Evaluation of Quartzite for the Manufacture of Silica Bricks

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Chemical, physical and inversion characteristics of quartzites from different sources have been studied to evaluate their suitability for the conventional as well as superduty type of silica refractories. Results of small scale trials carried out on quartzite samples with addition of lime and iron oxide and physical properties of the specimens after firing to 1450°C have also been furnished and, in the light thereof, the suitability of indigenous quartzites have been assessed.

SILICA refractories find wide application for high temperature furnaces in the iron and steel and allied industries as well as in non-metallurgical fields. The indigenous production of silica refractories during 1955-56 was of the order of 30,000 tons per annum produced by two firms in Bihar, from good quality raw materials available in abundance in the districts of Gaya, Monghyr, Bihar-Sheriff and Hazaribagh.

The demand for silica refractories in India at the end of Second Five Year Plan in 1960-61, has been estimated at 1,60,000 tons per annum[1]. 10% of this could easily be superduty silica bricks, the advantages of which are well known and have been recently reviewed by one of the authors[2], for use in the roofs of open hearth as well as other high temperature furnaces. However, superduty quality bricks are not manufactured in the country at present. To study the possibility of making superduty quality bricks and to meet the increased demand for the conventional type of silica refractories, fresh sources of raw materials have to be explored and their suitability for commercial production has to be evaluated. Besides, a comparative study[3] of silica bricks from different parts of the world with those of indigenous make has shown that though the indigenous bricks of conventional type compare very well with foreign ones of similar quality, considerable scope still exists for improvement in the quality of indigenous bricks, particularly in porosity and refractoriness-under-load. With this end in view, silica raw materials were

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1 Indian Ceramics—Jan. 1957, pp. 298-99.
2 H. V. Bhaskar Rao—Research & Industry, Vol. 3, No. 7, July 1958. pp. 173-76.
3 H. V. Bhaskar Rao & Rabindra Singh.—J.S.I.R., Vol. 16A, No. 4, 1957, pp 183-188.

collected from different sources to assess their suitability for the manufacture of conventional as well as superduty silica bricks.

Raw materials

Though there is no rigid specification for the essential raw material, quartzite, used for silica brick manufacture, experience has shown that quartzite used for good quality bricks should contain not less than 97% silica, not more than 1% alumina and 0·3% alkalies. While small quantities of clay, lime and iron oxide are tolerable or even beneficial, mica and felspar are undesirable. For the superduty quality, the combined alumina and alkali content should be below 0·5% and preferably below 0·3%. The nature of the rock, its texture and porosity before and after firing, its behaviour on calcination and its inversion charcteristics are even more important than chemical composition in determining its suitability for brick manufacture. A good quartzite should have a crypto-crystalline structure with very little porosity which on firing should not show any tendency to shatter and should also develop low porosity and have a high rate of inversion to trydimite at a reasonably low temperature.

As many as nine samples of quartzite were studied of which one was from Delhi area, another from Bada Jamda, two from Hyderabad, three from Monghyr, supplied by the Geological Survey of India and one each from Mihijam and Jharia.

Experimental procedure

The porosity and specific gravity of quartzite in the raw state as well as after firing at different temperatures were determined according to standard methods and their inversion characteristics and shattering tendencies, if any, on firing, were observed. Thin sections of the quartzite specimens were examined under the petrographic microscope. The rock was crushed and graded to get a mixture of maximum packing density. 2% lime and 1% Fe_2O_3 were added to the above mixture and 2″ dia. buttons were pressed at 5,000 lb/sq. in. with 5% sulphite lye as temporary bond to give the necessary green strength. After drying, the buttons were fired in a gas fired furnace at 1,450°C. according to a predetermined schedule and later cooled down in the furnace to below 100°C. before unloading. The physical properties like specific gravity, porosity, refractoriness-under-load, etc., were determined.

After the preliminary study of inversion characteristics, quartzites from Delhi and Jamda were selected for further study with Mihijam quartzite as a standard reference sample. With these quartzites, packing density experiments were carried out with two different sets of gradings. Briquettes and half size bricks were made by pressing as well as by hand moulding. These were fired at 1,450°C. with a soaking for 24 hours at the maximum temperature. The physical properties of the specimens were studied. With the three selected quartzites, experiments were carried out by the incorporation of low alumina quartzite fines from Hyderabad.

