An insight into the properties of magnesite and magnesite-chromite refractories for ferro-chrome industry

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ABSTRACT

A few qualities of magnesite and magnesite-chromite bricks and magnesite ramming masses manufactured indigenously are being used in making ferro-chrome alloy in India. In this paper an attempt has been made for evaluating different qualities of magnesite and magnesite-chromite refractories by studying the relevant physico-chemical properties. As the bricks are to withstand severe corrosion and erosion by the molten metal and slag at high temperatures, the mineralogy, microstructure and the modulus of rupture at different temperatures were studied. The hot modulus of rupture values are correlated with the mineralogical compositions of the bricks. A ramming mass based on sea water magnesia has been developed for chute area application and the detailed properties of the same are given.

Introduction

Basic refractories are one of the best suitable building materials for lining the ferro-chrome making furnaces and ladles. A few qualities of magnesite and magnesite-chromite bricks and magnesite ramming masses manufactured indigenously are being used in making ferro-chrome alloy. In this paper, an attempt has been made to evaluate some of the qualities of magnesite and magnesite-chromite refractories manufactured in India. In magnesite bricks, MGR, MGW, MGD and MGD(I) qualities and in magnesite-chromite bricks, MCR, MCN, MCL and MCD qualities being commercially manufactured indigenously are taken up for a detailed investigation. Since there is a wide spread interest these days in the hot strength properties of basic refractories, besides determining the physico-chemical properties, the microstructure and hot M. O. R. at different temperatures for the bricks under study were also carried out.

A number of workers have undertaken the study of hot strength properties of basic bricks and tried to correlate the high temperature

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strength data with chemical and mineralogical composition of the bricks, firing temperature and other parameters of the manufacturing process. Attempts have also been made to find out correlation between hot strength and service performance of the basic refractories. In this paper, some of the important data from the published work on hot strength of basic bricks have been concised and these results have been compared with the hot strength results of commercial brands of indigenous magnesite and magnesite-chromite refractories which are found suitable for lining ferro-chrome making furnaces and ladles.

Raw Materials and Refractory Brick Qualities

Raw Materials

Selection of suitable raw materials is very much essential for manufacturing high hot strength basic refractories to withstand severe service conditions in the ferro-chrome making furnaces and ladles. In the indigenously available magnesites of Salem and Almora, the impurity levels are high and the lime, silica proportions are not adequate to get desirable mineralogical assemblage in the refractories. Sea water magnesia selected for making refractory bricks is of high purity having very less amount of boron.

The chrome ore occurring in Sukinda area of Orissa with moderate silica content is used in manufacturing magnesite-chromite bricks. The physico-chemical properties of magnesites and chrome ore are presented in Table 1. The major raw materials used in making the magnesite and magnesite chromite bricks are Salem, Almora and Sea water D. B. M.s and Chrome ore of Sukinda.

TABLE — 1

Physico-Chemical properties and Mineralogy of Raw materials

Chemical Analysis%	Salem DBM	Almora DBM	Imported Sea Water D. B. M.s A	Imported Sea Water D. B. M.s B	Chrome Ore A	Chrome Ore B
L.O.I.	0.33	1.06	0.08	0.12	1.12	1.85
MgO	90.52	89.40	99.03	98.10	13.61	14.00
SiO_2	5.82	2.54	0.22	0.44	2.24	4.62
CaO	1.79	1.43	0.47	1.20	0.12	0.10
Al_2O_3	0.96	1.38	0.06	0.06	13.79	14.30
Fe_2O_3	0.48	4.20	0.06	0.07	11.98	12.50
B_2O_3	—	—	0.006	0.02	—	—
Cr_2O_3	—	—	—	—	57.18	52 80
Total	99 90	100.01	99.926	100.01	100.04	100.17
CaO/SiO_2 ratio	0.29	0.52	1.99	2.54	0.02	0.05
A. P.	3.21	19.05	0.22	2.83	0.30	2.37
B.D.(gms/cc)	7.10	2.85	3.45	3 37	4.23	3.94
Ap.Sp.Gr.	3.487	3.50	3.50	3.47	4.248	4.04
X-Ray Diffraction results :						
Major —	Periclase	Periclase	Periclase	Periclase	Chromite	Chromite
Minor —	Forsterite	Monticellite Forsterite	Dicalcium Silicate	Dicalcium Silicate	—	Serpentine
Traces —	Monticellite	—	—	Tricalcium Silicate	Serpentine	Quartz.

