STUDY OF RH REFRACTORIES AND OPERATION PARAMETERS

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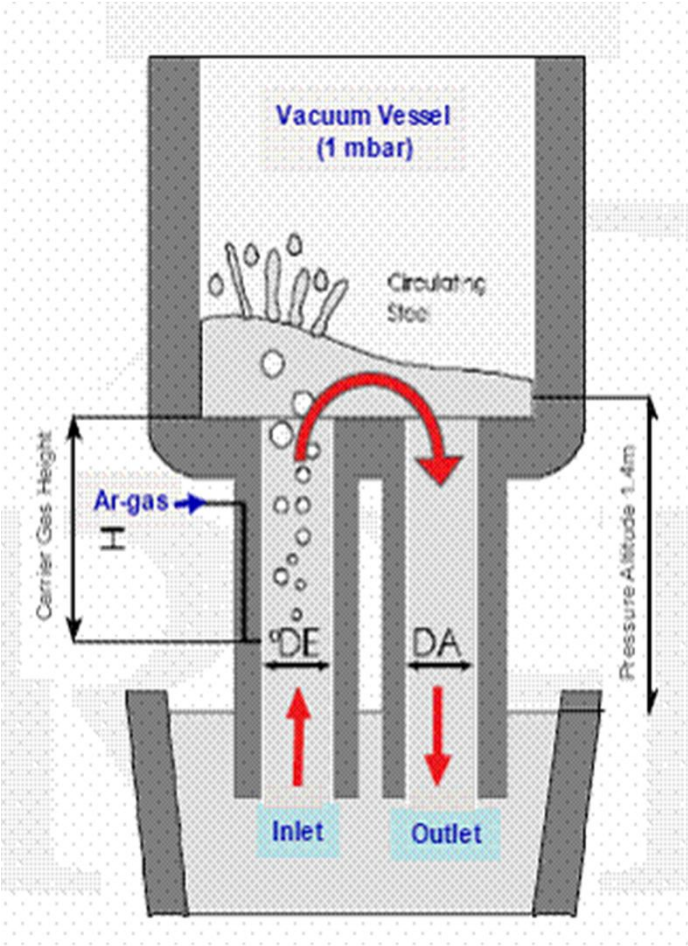
RH-Degasser

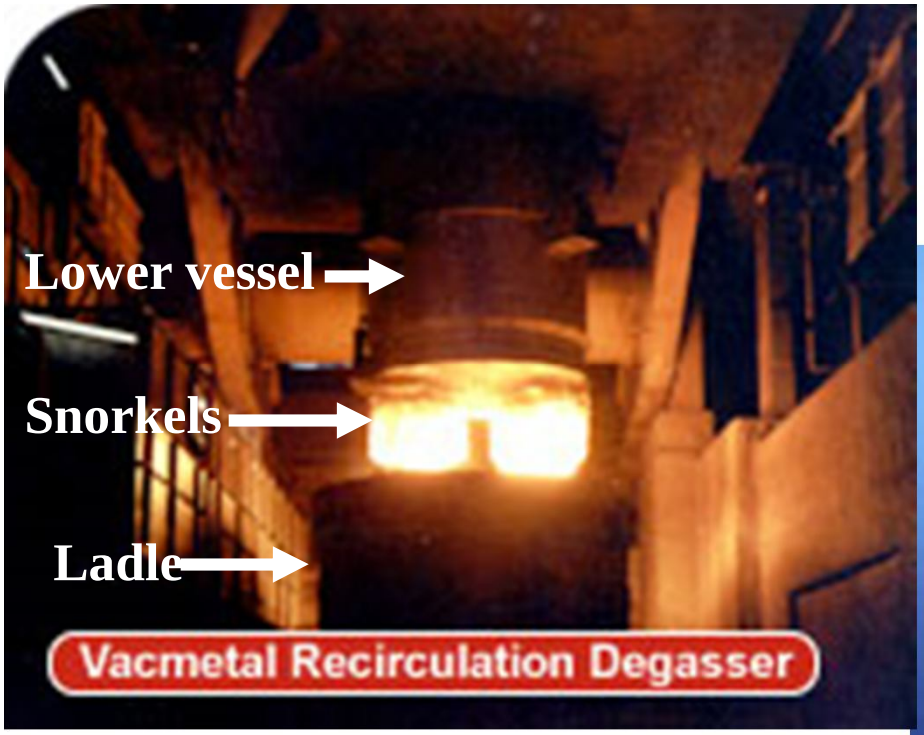
RH i.e. Ruhrstahl Heraeus named on The steel works in Ruhrstahl Germany, where the first RH-D installed & Heraeus was the main supplier of vacuum pump for the first RH- Degasser.

