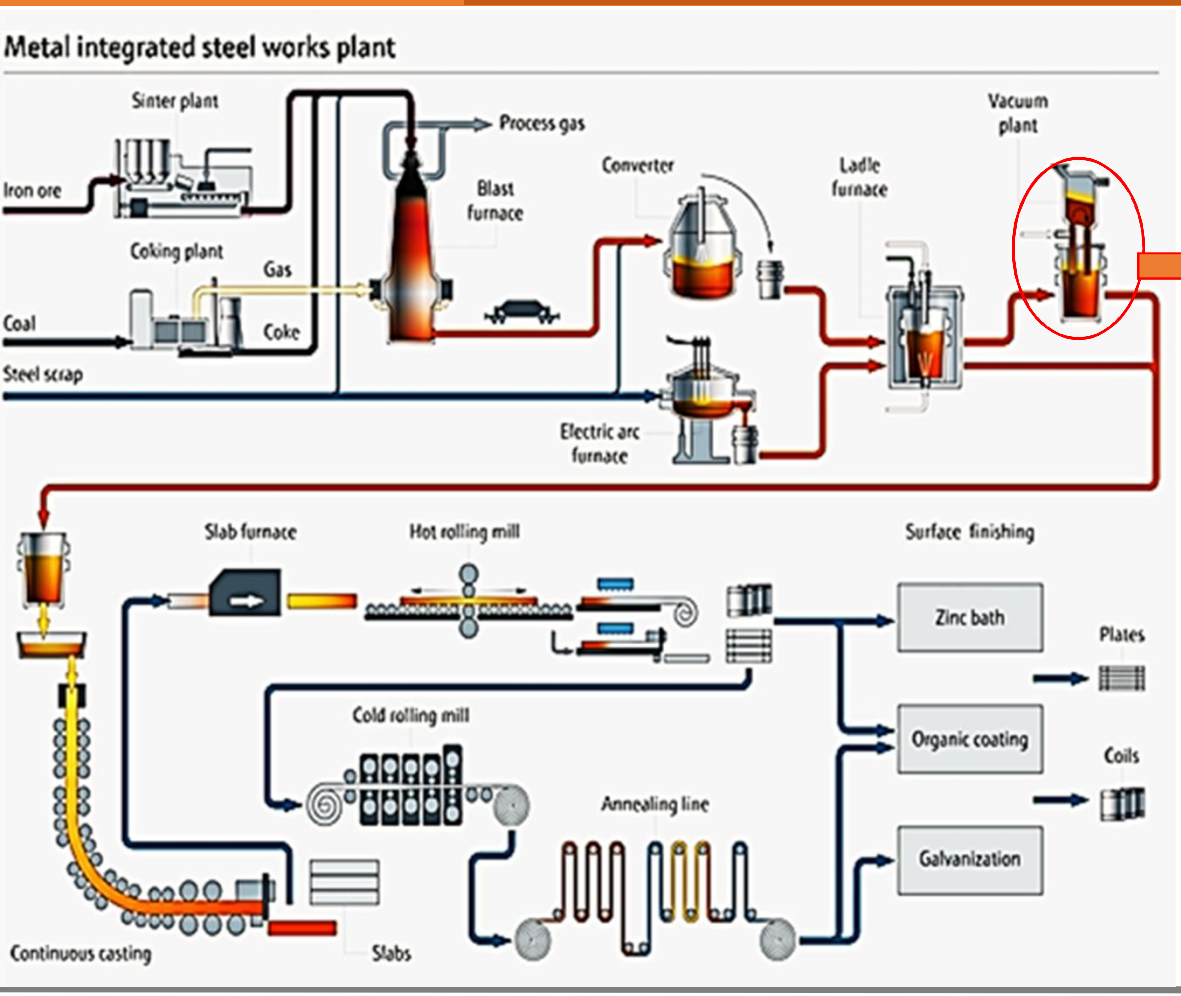
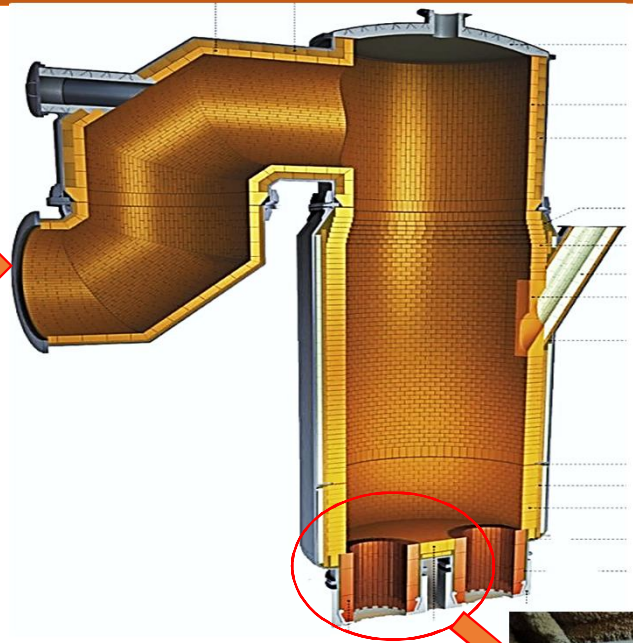
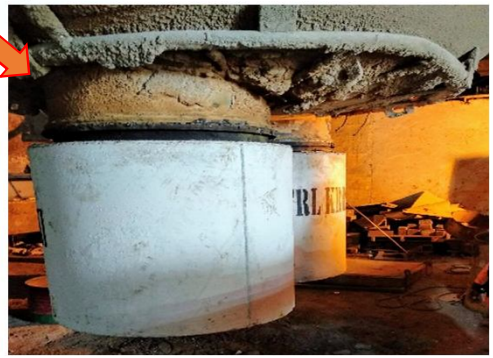
INTRODUCTION