Refractory brick qualities

In the studies reported here, the bricks were manufactured with proportionate selection of suitable raw materials, grading, mixing pressing, drying and firing procedures. Four commercial qualities of magnesite refractory bricks manufactured in the author's company were taken up for the investigation. The brand "R" brick consists of a little higher percentage of Fe_2O_3 and is being used in some of the Ferro-chrome slag making furnaces in India. The brand "W" is a low iron magnesite brick with higher percentage of MgO when compared to brand "R". The bricks with brand names "D" and "D(I)" are special quality products with low porosity and high strength. The brand "D(I)" is made with imported sea water magnesia. These qualities of bricks are suitable for lining the slag furnaces for making ferro chrome alloys. Similarly in magnesite-chromite group of bricks also, four commercial qualities of bricks manufactured in the author's company namely MCR (roof quality), MCN (normal quality), MCL (low chrome quality) and MCD (dense quality) bricks are taken up for investigation. These qualities of magnesite-chromite bricks are mostly suitable for reaction ladle lining. Depending upon the composition of the slag, the quality of the brick may be selected.

Refractory Brick Properties

Physico-chemical properties

All the qualities of Magnesite and magnesite-chrome bricks manufactured were tested for their different properties like apparent porosity, bulk density, refractoriness under load, permanent linear change on re-heating and chemical analysis.

The physico-chemical properties of the four qualities of magnesite bricks are given in Table 2. Red and white magnesite bricks consists of respectively 87.8% and 90 5% MgO contents with a porosity range of 18 to 20 % in both the qualities.

The special quality dense magnesite bricks MGD & MGD(I) are having low porosity of maximum 17% with respectively 86.6% and 96.63% MgO contents, the latter being manufactured with sea water magnesia.

The properties of magnesite-chromite bricks are presented in Table 3.

In magnesite-chromite bricks, the MCR, MCN, MCL and MCD bricks are having respectively 15.4% 17.4%, 8.5% and 8.7% minimum Cr_2O_3 contents with a porosity not exceeding 22%, 25%, 23% and 16%.

Hot Strength Properties

While making ferro-chrome, the bricks are to withstand severe corrosion and erosion by the molten metal and slag at high temperatures. The temperature in the reaction ladle where magnesite-chromite bricks are being used may exceed even 2000°C. To withstand these vagaries, the bricks should have good hot strength properties. The modulus of rupture at different temperatures for all the qualities of bricks under investigation were studied. There is a wide-spread interest these days in the hot strength properties of refractories. The modulus of rupture for all the qualities of bricks were carried at the room temperature and also at the temperatures of 1260°C, 1400°C and 1500°C. The range of test results of M.O.R. reported in this work are taken from the six different bricks obtained from each quality at the particular temperature in question. The X-ray diffraction studies for these bricks were carried out for correlating the hot strength properties with mineralogy of the bricks. The hot modulus of rupture properties at various temperatures and the X-ray diffraction results for the magnesite and magnesite-chromite bricks are given in Table 4.

From the table, it is evident that the hot modulus of rupture of MGR and MGW quality bricks at 1500°C is found to range between 100-120 kg/cm^2.

TABLE — 2

Physico-Chemical Properties of Magnesite Refractories

Physical Properties	BRL-MGR	BRL-MGW	BRL-MGD	BRL-MGD(I)
A. P. (%)	18 - 20	18 - 20	14 - 16	15 - 17
B.D. Gms/CC (Min)	2.85	2.87	2.98	3.00
CCS (Kg/Cm²)	380-450	350-400	650-700	550-600
R.U.L. (t°C)	1600	1640	1620	+ 1750
PLC at 1600°C/1 hr	± 0 8	± 0.8	— 0.8	— 0.5
Chemical Analysis%				
MgO	87.80	90.50	86.60	96.63
SiO_2	5.91	6.00	5.97	0.43
CaO	1.85	1.52	1.79	0.77
Fe_2O_3	3.28	0.54	1.48	0.13
CaO : SiO_2	0.29	0.24	0.29	1.67