RH Process

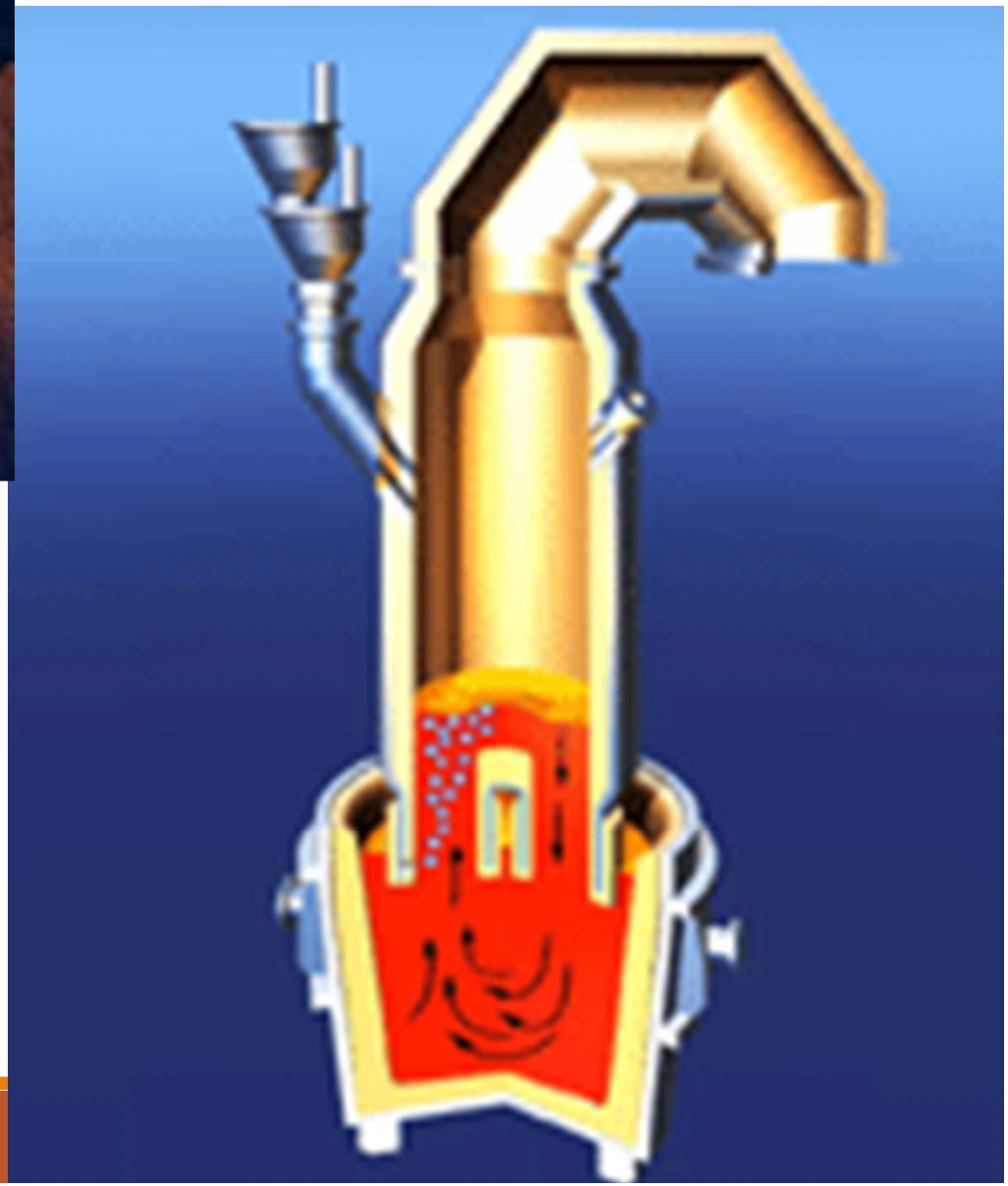


- RH snorkels are immersed in to the liquid steel up to a certain standard level. This initiates vacuum creation in the vessel.
- Molten steel is sucked upward through inlet snorkels while some level of vacuum force is maintained.
- Argon purging begins from inlet snorkel allows metal flow upward that snorkel and at the same time some metal flow downwards from the outlet snorkel. This continuous purging provides circulation of metal from ladle to both the snorkel and back to the ladle.
- Due to this circulation, the metal comes in contact with vacuum and gases are removed from the steel bath.

RH OPERATION



- *Two snorkels/legs*
- *Ar injection in up leg to pump metal in RH unit(~ 150Nm^3/Hr)*
- *Metal comes back into ladle through down leg*
- *Circulation rate(100-200T/min) depends on snorkel dia(500-750mm) & Ar flow rate(2000-3000Nlpm)*
- *No. of circulation varies 20-40 depending on process requirements*



Types of RH-Degasser

- **RH-O** : O_2 is blown on circulating molten steel in vacuum chamber from its top with water cooling O_2 lance for refining low carbon stainless steel

- **RH-OB** : O_2 blowing decarburizing and Al-adding temperature rising of circulating flowing molten steel are achieved by Ar cooling O_2 blowing nozzle installed in tuyere bricks lined in side wall of lower vessel

Types of RH-Degasser

- **RH-TOB** : O_2 blowing, vacuum decarburizing, and CO secondary combustion temperature rising of circulating flowing molten steel are achieved by the top O_2 blowing lance for producing ultra low carbon

- **RH-IJ** : Ar and desulphurization powder are injected from the molten steel below the RH up-leg through the injection lance inserting

Types of RH-Degasser

- **RH-PB** : Desulphurization powder or other powders are blown into flowing molten steel from O_2 blowing hole in side wall of lower vessel

- **RH-KPB** :Desulphurization powder and refining powder are blown into flowing molten steel from the top of vacuum chamber

- **RH-MFB** : Multifunction burner developed by Nippon Steel. Natural gas is blown during vacuum blowing refining. Combustion of gas raise steel temp. and cause less skull in vacuum chamber

RH DEGASSING PROCESS

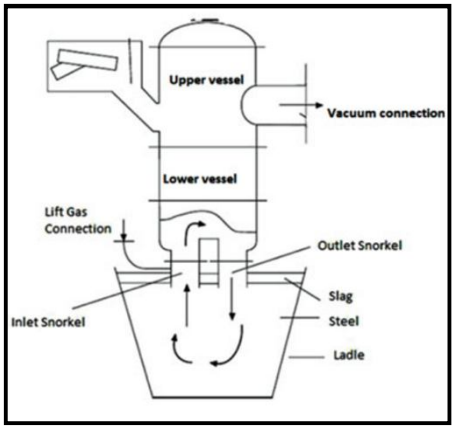


Fig: - RH Degasser Circulation

Two snorkels are immersed into liquid steel ladle.

Due to this circulation, liquid metal comes in contact with vacuum and gases are removed from the steel bath.

Molten steel is sucked upwards into the vessel due to vacuum

Argon gas is purged from inlet snorkel and liquid steel moved up through inlet snorkel.

