Optimisation Of Mungher Quarzite And Raigarg Quartzite Fractions In Making Of Silica Bricks For Use In Coke Oven

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ABSTRACT

Silica Brick is generally used in Coke oven and in Blast furnace stove in an iron and steel plant.This work describes the detailed experimental work carried out in replacement of conventional Mungher Quartzite from Bihar,India by a non-conventional quartzite from Raigarh district ,MP,India, as was deemed necessary due to environment regulations .Detailed evaluation of physical and chemical properties indicated that a maxium of 25% replacement of Raigarh quartzite in a coarser fraction (25%) is possible and the refractories thus produced meet the ISO specifications

1. INTRODUCTION :-

Silica Brick is generally used in Coke oven and in Blast furnace stove in an iron and steel plant . The main raw material is Quartzite which is found abundantly in Munger District , Bihar India. Quartzite should be of fine grain structure with a minimum of 96-97%, % silica (SiO_2), Alumina (less than 1%), Iron Oxide (Fe_2O_3) less than 1% and alkalies(Na_2O and K_2O) less than 0.5%

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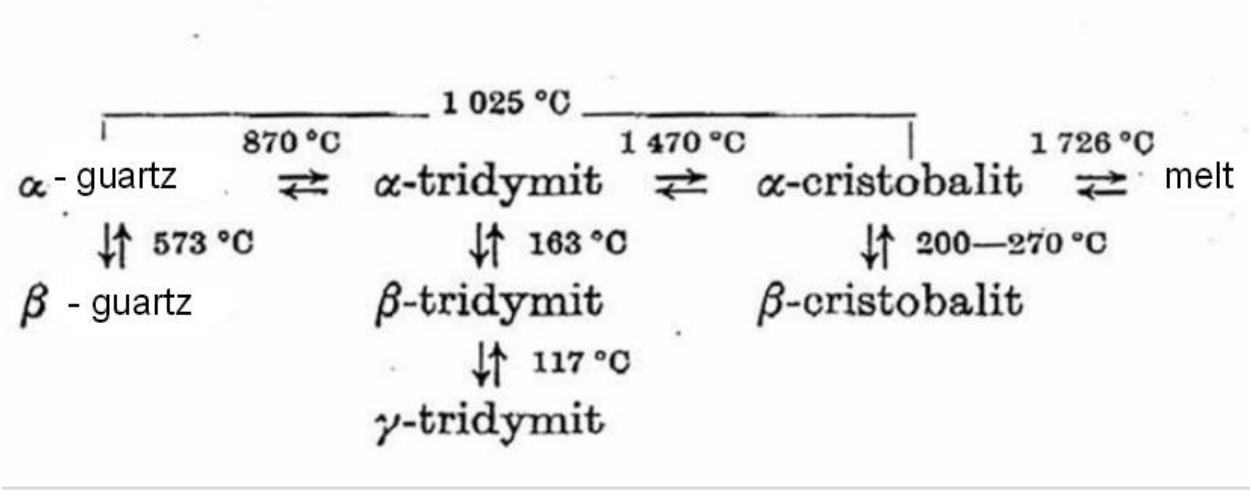
Silica mineral has four different polymorphic transformations namely Quartz,Tridymite,Cristoballite and Silica Glass. Each of these forms has has its low and high temperature modifications and is stable at different temperature range. Thus α ->β conversion takes place at 573 ^{0}Cresulting in 0.82% volume expansion,β – quartz converts to Tridymite at 867^{0}C and is stable upto 1470^{0}C.The conversion of tridymite to cistobaliteis associated with very little volume changeat higher temperature of firing.At 1723^{o}C it melts to give silica glass. Specific gravities of Quartz,Tridymite, Cristobalite and Quartz glass are 2.65,2.27,2.33 AND 2.21 respectively.Almost irreversible phase(volume) change during tridymite to cristobalite makes application of Silica as refractories for furnace lining ideal.However this small polymorphic phase change in tridymite-> cristobalite is associated with a small volumeexpansion making masonary structure ideal for leak proof applications in coke oven refractories.