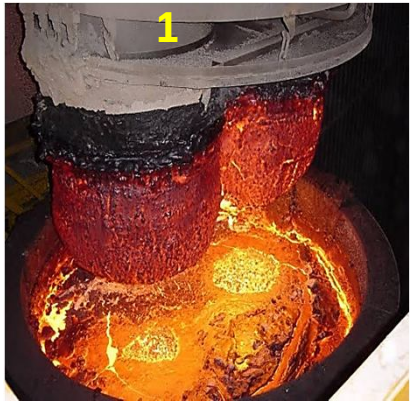


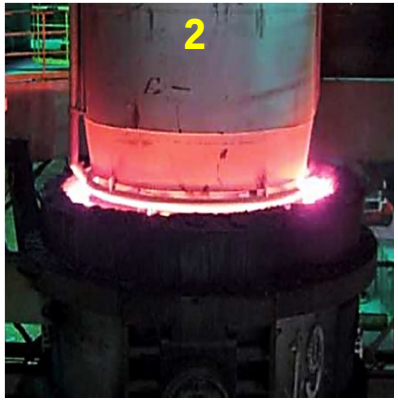


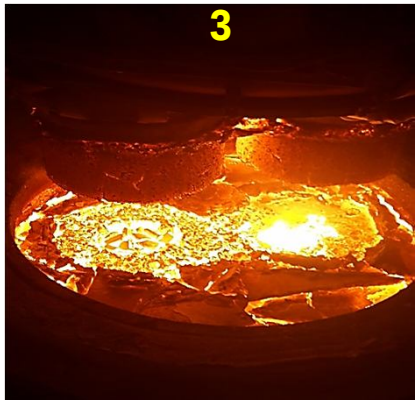
RH- DEGASSING TECHNOLOGY

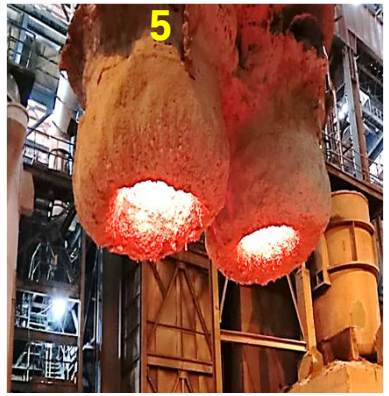
- RH (Ruhrstahl-Herraeus) De-gasser is used for manufacturing of auto-grade and higher-grade steels and the process involves decarburization and degassing.
- In this De-gassing process, RH Snorkel, which is a complex refractory assembly, inner lined with bricks and outer lined with castables over a cylindrical steel core shell is used.
- At the time of De-gassing, Steel is raised in one leg (inlet) and again it falls back into the ladle through the second leg(outlet). Argon gas is injected through the inlet snorkel to increase the molten steel velocity of steel.
- Removal of Hydrogen, Oxygen & Nitrogen gases dissolved in steel along with Decarburization raises the steel purity thereby improving its mechanical properties.