Results and discussion

The chemical analyses of the quartzites studied are given in Table I. The physical properties of the quartzites in raw state as well as after firing at different temperatures are given in Table II and the properties of silica brick specimens made from selected raw materials are given in Table III.

Quartzite from Delhi area

This is a coarse grained quartzite with traces of talc, tourmaline and hematite as accessory minerals (Fig. 1). As may be seen from Tables I, II & III, the alumina content of this quartzite is within the usual limits used in silica brick manufacture. It has fairly good conversion and fairly low porosity after firing, viz. 12·6%. The rock does not shatter on firing. The brick specimen made out of this material has a porosity of 21% and refractoriness-under-load of 1,665°C. ta, at 50 lb/sq. in. From this it can be concluded that this will be a suitable raw material for the conventional type of silica brick.

Quartzite from Jamda area

This is a crypto-crystalline variety of quartzite with some of the specimen showing alternate bands of coarse and fine crystals (Fig. 2). Accessory mineral found was mostly hematite. Though the initial porosity of the rock was about 3%, this increased to only 10% when fired at 1500°C. for 2 hours and the specimen did not shatter. Silica brick specimen prepared from this material had the normal porosity of 24% and very good refractoriness-under-load value of 1,690°C. ta and 1,710°C. te with 50 lb/sq. in. load. This higher refractoriness-under-load could be expected from the very low alumina content of the raw material and from this point of view it may be considered as a superduty silica brick, though there is still room for improvement of its porosity, to bring it below

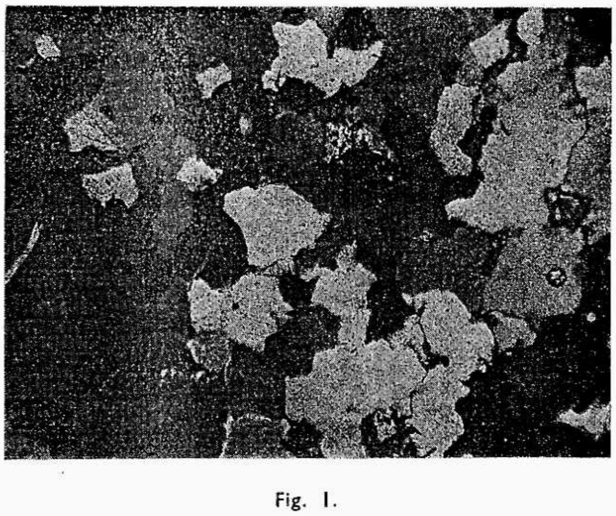

Fig. 1.
Quartzite from Delhi area.

TABLE I

Chemical analysis of Silica Raw Materials.

	Delhi 1	Bada Jamda 2	Hyderabad k (3)	Hyderabad B (4)	Jharia 5	G. S. I. 6	G. S. I. 7	G. S. I. 8	Mihijam 9
Loss on Ignition	0.45	0.12	trace	trace	trace	0.30	0.22	0.26	trace
Moisture	trace	0.07	0.04	0.04	0.02	trace	trace	trace	0.04
SiO_2	99.26	99.72	99.28	99.28	99.16	98.02	97.53	97.44	98.76
Al_2O_3	1.06	0.04	0.20	0.21	0.33	0.81	0.94	0.98	0.84
Fe_2O_3	0.67	0.06	0.04	0.03	0.07	0.50	0.48	1.28	0.10
TiO_2	0.29	nil	trace	trace	trace	0.05	0.04	0.04	0.02
CaO	trace	trace	0.24	0.32	0.23	trace	trace	trace	0.22
MgO	trace	N.E.	trace	trace	trace	trace	trace	trace	trace
Alkalies.	0.25 Na_2O trace K_2O	nil	trace	trace	trace	trace	trace	trace	0.11 Na_2O trace K_2O

TABLE II

Physical properties of Silica Raw Materials.