TABLE — 3

Physico-Chemical Properties of Magnesite Chromite Refractories

Physical Properties	BRL-MCR	BRL-MCN	BRL-MCL	BRL-MCD
A. P. (%)	19 - 21	23 - 25	21 - 23	14 - 16
B.D. Gms/cc	2.95	2 87	2.80	3.00
CCS Kg/Cm²	350 - 400	200 - 250	200 - 280	450 - 500
R.U.L. (t°C)	1620	1600°C	1520	1630
PLC at 1600°C/1 hour	± 0.5	± 1.0	— 1.0	— 0.8
Chemical Analysis %				
MgO	68.90	66.67	75.5	78.5
SiO_2	5.45	5.27	6.8	4.60
Cr_2O_3	15.40	17.40	8.5	8.7

TABLE — 4

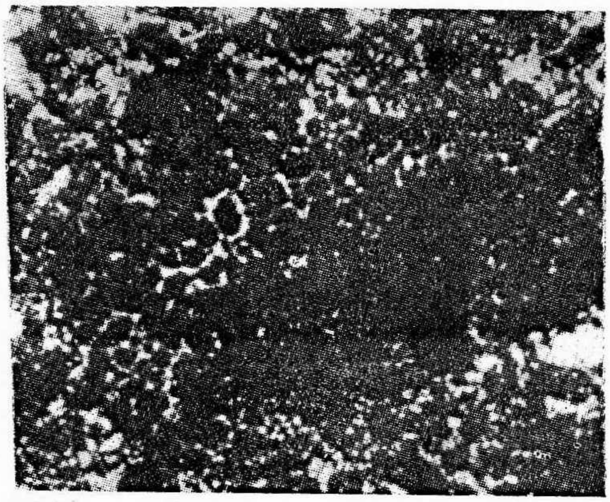
Modulus of rupture and mineralogy of magnesite refractories

Modulus of rupture (Kg/CM²)	BRL-MGR	BRL-MGW	BRL-MGD	BRL-MGD (I)
At room temperature	200 - 220	140 - 160	300 - 320	180 - 200
At 1260°C	140 - 160	160 - 180	120 - 140	180 - 200
At 1400°C	110 - 130	120 - 140	80 - 100	180 - 200
At 1500°C	100 - 120	110 - 120	70 - 80	180 - 200
XRD results				
Major	Periclase	Periclase	Periclase	Periclase
Minor	Forsterite Magnesioferrite Monticellite	Forsterite Monticellite	Forsterite Monticellite Magnesioferrite	Dicalcium Silicate
Traces		Magnesioferrite		

The MGD quality bricks are having a hot MOR of 80 to 90 kg/cm^2 at 1500°C, whereas the MGD(I) quality is having highest MOR of 180 to 200 kg/cm^2 at all the ranges of temperatures. In the four magnesite-chromite qualities of bricks the MOR values at 1500°C are found to range between 40 to 70 kg/cm^2. Out of all these mag-chrome qualities the MCD quality is found to have maximum M. O. R. value of 60 - 70 kg/cm^2 at 1500°C.

Microstructure

For microscopic study, both thin and polished sections were prepared from the bricks and examined respectively under transmitted and reflected lights. Appraisal of mineralogy and microstructure plays a very prominent role in the development of better quality high hot strength refractories. The constitution and microstructure of magnesite and magnesite-chromite bricks under investigation are as given under :



Photomicrograph — 1

Microstructure of MGR brick with monticellite and forsterite matrix within the intergranular spaces of periclase.