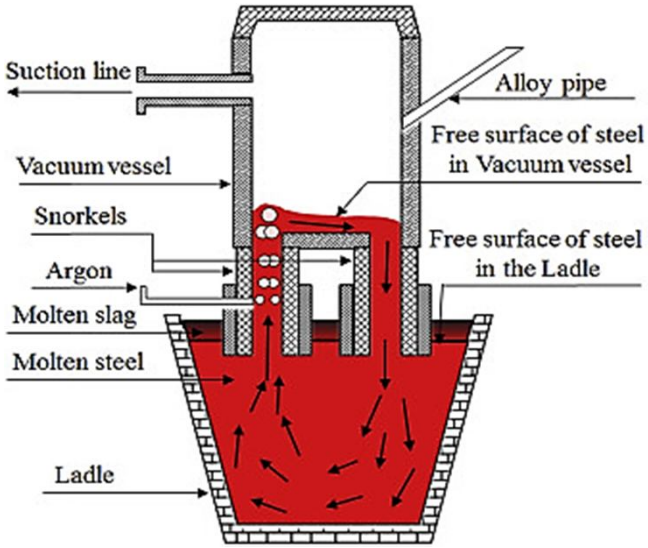
RH OPERATION PROCESS





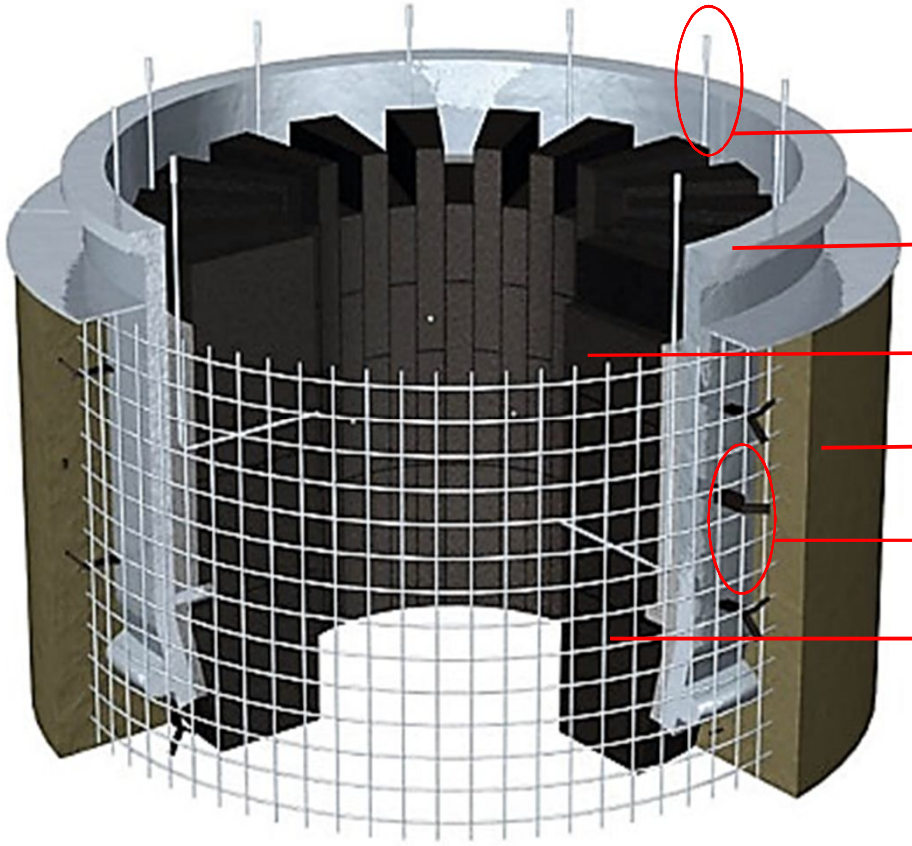






1. Steel Ladle is placed under the De-gassing Unit
2. Snorkel is dipped into the steel & argon gas is circulated
3. Snorkel is removed from steel ladle after checking steel chemistry
4. Repairing and thickness build up with Gunning refractory
5. Ready for next heat