		Delhi 1	Bada Jamda 2	Hyderabad k(3)	Hyderabad B (4)	Jharia 5	G. S. I. 6	G. S. I. 7	G. S. I. 8	Mihijam 9
Raw state	Sp.Gr.	2.675	2.674	2.627	2.617	2.638	2.628	2.648	2.630	2.589
	Porosity	1.4%	3%	0.43%	0.37%	0.27%	1.0%	1.7%	2.5%	0.30%
Fired at 1400°C for 2 hours.	Sp. Gr.	2.537	2.662	2.621	2.615	2.631	2.605	2.618	2.610	2.573
	Porosity	7.0%	4.4%	3.5%	N.D.	0.48%	2.3%	3.3%	4.8%	1.5%
Fired at 1450°C for 2 hours	Sp. Gr.	-	-	2.618	2.611	2.628	2.440	2.586	2.578	2.553
	Porosity	-	-	6.4%	5.8%	4.52%	-	-	-	5.0%
Fired at 1450°C for 6 hours.	Sp. Gr.	-	-	2.616	2.608	2.610	-	-	-	2.544
	Porosity	-	-	6.8%	5.8%	4.5%	-	-	-	5.0%
Fired at 1500°C for 2 hours.	Sp. Gr.	2.418	2.301	2.60	2.598	2.538	-	-	-	2.526
	Porosity	12.6%	10.0%	6.4%	5.8%	6.8%	-	-	-	5.0%
Brick* specimens fired at 1450°C for 6 hours.	Sp.Gr.	2.346	-	2.360	2.344	2.351	2.355	2.242	2.411	-
	Porosity.	21.0%	-	S H A T	T E R	E D	22.5%	26.0%	25.0%	-
Raw state	P.C.E.		31-32 cone	32 cone	Shattered	32 cone				30-31 cone.

* Brick specimens were made as follows:

Addition to graded quartzite	Mixing proportion C - M - F	GRADING used.
5 % sulphite lye	45 - 10 - 45	+ 5
2% CaO		- 5 + 10 } C
1% Fe_2O_3		- 10 + 30 } C
2% Moisture		- 30 + 60 M
		- 60 +100 } F
		-100 +150 } F
		-150

Table III

Physical properties of silica brick specimens made from selected raw materials and fired at 1,450°C. soaking for 24 hours.

			Mixing proportions			Bulk den.	Sp. Gr.	Approx. Porosity	Refractoriness-under-load of 50 lbs/sq.inch.			Cold crushing Strength.
			C	M	F	gm/cc.		%	ta		te	lb./sq.inch.
Mihijam		a*	45	10	45	2.18	2.346	27.7	1680°C	-	1710°C	820
Mihijam		b	50	10	40	2.19	2.348	24.0	1690°C	-	1710°C	---
Mihijam	k	a**	45	10	45	2.18	2.317	26.5	1700°C	-	1715°C	800
Mihijam	k	b**	50	10	40	2.19	2.345	26.0	1710°C	-	1730°C	---
Delhi		a	45	10	45	2.18	2.313	31.1	1640°C	-	1680°C	825
Delhi		b	40	20	40	2.24	2.34	21.0	1665°C	-	1680°C	---
Delhi	k	a**	45	10	45	2.18	2.339	28.6	1665°C	-	1680°C	1500
Jamda		a	45	10	45	2.19	2.324	24.3	1680°C	-	1700°C	1000
Jamda		b	45	10	45	2.24	2.345	24.5	1690°C	-	1710°C	----
Jamda	k	a**	45	10	45	2.19	2.328	25.0	1690°C	-	1700°C	900

* : Grading

Grading	- C	- M	- F
a	- 7 + 14 -14 + 30	-30 + 60	-60 + 100 B.S.S. -100+ 150 - 150
b	- 5 + 18,	-30 + 60,	- 72+ 100/25% -100+ 200/15% -200/60%