Parameters, Unit	Value
Capacity (t)	165
Up-leg snorkel diameter(mm)	500
Down-leg snorkel diameter(mm)	500
Lift gas flow rate (Nm3/hr)	115
Oxygen Blowing method in MFB	Top blowing
Blowing O2 flow rate (Nm3/hr)	1650
Heating O2 flow rate (Nm3/hr)	420
Heating propane flow rate (Nm3/hr)	70
Blowing height(mm)	4000
Burner heating rate (deg C/min)	20-50
Vessel stroke length(mm)	2700

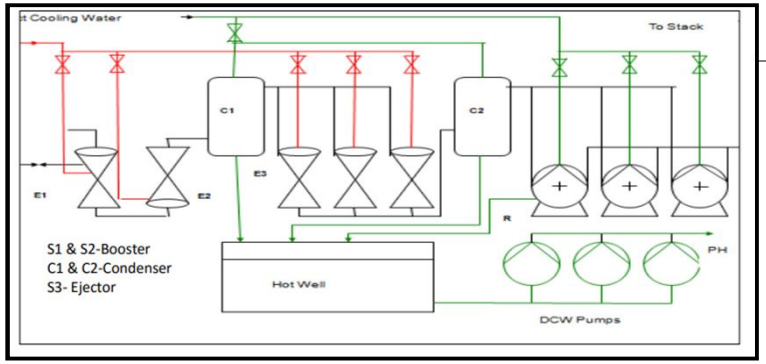


Fig: - RH Operation system

1.Steam inlet pressure- 13 bar
2.Pressure at water ring pumps- 400 mbar
3. Pressure at Ejectors- 80mbar
4.Ultimate pressure- <5 mbar

Vacuum system of RH has:-
3 water pumps
3 ejectors
2 condensers
2 boosters

Recent technology- Water ring pumps are not installed and ejectors are self-sufficient

Operating Conditions of RH refining abroad

- Refining temperature:1560-1650°C
- Vacuum degree max. : 66 Pa (0.5 Tor)
- Longest vacuum treating/heat: 40 min.
- RH degasser capacity: 265 ton
- Steel circulating quantity: 200t/min.
- Slag layer thickness in ladle: 50-100 mm
- Basicity of slag: >2.0

Operational Control of RH

- Initial temperature
- Slag conditions

* Actual Treatment Time : 10-45 minutes

* Ultra low C (30ppm) : 30 minutes

* Light treatment for low H (6ppm to 1ppm) : 10 minutes

Handling Time: 10-12 minutes

RH refractories

- Upper Vessel

Free space for steel erosion & slag corrosion

Refractories used:

-Ordinary magnesite-chrome

-Magnesia spinel bricks is also used

-MgO-C not used as its self consumption reaction in vacuum[$MgO+C \quad Mg(g)+CO(g)$]

-Al_2O_3-$MgO.Al_2O_3$ castable lining

RH refractories

Lower Vessel,Bottom& Throat
Erosion for high speed circular flow of molten steel
Refractories used:

- **Direct bonded mag-chrome bricks with high Cr_2O_3 in the matrix**
- **Fused grain rebonded mag-chrome bricks with high Cr_2O_3 in the matrix**
- **New generation mag- chrome bricks with lower porosity and permeability**

RH refractories

Lower Vessel

Future trend of Refractories :

-Chrome free bricks($MgO-Al_2O_3-ZrO_2$)

-$MgO-Y_2O_3$ bricks(new phase $Ca_4Y_6O(SiO_4)_6$ with high melting point found near hot face as a result of $CaO\&SiO_2$ in slag&Y_2O_3 in brick →

- Low carbon containing MgO-C bricks
(Fused MgO,Fine graphite2-3%with high specific surface area5$m^2.g^{-1}$, Si powder)

RH refractories

- Snorkel(Inner lining)

Errosin by high circulation,Corrosion by >2 basicity slag,Thermal&structural

Refractories used:

-Magnesite-chrome bricks with less FeO & more Al_2O_3

-Chrome free magnesia spinel bricks

- Low carbon containing MgO-C/MgO-CaO-C bricks if refining is not ultra low C steel

RH refractories

- Snorkel(Outer lining)

Directly contact with basic slag thus requires corrosion resistance

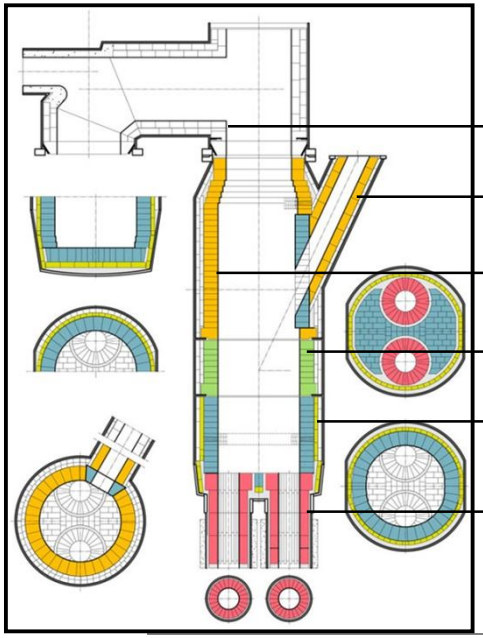
Refractories used:

-Calcium aluminate cement bonded → corrundum or high Al_2O_3 spinel castable

-Magnesia spinel castable

- Repair by Al2O3-MgO/MgO-Cr_2O_3 based injection material

RH REFRACTORIES



Offtake – DBMC bricks

Alloy chute – PCPF Blocks/Semi-rebounded magnesia bricks

Upper vessel – DBMC bricks

Middle vessel – DBMC bricks

Lower vessel – Semi re-bonded MC bricks

Snorkel (Inner)- DBMC bricks
Snorkel (outer)- Alumina castable

Fig 4: RH Lining

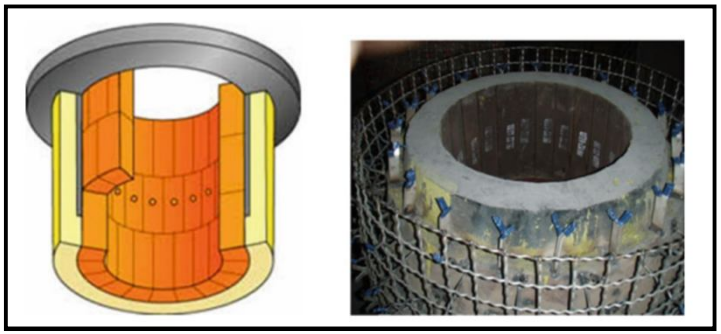


Fig 5: RH Snorkel

Application of chrome free bricks is the new emerging technology

Snorkel

Inner: -
- Mag-Chrome bricks with Al2O3 content.
- Chrome free magnesia spinel bricks.