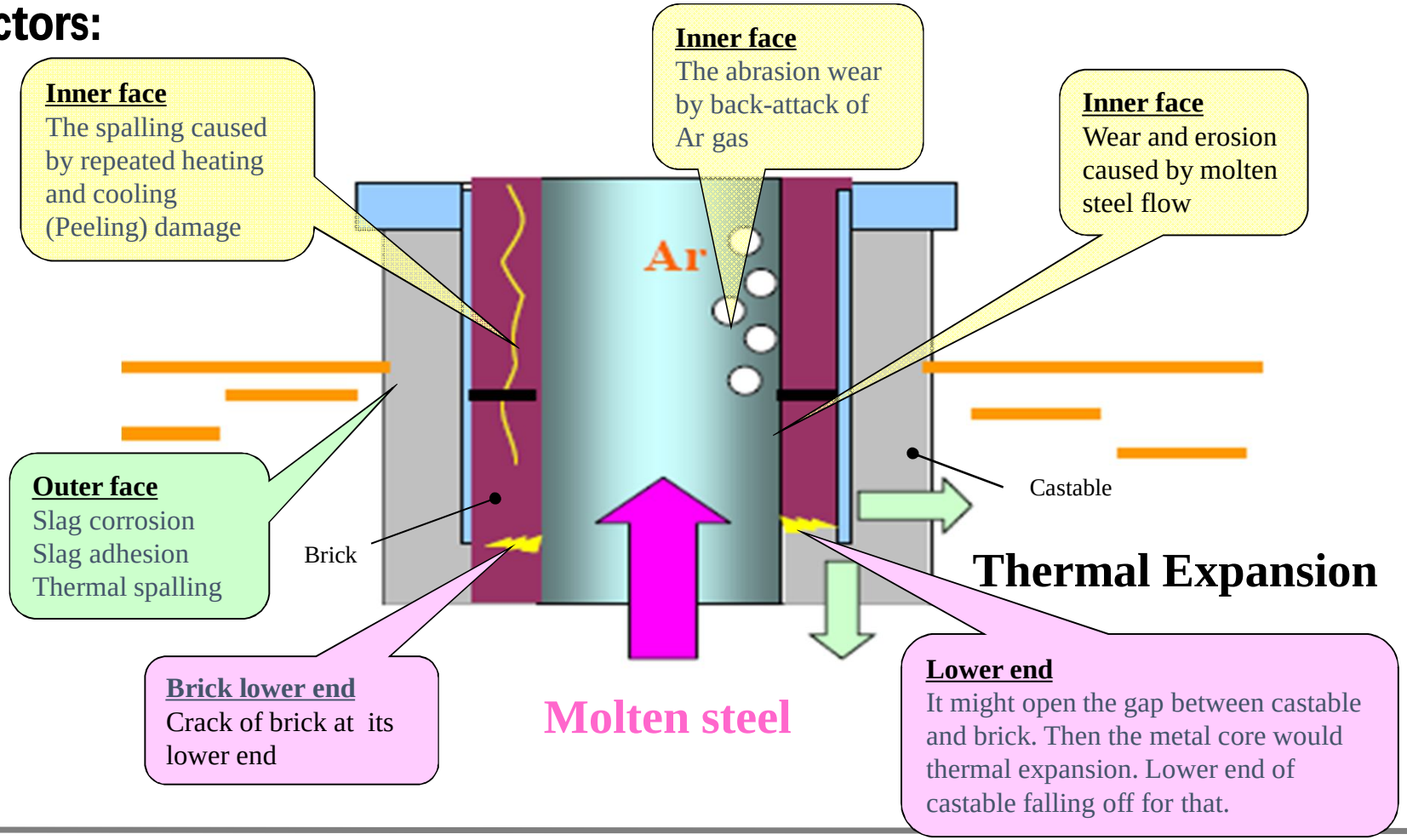
COMPOSITE STRUCTURE OF RH-SNORKEL



- ARGON - PIPE
- STEEL SHELL
- BASIC BRICK
- OUTER CASTABLE
- STEEL ANCHOR
- STEEL MESH

PERFORMANCE MONITORING PARAMETERS

Damage factors:



KROSAKI GROUP

QUALITY SELECTION CRITERIA

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

BRICK

- → VOLUME STABILITY
- → HOT MODULUS OF RUPTURE
- → THERMAL SHOCK RESISTANCE
- → HIGH RESISTANCE TO IRON OXIDE
- → NO CARBON PICKUP

CASTABLE

- → VOLUME STABILITY
- → SPALLING RESISTANCE
- → SLAG CORROSION
- → THERMAL SHOCK RESISTANCE

HARDWARE

- → HIGH TENSILE STRENGTH
- → OPTIMUM YIELD STRENGTH
- → LEAST STRUCTURAL DEFORMATION DURING HEAT LOAD
- → PROPER DIMENSION

REFRACTORY QUALITY SELECTION

- DBMC
- Mag-Carbon

- Alumina -Spinel
- Self flow

- IS-2062
- IS-2002
- IS-304

DBMC BRICK PROPERTIES

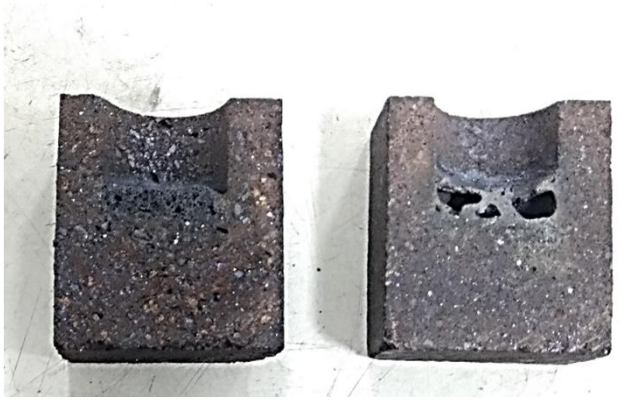
- Direct Bonded Mag-Chrome bricks are lined inside Snorkel leg
- Bricks are manufactured in high-capacity Hydraulic Presses and fired in High temperature kilns (>1800°C) with an optimum firing cycle
- Statistical Quality Control and Analysis

Parameters	Typical Values
MgO (%)	56.7
Cr_2O_3 (%)	25.2
Apparent Porosity (%)	15.2
Bulk Density (gm/cc)	3.31
Cold Crushing Strength (MPa)	75.4
HMOR (MPa) at 1500°C	8.2