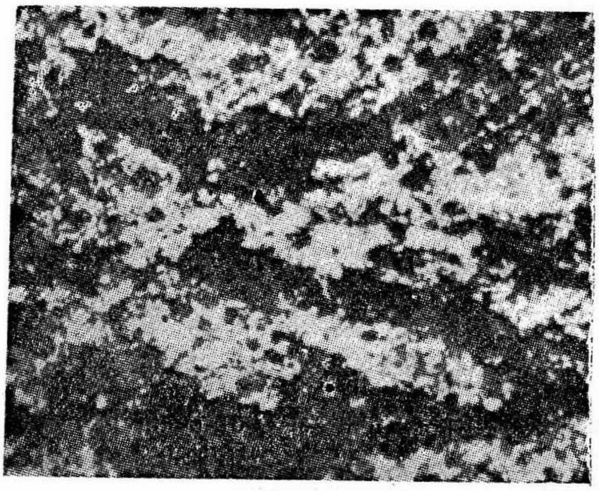
Transmitted light 150 X

i) Magnesite Bricks

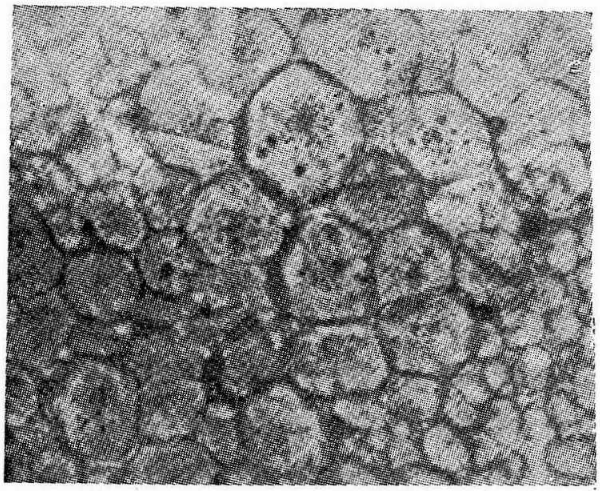
The periclase grains in MGR bricks are found to be dark brownish to brownish red in colour with rounded to oval and occasionally octahedral outlines showing granular texture. Deep brown colour of the periclase is due to the absorption of ferrous oxide. The ferric oxide present has been combined with magnesia forming magnesioferrite. At a few places clusters of magnesioferrite are observed on the periclase grains. Some times globules of magnesio-ferrite are found within periclase grains as nuclei at the centre. The matrix in between the periclase grains is essentially monticellite and forsterite. Some times veins and patches of concentrated silicate phases are found within the intergranular spaces of periclase (Photomicrograph 1). Rarely monticellite occurs around the edges and margins or rhombohedral cracks indicating the migration.

In MGW bricks, the periclase grains are white to greyish white in colour with rounded to oval shape. The texture is fairly inhomogenous with respect to the size of periclase grains and also with regard to the silicate matrix. Because of the unfavourable CaO/SiO_2 ratio, the silicate phase found is mostly forsterite with a little amount of monticellite. Magnesioferrite globules are very rarely observed within the periclase grain. Patches and veins of forsterite are observed in some of the samples showing silicate rich and poor areas alternating with each other (Photomicrograph 2).

In MGD bricks, the matrix is mostly monticellite and forsterite and is inhomogenously distributed in between the periclase grains. The MGD(I) quality bricks under microscope are found to be dense, compact and with much improved homogenity in texture when compared to other three qualities of bricks. The quantity of silicate phase is very less when compared to the other bricks. The periclase grains are found to be oval in shape and due to the favourable CaO/SiO_2 ratio, the matrix found is mostly dicalcium silicate and at a very few places rarely forsterite is observed as thin layers within the periclase grains. Often direct bond-



Photomicrograph — 2
Microstructure of MGW brick showing forsterite rich and poor areas alternating with each other.
Transmitted light 150 X

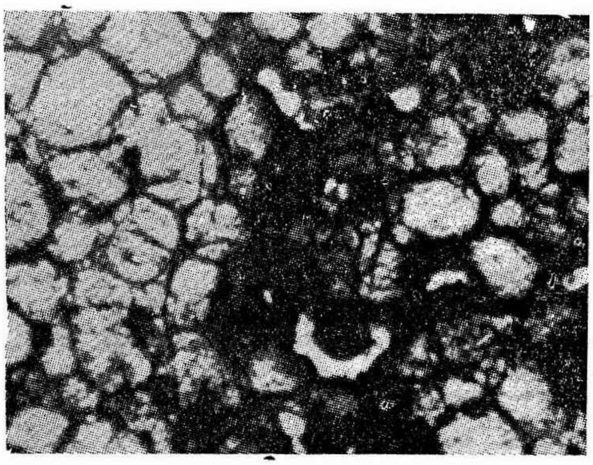


Photomicrograph - 3
Microstructure of MGD (I) brick showing direct bonding between the periclase grains.
Transmitted light 150 X

