Latest Trend in Refractory Practices for RH Degasser

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Due to increase in demand of more clean steel particularly with very low hydrogen content with ultra low carbon RH degassing process is gaining popularity among the steel manufactures. RH degasser is the typical one among various secondary refining process (Degassing) due to its high refining efficiency and high productivity.

Depending on the different type stresses encountered during operation the requirement of refractories are different. On the basis of the thermo-mechanical stresses encountered the RH degasses is broadly divided in four zone i.e. Snorkel, Lower vessel, Upper vessel and uptake.

On top of that the well balanced uniform life is required for each segment for efficient furnace operation.

Conventionally direct bonded magnesia chrome has been chiefly applied to different area of RH degasser but due to environmental problem now MTA and Mgo-C are increasingly popular. But due to some inherent problem still Mgo-C has not find its way and till date direct bonded magnesia chrome are still the choicest refractories.

Refractories for RH Degasser Uptake

The main requirement of uptake refractories is resistance against thermal spalling and corrosion against the gaseous product. Mainly direct bonded magnesia chrome is employed having low apparent porosity and high spalling resistance backed up by insulation refractories.

Refractories for RH Degasser Upper Vessel

Upper vessel is exposed to repetitive heating and cooling when the lower vessel is exchanged. Upper vessel is corroded by FeO when oxygen top lance is employed from the vessel top to melt down the skull. Requirement of top vessel refractories are good spalling resistance, low apparent porosity and superior hot strength.

Still direct bonded bricks based on magnesia chrome are the most preferred refractories due to high hot strength and superior spalling resistance.

Refractories for RH Degasser Lower Vessel

The lower vessel refractories are subjected to thermal spalling due to intermittent operation and corrosion against the violent erosion by FeO produced during oxygen blowing through the lance inserted from the furnace top. Above, all the bricks lined in the throat, bottom and leg connecting to snorkel are exposed to severe operating condition and abrasion against metal. Bricks having superior hot strength at operating temperature are requested to have balanced life.

Refractories for RH Snorkel

Generally the snorkel is a complicated refractory assembly which is inner lined with brick and outer lined with castable on the cylindrical steel shell. The inner lined bricks are abraded by gas blowing and metal where high hot strength at operating temperature is required. Also the

outer castable lining is subjected to corrosion due to carry over slag.

Design & Manufacturing Process

The physical-chemical properties of raw materials used to manufacture direct bonded dense magchrome refractories are shown in Table-1.Optimum grading of these raw materials are selected added with special additives to achieve optimum density. Compositions were formulated & mixed with green binder in a high intensive mixer. The mixture was formulated to brick shapes with a specific pressure greater than 2000kg/cm2. The green bricks are dried and fired at temperature more than 1700°C in tunnel kiln. Physical, chemical, thermos-mechanical, pyro-chemical and mineralogical properties are evaluated and discussed in subsequent chapters.

TABLE -1 : PROPERTIES OF RAW MATERIALS

CA (wt%)	FMCR	Chrome	Eskolite	SWM	DBM	FM
MgO (%)	62	11.9		98.4	97.5	98
Cr2O3 (%)	21	59.6	97.5	==	==	
SiO2 (%)	0.82	0.41		0.15		0.5
Fe2O3 (%)	9.7	18.5		0.44		0.5
Al2O3 (%)	5.9	8.9		==	==	==
Physical Properties						
Grain B.D. (gm/cc)	3.79	==	==	3.42	3.40	3.53
TP (%)	3.6	==		4.3	4.5	1.5

Rebonded Fused Grain Refractories for Critical Area:

In RH degasser the refractory part i.e. snorkel leg, bottom and lower vessel undergo severe erosion by metal and corrosion along with thermal spalling. These areas require refractories with low porosity, high resistance to corrosion, erosion and thermal spalling. Properties of these bricks are given in Table no 2. Properties of monolithics required for Snorkel and adjoining area of leg and bottom is given in Table No. 2A.

TABLE - 2 : PROPERTIES OF REBONDED FUSED GRAIN BRICKS.