** 20% fines from Hyderabad (k)

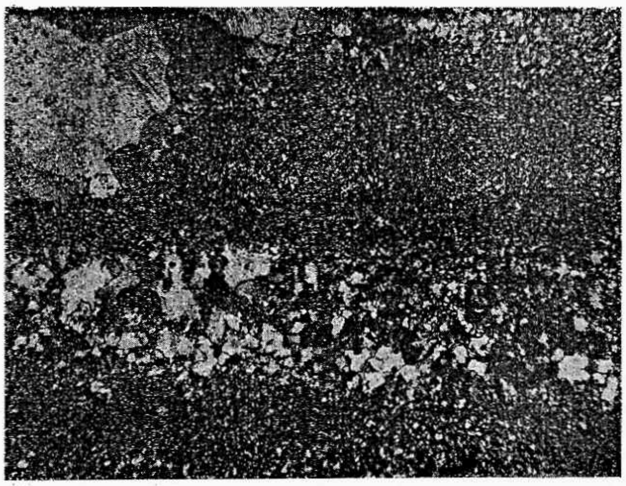

Fig. 2.
Quartzite from Jamda area.

20%. It may be possible to achieve this by carrying out detailed packing density studies with different gradings in order to get dense packing and also by varying the lime addition to get optimum glass formation to give low porosity and good strength.

Low alumina quartzite from Hyderabad

These two quartzites were included in this study as they are known to contain very low alumina which is one of the special requisites of superduty silica brick (Fig. 3). But as these materials were of a very friable nature even in the raw state

Fig. 3.
Low alumina-quartzite from Hyderabad.

and more so on firing, these did not give satisfactory results. However, in view of the fact that these were very pure but friable raw materials, it was decided to incorporate them as fines along with other normal types of quartzites to see if any improvement could be effected. Results given in Table III show that though incorporation of low-alumina quartzite fines along with graded quartzite from Mihijam area improved its refractoriness-under-load to a certain extent, in the other two cases no improvement was noticed.

Quartzite from Jharia area

This was a coarsely crystalline quartz with felspathic and micaceous impurities from pegmatites (Fig. 4). Though the raw material was very pure because of its shattering tendency on firing, it did not give satisfactory results.

Quartzite from Monghyr area, supplied by G. S. I.

Samples Nos. 6, 7 and 8 were medium to fine grained quartzites with irregular boundaries having a crushed appearance and with streaks of hematite, needles of apatite or shreads of talc as accessory minerals (Figs. 5, 6 and 7). These had porosities ranging from 1 to 2·5% in the raw state and did not show any shattering tendency on firing. Silica brick specimen prepared with these raw materials had porosities ranging from 22·5 to 26%. From this preliminary study these raw materials appeared to be suitable for the manufacture of silica bricks, though a detailed study would be needed to work out suitable gradings, optimum additions and proper heat treatment.

Quartzite from Mihijam area

This raw material is one which is currently being used by one of the silica brick manufacturers and

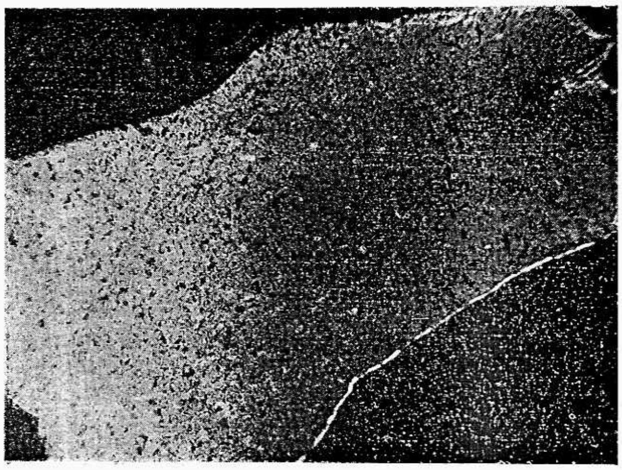

Fig. 4.
Quartzite from Jharia area.

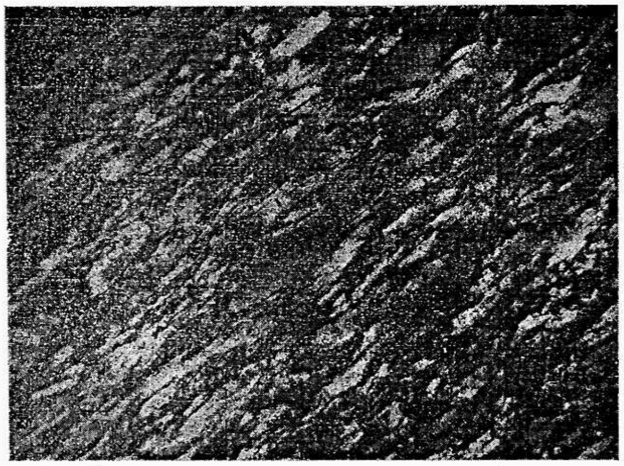

Fig. 5.
Quartzite from Monghyr area (supplied by G.S.I. No. 6).