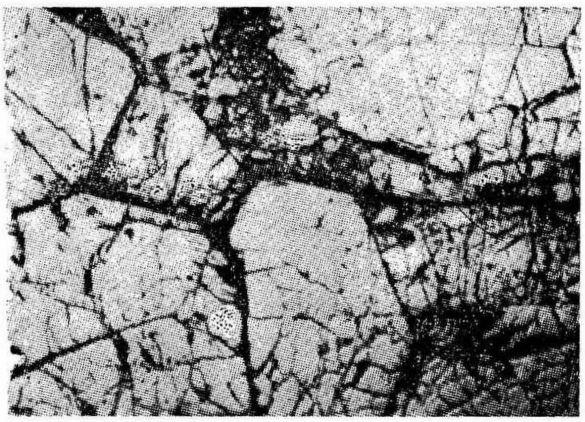
ing is observed between periclase to periclase (Photomicrograph 3). It may be concluded that a high degree of direct bonding and very less amount of silicate phases more uniformly distributed in the brick and remarkably low boron content have imparted high hot strength of 180 to 200 kg/cm^2 even at 1500°C.

ii) Magnesite-chromite bricks

The major phases found in MCR & MCN quality bricks are chromite, periclase, forsterite, monticellite and precipitate of ferrites (Photomicrograph 4). The coarser grains of chromite are having a number of cracks filled up with silicate matrix of forsterite and monticellite (Photomicrograph 5). The texture of MCN bricks is more open than the MCR quality brick.



Photomicrograph — 4
Microstructure of MCR brick with periclase and precipitates of ferrites.
Transmitted light 150 X



Photomicrograph — 5
Microstructure of chromite grain in MCR brick with a number of cracks filled up with silicate matrix of forsterite and monticellite.
Reflected light 300 X

TABLE — 5

Modulus of rupture and mineralogy of magnesite-chromite refractories

Modulus of rupture (Kg/Cm^2)	BRL-MCR	BRL-MCN	BRL-MCL	BRL-MCD
At room temperature	100 - 120	70 - 90	80 - 100	200 - 210
At 1260°C	70 - 80	60 - 70	70 - 80	80 - 100
At 1400°C	60 - 70	55 - 65	65 - 75	70 - 80
At 1500°C	50 - 60	40 - 50	50 - 60	60 - 70
X-Ray Diffraction results :				
Major	Periclase Chromite	Periclase Chromite	Periclase Chromite	Periclase
Minor	Forsterite Monticellite Magnesioferrite	Forsterite Monticellite Ferrites	Forsterite Monticellite Spinels	Chromite Forsterite Spinels

In MCL quality brick the major phase found is periclase followed by monticellite, forsterite, chromite and magnesioferrite. The texture is more or less similar to that of MCR quality brick.

In MCD brick, the texture is very much compact with rounded to oval shaped periclase and chromite grains. Occasional direct bonding is observed between periclase to periclase and periclase to chromite. Magnesioferrite is found as exsolved precipitate in most of the sections studied. Secondary spinel crystallisation is observed in the dense quality brick (Table 5).

Literature Survey

The subject of high temperature strength of basic bricks has assumed considerable importance in recent years. Various workers have undertaken work on hot strength of basic bricks and tried to correlate the high temperature strength data with the chemical and mineralogical composition of the bricks, firing temperature and other parameters of the manufacturing process. Attempts have also been made to find out correlation between hot strength and service performance of the basic refractories. The data available in literature show that more work has been done on straight magnesite bricks, obviously because the number of mineral phases present in a magnesite brick are not many and an interpretation of the results obtained are simpler. The situation becomes complicated with the presence of chrome ore and the published data on magnesite-chrome bricks merely gives the hot strength values of such bricks in relation to chemical composition and other properties.

In this paper, some of the important data from the published articles on the hot strength of magnesite and magnesite-chromite refractories have been concised.

Van Dreser undertook the study of hot M.O.R. upto 1400°C for magnesite bricks and concluded that bricks with above 1.7 CaO/SiO_2 gave better hot M.O.R. when compared to the brick with less than 1.7 lime/silica ratio His studies also showed that the hot M.O.R. of any particular brick decreases with increase in test temperatue (Table 6). Buist, Highfield and Pressley reported that there is a sharp drop in the hot M.O.R. results of sea water magnesia based bricks with a lime/silica ratio of 2 : 1 because of the presence of B_2O_3 which forms a low melting boro silicate glass. Busby and Carter carried out high temperature M.O.R. on a series of sea water magnesia and natural magnesite bricks. The results reported by them on

TABLE — 6

Modulus of rupture of pure magnesite bricks at various temperatures as reported by Van Dreser