Formulation	A	B	C	D	E
Fused grains	****	***	***	**	**
Magnesia				*	*
Chromite				*	*
Special Additive - A		*	*	*	*
Special Additive - B			*	*	*
CA (wt%)					
MgO	61.5	60.5	58	67	56.5
Cr2O3	20	20.5	24	20	26
Al2O3	4.8	7	6.5	6.5	6
Fe2O3	10.2	7.5	6.5	4.5	5
SiO2	0.8	0.8	0.7	0.7	0.7
Physical Properties					
AP%	14.5	15.1	14.6	14.8	15
BD (gm/cc)	3.30	3.28	3.32	3.30	3.34
CCS (kg/cm2)	950	920	875	925	850
MOR (kg/cm2)	125	122	115	118	107
Thermal & Thermo-mechanical Properties					
HMOR at 1500°C	75	82	85	88	92
RUL Ta°C	>1750	>1750	>1750	>1750	>1750
Spalling DIN 51068/Air	35	60	70	75	75

TABLE 2A : PROPERTIES OF MONOLITHICS

CA (wt%)	M1	M2	M3
MgO	==	2.5	58
Cr2O3	==	==	24
Al2O3	97	94	6.5
CaO	2	2	==
SiO2	0.1	0.1	0.5
Physical Properties			
CCS (kg/cm2) After Drying at 110°C/24 Hours	600	600	500
BD (gm/cc)	3.0	2.95	3.2
CCS (kg/cm2) After Firing at 1000°C	450	420	300
MOR (kg/cm2) After Firing at 1000°C	100	100	75
CCS (kg/cm2) After Firing at 1500°C	750	750	450
MOR (kg/cm2) After Firing at 1000°C	125	125	90

Partially Rebonded and Direct Bonded Bricks for Other Area

Other area like middle vessel, upper vessel, uptake and alloy chute undergo less severity than the critical area refractories. For these areas bricks made from partially rebonded grains are more suitable to have a balanced life. Properties of these bricks are compared in Table 3.

TABLE - 3 : PROPERTIES OF DEVELOPED BRICKS.

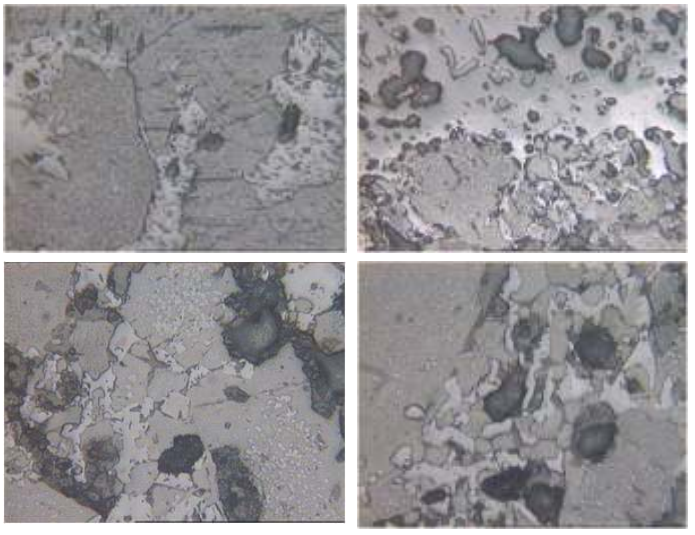
Formulation	F	G	H	I
Fused grains	***	***	**	**
Magnesia	*	*	*	*
Chromite	*	*	**	*
Special Additive A		*	*	*
Special Additive B			*	
CA (wt%)				
MgO	61.2	59.5	55.3	60.5
Cr2O3	20.8	20.1	25.2	18.5
Al2O3	5.1	6.8	5.1	5.2
Fe2O3	9.6	8.1	11.4	9.8
SiO2	1.0	0.9	1.0	1.5
Physical Properties				
AP%	16.5	16.1	15.8	17.8
BD (gm/cc)	3.23	3.24	3.29	3.19
CCS (kg/cm2)	750	720	675	625
MOR (kg/cm2)	110	108	89	78
Therml and Thermo-mechanical Properties				
HMOR at 1500°C	52	48	55	41
RUL Ta°C	>1700	>1700	>1700	>1700
Spalling DIN 51068/Air	55	75	70	50

Microscopic Evaluation

Photomicrographs of fused grain series shows large crystal of spinel mostly in metasomatic form.Magnesia grains show high degree of exsolution. Photo micrograph of partially rebounded bricks show metasomatic, porphyritic and exsloved spinel. Magnesia grains show high degree of direct bonding with chromite. Magnesia grains also show exsolution phases. Photomicrographs of Rebonded fused grain bricks are given in Fig no 1. To Fig 3.

FIG. 1 X 2000 BRICK A REBONDED FUSED GRAIN

FIG 2 X 200 BRICK B REBONDED FUSED GRAIN



Conclusion

In RH degasser refractories are subjected to different type of thermal, thermos-mechanical and pyro chemical stresses. Refractories selection for different areas are based on simulative testing and operating condition of the furnaces which has direct bearing on the raw materials used , firing temperature and atmosphere.