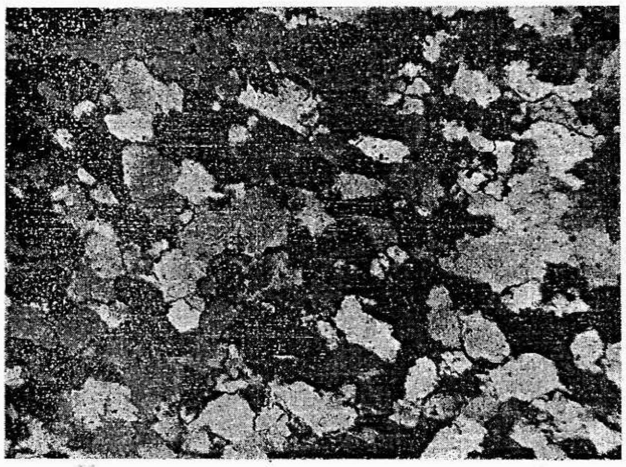

Fig. 6.
Quartzite from Monghyr (supplied by G.S.I. No. 7.)

was included in this study as a standard reference material (Fig. 8). It consisted of medium grained quartz crystallites, fine shreads of talcose, micaceous material and apatite as accessory minerals. The porosity of the rock increased from 0·3% in the raw state to 5% when fired at 1,500°C. for 2 hours. The fired rock had a very hard and dense structure and did not show any tendency to shatter. The porosity of the brick specimen fired at 1,450°C. for 6 hours was 29% and this was lowered to 24% when the gradings were changed and the soaking was continued for 24 hours. The refractoriness-under-load was quite high and this was further improved by the incorporation of low alumina quartzite fines to the extent of 20%. It should be possible to reduce the porosity to below 20% by

Fig. 7.
Quartzite from Monghyr area (supplied by G.S.I. No. 8.)

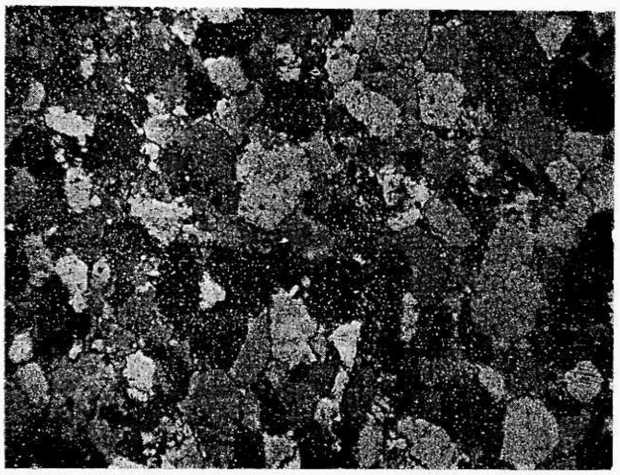

Fig. 8.
Quartzite from Mihijam.

further packing density studies with different gradings and varying the lime addition to increase the glass phase to the optimum value.

Summary and conclusion

From the study of the inversion characteristics of the indigenous quartzites and their physical properties when made into silica brick specimen with 2% lime and 1% Fe_2O_3 addition, the quartzites from Jharia area and low alumina quartzites from Hyderabad do not appear to be suitable by themselves for the manufacture of silica bricks, due to their extremely friable nature. The quartzites from Delhi area and those from Monghyr appear to be suitable for the manufacture of the conventional type of silica brick.

It appears from this study that the cryptocrystalline quartzite from Jamda area could be utilised for superduty silica brick and that the properties of silica brick which can be made from the Mihijam quartzites can possibly be improved further to superduty quality by the incorporation of low alumina quartzite fines and proper dense packing and high pressure forming. This would, of course, need further detailed study.

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