MgO in Brick (%)	CaO/SiO_2 ratio	Modulus of rupture at 1260°C (Kg/Cm^2)	Modulus of rupture at 1400°C (Kg/Cm^2)
93	> 1.7	186	73
	< 1.7	44	23
95	> 1.7	174	65
	< 1.7	28	22
98	> 1.7	148	57
	< 1.7	27	29

TABLE — 7

Modulus of rupture of magnesite refractories at various temperatures as reported by Busby and Carter

Chemical analysis (%)	Natural Grecian	Sea Water DBM			
	D.B.M.	222	215	212 SPX	21 SPX
MgO	94.3	93.2	91.4	94.4	97.23
CaO	3.3	2.0	1.9	2.1	1.70
SiO_2	1.8	1.75	0.9	0.9	0.48
Fe_2O_3	0.5	1.90	4.9	1.4	0.12
Al_2O_3	0 1	1.10	0.7	0,9	0.22
Cr_2O_3	0.009	0.02	0.02	0.15	0.35
B_2O_3	0 033	0.161	0.155	0.10	0.04
Molar ratio CaO/SiO_2	1.80	1.14	2.10	2.30	3.40
Mineral Phases	Periclase Dicalcium Silicate	Periclase Magnesio-ferrite dicalcium silicate	Periclase Magnesio-ferrite dicalcium silicate	Periclase Dicalcium Silicate Magnesio ferrite	Periclase Tricalcium Silicate Dicalcium Silicate
Bricks fired to temp.	1550-1680°C	1550-1680°C	1550-1680°C	1550-1680°C	1550-1680°C
Modulus of rupture (kg/cm^2)					
at 1260°C	170-187	16-18	21-22	67-72	89-103
at 1400°C	174-156	5-3	9-9	8-13	74-108

M.O.R. are presented in Table 7. The main conclusions of their work are :

1. Sea water magnesia bricks with higher B_2O_3 results in lower hot strength than bricks made from natural magnesite.
2. Natural magnesite bricks having C_2S bond have better hot strength.
3. Higher firing temperature improved the hot strength.

Kienow, Jesochke and Das have published some data on modulus of rupture of basic

TABLE — 8

Modulus of rupture of magnesite refractories at various temperatures as reported by Kienow, Jeschke & Das

	Natural Grecian Magnesite			Sea Water Magnesite		
	V16	V18	V20	S16	S18	S20
Firing Temp. (°C)	1620	1770	2000	1620	1770	2000
Chemical Analysis %						
SiO_2	1.5	1.5	1.5	0.8	0.8	0.8
Al_2O_3	0.07	0.07	0.07	0.3	0.3	0.3
Fe_2O_3	0.70	0.70	0.70	0.2	0.2	0.2
CaO	2.90	2.90	2.90	1.7	1.7	1.7
MgO	95.0	95.00	95.00	96.5	96.5	96.5
Cr_2O_3	—	—	—	0.3	—	—
B_2O_3	0.016	0.016	0.016	0.04	0.04	0.04
Hot modulus of rupture (kg/cm²)						
at 1300°C	124	155	168	119	108	110
at 1400°C	120	155	168	90	90	190
at 1500°C	110	150	160	70	80	70
Physical Properties						
True Porosity %	17.3	14.5	13.1	20.4	19.8	19.3
Cold Crushing Strength (kg/cm²)	45	93.0	126	60	75	85
Mineral Phases						
Major	Periclase	Periclase	Periclase	Periclase	Periclase	Periclase
Minor	Monticellite dicalcium Silicate	Monticellite dicalcium silicate	Monticellite dicalcium silicate	Monticellite dicalcium silicate	Monticellite dicalcium silicate	Monticellite dicalcium silicate

refractories at different temperatures and the results are presented in Table 8. More recently the deleterious effect of boron content on the hot strength property of magnesite refractories has been emphasized by Hardy. As per him, the hot modulus of rupture of magnesite bricks with 0.2% boron content would be just half the hot modulus of rupture with the bricks having 0.1% B_2O_3 content.

Spencer and Gittins, Spencer and Bale have correlated the hot M.O.R. property of magnesite and magnesite-chrome bricks with the service performance in an electric arc furnace. The hot M.O.R. of the bricks studied by them are given in Table 9.