Outer: -
- High alumina spinel castable.
- Magnesia spinel castable.

Lower vessel, bottom & throat

DBMC Bricks with high chromite content

MgO-Y2O3(alternate chrome free bricks)

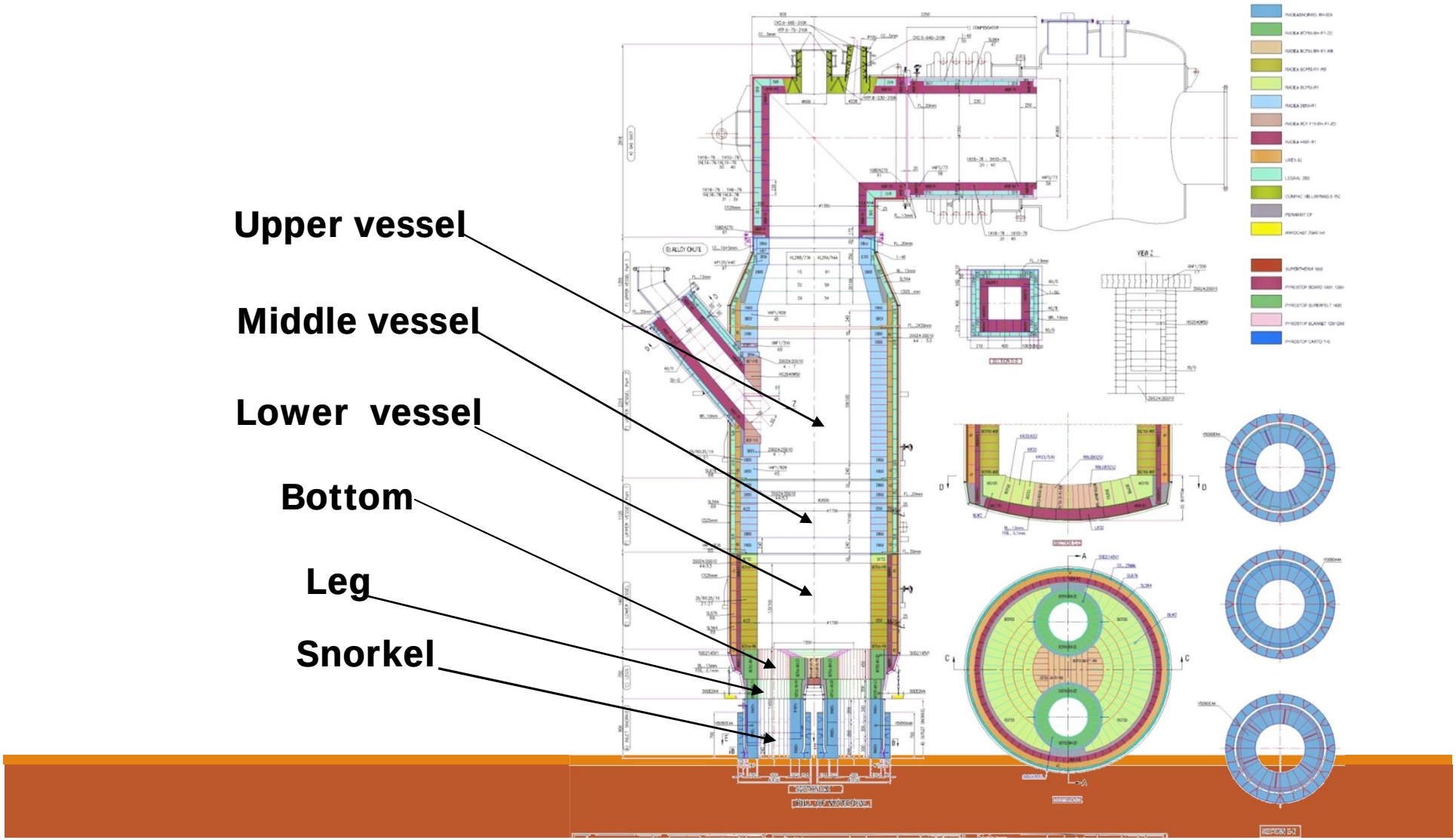
Upper vessel

Magnesia spinel bricks

Ordinary Mag-Chrome bricks

Al2O3-MgO.Al2O3 castable lining

RH Degasser at RSP