Polymorphic Transformations in Quartz Mineral



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The physico chemical properties of indian Coke Oven Silica bricks is given below.

COKE OVEN SILICA BRICKS (as per DIN 1089 Part-1)				
		Regenerator Oven walls Oven roof	Oven walls	Oven Sole
CHEMICAL PROPERTIES				
SiO_2 (%)	m	>=94.5	>=95	>=95
	s	1.0	1.0	1.0
Al_2O_3 (%)	m	<=2.0	<=1.5	<=1.5
	s	0.3	0.3	0.3
Fe_2O_3 (%)	m	<=1.0	<=1.0	<=1.0
	s	0.2	0.2	0.2
CaO (%)	m	<=3.0	<=3.0	<=3.0
	s	0.35	0.35	0.35
Na_2O+K_2O (%)	m	<=0.35	<=0.35	<=0.35
	s	0.02	0.02	0.02
Residual quartz content				
Raw material type A (%)	m	As per mutual agreement		
(coarse crystalline)	s	Max 6.0		
Raw material type B (%)	m	1.5		
(coarse crystalline)	s	0.5		
PHYSICAL PROPERTIES				
Cold Crushing Strength (N/mm^2)	m	>=28	>=35	>=45
	s	10	10	10
	Min	20	25	30
Apparent porosity (%)	m	<=24.5	<=22.0	<=22.0
	s	1.3	1.3	1.3
Refractoriness under load (DEFta°C)	m	>=1640	<=1650	<=1650

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India has quartzite deposits in every state but the raw material from Bihar Sarif andMunghер district in Bihar Sarif District is ideally suited for silica brick production.

After primary washing to remove the clayey impurities , the quartzite is passed through primary Jaw crusher for coarse grinding . This is further subjected to re-crushing in Gyratory Crushers, roll mill and impact mills for getting finer particles while the oversize is reground into finer fractions. The different grain sized particles are mixed on optimum proportions and mixed with an organic bond (organic Lye-1-2%) and 2-3% milk of lime. The sequence of charging these ingredients is critically done so that the individual grains are thoroughly coated with milk of lime and the organic bond. The addition of milk of lime helps in easy polymorphic transformation of quartz at higher polymorphic transformation temperatures. A suitable blend size with different proportions of coarse (1-3mm), medium (appx 1mm)

and fines(less than 1mm) size fractions are ideal for the blend mixture to achieve green strength and lowering of porosity in the green compacts

In Steel Authority of India silica bricks are manufactured inBhilai Refractories Plant. Quartzite from Munger district is used is generally used for preparation of Silica Bricks.Quartzite is use in the manufacture of silica bricks as it has high refractoriness. Refractoriness is lowered by the presence of fluxes such as lime, iron oxide, magnesia and alkalies. The purity of raw material i.e., high silica content is essential with least possible Al_2O_3. The presence of 0.01% Al_2O_3 lowers the refractoriness of silica. Silica rock of metamorphic origin is better than that of igneous origin because the silica grains are cemented with cristobalite and tridymite and are stable phases of silica. Physically, quartzite should be of fine grained, compact and cryptocrystalline type.

The raw materials sub-committee of the directorate general of technical development on refractories in its report dated September 1985 has stipulated the following specifications for quartzite.

Physical characteristics:

Grade-I	Grade-II
Medium to fine grained, compact, granular texture, homogenous, free from iron bands, patches, pyrite spots, pyrophyllite, coating, devoid of mica coating.	Occasional iron patches may be allowed free from iron bands.

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The thermal characteristic of quartzite should be such that (i) there is uniformity during thermal conversion; (ii) specify gravity of fired quartzite lumps in conventional kilns at 1430 C with proper firing schedule should be less than 2.46 %, and (iii) fired quartzite lumps should be clean, white and spot free.