Reasons for development of high temperature strength

Recently much attention has been paid to the role of minor impurities like B_2O_3, R_2O_3, CaO and SiO_2 in magnesite refractories. Particularly the ability of these minor constituents to wet the periclase at a higher temperature is expected to be the reason for reducing the hot strength at that temperature. The recent discovery has proved that the B_2O_3 content present in very small amount can have an effect out of proportion to its concentration. The mechanism by which the effect is produced may be explained by that the B_2O_3 present produces a liquid phase at a temperature between 1100°C

TABLE — 9

Modulus of rupture of basic refractories at various temperatures as reported by Spencer & Gittins, Spencer and Ball

Brand	A	E	D	E
	Chrome-Mag 70/30	Rebonded fired Mag-Chrome	60/40 Mag-Chrome fired at 1600°C	Mag-Chrome 60/40 direct bond fired at 1700-1750°C
Chemical Analysis %				
SiO_2	2.4	2.4	3.2	2.1
Fe_2O_3	12.00	13.8	7.5	6.5
Al_2O_3	12.00	7.7	11.5	11.2
Cr_2O_3	24.00	21.2	13.4	13.8
CaO	1.00	0.9	1.4	1.0
MgO	41.20	54.1	63.0	64.0
Molar ratio CaO/SiO_2	0.40	0.38	0.44	0.48
Modulus of rupture (Kg/Cm^2)				
at 1260°C	120	160	50	95
at 1400°C	65	60	10	65
at 1500°C	15	30	—	30
at 1600°C	—	17	—	—
Permanent Linear Change (average 0 at 1800°C)	+ 1.5	— 0.7	— 0.6	— 1.0

to 1200°C. The wetting characteristic of this is such that a very thin film of liquid penetrates the grain boundry thereby reducing hot M. O.R.

From room temperature upto 1200°C little liquid develops in periclase refractories and M.O.R. values are much influenced by the physical properties and on the extent to which solid-solid bonds were formed at the previous firing temperature. Above 1200°C, hot M.O.R. values decline because reactions will proceed within the brick to form liquid and the amount of liquid present in the samples largely controls the hot M.O.R.

Ramming Mass for the Chute

The chute area of the reaction ladle in some of the ferro-chrome manufacturing units is being rammed with indigenously manufactured Belmante-84 ramming mass. For withstanding severe physico-chemical actions of the molten metal and slag of the chute area of the reaction ladle, a ramming mass based on sea water dead burnt magnesia, Belram M-95 has been developed. The physico-chemical properties of Belmante-84 and Belram M-95 are presented in Table 10. The newly developed ramming mass with a cold crushing strength of 450 at 110°C and 350 kg/cm^2 at sintering temperature combined with chemical purity is expected to withstand the vagaries in the chute region of the reaction ladle.

Summary and Conclusion

In this paper an attempt has been made to evaluate some of the magnesite and magnesite-chromite bricks and magnesite ramming masses which are found suitable for ferro-chrome manufacturing furnaces and ladles. The hot M.O.R. values of the magnesite, magnesite-chromite refractories are found to be

TABLE — 10

Physico-Chemical Properties of ramming masses for chute area of reaction ladle.

Brand Name		Belmante-84	Belram-M-95
Quality		Basic	Basic
Max. Service Temp. °C		1750 - 1800	1750 - 1800
Chemical Composition			
MgO %		84 - 85	95 - 96
Sintering temp. °C		1500	1550
Grading mm.		(0-5)	(0-5)
Setting		Chemical	Chemical
B.D.(Gms/cc) after drying at 110°C		2.85	2.95
Linear change %			
After drying at	110°C	± 0	± 0
After heating to	500°C	± 0	± 0
	800°C	± 0	± 0
	1000°C	± 0	— 2
	1500°C	—0.4 to —0.6	—1.0 to —1.20
	1600°C	—0.6 to —0.8	—1.25 to —1.30
CCS (kg/cm²) of rammed blocks.			
after dring at	110°C	200	450
after heating to	500°C	200	350
	800°C	190	250
	1000°C	195	250
	1500°C	250	300
	1550°C	—	350
	1600°C	300	450

quite comparable to the best qualities of magnesite and magnesite-chromite bricks made with natural magnesite. The fall in hot M.O.R. strength of magnesite bricks made with sea water magnesia is found to be because of the deleterious effect of the boron present. There is no reason to believe that the bricks with slightly higher silica and lower MgO content are inferior to the bricks available elsewhere. The newly developed ramming mass is expected to give better performance in the chute region of the reaction ladle.