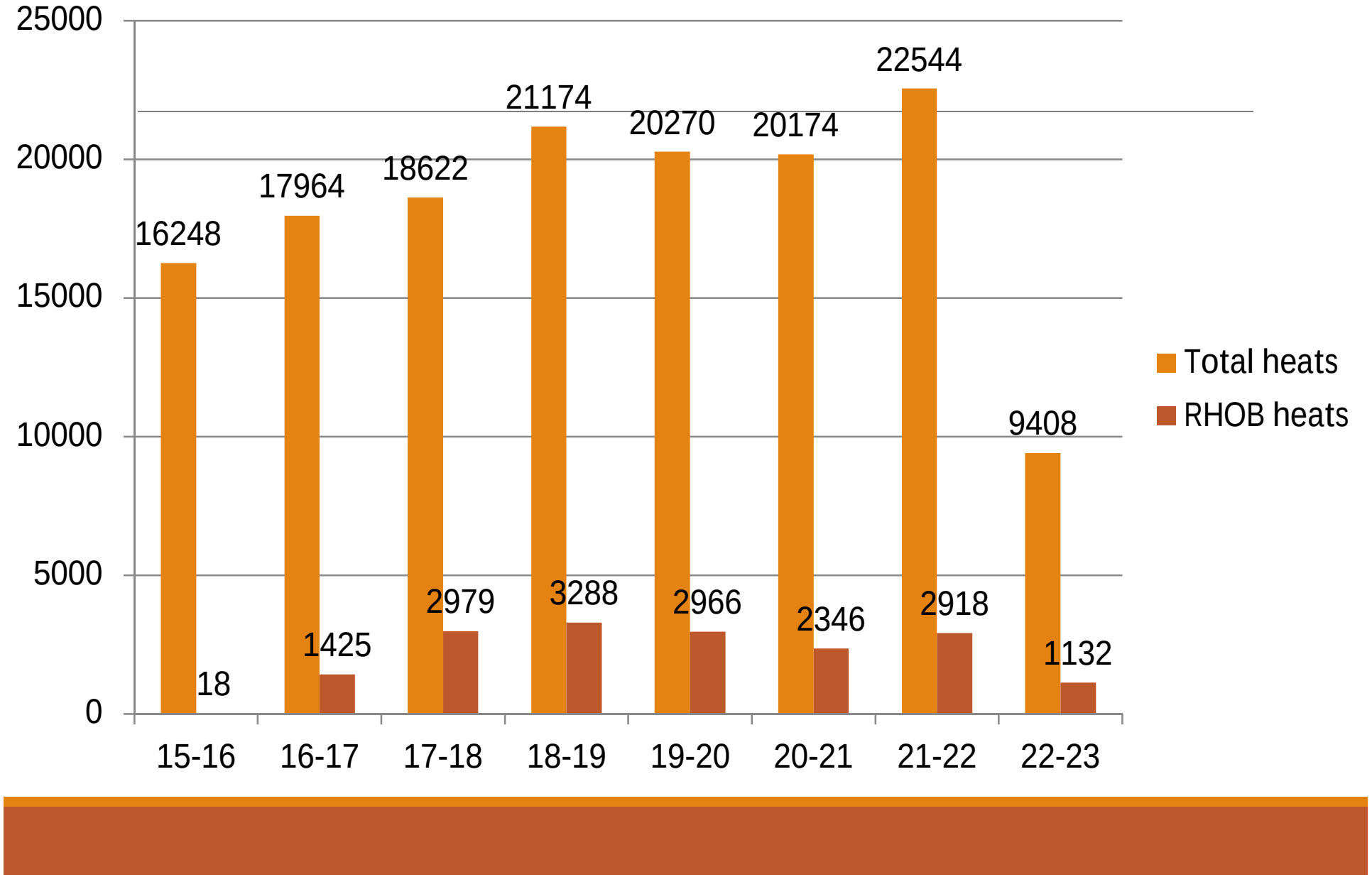
RH refractories at RSP

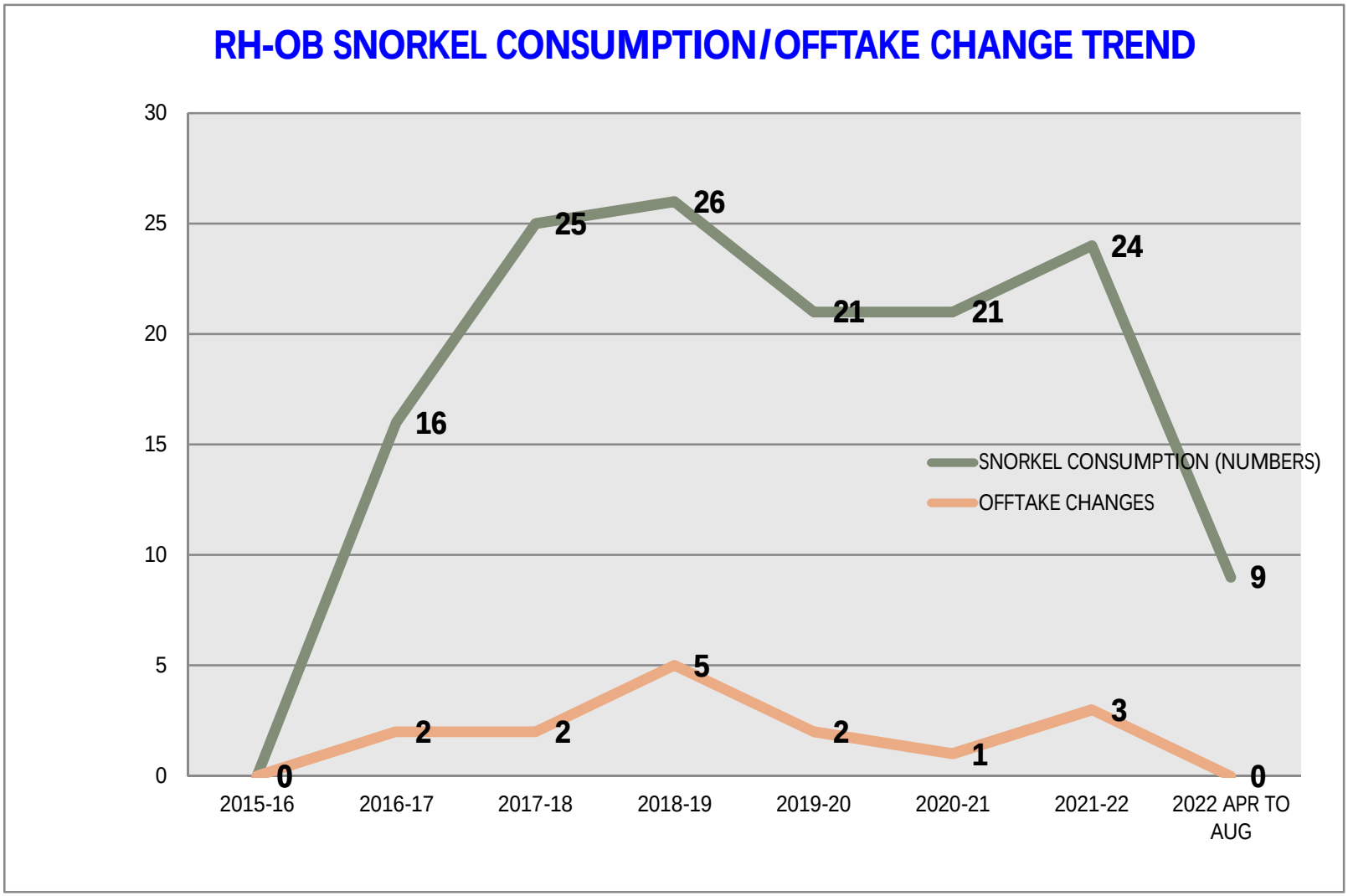
Properties	Upper vessel	Lower vessel, Bottom & Leg
MgO(%), min.	55	60
Cr_2O_3 (%), min.	18	20
Fe_2O_3 (%), max.	20	10
SiO_2 (%), max	-	1.5
B.D(g/cm^3), min.	3.25	3.0
A.P(%),max.	17	16
RUL, ^0C min.	-	1680
C.C.S(kg/cm^2),min.	550	550