Spalling Resistance

950°C to Air, no cracks are observed up to 30 cycle

Slag Corrosion



High slag corrosion resistance

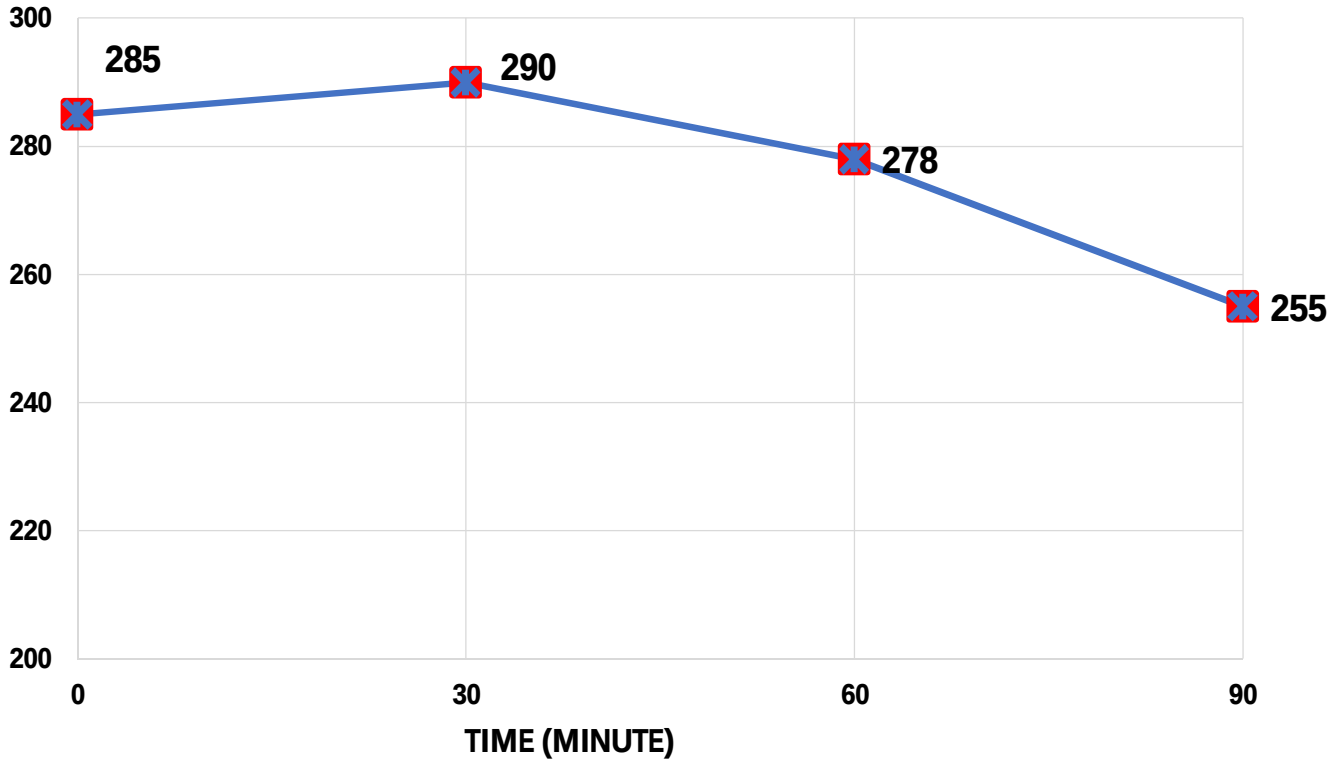
CASTABLE PROPERTIES

- ❑ Excellent Slag Corrosion Resistance
- ❑ High Mechanical Strength
- ❑ Volume stability at application temperature
- ❑ Good Thermal Shock Resistance
- ❑ Minimal tendency for crack formation during application
- ❑ Limited infiltration of slag at high temperature

CASTABLE FLOWABILITY

Free Flow @243 mm

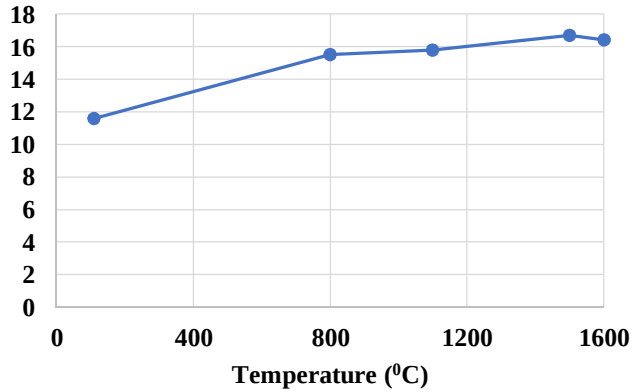
Tab Flow @272 mm



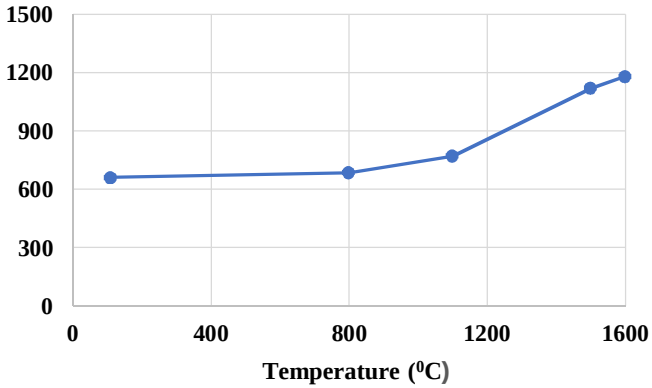
Free Flow Behaviour of Alumina-Spinel Castable is attributed to proper grain size distribution in the matrix