Chemical Characterstics

Chemical Composition	Grade-I	Grade-II
SiO_2	Above 98%	Above 96%
Al_2O_3	Less than 0.75%	Less than 1%
Fe_2O_3	Less than 0.75%	Less than 1.5% (in distributed form)

However due to environmental problems the mining in Mungher area is restricted. Although sufficient quantity of quartzite is available from Raigarh area its use is restricted as it exhibits significant expansion while firing. The present work was therefore undertaken to explore the

amount of quartzite from Raigarh to be mixed with Mungher Quartzite while retaining the properties suitable for application as an ideal Silica Refractory material

2. Experimental:

Experiment 1 :Determination of optimum grain size distribution of Mungher Quartzite :

Coarse (1.4-3.0 mm) and medium (0.3-1.4mm) sized grains were mixed with lime water , calcium salt, sodium lignosulphate, fine silica and fine (0.3-1.4mm) quartzite and the mixture was finally mixed with molasses which acts as a bond. A pressure of 15 tonnes was applied on cylindrical samples and the pressure was held for 30 seconds after which the samples were cured at room temperature. The details of the batch compositions are given in Table -1

Table-1: Batch compositions of Mungher quartzite with different grain size additions

Ingredients	**Batch-1 Munger (gm)**	**Batch-A (gm)**	**Batch-H (gm)**	**Batch-S (gm)**
Munger				
Coarse	100	120	140	140
Medium	200	200	100	172
Fine	100	80	160	88
Total quartzite	**400**	**400**	**400**	**400**
Lime(dry)	10	10	10	10
Mill scale	1.6	1.6	1.6	1.6
Caicium salt	3.2	3.2	3.2	3.2
Fine silica	4	4	4	4
Lignosulphate	4	4	4	4
Molasses	18	18	18	18
Additives	**40.8**	**40.8**	**40.8**	**40.8**
Total batch	**440.8**	**440.8**	**440.8**	**440.8**
Water for making milk of lime	16.5	16.5	16.5	16.5

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The samples were fired in a rotary hearth furnace at 1400^0 C and were soaked for 7.15 hours. The AP (open porosity) and BD (Bulk Density) of the samples are given in Table 2 below

Table -2 Density, porosity and Volume expansion of samples prepared from different size fractions of Mungher Quartzite

Batch no.	**Dry W.t. (g)**	**Sus. W.t. (g)**	**Sat. W.t.(g)**	**A.P. (%)**	**Fired B.D(d_f). (gm/cc)**	**Green BD(d_g) (gm/cc**	**C.C.S. (kg/cm^2)**	**Volume expansion ($1/d_f$ - $1/d_g$)%**
1/1	204.34	120.20	225.63	20.19	1.94	2.21	-	6.0
1/2	204.21	120.32	225.58	20.30	1.94	2.20	-	6.0
A/1	206.07	121.42	226.03	19.08	1.97	2.23	-	5.8
A/2	206.02	121.34	227.68	20.37	1.94	2.18	-	5.6
H/1	206.34	121.06	228.75	20.81	1.92	2.14	-	5.4
H/2	206.50	121.30	228.89	20.81	1.92	2.14	-	5.4
S/1	205.30	121.17	225.99	19.74	1.96	2.22	-	5.9
S/2	205.66	121.16	226.30	19.63	1.96	2.22	-	5.9

The general observation from the above mentioned experiment is that even with change of coarse, medium and finer fractions of Mungher quartzite there is no appreciable change in the volume expansion of the samples

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Experiment 2 :Optimisation of Raigarh quartzite and Mungher Quartzite blends

The batch mixtures of various combinations of Raigarh and Mungher Quartzite is given in the table below (Table 3)Coarse (1.4-3.0 mm) and medium (0.3-1.4mm) sized grains were mixed with lime water , calcium salt, sodium lignosulphate, fine silica and fine (0.3-1.4mm) quartzite and the mixture was finally mixed with molasses which acts as a bond. A pressure of 15 tonnes was applied on cylindrical samples and the pressure was held for 30 seconds after which the samples were cured at room temperature for a period of 40 hours. The details of the batch compositions are given in Table -3. The samples were fired in a rotary hearth furnace at 1400^0 C and the BD and Open porosity data are given in table -4.