Performance of RH at RSP

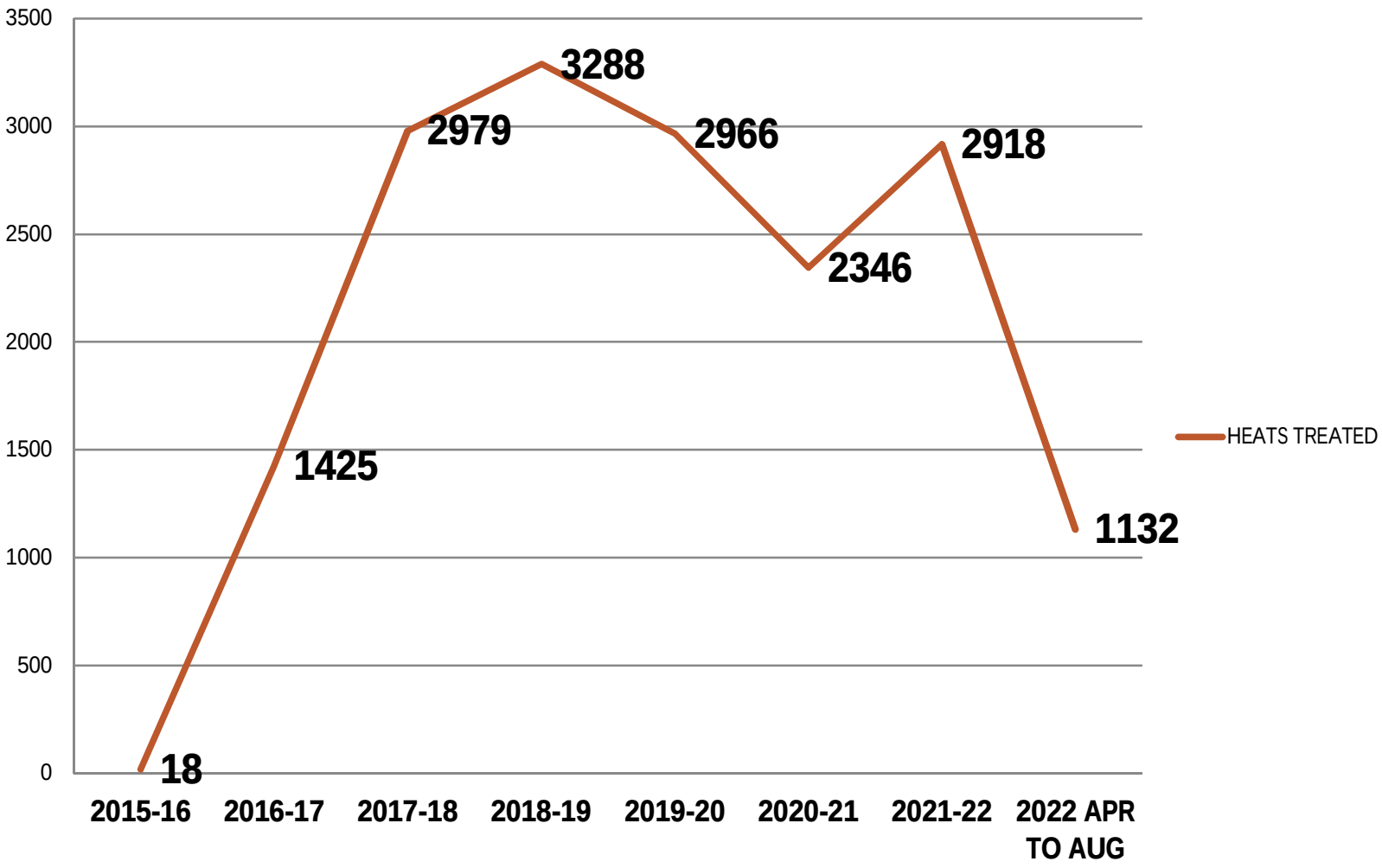
Description	Unit	RH-OB
Avg. Life of Snorkel	Heats	120
Life of Leg/ Bottom/ Lower Vessel	Heats	120
Life of Middle Vessel	Heats	6*120
Life of Upper Vessel	Years	2
Heats/day/RH	Nos	25-26
Process Time	Min.	~ 20
Refr. Materials	-	Direct Bonded Mag. Chrome