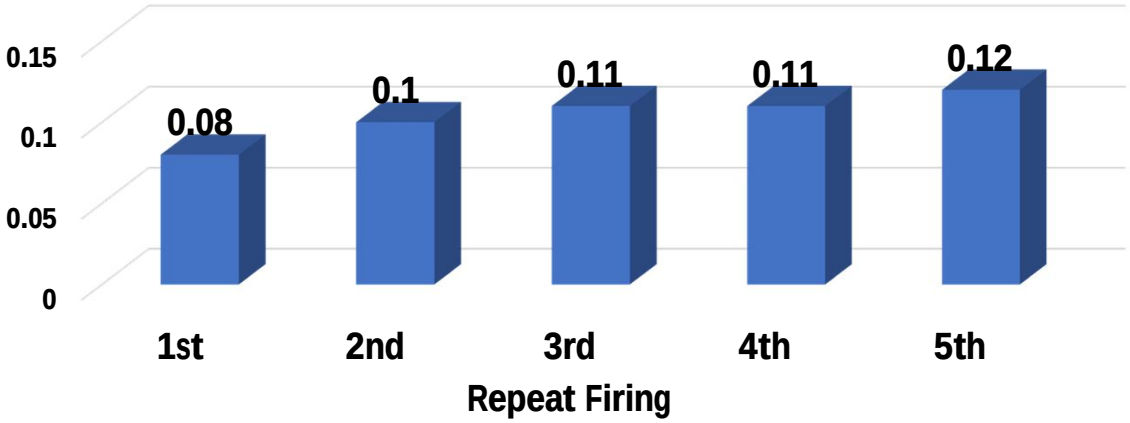
CASTABLE PROPERTIES

Variation of Porosity with Temperature



Variation of CCS with Temperature

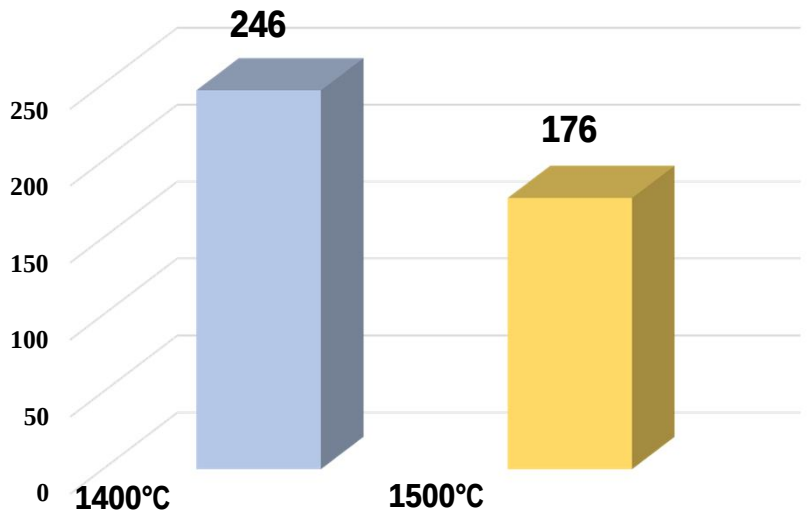




Repeat PLC measured at 1600°C

- Decrease in AP from 1500°C to 1600°C, due to sintering of castable.
- CA and CA_2 phases help in strength development after drying and firing.
- Better Volume Stability helps to prevent crack formation as well as propagation