Table 3: Optimization of Mungher and Raigarh Quartzite blends

Ingredients	**Batch-1 Munger (gm)**	**Batch-2 Raigarh (gm)**	**Batch-3 R25m (gm)**	**Batch-4 R25f (gm)**	**Batch-5 R25c (gm)**	**Batch-6 R25m25f (gm)**	**Batch-7 R50m (gm)**	**Batch-8 R25c25m (gm)**
Munger								
Coarse	100		100	100	0	100	100	0
Medium	200		100	200	200	100	0	100
Fine	100		100	0	100	0	100	100
Raigarh								
Coarse(c)		100	0	0	**100**	0	0	**100**
Medium (m)		200	**100**	0	0	**100**	**200**	**100**
Fine (f)		100	0	**100**	0	**100**	0	0
Total quartzite	**400**	**400**	**400**	**400**	**400**	**400**	**400**	**400**
Lime(dry)	10	10	10	10	10	10	10	10
Mill scale	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Calcium salt	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
Fine silica	4	4	4	4	4	4	4	4
Lignosulphate	4	4	4	4	4	4	4	4
Molasses	18	18	18	18	18	18	18	18
Additives	**40.8**	**40.8**	**40.8**	**40.8**	**40.8**	**40.8**	**40.8**	**40.8**
Total batch	**440.8**	**440.8**	**440.8**	**440.8**	**440.8**	**440.8**	**440.8**	**440.8**
Water (ml)	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5

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Table-4 Density ,Porosity and CCS (Cold Crushing Strength) ofMmunger and Raigarh Quartzite mixtures

In different grain size fractions.

Batch no.	Dry W.t. (g)	Sus. W.t. (g)	Sat. W.t.(g)	A.P. (%)	Fired B.D(d_f) (gm/cc)	Green B.D(d_g) (gm/cc)	Volume expansion ($1/d_f$ - $1/d_g$)%	C.C.S. (kg/cm^2)
2/1	204.04	119.15	228.37	22.28	1.87	2.15	6.8	408.30
2/2	201.88	119.16	227.33	23.53	1.87	2.10	6.7	307.39
3/1	204.01	120.18	225.67	20.53	1.93	2.17	5.8	302.67
3/2	198.21	118.31	218.76	20.46	1.97	2.17	5.0	395.16
4/1	206.14	121.56	228.62	21.00	1.93	2.17	5.8	398.80
4/2	203.05	121.09	224.45	20.70	1.96	2.17	5.0	264.17
5/1	205.88	121.06	227.18	20.07	1.94	2.20	6.1	424.00
5/2	204.27	121.55	224.37	19.55	1.99	2.20	4.8	336.62
6/1	201.58	118.36	224.46	21.56	1.90	2.13	5.7	321.59
6/2	203.35	120.69	225.22	20.92	1.95	2.15	4.3	330.45
7/1	204.44	119.74	227.28	21.24	1.90	2.16	5.7	384.55
7/2	202.84	120.28	224.30	20.63	1.95	2.17	5.2	384.24
8/1	204.74	119.66	226.25	20.18	1.92	2.18	6.1	489.96
8/2	203.39	120.46	223.85	19.79	1.92	2.19	6.5	417.86

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It may be noted that Batch 4 which consists of 25% Raigarh fines and Batch 5 which contains 25% of Raigarh coarse fractions although did not indicate substantial change in volume expansion and open porosity values , they exhibited significant changes in their CCS values such that the inclusion of finer fractions (Batch-4/1 and 4/2) brings down the CCS values significantly lower (398.8 and 264.17) respectively as compared to the coarser fractions (Batch 5/1 and 5/2) which shows higher values of CCS (424.0 and 336.6 respectively).

Conclusion :

It has been made possible to produce silica bricks using a replacement of Mungher Quartzite by Raigarh Quartzite fractions up to a maximum level of 25%. However the addition of finer variety brings down the ColdCrushin Strength (CCS) values . The AP values however did not show significant variation. The samples made with replacement of Mungher quartzite with Raigarh fractions followed ISI standards

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