RSP Total heats/RHOB heats



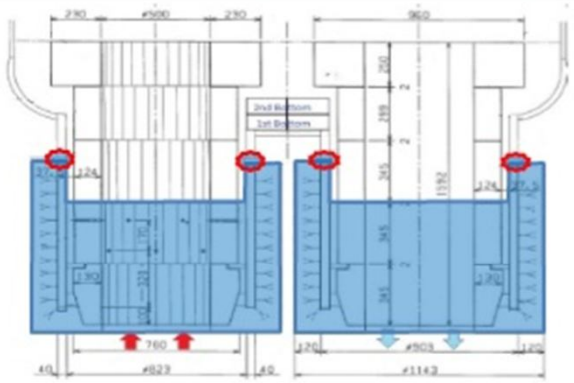

RH-OB SNORKEL CONSUMPTION/OFFTAKE CHANGE TREND
30
25
20
15
10
5
0
16
25
26
21
21
24
9
0
2
2
5
2
1
3
0
SNORKEL CONSUMPTION (NUMBERS)
OFFTAKE CHANGES
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022 APR TO AUG

HEATS TREATED RH-OB



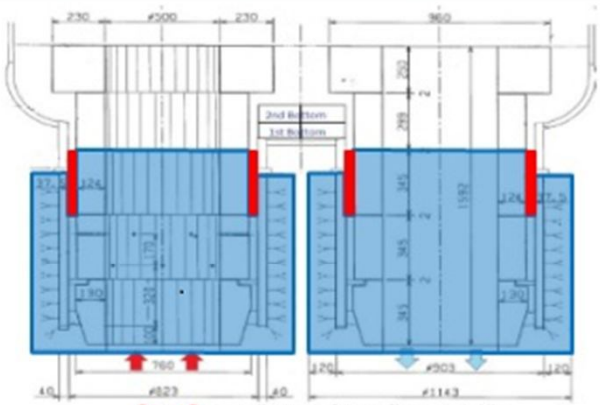
Installation of RH at RSP

(RH Snorkel & Bottom) Installation process & checklist

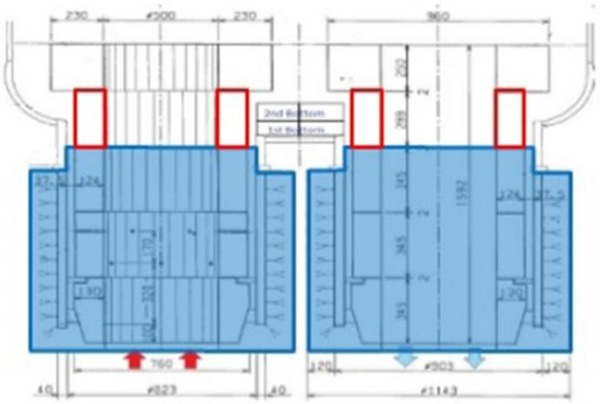


Step 1: Installation of Snorkel Up Leg & Down Leg By Welding Process

Step 2: Installation of 3rd Ring Bricks, max 2 mm Mortar. Gap between shell - **20-35 mm.** (if not- Report)

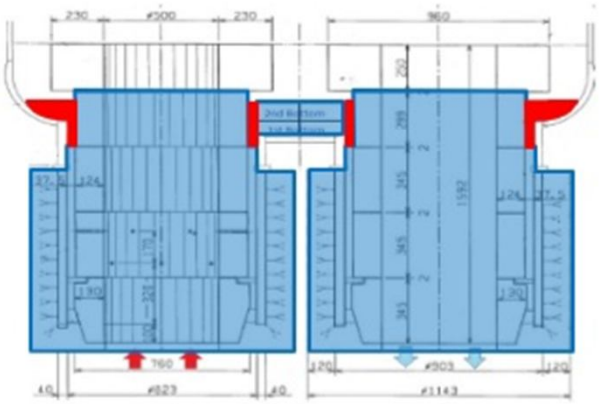


Step 3: Installation of Free flow castable



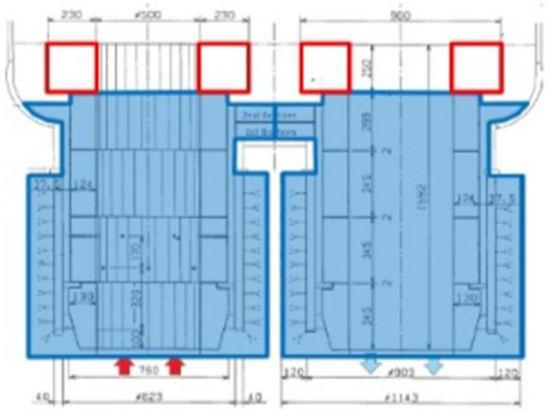
Step 4: 4th Ring Bricks installation

Step 5: Installation of 1st and 2nd layer of DBMC Safety Bricks

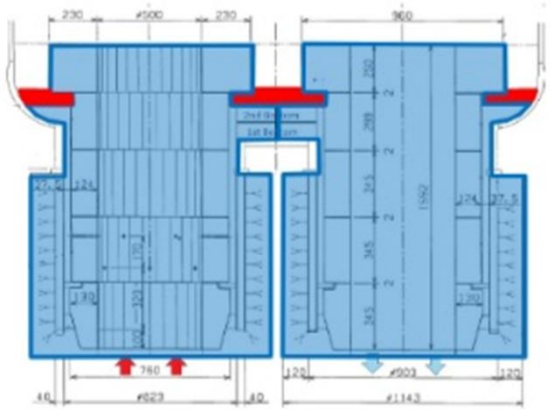


Step 6: Installation of Free flow castable upto 2nd Bottom safety layer

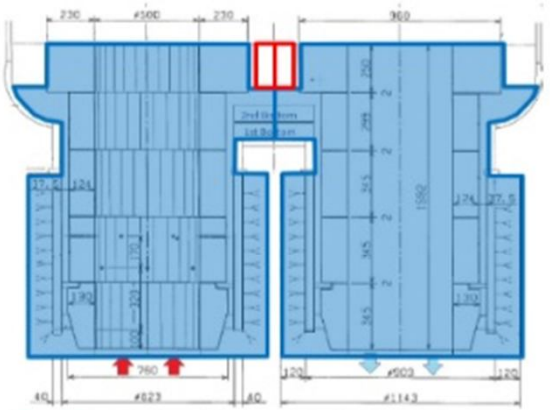
(RH Snorkel & Bottom) Installation process & checklist