CASTABLE PROPERTIES



HMOR at 1400°C & 1500°C

Normal castable at 26th cycle

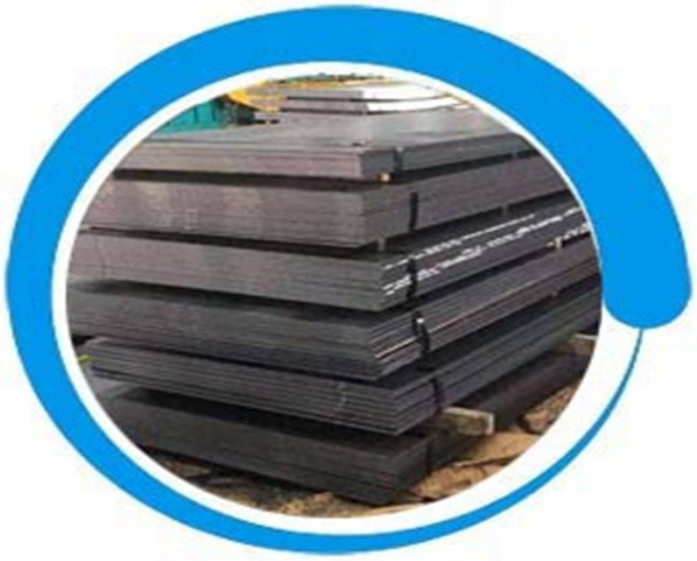
Special castable at 64th cycle

Spalling Test at 1300°C

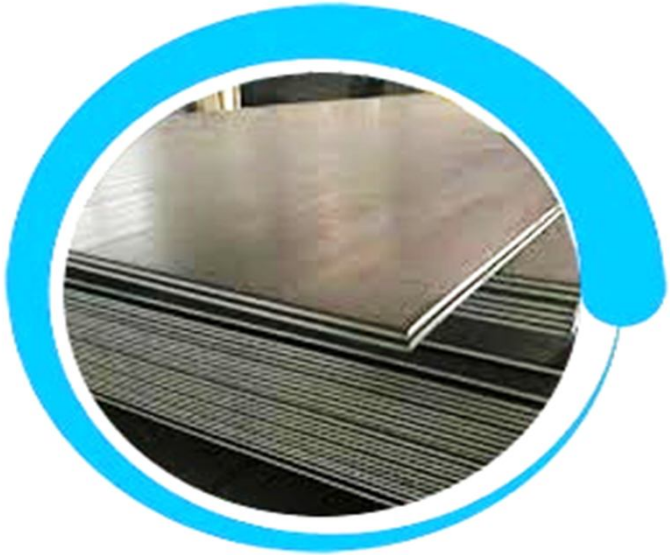
❑ Better Thermal Spalling Resistance & High HMOR at higher temperatures support structural stability during operation

HARDWARE PROPERTIES

Yield Strength (MPa)	Ultimate Strength (Mpa)	Flexural Rigidity (%)	Bending Test	C (%)	Mn (%)	P (%)	S(%)	Si(%)	(CE), Max
283	441	29	Ok	0.17	1.05	0.016	0.013	0.191	0.345