Acknowledgement

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References

1. Buist D.S., Highfield A., and Pressly H, (1967) "Transverse breaking strength as an index of potential performance in service". Refractories Journal., pp 441-445.

2. Busby T. S., and Carter M., (1969) "The effect of firing temperatures and composition on the Creep Properties of Magnesite bricks." Trans. Brit, Cerem, 50C., Vol. 68(5) pp 205-210.

3. Gittins D. J., Spencer D. R. F., and Ball N., (1973) "The application of basic materials in electric arc furnaces". Refract Journal., pp. 12-20.

4. Hardy C. W., (1978) Paper presented to the Refractory Association of Great Britain on the effect of B_2O_3 content on hot strength of magnesite bricks.

5. Jackson B., and Laming J., (1969) "The significance of mechanical properties of basic refractories at elevated temperatures". Trans. Brit. Cerm. 50C., Vol. 68 (I), pp. 21-28.

6. Kienow S. Von., Jeschke P., and Das T. K., (1977) "Mechanische Engenschaften von Magnesiateinen in Abhangigkeit vonder lusammensetzung und dem Gefuge". Tonind-Jtg , pp. 83-94.

7. Konopicky K., Routschka, und Kowalczyk F., (1967) "Eigenschaften von steinen Magnesite-Chromerz-Reihe". Ber. DKG., Vol. 44, pp. 362-365.

8. Richardson M. H., Lester M. Patin, F. I. and Hedson, P. T. A., (1969) "The effect of Boric Oxide on some properties of Magnesia". Trans Brit, Ceram. SOC , Vol. 68 (I), pp. 29-33.

9. Spencer D. R. F., (1975) "Critical refractory properties and Magnesia-Chrome Clinker brick developments for AOD application". Refractories Journal., pp. 10 16.

10. Van Dreser M. L., (1967) "Development with High purity periclase". Am, Cerm. Soc. Bult., Vol. 46 (2), pp. 196-201.

11. Van Dreser M. L., and Boyer W. H. (1963) "High temperature firing of basic refractories". Journal. Amer. Ceram. Soc., Vol. 46(6), pp. 257-264.

Discussion

C. B. Raju, R. R. L., Bhubaneswar

Q. What is the percentage of MgO in sea water magnesla that you used ?

A. The percentage of MgO in sea water magnesia is 99.

Q. Have you tried to substitute the imported sea water magnesia with the local origin ?

A. We are trying to upgrade natural magnesite to the level of 99% MgO which will substitute the imported sea water magnesia.

Q. What are economic implications involved in using the importad sea water magnesia ? How it influences on the cost of refractory that you developed ?

A. The initial cost of the refractory products manufactured with sea water magnesia will be high when compared to the bricks made with natural magnesia. The performance of the refractories with imported sea water D. B. M. is much better and found to be economical when compared to the life of the refractories made with internal qualities of D. B. Magnesites.

G. B. Azeemulla Beig, VISL, Bhadravati

Q. Can we use Belmante-84 for tap-hole repairs in HcFeCr producing furnace ?

A. Belmante-84 can be used for tap hole repairs in high carbon Fe-Cr producing furnaces.

Q. If it can be used, please enumerate the procedure for its usage and indicate the time to be allowed before making tappings after repair ?

A. For cold ramming 4.5 to 5 litres of clear tap water per 100 kgs dry material will be required. The ramming can be done either by hand or with pneumatic rammers. After ramming, the material is to be dried for 12 to 24 hrs. at about 100°C. After drying, the furnace can be heated up slowly to the required temperature.

Q. If Belmante-84, is not suitable could you please suggest suitable refractory for tap hole zone ?

A. In place of Belmante-84, in vulnerable areas Belram-M-95, which is based on sea water magnesia may be tried.

S. S. Tippannavar, VISL, Bhadravati

Q. What is the fusion point of Mag ore and Mag-chrome bricks ?

A. Fusion point of pure periclase is 2800°C. With the presence of impurities, the melting point will decrease. The fusion point of Mag-chrome bricks also depends upon the percentages of magnesite and chromite and on the impurities present. The fusion point of normal magnesite-chromite brick is well above 2000°C.

Q. What is the CaO and Fe_2O_3 limits in Mag-chrome bricks ?

A. In magnesite-chromite bricks, the percentages of CaO and Fe_2O_3 will range anywhere between 1.5 to 3% of CaO and 3 to 8% of Fe_2O_3.