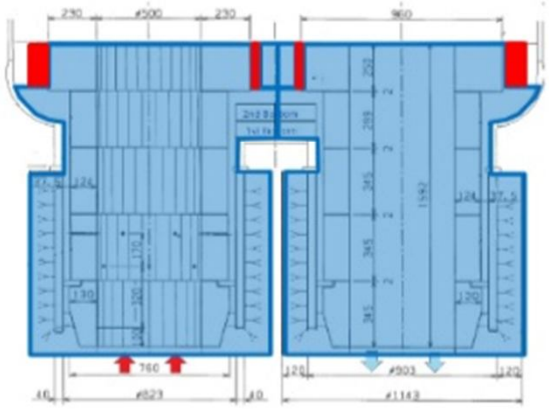
Step 7: 5th Ring Bricks installation



Step 8: Installation of Free Flow castable Layer above 2nd safety for approx.40mm (covering 5mm of 5th ring.)



Step 9: Installation of Bottom Working Lining Surrounding the 5th ring Leg bricks Gap approx. 30-40 mm



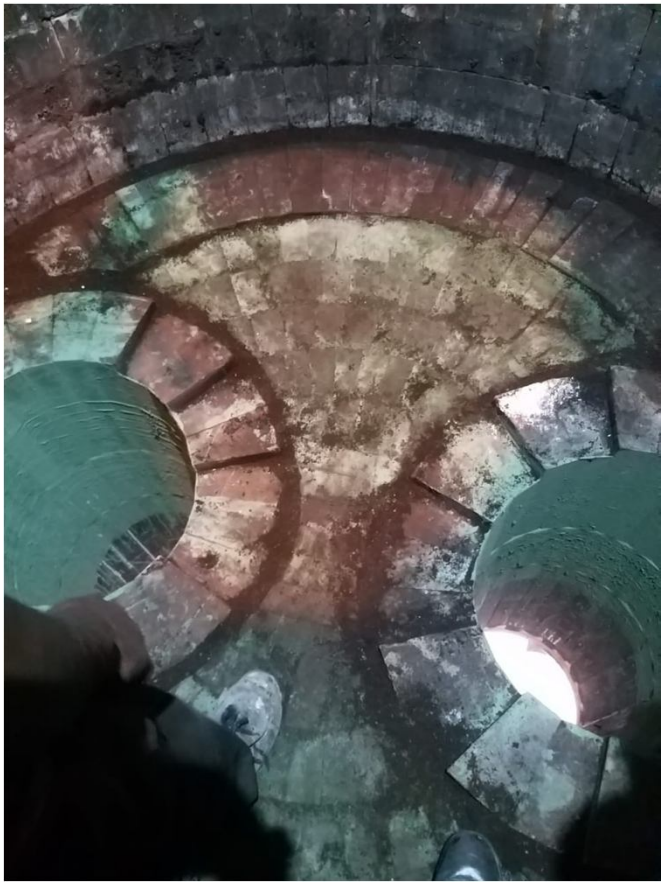
Step 10: Installation of Free Flow castable filling the gap between Ring Bricks –Bottom working lining & Side wall safety


RHI MAGNESITA


RHI MAGNESITA

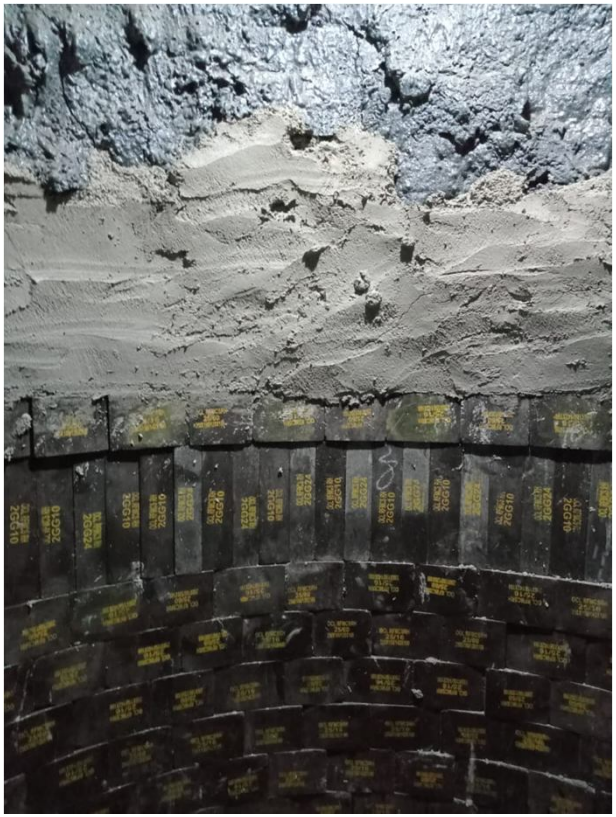
Lower and Upper Leg Installation

Bottom Installation



Bottom Casting and Lower vessel

Full Bottom casting, giving us good result



Patching between Lower Vessel and middle Vessel

MAINTENANCE AND WAYS OF IMPROVEMENT

Inner Gunning Material –
Al2O3: 73%
MgO: 15%
SiO2 : 7.3%
Outer Gunning Material –
MgO: 87%
SiO2: 5%

Ways of Improving the RH Lining: -

- Selecting one kind of steel refining in a campaign
- Operating temperature not >1650˚C
- Inner temperature not< 900˚C during non-operating.
- Regular snorkel maintenance
- Vacuum treatment time not >40min

Conclusions

- Under modernization of all steel plants RH and RH-OB will be an essential vacuum degassing units for production of ultra low C(< 30ppm),extra low H(<1ppm),extra low N(<30ppm)& special quality steels

- Selection and application of suitable bricks particularly in lower vessel and snorkel inner along with proper repair in snorkel outer are the deciding factors for increasing RH degasser life


" THANK YOU "
There's a little bit of SAIL in everybody's life