MS Grade

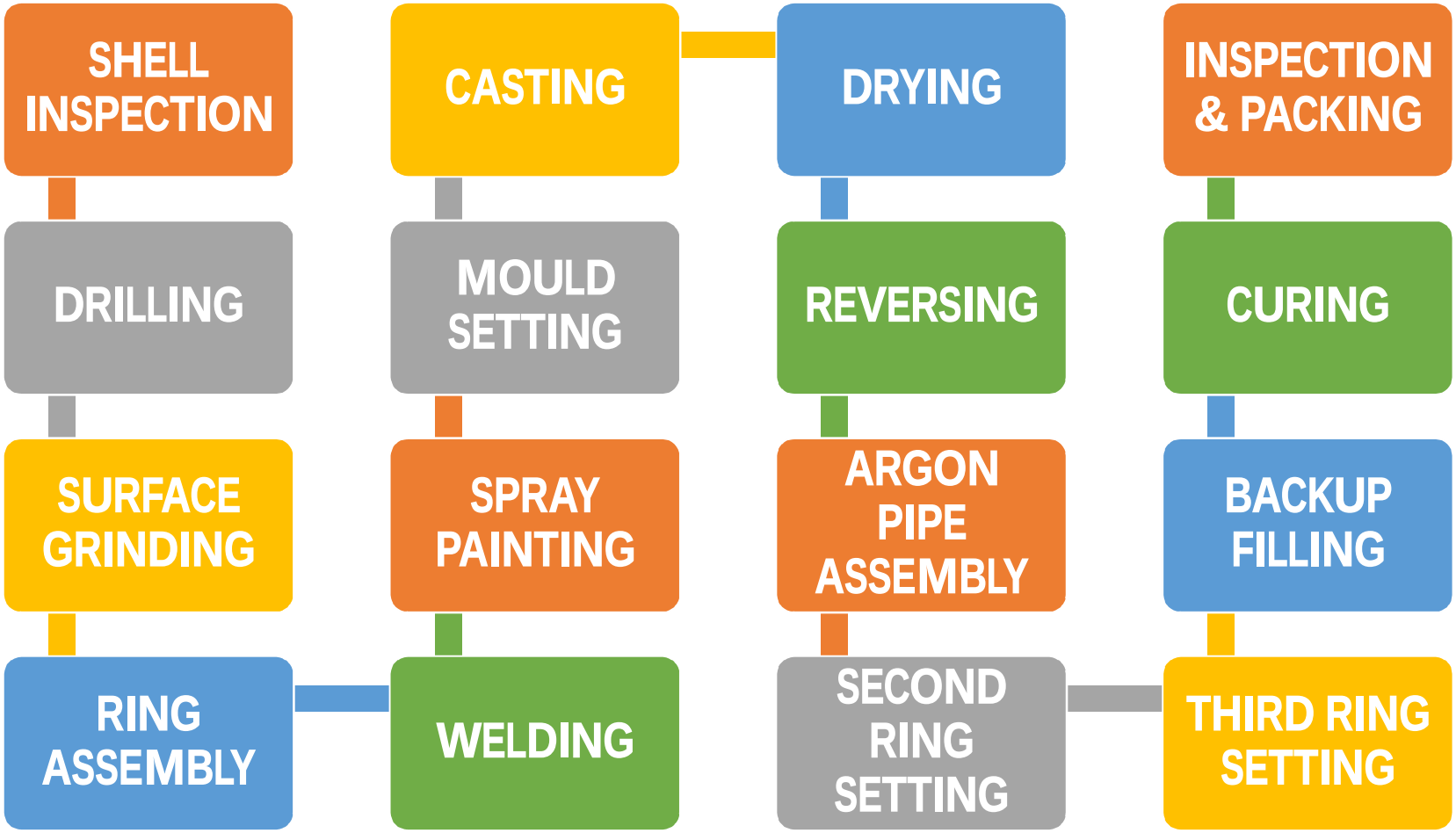


SS Grade

MANUFACTURING FACILITIES AT TRL KROSAKI

Activity	Facility	Features
Surface Grinding	Automatic Grinders	Highly Sophisticated & Automated machine capable of grinding the surface at required dimensions precisely
Drilling	Drilling Machine	Automated machine with high accuracy drill bits
Mixing	Mixer	Specially designed automated mixer machine for homogenous mixing.
Curing	Furnace	Automated furnace having high accuracy of temperature profile
Flow rate measurement	Rotameter	Customized Rotameter for measurement of argon pipe flow

MANUFACTURING PROCESS FLOW



RING ASSEMBLY MAKING

- Surface Grinding of individual bricks at micron level in automated grinders
- Zero Gaps between bricks ensures no metal penetration during usage
- Interlocking of bricks without mortar
- Zig-Zag structure assembly enhances high structural strength

FINAL INSPECTION

FLOW MEASUREMENT

SURFACE FINISHING

PACKING

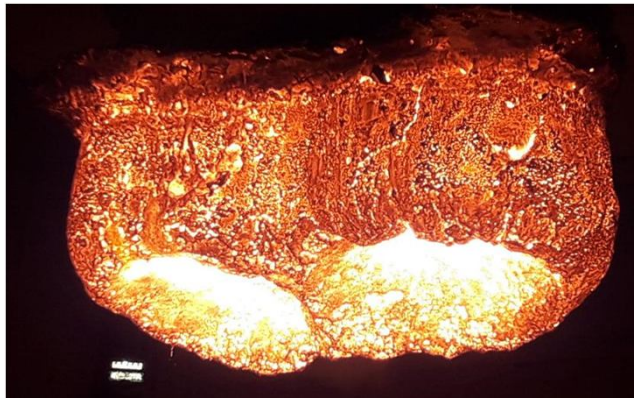
PERFORMANCE DATA

Performance data of Snorkel manufactured in TRL Krosaki at different Integrated Steel Plants

Parameters	Vacuum Treatment Time (Min)	Avg. Life (Heats)
Plant- A	33	65
Plant - B	17	103
Plant - C	25	117

After 1st heat

After 31st heat



After 115th heat

MAINTENANCE REQUIREMENTS

Damage factors: Countermeasures

Inner face
The spalling caused by repeated heating and cooling (Peeling) damage

- Suggestion to maintain proper sequence
- Good quality Refractory

Inner face
Wear and erosion caused by molten steel flow

Inner face
The abrasion wear by back-attack of Ar gas

- Suggestion to slow down lift gas flow rate
- Good quality Refractory

Outer face
Slag corrosion
Slag adhesion
Thermal spalling

- Suggestion to Proper gunning practice
- Good quality Refractory

Brick lower end
Crack of brick at its lower end

- Good quality Refractory

Lower end
It might open the gap between castable and brick. Then the metal core would thermal expansion. Lower end of castable falling off for that.

CONCLUSION

- Faster operations and the ability to perform Gas Removal, Decarburization, Desulphurization and alloy addition with precise composition control makes RH degassers superior to other metallurgical equipment like the vacuum arc degassers.

- Proper selection of bricks, castable and manufacturing of snorkel assembly is vital for performance of snorkel refractory due to the abrasion caused by the high circulation rate of treated molten steel, thermal and structural spalling by the violent temperature changes, high corrosion by the Fe-oxides containing siliceous slag and CaF_2-riched desulfurization powders attack.

- TRL Krosaki is well equipped with superior quality DBMC brick manufacturing press and kilns, high intensity monolithic mixers and state-of-the-art technology of RH Snorkel manufacturing.

KROSAKI

THANK YOU

TRL KROSAKI